Appendices

Title	
1	Assessment of BassGas operations against the management aims of marine park management plans
2	Assessment of BassGas operations against the management aims of threatened species' management plans
3	Stakeholder consultation flyer
4	Stakeholder communications *Provided to NOPSEMA separately as sensitive information under Regulation 9(8) of the OPGGS(E)*
5	EPBC Act Protected Matters Search Tool (PMST) results
6	Victorian Biodiversity Atlas (VBA) search tool results
7	Victorian Oil Spill Response Atlas (OSRA) maps
8	Assessment of BassGas operations against the aims of approved conservation advice for Threatened Ecological Communities (TECs)
9	Yolla platform produced formation water ALARP assessment (AECOM, 2020)
10	Yolla Platform – Bass Strait Produced Water Dispersion Near-Field Modelling (RPS, 2017)
11	Beach Yolla Platform Produced Water Dispersion Far-Field Modelling Study (RPS, 2020)

Appendix 1

Assessment of BassGas operations against the management aims of marine park management plans

Assessment of BassGas operations against the aims of marine park management plans	
COMMONWEALTH	
1a	South-east Commonwealth Marine Reserves Network
1b	The National Light Pollution Guidelines for Wildlife
VICTORIAN RESERVES (west to east)	
1c	Great Otway National Park
1d	Marengo Reef Marine Sanctuary
1e	Mornington Peninsula National Park
1f	Mushroom Reef Marine Sanctuary
1g	Flinders Foreshore Reserve
1h	Phillip Island Nature Park
1i	Churchill Island Marine National Park
1j	French Island National Park
1k	San Remo Coastal Reserve
1l	Kilcunda Foreshore Reserve
1m	Bunurong-Kilcunda-Harmers Parks
1n	Cape Liptrap Coastal Park
1o	Wilsons Promontory (three marine) Parks
1p	Corner Inlet Marine National Park
1q	Gippsland Lakes Coastal Park
1r	Cape Conran Coastal Park
1s	Point Hicks Marine National Park
1t	Croajingolong National Park
1u	Cape Howe Marine National Park
TASMANIAN RESERVES (west to east)	
1v	Arthur-Pieman Conservation Area
1w	The Nut State Reserve
1x	Small Bass Strait Island Reserves
1y	Kent Group National Park
New SOUTH WALES RESERVES (south to north)	
1z	Nadgee Nature Reserve
1za	Ben Boyd National Park

Assessment of BassGas operations against the stated management strategies and actions of the South-east Commonwealth Marine Reserves Network Management Plan 2013-2023 (DNP, 2013)

The following information summarises the risk to the park from the spill scenarios.

AMPs:	Beagle	Boags	Apollo	East Gippsland	Franklin
204,250 bbl subsea blowout of Yolla condensate over 86 Days					
Sea surface:	No contact.				
Entrained hydrocarbons:	75% probability of low exposure at 0-10 m below sea surface.	47% probability of low exposure at 0-10 m below sea surface.	No contact.	4% probability of low exposure at 0-10 m below sea surface.	15% probability of low exposure at 0-10 m below sea surface.
Dissolved hydrocarbons:	4% probability of low exposure at 0-10 m below sea surface. 1% probability of low exposure at 10-20 m below sea surface.	6% probability of low exposure at 0-10 m below sea surface. 1% probability of low exposure at 10-20 m below sea surface.	No contact.	No contact.	1% probability of low exposure at 0-10 m below sea surface.
Shoreline contact:	N/A (AMPs are in Commonwealth waters)				
300 m^3 surface release of MDO over 6 Hours					
Sea surface:	No contact.				
Entrained hydrocarbons:	17% probability of low exposure at 0-10 m below sea surface. 1% probability of high exposure at 0-10 m below sea surface.	No contact.	1% probability of low exposure at 0-10 m below sea surface.	No contact.	No contact.
Dissolved hydrocarbons:	No contact.				
Shoreline contact:	N/A (AMPs are in Commonwealth waters)				
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes					
Sea surface:	No contact.				

AMPs:	Beagle	Boags	Apollo	East Gippsland	Franklin
Entrained hydrocarbons:	3% probability of low exposure 0-10 m below sea surface.	No contact.			
Dissolved hydrocarbons:	2% probability of low exposure 0-10 m below sea surface.	No contact.			
Shoreline contact:	N/A (AMPs are in Commonwealth waters)				

The table on the following page provides an assessment of routine and non-routine operations against the stated management strategies and actions of the South-east Commonwealth Marine Reserves Network Management Plan 2013-2023.

Management Strategy	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Improve knowledge and understanding of the conservation values of the Marine Reserves Network and of the pressures on those values		
As part of a national-scale program for Commonwealth marine reserves, develop and implement a South-east Commonwealth Marine Reserves Network Research and Monitoring strategy that contribute to increased understanding of the values of the reserves and provides for ongoing reporting of their condition	No impacts.	No impacts.
Develop and implement a framework for the long-term scientific monitoring of changes in key conservation values protected by the Commonwealth marine reserves and on the pressures on those values.	No impacts.	No impacts.
Adopt standards and protocols for managing biophysical and ecological data collected within Commonwealth Marine Reserves.	No impacts.	No impacts.
Collaborate, including through developing partnerships, with national research facilities, science and academic institutions and, as appropriate, marine reserve users, to deliver on strategic information needs and to inform research programs and government and industry investment in marine research.	No impacts.	No impacts.
Minimise impacts of activities through effective assessment of proposals, decision-making and management of reserve-specific issues		
Establish in consultation with relevant stakeholders, efficient, effective and transparent processes for assessment, decision-making and authorisation of activities, and implement within the marine reserves network.	No impacts.	No impacts.
When the interests of a person or group are likely to be affected by a decision under this Management Plan, the Director will: a) as far as practicable consult them in a timely and appropriate way; b) provide an opportunity to comment on the proposed decision and associated actions; c) take any comments into account; d) give reasonable notice before decisions are taken or implemented (except in cases of emergency); and e) provide reasons for decisions.	No impacts.	No impacts.
Comply with Division 14.3 of the EPBC Regulations in relation to reconsideration of decisions about permits.	No impacts.	No impacts.
Reconsider a decision about a class approval when requested by a person whose interests are affected by the decision. A request for reconsideration must be made and considered in the same manner as provided by Divison14.3 of the EPBC Regulations. Subject to the Administrative Appeals Tribunal Act 1975, a person who has requested a reconsideration may apply to the Administrative Appeals Tribunal for review of the reconsideration.	No impacts.	No impact.
Consider further use of class approvals where there is a sound case for effectively assessing and efficiently approving users that carry out a class of activities in a uniform way.	No impacts.	No impact.

Identify reserve specific issues and develop, implement and evaluate management responses where appropriate.	No impacts.	No impact.
Protect the conservation values of the Marine Reserves Network through management of environmental incidents		
Establish systems for timely reporting of, and assisting with responses to, environmental incidents.	No impacts.	No impacts.
Collaborate with responsible agencies and assist with responding to environmental incidents that threaten the values of the marine reserves network.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Maintain effective liaison and partnerships with relevant environmental incident response agencies and organisations.	No impacts.	No impact.
Identify and assess potential incidents that may threaten conservation values of the Reserves and implement if feasible approaches to reduce the likelihood or consequence of such incidents.	No impacts.	No impact.
Facilitate compliance with this Management Plan through education and enforcement		
Implement reliable methods for monitoring compliance with this Plan.	No impacts.	No impact.
Develop, maintain and disseminate appropriate information to assist users of the marine reserves network to comply with the provisions of this Plan.	No impacts.	No impact.
Consult with users of the network to identify opportunities to improve the effectiveness and efficiency of compliance measures.	No impacts.	No impact.
Implement a risk-based annual compliance plan.	No impacts.	No impact.
Establish a reporting system that supports users and visitors of the marine reserves network to report suspected non-compliant activity.	No impacts.	No impact.
Build effective working partnerships and agreements with Commonwealth and state government agencies for the delivery of compliance services.	No impacts.	No impact.
Investigate and monitor suspected non-compliant activity and, where appropriate, take enforcement action.	No impacts.	No impact.
Support initiatives and programs which promote best practice standards that guide use, and minimise impacts on the marine environment	No impacts.	No impact.
Promote community understanding of, and stakeholder participation in, the management of the Marine Reserves Network		

Develop and implement a communication and education plan that increases community understanding of the importance of the marine reserves network and meets reserve-specific needs for communication about the values protected and management arrangements and requirements.	No impacts.	No impact.
Maintain effective working relationships with user groups to facilitate the exchange of knowledge, understanding and participation in the management of the marine reserves network.	No impacts.	No impact.
Within the first 12 months of the Plan's operation, establish consultative structures (e.g. committees) to guide and participate in the management of the marine reserves network.	No impacts.	No impact.
Support involvement of Indigenous people in management of Commonwealth Marine Reserves		
Drawing on the significant body of knowledge built as part of sea country planning and similar initiatives across Australia, and in consultation with relevant representative organisations, consolidate and communicate information about cultural values protected in the South-east Commonwealth Marine Reserves Network.	No impacts.	No impact.
Identify, and where feasible support, opportunities for Indigenous people to engage in the management of sea country in Commonwealth marine reserves, for example through the delivery of critical management services, such as monitoring surveillance, compliance and research.	No impacts.	No impact.
Build effective partnerships with Indigenous communities and organisations that have an interest in the marine reserves network.	No impacts.	No impact.
Comply with the requirements of the Native Title Act 1993.	No impacts.	No impact.
Evaluate and report on the effectiveness of this Management Plan through monitoring and review		
Within the first twelve months of the Plan's operation, design and initiate a program to measure and monitor progress on Actions and outcomes.	No impacts.	No impact.
Report annually on the South-east Commonwealth Marine Reserves Network in the Director of National Parks annual report.	No impacts.	No impact.
Evaluate and report on the implementation of the Management Plan before its expiry. The report will consider: a. An assessment of the existing measures to protect the South-east Commonwealth Marine Reserves Network; b. Progress of the strategies and actions towards achieving the stated outcomes; c. options for improving management of the marine reserves network.	No impacts.	No impact.

<u>Assessment of BassGas operations against the stated management actions of National Light Pollution Guidelines (DoEE, 2020)</u>

The table on the following pages provide an assessment of BassGas operations against the stated management actions of the Guidelines.

Note: impacts to turtles are not assessed because there are only vagrant individuals and no nesting beaches present in Bass Strait. Similarly, impacts to shorebirds are not assessed given that Yolla-A is located 90 km from the nearest shoreline at Wilsons Promontory.

Management Actions	**Achievable?**	**Assessment of BassGas operations against stated management actions**
Implement management actions during the breeding season.	N/A	To date, personnel based on Yolla-A have not encountered any unusual bird behaviour, injuries or deaths around light sources. This suggests that this measure is not necessary.
Maintain a dark zone between the rookery and the light sources.	Yes	The nearest bird rookery location is 80 km away on Curtis Island. As such, there is a large dark zone between the rookery and Yolla-A.
Turn off lights during fledgling season.	N/A	BassGas operations are conducted 24-hours a day and light is necessary for personnel safety. Most seabirds in the region are migratory with breeding occurring internationally, so fledglings are not an important consideration in this area.
Use curfews to manage lighting.	N/A	Platform operations are conducted 24-hours a day and deck lighting is necessary for personnel safety. Lighting maintained in accordance with legislation and for human safety overrides environmental considerations.
Aim lights downwards and direct them away from nesting areas.	N/A	The nearest rookery location is 80 km away on Curtis Island. As such, aiming lights downwards is not necessary.
Use flashing/intermittent lights instead of fixed beam.	No	Platform operations are conducted 24-hours a day and deck lighting is necessary for personnel safety. Platform lighting is installed and maintained in accordance with the *Navigation Act* 2012. Lighting for human safety overrides environmental considerations.
Use motion sensors to turn lights on only when needed.	No	Platform operations are conducted 24-hours a day and lighting of all areas is necessary for personnel safety. Lighting for human safety overrides environmental considerations.
Prevent indoor lighting reaching outdoor environment.	N/A	Due to the low staffing requirements on the platform, there are very few accommodation areas with windows. Indoor lighting is an insignificant source of light.
Manage artificial light on jetties, wharves, marinas, etc.	N/A	Not relevant.

Reduce unnecessary outdoor, deck lighting on all vessels and permanent and floating oil and gas installations in known seabird foraging areas at sea.	No	Platform operations are conducted 24-hours a day and lighting of all areas is necessary for personnel safety. Lighting for human safety overrides environmental considerations.
Night fishing should only occur with minimum deck lighting.	N/A	Not applicable - fishing is not permitted from the platform.
Avoid shining light directly onto fishing gear in the water.	N/A	Not applicable - fishing is not permitted from the platform.
Ensure lighting enables recording of any incidental catch, including by electronic monitoring systems.	N/A	Not applicable - fishing is not permitted from the platform.
Avoid shining light directly onto longlines and/or illuminating baits in the water.	N/A	Not applicable - fishing is not permitted from the platform.
Vessels working in seabird foraging areas during breeding season should implement a seabird management plan to prevent seabird landings on the ship, manage birds appropriately and report the interaction.	N/A	Relevant only to the Platform Supply Vessel (PSV) trip approximately once a week. The PSV is equipped with lighting required under legislation to identify itself to other vessels, reduce the risk of at-sea collision and provide for the safety of its crew. Most seabirds in the region are migratory with breeding occurring internationally, with no breeding areas (i.e., islands) in close proximity to the platform.
Use luminaires with spectral content appropriate for the species present.	No	To date, personnel based on Yolla-A have not encountered any unusual bird behaviour, injuries or deaths around light sources. This indicates that the spectral source and intensity of platform lighting is not a relevant concern in this location.
Avoid high intensity light of any colour.	No	
Shield gas flares and locate inland and away from seabird rookeries.	No	Flaring from the platform may be required at times for the safety of personnel and integrity of the installation. The flare cannot be shielded. The nearest land (and thus closest potential rookery location) is 80 km away on Curtis Island. The infrequent nature of flaring at Yolla-A means implementing this measure is not justified.
Minimise flaring on offshore oil and gas production facilities.	Yes	Flaring at Yolla-A is minimised because it is an infrequent activity.
In facilities requiring intermittent night-time inspections, turn on lights only during the time operators are moving around the facility.	No	BassGas operations are conducted 24-hours a day and lighting of all areas is necessary for personnel safety. Lighting for human safety overrides environmental considerations.
Ensure industrial site/plant operators use head torches.	No	BassGas operations are conducted 24-hours a day and lighting of all areas is necessary for personnel safety. As such, the use of head torches is not necessary.
Supplement facility perimeter security lighting with computer monitored infrared detection systems.	N/A	Not applicable, the installation is located 80 km offshore from the nearest land and does not feature perimeter security lighting.

Tourism operations around seabird colonies should manage torch usage so birds are not disturbed.	N/A	Not applicable.
Design and implement a rescue program for grounded birds.	No	To date, personnel based on Yolla-A have not encountered any unusual bird behaviour, injuries or deaths around light sources. This suggests that this measure is not necessary.

Assessment of BassGas operations against the stated aims of the Great Otway National Park Management Plan (Parks Victoria, 2007)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	5% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Climate change and resilience planning		
Increase park manager and community understanding of climate change, its consequences and resilience planning.	No impacts.	No impacts.
Develop and implement management strategies to build ecosystem and species resilience to climate change.	No impacts.	No impacts.
4.2 Landscape		
Protect, enhance and restore landscape values in the parks and minimise impacts of management or visitor activities on landscape values.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Encourage neighbouring developments and activities to have minimal adverse impact on landscape values.	No impacts.	No impacts.
4.3 Geological and geomorphological features		
Protect significant and fragile geological and geomorphological values.	No impacts.	No impacts.
4.4 Rivers, catchments, groundwater and coasts		
Protect, enhance and restore natural, social and resource values associated with rivers, catchments, groundwater and coasts.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil towards the shoreline.
Improve the condition of high-value streams that are not in good condition.	No impacts.	No impacts.
4.5 Vegetation		
Protect, enhance and restore indigenous flora species and communities.	No impacts.	No impacts.
Where possible, allow natural processes that shape floral biodiversity to continue with minimal interference.	No impacts.	No impacts.
Increase knowledge of flora species and communities, and threatening processes to improve management effectiveness.	No impacts.	No impacts.

4.6 Fauna		
Protect indigenous fauna and habitats from threatening processes where possible.	No impacts.	No impacts.
Where possible, allow natural processes that shape faunal biodiversity to continue with minimal interference.	No impacts.	No impacts.
Increase knowledge of fauna and threatening processes to improve management effectiveness.	No impacts.	No impacts.
4.7 Fire Management		
Protect human life, property and public assets as far as practicable from the deleterious consequences of wildlife.	No impacts.	No impacts.
Investigate, evaluate and where appropriate implement fire regimes and strategies to reduce the potential for the development of landscape scale fires and also maintain the environmental integrity of the landscape.	No impacts.	No impacts.
In partnership with other agencies and the community, undertake effective fire prevention, preparedness, response and recovery activities.	No impacts.	No impacts.
4.8 Pest Plants and Animals, and Diseases		
Eradicate or prevent the establishment of new or emerging pest plants, animals and diseases.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Control and where possible eradicate pest plants, animals and diseases from the parks, giving priority to areas with priority species and communities or areas in good condition.	No impacts.	No impacts.
Improve the effectiveness of pest and disease management by increasing the knowledge of pest species and treatment methods through research, record-keeping and monitoring.	No impacts.	No impacts.
5.1 Aboriginal and cultural heritage		
Recognise and respect the cultural connections that Traditional Owners and other Aboriginal people have with Country within the parks.	No impacts.	No impacts.
Provide and maintain opportunities for Aboriginal cultural connections and practices within the parks.	No impacts.	No impacts.
Work together with the Traditional Owners to protect and enhance Aboriginal cultural heritage.	No impacts.	No impacts.

5.2 Historic heritage		
Protect, conserve and present places with significant historic (non-indigenous) cultural heritage values in accordance with applicable legislation, strategies and charters.	No impacts.	No impacts.
Increase visitor and local community involvement, understanding and appreciation of Otway historic heritage, including sustainable provision of access, presentation, interpretation and promotion of selected sites.	No impacts.	No impacts.
5.3 Social values		
Understand the social values of the parks, and enhance and protect places, landscapes, features and character that contribute to social values.	No impacts.	No impacts.
6.1 Tourism and recreation directions		
Provide and enhance a sustainable range of tourism and recreation opportunities and products within the parks. Contribute to the region's tourism and recreation opportunities and profile.	No impacts.	No impacts.
Provide high quality, memorable, authentic and educational experiences for visitors that capitalise on the Otways unique attributes, to generate an understanding and appreciation of park values, and meet or exceed visitor expectations.	No impacts.	No impacts.
Increase opportunities for participation of commercial and community partners in the provision of tourism and recreation experiences, particularly the Aboriginal community.	No impacts.	No impacts.
Ensure that tourism and recreation activities and infrastructure are conducted and managed in a way that respects natural settings, conservation requirements, and cultural sensitivities.	No impacts.	No impacts.
6.2 Information, interpretation and education		
Promote and encourage visitors' safe and sustainable discovery, enjoyment, understanding and appreciation of the parks natural and cultural values.	No impacts.	No impacts.
6.3 Motor vehicle access		
Provide and maintain a sustainable network of roads for a variety of uses, including general access for recreation, tourism and transit, and access for park management activities, fire suppression and authorised resource extraction.	No impacts.	No impacts.
Provide opportunities for people to enjoy car and motorcycle touring, four-wheel driving and trail bike riding experiences within the parks, where this is sustainable and compatible with the protection of other park values.	No impacts.	No impacts.

Minimise impacts of the road network on natural, cultural and resource values of the parks.	No impacts.	No impacts.
Encourage responsible vehicle use to minimise damage to the road network and the environment, and minimise conflict between park users and with neighbours.	No impacts.	No impacts.
6.4 Visitor sites and services		
Provide a system of designated visitor sites and services for sustainable recreation, education and enjoyment of experiences in the parks, and as nodes for access to park features and recreation areas.	No impacts.	No impacts.
Minimise conflicts between parks users and impact on park values from visitor facilities.	No impacts.	No impacts.
6.5 Bushwalking		
Provide opportunities for visitors (including disabled and low mobility visitors) to enjoy a diverse range of bushwalking experiences in the parks by accessing a sustainable network of walking tracks of various lengths, standards, and degrees of challenge.	No impacts.	No impacts.
Minimise impacts of the track network and bushwalking activities on park values and on other park users, and minimise excessive safety risks. Encourage responsible bushwalking behaviour.	No impacts.	No impacts.
6.6 Camping		
Provide a sustainable range of opportunities for people to enjoy camping experiences in the parks, and utilise camping areas as a base for recreation activities.	No impacts.	No impacts.
Minimise impacts on park values and conflicts between park users from camping.		
6.7 Cycling		
Provide opportunities for people to enjoy cycling experiences in the parks, including mountain biking and bicycle touring, where this is sustainable and compatible with the protection of other park values.	No impacts.	No impacts.
Minimise conflicts with other park users and impacts on park values from cycling activities.	No impacts.	No impacts.
6.8 Companion dogs		
Provide opportunities for people to enjoy experiences with dogs in the parks where this is sustainable and compatible with the protection of other park values.	No impacts.	No impacts.

Minimise impacts on park values and conflicts with other park users from dogs.	No impacts.	No impacts.
6.9 Horse riding		
Provide opportunities for enjoyable and diverse nature-based horse riding experiences in the parks, including trail riding and camping with horses, where this is sustainable and compatible with the protection of other park values.	No impacts.	No impacts.
Minimise impacts on park values and conflicts with other park users from horse riding activities.	No impacts.	No impacts.
6.10 Recreational fishing		
Provide high quality opportunities for recreational fishing in and adjacent to the parks, where this is sustainable and compatible with the protection of park values.	No impacts.	No impacts.
Maintain recreational fishing access while protecting environmental and cultural values.	No impacts.	No impacts.
Minimise conflicts with other park users and impacts on park values from fishing.	No impacts.	No impacts.
6.11 Recreational hunting		
Provide opportunities for enjoyable recreational hunting experiences in Otway Forest Park, where compatible with the protection of other park values and visitor safety.	No impacts.	No impacts.
Minimise conflicts with other parks users and impacts on park values from recreational hunting.	No impacts.	No impacts.
6.12 Fossicking and prospecting		
Provide opportunities for gemstone fossicking at Wreck Beach in Great Otway National Park, and fossicking and prospecting in all areas of Otway Forest Park.	No impacts.	No impacts.
6.13 Boating and other water sports		
Provide opportunities for enjoyable water sports including boating, swimming and surfing in and adjacent to the parks, where this is sustainable and compatible with the protection of park values.	No impacts.	No impacts.

Minimise conflicts with other park users and impacts on park values from boating, swimming and other water sports.	No impacts.	No impacts.
6.14 Recreational aircraft		
Permit opportunities for hang-gliding and paragliding activities in the parks, where this is sustainable and compatible with the protection of park values and does not significantly impact on the enjoyment of other park visitors.	No impacts.	No impacts.
Provide appropriate access by powered aircraft for scenic over-flights of the parks, where this is sustainable and compatible with the protection of park values and does not significantly impact on the enjoyment of other park visitors.	No impacts.	No impacts.
Minimise conflicts with other park users and impacts on park values from air sports and aircraft.	No impacts.	No impacts.
6.15 Events and commercial activities		
Allow and manage appropriate events and functions and minimise impacts on park values.	No impacts.	No impacts.
Provide for appropriate commercial businesses to operate within the parks.	No impacts.	No impacts.
Ensure commercial operators are licensed to conduct their business within the parks.	No impacts.	No impacts.
6.16 Public safety		
Promote awareness of recreation risks, responsibility for considering risks, and adherence to safe practices to park users.	No impacts.	No impacts.
Identify public safety risks and implement risk management strategies.	No impacts.	No impacts.
Plan for and respond appropriately to public safety incidents and emergencies.	No impacts.	No impacts.
7.1 Firewood harvesting		

Allow firewood harvesting for commercial and personal use from the Otway Forest Park in accordance with relevant legislation, codes of practice, procedures and prescriptions.	No impacts.	No impacts.
Minimise the impacts of harvesting firewood on the natural, cultural and recreational values of the Otway Forest Park.	No impacts.	No impacts.
7.2 Minor forest produce harvesting		
Allow minor forest produce harvesting in Otway Forest Park in alignment with relevant legislation, codes of practice, procedures and prescriptions.	No impacts.	No impacts.
Minimise the impacts of minor forest produce harvesting on the natural, cultural and recreational values of Otway Forest Park.	No impacts.	No impacts.
8.1 Public utilities infrastructure		
Manage authorised public utilities infrastructure within the parks through formal consents, leases, licences, permits and agreements in accordance with relevant legislation, and to minimise impacts on park values.	No impacts.	No impacts.
8.2 Private occupancies		
Manage authorised occupancies to allow for specified uses while minimising their impacts on park values.	No impacts.	No impacts.
Resolve unauthorised occupancies by removal or authorisation.	No impacts.	No impacts.
8.3 Cape Otway Lightstation		
Provide for the ongoing commercial operation of the Cape Otway Lightstation Tourist and Heritage precinct.	No impacts.	No impacts.
Provide for the ongoing operation of marine navigation and weather recording instruments.	No impacts.	No impacts.
8.4 Designated and Special Water Supply Catchment Areas		

Minimise impacts on water quality and yield in water supply catchment areas from fire, recreation, extraction and management activities.	No impacts.	No impacts.
Manage Designated Water Supply Catchments as closed catchments.	No impacts.	No impacts.
Protect the public health of communities that depend on water supply catchments, through minimising threats to water quality and yield within water supply catchment areas.	No impacts.	No impacts.
8.5 Grazing		
Permit low-intensity grazing in cleared areas of Otway Forest Park where it is pre-existing and consistent with conservation and recreation objectives.	No impacts.	No impacts.
Phase out grazing in Great Otway National Park.	No impacts.	No impacts.
8.6 Apiculture		
Provide for apiculture in Otway Forest Park while minimising impacts on other park values.	No impacts.	No impacts.
Do not allow apiculture in Great Otway National Park.	No impacts.	No impacts.
8.7 Commercial fishing		
Provide for existing commercial eel fishing entitlements in Great Otway National Park.	No impacts.	No impacts.
8.8 Earth resources		
Ensure that earth resources activities are conducted in accordance with the relevant legislation and that park values are adequately protected.	No impacts.	No impacts.
8.9 Occasional uses		
Allow authorised occasional uses and minimise their impacts on park values.	No impacts.	No impacts.

8.10 Park boundaries and adjacent uses		
Coordinate management activities with those of park neighbours where these are complementary to the protection of park values.	No impacts.	No impacts.
Work with park neighbours to address issues of pest plant and animal control.	No impacts.	No impacts.
Provide access through the parks to neighbouring properties for authorized uses such as timber carting where that access does not impact on park values.	No impacts.	No impacts.
Provide reasonable rights of access to freehold land abutting or surrounded by the Great Otway National Park and minimise the impacts on park values.	No impacts.	No impacts.
9.1 Community awareness		
Increase the community's awareness and understanding of the parks' values and management activities.	No impacts.	No impacts.
9.2 Traditional Owner partnerships		
Build collaborative relationships to engage Traditional Owners in the parks' planning and management.	No impacts.	No impacts.
Improve opportunities for Aboriginal participation in the parks' management.	No impacts.	No impacts.
9.3 Community participation		
Build a sense of shared ownership and custodianship for the parks among community groups and individuals.	No impacts.	No impacts.
Support and encourage people to actively assist in implementing the plan and managing the parks.	No impacts.	No impacts.
9.4 Agency partnerships		
Enhance park management by collaborating with other agencies to ensure they consider park values in planning and implementing activities that relate to the parks.	No impacts.	No impacts.

Contribute to cooperative programs and activities undertaken by other agencies where these complement management of the parks.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Marengo Reefs Marine Sanctuary Management Plan (Parks Victoria, 2007)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	1% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Geological and landform features		
Protect significant and fragile geological and seabed features in the park and sanctuaries.	No impacts.	No impacts.
4.2 Catchment and water quality		
Prevent where practicable, and minimise the impact of pollution and litter on sanctuary values.	The EP contains control measures aimed to minimise the risk of pollution and litter to Victorian waters.	No impacts.
4.3 Hydrodynamics		
Minimise impacts on sanctuary values from human-induced changes to local hydrodynamics.	No impacts.	No impacts.
4.4 Habitats and communities		
Protect marine ecological communities and indigenous flora and fauna, and allow natural processes to continue.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Improve knowledge of marine ecological communities, flora and fauna and threatening processes to improve management, protection and appreciation.	No impacts.	No impacts.
4.5 Landscape and seascape		
Protect landscape and seascape values.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Minimise the visual impact of signs, infrastructure and management activities associated with the sanctuary.	No impacts.	No impacts.
4.6 Marine pests		
Minimise the risk of introduction of marine pests by human activities, and their subsequent establishment in the sanctuary.	The EP contains control measures aimed to minimise the	No impacts.

Establish arrangements for the detection of new incursions within the planning area in support of Victorian marine pest management arrangements.	risk of introducing marine pests to Victorian waters.	No impacts.
Implement national or Victoria-wide control arrangements as they relate to the sanctuary.		No impacts.
5.1 Indigenous cultural heritage		
Protect Indigenous places and objects from interference or damaging activities.	No impacts.	No impacts.
Support the views of the Traditional Owners in managing the sanctuary.	No impacts.	No impacts.
5.2 Maritime and other cultural heritage		
Conserve and protect places of historical significance.	No impacts.	No impacts.
Encourage learning and understanding about the historical heritage of the sanctuary.		
6.1 Information, interpretation and education		
Promote and encourage visitors' discovery, enjoyment and appreciation of the park and sanctuaries' natural and cultural values in a safe and appropriate manner through information, interpretation and education.	No impacts.	No impacts.
Encourage public support for marine national parks and marine sanctuaries and management practices.	No impacts.	No impacts.
6.2 Access		
Support and manage the provision of appropriate and safe access to the sanctuary.	No impacts.	No impacts.
6.3 Recreational boating and surface water sports		
Provide for boating activities in the sanctuary consistent with management objectives.	No impacts.	No impacts.
6.4 Diving and snorkelling		
Provide opportunities for diving and snorkelling that are consistent with the protection of sanctuary values.	No impacts.	No impacts.
6.5 Tourism services		
Provide opportunities for and encourage provision of external tourism services while minimising impacts on natural and cultural values of the sanctuary.	No impacts.	No impacts.
6.6 Public safety		

Promote awareness of safety issues and risks, and safe practices, in use of the sanctuary.	No impacts.	No impacts.
Cooperate with emergency services.	No impacts.	No impacts.
7.1 Authorised uses		
Minimise the impact on sanctuary values of authorised uses.	No impacts.	No impacts.
Manage authorised uses in accordance with legislation.	No impacts.	No impacts.
7.2 Boundaries and adjacent uses		
Effectively communicate the location of the sanctuary boundaries.	No impacts.	No impacts.
Minimise impact on sanctuary values from adjacent developments.	No impacts.	No impacts.
8.1 Community awareness		
Increase community awareness and understanding of the sanctuary's values and management activities.	No impacts.	No impacts.
Build a common vision and sense of shared custodianship for the sanctuary in community groups and individuals.		
8.2 Community participation		
Support and encourage the whole community, including community groups and volunteers to contribute their knowledge, skills and enthusiasm to the sanctuary's management.	No impacts.	No impacts.
Inform and strengthen management with cultural lore of the Traditional owners.	No impacts.	No impacts.
8.3 Agency partnerships		
Enhance sanctuary management by collaborating with other agencies to ensure appropriate consideration to sanctuary values in planning and implementing activities that relate to the sanctuary.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Mornington Peninsula National Park Management Plan (Parks Victoria, 1998)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	2% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
3.1 Geological and landform features		
Minimise impacts from visitors on sensitive geological features.	No impacts.	No impacts.
Protect significant dune systems	No impacts.	No impacts.
Provide opportunities for appropriate research, appreciation and education of geological and geomorphological sites and processes.	No impacts.	No impacts.
Allow natural environmental processes to continue with minimum disturbance.	No impacts.	No impacts.
Protect significant historical sites and structures from coastal erosion.	No impacts.	No impacts.
3.2 Vegetation		
Conserve native plant communities in their natural condition and maintain and enhance habitat diversity while allowing natural environmental processes to continue	No impacts.	No impacts.
Improve knowledge of flora in the Park and associated management requirements.	No impacts.	No impacts.
Provide special protection for significant plant species and communities.	No impacts.	No impacts.
3.3 Fauna		
Conserve native fauna species and maintain the integrity of their habitats.	No impacts.	No impacts.
Provide special protection for significant fauna.	No impacts.	No impacts.
Protect genetic diversity of native populations and maintain habitat diversity.	No impacts.	No impacts.
3.4 Landscape		
Protect and preserve the landscape values of the Park in areas of scenic quality and viewer interest, especially along the coastal section.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil towards the shoreline.
3.5 Cultural Heritage		

Protect all Aboriginal archaeological sites.	No impacts.	No impacts.
Interpret the Aboriginal cultural heritage values of the Park.	No impacts.	No impacts.
Conserve significant features and landscapes of historic and cultural significance.	No impacts.	No impacts.
Interpret the cultural values of the Park, especially at Point Nepean, assisting visitors to gain an understanding and appreciation of past activities in the Park	No impacts.	No impacts.
4.1 Fire Management		
Protect human life, property and park values from injury by fire.	No impacts.	No impacts.
Improve knowledge of the ecological effects of lack of fire on coastal vegetation.	No impacts.	No impacts.
Maintain fire regimes appropriate to the conservation of native flora and fauna.	No impacts.	No impacts.
Minimise the adverse effects of all fires and fire suppression methods on park values.	No impacts.	No impacts.
4.2 Pest plants and animals, and diseases		
Control, and where possible eradicate, pest plants and animals in the Park.	No impacts.	No impacts.
Protect the Park from other threats and diseases, in particular Cinnamon Fungus and new infestations of non-indigenous species.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Minimise the impact of control programs on native flora and fauna.	No impacts.	No impacts.
4.3 Soil conservation		
Prevent and control soil erosion and dune destabilisation from visitor and management activities and adjoining activities.	No impacts.	No impacts.
5.1 Park visitors		
Provide a wider choice of quality visitor opportunities and experiences.	No impacts.	No impacts.
Develop a more detailed understanding of current and potential visitors	No impacts.	No impacts.
Provide for visitors in accordance with the above overview of future management for visitors.	No impacts.	No impacts.

Provide a hierarchy of orientation, interpretation and visitor support facilities across the Park.	No impacts.	No impacts.
Ensure that visitor use has minimal impact on the Park and park values.	No impacts.	No impacts.
Increase awareness of the Park and experiences available to visitors, by creating distinctively imaged precincts and opportunities within the Park.		
5.2 Marketing		
Ensure that the Park is marketed as one of Victoria's icon parks.	No impacts.	No impacts.
Market the Park as a 'standalone attraction' and in conjunction with other related natural and cultural attractions.	No impacts.	No impacts.
Target international, interstate and other appropriate market segments in marketing and promotion of the Park.	No impacts.	No impacts.
5.3.1 Visitor orientation		
Provide motivational and tour planning information to visitors before they undertake their visit to the Park.	No impacts.	No impacts.
Orientate the independent car-based traveller to the Park in relation to Park features	No impacts.	No impacts.
Inform visitors of appropriate codes of behaviour before and during their visit and provide key safety messages	No impacts.	No impacts.
5.3.2 Interpretation and education		
Enhance visitor understanding and enjoyment of the Park through the provision of interpretative information.	No impacts.	No impacts.
5.4.1 Day use areas		
Upgrade and maintain day visitor facilities that enhance visitor enjoyment and are consistent with protecting park values.	No impacts.	No impacts.
Provide and maintain facilities suitable for persons with limited mobility.	No impacts.	No impacts.
5.4.2 Major attractions		
Develop the Cape Schanck precinct as a key destination providing quality facilities and services compatible with the area's high natural and cultural values.	No impacts.	No impacts.
5.4.3 Vehicle access		

Provide and maintain an appropriate network of sign-posted roads, tracks and car parking facilities for visitor use and management purposes.	No impacts.	No impacts.
Minimise the impacts of vehicles on the Park's values.	No impacts.	No impacts.
5.4.4 Walking		
Maintain and improve the existing walking track system to provide a range of walking opportunities while protecting park values.	No impacts.	No impacts.
Increase use and enjoyment of the track system	No impacts.	No impacts.
5.4.5 Camping		
Protect Park resources and ensure visitor safety.	No impacts.	No impacts.
Provide for basic walk-in camping	No impacts.	No impacts.
5.4.6 Beach-going, surfing and fishing		
Provide for a range of beach-related and water-based activities while protecting park values.	No impacts.	No impacts.
Ensure that visitors are aware of major hazards along the coast.	No impacts.	No impacts.
5.4.7 Horse riding		
Provide opportunities for both commercial and recreational horse riders without compromising other Park management objectives.	No impacts.	No impacts.
Minimise any environmental impacts caused by horse riding.	No impacts.	No impacts.
5.4.8 Cycling		
Provide cycling access to the Park and improve opportunities for on-road cycling at Point Nepean.	No impacts.	No impacts.
5.4.9 Hang gliding and paragliding		
Provide for hang gliding and paragliding consistent with management objectives.	No impacts.	No impacts.

5.4.10 Fossicking		
Protect park values from damage by fossicking	No impacts.	No impacts.
5.4.11 Dogs		
Minimise the impacts of dogs on park values and visitor experiences	No impacts.	No impacts.
5.5 Commercial tourism operations		
Encourage commercial nature and culture-based tourism services consistent with park management objectives.	No impacts.	No impacts.
Complement other tourism opportunities and activities on the Peninsula	No impacts.	No impacts.
5.6 Public safety		
Warn visitors about the Park's risks.	No impacts.	No impacts.
Promote and encourage safe practices among staff and visitors to the Park	No impacts.	No impacts.
Minimise exposure of visitors to the Park's coastal hazards.	No impacts.	No impacts.
Comply with Parks Victoria guidelines on risk management	No impacts.	No impacts.
6.1 Friends and volunteers		
Encourage and maintain volunteer involvement in managing the Park.	No impacts.	No impacts.
6.2 Community awareness and Park neighbours		

Increase community awareness of management activities undertaken in the Park.	No impacts.	No impacts.
Create a positive image of the Park.	No impacts.	No impacts.
Encourage conservation and sound land management and recreation practices on private land adjoining the Park.	No impacts.	No impacts.
6.3 Schools and other education		
Ensure that the Park's unique attributes and opportunities for education are incorporated in the state-wide schools curriculum program.	No impacts.	No impacts.
Promote the Park as a venue for school visits.	No impacts.	No impacts.
Provide appropriate resource materials to support the schools program and other educators.	No impacts.	No impacts.
7.1.1 Public utilities and occupancies		
Provide for the appropriate continuing use of existing public utilities and occupancies in the Park.	No impacts.	No impacts.
Minimise the impacts of the construction, maintenance and operation of utility installations on the Park.	No impacts.	No impacts.
7.1.2 Apiculture		
Minimise the potential effect of apiculture on park values.	No impacts.	No impacts.
7.1.3 Major Events		
Provide opportunities for special events consistent with Park management objectives.	No impacts.	No impacts.

7.2 Boundaries and adjacent land uses		
Encourage co-operation with adjoining landholders in the protection of the Park.	No impacts.	No impacts.
Minimise conflicts between park values and surrounding land use.	No impacts.	No impacts.
Ensure that key identified areas are considered for addition to the Park as opportunities for acquisition or inclusion arise.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Mushroom Reef Marine Sanctuary Management Plan (Parks Victoria, 2007)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	1% probability of low exposure to entrained hydrocarbons 0-10 m below sea.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Geological and geomorphological features		
Protect the geological and geomorphological features of the sanctuary from the impacts of human activity.	No impacts.	No impacts.
Increase knowledge of the geological and geomorphological significance of the sanctuary.	No impacts.	No impacts.
4.2 Catchment and water quality		
Protect and maintain water quality within the sanctuary to ensure that sanctuary values are protected.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Minimise the impact of threatening processes from catchment-derived activities.	No impacts.	No impacts.
4.3 Hydrodynamics		
Minimise the impacts on sanctuary values from human-induced changes to local hydrodynamic processes.	No impacts.	No impacts.
Increase knowledge of the way in which local hydrodynamic processes, especially wave refraction, influence the intertidal structures within the sanctuary.	No impacts.	No impacts.
4.4 Habitats and communities		
Protect marine ecological communities and indigenous flora and fauna, and allow natural processes to continue.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Improve knowledge of marine ecological communities, flora and fauna and threatening processes to improve management, protection and appreciation.	No impacts.	No impacts.
4.5 Landscape and seascape		
Protect landscape and seascape values within the sanctuary, including the natural beauty and character.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.

Minimise visual impacts on the seascape and landscape of management activities and any future developments.	No impacts.	No impacts.
4.6 Marine pests		
Minimise the risk of introduction of marine pests by human activities, and their subsequent establishment in the park.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Establish arrangements for the detection of new incursions within the sanctuary in support of Victorian marine pest management arrangements.	No impacts.	No impacts.
Implement national or Victoria-wide control arrangements as they relate to the sanctuary.	No impacts.	No impacts.
5.1 Indigenous cultural heritage		
Protect Indigenous cultural heritage from interference or damaging activities.	No impacts.	No impacts.
Support the views of the Traditional Owners in managing the sanctuary.	No impacts.	No impacts.
5.2 Maritime and other cultural heritage		
Conserve places of historic significance.	No impacts.	No impacts.
Encourage learning and understanding about historic heritage of the sanctuary.	No impacts.	No impacts.
6.1 Information, interpretation and education		
Promote and encourage visitors to discover, enjoy and appreciate the sanctuary’s natural and cultural values in a safe and appropriate manner through information, interpretation and education.	No impacts.	No impacts.
Encourage public support for the sanctuary and the sanctuary’s management practices.	No impacts.	No impacts.
6.2 Access		
Facilitate access to the sanctuary while minimising the impact on natural and cultural values of the sanctuary and abutting natural areas.	No impacts.	No impacts.
6.3 Intertidal activities		
Encourage the exploration and enjoyment of intertidal platform habitats within the sanctuary while minimising impacts on natural and cultural values.	No impacts.	No impacts.

6.4 Diving and snorkelling		
Encourage snorkelling and diving activities that are for enjoyment and understanding of the sanctuary and have minimal impact on natural or cultural values.	No impacts.	No impacts.
6.5 Dog walking		
Protect natural and cultural values, and visitor enjoyment from the impacts of dogs.	No impacts.	No impacts.
6.6 Other activities		
Permit activities, including the landing of hang gliders and paragliders in the sanctuary that have minimal impact on natural or cultural values and the enjoyment of other visitors.	No impacts.	No impacts.
6.7 Tourism services		
Encourage the promotion and interpretation of the sanctuary and its values by licensed tour operators in a manner consistent with the aims for the sanctuary and visitor safety.	No impacts.	No impacts.
6.8 Public Safety		
Promote visitor safety and awareness of safety issues and risks within the sanctuary associated with access and use.	No impacts.	No impacts.
Promote and observe safe practices, and cooperate with emergency services.	No impacts.	No impacts.
7.1 Authorised uses		
Manage authorised uses in accordance with the National Parks Act and minimise their impact on sanctuary values.	No impacts.	No impacts.
7.2 Boundaries and adjacent uses		
Minimise impacts on sanctuary values from adjacent uses and developments.	No impacts.	No impacts.
8.1 Community awareness		
Increase the community's awareness and understanding of the sanctuary's values and management activities.	No impacts.	No impacts.
Build a sense of shared ownership and custodianship for the sanctuary in community groups and individuals.	No impacts.	No impacts.

8.2 Community participation		
Encourage and support the whole community, particularly Traditional Owners, in undertaking projects that contribute to or complement sanctuary programs.	No impacts.	No impacts.
Inform, enrich and strengthen the sanctuary's management with the community's tradition, knowledge, experience, skills and enthusiasm, particularly that of the Traditional Owners.	No impacts.	No impacts.
8.3 Agency partnerships		
Enhance sanctuary management by collaborating with other agencies to ensure they give appropriate consideration to sanctuary values in planning and implementing activities that relate to the sanctuary but for which they are responsible.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of Flinders Foreshore Reserve Coastal Management Plan (URS, 2008)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	2% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
1. Natural Environment		
Manage erosion on the Flinders Foreshore	No impacts.	No impacts.
Enhance views out to Western Port for all users	No impacts.	No impacts.
Protect the intertidal zone from damage caused by vehicles	No impacts.	No impacts.
Protect and manage terrestrial flora and fauna values within the Flinders Foreshore Reserve	No impacts.	No impacts.
Protect and manage marine ecological values	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Protect the EPBC listed syngnathids colonies and their environment	No impacts.	No impacts.
Protect the seagrass beds offshore of Flinders and other environmental values	No impacts.	No impacts.
Protect marine ecological values and EPBC listed marine species	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Minimise factors contributing to climate change	No impacts.	No impacts.
Continue with the practice of retaining seaweed on Flinders Foreshore	No impacts.	No impacts.
Manage dogs on the Flinders Foreshore to protect environmental values	No impacts.	No impacts.
Understand and prepare for any potential future changes in use and management arrangements to West Head	No impacts.	No impacts.
Manage commercial vessel refuelling to minimise impact on other users and the environment	No impacts.	No impacts.
2. Cultural Heritage		
Monitor and protect Aboriginal values and sites of significance within the Flinders Foreshore precinct	No impacts.	No impacts.

Protect European Cultural Heritage within the Flinders Foreshore and Pier precinct	No impacts.	No impacts.
Develop an historic walk to recognise historic sites on Flinders Foreshore	No impacts.	No impacts.
3. Built Environment		
Upgrade Flinders Pier to meet user needs and maintain marine ecological values, heritage values and safety standards	No impacts.	No impacts.
Identify and provide locations for overflow parking in close proximity to Flinders Foreshore for use during peak times	No impacts.	No impacts.
Provide a carpark on the Flinders Foreshore for commercial use	No impacts.	No impacts.
Upgrade the existing septic systems at Flinders Yacht Club and foreshore toilet blocks	No impacts.	No impacts.
Investigate the need for additional swing moorings surrounding Flinders Pier	No impacts.	No impacts.
Maintenance of Cable Station walk	No impacts.	No impacts.
Provide additional picnic facilities on Flinders Foreshore to meet public demand	No impacts.	No impacts.
Maintenance of existing infrastructure, and new infrastructure to be designed to be in character with the surrounding environment	No impacts.	No impacts.
Monitor existing use of the Flinders boat ramp	No impacts.	No impacts.
Improve the amenity and visual appearance of the open space area adjacent to the slipway	No impacts.	No impacts.
Repair broken fencing	No impacts.	No impacts.
Improve efficiency of car parking	No impacts.	No impacts.
4. Access		
Ensure foreshore access is appropriately designed, results in minimal environmental impact, and access links are rationalised	No impacts.	No impacts.

Improve the entrance to Flinders Foreshore and the visual connection with Bass Street	No impacts.	No impacts.
Maintain access to the Flinders Yacht Club building	No impacts.	No impacts.
Improve pedestrian access from Bass Street to Flinders Pier	No impacts.	No impacts.
Where possible, improve disabled access at key locations on Flinders Foreshore	No impacts.	No impacts.
Create a pedestrian link on the foreshore reserve between The Esplanade and Spindrift Avenue	No impacts.	No impacts.
Improve the standard of pedestrian access of Dodds Creek access track	No impacts.	No impacts.
Formalise the existing circuit walk and promote for use.	No impacts.	No impacts.
Provide a new pedestrian link between the Flinders Foreshore Reserve and the Mornington Peninsula National Park precinct	No impacts.	No impacts.
Maintain pedestrian access along Right-of-Way	No impacts.	No impacts.
5. Maintenance and Public Risk		
Identify and address maintenance issues on the foreshore to minimise public risk	No impacts.	No impacts.
Review the current waste management collection cycle and ensure it meets waste management needs for the foreshore	No impacts.	No impacts.
Separate pedestrian and vehicle movements within Flinders car park to improve public safety	No impacts.	No impacts.
Minimise risk of fire occurrence	No impacts.	No impacts.
Manage unstable cliff/slope environment	No impacts.	No impacts.
6. Community Awareness and Involvement		
Develop local ownership and assistance with the management of Flinders Foreshore Reserve.	No impacts.	No impacts.

Coordinate communication between MPS and the Flinders community	No impacts.	No impacts.
Orientation of visitors to the Flinders Foreshore Reserve and co-ordinated signage.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Phillip Island Nature Parks Management Plan (Phillip Island Nature Parks, 2018)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Entrained hydrocarbons:	No contact.
Dissolved hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	1% probability of low oil exposure at sea surface. No contact at higher thresholds.
Dissolved hydrocarbons:	1% probability of low exposure to dissolved hydrocarbons at 0-10 m below sea surface. No contact at higher thresholds.
Entrained hydrocarbons:	25% and 8% probability of low and high exposure respectively to entrained hydrocarbons at 0-10 m below sea surface.
Shoreline contact:	1% probability of low shoreline loading. 1% probability of moderate shoreline loading. No contact at higher thresholds.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	8% probability of low exposure and 2% probability of moderate exposure to dissolved hydrocarbons at 0-10 m below sea surface. 1% probability of low exposure to dissolved hydrocarbons at 10-20 m below sea surface.
Entrained hydrocarbons:	17% probability of low exposure and 3% probability of high exposure to entrained hydrocarbons at 0-10 m below sea.
Shoreline contact:	No contact.

The table on the following pages provides an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
1. Conservation Excellence		
Building resilience in little penguin, seabird and Australian fur seal populations through research-led conservation programs.	No impact.	No impact.
Investing in habitat restoration and developing innovative wildlife protection solutions.	No impact.	No impact.
Enhancing Phillip Island as a safe haven for wildlife through identifying and controlling threats.	No impact.	No impact.
Engaging young people in conservation challenges through education at schools and across all Nature Parks sites.	No impact.	No impact.
Establish a Research Centre to increase awareness of our programs and create new opportunities.	No impact.	No impact.
Revolutionise oiled wildlife rehabilitation practices through the live application of magnetic cleaning technology.	No impact.	No impact.
Work with key partners to develop a plan for the management of native threatened wildlife with priority given to the strategic re-introduction of species to Phillip Island.	No impact.	No impact.
Utilise our research to influence marine and fisheries policy.	No impact.	No impact.
Implement conservation campaigns that inspire our visitors and community to take action.	No impact.	No impact.
Strengthen partnerships with key conservation and scientific organisations to influence global seabird conservation efforts.	No impact.	No impact.
Develop an understanding of the Caring for Country practices of Aboriginal and Torres Strait Islander Peoples and establish partnerships to help integrate these practices on Phillip Island.	No impact.	No impact.
Work with Parks Victoria and other key agencies to help establish Victorian Island Arks.	No impact.	No impact.
Partner with Bass Coast Shire Council and our community to eliminate the impact of cats on native fauna.	No impact.	No impact.
2. Extraordinary Visitor Experiences		
Partnering with organisations to deliver new and engaging experiences that meet our conservation objectives.	No impact.	No impact.

Building a Penguin Parade visitor centre that represents a world class ecotourism attraction.	No impact.	No impact.
Maintaining market leadership as an International Tourism destination.	No impact.	No impact.
Managing and interpreting the natural and cultural history of Nature Parks sites.	No impact.	No impact.
Develop more intimate and tailored tourism experiences that meet the changing needs of our visitors.	No impact.	No impact.
Establish penguin viewing experiences that complement the new world class Penguin Parade visitor centre.	No impact.	No impact.
Enhance the daytime use of the Summerland Peninsula and its spectacular coastline through the creation and promotion of walking and cycling experiences that improve access for all. (Summerland Peninsula Infrastructure and Procurement Master Plan)	No impact.	No impact.
Work with Traditional Custodians and the Aboriginal and Torres Strait Islander Community to develop and deliver authentic cultural experiences.	No impact.	No impact.
Create new and diverse volunteer opportunities to double volunteer participation across the Nature Parks.	No impact.	No impact.
Strengthen our visitors' connection with the natural environment to influence behaviour change and improve environmental outcomes.	No impact.	No impact.
Plan for the future of the Koala Reserve and its valued wildlife to provide more diverse and engaging experiences that complement our conservation values.	No impact.	No impact.
Increase visitation to Churchill Island through new visitor experiences and events that showcase the heritage precinct.	No impact.	No impact.
Advocate for increased accommodation options on Phillip Island to grow overnight group visitation and visitor yield.	No impact.	No impact.
3. Community Partnerships		
Developing respectful partnerships with Phillip Island's Traditional Custodians and wider Aboriginal and Torres Strait Islander Community	No impact.	No impact.
Enabling opportunities for community engagement such as the Community and Environment Advisory Committee and Community Open Day.	No impact.	No impact.
Investing in quality infrastructure at beach access areas that is sympathetic to the surrounding environment and promotes access for all.	No impact.	No impact.
Establish a new site to make the Nature Parks more visible and accessible to our community.	No impact.	No impact.

Utilise new technology to connect with the local community to deliver on our clear conservation, ecotourism and reconciliation objectives	No impact.	No impact.
Partner with Bass Coast Shire Council and Destination Phillip Island to implement the Phillip Island and San Remo Visitor Economy Strategy and foster a collaborative approach to environmental and tourism planning.	No impact.	No impact.
Collaborate with our community and key partners to establish Phillip Island as an accredited ecotourism destination (Global Sustainable Tourism Certification program).	No impact.	No impact.
Promote how to live with wildlife throughout our community to build a greater affiliation with nature.	No impact.	No impact.
Work with key partners to improve walking and cycling links on Phillip Island which will enhance the Island's liveability and people's connection with nature.	No impact.	No impact.
4. Sustainable Future		
Maintaining financial stability through growth in premium visitor experiences and improved visitation throughout shoulder periods.	No impact.	No impact.
Driving visitors to Phillip Island through its promotion as a must see wildlife destination to key international and domestic markets.	No impact.	No impact.
Align our commercial activities to our renewed commitment to environmental sustainability whilst maintaining overall financial return.	No impact.	No impact.
Commit to becoming a carbon neutral organisation by 2030.	No impact.	No impact.
Transition all sites to be waste and water neutral.	No impact.	No impact.
Improve the Nature Parks' sustainability credentials by expanding our Ecotourism Accreditation and seeking to join a carbon neutral accreditation program.	No impact.	No impact.
Build funding support for our conservation outcomes through philanthropic and corporate partnerships, grants and other funding opportunities.	No impact.	No impact.
5. Agile Organisation, Inspired People		
Fostering a safe and inclusive culture for all of our team, volunteers, contractors, community and visitors.	No impact.	No impact.
Developing our passionate, empowered and valued team.	No impact.	No impact.
Strengthen our global networks to enhance innovation in product development and conservation.	No impact.	No impact.

Embed a deep respect and understanding of Aboriginal and Torres Strait Islander Peoples' cultural values and protocols across our organisation.	No impact.	No impact.
Review our values to align with the organisation's conservation and sustainability ambitions.	No impact.	No impact.
Create collaborative work spaces for our team that encourage interaction and allow everyone to move easily across all sites.	No impact.	No impact.
Use technology to ensure business efficiencies, improve environmental outcomes and build collaboration.	No impact.	No impact.

Assessment of BassGas operations against the stated aims of the Yaringa, French Island and Churchill Island Marine National Parks Management Plan (Parks Victoria, 2007)

The following information summarises the risk to the park from the spill scenarios.

Note: Yaringa Marine National Park and French Island Marine National Park are not intersected by the EMBA and are not under assessment here.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	5% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Geological and geomorphological features		
Protect features of geological and geomorphological significance from the impacts of human activity.	No impacts.	No impacts.
4.2 Catchment and water quality		
Protect and maintain water quality within the parks to ensure that park values are protected.	No impacts.	No impacts.
Minimise the impact of threatening processes from catchment-derived activities.	No impacts.	No impacts.
4.3 Hydrodynamics		
Minimise impacts on the values of the parks from human-induced changes to local hydrodynamic processes.	No impacts.	No impacts.
4.4 Habitats and communities		
Protect marine ecological communities and indigenous flora and fauna, and allow natural processes to continue.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Improve knowledge of marine ecological communities, flora and fauna and threatening processes to improve management, protection and appreciation.	No impacts.	No impacts.
4.5 Landscape and seascape		
Protect landscape and seascape values within the parks.	No impacts.	No impacts.
Minimise visual impacts on the seascape and landscape, including management activities, and ensure any future developments are sensitively integrated with their natural settings.	No impacts.	No impacts.
4.6 Marine and other pests		
Minimise the risk of introduction of marine pests by human activities, and their subsequent establishment in the parks.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.

Establish arrangements for the detection of new incursions within the parks in support of Victorian marine pest management arrangements.	No impacts.	No impacts.
Implement national or Victoria-wide control arrangements as they relate to the parks	No impacts.	No impacts.
Control terrestrial pest plants and animals and minimise the impacts of control programs on the parks.	No impacts.	No impacts.
5.1 Indigenous Cultural Heritage		
Protect Aboriginal places and objects from interference or damaging activities.	No impacts.	No impacts.
Respect the views of the Traditional Owners in managing the parks.	No impacts.	No impacts.
5.2 Maritime and other cultural heritage		
Conserve and protect places and values of historic and cultural significance.	No impacts.	No impacts.
Encourage learning and understanding about historic heritage of the parks.	No impacts.	No impacts.
6.1 Information, education and interpretation		
Promote and encourage visitors to discover, enjoy and appreciate the parks' natural and cultural values in a safe and appropriate manner through information, interpretation and education.	No impacts.	No impacts.
Encourage public support for the parks and park management practices.	No impacts.	No impacts.
6.2 Access		
Ensure that access to the parks is appropriate and safe.	No impacts.	No impacts.
6.3 Recreational boating and surface water sports		
Provide for a range of boating and water sports activities within the parks while minimising impacts on the natural values.	No impacts.	No impacts.
6.4 Diving and snorkelling		
Provide for appropriate opportunities for diving and snorkelling in the parks.	No impacts.	No impacts.

6.5 Swimming and shore-based activities		
Protect the natural values of the parks from impacts of shore-based recreation.	No impacts.	No impacts.
6.6 Dogs and horses		
Prohibit dogs and horses from the parks, to protect the parks' natural values and ensure visitor safety.	No impacts.	No impacts.
6.7 Tourism services		
Provide opportunities for and encourage provision of external tourism services while minimising impacts on the natural and cultural values of the parks.	No impacts.	No impacts.
6.8 Public safety		
Promote visitor safety and awareness of safety issues and risks within the parks associated with access and use.	No impacts.	No impacts.
Promote and observe safe practices, and cooperate with emergency services.	No impacts.	No impacts.
7.1 Authorised uses		
Manage authorised uses in accordance with the National Parks Act and minimise their impact on park values.	No impacts.	No impacts.
7.2 Boundaries and adjacent uses		
Effectively communicate the location of the parks' boundaries.	No impacts.	No impacts.
Minimise impacts on parks' values from adjacent developments.	No impacts.	No impacts.
8.1 Community awareness		
Increase the community's awareness and understanding of the parks' values and management activities.	No impacts.	No impacts.
Support the sense of shared ownership and custodianship for the parks among community groups and individuals.	No impacts.	No impacts.
8.2 Community participation		
Encourage and support the active participation of community groups and volunteers, particularly Indigenous communities, in projects that contribute to or complement park programs.	No impacts.	No impacts.

Inform, enrich and strengthen the parks' management with the community's tradition, knowledge, experience, skills and enthusiasm, particularly that of the Traditional Owners.	No impacts.	No impacts.
8.3 Agency partnerships		
Enhance park management by collaborating with other agencies to ensure they give appropriate consideration to parks values in planning and implementing activities that relate to the parks	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the French Island National Park Management Plan (Parks Victoria, 1998)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	1% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	3% probability of low exposure to dissolved hydrocarbons 0-10 m below sea surface.
Entrained hydrocarbons:	9% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
3.1 Geological and landform features		
Protect the outstanding geomorphological and geological features, and maintain the natural processes and functioning of the natural aquatic ecosystems.	No impacts.	No impacts.
Provide for the appreciation and study of the physical features and associated geomorphological processes.	No impacts.	No impacts.
3.2 Marine and intertidal environment		
Protect and maintain the quality of the marine and intertidal environment in the Park, in conjunction with adjacent waters.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
3.3 Vegetation		
Conserve the indigenous vegetation communities in their natural condition, and maintain natural ecological processes.	No impacts.	No impacts.
Rehabilitate disturbed areas and provide special protection and management to maintain and/or enhance genetic and species diversity	No impacts.	No impacts.
Provide for appropriate research and appreciation of the flora which involves minimal disturbance to the environment.	No impacts.	No impacts.
3.4 Fauna		
Ensure the conservation of indigenous terrestrial, freshwater and marine fauna.	No impacts.	No impacts.
Maintain the terrestrial and aquatic ecosystems in healthy condition	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Meet international commitments of the Ramsar Convention and the JAMBA and CAMBA agreements for protection of waterfowl and migratory wading birds.	No impacts.	No impacts.
Provide for appropriate research and appreciation of wildlife, which involves minimal disturbance.	No impacts.	No impacts.

3.5 Landscape		
Protect the landscape and minimise impacts on natural values, particularly as seen from major viewing points.	No impacts.	No impacts.
3.6 Cultural heritage		
Preserve and protect archaeological and historic sites and features of significance, and where appropriate interpret particular features.	No impacts.	No impacts.
Improve understanding of the historic and cultural values and their significance.	No impacts.	No impacts.
3.7 UNESCO Biosphere Reserves		
Investigate creation of a Biosphere Reserve incorporating the planning area and surrounding Western Port area.	No impacts.	No impacts.
4.1 Fire management		
Protect life, property and Park values from injury by fire.	No impacts.	No impacts.
Minimise the adverse effects of fires and fire suppression methods.	No impacts.	No impacts.
Develop and maintain fire regimes appropriate to the conservation of indigenous flora and fauna.	No impacts.	No impacts.
4.2 Pest plants and animal, and diseases		
Control, and where possible eradicate, pest plants and animals using methods having minimal adverse impact on the Park.	No impacts.	No impacts.
Minimise opportunities for new pests and diseases becoming established, particularly the fox and Cinnamon Fungus.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
4.3 Soil conservation		
Prevent and control soil degradation, and rehabilitate degraded areas.	No impacts.	No impacts.
5.1 Park visitors		
Provide for visitors in accordance with the above overview of future management.	No impacts.	No impacts.

Ensure minimal impact on the Park from visitor activities.	No impacts.	No impacts.
5.2.1 Vehicle access		
Continue support for the French Island Access Strategy.	No impacts.	No impacts.
Maintain an appropriate network of roads and tracks in the Park, primarily for management and emergency purposes.	No impacts.	No impacts.
Encourage visitors to use this network for walking and cycling.	No impacts.	No impacts.
Minimise the impact of vehicle use on the Park's natural and cultural values.	No impacts.	No impacts.
5.2.2 Day use areas		
Establish and maintain high standard but low-key day visitor facilities which enhance visitor enjoyment and are consistent with protecting Park values.	No impacts.	No impacts.
Where practicable, provide facilities suitable for visitors with limited mobility.	No impacts.	No impacts.
5.2.3 Camping		
Provide opportunities for accessible and remote camping experiences with limited facilities in attractive settings, while minimising impacts on park values.	No impacts.	No impacts.
5.2.4. Walking		
Increase the range of bushwalking opportunities in the Park while minimising impacts on park values.	No impacts.	No impacts.
5.2.5 Horse riding		
Minimise any environmental impacts caused by horse riding.	No impacts.	No impacts.
Minimise conflict between horse riders and other Park users	No impacts.	No impacts.
5.2.6 Cycling		
Provide access for cycling while minimising environmental damage and conflicts with other recreation activities.	No impacts.	No impacts.
5.2.7 Fishing		

Provide opportunities in marine waters for fishing and bait collecting where it is consistent with the protection of park values.	No impacts.	No impacts.
5.2.8 Boating		
Provide opportunities for boating in the Park while minimising the environmental impact of the activity on sensitive shoreline areas.	No impacts.	No impacts.
5.2.9 Orienteering, regaining and competitive events		
Do not provide for these activities in the Park.	No impacts.	No impacts.
5.3 Visitor information, interpretation and education		
Orientate visitors to the Park and its features.	No impacts.	No impacts.
Enhance visitors' appreciation of the Park and provoke interest in the area's natural and cultural environment.	No impacts.	No impacts.
5.4 Commercial tourism operations		
Encourage commercial tourism services to be provided, consistent with park management objectives	No impacts.	No impacts.
Monitor tourist use of the Park to ensure that impacts are not detrimental.	No impacts.	No impacts.
5.5 Public safety		
Promote public safety in the use of the Park.	No impacts.	No impacts.
Ensure that procedures are in place to assist in emergency situations.	No impacts.	No impacts.
6.1 Friends and volunteers		
Assist volunteer groups to undertake appropriate management tasks in the Park.	No impacts.	No impacts.
6.2 Community awareness and Park neighbours		

Increase awareness and knowledge of the Park, and maintain good relations within local communities.	No impacts.	No impacts.
Co-operate with landholders outside the Park in the protection of both private property and public land from fire, pests and other hazards.	No impacts.	No impacts.
Encourage conservation and sound land management practices on private land adjoining the Park.	No impacts.	No impacts.
6.3 Schools, education and special interest groups		
Promote the educational value of the Park to schools, tertiary institutions and special interest groups.	No impacts.	No impacts.
Encourage participation in park monitoring and research programs.	No impacts.	No impacts.
7.1.1 Landholder access from the sea		
Provide access for landholder boats while minimising environmental damage to the Park.	No impacts.	No impacts.
7.1.2 Apiculture		
Minimise the adverse effects of apiculture on park values.	No impacts.	No impacts.
7.1.3 Other uses		
Ensure appropriate use and authorisation of public utilities.	No impacts.	No impacts.
Allow appropriate uses in the Park when alternative sites are not available, subject to minimal impacts.	No impacts.	No impacts.
7.2 Boundaries and adjacent land use		
Minimise conflicts between park values and neighbouring land use.	No impacts.	No impacts.
7.3 Park office and depot		

Efficiently co-ordinate administration, supervision and operations functions associated with the management of the Park.	No impacts.	No impacts.
Minimise the impact of operations on the Park's landscape.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the San Remo Coastal Reserve Management Plan
(San Remo Foreshore Reserve Committee of Management, 2010)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	79% probability of low exposure to entrained hydrocarbons at 0-10 m below sea. 56% probability of high exposure to entrained hydrocarbons at 0-10 m below sea.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	3% probability of low exposure to dissolved hydrocarbons 0-10 m below sea.
Entrained hydrocarbons:	9% probability of low exposure to entrained hydrocarbons 0-10 m below sea.
Shoreline contact:	No contact.

The table on the following page provides an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
High Priority Management Actions		
Maintain and protect the natural and built environment of the San Remo Foreshore Reserve.	No impacts.	No impacts.
Develop a track around the entire San Remo Foreshore Reserve.	No impacts.	No impacts.
Clarification and documentation of the San Remo Reserve boundaries.	No impacts.	No impacts.
Facilitate the development of a plan for the Jetty Precinct.	No impacts.	No impacts.
Ensure ongoing financial viability of the Foreshore Committee of Management.	No impacts.	No impacts.
Implement the Master Plan for the Lions Park (San Remo Community Park).	No impacts.	No impacts.
Develop and implement a Management Plan that ensures the commercial and environmental viability of the Foreshore caravan park.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Kilcunda Foreshore Reserve Management Plan (Bass Coast Shire Council, 2016)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	30% probability of low oil exposure. 7% probability of moderate oil exposure.
Dissolved hydrocarbons:	10% probability of low exposure to dissolved hydrocarbons at 0-10 m below sea. 1% probability of moderate exposure to dissolved hydrocarbons at 0-10 m below sea.
Entrained hydrocarbons:	2% probability of low exposure to entrained hydrocarbons at 0-10 m below sea.
Shoreline contact:	34% probability of low loading. 31% probability of moderate loading. 7% probability of high loading.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	6% probability of low oil exposure on the sea surface.
Dissolved hydrocarbons:	65% probability of low exposure to dissolved hydrocarbons at 0-10 m below sea. 25% probability of moderate exposure to dissolved hydrocarbons at 0-10 m below sea. 5% probability of low exposure to dissolved hydrocarbons at 10-20 m below sea.
Entrained hydrocarbons:	73% probability of low exposure to entrained hydrocarbons at 0-10 m below sea. 33% probability of high exposure to entrained hydrocarbons at 0-10 m below sea.
Shoreline contact:	8% probability of low loading. 6% probability of moderate loading.

The table on the following page provides an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
1. Management		
Ensure ongoing sustainable and efficient management of the Kilcunda Foreshore Reserve and engage community involvement in management activities.	No impact.	No impact.
2. Recreation		
Maintain and improve facilities and amenities within the Kilcunda Foreshore Reserve to enable continued safe recreational use and enjoyment of the foreshore.	No impact.	No impact.
3. Protection of the Environment		
Protect and enhance native vegetation, threatened species and coastal habitats within the Kilcunda Foreshore Reserve and improve community knowledge of key values.	No impact.	No impact.
4. Fire Management		
The Kilcunda Foreshore Reserve will be managed to minimise fire risk in accordance with the Kilcunda Foreshore Reserve Fire Protection Plan.	No impact.	No impact.
5. Cultural Heritage		
Protect cultural and heritage values throughout the Kilcunda Foreshore Reserve.	No impact.	No impact.
6. Coastal Erosion		
Coastal erosions within the Kilcunda Foreshore Reserve will be managed to minimise impacts to infrastructure assets and natural values, whilst working with natural coastal processes.	No impact.	No impact.
7. Climate Change		
Monitoring and plan for the potential impacts of climate change for all development and improvement activities or proposals within the Kilcunda Foreshore Reserve.	No impact.	No impact.

Assessment of BassGas operations against the stated aims of the Bunurong Marine National Park, Bunurong Marine Park, Bunurong Coastal Reserve and Kilcunda-Harmers Haven Coastal Reserve Management Plan (Parks Victoria, 2006)

The following information summarises the risk to the park from the spill scenarios.

Parks:	**Bunurong Marine National Park**	**Bunurong Marine Park**	**Kilcunda-Harmers Haven Coastal Reserve**
204,250 bbl subsea blowout of Yolla condensate over 86 Days			
Sea surface:	No contact.		
Dissolved hydrocarbons:	No contact.		
Entrained hydrocarbons:	No contact.		
Shoreline contact:	No contact.		
300 m^3 surface release of MDO over 6 Hours			
Sea surface:	1% probability of low exposure at sea surface.	7% probability of low exposure at sea surface. 1% probability of moderate exposure at sea surface.	30% probability of low exposure at sea surface. 7% probability of moderate exposure at sea surface.
Dissolved hydrocarbons:	6% probability of low exposure to dissolved hydrocarbons 0-10 m below sea surface.	9% probability of low exposure to dissolved hydrocarbons 0-10 m below sea surface.	10% probability of low exposure to dissolved hydrocarbons 0-10 m below sea surface.
Entrained hydrocarbons:	81% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface. 39% probability of high exposure to entrained hydrocarbons 0-10 m below sea surface.	79% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface. 46% probability of high exposure to entrained hydrocarbons 0-10 m below sea surface.	2% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.	No contact.	34% probability of low shoreline loading. 31% probability of moderate shoreline loading. 7% probability of high shoreline loading.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes			
Sea surface:	No contact.	1% probability of low exposure at sea surface.	6% probability of low exposure at sea surface.
Dissolved hydrocarbons:	50% probability of low exposure to dissolved hydrocarbons 0-10 m below sea.	59% probability of low exposure to dissolved hydrocarbons 0-10 m below sea surface.	65% probability of low exposure to dissolved hydrocarbons 0-10 m below sea surface.

	9% probability of moderate exposure to dissolved hydrocarbons 0-10 m below sea surface. 3% probability of low exposure to dissolved hydrocarbons at 10-20 m below sea surface.	19% probability of moderate exposure to dissolved hydrocarbons 0-10 m below sea surface. 4% probability of low exposure to dissolved hydrocarbons at 10-20 m below sea surface.	25% probability of moderate exposure to dissolved hydrocarbons 0-10 m below sea surface. 5% probability of low exposure to dissolved hydrocarbons at 10-20 m below sea surface. 1% probability of moderate exposure to dissolved hydrocarbons at 10-20 m below sea surface.
Entrained hydrocarbons:	66% probability of low exposure to dissolved hydrocarbons 0-10 m below sea. 17% probability of high exposure to dissolved hydrocarbons 0-10 m below sea.	69% probability of low exposure to dissolved hydrocarbons 0-10 m below sea. 23% probability of high exposure to dissolved hydrocarbons 0-10 m below sea.	73% probability of low exposure to dissolved hydrocarbons 0-10 m below sea surface. 33% probability of high exposure to dissolved hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.	No contact.	8% probability of low loading. 6% probability of moderate loading.

The table on the following pages provides an assessment of routine and non-routine operations against the management aims of the parks.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Landscape and seascape		
Preserve and protect the landscape and seascape values of the planning area, particularly the natural character and places of high scenic quality and areas of significance to the indigenous community.	No impacts.	No impacts.
Minimise the impact of developments and management activities on the planning area's landscape values.	No impacts.	No impacts.
4.2 Geological and geomorphological features		
Protect geological and geomorphological features of the planning area and minimise impacts from management activities and visitor use.	No impacts.	No impacts.
Allow natural geological and geomorphological processes to continue with minimal human interference.	No impacts.	No impacts.
Provide opportunities for appropriate research into, appreciation of, and education about the geological and geomorphological features of the planning area.	No impacts.	No impacts.
4.3 Catchment and water quality		
Ensure the integration of future planning and management between the planning area and adjacent catchment.	No impacts.	No impacts.
Maintain a high quality of water within the planning area and surrounding waters to ensure that natural biological and physical processes can occur.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Minimise impacts of threatening processes from catchment-sourced activities.	No impacts.	No impact.
4.4 Hydrodynamics		
Allow natural hydrodynamic processes to continue without human interference.	No impacts.	No impacts.
Minimise impacts on planning area values from human-induced changes to local hydrodynamic processes.	No impacts.	No impacts.
4.5 Marine habitats and communities		
Protect marine ecological communities and indigenous flora and fauna, particularly threatened species.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.

Increase knowledge of marine ecological communities, flora and fauna to aid management, protection and appreciation.	No impacts.	No impacts.
Increase knowledge of key threatening processes to marine ecological communities, flora and fauna, to limit impacts.	No impacts.	No impacts.
4.6 Marine pests		
Minimise the risk of introduction of marine pests by human activities, and their subsequent establishment in the planning area.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Establish arrangements for the detection of new incursions within the planning area in support of Victorian marine pest management arrangements.	No impacts.	No impacts.
Implement national or Victoria-wide control arrangements as they relate to the planning area.	No impacts.	No impacts.
4.7 Terrestrial flora		
Maintain the floristic structure and diversity of vegetation communities, and protect them from threatening processes.	No impacts.	No impacts.
Increase knowledge of the planning area's vegetation communities and species, particularly its threatened species, to aid management, protection and appreciation.	No impacts.	No impacts.
4.8 Terrestrial fauna		
Protect and preserve indigenous fauna and faunal habitats from visitor use and management activities, and maintain genetic diversity.	No impacts.	No impacts.
Increase knowledge of the planning area's fauna species and habitats, particularly threatened species, to aid management, protection and appreciation.	No impacts.	No impacts.
4.9 Terrestrial pests		
Control, and where possible eradicate, non-indigenous plants, animals and diseases.	No impacts.	No impacts.
Minimise the potential for the introduction and spread of pest plants and animals and diseases.	No impacts.	No impacts.
Minimise the impact of control programs on native flora and fauna species.	No impacts.	No impacts.
Restore native vegetation in areas where weeds have been controlled or eradicated.	No impacts.	No impacts.
4.10 Soil conservation		

Prevent and control soil degradation, and rehabilitate areas affected by soil degradation caused by visitor and management activities.	No impacts.	No impacts.
4.11 Fire management		
Protect planning area values from the deleterious effects of wildfire or inappropriate fire regimes.	No impacts.	No impacts.
Cooperate with relevant agencies and land managers in the protection of human life, neighbouring properties and assets.	No impacts.	No impacts.
5.1 Indigenous cultural heritage		
Protect Indigenous cultural heritage, including places and objects, from interference or damaging activities.	No impacts.	No impacts.
Nurture Indigenous cultural lore relating to the planning area.	No impacts.	No impacts.
5.2 Maritime and other cultural heritage		
Conserve places and values of historic and cultural significance within the planning area.	No impacts.	No impacts.
Increase learning about and appreciation of the historic heritage of the planning area.	No impacts.	No impacts.
6.1 Information, interpretation and education		
Promote and encourage visitors' discovery, enjoyment and appreciation of the planning area's natural and cultural values in a safe and appropriate manner through information, interpretation and education.	No impacts.	No impacts.
Encourage public support for parks and management practices.	No impacts.	No impacts.
Provide opportunities to learn about and understand the cultural and spiritual significance of the planning area to the Indigenous community.	No impacts.	No impacts.
6.2 Access		
Provide and maintain appropriate access to the planning area for visitor use and management purposes.	No impacts.	No impacts.
Minimise the impact of access on natural and cultural values of the planning area.	No impacts.	No impacts.
6.3 Visitor site activities		
Establish and maintain visitor facilities that enhance visitor enjoyment and are consistent with the protection of planning area values.	No impacts.	No impacts.
6.4 Recreational boating and associated facilities		

Provide opportunities for recreational boating and appropriate surface water sports while protecting natural and cultural values.	No impacts.	No impacts.
Promote safe boating and water safety within the planning area.	No impacts.	No impacts.
6.5 Diving and snorkelling		
Provide opportunities for diving and snorkelling in the planning area while protecting natural and cultural values.	No impacts.	No impacts.
6.6 Swimming, surfing and shore-based activities		
Provide opportunities for appropriate shore-based recreation within the planning area, while minimising impacts on the natural and cultural values.	No impacts.	The OPEP takes into accounts risks to the shoreline and prioritises actions to reduce the spread and extent of oil towards the shoreline.
6.7 Dog walking		
Provide opportunities for dog walking in appropriate areas of the planning area, while protecting park and reserve values and the experience of visitors.	No impacts.	No impacts.
6.8 Horse riding		
Minimise conflicts with recreational activities, threats to visitor safety and natural values within the planning area.	No impacts.	No impacts.
6.9 Hang gliding		
Protect visitors and values in the planning area from impacts of hang gliding and paragliding within the planning area.	No impacts.	No impacts.
6.10 Recreational fishing		
Provide opportunities for sustainable recreational fishing while minimising impacts to natural and cultural values.	No impacts.	No impacts.
6.11 Tourism services		
Provide opportunities for and encourage provision of external tourism services while minimising impacts on natural and cultural values of the planning area.	No impacts.	No impacts.
6.12 Public Safety		
Promote visitor safety and awareness of safety issues and risks within the planning area associated with access and use.	No impacts.	No impacts.
Promote and observe safe practices and cooperate with emergency services.	No impacts.	No impacts.

7.1 Authorised uses		
Manage authorised uses in accordance with relevant legislation, and minimise their impact on the planning area’s values.	No impacts.	No impacts.
7.2 Occasional uses		
Manage uses and permitted activities in accordance with relevant legislation, and minimise their impacts on the planning area’s values.	No impacts.	No impacts.
7.3 Boundaries and adjacent uses		
Minimise impacts on planning area values from adjacent uses and developments.	No impacts.	No impacts.
Ensure the integration of management with adjoining land and waters in accordance with principles for ecologically sustainable development.	No impacts.	No impacts.
Effectively communicate the location of Marine National Park and other planning area boundaries.	No impacts.	No impacts.
8.1 Community awareness		
Build a shared sense of ownership and custodianship for the planning area among community groups and individuals.	No impacts.	No impacts.
Increase community awareness and understanding of the values and management activities of the planning area.	No impacts.	No impacts.
8.2 Community participation		
Support and encourage community groups and volunteers to assist actively in the area’s management by participating and by contributing their knowledge and skills.	No impacts.	No impacts.
Encourage tertiary students to undertake volunteer work experience and research that is consistent with aims for the planning area.	No impacts.	No impacts.
Inform, enrich and strengthen the planning area’s management with the community’s traditions and customs, especially Traditional Owner’s cultural lore.	No impacts.	No impacts.
8.3 Agency partnerships		
Enhance management by collaborating with other agencies to ensure that they give appropriate consideration to natural and cultural values in planning and implementing activities that relate to the planning area.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Cape Liptrap Coastal Park Management Plan (Parks Victoria, 2003)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Entrained hydrocarbons:	No contact.
Dissolved hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	5% probability of low exposure to dissolved hydrocarbons at 0-10 m below sea surface. No contact at higher thresholds.
Entrained hydrocarbons:	1% probability of low exposure to entrained hydrocarbons at 0-10 m below sea surface. No contact at higher thresholds.
Shoreline contact:	3% probability of low loading. 2% probability of moderate loading.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	29% probability of low and 3% probability of moderate exposure to dissolved hydrocarbons at 0-10 m below sea. 2% probability of low exposure to dissolved hydrocarbons at 10-20 m below sea surface.
Entrained hydrocarbons:	52% probability of low exposure and 9% probability of high exposure to entrained hydrocarbons at 0-10 m below sea surface.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Geological and landform features		
Manage sites of geological and geomorphological significance to allow public access and interpretation.	No impact.	No impact.
4.2 Rivers and Catchments		
Maintain water quality in the park's catchments.	No impact.	No impact.
4.3 Vegetation		
Manage ecosystems to ensure the protection of indigenous flora species and vegetation communities, particularly significant species and communities.	No impact.	No impact.
Improve knowledge about the conservation of natural values with minimal disturbance to the environment.	No impact.	No impact.
4.4 Fauna		
Ensure the preservation and protection of indigenous fauna.	No impact.	No impact.
Manage park ecosystems to provide for the long-term protection and preservation of significant communities, habitats and species.	No impact.	No impact.
Improve knowledge about the conservation of fauna and their habitat requirements.	No impact.	No impact.
4.5 Landscape		
Minimise the visual intrusions on natural landscape within the park, especially from major viewing points.	No impact.	No impact.
Where possible, remove or shield undesirable visual intrusions.	No impact.	No impact.
4.6 Fire Management		
Protect life, property and park values from damage by fire.	No impact.	No impact.
Suppress wildfires in a manner appropriate to seasonal conditions, with the objective of minimising impacts on park values.	No impact.	No impact.
Sustain the vigour, diversity and successional development of the park's plant and animal communities by ecological burning on the basis of current and future knowledge.	No impact.	No impact.
4.7 Pest plants and animals		

Eradicate or control pest plant and animal species using methods that minimise disturbance to natural systems and park values.	No impact.	No impact.
Restore native vegetation to areas where weeds have been removed.	No impact.	No impact.
4.8 Soil Conservation		
Prevent and control soil degradation caused by visitor and management activities	No impact.	No impact.
Rehabilitate sites where unnatural soil degradation has occurred.	No impact.	No impact.
Protect important economic, cultural and natural assets from soil erosion.	No impact.	No impact.
4.9 Aboriginal Cultural Heritage		
Preserve and protect features of Aboriginal cultural and archaeological significance.	No impact.	No impact.
Provide opportunities for people to learn about and understand the park's Aboriginal cultural values.	No impact.	No impact.
4.10 Post-settlement Cultural Heritage		
Preserve and protect features of cultural, archaeological and historical significance.	No impact.	No impact.
Provide opportunities for people to learn about and understand the park's historic and cultural values.	No impact.	No impact.
5.1 Information, interpretation and education		
Encourage visitors' discovery, enjoyment and appreciation of the park's natural and cultural values.	No impact.	No impact.
Orientate visitors in relation to park features.	No impact.	No impact.
Inform visitors of appropriate behaviour during their park visit.	No impact.	No impact.
Provide high-quality interpretive and educational opportunities to promote an understanding and appreciation of the park's values.	No impact.	No impact.
5.2 Access		
Maintain roads and tracks to standards consistent with management aims.	No impact.	No impact.
5.3 Day Visits		
Establish and maintain day visitor facilities that enhance visitor enjoyment of the park and are consistent with protecting park values.	No impact.	No impact.

Improve visitor facilities and raise the profile of the park as a day visitor destination.	No impact.	No impact.
5.4 Camping		
Provide opportunities for a range of camping experiences while minimising impacts on park values.	No impact.	No impact.
5.5 Boating		
Support the Walkerville Foreshore Committee of Management in providing basic boat launching facilities at Walkerville North.	No impact.	No impact.
5.6 Fishing		
Provide opportunities for recreational fishing while minimising the impacts on park values.	No impact.	No impact.
5.7 Bushwalking		
Provide a variety of high-quality walking opportunities within the park, while minimising impacts on park values.	No impact.	No impact.
5.8 Horse Riding		
Provide opportunities for horse riding while minimising this activity’s adverse environmental effects and conflicts with other users.	No impact.	No impact.
5.9 Cycling		
Provide access for cycling, and at the same time minimise the environmental impact of cycling and the conflict with other recreational activities.	No impact.	No impact.
5.10 Dogs		
Provide for dogs in certain areas of the park, consistent with protecting park values and the experience of visitors.	No impact.	No impact.
5.11 Hang-gliding and Paragliding		

Provide opportunities for hang-gliding and paragliding while minimising the impact on park values and other uses.	No impact.	No impact.
5.12 Fossicking		
Provide an opportunity for gemstone collecting in the park, while ensuring that the impact on environmental values and other visitors is minimised.	No impact.	No impact.
5.13 Commercial Services		
Provide opportunities for commercial tourism and the touring public while minimising environmental impacts and effects on other visitors.	No impact.	No impact.
5.14 Public Safety		
Promote safe visitor use of the park.	No impact.	No impact.
Ensure that park management has adequate capacity to respond to emergency situations.	No impact.	No impact.
6.1 Friends and Volunteers		
Provide opportunities for and encourage the participation of groups and volunteers in protection, conservation and maintenance projects to enhance the management of the park.	No impact.	No impact.
Provide opportunities for and encourage tertiary students to undertake volunteer work experience and research consistent with park management aims.	No impact.	No impact.
6.2 Community Awareness and Park Neighbours		
Increase community awareness of park management activities, including prescribed burning, pest plant and animal control and visitor management activities.	No impact.	No impact.
Encourage conservation and sound land management practices on private land adjacent to the park.	No impact.	No impact.
7.1 Authorised Uses		

Manage public utilities and authorised uses in accordance with the National Parks Act, to minimise their impacts on the parks natural and scenic values.	No impact.	No impact.
Protect water quality in the park and provide for appropriate use of water resources.	No impact.	No impact.
7.2 Boundaries and Adjacent Uses		
Accurately define park boundaries on the ground.	No impact.	No impact.
Ensure adequate planning controls for adjoining land developments are in place.	No impact.	No impact.
Co-operate with adjacent landowners to protect both private and park areas from fire, pests and other hazards.	No impact.	No impact.

Assessment of BassGas operations against the stated aims of the Wilsons Promontory Marine National Park, Marine Park and Marine Reserve Management Plan (Parks Victoria, 2006).

The following information summarises the risk to the parks from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	12% probability of low exposure to entrained hydrocarbons at 0-10 m below sea surface. No contact at higher thresholds.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	1% probability of low exposure to dissolved hydrocarbons at 0-10 m below sea surface.
Entrained hydrocarbons:	46% probability of low exposure to entrained hydrocarbons at 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	3% probability of low exposure to dissolved hydrocarbons at 0-10 m below sea surface. 1% probability of low exposure to dissolved hydrocarbons at 10-20 m below sea surface.
Entrained hydrocarbons:	9% probability of low exposure to entrained hydrocarbons at 0-10 m below sea surface.
Shoreline contact:	No contact.

The table on the following pages provides an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Geological and geomorphological features		
Identify geological and geomorphological features of the planning area and protect them from potentially damaging human activities	No impacts.	No impacts.
Allow natural geological and geomorphological processes to continue without human interference.	No impacts.	No impacts.
Provide opportunities for appropriate research into, appreciation of, and education about geological and geomorphological features.	No impacts.	No impacts.
4.2 Catchment and water quality		
Ensure the integration of future planning and management for the planning area and adjacent catchment.	No impacts.	No impacts.
Maintain a high quality of water within the planning area and surrounding waters to ensure that natural biological and physical processes can occur.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Minimise the impacts on water quality within the planning area from activities within the catchment.	No impacts.	
4.3 Hydrodynamics		
Allow natural hydrodynamic processes to continue without human interference.	No impacts.	No impacts.
Minimise impacts on planning area values from human-induced changes to local hydrodynamic processes.	No impacts.	No impacts.
4.4 Habitats and communities		
Protect marine ecological communities and indigenous flora and fauna, particularly threatened species.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Increase knowledge of marine ecological communities, flora and fauna to aid management, protection and appreciation.	No impacts.	No impacts.
Increase knowledge of key threatening processes to marine ecological communities, flora and fauna, to limit impacts.	No impacts.	No impacts.
4.5 Landscape and seascape		

Preserve and protect the landscape and seascape values of the park, including the natural character, aesthetic qualities and values of significance to Indigenous communities.	No impacts.	No impacts.
Minimise the visual impact of developments and management activities, including those adjacent to the park.	No impacts.	No impacts.
4.6 Marine pests		
Minimise the risk of introduction of marine pasts by human activities, and their subsequent establishment in the planning area.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters	No impacts.
Establish arrangements for the detection of new incursions within the planning area in support of Victorian marine pest management arrangements.	No impacts.	No impacts.
Implement national or Victoria-wide control arrangements as they relate to the planning area.	No impacts.	No impacts.
5.1 Indigenous cultural heritage		
Protect Indigenous cultural heritage from interference or damaging activities.	No impacts.	No impacts.
Nurture Indigenous cultural lore relating to the planning area.	No impacts.	No impacts.
5.2 Maritime and other cultural heritage		
Conserve and protect places and values of historic significance associated with maritime exploration, commercial exploitation, coastal trading and navigation	No impacts.	No impacts.
Encourage learning and understanding about the historic heritage of the planning area, particularly as they relate to the historic theme ‘Shipping along the Coast’.	No impacts.	No impacts.
6.1 Information, interpretation and education		
Promote and encourage visitors’ discovery, enjoyment and appreciation of the natural and cultural values of the planning area in a safe and appropriate manner through information, education and interpretation.	No impacts.	No impacts.
Encourage public support for the planning area and management practices.	No impacts.	No impacts.
Provide opportunities to learn about and understand the cultural and spiritual significance of the planning area to the Traditional Owners.	No impacts.	No impacts.
Promote an awareness of past European cultural activities in the park.	No impacts.	No impacts.
6.2 Access		

Provide for the use and enjoyment of the planning area.	No impacts.	No impacts.
Minimise the impact of access on natural and cultural values of the planning area	No impacts.	No impacts.
6.3 Recreational boating and surface water sports		
Provide opportunities for recreational boating and appropriate surface water sports while protecting natural and cultural values	No impacts.	No impacts.
Promote safe boating and water safety within the planning area.	No impacts.	No impacts.
Provide opportunities for marine mammal observation while ensuring their long-term protection.	No impacts.	No impacts.
6.4 Diving and snorkelling		
Provide opportunities for diving and snorkelling in the planning area while protecting natural and cultural values.	No impacts.	No impacts.
6.5 Swimming and shore-based activities		
Provide for appropriate shore-based activities while protecting natural and cultural values.	No impacts.	The OPEP takes into accounts risks to the shoreline and prioritises actions to reduce the spread and extent of oil towards the shoreline.
6.6 Recreational fishing		
Provide opportunities for sustainable recreational fishing while minimising impacts on the marine park and marine reserve.	No impacts.	No impacts.
6.7 Tourism services		
Encourage the provision of appropriate tourism services to improve the quality and range of recreational experiences available to visitors.	No impacts.	No impacts.
Ensure that licensed tour operators recognise and respect the natural and cultural values of the planning area, including Indigenous cultural heritage values.	No impacts.	No impacts.
6.8 Aircraft		
Monitor and minimise the impact of fixed wing aircraft and helicopters on the natural values of the planning area.	No impacts.	No impacts.
6.9 Public Safety		
Promote visitor safety and awareness of safety issues and risks within the planning area associated with access and use.	No impacts.	No impacts.
Promote and observe safe practices, and cooperate with emergency services.	No impacts.	No impacts.

7.1 Authorised uses		
Manage authorised uses and permitted activities in accordance with the National Parks Act, and minimise their impact on park values.	No impacts.	No impacts.
7.2 Boundaries and adjacent uses		
Ensure the integration of management of the planning area with adjoining land and waters in accordance with principles for ecologically sustainable development.	No impacts.	No impacts.
Ensure that necessary boundaries are clearly identifiable.	No impacts.	No impacts.
Minimise confusion by simplifying land tenure in the planning area.	No impacts.	No impacts.
8.1 Community awareness		
Build a shared sense of ownership and custodianship for the planning area in community groups and individuals.	No impacts.	No impacts.
Increase the community's awareness and understanding of the planning area's values, management activities and catchment impacts.	No impacts.	No impacts.
8.2 Community participation		
Support and encourage the active participation of community groups and volunteers in protection, conservation and monitoring projects to enhance management of the planning area.	No impacts.	No impacts.
Provide opportunities for, and encourage, tertiary students to undertake volunteer work experience and research consistent with aims for the planning area.	No impacts.	No impacts.
Inform, enrich and strengthen the planning area's management with the community's tradition and customs, especially the Traditional Owner's cultural lore.	No impacts.	No impacts.
8.3 Agency partnerships		
Enhance management of the planning area by collaborating with other agencies to ensure that they give appropriate consideration to park values in planning and implementing activities that relate to the planning area.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Corner Inlet Marine National Park Management Plan (Parks Victoria, 2005)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	5% probability of low exposure to entrained hydrocarbon 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Geological and geomorphological features		
Protect geological and geomorphological features of the park from potentially damaging human activities.	No impacts.	No impacts.
Allow natural geological and geomorphological processes to continue without human interference.	No impacts.	No impacts.
Provide opportunities for appropriate research on geological and landform features.	No impacts.	No impacts.
4.2 Catchment and water quality		
Maintain a high quality of water within the park and surrounding waters to ensure that natural biological and physical processes can occur.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Minimise the impacts on water quality from activities in the catchment.	No impacts.	No impacts.
4.3 Hydrodynamics		
Allow natural hydrodynamic processes to continue without human interference.	No impacts.	No impacts.
Minimise impacts on park values from human-induced changes to local hydrodynamic processes.	No impacts.	No impacts.
4.4 Habitats and communities		
Protect marine ecological communities and indigenous flora and fauna.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Increase knowledge of marine ecological communities, flora and fauna, to aid management, protection and appreciation.	No impacts.	No impacts.
Increase knowledge of key threatening processes for marine ecological communities, flora and fauna.	No impacts.	No impacts.
4.5 Landscape and seascape		

Preserve and protect the landscape and seascape values of the park, including the natural character and aesthetic qualities.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Minimise the visual impact of developments and management activities within and adjacent to the park.	No impacts.	No impacts.
4.6 Marine pests		
Minimise the risk of introduction by human activities, and subsequent establishment of, marine pests in the park.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Establish arrangements for the detection of new incursions within the park in support of Victorian marine pest management arrangements.	No impacts.	No impacts.
Implement national or Victoria-wide control arrangements as they relate to the park.	No impacts.	No impacts.
5.1 Indigenous cultural heritage		
Protect Indigenous cultural heritage from interference or damaging activities.	No impacts.	No impacts.
Nurture Indigenous cultural lore relating to the park.	No impacts.	No impacts.
5.2 Maritime and other cultural heritage		
Provide opportunities for people to learn about and understand the historic heritage of the park.	No impacts.	No impacts.
6.1 Information, interpretation and education		
Promote and encourage visitors' discovery, enjoyment and appreciation of the park's natural and cultural values in a safe and appropriate manner through information, education and interpretation.	No impacts.	No impacts.
Encourage public support for parks and park management practices.	No impacts.	No impacts.
Promote an awareness of Indigenous and non-Indigenous culture.	No impacts.	No impacts.
6.2 Access		
Provide and maintain appropriate access to the park for visitor use and management purposes.	No impacts.	No impacts.

Minimise the impact of access on the park's natural and cultural values.	No impacts.	No impacts.
6.3 Recreational boating and surface water sports		
Provide for a range of recreational boating activities and surface water sports that are compatible with the protection of natural, cultural and other recreational values.	No impacts.	No impacts.
Promote safe boating and water safety within the parks.	No impacts.	No impacts.
6.4 Diving and snorkelling		
Provide opportunities for diving and snorkelling in the park that are consistent with the protection of natural and cultural values.	No impacts.	No impacts.
6.5 Swimming and shore-based activities		
Provide for appropriate shore-based activities that are consistent with the protection of park values and the adjacent Wilderness Zone within Wilsons Promontory National Park.	No impacts.	No impacts.
6.6 Tourism services		
Encourage the provision of appropriate tourism services to enhance the quality and range of recreational experiences in the park and minimise impacts on park values.	No impacts.	No impacts.
6.7 Public safety		
Promote visitor safety and awareness of safety issues and risks within the park associated with access and use.	No impacts.	No impacts.
Promote and observe safe practices, and cooperate with emergency services.	No impacts.	No impacts.
7.1 Authorised uses		
Manage authorised uses and permitted activities consistent with legislation, and minimise their impact on park values.	No impacts.	No impacts.
7.2 Boundaries and adjacent uses		
Ensure that boundaries are clearly identifiable from land and sea.	No impacts.	No impacts.
Minimise impacts from adjacent uses on park values.	No impacts.	No impacts.
8.1 Community awareness		

Increase the community's awareness and understanding of the park's values and management activities.	No impacts.	No impacts.
Build a sense of shared ownership and custodianship for the park among community groups and individuals.	No impacts.	No impacts.
8.2 Community participation		
Support and encourage the active participation of Friends groups and volunteers in protection, conservation and monitoring projects to enhance management of the park.	No impacts.	No impacts.
Provide opportunities for, and encourage tertiary students to undertake volunteer work experience and research that is consistent with aims for the park.	No impacts.	No impacts.
Inform, enrich and strengthen the park's management with the community's tradition, especially relevant Indigenous cultural lore.	No impacts.	No impacts.
8.3 Agency partnerships		
Enhance park management by collaborating with other agencies to ensure that they give appropriate consideration to park values in planning and implementing activities that relate to the park.	No impacts.	No impacts.

Assessment of BassGas operations against the stated actions of the Lakes National Park & Gippsland Lakes Coastal Park Management Plan (Gunaikurnai Traditional Owner Land Management Board and State of Victoria, 2018)

Note: The Lakes National Park is not intersected by the EMBA and is not assessed here.

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	4% probability of low exposure to entrained hydrocarbons 0-10 m below sea.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management actions of the Gippsland Lakes Park Management Plan.

Management Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Land and water		
Protect and restore the area by implementing the land and water conservation strategies detailed in Table 5 including the implementation of relevant parts of action statements and recovery plans for threatened and endangered species in the area, ensuring integration with the implementation of the Gippsland Lakes Ramsar Site Plan.	No impacts.	No impacts.
Work with West Gippsland Catchment Management Authority (WGCMA) to control pest plants and animals consistent with the East Gippsland Invasive Plants and Animals Plan including fox, cat and domestic dog threats to native birds and in particular Little Tern nesting sites, Hooded Plover and New Holland Mouse. Increase control of emerging threats including pigs and Sambar Deer, and priority weeds including Bridal Creeper, Box Thorn, Sea Spurge, Dolichos Pea and Wheel Cactus.	No impacts.	No impacts.
Undertake stabilisation and restoration of marsh and dune areas affected by erosion, and renourish islands critical to water bird habitat as required.	No impacts.	No impacts.
Work with the local government, WGCMA and affected landholders to control shoreline erosion in The Lakes National Park and the eastern Gippsland Lakes Coastal Park around private land while minimising the use of groynes and other infrastructure that may disrupt natural coastal processes elsewhere along the shoreline except where necessary.	No impacts.	No impacts.
Work with DELWP to protect the area, assets and communities from bushfire through fuel management strategies that do not adversely affect migratory bird habitat and other fire-sensitive values.	No impacts.	No impacts.
Identify areas where planned burning is required to achieve conservation objectives for park ecosystems and habitats and seek burns to be programmed and implemented as part of DELWP's fire operations planning process.	No impacts.	No impacts.
Investigate means by which inflows of water from Merriman Creek can be restored to Lake Reeve, subject to preventing flooding risks to the Seaspray township.	No impacts.	No impacts.
Include the parks in the development of a comprehensive conservation action plan aligned to the Gunaikurnai Whole-of-Country Plan and broader Gippsland park landscape conservation.	No impacts.	No impacts.
Cultural heritage		

Increase the priority given to protection and restoration of Aboriginal cultural heritage sites and values in the parks, investing comparable focus and resourcing to that applied to environmental and visitor management.	No impacts.	No impacts.
Increase the visibility of Gunaikurnai cultural values in the parks through Welcome to Country and other appropriate signage, based on the Tatungalung clan at entry points and visitor nodes. Consider establishing a totemic plant or animal emblem for the parks.	No impacts.	No impacts.
Undertake mapping and survey of Gunaikurnai cultural values in the parks, and consider the scanning of the intermittent areas of Lake Reeve near The Lakes National Park. Consider the need for any boundary amendments, and implementation of a park zoning Cultural Values Overlay, in light of mapping and survey outcomes.	No impacts.	No impacts.
Seek to rename places in the park using traditional Gunaikurnai names through the Naming Rules of the Office of Geographic Names.	No impacts.	No impacts.
Create opportunities for greater Gunaikurnai connection through visiting the parks, and undertaking community cultural activities, including partnering with tour operators, and development of Point Wilson as a hub of cultural information and activity for the community and visitors	No impacts.	No impacts.
Investigate use of Rotamah Island as a cultural education operation	No impacts.	No impacts.
Explore opportunities with the Gippsland Lakes User Group for Gunaikurnai to provide education and guiding services to schools and camps based on Banksia Peninsula.	No impacts.	No impacts.
Seek opportunities to implement traditional cultural burning practices as part of planned burning programs through liaison and partnership with DELWP fire managers.	No impacts.	No impacts.
Upgrade the presentation of cultural information, joint management and other park information at the Parks Victoria Loch Sport Office.	No impacts.	No impacts.
Incorporate cultural values information into induction processes for contractors and others working in the area.	No impacts.	No impacts.
Ensure Gunaikurnai are included in the assessment and approval of research applications in the area in accordance with the Aboriginal Heritage Act.	No impacts.	No impacts.
Implement relevant entitlements or obligations under the Native Title Act 1993, and any future Land Use Activity Agreement that is established under the Traditional Owner Settlement Act 2010, relating to Gunaikurnai rights to negotiate long---term and high---impact leases and comment	No impacts.	No impacts.

on lower impact authorisations in the parks.		
People in the Parks		
Manage visitor experiences in the parks in accordance with the goals and strategy in Table 6 or each of the broadly defied visitor experience areas of the two parks.	No impacts.	No impacts.
Manage visitor activities in accordance with Table 7. Generally, maintain existing regulatory settings for activities and uses in the parks, apart from changes set out in this plan (including approved variations) or changes arising from statutory requirements.	No impacts.	No impacts.
Continue current public access arrangements on roads and tracks in both parks.	No impacts.	No impacts.
Maintain education and enforcement to ensure that access, visitor activity, campfires, waste and other regulations are complied with, giving priority to hunting areas during hunting season, and the Bunga Arm Special Management Area. Work with hunting groups to eliminate cutting of standing vegetation for hides, through education and enforcement.	No impacts.	No impacts.
Seek policy approval to re-introduce camping registration and fees in areas between the Honeysuckles and Paradise Beach.	No impacts.	No impacts.
Explore the opportunity for Gunaikurnai-operated education and visitor services at the Rotamah Island Homestead as part of the current lease arrangements or at the end of the lease terms.	No impacts.	No impacts.
Control risks to visitor safety especially in relation to campfires, surf fishing and safe boating. Maintain emergency beach access point at Barrier Landing.	No impacts.	No impacts.
Extend the arrangements for Hog Deer hunting on Boole Poole Peninsula. Provide an annual hunting area equal in extent to the existing balloted area, rotated within a larger area of the Coastal Park extending east of Bunga Arm Track. Undertake further engagement with agency and park stakeholders and neighbours regarding detailed planning and implementation.	No impacts.	No impacts.
Improve the definition and signage of park walking tracks around Ocean Grange and other residential areas abutting the Coastal Park to clarify the public---private boundary for park visitors.	No impacts.	No impacts.
Ensure all tour operators undertake cultural awareness training conducted by Gunaikurnai, to enhance knowledge and protection of cultural heritage, and to improve interpretation of Gunaikurnai culture to visitors.	No impacts.	No impacts.
Working Together		

Maintain close collaboration with the West Gippsland Catchment Management Authority and DELWP biodiversity and fire staff in relation to management programs and priorities in and around the parks. Ensure co-ordinated management of the parks and the broader Gippsland Lakes Ramsar site.	No impacts.	No impacts.
Increase participation and input of Gunaikurnai in DELWP fire management programs in and around the parks.	No impacts.	No impacts.
Work with Gippsland Ports to: ensure safe and sustainable boating access to the parks; provide maintenance access to the Barrier Landing sand pipeline and minimise effects on the Coastal Park and visitors of maintenance operations; retain provision of a sewage pump-out barge in the Bunga Arm.	No impacts.	No impacts.
Collaborate with Destination Gippsland to market and promote the parks as part of regional tourism experiences and attractions.	No impacts.	No impacts.
Work with local tourism, business and community groups to promote the parks and provide complementary services to visitors.	No impacts.	No impacts.
Collaborate with Victorian Fisheries Authority and recreational fishing groups to ensure the sustainability of fish populations in the waters of the parks, and to manage shoreline impacts.	No impacts.	No impacts.
Work with recreational hunting groups to achieve responsible hunting practices and expand existing volunteer partnerships to control feral animals, especially pigs and Sambar Deer.	No impacts.	No impacts.
Provide opportunities for Parks Victoria rangers in the area to interact with other parks and partners in the Settlement Area to develop their understanding and knowledge of joint management approaches.	No impacts.	No impacts.
Pursue opportunities to create more effective boundaries or to negotiate improved access to the parks through acquisitions or landholder agreements as they arise.	No impacts.	No impacts.
Improve the on-water operational capability of the Gunaikurnai joint management ranger team through provision/access to watercraft and the necessary boat-handling training and certifications.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Cape Conran Coastal Park Management Plan (Parks Victoria, 2005)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	1% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Geological and landform features		
Provide for the protection of geological and geomorphological features of scientific or landscape interest, or cultural significance.	No impacts.	No impacts.
Minimise disturbances to geomorphological processes or features.	No impacts.	No impacts.
Provide for study, education and appreciation of geological and landform features and coastal geomorphological processes.	No impacts.	No impacts.
4.2 Rivers and catchments		
Protect and maintain the integrity of streams and catchments within the park.	No impacts.	No impacts.
Minimise the impact of management and visitor activities on rivers and catchments in the park.	No impacts.	No impacts.
4.3 Vegetation		
Conserve native plant communities and maintain genetic diversity.	No impacts.	No impacts.
Enhance the long-term survival of threatened and significant plant species and communities.	No impacts.	No impacts.
Provide for scientific investigation relating to conservation of flora and biodiversity.	No impacts.	No impacts.
4.4 Fauna		
Protect indigenous fauna.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Maintain genetic diversity of fauna communities.	No impacts.	No impacts.
Enhance the long-term survival prospects of threatened or significant faunal species and populations.	No impacts.	No impacts.
4.5 Landscape		

Protect the natural landscape, particularly places of special significance to the Traditional Owners, interest to visitors, or high scenic quality.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Minimise visual impacts on the landscape and remove or ameliorate undesirable visual intrusions.	No impacts.	No impacts.
4.6 Fire Management		
Protect human life, property and park values from injury by fire.	No impacts.	No impacts.
Maintain fire regimes appropriate to the conservation of native flora and fauna.	No impacts.	No impacts.
Minimise the adverse effects of all fires and fire suppression methods on park values.	No impacts.	No impacts.
4.7 Pest plants and animals, and diseases		
Eradicate or control pest plants and animals using methods which minimise disturbance to natural systems and effects on park values.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Restore native vegetation to areas where weeds have been removed.	No impacts.	No impacts.
Minimise the spread of any Phytophthora in the park.	No impacts.	No impacts.
4.8 Soil conservation		
Prevent and control soil degradation caused by visitor or management activities and restore disturbed sites, avoiding damage to natural and cultural values.	No impacts.	No impacts.
5.1 Indigenous cultural heritage		
Protect Indigenous cultural heritage from interference or damaging activities.	No impacts.	No impacts.
Nurture Indigenous cultural lore relating to the park.	No impacts.	No impacts.
5.2 Historic cultural heritage		
Protect and conserve historic cultural places.	No impacts.	No impacts.
Provide opportunities for people to learn about and understand the historic and cultural values of the park.	No impacts.	No impacts.

6.1 Visitor information, interpretation and education		
Encourage visitors to discover, enjoy and appreciate the park's natural and cultural values.	No impacts.	No impacts.
Orientate visitors in relation to park features.	No impacts.	No impacts.
Inform visitors of appropriate behaviour during their park visit.	No impacts.	No impacts.
Improve visitor satisfaction and promote sustainable visitor use of the park.	No impacts.	No impacts.
Provide a range of high-quality interpretation and education opportunities to promote understanding and appreciation of the park's values.	No impacts.	No impacts.
Promote Indigenous heritage values and reconciliation through a range of tourism, interpretive, information and education mediums.	No impacts.	No impacts.
6.2 Vehicular access		
Provide an appropriate level of vehicle access to visitor nodes for bush and scenic driving and for park management purposes.	No impacts.	No impacts.
Minimise the impact of road and track management and vehicle use on the park's natural and cultural values.		
6.3 Day visits		
Provide day visitor facilities that enhance visitors' enjoyment of the park and are consistent with protecting park values.	No impacts.	No impacts.
Protect areas critical to wildlife from disturbance by day visitors.	No impacts.	No impacts.
Address hygiene and environmental issues associated with a lack of appropriate facilities at key day-visitor destinations.	No impacts.	No impacts.
6.4 Camping		
Provide opportunities to meet current market needs for a range of camping experiences while minimising impacts on park values.	No impacts.	No impacts.
Maintain the bush setting camping experience of the Banksia Bluff campground.	No impacts.	No impacts.
6.5 Roofed accommodation		
Maintain the integrity of the natural setting of the site.	No impacts.	No impacts.

Continue to provide roofed accommodation to cater for a broad range of user groups.	No impacts.	No impacts.
6.6 Boating		
Provide opportunities for boating whilst minimising associated impacts on park values and conflict with other visitors.	No impacts.	No impacts.
Continue to provide access for ocean boat launching at West Cape.	No impacts.	No impacts.
Encourage safe boating within and from the park.	No impacts.	No impacts.
6.7 Fishing		
Provide opportunities for recreational fishing and bait collection in accordance with aims for the park.	No impacts.	No impacts.
6.8 Bushwalking		
Provide a variety of high-quality walking opportunities within the park, while minimising impacts on park values.	No impacts.	No impacts.
Facilitate improved walking access to the park from neighbouring townships.	No impacts.	No impacts.
6.9 Hunting		
Provide opportunities for duck hunting on the lake at Sydenham Inlet while minimising its impact on park values.	No impacts.	No impacts.
6.10 Dogs		
Permit dogs in specified areas of the park, while protecting park values and the experience of visitors.	No impacts.	No impacts.
6.11 Horse riding		
Provide opportunities for horse riding while minimising impacts on park values and protecting the experience and safety of other visitors.	No impacts.	No impacts.
6.12 Cycling		

Provide a range of cycling opportunities within the park while minimising impacts on park values and protecting the experience and safety of other park visitors.	No impacts.	No impacts.
6.13 Tourism services		
Encourage the provision of appropriate licensed services to improve the quality and range of recreational experiences available in the park.	No impacts.	No impacts.
Minimise impacts of licensed operations on park values and the experiences of other visitors.	No impacts.	No impacts.
6.14 Public safety		
Promote safe visitor use of the park.	No impacts.	No impacts.
Ensure that park management has adequate capacity to respond to emergency situations.	No impacts.	No impacts.
7.1 Authorised uses		
Minimise the impacts of authorised occupations and activities on the park, visitors and other users.	No impacts.	No impacts.
7.2 Boundaries and adjacent uses		
Minimise the adverse impacts on the park of activities occurring outside the park boundaries.	No impacts.	No impacts.
Minimise conflicts between park management activities and adjoining land use.	No impacts.	No impacts.
8.1 Community awareness		
Build a sense of custodianship for the park among community groups and individuals.	No impacts.	No impacts.
Increase public awareness of the park’s values, regulations and management activities.	No impacts.	No impacts.

8.2 Community participation		
Inform, enrich and strengthen park management with the community's heritage, knowledge, skills and enthusiasm.	No impacts.	No impacts.
8.3 Agency partnerships		
Collaborate with other agencies on matters of mutual interest towards obtaining the best possible outcomes for the park and its values.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Point Hicks Marine National Park Management Plan (Parks Victoria, 2006)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	6% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	1% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Geological and geomorphological features		
Allow natural geological and geomorphological processes to continue without human interference.	No impacts.	No impacts.
Provide opportunities for appropriate research, appreciation and education in relation to geological and geomorphological features.	No impacts.	No impacts.
4.2 Catchment and water quality		
Ensure the integration of planning and management for the park, Croajingolong National Park, Point Hicks Lighthouse Reserve and nearby public and freehold land.	No impacts.	No impacts.
Maintain a high quality of water within the park and surrounding waters to ensure that natural biological and physical processes can occur.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Minimise impacts of threatening processes from activities in the catchment.	No impacts.	No impacts.
4.3 Hydrodynamics		
Minimise impacts on park values from human-induced changes to local hydrodynamic processes.	No impacts.	No impacts.
4.4 Habitats and communities		
Protect marine ecological communities and indigenous flora and fauna, and allow natural processes to continue.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Improve knowledge of marine ecological communities, flora and fauna and threatening processes to aid management, protection and appreciation.	No impacts.	No impacts.
4.5 Landscape and seascape		
Avoid any development on the coastal side of dunes and contain new works to inland inlets and rivers to ensure that the coastline retains its rugged non-developed wilderness character.	No impacts.	No impacts.
This area is of outstanding scenic quality and requires special landscape protection to ensure that development does not impact on landscape values.	No impacts.	No impacts.

Preserve and protect landscape and seascape values of the park, including the natural character, aesthetic qualities and values of significance to Indigenous communities.	No impacts.	No impacts.
Minimise the visual impact of developments and management activities, including those adjacent to the park.	No impacts.	No impacts.
4.6 Marine pests		
Minimise the risk of introduction of marine pests by human activities, and their subsequent establishment in the park.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Establish arrangements for the detection of new incursions within the park in support of Victorian marine pest management arrangements.	No impacts.	No impacts.
Implement national or Victoria-wide control arrangements as they relate to the park.	No impacts.	No impacts.
5.1 Indigenous cultural heritage		
Protect Indigenous cultural heritage from interference or damaging activities.	No impacts.	No impacts.
Nurture Indigenous cultural lore relating to the park.	No impacts.	No impacts.
5.2 Maritime and other cultural heritage		
Conserve places of historic and cultural significance.	No impacts.	No impacts.
Encourage learning about and understanding of the historic heritage of the park.	No impacts.	No impacts.
6.1 Information, interpretation and education		
Promote and encourage visitors to discover, enjoy and appreciate the park's natural and cultural values in a safe and appropriate manner through information, interpretation and education.	No impacts.	No impacts.
Encourage public support for the park and park management practices.	No impacts.	No impacts.
Foster relevant collaborative education projects with other organisations or groups delivering environmental education in the East Gippsland area.	No impacts.	No impacts.
Provide opportunities for people to learn about and understand the cultural and spiritual significance of the park to Indigenous people.	No impacts.	No impacts.
6.2 Access		

Provide for the use and enjoyment of the park by visitors, while protecting the park's natural and cultural values.	No impacts.	No impacts.
6.3 Recreational boating and surface water sports		
Allow for a range of recreational boating activities, surface water sports and marine mammal observation while protecting natural, cultural and other recreational values.	No impacts.	No impacts.
Promote safe boating and water safety within the park.	No impacts.	No impacts.
6.4 Diving and snorkelling		
Provide opportunities for diving and snorkelling in the park while protecting natural and cultural values.	No impacts.	No impacts.
6.5 Swimming and shore-based activities		
Provide for appropriate shore-based activities while minimising impacts to sensitive natural and cultural values within the park and the adjacent Croajingolong National Park and Point Hicks Lighthouse Reserve.	No impacts.	No impacts.
6.6 Other activities		
Monitor and minimise the impact of helicopters and aircraft on natural and cultural values.	No impacts.	No impacts.
Minimise impacts of dogs on the natural and cultural values of the park.	No impacts.	No impacts.
6.7 Tourism services		
Encourage the provision of appropriate tourism services, while minimising impacts on the natural and cultural values of the park.	No impacts.	No impacts.
6.8 Public safety		
Promote visitor safety and awareness of safety issues and risks within the park.	No impacts.	No impacts.
Promote and observe safe practices, and cooperate with emergency services.	No impacts.	No impacts.
7.1 Authorised uses		
Manage authorised uses and permitted activities in accordance with the National Parks Act, and minimise their impact on park values.	No impacts.	No impacts.
7.2 Boundaries and adjacent uses		

Ensure the integration of management with adjoining land and waters, consistent with the protection of remote and wilderness values.	No impacts.	No impacts.
Effectively communicate the location of park boundaries.	No impacts.	No impacts.
8.1 Community awareness		
Increase the community's awareness and understanding of the park's values and management activities.	No impacts.	No impacts.
Build a sense of shared ownership and custodianship for the park among community groups and individuals.	No impacts.	No impacts.
8.2 Community participation		
Support and encourage the active participation of community groups and volunteers in protection, conservation and monitoring projects to enhance management of the park.	No impacts.	No impacts.
8.3 Agency partnerships		
Enhance park management by collaborating with other agencies to ensure that they give appropriate consideration to park values in planning and implementing activities that may relate to the park.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Croajingolong National Park Management Plan (Parks Victoria, 1996)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	4% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	2% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
3.1 Geological and landform features		
Protect areas of geological and geomorphological interest.	No impacts.	No impacts.
Provide opportunities for appropriate research, appreciation and education of geological and geomorphological sites and processes.	No impacts.	No impacts.
Maintain the functioning of natural aquatic ecosystems in inlets throughout the Park.	No impacts.	No impacts.
3.2 Rivers and catchments		
Protect and maintain the integrity of catchments within the Park.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Protect and enhance the conservation and recreation values of all rivers in the Park.	No impacts.	No impacts.
3.3 Vegetation		
Protect native plant communities in their natural condition, and maintain genetic diversity.	No impacts.	No impacts.
Enhance the long-term survival prospects of threatened or significant plant species or communities.	No impacts.	No impacts.
3.4 Fauna		
Protect native animal communities, and maintain genetic diversity.	No impacts.	No impacts.
Enhance the long-term survival prospects of threatened or significant faunal species and populations.	No impacts.	No impacts.
3.5 Landscape		
Protect and enhance landscape values.	No impacts.	No impacts.
3.6 Cultural heritage		
Identify, protect, and where appropriate interpret, Koori sites.	No impacts.	No impacts.

Promote further investigations into Koori history and culture	No impacts.	No impacts.
Encourage Koori involvement in the management of sites within the Park.	No impacts.	No impacts.
Identify and conserve sites and artefacts of European historical interest and significance.	No impacts.	No impacts.
Improve knowledge and understanding of history in the Park and the effects of past land use.	No impacts.	No impacts.
4.1 Fire management		
Protect life, property and Park values from injury by fire.	No impacts.	No impacts.
Minimise the adverse effects of fires and fire suppression methods.	No impacts.	No impacts.
Maintain fire regimes appropriate to the conservation of native flora and fauna.	No impacts.	No impacts.
4.2 Pest plants and animal, and diseases		
Control, and where possible eradicate, pest plants and animals in the Park.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Minimise the impact of control programs on native flora and fauna.	No impacts.	No impacts.
Protect the Park from threats and diseases, in particular Cinnamon Fungus.	No impacts.	No impacts.
5.1 Park visitors		
Provide for visitors in accordance with the above overview of future management for visitors.	No impacts.	No impacts.
5.2.1 Vehicle access		
Provide and maintain an access network for visitor enjoyment, management purposes and private property access	No impacts.	No impacts.
Minimise the impact of vehicle and track management on the Park’s natural and cultural values.	No impacts.	No impacts.
5.2.2 Day visits		

Establish and maintain high standard but low-key day visitor facilities which enhance visitor enjoyment and are consistent with protecting Park values.	No impacts.	No impacts.
5.2.3 Camping		
Provide opportunities for a variety of camping experiences in keeping with the Park's unspoilt and remote character while minimising impacts on Park values.	No impacts.	No impacts.
5.2.4. Bushwalking		
Provide a range of opportunities for walking, while minimising impacts on Park values.	No impacts.	No impacts.
Promote the walking track network as a significant nature-based opportunity within the Park	No impacts.	No impacts.
5.2.5 Fishing		
Provide opportunities for fishing including bait collection and intertidal collecting, where it is consistent with the protection of Park values.	No impacts.	No impacts.
5.2.6 Boating		
Provide opportunities for boating in the Park, where appropriate.	No impacts.	No impacts.
5.2.7 Jetties		
Provide for appropriate boating access to and use of Park inlets and waterways.	No impacts.	No impacts.
5.2.8 Canoeing and sea kayaking		
Provide for the use of Park inlets and waterways for canoeing and kayaking.	No impacts.	No impacts.
5.2.9 Other activities		
Provide for a range of other recreational activities, as appropriate.	No impacts.	No impacts.
5.3 Visitor information, interpretation and education		
Enhance visitor appreciation and visitors enjoyment of the natural and cultural features of the Park, and the value of national parks generally.	No impacts.	No impacts.
Increase public awareness of management activities including fuel reduction burning, pest plant and animal control, the conservation of threatened species, natural and cultural features and the impacts of people on the Park.	No impacts.	No impacts.

5.4 Commercial tourism operations		
Provide for tourism activities based on the Park's remote and unspoilt character - its distinctive quality and competitive advantage.	No impacts.	No impacts.
Provide opportunities for sustainable, high quality adventure and nature-based experiences.	No impacts.	No impacts.
Support and complement broader tourism opportunities and activities in the region.	No impacts.	No impacts.
5.5 Public safety		
Promote and encourage safe practices among visitors and staff.	No impacts.	No impacts.
6.1 Friends and volunteers		
Assist volunteer groups to undertake appropriate management tasks in the Park.	No impacts.	No impacts.
6.2 Community awareness and Park neighbours		
Increase public awareness of management activities, including fuel reduction burning, pest plant and animal control, and the conservation of threatened species.	No impacts.	No impacts.
Encourage conservation and sound land management practices on private land adjoining the Park.	No impacts.	No impacts.
7.1.1 Commercial fishing		
Phase commercial fishing out of the Tamboon Inlet in accordance with the government-approved LCC recommendation.	No impacts.	No impacts.
7.1.2 Apiculture		
Allow apiculture in the Park in accordance with LCC recommendations and NRE guidelines.	No impacts.	No impacts.
7.1.3 Gravel extraction		

Minimise the environmental and visual impacts of gravel extraction operations.	No impacts.	No impacts.
Provide material for road maintenance in the Park where this has only minimal impact on the Park	No impacts.	No impacts.
7.1.4 Public utilities		
Minimise the impact of public utilities on the Park.	No impacts.	No impacts.
Ensure appropriate use and licensing of existing and any proposed new public utilities in the Park.	No impacts.	No impacts.
7.1.5 Training exercises		
Allow appropriate training exercises by the Defence Forces, Emergency Services and other groups.	No impacts.	No impacts.
7.1.6 Pollution and water quality		
Reduce pollution in the Park from point source discharges and recreational use.	No impacts.	No impacts.
Ensure an effective oil and chemical spill response.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
7.2 Boundaries and adjacent land use		
Enhance the collective values and cooperative management of the Park, the proposed Cape Conran Coastal Park and Nadgee Nature Reserve (NSW).	No impacts.	No impacts.
Minimise impacts on Park values from surrounding land use, including timber harvesting in adjacent State forest	No impacts.	No impacts.

<u>Assessment of BassGas operations against the stated aims of the Cape Howe Marine National Park Management Plan (Parks Victoria, 2006)</u>

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	1% probability of low exposure to entrained hydrocarbons 0-10 m below sea.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact
Entrained hydrocarbons:	1% probability of low exposure to entrained hydrocarbons 0-10 m below sea.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
4.1 Geological and geomorphological features		
Allow natural geological and geomorphological processes to continue without human interference.	No impacts.	No impacts.
Provide opportunities for appropriate research, appreciation of, and education about geological and landform features.	No impacts.	No impacts.
4.2 Catchment and water quality		
Ensure the integration of planning and management for the park and adjacent Croajingolong National Park and nearby public and private land.	No impacts.	No impacts.
Maintain a high quality of water within the park and surrounding waters to ensure that natural biological and physical processes can occur.	No impacts.	The OPEP takes into account risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Minimise impacts of threatening processes from activities in the catchment.	No impacts.	No impacts.
4.3 Hydrodynamics		
Minimise impacts on park values from human-induced changes to local hydrodynamic processes.	No impacts.	No impacts.
4.4 Habitats and communities		
Protect marine ecological communities and indigenous flora and fauna, and allow natural processes to continue.	No impacts.	The OPEP takes into account risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Improve knowledge of marine ecological communities, flora and fauna and threatening processes to aid management, protection and appreciation.	No impacts.	No impacts.
4.5 Landscape and seascape		
Preserve and protect landscape and seascape values of the park, including the natural character, aesthetic qualities and values of significance to Indigenous communities.	No impacts.	No impacts.
Minimise the visual impact of developments and management activities, including those adjacent to the park.	No impacts.	No impacts.

4.6 Marine pests		
Minimise the risk of introduction of marine pests by human activities, and their subsequent establishment in the park.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Establish arrangements for the detection of new incursions within the park in support of Victorian marine pest management arrangements.	No impacts.	No impacts.
Implement national or Victoria-wide control arrangements as they relate to the park.	No impacts.	No impacts.
5.1 Indigenous cultural heritage		
Protect Indigenous cultural heritage from interference or damaging activities.	No impacts.	No impacts.
Nurture Indigenous cultural lore relating to the park.	No impacts.	No impacts.
5.2 Maritime and other cultural heritage		
Conserve places of historic and cultural significance.	No impacts.	No impacts.
Encourage learning about and understanding of the historic heritage of the park.	No impacts.	No impacts.
6.1 Information, interpretation and education		
Promote and encourage visitors to discover, enjoy and appreciate the park's natural and cultural values in a safe and appropriate manner through information, interpretation and education.	No impacts.	No impacts.
Encourage public support for the park and park management practices.	No impacts.	No impacts.
Foster relevant collaborative education projects with other organisations or groups delivering environmental education in the East Gippsland area.	No impacts.	No impacts.
Provide opportunities for people to learn about and understand the cultural and spiritual significance of the park to Indigenous people.	No impacts.	No impacts.
6.2 Access		
Provide for the use and enjoyment of the park by visitors, while protecting the park's natural and cultural values.	No impacts.	No impacts.
6.3 Recreational boating and surface water sports		

Allow for a range of recreational boating activities, surface water sports and marine mammal viewing while protecting natural, cultural and recreational values.	No impacts.	No impacts.
Promote safe boating and water safety within the park.	No impacts.	No impacts.
6.4 Diving and snorkelling		
Provide opportunities for diving and snorkelling in the park, while protecting natural and cultural values.	No impacts.	No impacts.
6.5 Swimming and shore-based activities		
Provide for appropriate shore-based activities while minimising impacts to sensitive natural and cultural values within the park and the adjacent Cape Howe Wilderness Zone of Croajingolong National Park.	No impacts.	No impacts.
6.6 Other activities		
Monitor and minimise the impact of helicopters and aircraft on natural and cultural values.	No impacts.	No impacts.
Minimise impacts of dogs on the natural and cultural values of the park.	No impacts.	No impacts.
6.7 Tourism services		
Encourage the provision of appropriate tourism services, while minimising impacts on the natural and cultural values of the park.	No impacts.	No impacts.
6.8 Public safety		
Promote visitor safety and awareness of safety issues and risks within the park.	No impacts.	No impacts.
Promote and observe safe practices, and cooperate with emergency services.	No impacts.	No impacts.
7.1 Authorised uses		
Manage authorised uses and permitted activities in accordance with the National Parks Act, and minimise their impact on park values.	No impacts.	No impacts.
7.2 Boundaries and adjacent uses		
Ensure the integration of management with adjoining land and waters, consistent with the protection of remote and wilderness values.	No impacts.	No impacts.

Effectively communicate the location of park boundaries.	No impacts.	No impacts.
8.1 Community awareness		
Increase the community’s awareness and understanding of the park’s values and management activities.	No impacts.	No impacts.
Build a sense of shared ownership and custodianship for the park among community groups and individuals.	No impacts.	No impacts.
8.2 Community participation		
Support and encourage the active participation of community groups and volunteers in protection, conservation and monitoring projects to enhance management of the park.	No impacts.	No impacts.
8.3 Agency partnerships		
Enhance park management by collaborating with other agencies to ensure that they give appropriate consideration to park values in planning and implementing activities that may relate to the park.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Arthur-Pieman Conservation Area Management Plan (Parks and Wildlife Service, 2002)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	5% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
3.2 Geodiversity		
Preserve and maintain geodiversity.	No impacts.	No impacts.
Preserve and maintain significant geoconservation sites.	No impacts.	No impacts.
Maintain the natural rates and magnitudes of change in earth processes.	No impacts.	No impacts.
Minimise harmful impacts on geoconservation sites.	No impacts.	No impacts.
3.3 Landscape and wilderness		
Sustain naturalness and a lack of recent human disturbance.	No impacts.	No impacts.
Preserve a sense of tranquillity for visitors.	No impacts.	No impacts.
Maintain the perception of isolation from settlement and human activities.	No impacts.	No impacts.
Retain the character of the reserve as a living landscape much as it is today.	No impacts.	No impacts.
3.4 Water quality		
Maintain or enhance aquatic ecosystems.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Maintain or enhance recreational water quality.	No impacts.	No impacts.
3.5 Aboriginal values		
Identify and record sites and landscapes of Aboriginal heritage.	No impacts.	No impacts.
Protect and conserve Aboriginal heritage.	No impacts.	No impacts.

Where possible enlist the assistance of the wider community in collaboration with Aboriginal groups to assist in properly managing and protecting the sites.	No impacts.	No impacts.
Interpret Aboriginal heritage to assist in educating the wider community about the importance of the Aboriginal sites along the coast.	No impacts.	No impacts.
Facilitate and enrich Aboriginal community use of the area, its resources and its educational opportunities.	No impacts.	No impacts.
3.6 Historical heritage		
Identify and record historic heritage sites in the reserve.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Protect and conserve all remaining significant heritage fabric and features.	No impacts.	No impacts.
Consult with the community on management changes.	No impacts.	No impacts.
Maintain the integrity and authenticity of structural and other historic remains and movable heritage.	No impacts.	No impacts.
Present and interpret historic heritage.	No impacts.	No impacts.
Exclude intrusive development and activity.	No impacts.	No impacts.
3.7 Flora		
Conserve and maintain natural diversity and natural ecosystems.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Conserve and protect threatened flora species.	No impacts.	No impacts.
Conserve and protect plant communities of high conservation value.	No impacts.	No impacts.
Maintain natural processes.	No impacts.	No impacts.
Minimise harmful impacts on reserve vegetation.	No impacts.	No impacts.

Prevent, contain or eradicate weeds threatening native vegetation.	No impacts.	No impacts.
3.8 Fauna		
Ensure threatened fauna species are protected.	No impacts.	No impacts.
Maintain viable populations of indigenous species of fauna throughout their natural range..	No impacts.	No impacts.
Maintain the diversity of natural habitats of indigenous fauna.	No impacts.	No impacts.
Eradicate introduced species where this is feasible and warranted by the damage being caused.	No impacts.	No impacts.
Control and manage introduced species where eradication is not possible or warranted.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Tasmanian waters.	
4.1 Fire Management		
To protect people from wildfires.	No impacts.	No impacts.
To protect buildings, facilities and visitor, belongings from wildfires.	No impacts.	No impacts.
To prevent wildfires burning onto neighbouring properties.	No impacts.	No impacts.
To protect those natural and cultural assets that will be damaged by wildfire.	No impacts.	No impacts.
Maintain peat soils.	No impacts.	No impacts.
Maintain the diversity of plant and animal communities.	No impacts.	No impacts.
4.2 *Phytophthora* protection		
Limit the spread of *Phytophthora cinnamomi* in the reserve	No impacts.	No impacts.
Educate the community in Phytophthora prevention hygiene measures	No impacts.	No impacts.
4.3 Reserve boundaries		
Provide, where possible, for ecological boundaries.	No impacts.	No impacts.
Provide boundaries that are clearly justifiable from a management perspective.	No impacts.	No impacts.

Simplify and clarify boundaries.	No impacts.	No impacts.
4.4 Assessing and approving development		
To ensure that decisions related to proposed developments or activities reflect the management objectives of this plan.	No impacts.	No impacts.
To ensure that sound processes exist for the assessment of potential impacts of proposed developments and activities (including scientific and management activities).	No impacts.	No impacts.
5.1 Stock agistment		
Clear demonstration of sustainability	No impacts.	No impacts.
Protection of natural and cultural heritage sites and landscapes	No impacts.	No impacts.
Financial neutrality for the Crown	No impacts.	No impacts.
Protection for the Crown from any liability under the provisions of the Animal Welfare Act	No impacts.	No impacts.
Presentation, where appropriate, of traditional practices for the benefit of visitors and the local community	No impacts.	No impacts.
5.2 Electricity generation potential		
Allow for wind resource investigation subject to appropriate conditions to protect the environment.	No impacts.	No impacts.
Any further development of the wind resource will be subject to the preparation of a full environmental impact assessment process that includes community review.	No impacts.	No impacts.
5.3 Mineral resources		
To ensure that exploration or any subsequent extraction and rehabilitation are undertaken in accordance with best practice to provide maximum environmental protection.	No impacts.	No impacts.
5.4 Leases and licences		
Allow for a range of activities while protecting and conserving natural and cultural values.	No impacts.	No impacts.
5.5 Commercial fishing infrastructure		
To develop protocols and codes of conduct with and for commercial fishers which identify best practice in environmental management of shore-based activities, and which reward compliance.	No impacts.	No impacts.

To minimise any adverse impacts commercial fishing infrastructure may have on the conservation area.	No impacts.	No impacts.
To develop ways of interpreting the social and economic contribution of those commercial fishers based in the Arthur-Pieman Conservation Area, with particular reference to the growing tourism market.	No impacts.	No impacts.
5.6 Development works including visitor services		
Provide for development or resource utilisation in identified locations;	No impacts.	No impacts.
Minimise their impacts on conservation area values;	No impacts.	No impacts.
Protect and conserve tourism and recreational values;	No impacts.	No impacts.
Foster public confidence in developments and resource utilisation;	No impacts.	No impacts.
Ensure that all developments or works are ecologically sustainable.	No impacts.	No impacts.
6.1 Camping		
Provide for the unique recreational experiences provided by camping in the APCA in such a way as to minimise the impact on social, environmental and cultural values;	No impacts.	No impacts.
Work with the local community and the community of users to address the environmental impacts of free-range camping	No impacts.	No impacts.
6.2 Shacks		
Conform with the conclusions of the shack categorisation process being undertaken by the Department of Primary Industries, Water and Environment.	No impacts.	No impacts.
6.3 On-road access		
Define a set of roads that will be used by the public and that can be maintained;	No impacts.	No impacts.
Develop protocols for management of roads in keeping with the Reserve Management Code of Practice (under development)	No impacts.	No impacts.
Develop information for visitors and locals on appropriate use of roads	No impacts.	No impacts.
Develop partnerships with users providing for management of roads and tracks	No impacts.	No impacts.

6.4 Vehicles used off-road		
Provide for responsible, low-impact experiences within the reserve	No impacts.	No impacts.
Recognise the contribution to responsible use that can be made by clubs	No impacts.	No impacts.
Develop a system that is enforceable	No impacts.	No impacts.
Minimise conflicts with other recreational activities	No impacts.	No impacts.
Minimise conflicts with conservation of the natural and cultural values of the conservation area	No impacts.	No impacts.
6.5 Walking		
Identify and, subject to resources, develop and promote walking opportunities in the Arthur–Pieman which enable visitors to appreciate the special natural and cultural values of the area	No impacts.	No impacts.
Provide relevant information about settings and develop protocols between different recreational groups so that recreational users can make informed choices about the location and character of the recreational experience they seek	No impacts.	No impacts.
6.6 Family pets		
Permit dogs into parts of the conservation area under conditions that ensure they create minimal disturbance to wildlife and visitors.	No impacts.	No impacts.
6.7 Hunting		
Continue to allow sustainable hunting in parts of the conservation area.	No impacts.	No impacts.
6.8 Horse access		
Provide for controlled horse riding in the conservation area so as to minimise environmental damage and conflicts with other users.	No impacts.	No impacts.
6.9 Air access		
Allow the continued use of Balfour airstrip and to control other aircraft landings by permit.	No impacts.	No impacts.
6.10 Tourism		
Facilitate development of the regional economy through encouraging tourism based on and consistent with the maintenance of reserve values.	No impacts.	No impacts.

6.11 Interpretation and education		
Concentrate on developing a partnership with the Aboriginal community to develop strategies for revealing the richness of the Aboriginal heritage values in the reserve	No impacts.	No impacts.
Reveal through interpretation the richness of wilderness and National Estate values	No impacts.	No impacts.
Reveal through interpretation some of the richness of the European history of the area, particularly the association of the area with cattle grazing	No impacts.	No impacts.
Inform visitors of minimal impact practices and approaches to minimise adverse impact on other users	No impacts.	No impacts.
Interpret the geomorphic and biological diversity of the region	No impacts.	No impacts.
6.12 Enterprise unit		
Initiate an enterprise unit based on the implementation of a userpays system for the provision of common services in the Arthur– Pieman region and to oversee subsequent financial management.	No impacts.	No impacts.
Provide upgraded and enhanced visitor facilities through revenues generated	No impacts.	No impacts.
7.1 Community support		
Develop community appreciation of and support for reserve values;	No impacts.	No impacts.
Promote a positive image of the reserve and its benefit to the community	No impacts.	No impacts.
Involve the local and broader community in reserve management partnerships	No impacts.	No impacts.
7.2 Working with neighbours		
Take account of concerns of neighbours in managing the conservation area.	No impacts.	No impacts.
Encourage conservation and sound land management practices on lands adjoining the conservation area.	No impacts.	No impacts.
Co-ordinate protective works between the conservation area and surrounding land.	No impacts.	No impacts.
7.3 Management options & community involvement		
To achieve an appropriate level of public involvement in management of the conservation area consistent with the principles outlined above.	No impacts.	No impacts.

To achieve community ownership through involvement in policy development, planning and on ground management.	No impacts.	No impacts.
To increase the efficiency of management by encouraging community groups to take responsibility for managing their particular activities in the conservation area.	No impacts.	No impacts.
8.1 Monitoring and research		
Improve the inventory and understanding of natural features and processes;	No impacts.	No impacts.
Improve the inventory and understanding of cultural features;	No impacts.	No impacts.
Use the reserve as a scientific reference area;	No impacts.	No impacts.
Encourage socio-anthropological studies to understand the significance of the APCA to the north-west and Tasmanian community;	No impacts.	No impacts.
Monitor the natural rates and magnitudes of change;	No impacts.	No impacts.
Improve knowledge and understanding of visitor behaviour in the reserve;	No impacts.	No impacts.
Assess impacts of and long term cumulative changes caused by development or use of the reserve;	No impacts.	No impacts.
Assess and improve management of the reserve.	No impacts.	No impacts.

Assessment of BassGas operations against the stated objectives of The Nut State Reserve Management Plan (Parks and Wildlife Service, 2003)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	11% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management objectives of the park.

Management Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
3.2 Geoheritage		
Protect, maintain and monitor geodiversity.	No impacts.	No impacts.
Maintain the natural rates and magnitudes of change in earth processes.	No impacts.	No impacts.
Minimise harmful impacts on geoconservation sites.	No impacts.	No impacts.
3.3 Natural landscape		
Protect, maintain and monitor the National Estate values of the natural landscape.	No impacts.	No impacts.
Protect the scenic value of the skyline of the reserve.	No impacts.	No impacts.
3.4 The coastal zone		
Natural and cultural values of the coast shall be protected	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil towards the shoreline.
The coast shall be used and developed in a sustainable manner	No impacts.	No impacts.
Integrated management and protection of the coastal zone is a shared responsibility	No impacts.	No impacts.
3.5 Water quality		
Maintain or enhance marine water quality.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
3.6 Flora		
Protect, maintain and monitor natural flora diversity.	No impacts.	No impacts.
Protect, maintain and monitor threatened flora species.	No impacts.	No impacts.
Protect, maintain and monitor plant communities of conservation significance.	No impacts.	No impacts.

Minimise harmful impacts on the indigenous flora.	No impacts.	No impacts.
3.7 Fauna		
Protect, maintain and monitor all indigenous fauna species and their habitat.	No impacts.	No impacts.
Protect, maintain and monitor the diversity of indigenous fauna and habitat.	No impacts.	No impacts.
Minimise, and where possible eradicate, harmful impacts on indigenous fauna and habitats.	No impacts.	No impacts.
Provide opportunities for visitors to encounter wildlife.	No impacts.	No impacts.
3.8 Cultural heritage		
Identify and record sites of Aboriginal heritage.	No impacts.	No impacts.
Protect and conserve Aboriginal heritage.	No impacts.	No impacts.
Interpret Aboriginal heritage.	No impacts.	No impacts.
Identify and record historic heritage in the reserve.	No impacts.	No impacts.
Protect and actively conserve historic heritage from damage.	No impacts.	No impacts.
Present and interpret historic heritage.	No impacts.	No impacts.
Exclude intrusive development and activity.	No impacts.	No impacts.
Identify and maintain significant heritage vegetation and cultural landscapes such as the skyline.	No impacts.	No impacts.
Revegetate or allow natural regeneration of all other disturbed areas.	No impacts.	No impacts.
4.1 Fire Management		
Protect people from wildfires.	No impacts.	No impacts.
Protect neighbours and their property	No impacts.	No impacts.
Protect reserve facilities and assets	No impacts.	No impacts.
Maintain or improve nature conservation values	No impacts.	No impacts.

4.2 Introduced fauna		
Eradicate introduced species where feasible and warranted by the damage being caused.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters.	No impacts.
Control and manage introduced species where eradication is not practical or warranted.		No impacts.
4.3 Weed management and revegetation		
Eradicate weeds where this is feasible and warranted.	No impacts.	No impacts.
Control and manage weeds where eradication is not possible or warranted.	No impacts.	No impacts.
Revegetate areas with local provenance native species in conjunction with weed control programs.	No impacts.	No impacts.
Revegetate the reserve in a manner that will provide a mosaic of vegetation and shelter for visitors and encourage more abundant and diverse native wildlife.	No impacts.	No impacts.
4.4 Soil conservation and erosion control		
Prevent erosion and rehabilitate damaged areas.	No impacts.	No impacts.
4.5 Managing visitor impacts		
Protect, maintain and monitor natural and cultural values.	No impacts.	No impacts.
Protect, maintain and monitor the special tourism and recreation character of the reserve.	No impacts.	No impacts.
Perpetuate the reserve in a state that is valued by locals and visitors.	No impacts.	No impacts.
4.6 Managing development		
Avoid or minimise the impact of development works on reserve values.	No impacts.	No impacts.
Protect, maintain and monitor the special tourism and recreation character of the reserve.	No impacts.	No impacts.
Foster public confidence in the approval process for new developments.	No impacts.	No impacts.
5.1 The Reserve visit		
Understand visitor pressures on the reserve	No impacts.	No impacts.

Provide the basis for effective visitor management.	No impacts.	No impacts.
5.2 Promoting the Reserve		
Promote the reserve to potential visitors by emphasising its features and values.	No impacts.	No impacts.
5.3 Interpretation and Education		
Encourage pre-visit awareness of the reserve's special recreational and tourism character, facilities, opportunities and experiences.	No impacts.	No impacts.
Reveal the diversity and values of the natural and cultural heritage features of the reserve.	No impacts.	No impacts.
Explain the different uses of the reserve over time and the effects of those uses on the reserve.	No impacts.	No impacts.
Explain the change in vegetation from forest to pasture to weeds and the efforts of managers and local volunteers in rehabilitation of the reserve.	No impacts.	No impacts.
Encourage visitors to pursue their interests and explore what the reserve has to offer.	No impacts.	No impacts.
Realise the educational values of the reserve.	No impacts.	No impacts.
Canvas issues to be confronted in managing the reserve.	No impacts.	No impacts.
Increase public awareness of safety issues.	No impacts.	No impacts.
Inform visitors of reserve etiquette and minimal impact practices.	No impacts.	No impacts.
5.4 Access to the Reserve		
Maintain, develop and promote opportunities for people, including those with disabilities, to visit.	No impacts.	No impacts.
Protect reserve values by concentrating and limiting developed visitor arrival points and travel routes to designated locations.	No impacts.	No impacts.
Direct and develop access within the reserve appropriate to the zone in which it occurs.	No impacts.	No impacts.

5.5 Facilities and services		
Provide opportunities for activities, relaxation, contemplation, enjoyment and educational experiences through direct contact or participatory involvement with the values of the reserve.	No impacts.	No impacts.
Enrich visitor experiences of the reserve.	No impacts.	No impacts.
Encourage understanding of and support for the reserve by highlighting and presenting its values.	No impacts.	No impacts.
Safeguard the special tourism and recreational character of the reserve.	No impacts.	No impacts.
Minimise impacts on reserve values.	No impacts.	No impacts.
Promote sound and sustainable environmental behaviour and practices.	No impacts.	No impacts.
Contribute directly to meeting the costs of research, management and protection of the reserve.	No impacts.	No impacts.
Provide economic benefit to the community.	No impacts.	No impacts.
6.1 Community involvement and support		
Develop community appreciation of and support for reserve values.	No impacts.	No impacts.
Promote a positive image of the reserve and its contribution to the community.	No impacts.	No impacts.
Encourage community involvement in reserve management.	No impacts.	No impacts.
6.2 Working with neighbours		
Take account of concerns of neighbours, particularly those who live on Alexander Terrace, in managing the reserve.	No impacts.	No impacts.
Encourage conservation and sound land management practices on nearby farmlands and in gardens adjoining the reserve	No impacts.	No impacts.
Enlist the cooperation of neighbours in conserving reserve values.	No impacts.	No impacts.
7.2 Leases, licences and authorities		
Provide efficient high-quality facilities and services to the public.	No impacts.	No impacts.

Manage and control uses, and activities not undertaken by the managing authority.	No impacts.	No impacts.
Contribute to recovery of costs arising from leased, licensed or authorised uses.	No impacts.	No impacts.
Ensure reserve values are protected.	No impacts.	No impacts.
7.3 Research		
Provide a sound basis of knowledge for managing the reserve to achieve the management objectives.	No impacts.	No impacts.
Assist in resolving complex or controversial management issues.	No impacts.	No impacts.
Improve overall reserve management approaches and practices.	No impacts.	No impacts.
Enhance knowledge of the natural and cultural values of the reserve, and related management issues.	No impacts.	No impacts.
Improve knowledge and management of visitors and their behaviour.	No impacts.	No impacts.
Assess impacts (including long term cumulative changes) associated with development and other use of the reserve.	No impacts.	No impacts.
Avoid putting at risk significant natural or cultural values of the reserve.	No impacts.	No impacts.
Provide for use of the reserve as a scientific reference area.	No impacts.	No impacts.
7.4 Administration		
Coordinate and integrate reserve management and implementation of this management plan.	No impacts.	No impacts.
Ensure management responsibilities are efficiently and effectively carried out in accordance with the National Parks and Reserves Management Act 2002 and the National Parks and Reserved Land Regulations 1999 and this management plan.	No impacts.	No impacts.
Ensure public safety and prompt response in emergencies.	No impacts.	No impacts.
Enforce the management plan and any other relevant Acts and Regulations.	No impacts.	No impacts.
7.5 Monitoring and evaluation		
Assess the effectiveness of management under this plan in achieving the management objectives.	No impacts.	No impacts.

Provide feedback that will assist the progressive improvement in reserve management.	No impacts.	No impacts.

Assessment of BassGas operations against the stated objectives of the Small Bass Strait Island Reserves Management Plan (Parks and Wildlife Service, 2000)

The following Nature Reserves are assessed under the Management Plan:

- *West Moncoeur Island;*
- *Rodondo Island;*
- *Albatross Island; and*
- *Judgement Rocks.*

The following information summarises the risk to the parks from the spill scenarios.

	West Moncoeur	**Rodondo Island**	**Albatross Island**	**Judgement Rocks**
204,250 bbl subsea blowout of Yolla condensate over 86 Days				
Sea surface:	No contact			
Dissolved hydrocarbons:	No contact		1% probability of low exposure to dissolved hydrocarbons 0-10 m below sea surface.	4% probability of low exposure to dissolved hydrocarbons 0-10 m below sea surface. 1% probability of low exposure to dissolved hydrocarbons 10-20 m below sea surface.
Entrained hydrocarbons:	11% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.	10% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.	19% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.	67% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact			
300 m^3 surface release of MDO over 6 Hours				
Sea surface:	No contact			
Dissolved hydrocarbons:	No contact			
Entrained hydrocarbons:	11% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface. 2% probability of high exposure to entrained hydrocarbons 0-10 m below sea surface.	14% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface. 2% probability of high exposure to entrained hydrocarbons 0-10 m below sea surface.	No contact	

Shoreline contact:			
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes			
Sea surface:		No contact	
Dissolved hydrocarbons:	No contact	1% probability of low exposure to dissolved hydrocarbons 0-10 m below sea surface.	No contact
Entrained hydrocarbons:	3% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.	3% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.	No contact
Shoreline contact:		No contact.	

The table on the following pages provide an assessment of routine and non-routine operations against the management objectives of the Plan.

Management Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conserve natural biological diversity	No impacts.	No impacts.
Conserve geological diversity	No impacts.	No impacts.
Preserve the quality of water and protect catchments	No impacts.	The OPEP takes into account risks to the shoreline and prioritises actions to reduce the spread and extent of oil towards the shoreline.
Conserve sites or areas of cultural significance	No impacts.	No impacts.
Encourage education based on the purposes of reservation and the natural or cultural values of the nature reserve or both	No impacts.	No impacts.
Encourage research, particularly that which furthers the purposes of reservation	No impacts.	No impacts.
Protect the nature reserve against, and rehabilitate the nature reserve following, adverse impacts such as those of fire, introduced species, diseases and soil erosion on the nature reserve's natural and cultural values and on assets within and adjacent to the nature reserve	The EP contains control measures aimed to minimise the risk of introducing marine pests to Tasmanian waters.	No impacts.
Encourage cooperative management programs with Aboriginal people in areas of significance to them in a manner consistent with the purposes of reservation and the other management	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Kent Group National Park (Terrestrial Portion) Management Plan (Parks and Wildlife Service Tasmania, 2005)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	4% probability of low exposure to dissolved hydrocarbons 0-10 m below sea. 1% probability of low exposure to dissolved hydrocarbons 10-20 m below sea.
Entrained hydrocarbons:	67% probability of low exposure to entrained hydrocarbons 0-10 m below sea.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
2.1 Geodiversity		
Preserve and maintain sites of geoconservation significance and geodiversity.	No impacts.	No impacts.
2.2 Natural and Cultural Landscape Values		
Preserve a sense of a simple, lonely and isolated settlement focussed on the task of maritime safety.	No impacts.	No impacts.
2.4 Flora		
Conserve and maintain natural diversity and natural ecosystems.	No impacts.	No impacts.
2.5 Fauna		
Protect threatened fauna species and their habitat.	No impacts.	No impacts.
2.6 Aboriginal Heritage		
In cooperation with the Aboriginal community, protect and conserve Aboriginal heritage.	No impacts.	No impacts.
2.7 Historic Heritage		
Conserve the Deal Island Lightstation, protecting and conserving its conservation significance, with controlled adaption to encourage tenancy and viability.	No impacts.	No impacts.
Present and interpret historic heritage.	No impacts.	No impacts.
3.1 Fire Management		
Protect the historic assets.	No impacts.	No impacts.
3.2 Rehabilitation		
Prevent erosion and rehabilitate badly damaged areas.	No impacts.	No impacts.

3.3 Weeds and Diseases		
Control or eradicate weed species.	No impacts.	No impacts.
3.4 Introduced Fauna		
Eradicate introduced species where this is feasible and warranted by the damage being caused.	No impacts.	No impacts.
6.1 Management of the National Park		
Ensure any co-management partnership struck with the Crown is being conducted in a way that is consistent with this plan and the broader public interest.	No impacts.	No impacts.

<u>Assessment of BassGas operations against the stated objectives of the Nadgee Nature Reserve Plan of Management</u>
<u>(NSW National Parks and Wildlife Service, 2003)</u>

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	1% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management objectives of the park.

Management Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Protection of the reserve as a largely undisturbed sample of the landforms and plant and animal communities of the far south coast;	No impacts.	No impacts.
Maintenance of populations of the rare, threatened and biogeographically significant plant and animal species which occur in the reserve, and protection of rare vegetation types	No impacts.	No impacts.
Protection of high-water quality in the estuaries and elsewhere within the reserve	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil on the sea surface.
Provision of opportunities for appropriate scientific research;	No impacts.	No impacts.
Provision of opportunities for low key day use in the northern section of the Nature Reserve and for self-reliant recreation under permit in the Wilderness Area	No impacts.	No impacts.
Promotion of community awareness of the significant conservation values of the reserve	No impacts.	No impacts.

Assessment of BassGas operations against the stated objectives of the Ben Boyd National Park Plan of Management (NSW National Parks and Wildlife Service, 2010)

The following information summarises the risk to the park from the spill scenarios.

204,250 bbl subsea blowout of Yolla condensate over 86 Days	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.
300 m^3 surface release of MDO over 6 Hours	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	1% probability of low exposure to entrained hydrocarbons 0-10 m below sea surface.
Shoreline contact:	No contact.
3,144.9 bbl pipeline rupture of Yolla condensate over 57.6 minutes	
Sea surface:	No contact.
Dissolved hydrocarbons:	No contact.
Entrained hydrocarbons:	No contact.
Shoreline contact:	No contact.

The table on the following pages provide an assessment of routine and non-routine operations against the management aims of the park.

Management Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Protection of Aboriginal sites from disturbance.	No impacts.	No impacts.
Protection of the park and reserve as a sample of the coastal landforms and vegetation communities of the far south coast of NSW.	No impacts.	The OPEP takes into accounts risks to the open ocean and prioritises actions to reduce the spread and extent of oil towards the shoreline.
Protection of areas of heathland, dune dry scrub forest, estuarine and floodplain wetlands, moist forest communities and old growth areas, and their habitat value for native animals.	No impacts.	No impacts.
Protection of habitat and populations of significant species, in particular the threatened southern brown bandicoot, ground parrot and biogeographically significant heathland plants.	No impacts.	No impacts.
Protection of significant geological features from disturbance, particularly occurrences of Devonian fossils.	No impacts.	No impacts.
Facilitation of Aboriginal cultural activities through the Aboriginal Culture Camp at Haycock Point.	No impacts.	No impacts.
Conservation of Boyds Tower, Green Cape lightstation and the Bittangabee store and house ruins.	No impacts.	No impacts.
Promotion of visitor, tourist and community appreciation of the natural and cultural values of the park and reserve, particularly geological significance, important historic features, the large number of threatened species and the value of the heathlands.	No impacts.	No impacts.
Provision of a variety of sustainable, low impact recreational and educational opportunities along the coastline which encourage appreciation of the natural environment and do not significantly affect habitat values.	No impacts.	No impacts.

Appendix 2

Assessment of BassGas operations against the management aims of threatened species' management plans

Assessment of BassGas operations against the aims of threatened species' management plans	
BIRDS	
2a	Albatross and petrels
2b	Soft-plumaged petrel
2c	Blue petrel
2d	Gould's petrel
2e	Australian painted snipe
2f	Bar-tailed godwit (northern Siberian)
2g	Bar-tailed godwit (western Alaskan)
2h	Curlew sandpiper
2i	Eastern curlew
2j	Fairy prion
2k	Fairy tern
2l	Great knot
2m	Greater sand plover
2n	Hooded plover
2o	Lesser sand plover
2p	Orange-bellied parrot
2q	Red knot
2r	Swift parrot
2s	Australasian bittern
MAMMALS	
2t	Blue whale
2u	Humpback whale
2v	Southern right whale
2w	Fin whale
2x	Sei whale
2y	Sub-Antarctic fur seal
2z	Southern elephant seal
FISH	

2za	Grey nurse shark (eastern population)
2zb	Black rockcod
2zc	Whale shark
2zd	Australian grayling
2ze	Dwarf galaxias
2zf	Great white shark
REPTILES	
2zg	Marine turtles

Assessment of BassGas operations against the stated aims of the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPC, 2011)

The following table provides an assessment of routine and non-routine operations against the management aims of the plan.

Criteria to measure performance of the Plan against the objective	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Specific Objectives		
Research and monitoring of the biology, ecology and population dynamics of albatrosses and giant petrels breeding within Australian jurisdiction is sufficient to understand conservation status and to implement effective and efficient conservation measures.	No impacts.	No impacts.
Land-based threats to the survival and breeding success of albatrosses and giant petrels breeding within areas under Australian jurisdiction are quantified and reduced.	No impacts.	No impacts.
Marine-based threats to the survival and breeding success of albatrosses and giant petrels foraging in waters under Australian jurisdiction are quantified and reduced.	No impacts.	The OPEP takes into account risks to marine bird species and prioritises actions to reduce the spread and extent of oil on the sea surface.
Fishers are educated and public awareness is raised on the threats to albatrosses and giant petrels.	No impacts.	No impacts.
Substantial involvement in the promotion and development of improved and, ultimately, favourable conservation status of albatrosses and giant petrels globally in international conservation and fishing fora is maintained.	No impacts.	No impacts.
Actions to achieve specific objectives		
Research and monitoring of the biology, ecology and population dynamics of albatrosses and giant petrels breeding within Australian jurisdiction is sufficient to understand conservation status and to implement effective and efficient conservation measures.	No impacts.	No impacts.
Quantify and reduce land-based threats to the survival and breeding parameters of albatrosses and giant petrels breeding within areas under Australian jurisdiction.	No impacts.	No impacts.
Quantify and reduce marine-based threats to the survival and breeding parameters of albatrosses and giant petrels foraging in waters under Australian jurisdiction.	No impacts.	The OPEP takes into account risks to marine bird species and prioritises actions to reduce the spread and extent of oil on the sea surface.
Educate fishers and promote public awareness of the threats to albatrosses and giant-petrels.	No impacts.	No impacts.
Achieve substantial progress towards global conservation of albatrosses and giant petrels in international conservation and fishing fora.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Approved Conservation Advice for the Soft-plumaged petrel (*Pterodroma Mollis*) (TSSC, 2015)

The following table provides an assessment of routine and non-routine operations against the management aims of the plan.

Stated management aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Continue to manage Maatsuyker and Macquarie Island in such a way that human disturbance is minimised.	No impacts.	No impacts.
Continue strict quarantine management practices for Maatsuyker and Macquarie Island to reduce the risk of any invasive species (re)establishing on the islands.	No impacts.	No impacts.
Survey and Monitoring Priorities		
Continue to monitor population numbers on Maatsuyker Island.	No impacts.	No impacts.
Include monitoring for soft-plumaged petrels in monitoring programs occurring on Macquarie Island to detect any breeding occurrences.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Approved Conservation Advice for the Blue Petrel (*Halobaena caerulea*). (TSSC, 2015)

The following table provides an assessment of routine and non-routine operations against the management aims of the plan.

Stated management aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Continue to manage Macquarie Island and its surrounds in such a way that human disturbance is minimised.	No impacts.	No impacts.
Continue strict quarantine management practices for Macquarie Island to reduce the risk of any invasive species (re)establishing on the island.	No impacts.	No impacts.
Survey and Monitoring Priorities		
Continue monitoring the species, and if decreases become evident in the population, identify potential causes and adapt management actions as required.	No impacts.	No impacts.
Include monitoring for blue petrels in monitoring programs occurring on Macquarie Island to detect any future breeding occurrences	No impacts.	No impacts.
Information and Research Priorities		
Monitor breeding population size and success on Macquarie Island offshore rock stacks.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Gould's Petrel (*Pterodroma leucoptera leucoptera)* Recovery Plan (DEC, 2006)

The following table provides an assessment of routine and non-routine operations against the management aims of the plan.

Stated objectives of the recovery plan	**Assessment of impacts of routine activities against management aims**	**Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives**
To identify and manage the threats operating at sites where the subspecies occur.	No impacts.	No impacts.
To establish and maintain a translocated second colony at Boondelbah Island.	No impacts.	No impacts.
To raise awareness of the subspecies with the local community and involve volunteers in the recovery program.	No impacts.	No impacts.
To promote research and continue monitoring that will assist with the management of the subspecies.	No impacts.	No impacts.
To co-ordinate recovery actions through a recovery team and annual reporting on Recovery Plan implementation.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Australian paint-snipe (*Rostratula australis*) (DSEWPC, 2013)

The following table provides an assessment of routine and non-routine operations against the management aims of the conservation advice.

Regional Priority Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Habitat Loss, Disturbance and Modification		
Develop management guidelines for breeding and non-breeding habitat.	No impacts.	No impacts.
Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.	No impacts.	No impacts.
Ensure there is no disturbance in areas where the species is known to breed, excluding necessary actions to manage the conservation of the species.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response. The impacts related to coastal oil spill clean-up activities will be carefully managed to avoid feeding, roosting or nesting birds.
Control access routes to suitably constrain public access to existing and future breeding sites on public land.	No impacts.	No impacts.
Suitably control and manage access on private land and other land tenure.	No impacts.	No impacts.
Minimise adverse impacts from land use at known sites.	No impacts.	No impacts.
Manage any changes to hydrology that may result in changes to water table levels, run-off, salinity, algal blooms, sedimentation or pollution.	No impacts.	No impacts.
Manage any disruptions to water flows.	No impacts.	No impacts.
Investigate formal conservation arrangements, management agreements and covenants on private land, and for crown and private land investigate/secure inclusion in reserve tenure if possible.	No impacts.	No impacts.

Regional Priority Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Manage any other known, potential or emerging threats including inappropriate fire regimes and coastal port/infrastructure development.	No impacts.	No impacts.
Invasive Weeds		
Implement the Parkinsonia (Parkinsonia aculeata) Strategic Plan (Commonwealth of Australia, 2000) for the control of this species within the range of the Australian painted snipe.	No impacts.	No impacts.
Identify and remove weeds in wetland areas that could become a threat to the Australian painted snipe, using appropriate methods.	No impacts.	No impacts.
Ensure chemicals or other mechanisms used to eradicate weeds do not have a significant adverse impact on the Australian painted snipe	No impacts.	No impacts.
Trampling, Browsing or Grazing		
Develop and implement a stock management plan for roadside verges and travelling stock routes which include swamps, marshes or wetlands.	No impacts.	No impacts.
If livestock grazing occurs in known Australian painted snips habitats, ensure land owners/managers use an appropriate management regime and density that does not detrimentally affect Australian painted snipe nesting.	No impacts.	No impacts.
If appropriate, manage total grazing pressure at important breeding sites through exclusion fencing or other barriers.	No impacts.	No impacts.
Animal Predation or Competition		
Implement the national threat abatement plans for the European red fox (DEWHA, 2008a) and feral cats (DEWHA, 2008b) to control the adverse impacts of foxes (*Vulpes vulpes*) and cats (*Felis catus*) in the species' range.	No impacts.	No impacts.
Continue baiting to control population numbers of feral animals.	No impacts.	No impacts.
Fire		
Develop and implement a suitable fire management strategy for the habitat of the Australian painted snipe.	No impacts.	No impacts.
Conservation Information		

Regional Priority Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Raise awareness of the Australian painted snipe within the local community and the importance of reporting observations to BirdLife Australia, using fact sheets and/or brochures.	No impacts.	No impacts.
Advertise and encourage use of Australian painted snipe survey techniques and survey forms (Birds Australia, 2012).	No impacts.	No impacts.
Organise field days with industry and interest groups to raise awareness and share information on the species. These groups may include natural resource management groups, catchment management authorities, Indigenous groups, conservation organisations, local and state governments, and private landholders.	No impacts.	No impacts.
Engage with private landholders and land managers responsible for the land on which populations occur and encourage these key stakeholders to contribute to the implementation of conservation management actions.	No impacts.	No impacts.
Raise awareness of banded individuals (see BirdLife Australia, 2012) to increase the likelihood of re-sighting and reporting.	No impacts.	No impacts.
Facilitate the exchange of information between interested parties, including sightings, research and management approaches.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Bar-tailed Godwit (northern Siberian) (*Limosa lapponica menzbieri*) (TSSC, 2016)

The following table provides an assessment of routine and non-routine operations against the management aims of the conservation advice.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Work with governments along the East Asian – Australasian Flyway to prevent destruction of key breeding and migratory staging sites.	No impacts.	No impacts.
Protect important habitat in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Support initiatives to improve habitat management at key sites.	No impacts.	No impacts.
Maintain and improve protection of roosting and feeding sites in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Advocate for the creation and restoration of foraging and roosting sites.	No impacts.	No impacts.
Incorporate requirements for bar-tailed godwit (northern Siberian) into coastal planning and management.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Manage important sites to identify, control and reduce the spread of invasive species.	The EP puts in place control measures to reduce the risk of biofouling and introduction of invasive marine species.	No impacts.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Manage disturbance at important sites which are subject to anthropogenic disturbance when bar-tailed godwit (northern Siberian) are present – e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary site closures.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection.
Survey and Monitoring Priorities		
Enhance existing migratory shorebird population monitoring programmes, particularly to improve coverage across northern Australia.	No impacts.	No impacts.
Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.	No impacts.	No impacts.
Information and Research Priorities		
Undertake work to more precisely assess bar-tailed godwit (northern Siberian) life history, population size, distribution and ecological requirements particularly across northern Australia.	No impacts.	No impacts.
Improve knowledge about dependence of bar-tailed godwit (northern Siberian) on key migratory staging sites, and non-breeding sites to the in south-east Asia.	No impacts.	No impacts.
Improve knowledge about threatening processes including the impacts of disturbance and hunting.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Bar-tailed Godwit (western Alaskan) (*Limosa lapponica baueri*) (DoE, 2016)

The following table provides an assessment of routine and non-routine operations against the management aims of this conservation advice.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Work with governments along the East Asian – Australasian Flyway to prevent destruction of key breeding and migratory staging sites.	No impacts.	No impacts.
Support initiatives to improve habitat management at key sites.	No impacts.	No impacts.
Advocate for the creation and restoration of foraging and roosting sites.	No impacts.	No impacts.
Manage important sites to identify, control and reduce the spread of invasive species.	The EP puts in place control measures to reduce the risk of biofouling and introduction of invasive marine species.	No impacts.
Protect important habitat in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Maintain and improve protection of roosting and feeding sites in Australia.	No impacts.	
Incorporate requirements for bar-tailed godwit (western Alaskan) into coastal planning and management.	No impacts.	
Manage disturbance at important sites which are subject to anthropogenic disturbance when bar-tailed godwit (western Alaskan) are present – e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary site closures.	No impacts.	
Survey and Monitoring Priorities		
Enhance existing migratory shorebird population monitoring programmes, particularly to improve coverage across northern Australia.	No impacts.	No impacts.
Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.	No impacts.	No impacts.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Information and Research Priorities		
Undertake work to more precisely assess bar-tailed godwit (western Alaskan) life history, population size, distribution and ecological requirements particularly across northern Australia.	No impacts.	No impacts.
Improve knowledge about dependence of bar-tailed godwit (western Alaskan) on key migratory staging sites, and non-breeding sites to the in south-east Asia.	No impacts.	No impacts.
Improve knowledge about threatening processes including the impacts of disturbance and hunting.	No impacts.	No impacts.

<u>Assessment of BassGas operations against the stated aims of the Conservation Advice for the Curlew Sandpiper (*Calidris ferruginea*) (DoE, 2016)</u>

The following table provides an assessment of routine and non-routine operations against the management aims of this conservation advice.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
International Objectives		
Achieve a stable or increasing population.	No impacts.	No impacts.
Maintain and enhance important habitat.	No impacts.	No impacts.
Disturbance at key roosting and feeding sites reduced.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Australian Objectives		
Achieve a stable or increasing population.	No impacts.	No impacts.
Maintain and enhance important habitat.	No impacts.	No impacts.
Disturbance at key roosting and feeding sites reduced.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Raise awareness of curlew sandpiper within the local community.	No impacts.	No impacts.
Conservation and Management Actions		
Work with governments along the East Asian – Australasian Flyway to prevent destruction of key migratory staging sites.	No impacts.	No impacts.
Support initiatives to protect and manage key staging sites of curlew sandpiper.	No impacts.	No impacts.
Manage important sites to identify, control and reduce the spread of invasive species.	No impacts.	No impacts.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.	No impacts.	No impacts.
Maintain and improve protection of roosting and feeding sites in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Incorporate requirements for curlew sandpiper into coastal planning and management.	No impacts.	
Manage disturbance at important sites when curlew sandpipers are present – e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary beach closures.	No impacts.	
Monitoring Priorities		
Enhance existing migratory shorebird population monitoring programmes, particularly to improve coverage across northern Australia.	No impacts.	No impacts.
Information and Research Priorities		
More precisely assess curlew sandpiper population size, distribution and ecological requirements particularly across northern Australia.	No impacts.	No impacts.
Improve knowledge about dependence of curlew sandpiper on key migratory staging sites, and wintering sites to the north of Australia.	No impacts.	No impacts.
Improve knowledge about threatening processes including the impacts of disturbance.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Eastern Curlew (*Numenius madagascariensis*) (DoE, 2015)

The following table provides an assessment of routine and non-routine operations against the primary conservation objectives of the advice.

Primary Conservation Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
International Objectives		
Achieve a stable or increasing population.	No impacts.	No impacts.
Maintain and enhance important habitat.	No impacts.	No impacts.
Reduce disturbance at key roosting and feeding sites.	No impacts.	No impacts.
Australian Objectives		
Achieve a stable or increasing population.	No impacts.	The OPEP takes into account beaches and shores of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Maintain and enhance important habitat.	No impacts.	
Reduce disturbance at key roosting and feeding sites.	No impacts.	
Raise awareness of eastern curlew within the local community.	No impacts.	No impacts.
Conservation and Management Actions		
Work with governments along the East Asian – Australasian Flyway to prevent destruction of key migratory staging sites.	No impacts.	No impacts.
Develop and implement an International Single Species Action Plan for eastern curlew with all range states.	No impacts.	No impacts.
Support initiatives to improve habitat management at key sites.	No impacts.	No impacts.
Maintain and improve protection of roosting and feeding sites in Australia.	No impacts.	The impacts related to coastal oil spill clean up activities will be carefully managed to avoid feeding, roosting or nesting birds.
Incorporate requirements for eastern curlews into coastal planning and management.	No impacts.	No impacts.

Primary Conservation Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Manage important sites to identify, control and reduce the spread of invasive species.	No impacts.	No impacts.
Manage disturbance at important sites when eastern curlews are present – e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary site closures.	No impacts.	No impacts.
Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.	No impacts.	No impacts.
Monitoring Priorities		
Enhance existing migratory shorebird population monitoring programmes, particularly to improve coverage across northern Australia	No impacts.	No impacts.
Information and Research Priorities		
More precisely assess eastern curlew life history, population size, distribution and ecological requirements particularly across northern Australia.	No impacts.	No impacts.
Improve knowledge about dependence of eastern curlew on key migratory staging sites, and wintering sites to the north of Australia.	No impacts.	No impacts.
Improve knowledge about threatening processes including the impacts of disturbance and hunting.	No impacts.	No impacts.

<u>Assessment of BassGas operations against the stated aims of the Conservation Advice for the Southern Fairy Prion (*Pachyptila tutur subantarctica*) (TSSC, 2015)</u>

The following table provides an assessment of routine and non-routine operations against the management aims of this conservation advice.

Conservations Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Continue to manage Macquarie Island and its surrounds in such a way that human disturbance is minimised.	No impacts.	No impacts.
Continue strict quarantine management practices for Macquarie Island and surrounding rock stacks to reduce the risk of any invasive species (re)establishing on the island.	No impacts.	No impacts.
Survey and Monitoring Priorities		
Continue to monitor the species, and if decreases become evident in the population, identify potential causes and adapt management actions as required.	No impacts.	No impacts.
Information and Research Priorities		
Continue to monitor breeding population size and success on Macquarie Island offshore rock stacks, including Bishop and Clerk Islands.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Fairy Tern (*Sternula nereis nereis*) (DSEWPC, 2011)

The following table provides an assessment of routine and non-routine operations against the management aims of the conservation advice.

Primary Conservation Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Regional Priority Actions		
Habitat Loss, Disturbance and Modification		
Monitor the progress of recovery (using a variety of methods such as survey and banding programs, video surveillance of breeding colonies and maintaining a central breeding and sightings database), including the effectiveness of management actions and the need to adapt them if necessary.	Location of fairy tern populations within the EMBA are identified within the EP.	Location of fairy tern populations within the EMBA are identified within the EP.
Identify populations of high conservation priority.	No impacts.	No impacts.
Manage any changes to hydrology that may result in changes to tide levels, increase salinity or pollution.	No impacts.	No impacts.
Manage any disruptions to water flows in wetland areas such as the Coorong in South Australia.	No impacts.	No impacts.
Introduce recreational codes of conduct and license commercial tourism operations utilising the subspecies' habitat.	No impacts.	No impacts.
Animal Predation or Competition		
Develop and implement a management plan for the control or eradication of foxes, dogs, cats and Black Rats where the species is found.	No impacts.	No impacts.
Establish programs to discourage gulls (such as Silver Gulls) competing with Fairy Terns. Examples of activities could include: education programs to raise awareness of the problems of feeding gulls and; minimising night time lighting from oil and gas rigs near the subspecies' habitat to reduce night time feeding opportunities for Silver Gulls.	No impacts.	No impacts.
Local Priority Actions		
Habitat Loss, Disturbance and Modification		
Use nest protection measures to safeguard nests from extreme weather/tides, including sandbagging and nest relocation.	No impacts.	No impacts.
Control access routes to suitably constrain public access to known sites on public and private land.	No impacts.	

Primary Conservation Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Reduce disturbance during the breeding season from human recreation such as the use of off road vehicles and predation by domestic dogs, using signage and/ or fencing where appropriate. The use of signage can restrict access to the site as well as raise awareness of the sites ecological importance.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response. The impacts related to coastal oil spill clean-up activities will be carefully managed to avoid feeding, roosting or nesting birds.
Ensure appropriate oil-spill contingency plans are in place for the subspecies' breeding sites which are vulnerable to oil spills, such as the breeding colonies in Victoria.	No impacts.	
Weed Control		
Remove weeds which could become a threat to the Fairy Tern, using appropriate methods outside the breeding season.	No impacts.	No impacts.
Manage sites to prevent introduction of invasive weeds, which could become a threat to the Fairy Tern, using appropriate methods.	No impacts.	No impacts.
Animal Predation		
Control introduced pests such as foxes, dogs, cats and Black Rats, using a variety of methods such as trapping and 1080 baiting.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Great Knot (*Calidris tenuirstris*) (TSSC, 2016)

The following table provides an assessment of routine and non-routine operations against the conservation actions of the conservation advice.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Work with governments along the East Asian – Australasian Flyway to prevent destruction of key breeding and migratory staging sites.	No impacts.	No impacts.
Protect important habitat in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Support initiatives to improve habitat management at key sites.	No impacts.	No impacts.
Maintain and improve protection of roosting and feeding sites in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Advocate for the creation and restoration of foraging and roosting sites.	No impacts.	No impacts.
Incorporate requirements for great knot into coastal planning and management.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Manage important sites to identify, control and reduce the spread of invasive species.	The EP puts in place control measures to reduce the risk of biofouling and introduction of invasive marine species.	No impacts.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Manage disturbance at important sites which are subject to anthropogenic disturbance when great knots are present – e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary site closures.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection.
Survey and Monitoring Priorities		
Enhance existing migratory shorebird population monitoring programmes, particularly to improve coverage across northern Australia.	No impacts.	No impacts.
Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.	No impacts.	No impacts.
Information and Research Priorities		
Undertake work to more precisely assess great knot life history, population size, distribution and ecological requirements particularly across northern Australia.	No impacts.	No impacts.
Improve knowledge about dependence of great knot on key migratory staging sites, and non-breeding sites to the in south-east Asia.	No impacts.	No impacts.
Improve knowledge about threatening processes including the impacts of disturbance and hunting.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Great Sand Plover (*Charadrius leschenaultii*) (TSSC, 2016)

The following table provides an assessment of routine and non-routine operations against the conservation actions of the conservation advice.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Work with governments along the East Asian – Australasian Flyway to prevent destruction of key breeding and migratory staging sites.	No impacts.	No impacts.
Protect important habitat in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Support initiatives to improve habitat management at key sites.	No impacts.	No impacts.
Maintain and improve protection of roosting and feeding sites in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Advocate for the creation and restoration of foraging and roosting sites.	No impacts.	No impacts.
Incorporate requirements for greater sand plover into coastal planning and management.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Manage important sites to identify, control and reduce the spread of invasive species.	The EP puts in place control measures to reduce the risk of biofouling and introduction of invasive marine species.	No impacts.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Manage disturbance at important sites which are subject to anthropogenic disturbance when greater sand plovers are present – e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary site closures.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection.
Survey and Monitoring Priorities		
Enhance existing migratory shorebird population monitoring programmes, particularly to improve coverage across northern Australia.	No impacts.	No impacts.
Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.	No impacts.	No impacts.
Information and Research Priorities		
Undertake work to more precisely assess greater sand plover life history, population size, distribution and ecological requirements particularly across northern Australia.	No impacts.	No impacts.
Improve knowledge about dependence of greater sand plover on key migratory staging sites, and non-breeding sites to the in south-east Asia.	No impacts.	No impacts.
Improve knowledge about threatening processes including the impacts of disturbance and hunting.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Hooded Plover (*Thinornis rubricollis rubricollis*) (DoE, 2014)

The following table provides an assessment of routine and non-routine operations against the recovery and impact avoidance guidance of this conservation advice.

Recovery and Impact avoidance guidance	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Primary Conservation Objectives		
1. Achieve stable numbers of adults in the population, and maintain a stable number of occupied and active breeding territories.	No impacts.	No impacts.
2. Improve breeding success, namely increase fledgling rates (which is a combination of improving egg and chick survival rates), via: a. reducing the destruction of nests and chicks, and the disturbance of breeding pairs, by human and human-related activities. b. reducing predation by feral animals and overabundant native predators.	No impacts.	No impacts.
3. Maintain, enhance and restore habitat, and integrate the subspecies' needs into coastal planning.	No impacts.	No impacts.
Information and Research Priorities		
1. Determine demographic trends including population size, breeding success, and status and trends in breeding populations.	No impacts.	No impacts.
2. Determine levels of nest predation and breeding success, in areas with and without predator and stock control programs.	No impacts.	No impacts.
3. Identify the causes of chick mortality, and factors which may mediate chick survival rates.	No impacts.	No impacts.
4. Identify habitat availability and risk of habitat loss due to weed invasion, rising sea levels and dune morphology changes, via: a) incorporating coastal weed mapping data into a single data set. b) utilising SmartLine for all population assessments; this maps coastal geomorphology and can indicate areas of coasts which are vulnerable to erosion and other weather/climate impacts. c) integrating coastal weed, geomorphology and hooded plover (eastern) nesting territory data, in order to provide an assessment of threats from invasive weeds and erosion.	No impacts.	No impacts.

Recovery and Impact avoidance guidance	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
5. For each breeding site/beach, assess the relative impacts of different threats and the likelihood of threat management measures being successful, so that beaches can be prioritised for management.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
6. Monitor the breeding and abundance of hooded plovers on an ongoing basis, ensuring that survey methods and data reporting are standardised as much as possible.	No impacts.	No impacts.
7. Undertake a population viability analysis to set breeding success targets for recovery programs.	No impacts.	No impacts.
Management Actions Required		
1. Manage the use of (and access to) key beaches for recreation when plovers are breeding – e.g. discourage or prohibit vehicle access, horse riding and dogs from beaches; implement temporary beach closures; erect fencing to prevent people entering.	No impacts.	No impacts.
2. Adequately police beaches to ensure compliance with regulations, especially those relating to dog walking, and undertake a review of existing regulations to assess whether there is room for improvement.	No impacts.	No impacts.
3. Educate the public in research, monitoring, management and advocacy efforts.	No impacts.	No impacts.
4. Incorporate requirements for the hooded plover into coastal planning and management, and erosion control activities, including: a) limiting levels of urban development within the coastal zone. b) adopting evidence-based best practice. c) consulting with relevant state and local government departments, research organisations, and community organisations.	No impacts.	No impacts.
5. Construct fencing to prevent livestock entering beaches.	No impacts.	No impacts.
6. Implement predator control programs for invasive species where necessary.	No impacts.	No impacts.
7. Evaluate the efficacy of management techniques such as the use of chick shelters, predator controls, mechanisms to alter human behaviour on beaches, habitat restoration and maintenance, and identify areas for improvement.	No impacts.	No impacts.

Recovery and Impact avoidance guidance	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
8. Further develop methods for reducing or controlling rates of colonisation by invasive plants and rehabilitating dunes colonised by invasive plants, and establish trials to recover habitat degraded by marram grass (*Ammophila arenaria*).	No impacts.	No impacts.
9. Prepare oil spill response plans to ensure effective rehabilitation of oiled birds.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response. The impacts related to coastal oil spill clean-up activities will be carefully managed to avoid feeding, roosting or nesting birds.
10. Reduce in-shore marine debris, including educating fishers and the public to properly dispose of fishing lines.	No impacts.	No impacts.
11. As a last resort, investigate control options for native predators such as ravens, magpies, currawongs and silver gulls, if their impacts are threatening a population and human activities cannot be sufficiently reduced to mitigate their impacts.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Lesser Sand Plover (*Charadrius mongolus*) (TSSC, 2016)

The following table provides an assessment of routine and non-routine operations against the conservation actions of this conservation advice.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Work with governments along the East Asian – Australasian Flyway to prevent destruction of key breeding and migratory staging sites.	No impacts.	No impacts.
Protect important habitat in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Support initiatives to improve habitat management at key sites.	No impacts.	No impacts.
Maintain and improve protection of roosting and feeding sites in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Advocate for the creation and restoration of foraging and roosting sites.	No impacts.	No impacts.
Incorporate requirements for lesser sand plover into coastal planning and management.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Manage important sites to identify, control and reduce the spread of invasive species.	The EP puts in place control measures to reduce the risk of biofouling and introduction of invasive marine species.	No impacts.
Manage disturbance at important sites which are subject to anthropogenic disturbance when lesser sand plovers are present – e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary site closures.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Survey and Monitoring Priorities		
Enhance existing migratory shorebird population monitoring programmes, particularly to improve coverage across northern Australia.	No impacts.	No impacts.
Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.	No impacts.	No impacts.
Information and Research Priorities		
Undertake work to more precisely assess lesser sand plover life history, population size, distribution and ecological requirements particularly across northern Australia.	No impacts.	No impacts.
Improve knowledge about dependence of greater sand plover on key migratory staging sites, and non-breeding sites to the in south-east Asia.	No impacts.	No impacts.
Improve knowledge about threatening processes including the impacts of disturbance and hunting.	No impacts.	No impacts.

<u>Assessment of BassGas operations against the stated aims of the National Recovery Plan for the Orange-bellied Parrot (*Neophema chrysogaster*) (DELWP, 2016)</u>

The following table provides an assessment of routine and non-routine operations against the primary conservation objectives of the plan.

Primary Conservation Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
To achieve a stable or increasing population in the wild within five years.		
Increase breeding output in the wild.	No impacts.	No impacts.
Increase survival in the wild.	No impacts.	No impacts.
Maintain wild behaviours.	No impacts.	No impacts.
To increase the capacity of the captive population, both to support future releases of captive-bred birds to the wild and to provide a secure long-term insurance population.		
Increase the size of the captive population as quickly as possible.	No impacts.	No impacts.
Manage genetics of the captive population.	No impacts.	No impacts.
Manage the wild and captive populations as a metapopulation.	No impacts.	No impacts.
To protect and enhance habitat to maintain, and support growth of, the wild population.		
Maintain the extent of habitat throughout the breeding and non-breeding range.	No impacts.	No impacts.
Increase the extent of high quality of habitat throughout the breeding and nonbreeding range.	No impacts.	No impacts.
To ensure effective adaptive implementation of the plan.		
Obtain and analyse key information required to measure and improve implementation to achieve the primary objectives.	No impacts.	No impacts.
Employ sound procedures for managing, reviewing and reporting on progress to ensure effective adaptive management.	No impacts.	No impacts.
Secure delivery partners and sufficient funding to ensure very high and high priority actions are implemented.	No impacts.	No impacts.
Foster and maintain relationships with key individuals, organisations and the broader community.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Red Knot (*Calidris canutus*) (TSSC, 2016)

The following table provides an assessment of routine and non-routine operations against the conservation actions of the conservation advice.

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Work with governments along the East Asian – Australasian Flyway to prevent destruction of key migratory staging sites.	No impacts.	No impacts.
Protect important habitat in Australia.	No impacts.	No impacts.
Support initiatives to improve habitat management at key sites.	No impacts.	No impacts.
Maintain and improve protection of roosting and feeding sites in Australia.	No impacts.	The OPEP takes into account beaches of importance to coastal bird species and prioritises those for protection and where necessary, beach clean-up and oiled wildlife response.
Incorporate requirements for red knot into coastal planning and management.	No impacts.	
Advocate for the creation and restoration of foraging and roosting sites in Australia.	No impacts.	No impacts.
Manage important sites to identify, control and reduce the spread of invasive species.	No impacts.	No impacts.
Manage disturbance at important sites which are subject to anthropogenic disturbance when red knot are present – e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary site closures.	No impacts.	No impacts.
Survey and Monitoring Priorities		
Enhance existing migratory shorebird population monitoring programmes, particularly to improve coverage across northern Australia	No impacts.	No impacts.
Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.	No impacts.	No impacts.
Information and Research Priorities		

Conservation Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Undertake work to more precisely assess red knot life history, population size, distribution and ecological requirements.	No impacts.	No impacts.
Improve knowledge about dependence of red knot on key migratory staging sites, and nonbreeding sites in south-east Asia.	No impacts.	No impacts.
Improve knowledge about threatening processes including the impacts of disturbance and hunting.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Swift Parrot (*Lathamus discolor*) (TSSC, 2016)

The following table provides an assessment of routine and non-routine operations against the conservation objectives of the conservation advice.

Primary Conservation Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Priorities		
Review and update management prescriptions for swift parrots for use in the Forest Practices System and Local Government land use planning and approvals processes across the breeding and non-breeding range of swift parrots.	No impacts.	No impacts.
Revise and update forestry prescriptions to reflect the most recent habitat information available in Victoria and New South Wales.	No impacts.	No impacts.
Develop and implement strategies to reduce predation from sugar gliders when circumstances require.	No impacts.	No impacts.
Consider installing nesting boxes suitable for swift parrots in areas of low sugar glider predation to enhance swift parrot breeding success	No impacts.	No impacts.
Continue to raise public awareness of the risks of collisions and how these can be minimised, targeting known high risk areas such as the greater Hobart, Melbourne and Western Sydney areas, and the central coast region of New South Wales (Wyong, Gosford, Lake Macquarie and Penrith Local Government areas).	No impacts.	No impacts.
Encourage and support the protection, conservation management and restoration of swift parrot nesting and foraging habitat through agreements with landowners, incentive programs and community projects.	No impacts.	No impacts.
Develop and implement a Disease Risk Assessment for swift parrots.	No impacts.	No impacts.
Survey and Monitoring Priorities		
Develop an effective population monitoring program.	No impacts.	No impacts.
Undertake monitoring of breeding locations on an annual basis to develop a better understanding of breeding success; the extent and number of important breeding areas; and the relative importance of non-aggregated breeding behaviour.	No impacts.	No impacts.
Establish a process for the coordination of volunteer surveys throughout breeding habitats to complement the existing mainland monitoring program.	No impacts.	No impacts.
Maintain coordination of the existing long-term volunteer monitoring throughout mainland habitats.	No impacts.	No impacts.

Primary Conservation Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Information and Research Priorities		
Prioritise conservation actions across the species range.	No impacts.	No impacts.
Identify and map movement patterns and foraging and nesting habitat throughout the breeding range.	No impacts.	No impacts.
Establish habitat phenology data collection in existing research and monitoring studies, analyse findings and incorporate into the recovery program.	No impacts.	No impacts.
Establish and maintain a database for all reported injuries and deaths.	No impacts.	No impacts.
Monitor the incidence of competition from aggressive honeyeaters, as well as introduced birds and invertebrates, for nesting and foraging resources.	No impacts.	No impacts.
Undertake research on breeding success, survival and mortality, as well as genetic structure, to provide insight into currently unknown population regulation parameters.	No impacts.	No impacts.
Update the PVA using data obtained from the above research to provide a greater understanding of the dynamics and long-term viability of the population.	No impacts.	No impacts.
Investigate the potential impact of climate change on the swift parrot and its habitat.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Approved Conservation Advice for the Australasian Bittern (*Botaurus poiciloptilus*) (TSSC, 2019)

The following table provides an assessment of routine and non-routine operations against the management aims of the plan.

Stated management aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Priorities		
Collate all recent location data to establish a list of priority sites for monitoring and for protection and management. Such a list should be updated as new sites are created or found and as knowledge is improved.	No impacts.	No impacts.
Work with key water managers (e.g., Australian, state and local government, water corporations, irrigators) to ensure adequate water flows into known Australasian Bittern habitat, both natural and artificial (e.g., rice paddies, urban ponds etc).	No impacts.	No impacts.
Ensure environmental water allocations are targeted to sustain Australasian Bittern habitat and known populations.	No impacts.	No impacts.
Prevent further vegetation clearance in wetlands, ponds and associated marshy areas known to support Australasian Bitterns	No impacts.	No impacts.
Where appropriate, develop new wetlands with suitable habitats for Australasian Bitterns.	No impacts.	No impacts.
Where possible, create suitable habitats for Australasian Bitterns in existing wetlands.	No impacts.	No impacts.
Where appropriate, develop incentives for rice growers to manage crops with a sufficient period of inundation to facilitate successful breeding before harvest.	No impacts.	No impacts.
Consideration given to strategic land purchases to aid in the protection and better management of Australasian Bittern habitat.	No impacts.	No impacts.
Monitor and manage agricultural and urban runoff into wetlands known to support Australasian Bitterns in order to maintain water quality.	No impacts.	No impacts.
Fence wetlands to exclude grazing animals.	No impacts.	No impacts.
Develop and implement a management strategy for wetlands where Australasian Bitterns occur, with a focus on ensuring appropriate diversity and density of reeds and rushes. Management strategy may include measures such as controlled burns, slashing when the wetland is dry and/or flooding to limit reed re-growth. Management strategy should be informed by research targeted at better understanding optimal habitat conditions.	No impacts.	No impacts.

Stated management aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Ensure adequate water volume and quality at urban and peri-urban wetlands where Australasian Bitterns have been detected.	No impacts.	No impacts.
Investigate opportunities to encourage state and local government and private landholders to undertake conservation of wetlands on their properties for the benefit of Australasian Bitterns.	No impacts.	No impacts.
Survey and Monitoring Priorities		
Agree on standard monitoring protocols that can be applied across the Australasian Bitterns' range.	No impacts.	No impacts.
Undertake regular and systematic monitoring at identified priority sites on an annual basis.	No impacts.	No impacts.
Using information from monitoring program, identify population trends across the Australasian Bitterns' range.	No impacts.	No impacts.
Investigate the use of predictive modelling to improve estimates of the number of mature individuals and to predict population trends and distribution	No impacts.	No impacts.
Information and Research Priorities		
Research to determine critical habitat values being targeted by Australasian Bitterns, with differentiation of needs during different parts of the breeding cycle. Factors such as water quality, salinity, vegetation composition and fire history should be investigated.	No impacts.	No impacts.
Determine prey availability in Australasian Bitterns habitat and identify methods for improving prey availability in order to improve the species breeding success.	No impacts.	No impacts.
Undertake genetic analyses to determine Australasian Bittern population structure. If population structuring occurs, this information should be used to inform management strategies.	No impacts.	No impacts.
Assess the relative importance for Australasian Bitterns occupancy and breeding success of: - introduced predators, - mortality associated with fixed structures, such as fence lines and towers, - grazing by introduced herbivores, - fire regimes.	No impacts.	No impacts.
Ensure processes to allow outcomes of research to influence ongoing management and monitoring programs, and to influence the development of new actions where required.	No impacts.	No impacts.
Stakeholder Engagement and Governance		

Stated management aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Develop broad promotional material to raise awareness about the Australasian Bittern, its status and the importance of protecting vegetated freshwater wetlands, and share this material with conservation groups and the general public.	No impacts.	No impacts.
Develop targeted fact sheets for landholders to increase awareness of the Australasian Bittern, including advice regarding improved wetland management for the species, and provide an avenue for reporting sightings.	No impacts.	No impacts.
Engage with private landholders, agricultural producers and public land managers responsible for land on which Australasian Bittern populations occur, and encourage them to contribute to the implementation of conservation management actions.	No impacts.	No impacts.
Promote the important ecosystem functions of wetlands, and their aesthetic and recreational values, to increase the interest of conservation groups and general public in their protection and restoration.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Management Plan for the Blue Whale (*Balaenoptera musculus*) 2015-2025 (DSEWPC, 2011)

The following table provides an assessment of routine and non-routine operations against the conservation objectives of the plan.

Primary Conservation Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Interim Recovery Objectives		
The conservation status of blue whale populations is assessed using cost effective and robust methodology.	No impacts.	No impacts.
The spatial and temporal distribution, identification of biologically important areas, and population structure of blue whales in Australian waters is described.	No impacts.	No impacts.
Current levels of legal and management protection for blue whales are maintained or improved and an appropriate adaptive management regime is in place.	No impacts.	No impacts.
Anthropogenic threats are demonstrably minimised.	No impacts.	No impacts.
Assess and Address Threats		
Maintain and improve existing legal and management protection.	No impacts.	No impacts.
Assess and addressing anthropogenic noise.	EPBC Act Policy 2.1 requirements will be implemented during wireline activities.	No impacts.
Understand impacts of climate variability and change.	No impacts.	No impacts.
Minimise vessel collisions.	Vessel collision guidelines are implemented.	Vessel collision guidelines will be implemented.
Enable and Measure Recovery		
Measure and monitor population recovery.	No impacts.	No impacts.
Investigate population structure.	No impacts.	No impacts.
Describe spatial and temporal distribution and define biologically important habitat.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Advice for the Humpback Whale (*Megaptera novaeangliae*) (TSSC, 2015)

The following table provides an assessment of routine and non-routine operations against the conservation and management actions of the conservation advice.

Conservation and Management Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Maintain and improve existing legal and management protection		
Continue or improve existing legislative management actions under the EPBC Act, including the Australian Whale Sanctuary provisions.	No impacts.	No impacts.
Australia should maintain its position on promoting high levels of protection for humpback whales in all relevant international agreements including the IWC, Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), Convention on the Conservation of Migratory Species of Wild Animals (CMS), fisheries related agreements, and the Antarctic Treaty Consultative Meetings (ATCM).	No impacts.	No impacts.
Understanding impacts of climate variability and change		
Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica.	No impacts.	No impacts.
Assessing and addressing anthropogenic noise; shipping, industrial and seismic surveys		
All seismic surveys must be undertaken consistently with the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales. Should a survey be undertaken in or near a calving, resting, foraging area, or a confined migratory pathway then Part B. Additional Management Procedures must also be applied.	No impacts.	No impacts.
For actions involving acoustic impacts (example pile driving, explosives) on humpback whale calving, resting, feeding areas, or confined migratory pathways site specific acoustic modelling should be undertaken (including cumulative noise impacts).	EPBC Act Policy 2.1 requirements will be implemented during wireline activities.	No impacts.
Should acoustic impacts on humpback calving, resting, foraging areas, or confined migratory pathways be identified a noise management plan should be developed.		No impacts.
Addressing infrastructure and coastal development impacts		
Environmental assessment processes must ensure that existing information about coastal habitat requirements of humpback whales, environmental suitability of coastal locations, historic high use and emerging areas are taken into consideration.	No impacts.	No impacts.

Conservation and Management Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Environmental assessment and approval processes must ensure that the impacts of coastal development on humpback whales are addressed and minimised. Mitigation and management measures for the construction stage and the ongoing operational impacts are to be included in any plans of management. Significant residual impacts must be offset.	No impacts.	No impacts.
Reducing commercial fishing entanglements		
Commonwealth and state governments with the pot and set net fishing industries to develop and implement codes of conduct to minimise interactions between commercial fishers and humpback whales.	No impacts.	No impacts.
Investigate alternative fishing techniques and technologies to reduce the risk of entanglement.	No impacts.	No impacts.
Minimising vessel collisions		
Develop a national vessel strike strategy that investigates the risk of vessel strikes on humpback whales and also identifies potential mitigation measures to reduce the risk of collision.	No impacts.	No impacts.
Maximise the likelihood that all vessel strike incidents are reported in the National Ship Strike Database. All cetaceans are protected in Commonwealth waters and, the EPBC Act requires that all collisions with whales in Commonwealth waters are reported. Vessel collisions can be submitted to the National Ship Strike Database at https://data.marinemammals.gov.au/report/shipstrike	No impacts.	No impacts.
Ensure the risk of vessel strike on humpback whales is considered when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required appropriate mitigation measures are implemented to reduce the risk of vessel strike.	No impacts.	No impacts.
Enhance education programs to inform vessel operators of best practice behaviours and regulations for interacting with humpback whales.	No impacts.	No impacts.
Measuring and monitoring population recovery		
Continue long-term monitoring of east and west coast populations at appropriate multi-annual intervals to quantify rates of population increase, abundance, migratory interchange and population structure	No impacts.	No impacts.
Information and research priorities		
Assess impacts of increasing anthropogenic threats and undertake a risk assessment to determine the increased exposure of these expanding populations to entanglement, ship strike and acoustic noise.	No impacts.	No impacts.

Conservation and Management Actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Expand genetic analyses to better define population structure and extent of interchange between subpopulations. In particular the genetic structure of the east coast population and interchange with Pacific humpback whale populations.	No impacts.	No impacts.
Assess the impact of whale watching on humpback whales detailing the benefits and negatives of human interactions and the potential for cumulative impacts on the species as they migrate along the coast.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Conservation Management Plan for the Southern Right Whale (*Eubalaena australis*) 2011-2021 (DSEWPC, 2012)

The following table provides an assessment of routine and non-routine operations against the primary conservation objectives of the plan.

Primary Conservation Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Interim Recovery Objectives		
Demonstrate that the number of southern right whales occurring off south-west Australia (nominally south-west Australian population) is increasing at or near the maximum biological rate.	No impacts.	No impacts.
Demonstrate that the number of southern right whales occurring off south-east Australia (nominally south-east Australian population) is showing signs of increase.	No impacts.	No impacts.
The nature and degree of difference between the south-eastern and south-western Australian populations of southern right whales is clearly understood.	No impacts.	No impacts.
Current levels of legal and management protection for southern right whales are maintained or improved and an appropriate adaptive management regime is in place.	No impacts.	No impacts.
Anthropogenic threats are demonstrably minimised.	No impacts.	No impacts.
Assess and Address Threats		
Maintain and improve existing legal and management protection.	No impacts.	No impacts.
Assess and address anthropogenic noise (shipping, industrial and seismic).	EPBC Act Policy 2.1 requirements will be implemented during wireline activities.	No impacts.
Reduce commercial fishing entanglements.	No impacts.	No impacts.
Impacts of climate variability and change.	No impacts.	No impacts.
Address vessel collisions.	Vessel collision guidelines are implemented.	Vessel collision guidelines will be implemented.
Address infrastructure and coastal development impacts.	No impacts.	No impacts.

Primary Conservation Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Measure Recovery		
Measure and monitor population recovery	No impacts.	No impacts.
Investigate the two-population model	No impacts.	No impacts.
Understand offshore distribution and migration	No impacts.	No impacts.
Characterise behaviour and movements	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Approved Conservation Advice for the Fin Whale (*Balaenoptera physalus*) (TSSC, 2015)

The following table provides an assessment of routine and non-routine operations against the management aims of the plan.

Stated management aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Continue or improve existing legislative management actions under the Environment Protection and Biodiversity Act 1999, including the Australian Whale Sanctuary provisions.	No impacts.	No impacts.
Australia should maintain its position on promoting high levels of protection for Fin whales in all relevant international agreements including the International Whaling Commission (IWC), Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), Convention on the Conservation of Migratory Species of Wild Animals (CMS), fisheries related agreements, and the Antarctic Treaty Consultative Meetings (ATCM).	No impacts.	No impacts.
Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica.	No impacts.	No impacts.
Once the spatial and temporal distribution (including biologically important areas) of fin whales is further defined an assessment of the impacts of increasing anthropogenic noise (including from seismic surveys, port expansion, and coastal development) should be undertaken on this species.	EPBC Act Policy 2.1 requirements will be implemented during wireline activities.	No impacts.
If required, additional management measures should be developed and implemented to ensure the ongoing recovery of Fin whales.	No impacts.	No impacts.
Develop a national vessel strike strategy that investigates the risk of vessel strikes on Fin Whales and also identifies potential mitigation measures.	No impacts.	No impacts.
Ensure all vessel strike incidents are reported in the National Vessel Strike Database.	Vessel collision guidelines are implemented.	Vessel collision guidelines are implemented.
Information and Research Priorities		
Determine population abundance, trends and population structure for Fin whales, and establish a long-term monitoring program in Australian waters.	No impacts.	No impacts.
Describe the spatial and temporal distribution of Fin Whales and further define biologically important areas (feeding and breeding), and migratory routes within Australian and Antarctic waters.	No impacts.	No impacts.

<u>Assessment of BassGas operations against the stated aims of the Approved Conservation Advice for the Sei Whale (*Balaenoptera borealis*) (TSSC, 2015)</u>

The following table provides an assessment of routine and non-routine operations against the management aims of the plan.

Management aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Continue or improve existing legislative management actions under the Environment Protection and Biodiversity Act 1999, including the Australian Whale Sanctuary provisions.	No impacts.	No impacts.
Australia should maintain its position on promoting high levels of protection for sei whales in all relevant international agreements including the International Whaling Commission (IWC), Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), Convention on the Conservation of Migratory Species of Wild Animals (CMS), fisheries related agreements, and the Antarctic Treaty Consultative Meetings (ATCM).	No impacts.	No impacts.
Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica.	No impacts.	No impacts.
Once the spatial and temporal distribution (including biologically important areas) of sei whales is further defined an assessment of the impacts of increasing anthropogenic noise (including from seismic surveys, port expansion, and coastal development) should be undertaken on this species.	EPBC Act Policy 2.1 requirements will be implemented during wireline activities.	No impacts.
If required, additional management measures should be developed and implemented to ensure the ongoing recovery of sei whales.	No impacts.	No impacts.
Develop a national vessel strike strategy that investigates the risk of vessel strikes on Sei Whales and also identifies potential mitigation measures.	No impacts.	No impacts.
Ensure all vessel strike incidents are reported in the National Vessel Strike Database.	Vessel collision guidelines are implemented.	Vessel collision guidelines are implemented.
Information and Research Priorities		
Determine population abundance, trends and population structure for sei whales, and establish a long-term monitoring program in Australian waters.	No impacts.	No impacts.
Describe the spatial and temporal distribution of Sei Whales and further define biologically important areas (feeding and breeding), and migratory routes within Australian and Antarctic waters.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Approved Conservation Advice for the Subantarctic fur seal (*Arctocephalus tropicalis*) (TSSC, 2016)

The following table provides an assessment of routine and non-routine operations against the conservation actions of the plan.

Management aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Active Mitigation of Threats		
Continue high levels of protection for subantarctic fur-seals in important breeding, foraging and haul-out sites. Ensure Macquarie Island/Heard Island management and fisheries management plans include reference to seal monitoring and protection.	No impact.	No impact.
Continue, and where necessary adapt, management actions to reduce disturbance and pollution/marine debris impacts on subantarctic fur-seals and their important breeding, resting and foraging habitats.	The EP contains control measures aimed to minimise the risk of pollution and litter to waters.	No impact.
Improve data collection and reporting of fisheries interactions throughout the seals' foraging ranges. Including improving species identification; expanding data collected by observers (photos/samples from mortalities); utilising deep sea observation systems (e.g. cameras) to observe underwater interactions.	No impact.	No impact.
Survey and Monitoring Priorities		
Resume long-term annual monitoring at Macquarie Island, and prioritise surveys of the population at Heard Island, to better quantify abundance, pup production and population trends, movements, hybridisation rates and population structure.	No impact.	No impact.
Expand surveys to better define the finescale distribution and breeding interactions among species, population and annual pup abundance, and movements of individuals.	No impact.	No impact.
Investigate new survey technologies (e.g. use of drones) that may provide an opportunity to increase knowledge of population data on remote islands (taking into account local weather conditions).	No impact.	No impact.
Information and Research Priorities		
Improve understanding of the potential for climate and oceanographic change, and associated seawater temperature rises, to affect fur-seal food resources and reproductive success	No impact.	No impact.
Improve understanding of the potential risks of fisheries interactions, and potential prey depletion to affect the recovery and growth rates of populations. This should include analysis of logbook data and any reported interactions between Macquarie Island/Heard Island fisheries and seals.	No impact.	No impact.

Assess the impacts of disturbance, pollution and associated risks of disease on the health status of subantarctic fur seals.	The EP contains control measures aimed to minimise the risk of pollution and litter to waters.	No impact.
Analyse the occurrence and characteristics of marine debris (including micro-plastics) on remote sub-Antarctic islands and associated impacts on seal species.	No impact.	No impact.
Assess the effectiveness of fisheries closures near colonies and other management actions in reducing potential impacts of fisheries on these fur-seals.	No impact.	No impact.
Expand genetic research to monitor changes in hybridisation rates and gene flow through immigration, in order to identify the extent to which populations might be partially maintained by extralimital populations.	No impact.	No impact.
Improve understanding of diet, foraging ecology, and life history parameters (including predation on pup cohort) controlling population growth, and determine the generation length for Australian populations.	No impact.	No impact.
Expand research to better understand key foraging habitats for subantarctic fur-seals and potential changes resulting from increased sea surface temperatures.	No impact.	No impact.
Investigate the efficacy of using remote survey techniques such as satellite imagery for census counts on remote islands	No impact.	No impact.

Assessment of BassGas operations against the stated actions of the Conservation Advice for the southern elephant seal (*Mirounga leonine*) (TSSC, 2016c)

The following table provides an assessment of routine and non-routine operations against the management actions of the advice.

Management actions	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Continue high levels of protection for the southern elephant seal in important breeding, foraging and haul-out sites. Ensure Macquarie Island/Heard Island management plans include reference to monitoring and protection for the species.	No impacts.	No impacts.
Continue, and where necessary adapt, management actions to reduce disturbance and pollution/marine debris impacts on southern elephant seals and their important breeding, foraging and resting habitats	No impacts.	No impacts.
Improve data collection and reporting of fisheries interactions (including entanglements) throughout the southern elephant seals' foraging ranges. This could incorporate improving species identification; expanding data collected by observers (photos/samples from mortalities); utilising deep-sea observation systems (e.g. cameras) to observe underwater interactions.	No impacts.	No impacts.
Continue long-term population and demographic monitoring at Macquarie Island, and prioritise surveys of the population at Heard Island, to better quantify current abundance, pup production, movements and population trends	No impacts.	No impacts.
Expand surveys to better define distribution patterns and movements of individuals between breeding colonies and key foraging areas and potential dispersal to Antarctica and other subantarctic islands	No impacts.	No impacts.
Investigate new survey technologies (e.g. use of drones) that may provide an opportunity to increase knowledge of population data on remote islands (taking into account local weather conditions).	No impacts.	No impacts.
Improve knowledge of climate and oceanographic variability, including El Niño events, that affect southern elephant seal foraging and reproductive success.	No impacts.	No impacts.
Improve understanding of the potential risks of fisheries interactions with the species. Including analysis of logbook data and any reported interactions between Macquarie Island/Heard Island fisheries and southern elephant seals.	No impacts.	No impacts.
ess the impacts of disturbance, pollution and associated risks of disease on the health status of southern phant seals.	The EP contains control measures aimed to minimise the risk of pollution and litter to Victorian waters.	No impacts.
Analysis of the occurrence and characteristics of marine debris (including micro-plastics) on remote sub-Antarctic islands and associated impacts on southern elephant seals.	No impacts.	No impacts.

Assess the effectiveness of fisheries management and monitoring in reducing potential impacts of fisheries on southern elephant seals	No impacts.	No impacts.
Expand research to better understand key foraging areas for southern elephant seals and changes resulting from climate and oceanographic variability and El Niño events	No impacts.	No impacts.
Improve understanding of diet and foraging ecology, and improve understanding of life history parameters controlling population growth and determine generation time for the Heard Island population of southern elephant seals	No impacts.	No impacts.
Investigate the efficacy of using remote survey techniques such as satellite imagery for census counts on remote islands	No impacts.	No impacts.

<u>Assessment of BassGas operations against the stated management actions of the Recovery Plan for the Grey Nurse Shark (*Carcharias Taurus*) (DoE, 2014)</u>

The following table provides an assessment of routine and non-routine operations against the conservation actions of the plan.

Management Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
1. Develop and apply quantitative monitoring of the population status (distribution and abundance) and potential recovery of the grey nurse shark in Australian waters.		
Monitor and re-survey grey nurse shark populations to assess population trends and dynamics, including estimates of population growth and mortality.	No impact.	No impact.
Develop monitoring protocols and establish a national database to record data collected on grey nurse sharks, to assist with population monitoring.	No impact.	No impact.
Evaluate the use of and develop new population models, using reliable data sets as they are collected, to reassess changes in extinction risks.	No impact.	No impact.
2. Quantify and reduce the impact of commercial fishing on the grey nurse shark through incidental (accidental and/or illegal) take, throughout its range.		
Monitor the bycatch and mortality of grey nurse sharks in relevant fisheries (all interactions are recorded) and report annually to DoE.	No impact.	No impact.
Ensure that fisheries management plans/ strategies or other documentation reviewed for accreditation under the EPBC Act contain actions consistent with the recovery of the grey nurse shark (where relevant), including reduction of bycatch and recording of all interactions.	No impact.	No impact.
Conduct research to quantify post-release mortality rates of grey nurse sharks caught incidentally in commercial fisheries.	No impact.	No impact.
Ensure appropriate controls are implemented in important habitat sites to reduce the risk of grey nurse shark interaction with commercial fishing gear.	No impact.	No impact.
Identify and classify commercial fishing gear that has, or could potentially, interact with grey nurse sharks to inform the development of management arrangements to mitigate interactions.	No impact.	No impact.
3. Quantify and reduce the impact of recreational fishing on the grey nurse shark through incidental (accidental and/or illegal) take, throughout its range.		
Develop mechanisms and protocols that facilitate reporting by recreational fishers of interactions with grey nurse sharks. Mechanisms chosen should foster the understanding that any reported interaction will be received without prejudice.	No impact.	No impact.

Management Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Encourage recreational fishers (and spear fishers) to utilise the sighting program to report and provide, where possible, photographic evidence of sightings and interactions with grey nurse sharks. Requested information from fishers should include estimated number, size and weight of sharks, as well as site location and depth.	No impact.	No impact.
Undertake research into grey nurse shark interactions with recreational fishing gear/ methods to inform the development of risk mitigation strategies such as spatial, temporal or methods-based restrictions.	No impact.	No impact.
Quantify (through monitoring, reports and, where necessary, estimations of grey nurse shark bycatch) mortality and non-lethal interactions in recreational fishing sectors and report annually to DoE.	No impact.	No impact.
4. Where practicable, minimise the impact of shark control activities on the grey nurse shark.		
Shark control programs to continue to report catches annually to the state governments.	No impact.	No impact.
Maintain review processes by state governments of the effect of shark control programs on the grey nurse shark.	No impact.	No impact.
Continue to evaluate alternatives to shark meshing/drumlining, where bycatch levels are high, including the use of non-lethal methods or alternate strategies.	No impact.	No impact.
Establish and implement uniform minimum standards for the continued biological, pathological, genetic, toxicological and other post-mortem data recording and sampling of grey nurse sharks caught in shark control programs, using well established protocols. Develop a national database to collect this information (link to action 4.1).	No impact.	No impact.
Develop a photo-tagging program for grey nurse sharks caught and released in shark control programs, in conjunction with existing programs.	No impact.	No impact.
5. Investigate and manage the impact of ecotourism on the grey nurse shark.		
Review and assess the effectiveness of voluntary and regulated diving arrangements, in relation to viewing grey nurse sharks in their natural habitat, to ensure associated impacts continue to be minimised. Promote a consistent approach, where possible, among sites and across jurisdictions.	No impact.	No impact.
Ensure that any new, non-scuba diving related tourist operations aimed at viewing grey nurse sharks have effective management arrangements to minimise impacts.	No impact.	No impact.
6. Manage the impact of aquarium collection on the grey nurse shark.		

Management Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Moratorium on the removal of grey nurse sharks from the wild.	No impact.	No impact.
Ensure consistent management protocols are developed and put in place for all existing captive grey nurse shark programs to ensure individuals are appropriately managed. Determine whether it is feasible and appropriate for management protocols to enable captive breeding and investigate survivorship in captivity, to maintain a sustainable captive population without further collection from the wild.	No impact.	No impact.
Develop and contribute to conservation-oriented education programs in those commercial aquaria with captive grey nurse sharks on display.	No impact.	No impact.
7. Improve understanding of the threat of pollution and disease to the grey nurse shark.		
Review and assess the potential threat of introduced species, pathogens and pollutants. Work undertaken under this action should be linked to action 4.4 on grey nurse shark post-mortem data recording and sampling.	No impact.	No impact.
8. Continue to identify and protect habitat critical to the survival of the grey nurse shark and reduce the impact of threatening processes in these areas.		
Continue research to locate habitat critical to the survival of the grey nurse shark, including pupping, nursery and foraging areas.	No impact.	No impact.
Review the level and spatial extent of protection measures at key aggregation sites to ensure appropriate levels of protection, and a consistent approach to the designation and implementation of protective measures, are applied.	No impact.	No impact.
Use Biologically Important Areas (BIA) to help inform the development of appropriate conservation measures, including through the application of advice in the marine bioregional plans on the types of actions which are likely to have a significant impact on the species and updating such conservation measures as new information becomes available.	No impact.	No impact.
Update and refine information on existing biologically important areas (BIAs) identified as part of the marine bioregional plans, and seek to identify new BIAs as information from research and other processes becomes available.	No impact.	No impact.
Monitor grey nurse shark occupancy and utilisation of key aggregation sites.	No impact.	No impact.
9. Continue to develop and implement research programs to support the conservation of the grey nurse shark.		

Management Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Collect, analyse and disseminate age, growth, reproduction, survival, mortality and diet information to further improve understanding of the population dynamics and habitat requirements of the grey nurse shark.	No impact.	No impact.
Continue to collect and analyse biological material for toxicology research and genetic analysis (for example to determine the stock structure, inbreeding depression, population boundaries and abundance), improve coordination of reporting and sampling programs and coordinate the collation of results and the storage of collected genetic, biological and toxicological material (Link to Action 7.1).	No impact.	No impact.
Examine habitat use, ontogeny and regional connectivity across life history stages through the use of tagging technologies, including acoustic listening station networks, satellite tagging and photo identification.	No impact.	No impact.
10. Promote community education and awareness in relation to grey nurse shark conservation and management.		
Update DoE's grey nurse shark recovery plan web page to reflect the most current information on the grey nurse shark. Ensure the web page is presented in a form that is easily understood by the public and is linked to the relevant website(s) of other jurisdictions with an interest in conservation of grey nurse sharks.	No impact.	No impact.
Strengthen awareness of, and encourage compliance with, the requirement to report grey nurse shark bycatch and mortality in commercial fisheries and recreational and charter fishing operations.	No impact.	No impact.
Assess and evaluate effectiveness of prior or current education and awareness programs to identify alternative methods or improve efficacy.	No impact.	No impact.
Encourage community involvement in collaborative research, monitoring and education.	No impact.	No impact.

Assessment of BassGas operations against the stated management actions of the Approved Conservation Advice for the Black rockcod (*Epinephelus daemelii*) (DSEWPC, 2012)

The following table provides an assessment of routine and non-routine operations against the conservation actions of the plan.

Management Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Research Priorities		
Research into the reproductive biology of black cod.	No impact.	No impact.
Research into the ecology and movements of larval and juvenile black cod.	No impact.	No impact.
Coordinated regular assessments of numbers and trends in black cod populations along the NSW coastline, including surveys for juveniles in areas where adult black cod are currently absent.	No impact.	No impact.
Further research into the relative impacts of by-catch of black cod by commercial fishers and recreational line fishers, including release of specimens suffering barotrauma.	No impact.	No impact.
Research into the extent of illegal fishing, particularly spearfishing.	No impact.	No impact.
Collection and analysis of more samples to confirm genetic connectivity between black cod populations along the NSW coastline and Elizabeth and Middleton Reefs.	No impact.	No impact.
Conservation and Recovery		
Monitor known black cod populations to identify key threats.	No impact.	No impact.
Monitor the progress of recovery in black cod numbers, including the effectiveness of management actions and the need to adapt them if necessary.	No impact.	No impact.
Increase enforcement of fishing regulations.	No impact.	No impact.
Increase monitoring of Marine Protected Areas where black cod occur.	No impact.	No impact.

Management Objectives	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Consider a complete closure to fishing in the Elizabeth and Middleton Reefs Marine National Nature Reserve to protect the high conservation value black cod populations that occurs there.	No impact.	No impact.
Implement protocols that ensure that illegally caught black cod that are seized by authorities, and are not releasable, are utilised for research into the species' biology, particularly age and sexual maturity.	No impact.	No impact.
Erect information signs, with colour illustrations of black cod and information on how to release fish, in locations where incidental captures of juvenile or adult black cod regularly occur.	No impact.	No impact.
Conservation Information		
Raise awareness of black cod within the local community and particularly fishing groups.	No impact.	No impact.

Assessment of BassGas operations against the stated management actions of the Approved Conservation Advice for the Whale shark (*Rhincodon typus*) (TSSC, 2015)

The following table provides an assessment of routine and non-routine operations against the conservation actions of the plan.

Management Action	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conservation and Management Actions		
Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations (Ningaloo Reef, Christmas Island and the Coral Sea) and along the northward migration route that follows the northern Western Australian coastline along the 200 m isobath (as set out in the Conservation Values Atlas, DotE, 2014).	No impacts.	No impacts.
Management of all domestic tourism industry interactions with whale sharks in accordance with the Western Australian 'Whale Shark Management with particular reference to Ningaloo Reef' Wildlife Management Program No. 57.	No impacts.	No impacts.
Continued advocacy of threat mitigation actions for whale sharks in international fora including, but not limited to, regional fishery management organisations.	No impacts.	No impacts.
Support for the development of eco-tourism industries in areas where traditional hunting of whale sharks occurs.	No impacts.	No impacts.
Survey and Monitoring Priorities		
Monitoring of the Ningaloo Reef, Christmas Island and Coral Sea aggregations, and collation and dissemination of data to support analysis of population trajectory.	No impacts.	No impacts.
Habitat critical to the survival of whale sharks in waters off Christmas Island further assessed and mapped.	No impacts.	No impacts.
Further research on migration routes for whale sharks from Ningaloo Reef to Christmas Island.	No impacts.	No impacts.
Information and Research Priorities		
Develop greater scientific certainty around migration, habitat use, emerging threats, and population trends in Australian waters.	No impacts.	No impacts.
Assess the impacts of offshore installations and associated environmental changes (light spill, chronic noise, changed water temperature, localised nutrient levels) on whale sharks and mitigation options for these impacts.	No impacts.	No impacts.

Management Action	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Conduct further research into the impacts of boat strike on whale sharks to determine the significance of the threat. Consider possible mitigation actions (collision avoidance systems) if required.	No impacts.	No impacts.
Assess environmental variables that determine whale shark presence. These can then be used to provide advice to shipping to help avoid boat strike.	No impacts.	No impacts.
Consider the implications of climate change on whale shark distribution in Australian waters (possibly through the Range Extension Database Mapping Project [REDMAP]).	No impacts.	No impacts.

<u>Assessment of BassGas operations against the stated objectives of the National Recovery Plan for the Australian Grayling (*Prototroctes maraena*) (DSE, 2008)</u>

The following table provides an assessment of routine and non-routine operations against the management aims of the plan.

Primary conservation objectives of the National Recovery Plan	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Identify important populations of Australian Grayling.	No impacts.	No impacts.
Protect and restore habitat for Australian Grayling.	No impacts.	No impacts.
Investigate important life history attributes to acquire targeted information for management.	No impacts.	No impacts.
Investigate and manage threats to populations and habitats.	No impacts.	No impacts.
Increase awareness of Australian Grayling conservation with resource managers and the public.	No impacts.	No impacts.

<u>Assessment of BassGas operations against the stated aims of the National Recovery Plan for the Dwarf Galaxias (*Galaxiella pusilla*) (DSE, 2010)</u>

The following table provides an assessment of routine and non-routine operations against the management aims of the plan.

Primary conservation objectives of the National Recovery Plan	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Determine the distribution and abundance of the Dwarf Galaxias.	No impacts.	No impacts.
Determine the genetic and taxonomic status of Dwarf Galaxias populations.	No impacts.	No impacts.
Determine Dwarf Galaxias habitat characteristics and requirements.	No impacts.	No impacts.
Identify and manage potentially threatening processes impacting on Dwarf Galaxias conservation.	No impacts.	No impacts.
Protect key populations across the range of the Dwarf Galaxias.	No impacts.	No impacts.
Determine population trends at key sights.	No impacts.	No impacts.
Investigate key aspects of biology and ecology of the Dwarf Galaxias.	No impacts.	No impacts.
Establish a captive breeding population of Dwarf Galaxias.	No impacts.	No impacts.
Establish new populations of Dwarf Galaxias.	No impacts.	No impacts.
Increase awareness and involvement.	No impacts.	No impacts.

<u>Assessment of BassGas operations against the stated aims of the National Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPC, 2013)</u>

The following table provides an assessment of routine and non-routine operations against the primary conservation objectives of the plan.

Conservation and Management Objectives	**Assessment of impacts of routine activities against management aims**	**Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives**
Develop and apply quantitative measures to assess population trends and any recovery of the white shark in Australian waters and monitor population trends.	No impacts.	No impacts.
Quantify and minimise the impact of commercial fishing, including aquaculture, on the white shark through incidental (illegal and/or accidental) take, throughout its range in Australian waters.	No impacts.	No impacts.
Quantify and minimise the impact of recreational fishing on the white shark through incidental (illegal and/or accidental) take, throughout its range in Australian waters.	No impacts.	No impacts.
Where practicable, minimise the impact of shark control activities on the white shark.	No impacts.	No impacts.
Investigate and manage (and where necessary reduce) the impact of tourism on the white shark.	No impacts.	No impacts.
Quantify and minimise the impact of international trade in white shark products through implementation of CITES provisions.	No impacts.	No impacts.
Continue to identify and protect habitat critical to the survival of the white shark and minimise the impact of threatening processes within these areas.	No impacts.	
Continue to develop and implement relevant research programs to support the conservation of the white shark.	No impacts.	No impacts.
Promote community education and awareness in relation to white shark conservation and management.	No impacts.	No impacts.
Encourage the development of regional partnerships to enhance the conservation and management of the white shark across national and international jurisdictions.	No impacts.	No impacts.

Assessment of BassGas operations against the stated aims of the Recovery Plan for Marine Turtles in Australia (DoEE, 2017).

The following table provides an assessment of routine and non-routine operations against the management targets of the plan.

Conservation management targets	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
Domestic and international legislation and other agreements that support the recovery of Australian marine turtles are maintained, and, where possible, strengthened.	No impacts.	No impacts.
Robust scientific information is available and used to support decision making.	No impacts.	No impacts.
The sustainable management of marine turtles by Aboriginal and Torres Strait Islander communities and ranger groups to maintain long-term cultural, spiritual and economic associations with marine turtles is supported.	No impacts.	No impacts.
The capacity of programs throughout northern Australia to conduct effective monitoring, management and research of marine turtles at nesting beaches and feeding grounds is maintained and increased.	No impacts.	No impacts.
Robust and adaptive management regimes that lead to a reduction in anthropogenic threats to marine turtles and their habitats are in place.	No impacts.	No impacts.
Threat mitigation strategies are supported by high quality information.	No impacts.	No impacts.
Effective monitoring programs are implemented and maintained at index beaches and foraging areas for each of the six species.	No impacts.	No impacts.
Measures of success identified for each stock are achieved within the life of the plan.	No impacts.	No impacts.

Appendix 3

Stakeholder consultation flyer

BassGas

The Yolla-A platform

October 2018

Environment Plan Revision

Beach Energy is revising the Environment Plan for its BassGas offshore operations in Victoria.

This information sheet provides an overview of the offshore operations, the regulatory framework for safety and environment requirements, potential impacts and risks in continuing these operations, and measures to reduce and manage these in accordance with State and Commonwealth regulations.

About Beach

Beach Energy (Beach) is an ASX listed oil and gas, exploration and production company headquartered in Adelaide. It has operated and non-operated, onshore and offshore, oil and gas production from five production basins across Australia and New Zealand and is a key supplier to the Australian east coast gas market. Beach is the operator of BassGas, including the Lang Lang Gas Plant, Yolla offshore platform, subsea pipeline, raw gas and sales gas pipelines.

For more information, visit:

beachenergy.com.au

BassGas overview

Construction of BassGas began in 2001, with gas production commencing in 2006. The Yolla gas field is located in Bass Strait, approximately 145km south of Kilcunda in Victoria and 135km north of Burnie in Tasmania.

Gas and liquids within the Yolla field are extracted from a sandstone reservoir over 3km in depth through four wells via the Yolla offshore platform which is located in 80 metres of water. Once extracted, over 147km of subsea pipeline transports the gas and liquids from the Yolla field to shore, intersecting land near Kilcunda beach. There, it joins the 32km-long raw gas pipeline to the processing plant.

Beach Energy (Beach) is the operating partner of the BassGas joint venture which also includes AWE Limited and Prize Petroleum International Pte Ltd[1].

Beach operates in compliance with the NOSPEMA accepted safety cases (for more information see: www.nopsema.gov.au/safety/safety-case/what-is-a-safety-case/).

The risk of a loss of containment of hydrocarbons or chemicals is managed through the equipment design process and the implementation of asset integrity and maintenance programs. In addition, process parameters are monitored 24 hours per day by trained and competent personnel who must follow documented procedures.

Contractors utilised by Beach are subject to a pre-qualification process and assurance over their activities to ensure compliance with the accepted Environment Plan and Safety Case.

BassGas has been developed over several stages:

Stage 1:

The installation of an offshore platform (referred to as Yolla-A), drilling of Yolla-3 and Yolla-4 development wells, and the construction of an export pipeline and onshore processing facility was completed in 2004.

Yolla Mid-Life Enhancement (MLE):

A mid-life enhancement project involving the installation of a new accommodation unit and associated safety facilities was completed in 2012.

Stage 2:

Two additional production wells, Yolla-5 and Yolla-6, were drilled in 2015 and commenced production in August of that year.

Our Traditional Custodians

Beach would like to respectfully acknowledge the Bunurong people, the Traditional Custodians of the land on which BassGas operates. Beach respects their historical and ongoing connection to country through cultural and spiritual sites, language and ceremony, and would like to pay our respect to their Elders past, present and future.

1. Lattice Energy Limited (37.5%), Lattice Energy Resources (BassGas) Ltd (5%), Beach Energy Limited (11.25%) AWE Petroleum Pty Ltd (22.5%), AWE (BassGas) Pty Ltd (12.5%), Prize Petroleum International Pte.Ltd (11.25%).

BassGas Facilities

BassGas consists of the following elements:

Offshore

- Yolla-A offshore production platform (Yolla platform) in 80m water depth at the Yolla Field located in Bass Strait, which supports the wellheads and topsides facilities required to cool and dehydrate the well fluids prior to export to shore
- Four gas production wells
- 147km subsea section of the Raw Gas Pipeline from the Platform to the shore crossing near Kilcunda.

Onshore

- 32.4 km section of the Raw Gas Pipeline running from the shore crossing to the gas plant
- Gas plant located near the township of Lang Lang – a continuously manned facility which processes the raw gas and liquids to produce sales gas and hydrocarbon liquids - LPG and condensate - and provides the overall control for the onshore and offshore facilities
- 35.1km onshore Sales Gas Pipeline, to carry sales gas from the gas plant to connect with the existing Longford to Dandenong gas transmission pipeline near Pakenham
- Multinet tie in for distribution of sales gas to local consumers via the South Gippsland Natural Gas Pipeline
- Road transport of condensate from the gas plant to refining and road transport of LPG products to local distribution centres
- Carbon dioxide rich off-gas stream to adjacent Air Liquide Australia (ALA/Air Liquide) facility.

Yolla-A is a steel gravity-based, self-installing platform, with a cantilevered helideck and flare boom. The platform was originally designed for unmanned operation, however, it has now been converted to enable manned operations with the installation of permanent accommodation modules and upgrade of the safety systems.

The Lang Lang Gas Plant is designed as a single train and separates the two phase stream into gas and liquid streams. Liquids storage and truck loading facilities are provided for export of these hydrocarbon liquid products by road tankers to markets.

Sales gas is exported via the Sales Gas Pipeline to the south eastern Australian gas market.

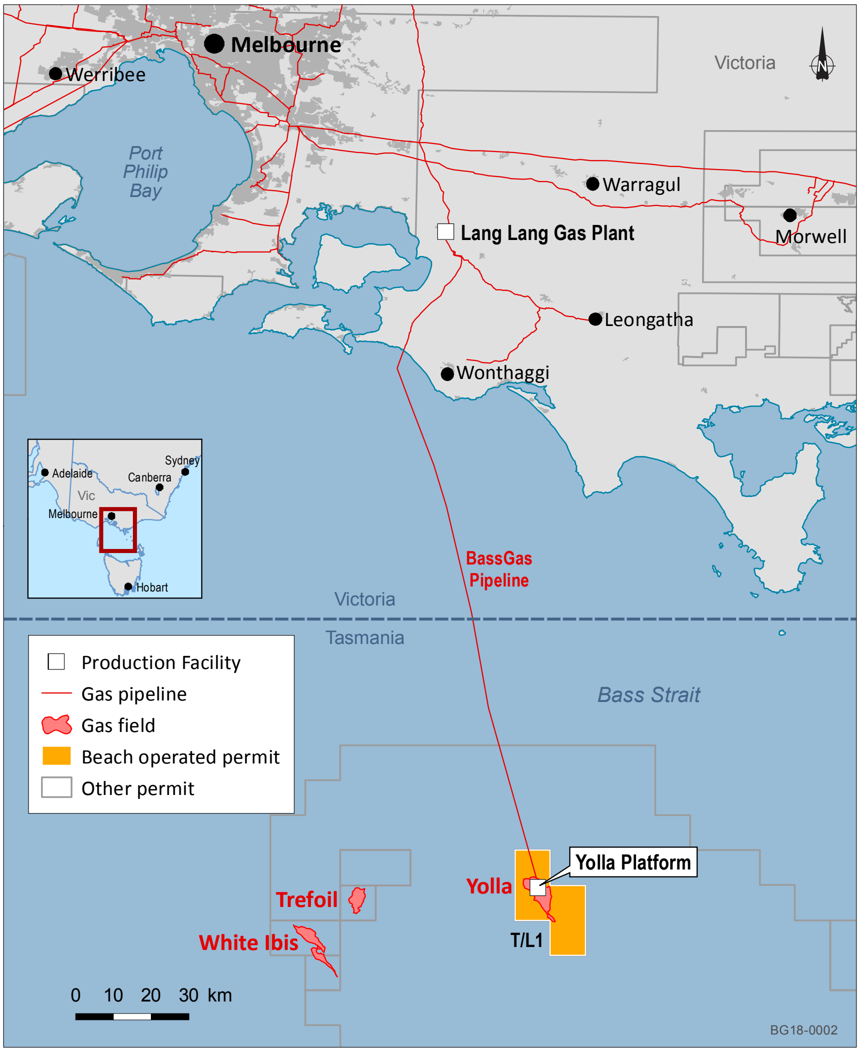
A carbon dioxide rich off-gas stream is piped to the adjacent Air Liquide facility for recovery of carbon dioxide.

As a continuation of the MLE Project, the Platform has been further modified with the following:

- Installation of export gas compression and condensate pumping systems to assist maximising recovery of the reservoir fluids and extending production life at plateau production rates
- Drilling of additional wells.

The Yolla-A facility has been designed such that it can be fully operated from either the onshore gas plant Central Control Room at Lang Lang or the offshore control panel on the platform. Post-MLE Project, the platform has continued to be primarily operated from the onshore Central Control Room which is continuously manned.

Maintenance of the platform is generally undertaken by work crews accommodated on the Yolla platform. The types of activities undertaken are routine operational checks and maintenance including instrument and mechanical maintenance, shutdown resets, corrosion monitoring and chemical replenishment. The platform is also visited approximately once per month by a supply vessel for the provision of fuel, chemicals, maintenance consumables, accommodation consumables and equipment. Vessels are also required for specific activities such as subsea inspection work using Remotely Operated Vehicles (ROVs) and/or divers.



The Yolla gas field is located in the Bass Strait approximately 145 km from Kilcunda on Victoria's south coast and 120 km from the north coast of Tasmania.

Regulatory Framework

Beach's BassGas offshore operations are regulated by the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006* and the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (the Regulations), which are administered by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

Operations in Victorian state waters (from the high water mark out to three nautical miles), which are limited to the asset's pipeline, are regulated by the Victorian *Offshore Petroleum and Greenhouse Gas Storage Regulations 2011* (the Victorian Regulations) and are administered by the Department of Economic Development, Jobs, Transport and Resources (DEDJTR).

The Environment Plan was previously updated and accepted by NOPSEMA on October 2014 for a period of five years, in line with the provisions in the Regulations. A revision of the Environment Plan is required now that the five-year period is drawing closer. Beach has completed an environmental risk review and no new significant risks have been identified since the current EP was accepted.

The revised Environment Plan will be submitted to both NOPSEMA and DEDJTR for acceptance.

Safety

Safety on the Yolla-A platform is managed in line with its associated Safety Case. A Safety Case is a document that describes the Yolla-A facility, the associated hazards and risks, and the safety management system in place to control and manage these risks. The Safety Case is revised every five years and is submitted to NOPSEMA for acceptance. The purpose of the Safety Case is to demonstrate that the facility complies with the relevant requirements of the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009*.

Environment Plan

The Environment Plan describes the operations of BassGas, the existing marine and shoreline environments and identifies environmental and socio-economic impacts. The Environment Plan also identifies risks and details a range of mitigation and management measures to reduce impacts and risks to As Low As Reasonably Practicable (ALARP) and to acceptable levels. These include:

- The Yolla platform and offshore pipeline are marked on navigational charts and the platform has a 500-metre safety exclusion zone
- Vessels servicing the platform comply with all applicable marine regulations and observe the minimum approach distances to whales and dolphins set out in national guidelines
- Gas venting is limited to the minimum required for safe operations
- The platform, pipeline and support vessels are maintained in good working condition in accordance with a suite of management system procedures, with regular inspections and audits undertaken to ensure these procedures are being effectively implemented.

Key changes and updates for the revised Environment Plan include:

- A description of Beach as the new asset owner
- A description of Beach's health, safety and environment management system (HSEMS)
- A revised impact and risk assessment that meets NOPSEMA's various guidelines released since acceptance of the current Environment Plan to demonstrate that the environmental impacts and risks are ALARP and acceptable
- A revised Oil Pollution Emergency Plan (OPEP) detailing the potential impacts of a hydrocarbon spill and Beach's response strategy to minimise environmental impact, in light of revised oil spill modelling
- Revised environmental performance outcomes and environmental performance standards that reflect current best practice and will allow Beach to measure and report on its environmental performance.

Questions and Answers

What is an Environment Plan and who assesses it?

An Environment Plan must be prepared by an operator and accepted by the regulator prior to conducting petroleum exploration, production or decommissioning activities.

- In Commonwealth waters, this is regulated under the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* and is administered by NOPSEMA.
- In Victorian state waters this is regulated under the Victorian *Offshore Petroleum and Greenhouse Gas Storage Regulations 2011* and administered by DEDJTR.

The contents of an Environment Plan are prescribed by the respective Commonwealth and Victorian regulations, and broadly include the requirement for a description of the activity and the existing environment, an evaluation of the impacts and risks associated with the activities, environmental performance outcomes and standards, implementation strategy and reporting requirements.

An Environment Plan must also include an OPEP, which describes how Beach will respond in the event of an oil spill.

Why is the Environment Plan being revised?

Environment Plans must be revised and re-submitted to the regulator every five years and this is scheduled to happen in 2019.

What is ALARP?

ALARP stands for "As Low As Reasonably Practicable". It is a safety assessment principle commonly used in the oil and gas industry to assess and reduce potential risks and impacts that cannot be eliminated. For information on how NOPSEMA assesses ALARP, see: https://www.nopsema.gov.au/assets/Guidelines/A524696.pdf

What does the Oil Pollution Emergency Plan (OPEP) cover?

An OPEP describes the arrangements for responding to and monitoring an oil spill and includes:

- An identification of environmental protection priorities;
- The suitability of various response measures for the two key hydrocarbon types (gas condensate and marine diesel);

Continued overleaf...

- A description of the arrangements and capabilities to ensure timely implementation of response measures and how these measures are maintained operationally ready at all times; and
- A description of the arrangements and capabilities to monitor the effects of oil pollution.

These arrangements are based on the results of scientific modelling of oil spill scenarios from a loss of control from a well, the pipeline and vessel.

Can I fish or scuba dive near the platform?

No. There is a 500m safety exclusion zone around the platform that vessels and divers cannot enter. This is to ensure the safety of the public and the platform.

Have potential impacts on marine life been considered?

Yes. The Environment Plan is a comprehensive document that identifies and assesses all impacts (known events) and risks (unplanned events) from platform, pipeline and vessel operations.

An Environment Plan summary is available at the NOPSEMA website at https://www.nopsema.gov.au/environmental-management/activity-status-and-summaries/details/248.

Do the offshore activities impact commercial fisheries?

There is limited impact to commercial fishing operations during routine operations. The platform has a 500m safety exclusion zone which is a relatively small area compared to the jurisdictions of the State- and Commonwealth-managed fisheries that are licensed to operate this area. In general, there is limited fishing activity near the platform.

Have potential impacts on whales been considered?

The current Environment Plan includes a description of whale populations and distribution in the Bass Strait and Beach has assessed the potential impacts of its activities on whales. Vessels and helicopters utilised by Beach are required to comply with the separation distances in the Australian National Guidelines for Whale and Dolphin Watching (DEH 2005) to minimise the impacts of noise and the risk of a vessel collision.

Contact us

Beach values stakeholder feedback as it is an important part of the process of revising the Environment Plan. Beach has prepared this information sheet to inform stakeholders and invite feedback from those who may be affected by Beach's offshore operations or who have an interest in the environmental performance of its offshore operations.

If you are seeking further information about the offshore operations of BassGas and the revision of the Environment Plan specific to your functions, interests or activities, or you wish to provide feedback, or meet with Beach to discuss, please contact us. Beach welcomes consultation with stakeholders potentially affected by these operations, including those stakeholders with specific local knowledge or an interest in the environmental performance of this asset. Feedback and consultation will inform the revision of the Environment Plan.

For further information please contact:

1800 797 011

community@beachenergy.com.au

Please be advised that all stakeholder feedback, records of consultation, copies of correspondence, including emails, will be provided to NOPSEMA and DEDJTR in the preparation of the Environment Plan as required by the OPGGS regulations.

BEACH ENERGY

Appendix 4

Stakeholder communications

(provided to NOPSEMA separately as sensitive information under Regulation 9(8) of the OPGGS(E))

Appendix 5

EPBC Act Protected Matters Search (PMST) Tool results

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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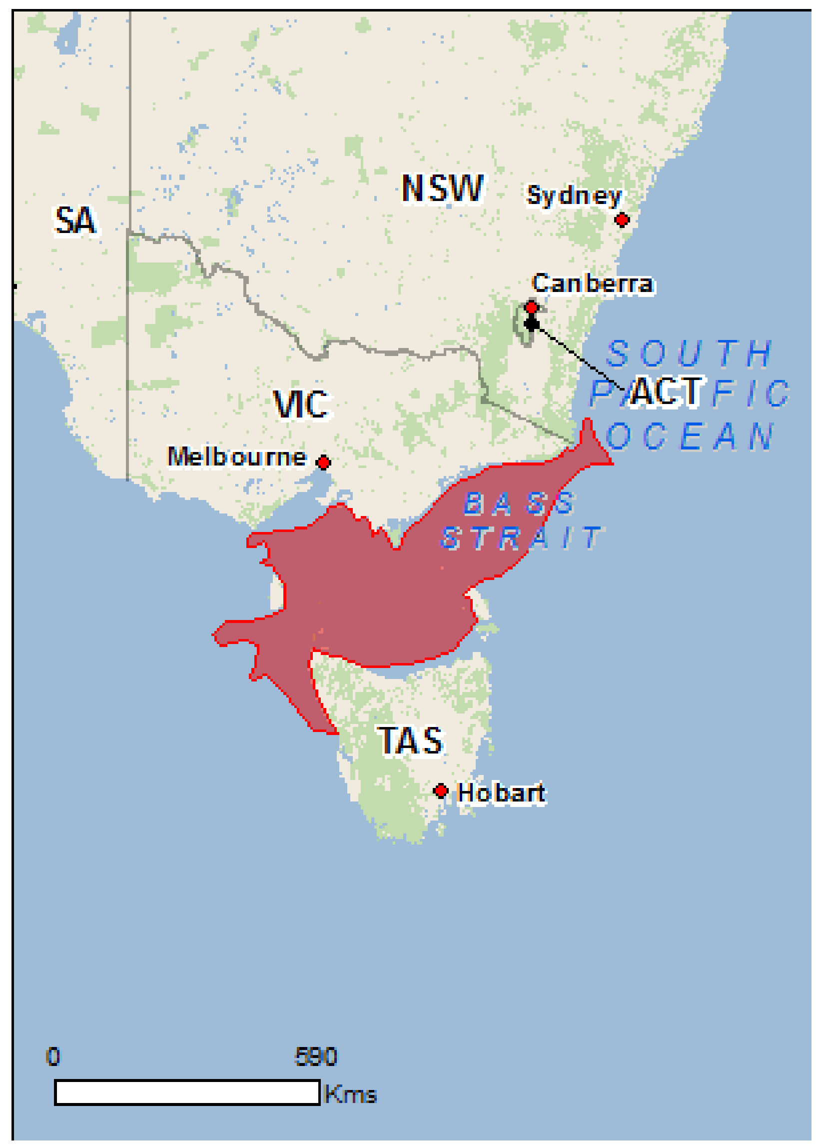

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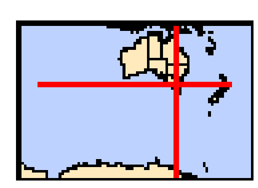

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	1
Wetlands of International Importance:	4
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	7
Listed Threatened Species:	113
Listed Migratory Species:	78

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	2
Commonwealth Heritage Places:	4
Listed Marine Species:	124
Whales and Other Cetaceans:	30
Critical Habitats:	1
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	5

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	103
Regional Forest Agreements:	3
Invasive Species:	50
Nationally Important Wetlands:	7
Key Ecological Features (Marine)	3

Details

Matters of National Environmental Significance

National Heritage Properties [Resource Information]

Name	State	Status
Indigenous		
Western Tasmania Aboriginal Cultural Landscape	TAS	Listed place

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Corner inlet	Within 10km of Ramsar
Gippsland lakes	Within 10km of Ramsar
Lavinia	Within Ramsar site
Western port	Within Ramsar site

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
South-east

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria ecological community	Endangered	Community likely to occur within area
Giant Kelp Marine Forests of South East Australia	Endangered	Community may occur within area
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Community likely to occur within area
Lowland Native Grasslands of Tasmania	Critically Endangered	Community likely to occur within area
Natural Damp Grassland of the Victorian Coastal Plains	Critically Endangered	Community likely to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area
Tasmanian Forests and Woodlands dominated by black gum or Brookers gum (Eucalyptus ovata / E. brookeriana)	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Acanthiza pusilla archibaldi		
King Island Brown Thornbill, Brown Thornbill (King Island) [59430]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Acanthornis magna greeniana King Island Scrubtit, Scrubtit (King Island) [82329]	Critically Endangered	Species or species habitat known to occur within area
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Aquila audax fleayi Tasmanian Wedge-tailed Eagle, Wedge-tailed Eagle (Tasmanian) [64435]	Endangered	Breeding likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Ceyx azureus diemenensis Tasmanian Azure Kingfisher [25977]	Endangered	Breeding known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Dasyornis brachypterus Eastern Bristlebird [533]	Endangered	Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Breeding known to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Migration route known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Pardalotus quadragintus Forty-spotted Pardalote [418]	Endangered	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Platycercus caledonicus brownii Green Rosella (King Island) [67041]	Vulnerable	Species or species habitat likely to occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat known to occur within area
Strepera fuliginosa colei Black Currawong (King Island) [67113]	Vulnerable	Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta cauta Shy Albatross [82345]	Vulnerable	Breeding known to occur

Name	Status	Type of Presence
		within area
Thalassarche cauta steadi		
White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma		
Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche eremita		
Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis rubricollis		
Hooded Plover (eastern) [66726]	Vulnerable	Species or species habitat known to occur within area
Tyto novaehollandiae castanops (Tasmanian population)		
Masked Owl (Tasmanian) [67051]	Vulnerable	Breeding known to occur within area
Crustaceans		
Astacopsis gouldi		
Giant Freshwater Crayfish, Tasmanian Giant Freshwater Lobster [64415]	Vulnerable	Species or species habitat likely to occur within area
Engaeus martigener		
Furneaux Burrowing Crayfish [67220]	Endangered	Species or species habitat may occur within area
Fish		
Epinephelus daemelii		
Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat may occur within area
Galaxiella pusilla		
Eastern Dwarf Galaxias, Dwarf Galaxias [56790]	Vulnerable	Species or species habitat likely to occur within area
Prototroctes maraena		
Australian Grayling [26179]	Vulnerable	Species or species habitat known to occur within area
Frogs		
Litoria aurea		
Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat likely to occur within area
Litoria littlejohni		
Littlejohn's Tree Frog, Heath Frog [64733]	Vulnerable	Species or species habitat may occur within area
Litoria raniformis		
Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog [1828]	Vulnerable	Species or species habitat known to occur within area
Insects		
Oreisplanus munionga larana		
Marrawah Skipper, Alpine Sedge Skipper, Alpine Skipper [77747]	Vulnerable	Species or species habitat known to occur within area

Name	Status	Type of Presence
Mammals		
Antechinus minimus maritimus		
Swamp Antechinus (mainland) [83086]	Vulnerable	Species or species habitat known to occur within area
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Dasyurus maculatus maculatus (SE mainland population)		
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (Tasmanian population)		
Spotted-tail Quoll, Spot-tailed Quoll, Tiger Quoll (Tasmanian population) [75183]	Vulnerable	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Isoodon obesulus obesulus		
Southern Brown Bandicoot (eastern), Southern Brown Bandicoot (south-eastern) [68050]	Endangered	Species or species habitat known to occur within area
Mastacomys fuscus mordicus		
Broad-toothed Rat (mainland), Tooarrana [87617]	Vulnerable	Species or species habitat may occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Perameles gunnii gunnii		
Eastern Barred Bandicoot (Tasmania) [66651]	Vulnerable	Species or species habitat known to occur within area
Petauroides volans		
Greater Glider [254]	Vulnerable	Species or species habitat likely to occur within area
Potorous longipes		
Long-footed Potoroo [217]	Endangered	Species or species habitat may occur within area
Potorous tridactylus tridactylus		
Long-nosed Potoroo (SE Mainland) [66645]	Vulnerable	Species or species habitat known to occur within area
Pseudomys fumeus		
Smoky Mouse, Konoom [88]	Endangered	Species or species habitat may occur within area
Pseudomys novaehollandiae		
New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sarcophilus harrisii		
Tasmanian Devil [299]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Plants		
Amphibromus fluitans River Swamp Wallaby-grass, Floating Swamp Wallaby-grass [19215]	Vulnerable	Species or species habitat known to occur within area
Caladenia caudata Tailed Spider-orchid [17067]	Vulnerable	Species or species habitat likely to occur within area
Caladenia dienema Windswept Spider-orchid [64858]	Endangered	Species or species habitat known to occur within area
Caladenia orientalis Eastern Spider Orchid [83410]	Endangered	Species or species habitat known to occur within area
Caladenia tessellata Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Caladenia tonellii Robust Fingers [64861]	Critically Endangered	Species or species habitat may occur within area
Commersonia prostrata Dwarf Kerrawang [87152]	Endangered	Species or species habitat likely to occur within area
Corunastylis brachystachya Short-spiked Midge-orchid [76410]	Endangered	Species or species habitat known to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat known to occur within area
Dianella amoena Matted Flax-lily [64886]	Endangered	Species or species habitat may occur within area
Diuris lanceolata Snake Orchid [10231]	Endangered	Species or species habitat known to occur within area
Dodonaea procumbens Trailing Hop-bush [12149]	Vulnerable	Species or species habitat may occur within area
Eucalyptus strzeleckii Strzelecki Gum [55400]	Vulnerable	Species or species habitat may occur within area
Glycine latrobeana Clover Glycine, Purple Clover [13910]	Vulnerable	Species or species habitat likely to occur within area
Hypolepis distans Scrambling Ground-fern [2148]	Endangered	Species or species habitat likely to occur within area
Leucochrysum albicans var. tricolor Hoary Sunray, Grassland Paper-daisy [56204]	Endangered	Species or species habitat known to occur within area
Prasophyllum atratum Three Hummock Leek-orchid [82677]	Critically Endangered	Species or species habitat known to occur within area
Prasophyllum favonium Western Leek-orchid [64949]	Critically Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Prasophyllum frenchii		
Maroon Leek-orchid, Slaty Leek-orchid, Stout Leek-orchid, French's Leek-orchid, Swamp Leek-orchid [9704]	Endangered	Species or species habitat likely to occur within area
Prasophyllum pulchellum		
Pretty Leek-orchid [64953]	Critically Endangered	Species or species habitat known to occur within area
Prasophyllum secutum		
Northern Leek-orchid [64954]	Endangered	Species or species habitat likely to occur within area
Prasophyllum spicatum		
Dense Leek-orchid [55146]	Vulnerable	Species or species habitat known to occur within area
Pterostylis chlorogramma		
Green-striped Greenhood [56510]	Vulnerable	Species or species habitat likely to occur within area
Pterostylis cucullata		
Leafy Greenhood [15459]	Vulnerable	Species or species habitat known to occur within area
Pterostylis rubenachii		
Arthur River Greenhood [64536]	Endangered	Species or species habitat known to occur within area
Pterostylis ziegeleri		
Grassland Greenhood, Cape Portland Greenhood [64971]	Vulnerable	Species or species habitat likely to occur within area
Senecio psilocarpus		
Swamp Fireweed, Smooth-fruited Groundsel [64976]	Vulnerable	Species or species habitat known to occur within area
Thelymitra epipactoides		
Metallic Sun-orchid [11896]	Endangered	Species or species habitat likely to occur within area
Thelymitra jonesii		
Sky-blue Sun-orchid [76352]	Endangered	Species or species habitat known to occur within area
Thelymitra matthewsii		
Spiral Sun-orchid [4168]	Vulnerable	Species or species habitat may occur within area
Xerochrysum palustre		
Swamp Everlasting, Swamp Paper Daisy [76215]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Sharks		
Carcharias taurus (east coast population)		
Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna grisea Sooty Shearwater [82651]		Species or species habitat likely to occur within area
Ardenna tenuirostris Short-tailed Shearwater [82652]		Breeding known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Sternula albifrons Little Tern [82849]		Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Vulnerable*	Breeding known to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat known to occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Breeding known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur

Name	Threatened	Type of Presence
		within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Migratory Terrestrial Species		
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Thalasseus bergii Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa incana Wandering Tattler [831]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Defence - WEST HEAD GUNNERY RANGE

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Historic		
Gabo Island Lighthouse	VIC	Listed place
Goose Island Lighthouse	TAS	Listed place
Table Cape Lighthouse	TAS	Listed place
Wilsons Promontory Lighthouse	VIC	Listed place

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Eudyptula minor Little Penguin [1085]		Breeding known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Breeding known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Larus dominicanus Kelp Gull [809]		Breeding known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Breeding known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Breeding known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding known to occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Migration route known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Pelagodroma marina White-faced Storm-Petrel [1016]		Breeding known to occur within area
Pelecanoides urinatrix Common Diving-Petrel [1018]		Breeding known to occur within area
Phalacrocorax fuscescens Black-faced Cormorant [59660]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Foraging, feeding or related behaviour likely to occur within area
Puffinus griseus Sooty Shearwater [1024]		Species or species habitat likely to occur within area
Puffinus tenuirostris Short-tailed Shearwater [1029]		Breeding known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area

Name	Threatened	Type of Presence
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Sterna striata White-fronted Tern [799]		Breeding known to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Vulnerable*	Breeding known to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche sp. nov. Pacific Albatross [66511]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Thinornis rubricollis rubricollis Hooded Plover (eastern) [66726]	Vulnerable	Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippocampus abdominalis Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
[Hippocampus breviceps](#) Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
[Hippocampus minotaur](#) Bullneck Seahorse [66705]		Species or species habitat may occur within area
[Histiogamphelus briggsii](#) Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
[Histiogamphelus cristatus](#) Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish [66243]		Species or species habitat may occur within area
[Hypselognathus rostratus](#) Knifesnout Pipefish, Knife-snouted Pipefish [66245]		Species or species habitat may occur within area
[Kaupus costatus](#) Deepbody Pipefish, Deep-bodied Pipefish [66246]		Species or species habitat may occur within area
[Kimblaeus bassensis](#) Trawl Pipefish, Bass Strait Pipefish [66247]		Species or species habitat may occur within area
[Leptoichthys fistularius](#) Brushtail Pipefish [66248]		Species or species habitat may occur within area
[Lissocampus caudalis](#) Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area
[Lissocampus runa](#) Javelin Pipefish [66251]		Species or species habitat may occur within area
[Maroubra perserrata](#) Sawtooth Pipefish [66252]		Species or species habitat may occur within area
[Mitotichthys mollisoni](#) Mollison's Pipefish [66260]		Species or species habitat may occur within area
[Mitotichthys semistriatus](#) Halfbanded Pipefish [66261]		Species or species habitat may occur within area
[Mitotichthys tuckeri](#) Tucker's Pipefish [66262]		Species or species habitat may occur within area
[Notiocampus ruber](#) Red Pipefish [66265]		Species or species habitat may occur within area
[Phycodurus eques](#) Leafy Seadragon [66267]		Species or species habitat may occur within area
[Phyllopteryx taeniolatus](#) Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
[Pugnaso curtirostris](#) Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Solegnathus robustus Robust Pipehorse, Robust Spiny Pipehorse [66274]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Stipecampus cristatus Ringback Pipefish, Ring-backed Pipefish [66278]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Vanacampus phillipi Port Phillip Pipefish [66284]		Species or species habitat may occur within area
Vanacampus poecilolaemus Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish [66285]		Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal [21]		Breeding known to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area

Name	Status	Type of Presence
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Berardius arnuxii Arnoux's Beaked Whale [70]		Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lissodelphis peronii Southern Right Whale Dolphin [44]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Mesoplodon bowdoini Andrew's Beaked Whale [73]		Species or species habitat may occur within area

Name	Status	Type of Presence
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		Species or species habitat may occur within area
Mesoplodon hectori Hector's Beaked Whale [76]		Species or species habitat may occur within area
Mesoplodon layardii Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale [25556]		Species or species habitat may occur within area
Mesoplodon mirus True's Beaked Whale [54]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Critical Habitats [Resource Information]

Name	Type of Presence
Thalassarche cauta (Shy Albatross) - Albatross Island, The Mewstone, Pedra Branca	Listed Critical Habitat

Australian Marine Parks [Resource Information]

Name	Label
Apollo	Multiple Use Zone (IUCN VI)
Beagle	Multiple Use Zone (IUCN VI)
Boags	Multiple Use Zone (IUCN VI)
East Gippsland	Multiple Use Zone (IUCN VI)
Franklin	Multiple Use Zone (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Albatross Island	TAS
Anser Island	VIC
Arthur-Pieman	TAS
Badger Island	TAS
Bass Pyramid	TAS
Big Bay	TAS
Big Green Island	TAS
Bird Island	TAS
Black Pyramid Rock	TAS

Name	State
Blyth Point	TAS
Boxen Island	TAS
Brick Islands	TAS
Bull Rock	TAS
Bun Beetons Point	TAS
Cape Liptrap Coastal Park	VIC
Chalky Island	TAS
City of Melbourne Bay	TAS
Cone Islet	TAS
Councillor Island	TAS
Craggy Island	TAS
Croajingolong	VIC
Curtis Island	TAS
Devils Tower	TAS
East Kangaroo Island	TAS
East Moncoeur Island	TAS
Egg Beach	TAS
Emita	TAS
Forwards Beach	TAS
Four Mile Beach	TAS
Gippsland Lakes Coastal Park	VIC
Goose Island	TAS
Harbour Islets	TAS
Harcus Island	TAS
Henderson Islets	TAS
Highfield	TAS
Hogan Group	TAS
Hunter Island	TAS
Isabella Island	TAS
Jacksons Cove	TAS
Kangaroo Island	TAS
Killiecrankie	TAS
Kings Run	TAS
Kings Run #2	TAS
Lavinia	TAS
Little Chalky Island	TAS
Little Island	TAS
Little Trefoil	TAS
Low Point	TAS
Lyons Cottage	TAS
Marshall Beach	TAS
Mile Island	TAS
Montagu Island	TAS
Mount Heemskirk	TAS
Mount Tanner	TAS
Mt Chappell Island	TAS
Nares Rocks	TAS
North East Islet	TAS
Palana Beach	TAS
Pasco Group	TAS
Penguin Islet	TAS
Petrel Islands	TAS
Phillip Island Nature Park	VIC
Pieman River	TAS
Prime Seal Island	TAS
Rame Head	VIC
Red Hut Point	TAS
Reef Island and Bass River Mouth N.C.R	VIC
Reid Rocks	TAS
Rocky Cape	TAS
Rodondo Island	TAS
Roydon Island	TAS
Sea Elephant	TAS
Seacrow Islet	TAS
Seal Islands W.R.	VIC
Sentinel Island	TAS

Name	State
Settlement Point	TAS
Sister Islands	TAS
Sisters Island	TAS
Slaves Bay	TAS
Southern Wilsons Promontory	VIC
Stack Island	TAS
Stanley	TAS
Stokes Point	TAS
Sugarloaf Rock	TAS
Sundown Point	TAS
Table Cape	TAS
Table Cape	TAS
Tatlows Beach	TAS
The Doughboys	TAS
The Nut	TAS
Three Hummock Island	TAS
Tikkawoppa Plateau	TAS
Unnamed C0293	VIC
Unnamed C1467	VIC
Ventnor B.R.	VIC
Wallaby Islands	TAS
West Moncoeur Island	TAS
West Point	TAS
Wilsons Promontory	VIC
Wilsons Promontory Islands	VIC
Wonthaggi Heathlands N.C.R	VIC
Wright Rock	TAS
Wybalenna Island	TAS

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
East Gippsland RFA	Victoria
Gippsland RFA	Victoria
Tasmania RFA	Tasmania

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Callipepla californica California Quail [59451]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Carduelis chloris European Greenfinch [404]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Meleagris gallopavo Wild Turkey [64380]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pavo cristatus Indian Peafowl, Peacock [919]		Species or species habitat likely to occur within area
Phasianus colchicus Common Pheasant [920]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Turdus philomelos Song Thrush [597]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus scandens Asparagus Fern, Climbing Asparagus Fern [23255]		Species or species habitat likely to occur within area
Carrichtera annua Ward's Weed [9511]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Cytisus scoparius Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Nassella neesiana Chilean Needle grass [67699]		Species or species habitat likely to occur within area
Nassella trichotoma Serrated Tussock, Yass River Tussock, Yass Tussock, Nassella Tussock (NZ) [18884]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Ulex europaeus Gorse, Furze [7693]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Anderson Inlet	VIC
Boulanger Bay - Robbins Passage	TAS
Lavinia Nature Reserve	TAS
Powlett River Mouth	VIC
Rocky Cape Marine Area	TAS
Unnamed Wetland	TAS
Western Port	VIC

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Big Horseshoe Canyon	South-east
Upwelling East of Eden	South-east
West Tasmania Canyons	South-east

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-37.116472 150.128575,-37.125232 150.128575,-37.06389 150.183507,-37.133991 150.282384,-37.396292 150.359288,-37.579359 150.579015,-37.80539 150.732823,-37.80539 150.337316,-37.883471 150.062657,-38.169061 149.700109,-38.582473 149.436437,-39.09591 149.095861,-39.359733 148.79923,-39.554831 148.491613,-39.639485 148.030187,-39.875967 147.744542,-39.934961 147.865392,-40.044386 147.909337,-40.279474 147.997228,-40.488686 147.799474,-40.722231 147.502843,-40.838698 147.085363,-40.913461 146.579991,-40.971552 145.975743,-40.95496 145.74503,-40.871936 145.492345,-40.788809 145.228673,-40.747206 144.888097,-40.663921 144.723302,-40.913461 144.635411,-41.368513 144.756261,-41.656446 144.91007,-41.983944 145.195714,-41.918578 144.723302,-41.368513 144.152013,-41.071018 143.778478,-41.153791 143.481847,-41.120694 143.415929,-40.971552 143.536779,-40.62224 143.602697,-40.572189 143.328038,-40.638916 142.84464,-40.463615 142.679845,-40.279474 142.943517,-40.287855 143.393956,-40.203999 143.844396,-40.061205 144.108068,-39.926536 144.141027,-39.816923 144.13004,-39.707134 144.119054,-39.631024 144.053136,-39.385211 143.866368,-39.359733 143.646642,-39.283241 143.833409,-39.15557 143.822423,-39.0362 143.690587,-39.104436 143.536779,-39.104436 143.371984,-38.967898 143.393956,-38.90808 143.481847,-38.916629 143.723546,-38.865322 144.097081,-38.805417 144.569493,-38.591061 144.921056,-38.487941 145.041905,-38.42772 145.305577,-38.479342 145.382482,-38.53952 145.470372,-38.71118 145.602208,-38.651145 145.74503,-38.719752 145.821935,-38.925176 145.920812,-38.882428 146.008702,-38.831097 146.085607,-38.899531 146.19547,-39.138529 146.349279,-39.138529 146.459142,-39.027666 146.492101,-38.839655 146.623937,-38.668303 146.898595,-38.28126 147.327062,-38.065339 147.656652,-38.004766 147.920323,-37.866127 148.282872,-37.822749 148.755284,-37.80539 149.249669,-37.779345 149.502355,-37.701154 149.722081,-37.59677 149.777013,-37.561943 149.842931,-37.579359 149.941808,-37.474804 150.073644,-37.116472 150.128575

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix 6

Victorian Biodiversity Atlas (VBA) search tool results

VICTORIAN BIODIVERSITY ATLAS - BASSGAS - ALL EMBAs				
Status	**Scientific Name**	**Common Name**	**Count of Sightings**	**Taxon ID**
		Seabirds		
	Aphrodroma brevirostris	Kerguelen Petrel	8	10935
	Ardenna bulleri	Buller's Shearwater	3	10975
	Ardenna carneipes	Flesh-footed Shearwater	9	10072
	Ardenna grisea	Sooty Shearwater	21	10070
	Ardenna pacifica	Wedge-tailed Shearwater	3	10069
	Ardenna tenuirostris	Short-tailed Shearwater	447	10071
	Calonectris leucomelas	Streaked Shearwater	1	10853
	Catharacta maccormicki	South Polar Skua	2	10979
	Daption capense	Cape Petrel	23	10080
VU vu L	Diomedea epomophora	Southern Royal Albatross	9	10974
VU en L	Diomedea exulans	Wandering Albatross	59	10086
	Fregetta tropica	Black-bellied Storm-Petrel	5	10066
	Fulmarus glacialoides	Southern Fulmar	20	10074
	Garrodia nereis	Grey-backed Storm-Petrel	3	10064
vu L	Haliaeetus leucogaster	White-bellied Sea-Eagle	430	10226
VU	Halobaena caerulea	Blue Petrel	20	10081
EN vu L	Macronectes giganteus	Southern Giant-Petrel	27	10929
VU nt L	Macronectes halli	Northern Giant-Petrel	26	10937
	Morus serrator	Australasian Gannet	349	10104
	Oceanites oceanicus	Wilson's Storm-Petrel	13	10063
	Pachyptila belcheri	Slender-billed Prion	25	10942
	Pachyptila crassirostris	Fulmar Prion	8	10947
	Pachyptila desolata	Antarctic Prion	14	10084
	Pachyptila salvini	Salvin's Prion	13	10941
vu	Pachyptila turtur	Fairy Prion	129	10083
	Pachyptila vittata	Broad-billed Prion	2	10082
	Pagodroma nivea	Snow Petrel	1	10984
	Pandion cristatus	Eastern Osprey	6	10241
vu	Pelagodroma marina	White-faced Storm-Petrel	38	10065
nt	Pelecanoides urinatrix	Common Diving-Petrel	85	10085
	Phaethon lepturus	White-tailed Tropicbird	4	10108
	Phaethon rubricauda	Red-tailed Tropicbird	1	10107
VU L	Phoebetria fusca	Sooty Albatross	2	10092
L	Phoebetria palpebrata	Light-mantled Sooty Albatr	2	10093
	Procellaria aequinoctialis	White-chinned Petrel	5	10915
	Procellaria cinerea	Grey Petrel	1	10073
	Procellaria parkinsoni	Black Petrel	4	10917
	Pterodroma inexpectata	Mottled Petrel	6	10919
	Pterodroma lessonii	White-headed Petrel	19	10077
EN	Pterodroma leucoptera	Gould's Petrel	6	10078
	Pterodroma macroptera	Great-winged Petrel	19	10075
	Pterodroma solandri	Providence Petrel	14	10971
	Puffinus assimilis	Little Shearwater	2	10067
	Puffinus gavia	Fluttering Shearwater	90	10068
	Puffinus huttoni	Hutton's Shearwater	14	10913

	Stercorarius antarcticus	Great Skua	27	10980
	Stercorarius longicaudus	Long-tailed Jaeger	3	10933
	Stercorarius parasiticus	Arctic Jaeger	42	10128
	Stercorarius pomarinus	Pomarine Jaeger	13	10945
VU L	Thalassarche bulleri	Buller's Albatross	11	10931
VU vu L	Thalassarche carteri	Indian Yellow-nosed Albatr	65	10089
VU vu L	Thalassarche cauta	Shy Albatross	140	10091
EN vu L	Thalassarche chrysostoma	Grey-headed Albatross	15	10090
VU vu	Thalassarche melanophris	Black-browed Albatross	160	10088
Shorebirds / Coastal Wetland / Wader				
vu	Actitis hypoleucos	Common Sandpiper	64	10157
	Aptenodytes patagonicus	King Penguin	2	10927
	Apus pacificus	Fork-tailed Swift	25	10335
vu L	Ardea alba	Great Egret	331	903268
en L	Ardea intermedia plumifera	Plumed Egret	522	10186
	Ardea pacifica	White-necked Heron	110	10189
vu	Arenaria interpres	Ruddy Turnstone	72	10129
EN en L	Botaurus poiciloptilus	Australasian Bittern	15	10197
	Bubulcus coromandus	Eastern Cattle Egret	50	10977
	Calidris acuminata	Sharp-tailed Sandpiper	107	10163
nt	Calidris alba	Sanderling	26	10166
EN en	Calidris canutus	Red Knot	107	10164
CR en L	Calidris ferruginea	Curlew Sandpiper	176	10161
nt	Calidris melanotos	Pectoral Sandpiper	2	10978
	Calidris pugnax	Ruff	1	10934
	Calidris ruficollis	Red-necked Stint	295	10162
CR en L	Calidris tenuirostris	Great Knot	34	10165
	Charadrius bicinctus	Double-banded Plover	155	10140
VU cr	Charadrius leschenaultii	Greater Sand Plover	13	10141
EN cr	Charadrius mongolus	Lesser Sand Plover	22	10139
	Charadrius ruficapillus	Red-capped Plover	379	10143
nt	Chlidonias hybrida	Whiskered Tern	20	10110
nt	Chlidonias leucopterus	White-winged Black Tern	2	10109
	Chroicocephalus novaehollandia	Silver Gull	1571	10125
	Cladorhynchus leucocephalus	Banded Stilt	8	10147
vu L	Dupetor flavicollis	Black Bittern	1	60196
en L	Egretta garzetta	Little Egret	172	10185
	Egretta novaehollandiae	White-faced Heron	1007	10188
	Egretta sacra	Eastern Reef Egret	15	10191
	Eudyptes chrysocome	Rockhopper Penguin	6	10003
	Eudyptes pachyrhynchus	Fiordland Penguin	4	10004
	Eudyptes sclateri	Erect-crested Penguin	1	10959
	Eudyptula minor	Little Penguin	556	10005
nt	Gallinago hardwickii	Latham's Snipe	84	10168
en L	Gelochelidon macrotarsa	Australian Gull-billed Tern	9	10111
nt	Haematopus fuliginosus	Sooty Oystercatcher	722	10131
	Haematopus longirostris	Pied Oystercatcher	586	10130
nt L	Hydroprogne caspia	Caspian Tern	829	10112
en L	Ixobrychus dubius	Australian Little Bittern	3	10195

	Larus dominicanus	Kelp Gull	108	10981
nt	Larus pacificus	Pacific Gull	2621	60126
CR en L	Lathamus discolor	Swift Parrot	25	10309
	Limicola falcinellus	Broad-billed Sandpiper	1	10167
VU	Limosa lapponica	Bar-tailed Godwit	299	10153
vu	Limosa limosa	Black-tailed Godwit	23	528553
	Microcarbo melanoleucos	Little Pied Cormorant	849	10100
CR cr L	Neophema chrysogaster	Orange-bellied Parrot	22	10305
CR vu L	Numenius madagascariensis	Eastern Curlew	575	10149
	Numenius minutus	Little Curlew	4	10151
vu	Numenius phaeopus	Whimbrel	394	10150
	Onychoprion fuscatus	Sooty Tern	1	10120
	Pelecanus conspicillatus	Australian Pelican	534	10106
	Phalacrocoracidae spp.		8	50316
	Phalacrocorax carbo	Great Cormorant	555	10096
nt	Phalacrocorax fuscescens	Black-faced Cormorant	378	10098
	Phalacrocorax sulcirostris	Little Black Cormorant	412	10097
nt	Phalacrocorax varius	Pied Cormorant	984	10099
	Platalea flavipes	Yellow-billed Spoonbill	140	10182
nt	Platalea regia	Royal Spoonbill	809	10181
vu	Pluvialis fulva	Pacific Golden Plover	33	10137
en	Pluvialis squatarola	Grey Plover	21	10136
	Procelsterna cerulea	Grey Ternlet	2	10982
EN cr L	Rostratula australis	Australian Painted-snipe	14	10170
	Spheniscus magellanicus	Magellanic Penguin	2	10858
	Sterna hirundo	Common Tern	36	10953
	Sterna paradisaea	Arctic Tern	6	10952
nt	Sterna striata	White-fronted Tern	66	10114
vu L	Sternula albifrons	Little Tern	73	10117
VU en L	Sternula nereis	Fairy Tern	84	10118
	Thalasseus bergii	Crested Tern	890	10115
VU vu L	Thinornis cucullatus	Hooded Plover	1522	10138
cr L	Tringa brevipes	Grey-tailed Tattler	19	10155
vu	Tringa glareola	Wood Sandpiper	4	10154
vu	Tringa nebularia	Common Greenshank	134	10158
vu	Tringa stagnatilis	Marsh Sandpiper	12	10159
en L	Xenus cinereus	Terek Sandpiper	6	10160
Terrestrial birds				
	Acanthagenys rufogularis	Spiny-cheeked Honeyeater	54	10640
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill	333	10486
	Acanthiza lineata	Striated Thornbill	166	10470
	Acanthiza nana	Yellow Thornbill	45	10471
	Acanthiza pusilla	Brown Thornbill	660	10475
	Acanthiza reguloides	Buff-rumped Thornbill	41	10484
	Acanthorhynchus tenuirostris	Eastern Spinebill	266	10591
	Accipiter cirrocephalus	Collared Sparrowhawk	42	10222
	Accipiter fasciatus	Brown Goshawk	207	10221
vu L	Accipiter novaehollandiae	Grey Goshawk	24	10220
	Accipitridae spp.	Hawks and Eagles	1	50392

*	Acridotheres tristis	Common Myna	210	10998
	Acrocephalus australis	Reed-Warbler	59	10524
	Aegotheles cristatus	Australian Owlet-nightjar	15	10317
*	Alauda arvensis	Eurasian Skylark	170	10993
*	Alectoris chukar	Chukar Partridge	1	10734
	Alisterus scapularis	Australian King-Parrot	70	10281
	Anas castanea	Chestnut Teal	618	10210
	Anas gracilis	Grey Teal	275	10211
*	Anas platyrhynchos	Mallard	11	10948
	Anas querquedula	Garganey	1	10209
	Anas spp.	Unidentified Ducks	4	9903
	Anas superciliosa	Pacific Black Duck	541	10208
*	Anas superciliosa X Anas platyr	Pacific Black Duck/Mallard	13	903490
	Anatidae spp.	Ducks, Geese, Swans	2	50239
	Anhinga novaehollandiae	Australasian Darter	17	10101
*	Anser anser	Domestic Goose	29	528558
	Anser spp.	Domestic Goose	1	50359
nt L	Anseranas semipalmata	Magpie Goose	37	10199
	Anthochaera carunculata	Red Wattlebird	616	10638
	Anthochaera chrysoptera	Little Wattlebird	537	10637
CR cr L	Anthochaera phrygia	Regent Honeyeater	13	10603
	Anthus australis	Australian Pipit	270	10647
vu L	Antigone rubicunda	Brolga	7	10177
	Aphelocephala leucopsis	Southern Whiteface	1	10466
	Aquila audax	Wedge-tailed Eagle	184	10224
cr L	Ardeotis australis	Australian Bustard	5	10176
	Artamus cyanopterus	Dusky Woodswallow	145	10547
	Artamus personatus	Masked Woodswallow	11	10544
	Artamus superciliosus	White-browed Woodswallo	32	10545
vu	Aythya australis	Hardhead	128	10215
	Barnardius zonarius barnardi	Mallee Ringneck	1	60291
	Barnardius zonarius zonarius	Port Lincoln Parrot	3	60294
vu	Biziura lobata	Musk Duck	335	10217
en L	Burhinus grallarius	Bush Stone-curlew	1	10174
	Butorides striata	Striated Heron	1	10193
	Cacatua galerita	Sulphur-crested Cockatoo	97	10269
	Cacatua sanguinea	Little Corella	5	10271
	Cacatua tenuirostris	Long-billed Corella	6	10272
	Cacomantis flabelliformis	Fan-tailed Cuckoo	222	10338
	Cacomantis pallidus	Pallid Cuckoo	103	10337
	Cacomantis variolosus	Brush Cuckoo	21	10339
	Calamanthus fuliginosus	Striated Fieldwren	83	10500
vu L	Calamanthus pyrrhopygius	Chestnut-rumped Heathwre	18	10498
	Caligavis chrysops	Yellow-faced Honeyeater	281	10614
	Callocephalon fimbriatum	Gang-gang Cockatoo	140	10268
	Calyptorhynchus funereus	Yellow-tailed Black-Cockat	226	10267
vu L	Calyptorhynchus lathami	Glossy Black-Cockatoo	10	10265
*	Carduelis carduelis	European Goldfinch	375	528559
	Cereopsis novaehollandiae	Cape Barren Goose	806	10198
nt	Ceyx azureus	Azure Kingfisher	69	10319

	Chenonetta jubata	Australian Wood Duck	197	10202
*	Chloris chloris	European Greenfinch	101	10997
	Chrysococcyx basalis	Horsfield's Bronze-Cuckoo	142	10342
	Chrysococcyx lucidus	Shining Bronze-Cuckoo	99	10344
nt	Chrysococcyx osculans	Black-eared Cuckoo	1	10341
	Cincloramphus cruralis	Brown Songlark	19	10508
	Cincloramphus mathewsi	Rufous Songlark	22	10509
nt	Cinclosoma punctatum	Spotted Quail-thrush	39	10436
	Circus approximans	Swamp Harrier	512	10219
nt	Circus assimilis	Spotted Harrier	14	10218
	Cisticola exilis	Golden-headed Cisticola	80	10525
	Colluricincla harmonica	Grey Shrike-thrush	538	10408
*	Columba livia	Domestic Pigeon	74	10957
	Coracina novaehollandiae	Black-faced Cuckoo-shrike	231	10424
	Coracina papuensis	White-bellied Cuckoo-shrik	6	10425
	Coracina tenuirostris	Common Cicadabird	9	10429
	Corcorax melanorhamphos	White-winged Chough	30	10693
	Cormobates leucophaea	White-throated Treecreepe	218	10558
	Climacteris erythrops	Red-browed Treecreeper	20	10560
	Corvidae spp.	Corvids	4	50287
	Corvus coronoides	Australian Raven	297	10930
	Corvus mellori	Little Raven	350	10954
*	Corvus splendens	House Crow	5	10867
	Corvus spp.	Ravens and Crows	62	50240
	Corvus tasmanicus	Forest Raven	80	10868
	Coturnix pectoralis	Stubble Quail	58	10009
	Cracticus torquatus	Grey Butcherbird	251	10702
	Cygnus atratus	Black Swan	1089	10203
	Dacelo novaeguineae	Laughing Kookaburra	392	10322
EN en L	Dasyornis brachypterus	Eastern Bristlebird	5	10519
nt L	Dasyornis broadbenti caryochrous	Rufous Bristlebird (Otway)	13	19011
	Dendrocygna arcuata	Wandering Whistling-Duck	2	10204
	Dendrocygna eytoni	Plumed Whistling-Duck	1	10205
	Dicaeum hirundinaceum	Mistletoebird	63	10564
	Dicrurus bracteatus	Spangled Drongo	10	10673
nt	Dromaius novaehollandiae	Emu	50	10001
	Elanus axillaris	Black-shouldered Kite	166	10232
	Elanus scriptus	Letter-winged Kite	8	10233
	Elseyornis melanops	Black-fronted Dotterel	156	10144
	Eolophus roseicapilla	Galah	212	10273
	Eopsaltria australis	Eastern Yellow Robin	461	10392
	Epthianura albifrons	White-fronted Chat	340	10448
	Epthianura tricolor	Crimson Chat	1	10449
	Erythrogonys cinctus	Red-kneed Dotterel	17	10132
	Eudynamys orientalis	Eastern Koel	3	10347
	Eurostopodus mystacalis	White-throated Nightjar	9	10330
	Eurystomus orientalis	Oriental Dollarbird	10	10318
	Falco berigora	Brown Falcon	231	10239
	Falco cenchroides	Nankeen Kestrel	246	10240

	Falco longipennis	Australian Hobby	55	10235
	Falco peregrinus	Peregrine Falcon	108	10237
vu L	Falco subniger	Black Falcon	12	10238
	Falcunculus frontatus	Eastern Shrike-tit	72	10416
	fam. Fregatidae gen. Fregata	Frigatebirds	1	10733
	Fregata minor	Great Frigatebird	1	10094
	Fulica atra	Eurasian Coot	253	10059
	Gallinula tenebrosa	Dusky Moorhen	150	10056
	Gavicalis virescens	Singing Honeyeater	116	10608
	Geopelia placida	Peaceful Dove	11	10030
	Gerygone mouki	Brown Gerygone	15	10454
	Gerygone olivacea	White-throated Gerygone	8	10453
	Glossopsitta concinna	Musk Lorikeet	91	10258
	Glyciphila melanops	Tawny-crowned Honeyeate	56	10593
	Grallina cyanoleuca	Magpie-lark	494	10415
	Gymnorhina tibicen	Australian Magpie	978	10705
	Haliastur sphenurus	Whistling Kite	224	10228
	Hieraaetus morphnoides	Little Eagle	54	10225
	Himantopus leucocephalus	Pied Stilt	91	528555
VU vu L	Hirundapus caudacutus	White-throated Needletail	145	10334
	Hirundo neoxena	Welcome Swallow	916	10357
	Hypotaenidia philippensis	Buff-banded Rail	26	10046
	Lalage tricolor	White-winged Triller	30	10430
	Latridopsis forsteri	Bastard Trumpeter	24	100053
	Leucosarcia melanoleuca	Wonga Pigeon	51	10044
vu L	Lewinia pectoralis	Lewin's Rail	19	10045
vu	Lichenostomus cratitius	Purple-gaped Honeyeater	1	10620
	Lichenostomus melanops	Yellow-tufted Honeyeater	26	10619
vu L	Lophoictinia isura	Square-tailed Kite	2	10230
	Lopholaimus antarcticus	Topknot Pigeon	2	10027
	Malacorhynchus membranaceus	Pink-eared Duck	18	10213
	Malurus cyaneus	Superb Fairy-wren	883	10529
	Malurus spp.	Fairywrens	1	50398
	Manorina melanocephala	Noisy Miner	75	10634
	Manorina melanophrys	Bell Miner	99	10633
nt L	Melanodryas cucullata	Hooded Robin	13	10385
	Meliphaga lewinii	Lewin's Honeyeater	69	10605
	Melithreptus brevirostris	Brown-headed Honeyeater	99	10583
	Melithreptus gularis	Black-chinned Honeyeater	2	10580
	Melithreptus lunatus	White-naped Honeyeater	219	10578
	Melopsittacus undulatus	Budgerigar	2	10310
	Menura novaehollandiae	Superb Lyrebird	46	10350
	Merops ornatus	Rainbow Bee-eater	9	10329
	Microeca fascinans	Jacky Winter	80	10377
	Milvus migrans	Black Kite	2	10229
	Mirafra javanica	Horsfield's Bushlark	8	10648
	Monarcha melanopsis	Black-faced Monarch	23	10373
	Motacilla alba	White Wagtail	1	10874
	Myiagra cyanoleuca	Satin Flycatcher	67	10366
	Myiagra inquieta	Restless Flycatcher	41	10369

	Myiagra rubecula	Leaden Flycatcher	36	10365
	Myzomela sanguinolenta	Scarlet Honeyeater	9	10586
	Neochmia temporalis	Red-browed Finch	326	10662
	Neophema chrysostoma	Blue-winged Parrot	58	10306
nt L	Neophema pulchella	Turquoise Parrot	2	10302
	Nesoptilotis leucotis	White-eared Honeyeater	268	10617
	Ninox boobook	Southern Boobook	124	10242
en L	Ninox connivens	Barking Owl	7	10246
vu L	Ninox strenua	Powerful Owl	16	10248
nt	Nycticorax caledonicus	Nankeen Night-Heron	239	10192
	Nymphicus hollandicus	Cockatiel	4	10274
	Ocyphaps lophotes	Crested Pigeon	2	10043
	Oriolus sagittatus	Olive-backed Oriole	59	10671
en L	Oxyura australis	Blue-billed Duck	57	10216
	Pachycephala olivacea	Olive Whistler	105	10405
	Pachycephala pectoralis	Golden Whistler	291	10398
	Pachycephala rufiventris	Rufous Whistler	144	10401
	Pardalotus punctatus	Spotted Pardalote	196	10565
	Pardalotus spp.	Pardalotes	14	50396
	Pardalotus striatus	Striated Pardalote	145	10976
	Parvipsitta porphyrocephala	Purple-crowned Lorikeet	12	10259
	Parvipsitta pusilla	Little Lorikeet	26	10260
*	Passer domesticus	House Sparrow	399	10995
*	Passer montanus	Eurasian Tree Sparrow	13	10994
*	Pavo cristatus	Indian Peafowl	2	10903
	Petrochelidon ariel	Fairy Martin	54	10360
	Petrochelidon nigricans	Tree Martin	88	10359
	Petroica boodang	Scarlet Robin	151	10380
	Petroica goodenovii	Red-capped Robin	3	10381
	Petroica phoenicea	Flame Robin	207	10382
	Petroica rodinogaster	Pink Robin	43	10383
	Petroica rosea	Rose Robin	42	10384
en L	Pezoporus wallicus	Ground Parrot	44	10311
	Phaps chalcoptera	Common Bronzewing	88	10034
	Phaps elegans	Brush Bronzewing	132	10035
	Philemon citreogularis	Little Friarbird	2	10646
	Philemon corniculatus	Noisy Friarbird	16	10645
	Phylidonyris novaehollandiae	New Holland Honeyeater	684	10631
	Phylidonyris pyrrhopterus	Crescent Honeyeater	168	10630
	Platycercus elegans	Crimson Rosella	318	10282
	Platycercus eximius	Eastern Rosella	306	10288
	Plectorhyncha lanceolata	Striped Honeyeater	1	10585
nt	Plegadis falcinellus	Glossy Ibis	9	10178
	Podargus strigoides	Tawny Frogmouth	41	10313
	Podiceps cristatus	Great Crested Grebe	31	10060
	Podicipedidae spp.	Grebes	3	50314
	Poliocephalus poliocephalus	Hoary-headed Grebe	225	10062
en L	Pomatostomus temporalis	Grey-crowned Babbler	7	10443
	Poodytes gramineus	Little Grassbird	67	10522
	Porphyrio melanotus	Australasian Swamphen	541	10058

	Porzana fluminea	Australian Spotted Crake	16	10049
vu L	Porzana pusilla	Baillon's Crake	7	10050
	Porzana tabuensis	Spotless Crake	8	10051
	Psephotus haematonotus	Red-rumped Parrot	12	10295
	Psophodes olivaceus	Eastern Whipbird	219	10421
	Ptilinopus regina	Rose-crowned Fruit-Dove	1	10021
	Ptilinopus superbus	Superb Fruit-Dove	1	10023
	Ptilonorhynchus violaceus	Satin Bowerbird	59	10679
	Ptilotula fusca	Fuscous Honeyeater	6	10613
	Ptilotula ornata	Yellow-plumed Honeyeater	3	10622
	Ptilotula penicillata	White-plumed Honeyeater	250	10625
	Pycnoptilus floccosus	Pilotbird	24	10506
vu L	Pyrrholaemus sagittatus	Speckled Warbler	6	10504
	Recurvirostra novaehollandiae	Red-necked Avocet	10	10148
	Rhipidura albiscapa	Grey Fantail	707	10361
	Rhipidura leucophrys	Willie Wagtail	666	10364
	Rhipidura rufifrons	Rufous Fantail	69	10362
	Sericornis frontalis	White-browed Scrubwren	579	10488
	Sericornis magnirostra	Large-billed Scrubwren	6	10494
	Smicrornis brevirostris	Weebill	9	10465
vu	Spatula rhynchotis	Australasian Shoveler	250	10212
*	Spilopelia chinensis	Spotted Dove	223	10989
	Stagonopleura bella	Beautiful Firetail	86	10650
nt L	Stagonopleura guttata	Diamond Firetail	12	10652
en L	Stictonetta naevosa	Freckled Duck	18	10214
	Stipiturus malachurus	Southern Emu-wren	85	10526
	Strepera graculina	Pied Currawong	159	10694
	Strepera versicolor	Grey Currawong	277	10697
*	Sturnus vulgaris	Common Starling	672	10999
en L	Synoicus chinensis	King Quail	4	10012
	Synoicus ypsilophorus	Brown Quail	22	10010
	Tachybaptus novaehollandiae	Australasian Grebe	216	10061
	Tadorna tadornoides	Australian Shelduck	306	10207
	Threskiornis molucca	Australian White Ibis	1082	10179
	Threskiornis spinicollis	Straw-necked Ibis	507	10180
	Todiramphus sanctus	Sacred Kingfisher	87	10326
	Tribonyx ventralis	Black-tailed Native-hen	9	10055
	Trichoglossus molucannus	Rainbow Lorikeet	214	10254
*	Turdus merula	Common Blackbird	577	10991
*	Turdus philomelos	Song Thrush	5	10992
	Turnix varius	Painted Button-quail	16	10014
nt	Turnix velox	Little Button-quail	5	10018
	Tyto alba	Barn Owl	54	10249
	Tyto longimembris	Eastern Grass Owl	2	10252
en L	Tyto novaehollandiae	Masked Owl	7	10250
vu L	Tyto tenebricosa	Sooty Owl	6	10253
	Vanellus miles	Masked Lapwing	1234	10133
	Vanellus tricolor	Banded Lapwing	37	10135
	Zoothera lunulata	Bassian Thrush	103	10779
	Zosterops lateralis	Silvereye	641	10574

Terrestrial Flora				
*	Acacia baileyana	Cootamundra Wattle	1	500014
	Acacia dealbata	Silver Wattle	2	500025
#	Acacia floribunda	White Sallow-wattle	1	500036
	Acacia genistifolia	Spreading Wattle	2	500038
	Acacia implexa	Lightwood	1	500045
#	Acacia longifolia	Sallow Wattle	10	505128
#	Acacia longifolia subsp. longifoli	Sallow Wattle	27	500053
#	Acacia longifolia subsp. sophora	Coast Wattle	35	500088
	Acacia mearnsii	Black Wattle	25	500056
	Acacia melanoxylon	Blackwood	9	500057
	Acacia mucronata subsp. longifo	Narrow-leaf Wattle	1	500062
	Acacia oxycedrus	Spike Wattle	2	500071
	Acacia paradoxa	Hedge Wattle	6	500072
	Acacia pycnantha	Golden Wattle	3	500078
#	Acacia retinodes s.l.	Wirilda	2	500079
*	Acacia saligna	Golden Wreath Wattle	1	500084
	Acacia spp.	Wattle	1	508003
	Acacia stricta	Hop Wattle	9	500091
	Acacia suaveolens	Sweet Wattle	2	500092
	Acacia terminalis	Sunshine Wattle	2	500095
	Acacia ulicifolia	Juniper Wattle	1	500098
r	Acacia uncifolia	Coast Wirilda	1	504210
	Acacia verticillata	Prickly Moses	33	500100
	Acacia verticillata subsp. ovoide	Ovoid Prickly Moses	1	504212
	Acacia verticillata subsp. verticil	Prickly Moses	4	504213
	Acaena agnipila	Hairy Sheep's Burr	3	500104
	Acaena agnipila/ovina complex	Hairy/Australian Sheep's B	1	505371
	Acaena novae-zelandiae	Bidgee-widgee	71	500105
	Acaena spp.	Sheep's Burr	1	508004
	Acaena X ovina	Australian Sheep's Burr	1	500107
*	Acetosella vulgaris	Sheep Sorrel	13	502966
*	Achillea distans	Tansyleaf Milfoil	1	505656
	Achrophyllum dentatum	Toothed Mitre-moss	2	506009
	Acianthus exsertus s.l.	Gnat Orchid	2	500111
	Acianthus pusillus	Small Mosquito-orchid	3	504439
	Acrocladium chlamydophyllum	Spear Moss	1	506013
r L	Acronychia oblongifolia	Yellow-wood	1	500116
	Acrotriche affinis	Ridged Ground-berry	3	500118
	Acrotriche prostrata	Trailing Ground-berry	1	500122
	Acrotriche serrulata	Honey-pots	10	500123
	Actites megalocarpus	Dune Thistle	22	500127
	Adiantum aethiopicum	Common Maidenhair	3	500129
vu	Adriana quadripartita	Coast Bitter-bush	2	504755
*	Agapanthus praecox subsp. orie	Agapanthus	5	503638
*	Agrostis capillaris	Brown-top Bent	12	500153
*	Agrostis capillaris var. capillaris	Brown-top Bent	1	504225
	Agrostis s.l. spp.	Bent/Blown Grass	3	508022
*	Agrostis stolonifera	Creeping Bent	1	500160

	Agrostis venusta	Misty Bent	2	500161
*	Agrostis viridis	Water Bent	1	500162
*	Aira caryophyllea subsp. caryop	Silvery Hair-grass	12	500164
*	Aira caryophyllea/elegantissima	Silvery/Delicate Hair-grass	3	507551
*	Aira cupaniana	Quicksilver Grass	7	500165
*	Aira elegantissima	Delicate Hair-grass	16	500166
*	Aira praecox	Early Hair-grass	4	500167
*	Aira spp.	Hair Grass	12	508024
	Ajuga australis	Austral Bugle	2	500168
*	Allium triquetrum	Angled Onion	3	500179
	Allocasuarina littoralis	Black Sheoak	2	500677
	Allocasuarina paludosa	Scrub Sheoak	7	500683
	Allocasuarina paradoxa	Green Sheoak	3	503647
	Allocasuarina spp.	Sheoak	1	508033
	Allocasuarina verticillata	Drooping Sheoak	31	500685
*	Aloe maculata	Common Soap Aloe	2	503651
	Althenia cylindrocarpa	Long-fruit Water-mat	1	501934
	Alyxia buxifolia	Sea Box	34	500188
	Amaranthus spp.	Amaranth	2	508038
*	Amaryllis belladonna	Belladonna Lily	1	503643
*	Ammophila arenaria	Marram Grass	34	500205
	Amperea xiphoclada var. xiphoc	Broom Spurge	3	500206
	Amphibolurus muricatus	Tree Dragon	13	12194
	Amphibromus archeri	Pointed Swamp Wallaby-gr	1	500208
vu	Amphibromus sinuatus	Wavy Swamp Wallaby-gras	5	503625
	Amphibromus spp.	Swamp Wallaby-grass	1	508046
	Amyema pendula	Drooping Mistletoe	4	500220
	Amyema spp.	Mistletoe	2	508049
	Angianthus preissianus	Salt Angianthus	1	500228
	Anisopogon avenaceus	Oat Spear-grass	3	500231
	Anous stolidus	Brown Noddy	1	10122
	Anthosachne scabra s.l.	Common Wheat-grass	28	500146
	Anthosachne scabra s.s.	Common Wheat-grass	2	528409
*	Anthoxanthum odoratum	Sweet Vernal-grass	44	500236
	Aotus ericoides	Common Aotus	5	500237
	Apalochlamys spectabilis	Showy Cassinia	2	500238
	Apium annuum	Annual Celery	2	500244
vu	Apium insulare	Island Celery	5	500246
	Apium prostratum subsp. prostr	Sea Celery	27	500247
	Apium prostratum subsp. prostr	Sea Celery	5	504236
	Apodasmia brownii	Coarse Twine-rush	4	501937
*	Arctotheca calendula	Cape weed	30	500255
	Areschougia congesta		4	100860
	Arthrocardia wardii		76	102559
	Arthropodium spp. (s.s.)	Vanilla Lily	2	508079
	Asparagopsis armata		5	100454
*	Asparagus asparagoides	Bridal Creeper	44	500274
*	Asparagus filicinus	Fern Asparagus	1	507556
*	Asparagus officinalis	Asparagus	1	500275
*	Asparagus scandens	Asparagus Fern	17	500276

	Asperula conferta	Common Woodruff	7	500278
	Asperula scoparia subsp. scopa	Prickly Woodruff	5	500284
	Asperula spp.	Woodruff	2	508082
	Asplenium flabellifolium	Necklace Fern	5	500288
vu	Asplenium obtusatum subsp. nc	Shore Spleenwort	15	500291
	Asteraceae spp.	Composite	6	507554
	Astralium tentoriformis	Common Tent Shell	6	100264
	Astroloma humifusum	Cranberry Heath	11	500304
	Astroloma spp.	Heath	1	508090
	Atriplex australasica	Native Orache	2	503621
ex L	Atriplex billardierei	Glistening Saltbush	2	503360
	Atriplex cinerea	Coast Saltbush	10	500316
r	Atriplex paludosa subsp. paludo	Marsh Saltbush	8	500326
*	Atriplex patula	Spear Orache	1	500328
*	Atriplex prostrata	Hastate Orache	27	500318
	Atriplex semibaccata	Berry Saltbush	1	500332
	Austrophyllis alcicornis		1	510645
	Austrostipa flavescens	Coast Spear-grass	23	503276
	Austrostipa mollis	Supple Spear-grass	3	503279
	Austrostipa pubinodis	Tall Spear-grass	2	503288
	Austrostipa rudis	Veined Spear-grass	2	503289
	Austrostipa rudis subsp. nervosa	Veined Spear-grass	1	504941
	Austrostipa semibarbata	Fibrous Spear-grass	2	503291
	Austrostipa spp.	Spear Grass	11	509099
	Austrostipa stipoides	Prickly Spear-grass	32	503293
*	Avena barbata	Bearded Oat	3	500340
*	Avena fatua	Wild Oat	3	500341
*	Avena spp.	Oat	11	508098
r	Avicennia marina subsp. austral	Grey Mangrove	4	500345
	Baloskion tetraphyllum subsp. te	Tassel Cord-rush	1	502926
	Banksia integrifolia subsp. integ	Coast Banksia	41	500362
	Banksia marginata	Silver Banksia	11	500363
	Banksia serrata	Saw Banksia	4	500366
	Barbula calycina	Common Beard-moss	3	506694
	Baumea acuta	Pale Twig-sedge	5	500373
	Baumea juncea	Bare Twig-sedge	13	500377
	Baumea spp.	Twig Sedge	1	508121
	Bedfordia arborescens	Blanket Leaf	1	500382
k	Berula erecta	Water Parsnip	1	503165
*	Beta vulgaris	Beet	1	503795
*	Billardiera heterophylla	Bluebell Creeper	1	503202
	Billardiera mutabilis	Common Apple-berry	2	504291
	Billardiera scandens s.l.	Common Apple-berry	4	500403
	Blechnum nudum	Fishbone Water-fern	1	500408
	Blechnum wattsii	Hard Water-fern	2	500413
	Bolboschoenus caldwellii	Salt Club-sedge	1	500416
*	Borago officinalis	Borage	1	500418
	Boronia muelleri	Forest Boronia	1	500427
	Boronia nana	Dwarf Boronia	1	500428
	Boronia parviflora	Swamp Boronia	2	500429

	Bossiaea prostrata	Creeping Bossiaea	11	500440
	Brachyloma daphnoides	Daphne Heath	5	500483
	Brachyscome aculeata	Branching Daisy	1	500448
	Brachyscome diversifolia	Tall Daisy	8	500456
	Brachyscome graminea	Grass Daisy	4	500460
	Brachyscome parvula	Coast Daisy	6	500469
	Brachyscome parvula var. parvu	Coast Daisy	1	504303
	Brachyscome spathulata	Spoon Daisy	3	500478
	Brachyscome spp.	Daisy	1	508146
*	Brassica fruticulosa	Twiggy Turnip	2	500488
*	Brassica nigra	Black Mustard	1	500491
*	Briza maxima	Large Quaking-grass	13	500495
*	Briza minor	Lesser Quaking-grass	19	500496
r	Bromus arenarius	Sand Brome	1	500497
*	Bromus catharticus	Prairie Grass	18	500498
*	Bromus catharticus var. elatus	Chilean Brome	1	503723
*	Bromus diandrus	Great Brome	44	500500
*	Bromus hordeaceus	Soft Brome	24	500501
*	Bromus madritensis	Madrid Brome	1	500503
	Bromus spp.	Brome	1	508150
	Brunonia australis	Blue Pincushion	1	500508
	Bryum argenteum	Silver Moss	1	506095
	Bulbine bulbosa	Bulbine Lily	5	500510
r	Bulbine crassa	Coast Lily	16	507703
	Bulbine glauca	Rock Lily	7	503657
	Bulbine semibarbata	Leek Lily	1	500511
	Burchardia umbellata	Milkmaids	5	500512
	Bursaria spinosa	Sweet Bursaria	14	505690
	Bursaria spinosa subsp. spinosa	Sweet Bursaria	43	500515
	Caladenia carnea sensu Willis (	Pink Fingers	2	500527
	Caladenia catenata s.l.	Pink Fingers/White Fingers	1	503667
	Caladenia congesta	Black-tongue Hood-orchid	1	500529
	Caladenia latifolia	Pink Fairies	22	500537
	Caladenia moschata	Musk Hood-orchid	5	500535
	Caladenia phaeoclavia	Brown-clubbed Spider-orch	3	504344
	Caladenia pusilla	Tiny Pink-fingers	1	500545
	Caladenia spp.	Caladenia	2	508171
	Caladenia tentaculata	Mantis Orchid	1	503677
VU vu	Caladenia tessellata	Thick-lip Spider-orchid	1	500547
r	Caladenia vulgaris	Slender Pink-fingers	5	504449
	Calandrinia calyptrata	Pink Purslane	9	500551
	Caleana major	Large Duck-orchid	1	500557
#	Callistemon citrinus	Crimson Bottlebrush	2	500562
	Callitriche spp.	Water Starwort	1	508177
*	Callitriche stagnalis	Common Water-starwort	1	500574
	Calocephalus lacteus	Milky Beauty-heads	30	500583
	Calochilus campestris	Copper Beard-orchid	1	500585
	Calomeria amaranthoides	Incense Plant	2	500590
	Calorophus (monotypic)	Rope Rush	1	508182
	Calyptrochaeta apiculata	Priest's-cap Mitre-moss	1	506251

	Calystegia sepium subsp. rosea	Large Bindweed	1	500604
	Campylopus clavatus	Broody Swan-neck Moss	1	506137
	Campylopus introflexus	Heath Star Moss	2	506140
	Campylopus spp.	Swan-neck Moss	2	509341
*	Capsella bursa-pastoris	Shepherd's Purse	1	500611
	Cardamine gunnii s.l.	Common Bitter-cress	4	500613
*	Cardamine hirsuta s.s.	Common Bitter-cress	2	505022
	Cardamine spp.	Bitter Cress	3	508191
P	Cardamine tenuifolia	Slender Bitter-cress	3	500617
*	Carduus pycnocephalus	Slender Thistle	4	500620
*	Carduus spp.	Slender Thistle	1	508193
*	Carduus tenuiflorus	Winged Slender-thistle	7	500621
	Carex appressa	Tall Sedge	2	500623
	Carex breviculmis	Common Grass-sedge	18	500627
	Carex fascicularis	Tassel Sedge	1	500638
	Carex incomitata	Hillside Sedge	1	503661
	Carex inversa	Knob Sedge	3	500642
	Carex pumila	Strand Sedge	4	500648
	Carex spp.	Sedge	3	508194
*	Carpobrotus aequilaterus	Angled Pigface	2	500654
*	Carpobrotus edulis	Hottentot Fig	1	500655
	Carpobrotus rossii	Karkalla	26	500657
	Carpobrotus spp.	Pigface	2	508196
	Caryophyllaceae spp.	Carnation	2	507065
	Cassinia aculeata subsp. aculea	Common Cassinia	6	500666
	Cassinia complanata	Sticky Cassinia	1	500670
	Cassinia longifolia	Shiny Cassinia	1	500668
r	Cassinia maritima	Coast Cassinia	2	507665
	Cassinia spp.	Cassinia	1	508200
	Cassytha glabella	Slender Dodder-laurel	11	500671
	Cassytha glabella f. dispar	Slender Dodder-laurel	1	504681
	Cassytha glabella f. glabella	Slender Dodder-laurel	1	504680
	Cassytha melantha	Coarse Dodder-laurel	9	500672
	Cassytha phaeolasia	Rusty Dodder-laurel	1	500673
	Cassytha pubescens s.s.	Downy Dodder-laurel	12	500674
	Cassytha spp.	Dodder Laurel	1	508201
*	Catapodium rigidum	Fern Grass	7	500687
	Caustis flexuosa	Curly Wig	1	500688
*	Cenchrus clandestinus	Kikuyu	27	502451
*	Centaurea melitensis	Malta Thistle	1	500698
*	Centaurium erythraea	Common Centaury	24	500702
*	Centaurium spp.	Centaury	12	508208
*	Centaurium tenuiflorum	Slender Centaury	22	500705
	Centella cordifolia	Centella	7	500706
	Centrolepis aristata	Pointed Centrolepis	3	500711
	Centrolepis fascicularis	Tufted Centrolepis	1	500713
	Centrolepis polygyna	Wiry Centrolepis	1	500715
	Centrolepis strigosa subsp. strig	Hairy Centrolepis	8	500716
*	Cerastium diffusum	Sea Mouse-ear Chickweed	1	500717
*	Cerastium glomeratum s.l.	Common Mouse-ear Chick	23	500719

*	Cerastium glomeratum s.s.	Sticky Mouse-ear Chickwee	4	505238
*	Cerastium semidecandrum s.s.	Little Mouse-ear Chickweed	1	505239
*	Cerastium spp.	Mouse-ear Chickweed	1	508213
	Ceratodon purpureus subsp. co	Redshank Moss	2	506154
	Chamaescilla corymbosa var. co	Blue Stars	2	500726
	Cheilanthes austrotenuifolia	Green Rock-fern	3	500730
	Cheilanthes sieberi subsp. siebe	Narrow Rock-fern	2	500733
	Cheilanthes spp.	Rock Fern	1	508220
	Chenopodiaceae spp.	Chenopod	1	507061
*	Chenopodium album	Fat Hen	7	500736
	Chenopodium glaucum	Glaucous Goosefoot	6	500744
*	Chenopodium murale	Sowbane	10	500746
	Chenopodium spp.	Goosefoot	5	508222
	Chiloglottis reflexa	Autumn Wasp-orchid	1	500753
	Chiloglottis trapeziformis	Dainty Wasp-orchid	1	500754
	Chiloscyphus semiteres s.l.	Common Crestwort	5	506447
*	Chloris gayana	Rhodes Grass	1	500755
	Chorizandra cymbaria s.l.	Heron Bristle-sedge	1	500764
	Chorizandra enodis	Black Bristle-sedge	3	500765
	Chromis hypsilepis	Onespot Puller	12	100045
*	Chrysanthemoides monilifera	Boneseed	1	500770
*	Chrysanthemoides monilifera su	African Boneseed	1	504359
	Chrysocephalum apiculatum s.l.	Common Everlasting	3	501606
	Chrysocephalum apiculatum s.s	Common Everlasting	4	504281
	Chrysocephalum baxteri	White Everlasting	2	501608
	Chrysocephalum semipapposun	Clustered Everlasting	1	501628
*	Cicendia quadrangularis	Square Cicendia	1	500777
*	Cirsium spp.	Thistle	1	508238
*	Cirsium vulgare	Spear Thistle	45	500782
	Clematis aristata	Mountain Clematis	16	500788
	Clematis glycinoides	Forest Clematis	2	500789
	Clematis microphylla s.l.	Small-leaved Clematis	83	500790
	Clematis microphylla s.s.	Small-leaved Clematis	3	507386
	Clematis microphylla var. microp	Small-leaved Clematis	2	504312
	Clematis spp.	Clematis	5	508243
nt	Climacteris picumnus	Brown Treecreeper	8	60555
	Comesperma calymega	Blue-spike Milkwort	1	500795
	Comesperma ericinum	Heath Milkwort	2	500797
	Comesperma volubile	Love Creeper	14	500801
	Coprosma quadrifida	Prickly Currant-bush	4	500822
*	Coprosma repens	Mirror Bush	29	500823
	Coronidium elatum subsp. elatu	Tall Everlasting	3	501617
	Coronidium scorpioides s.s.	Button Everlasting	1	501626
	Coronidium spp.	Everlasting	1	508527
	Correa alba	White Correa	38	500829
	Correa alba var. alba	White Correa	3	504363
	Correa reflexa	Common Correa	12	500832
	Correa reflexa var. reflexa	Common Correa	2	504370
	Correa reflexa var. speciosa	Eastern Correa	2	504368

	Correa spp.	Correa	1	508257
*	Cortaderia selloana	Pampas Grass	5	500825
	Corunastylis archeri	Elfin Midge-orchid	1	502698
k	Corunastylis ciliata	Fringed Midge-orchid	2	502040
	Corunastylis despectans	Sharp Midge-orchid	1	502705
r	Corunastylis nuda	Tiny Midge-orchid	1	502700
r	Corybas aconitiflorus	Spurred Helmet-orchid	1	500835
r	Corybas fimbriatus	Fringed Helmet-orchid	2	500839
	Corybas incurvus	Slaty Helmet-orchid	5	500837
	Corybas spp.	Helmet Orchid	11	508260
	Corybas unguiculatus	Small Pelican-orchid	2	500842
*	Cotoneaster spp.	Cotoneaster	1	508262
	Cotula australis	Common Cotula	5	500846
*	Cotula coronopifolia	Water Buttons	30	500848
	Cotula spp.	Cotula	1	508263
	Cotula vulgaris var. australasica	Slender Cotula	1	500851
	Craspedia variabilis	Variable Billy-buttons	1	504650
	Crassula colorata	Dense Crassula	1	500859
	Crassula decumbens var. decur	Spreading Crassula	6	500860
	Crassula helmsii	Swamp Crassula	7	500862
*	Crassula natans var. minus	Water Crassula	1	500863
	Crassula sieberiana s.l.	Sieber Crassula	18	500866
	Crassula sieberiana s.s.	Sieber Crassula	5	504378
	Crassula spp.	Crassula	3	508265
	Crassula tetramera	Australian Stonecrop	2	504337
*	Crataegus monogyna	Hawthorn	5	500867
*	Crataegus spp.	Hawthorn	1	508266
*	Crepis capillaris	Smooth Hawksbeard	1	500869
*	Crocosmia X crocosmiiflora	Montbretia	1	500875
	Cryptostylis subulata	Large Tongue-orchid	1	500884
*	Cupressus spp.	Cypress	1	508279
	Cyathea australis	Rough Tree-fern	1	500895
	Cymbonotus preissianus	Austral Bear's-ear	1	500903
*	Cynara cardunculus subsp. flav	Artichoke Thistle	1	500906
	Cynodon dactylon	Couch	9	500907
*	Cynodon dactylon var. dactylon	Couch	8	504554
	Cynoglossum australe	Australian Hound's-tongue	12	500908
	Cynoglossum spp.	Hound's Tongue	7	508289
	Cynoglossum suaveolens	Sweet Hound's-tongue	1	500910
*	Cynosurus echinatus	Rough Dog's-tail	6	500912
*	Cyperus eragrostis	Drain Flat-sedge	2	500918
	Cyrtostylis reniformis	Small Gnat-orchid	6	500112
	Cyrtostylis robusta	Large Gnat-orchid	4	500890
	Cyrtostylis spp.	Gnat Orchid	4	508294
*	Dactylis glomerata	Cocksfoot	30	500948
	Dampiera stricta	Blue Dampiera	2	500958
	Daphoenositta chrysoptera	Varied Sittella	68	10549
	Daucus glochidiatus	Australian Carrot	28	500989
	Daviesia benthamii subsp. humi	Spiny Bitter-pea	3	500992
	Daviesia ulicifolia	Gorse Bitter-pea	1	500999

*	Delairea odorata	Cape Ivy	5	503118
	Desmodium gunnii	Southern Tick-trefoil	4	501008
	Deyeuxia densa	Heath Bent-grass	1	501016
	Deyeuxia minor	Small Bent-grass	1	501020
	Deyeuxia quadriseta	Reed Bent-grass	14	501023
	Dianella brevicaulis	Small-flower Flax-lily	31	504412
	Dianella caerulea s.l.	Paroo Lily	1	501027
	Dianella laevis	Smooth Flax-lily	1	505559
	Dianella longifolia s.l.	Pale Flax-lily	11	501028
	Dianella longifolia var. longifolia	Pale Flax-lily	3	504420
	Dianella revoluta s.l.	Black-anther Flax-lily	23	501029
	Dianella revoluta var. revoluta s	Black-anther Flax-lily	3	504413
	Dianella sp. aff. revoluta (Coast	Coast Flax-lily	1	505557
	Dianella spp.	Flax Lily	7	508327
	Dianella tasmanica	Tasman Flax-lily	8	501030
	Dicathais orbita	Cart-wheel Purple	193	100250
	Dichelachne crinita	Long-hair Plume-grass	23	501033
	Dichelachne rara	Common Plume-grass	4	503792
	Dichelachne sciurea spp. agg.	Short-hair Plume-grass	6	501034
	Dichelachne sieberiana	Rough Plume-grass	1	503791
	Dichelachne spp.	Plume Grass	1	508330
	Dichondra repens	Kidney-weed	93	501036
	Dicksonia antarctica	Soft Tree-fern	2	501039
	Dicranoloma billarderi	Common Fork-moss	2	506201
*	Digitaria sanguinalis	Summer Grass	1	501048
	Dillwynia glaberrima	Smooth Parrot-pea	2	501051
	Dillwynia sericea	Showy Parrot-pea	4	501058
	Diplarrena moraea	White Iris	2	501063
	Dipodium punctatum s.l.	Hyacinth Orchid	3	501068
	Dipodium roseum s.l.	Rosy Hyacinth-orchid	1	504501
	Dipodium roseum s.s.	Rosy Hyacinth-orchid	3	504889
*	Dipogon lignosus	Common Dipogon	3	501069
*	Disa bracteata	South African Orchid	1	505483
	Disphyma crassifolium subsp. c	Rounded Noon-flower	51	501073
	Distichlis distichophylla	Australian Salt-grass	44	501076
	Distichophyllum pulchellum	Round-leaf Mitre-moss	1	506221
*	Dittrichia graveolens	Stinkwort	1	501077
	Diuris chryseopsis	Golden Moths	2	505423
	Diuris orientis	Wallflower Orchid	3	501079
	Diuris pardina	Leopard Orchid	1	501080
	Diuris spp.	Diuris	1	508349
	Diuris sulphurea	Tiger Orchid	2	501085
	Dodonaea spp.	Hop Bush	1	508350
#	Dodonaea viscosa	Sticky Hop-bush	1	501095
	Dodonaea viscosa subsp. cunea	Wedge-leaf Hop-bush	4	501089
	Dodonaea viscosa subsp. spatu	Sticky Hop-bush	5	504421
	Drosera auriculata	Tall Sundew	9	501102
	Drosera binata	Forked Sundew	1	501103
	Drosera macrantha subsp. plan	Climbing Sundew	1	501106
	Drosera peltata s.l.	Pale Sundew	3	503689

	Drosera peltata subsp. peltata s	Pale Sundew	1	501107
	Drosera pygmaea	Tiny Sundew	3	501108
	Drosera spatulata	Rosy Sundew	1	501109
	Drosera spp.	Sundew	1	508354
*	Echinochloa crus-galli	Barnyard Grass	1	501118
	Echinopogon ovatus	Common Hedgehog-grass	9	501122
*	Echium plantagineum	Paterson's Curse	2	501123
*	Ehrharta calycina	Perennial Veldt-grass	1	501127
*	Ehrharta erecta	Panic Veldt-grass	46	501128
*	Ehrharta longiflora	Annual Veldt-grass	33	501129
*	Ehrharta spp.	Veldt Grass	4	508377
	Einadia nutans	Nodding Saltbush	3	501133
	Einadia spp.	Einadia	1	508379
	Einadia trigonos subsp. trigonos	Lax Goosefoot	1	501134
	Elaeocarpus reticulatus	Blue Oliveberry	1	501137
	Eleocharis acuta	Common Spike-sedge	22	501139
	Eleocharis gracilis	Slender Spike-sedge	1	501141
	Eleocharis pusilla	Small Spike-sedge	1	501145
	Eleocharis sphacelata	Tall Spike-sedge	4	501146
	Empodisma minus	Spreading Rope-rush	4	501155
	Enchylaena tomentosa var. tom	Ruby Saltbush	9	501156
	Entolasia marginata	Bordered Panic	2	501161
	Epacris impressa	Common Heath	16	501165
	Epacris lanuginosa	Woolly-style Heath	1	501166
	Epacris obtusifolia	Blunt-leaf Heath	4	501168
	Epilobium billardiereanum	Variable Willow-herb	4	501174
	Epilobium billardiereanum subsp	Smooth Willow-herb	8	504444
	Epilobium billardiereanum subsp	Grey Willow-herb	7	504445
	Epilobium hirtigerum	Hairy Willow-herb	2	501179
	Epilobium spp.	Willow Herb	4	508397
	Eragrostis brownii	Common Love-grass	8	501185
	Eragrostis spp.	Love Grass	1	508398
	Ericaceae spp.	Heath, rhododendron, and	1	507133
*	Erigeron bonariensis	Flaxleaf Fleabane	16	500812
*	Erigeron canadensis s.l.	Canadian Fleabane	1	500813
*	Erigeron primulifolius	Rough Fleabane	7	500815
*	Erigeron spp.	Fleabane	14	508253
*	Erigeron sumatrensis	Tall Fleabane	3	500810
	Eriochilus cucullatus s.l.	Parson's Bands	3	501219
*	Erodium botrys	Big Heron's-bill	1	501230
*	Erodium cicutarium	Common Heron's-bill	2	501232
*	Erodium moschatum	Musky Heron's-bill	3	501235
	Erodium spp.	Heron's Bill	2	508409
	Eucalyptus baueriana subsp. ba	Blue Box	1	528437
	Eucalyptus baxteri s.l.	Brown Stringybark	1	501250
	Eucalyptus baxteri s.s.	Brown Stringybark	1	503759
	Eucalyptus blakelyi	Blakely's Red-gum	2	501252
#	Eucalyptus botryoides	Southern Mahogany	1	501254
	Eucalyptus consideniana	Yertchuk	1	501264
	Eucalyptus globoidea	White Stringybark	6	501281

#	Eucalyptus globulus	Southern Blue-gum	6	501282
r #	Eucalyptus globulus subsp. glob	Southern Blue-gum	8	504491
	Eucalyptus globulus subsp. pse	Gippsland Blue-gum	1	501285
	Eucalyptus goniocalyx s.s.	Bundy	2	503732
	Eucalyptus obliqua	Messmate Stringybark	4	501304
	Eucalyptus ovata	Swamp Gum	18	501307
	Eucalyptus ovata subsp. ovata	Swamp Gum	2	505179
	Eucalyptus polyanthemos subsp	Red Box	1	504335
	Eucalyptus radiata s.l.	Narrow-leaf Peppermint	2	501313
	Eucalyptus spp.	Eucalypt	1	508415
	Eucalyptus tricarpa subsp. trica	Red Ironbark	1	507656
	Eucalyptus viminalis	Manna Gum	12	501323
	Eucalyptus viminalis subsp. pryc	Coast Manna-gum	16	504487
	Euchiton involucratus s.l.	Common Cudweed	2	503749
	Euchiton japonicus s.l.	Clustered/Creeping Cudwe	3	504652
	Euchiton japonicus s.s.	Creeping Cudweed	13	501466
	Euchiton sphaericus	Annual Cudweed	1	501471
*	Euphorbia paralias	Sea Spurge	5	501331
*	Euphorbia peplus	Petty Spurge	6	501332
	Euphorbia spp.	Spurge	1	508418
	Eurychorda complanata	Flat Cord-rush	1	502925
r	Euryomyrtus ramosissima subsp	Nodding Baeckea	1	504258
	Eustrephus latifolius	Wombat Berry	1	501346
	Exocarpos cupressiformis	Cherry Ballart	10	501350
	Exocarpos spp.	Ballart	2	508425
	Exocarpos strictus	Pale-fruit Ballart	12	501353
r	Exocarpos syrticola	Coast Ballart	8	501354
*	Festuca arundinacea	Tall Fescue	3	501356
	Ficinia nodosa	Knobby Club-sedge	87	501782
*	Ficus carica	Fig	1	505516
	Fissidens megalotis	Curly Pocket-moss	1	506285
	Fissidens taylorii	Pygmy Pocket-moss	1	506283
*	Fraxinus spp.	Ash	3	508451
	Frullania probosciphora	Chocolate Scalewort	1	506319
	Frullania spp.	Scalewort	1	509386
*	Fumaria bastardii	Bastard's Fumitory	1	501379
*	Fumaria muralis subsp. muralis	Wall Fumitory	3	501382
*	Fumaria spp.	Fumitory	2	508447
	Gahnia filum	Chaffy Saw-sedge	13	501389
	Gahnia melanocarpa	Black-fruit Saw-sedge	1	501392
	Gahnia radula	Thatch Saw-sedge	15	501394
	Gahnia sieberiana	Red-fruit Saw-sedge	1	501395
	Gahnia spp.	Saw Sedge	3	508460
	Gahnia trifida	Coast Saw-sedge	7	501397
*	Galium aparine	Cleavers	20	501402
	Galium australe s.l.	Tangled Bedstraw	15	501403
	Galium australe s.s.	Tangled Bedstraw	1	528611
	Galium binifolium	Reflexed Bedstraw	1	501404
	Galium gaudichaudii	Rough Bedstraw	1	501409
	Galium leiocarpum	Maori Bedstraw	3	501413

	Galium liratum	Furrowed Bedstraw	1	501410
	Galium migrans s.l.	Wandering Bedstraw	1	501411
*	Galium murale	Small Goosegrass	1	501412
	Galium spp.	Bedstraw	3	508464
*	Gamochaeta purpurea s.l.	Purple Cudweed	3	501470
*	Gamochaeta purpurea s.s.	Spiked Cudweed	3	504336
*	Gamochaeta spicata	Spiked Cudweed	1	507786
*	Gazania linearis	Gazania	3	501371
*	Gazania rigens var. uniflora	Trailing Gazania	1	507761
*	Gazania spp.	Gazania	1	508503
	Geitonoplesium cymosum	Scrambling Lily	1	501420
*	Genista monspessulana	Montpellier Broom	5	501422
*	Geranium dissectum	Cut-leaf Crane's-bill	3	501426
	Geranium gardneri	Rough Crane's-bill	12	505345
*	Geranium molle	Dove's Foot	7	501428
	Geranium potentilloides	Soft Crane's-bill	3	501431
	Geranium potentilloides var. pot	Soft Crane's-bill	1	505340
	Geranium retrorsum s.l.	Grassland Crane's-bill	2	501432
	Geranium solanderi s.l.	Austral Crane's-bill	11	501434
	Geranium sp. 2	Variable Crane's-bill	1	505343
r	Geranium sp. 3	Pale-flower Crane's-bill	3	505344
	Geranium spp.	Crane's Bill	16	508474
*	Gladiolus undulatus	Wild Gladiolus	1	501438
	Glareola maldivarum	Oriental Pratincole	2	10172
*	Glaucium flavum	Yellow Horned-poppy	1	501439
	Gleichenia dicarpa	Pouched Coral-fern	2	501440
vu	Gleichenia rupestris	Rock Coral-fern	2	503757
	Glossodia major	Wax-lip Orchid	5	501445
	Glycine clandestina	Twining Glycine	8	501455
	Glycine microphylla	Small-leaf Glycine	1	503741
	Gnaphalium spp.	Cudweed	1	508488
*	Gomphocarpus cancellatus	Broad-leaf Cotton-bush	4	500273
	Gompholobium huegelii	Common Wedge-pea	2	501481
	Gonocarpus elatus	Tall Raspwort	2	501483
	Gonocarpus humilis	Shade Raspwort	8	501484
	Gonocarpus micranthus	Creeping Raspwort	1	503851
	Gonocarpus micranthus subsp.	Creeping Raspwort	1	501486
	Gonocarpus spp.	Raspwort	4	508491
	Gonocarpus tetragynus	Common Raspwort	27	501489
	Gonocarpus teucrioides s.s.	Germander Raspwort	4	504882
	Goodenia humilis	Swamp Goodenia	1	501503
	Goodenia ovata	Hop Goodenia	41	501507
	Goodenia spp.	Goodenia	2	508492
r	Goodenia stelligera	Spiked Goodenia	1	501514
	Grevillea lanigera	Woolly Grevillea	1	501540
r	Grevillea patulifolia	Swamp Grevillea	1	504924
	Grimmia pulvinata var. africana	Blunt-beak Grimmia	1	506356
	Gynochthodes jasminoides	Jasmine Morinda	1	502224
*	Hainardia cylindrica	Common Barb-grass	3	502216
	Hakea decurrens subsp. physoc	Bushy Needlewood	1	505071

	Hakea nodosa	Yellow Hakea	2	501568
	Hakea sericea s.l.	Bushy Needlewood	5	501571
	Hakea teretifolia subsp. hirsuta	Dagger Hakea	3	501573
k	Halophila australis	Paddle Weed	3	501578
	Hardenbergia violacea	Purple Coral-pea	1	501596
*	Hedera helix	English Ivy	8	501599
	Helichrysum leucopsideum	Satin Everlasting	1	501619
*	Helminthotheca echioides	Ox-tongue	7	502511
	Hemarthria uncinata var. uncina	Mat Grass	4	501654
	Hemichroa pentandra	Trailing Hemichroa	25	501656
*	Hesperocyparis macrocarpa	Monterey Cypress	4	500888
r	Heterozostera nigricaulis	Australian Grass-wrack	3	507763
r	Heterozostera tasmanica	Eelgrass	3	501660
	Hibbertia acicularis	Prickly Guinea-flower	1	501661
	Hibbertia aspera subsp. aspera	Rough Guinea-flower	1	505436
	Hibbertia empetrifolia s.l.	Tangled Guinea-flower	1	501667
	Hibbertia empetrifolia subsp. em	Tangled Guinea-flower	1	505437
	Hibbertia fasciculata var. prostra	Bundled Guinea-flower	1	501674
	Hibbertia obtusifolia	Grey Guinea-flower	2	501671
	Hibbertia sericea s.l.	Silky Guinea-flower	2	501677
	Hibbertia spp.	Guinea Flower	1	508535
	Hibbertia stricta s.l.	Upright Guinea-flower	1	501683
*	Holcus lanatus	Yorkshire Fog	83	501692
*	Hordeum (monospecific)	Barley	1	508542
*	Hordeum hystrix		6	515429
*	Hordeum leporinum	Barley-grass	9	501701
*	Hordeum marinum		2	515430
*	Hordeum murinum s.l.	Barley-grass	4	503695
*	Hordeum spp.	Barley Grass	9	508271
	Hornungia procumbens	Oval Purse	1	501732
	Howittia trilocularis	Blue Howittia	1	501708
r	Hybanthus vernonii subsp. verno	Erect Violet	1	501712
*	Hydrocotyle bonariensis	American Pennywort	1	501717
vu	Hydrocotyle comocarpa	Fringed Pennywort	1	504937
	Hydrocotyle hirta	Hairy Pennywort	14	501722
	Hydrocotyle laxiflora	Stinking Pennywort	7	501723
	Hydrocotyle muscosa	Mossy Pennywort	4	501725
	Hydrocotyle sibthorpioides	Shining Pennywort	4	501728
	Hydrocotyle spp.	Pennywort	3	508548
	Hydrocotyle tripartita	Slender Pennywort	1	501729
	Hydrocotyle verticillata	Shield Pennywort	2	501730
	Hypericum gramineum	Small St John's Wort	15	501741
*	Hypericum tetrapterum var. tetra	St Peter's Wort	1	501745
	Hypnum cupressiforme	Common Plait-moss	3	506387
*	Hypochaeris glabra	Smooth Cat's-ear	8	501747
*	Hypochaeris radicata	Flatweed	98	501748
	Hypolaena fastigiata	Tassel Rope-rush	4	501749
	Hypolepis muelleri	Harsh Ground-fern	2	501751
	Hypolepis spp.	Ground Fern	2	508556
	Hypoxis hygrometrica	Golden Weather-glass	1	501756

#	Imperata cylindrica	Blady Grass	6	501760
	Indigofera australis subsp. austr	Austral Indigo	2	501761
	Iridaceae spp.	Irid	2	507212
	Ischyrodon lepturus	Golden Silk-moss	1	506395
	Isolepis cernua	Nodding Club-sedge	1	505944
	Isolepis cernua var. cernua	Nodding Club-sedge	12	501772
	Isolepis cernua var. platycarpa	Broad-fruit Club-sedge	1	501783
	Isolepis fluitans	Floating Club-sedge	6	501775
	Isolepis hookeriana	Grassy Club-sedge	1	501777
*	Isolepis hystrix	Awned Club-sedge	2	501778
	Isolepis inundata	Swamp Club-sedge	8	501779
*	Isolepis levynsiana	Tiny Flat-sedge	6	500936
	Isolepis marginata	Little Club-sedge	4	501780
	Isolepis producta	Nutty Club-sedge	1	501784
	Isolepis spp.	Club Sedge	7	508581
	Isopogon ceratophyllus	Horny Cone-bush	5	501790
	Juncus amabilis	Hollow Rush	3	501803
*	Juncus articulatus subsp. articul	Jointed Rush	3	501806
	Juncus bufonius	Toad Rush	11	501810
	Juncus caespiticius	Grassy Rush	3	501812
*	Juncus capitatus	Capitate Rush	2	501813
	Juncus filicaulis	Thread Rush	2	501817
	Juncus gregiflorus	Green Rush	1	501820
	Juncus holoschoenus	Joint-leaf Rush	1	501821
	Juncus kraussii subsp. australie	Sea Rush	23	501826
*	Juncus microcephalus	Tiny-headed Rush	3	501828
	Juncus pallidus	Pale Rush	23	501830
	Juncus pauciflorus	Loose-flower Rush	1	501831
	Juncus planifolius	Broad-leaf Rush	5	501833
	Juncus procerus	Tall Rush	7	501835
r	Juncus revolutus	Creeping Rush	6	501839
	Juncus spp.	Rush	16	508601
	Juncus subsecundus	Finger Rush	5	501843
	Kennedia prostrata	Running Postman	5	501847
#	Kennedia rubicunda	Dusky Coral-pea	3	501848
*	Kniphofia uvaria	Red-hot Poker	1	503820
#	Kunzea ambigua	White Kunzea	14	501854
	Kunzea ericoides s.l.	Burgan	1	501856
	Lachnagrostis aemula s.l.	Leafy Blown-grass	2	500149
	Lachnagrostis billardierei s.l.	Coast Blown-grass	13	500152
	Lachnagrostis billardierei subsp	Coast Blown-grass	8	504221
	Lachnagrostis filiformis s.l.	Common Blown-grass	9	500151
	Lachnagrostis filiformis s.s.	Common Blown-grass	27	504219
r	Lachnagrostis robusta	Salt Blown-grass	1	504223
r	Lachnagrostis rudis subsp. rudis	Rough Blown-grass	1	500159
*	Lactuca serriola	Prickly Lettuce	3	501860
*	Lactuca spp.	Lettuce	1	508633
	Lagenophora gracilis	Slender Bottle-daisy	2	501861
	Lagenophora stipitata	Common Bottle-daisy	19	501863
*	Lagurus ovatus	Hare's-tail Grass	46	501864

	Laphangium luteoalbum	Jersey Cudweed	18	502762
	Lasiopetalum macrophyllum	Shrubby Velvet-bush	1	501874
*	Lavandula spp.	Lavender	1	508643
r	Lawrencia spicata	Salt Lawrencia	2	501888
	Laxmannia orientalis	Dwarf Wire-lily	3	501890
	Lembophyllum divulsum	Catkin Moss	1	506413
	Lemna disperma	Common Duckweed	3	501893
*	Leontodon saxatilis subsp. saxa	Hairy Hawkbit	39	501895
*	Lepidium africanum	Common Peppercress	3	501896
r	Lepidium desvauxii	Bushy Peppercress	3	501900
vu	Lepidium foliosum	Leafy Peppercress	6	501902
k	Lepidium pseudohyssopifolium	Native Peppercress	1	501908
	Lepidosperma concavum	Sandhill Sword-sedge	20	501917
	Lepidosperma elatius	Tall Sword-sedge	1	501919
	Lepidosperma filiforme	Common Rapier-sedge	2	501920
	Lepidosperma forsythii	Large-flower Rapier-sedge	2	501921
	Lepidosperma gladiatum	Coast Sword-sedge	28	501922
	Lepidosperma gunnii	Slender Sword-sedge	1	504699
	Lepidosperma laterale	Variable Sword-sedge	11	501923
	Lepidosperma laterale var. later	Variable Sword-sedge	2	504700
	Lepidosperma laterale var. maju	Variable Sword-sedge	1	504701
	Lepidosperma longitudinale	Pithy Sword-sedge	1	501926
	Lepidosperma neesii	Stiff Rapier-sedge	1	501927
	Lepidosperma spp.	Sword Sedge	6	508653
	Lepsiella (Lepsiella) vinosa	Grape Lepsithais	29	102769
vu	Leptecophylla juniperina subsp.	Crimson Berry	14	500900
	Leptinella longipes	Coast Cotula	2	504603
	Leptinella reptans s.l.	Creeping Cotula	3	500850
	Leptinella reptans s.s.	Creeping Cotula	2	503884
	Leptocarpus tenax	Slender Twine-rush	2	501938
	Leptoceras menziesii	Hare Orchid	2	500540
	Leptorhynchos nitidulus	Shiny Buttons	1	501943
	Leptospermum continentale	Prickly Tea-tree	16	501956
#	Leptospermum laevigatum	Coast Tea-tree	92	501957
	Leptospermum laevigatum x my	Coast Tea-tree x Heath Te	1	505864
	Leptospermum lanigerum	Woolly Tea-tree	3	501958
	Leptospermum myrsinoides	Heath Tea-tree	2	501961
*	Leucojum aestivum	Snowflake	1	503839
	Leucophyta brownii	Cushion Bush	41	500581
	Leucopogon affinis	Lance Beard-heath	4	501983
	Leucopogon australis	Spike Beard-heath	2	501972
	Leucopogon collinus	Fringed Beard-heath	4	501975
	Leucopogon ericoides	Pink Beard-heath	1	501978
r	Leucopogon esquamatus	Swamp Beard-heath	1	501979
	Leucopogon parviflorus	Coast Beard-heath	84	501987
	Leucopogon spp.	Beard Heath	5	508664
	Leucopogon virgatus	Common Beard-heath	1	501995
	Leucopogon virgatus var. virgat	Common Beard-heath	2	504391
	Lilaeopsis polyantha	Australian Lilaeopsis	6	502005
P	Limonium australe	Yellow Sea-lavender	1	903381

r	Limonium australe var. australe	Yellow Sea-lavender	8	502006
*	Limonium hyblaeum	Sicilian Sea-lavender	1	503840
*	Linaria pelisseriana	Pelisser's Toad-flax	1	502012
	Lindsaea linearis	Screw Fern	3	502014
	Linum marginale	Native Flax	1	502017
*	Linum trigynum	French Flax	4	502018
	Lissanthe strigosa subsp. subul	Peach Heath	1	502021
	Lobelia anceps	Angled Lobelia	36	502024
	Lobelia irrigua	Salt Pratia	4	502731
	Lobelia spp.	Lobelia	2	508680
*	Lolium loliaceum	Stiff Rye-grass	2	502034
*	Lolium perenne	Perennial Rye-grass	11	502036
*	Lolium perenne var. perenne	Perennial Rye-grass	2	504586
*	Lolium perenne x rigidum	Perennial Rye-grass x Wim	1	507269
*	Lolium rigidum	Wimmera Rye-grass	11	502037
*	Lolium spp.	Rye Grass	17	508683
*	Lolium temulentum var. temulen	Darnel	1	504706
	Lomandra filiformis	Wattle Mat-rush	4	502042
	Lomandra longifolia	Spiny-headed Mat-rush	25	502046
	Lomandra longifolia subsp. exilis	Cluster-headed Mat-rush	1	504713
	Lomandra longifolia subsp. long	Spiny-headed Mat-rush	26	504714
	Lomandra spp.	Mat-rush	1	508684
*	Lophopyrum ponticum	Tall Wheat-grass	12	500141
*	Lotus angustissimus	Slender Bird's-foot Trefoil	1	502056
k	Lotus australis var. australis	Austral Trefoil	2	502057
*	Lotus corniculatus	Bird's-foot Trefoil	2	502058
*	Lotus corniculatus var. cornicula	Bird's-foot Trefoil	4	505188
*	Lotus creticus	Lotus	2	503848
*	Lotus spp. (naturalised)	Trefoil	3	509285
*	Lotus subbiflorus	Hairy Bird's-foot Trefoil	7	502060
*	Lupinus arboreus	Tree Lupin	2	503833
	Luzula campestris s.l.	Field Woodrush	4	502068
	Luzula meridionalis	Common Woodrush	6	503841
	Luzula meridionalis var. densiflo	Common Woodrush	1	502069
	Luzula meridionalis var. flaccida	Common Woodrush	4	502070
	Luzula meridionalis var. meridio	Common Woodrush	2	502071
*	Lycium afrum	Kaffir Box-thorn	1	502075
*	Lycium ferocissimum	African Box-thorn	32	502078
*	Lysimachia arvensis	Pimpernel	33	500223
*	Lysimachia arvensis (Red-flowe	Scarlet Pimpernel	1	505170
	Lythrum hyssopifolia	Small Loosestrife	20	502092
*	Malva nicaeensis	Mallow of Nice	1	502121
*	Malva parviflora	Small-flower Mallow	10	502122
	Malva preissiana s.l.	Australian Hollyhock	9	501885
	Malva spp.	Mallow	3	508715
*	Marrubium vulgare	Horehound	1	502123
*	Medicago arabica	Spotted Medic	2	502134
*	Medicago polymorpha	Burr Medic	11	502140
*	Medicago spp.	Medic	2	508722
	Marsdenia rostrata	Milk Vine	1	502125

r #	Melaleuca armillaris subsp. arm	Giant Honey-myrtle	6	502145
#	Melaleuca ericifolia	Swamp Paperbark	72	502147
*	Melaleuca hypericifolia	Hillock Bush	1	505854
	Melaleuca lanceolata	Moonah	18	502150
#	Melaleuca parvistaminea	Rough-barked Honey-myrtl	2	502154
	Melaleuca spp.	Honey-myrtle	2	508723
	Melaleuca squarrosa	Scented Paperbark	3	502153
	Melicytus dentatus s.s.	Tree Violet	2	504933
	Melicytus spp.	Tree Violet	1	508549
*	Melilotus indicus	Sweet Melilot	12	502161
	Mentha diemenica var. serpyllifo	Slender Mint	1	504733
	Metzgeria spp.	Veilwort	1	509447
	Microlaena stipoides var. stipoid	Weeping Grass	57	502179
	Microseris walteri	Yam Daisy	1	503887
	Microsorum pustulatum subsp. p	Kangaroo Fern	3	502183
	Microtis arenaria	Notched Onion-orchid	7	502258
	Microtis oblonga	Sweet Onion-orchid	4	502188
	Microtis parviflora	Slender Onion-orchid	6	502187
	Microtis spp.	Onion Orchid	14	508739
	Microtis unifolia	Common Onion-orchid	5	502189
*	Minuartia mediterranea	Fine-leaved Sandwort	1	502198
	Mitrasacme pilosa var. stuartii	Hairy Mitrewort	1	504736
*	Modiola caroliniana	Red-flower Mallow	4	502213
	Monotoca elliptica s.l.	Tree Broom-heath	7	502218
	Monotoca elliptica s.s.	Tree Broom-heath	5	504980
r	Monotoca glauca	Currant-wood	8	503859
	Monotoca spp.	Broom Heath	2	508752
	Montia australasica	White Purslane	3	502221
*	Moraea lewisiae	Golden Iris	1	503771
	Muehlenbeckia adpressa	Climbing Lignum	19	502225
r	Muellerina celastroides	Coast Mistletoe	2	502232
	Muellerina eucalyptoides	Creeping Mistletoe	2	502233
#	Myoporum insulare	Common Boobialla	69	502239
	Myosotis australis	Austral Forget-me-not	1	502244
	Myosotis exarrhena	Sweet Forget-me-not	1	502246
	Myriophyllum salsugineum	Lake Water-milfoil	2	502259
	Myriophyllum simulans	Amphibious Water-milfoil	2	503873
	Myriophyllum spp.	Water Milfoil	2	508765
*	Nassella leucotricha	Texas Needle-grass	1	503997
*	Nassella neesiana	Chilean Needle-grass	2	503282
*	Nassella trichotoma	Serrated Tussock	4	502263
*	Nasturtium officinale	Watercress	2	502948
	Notelaea venosa	Large Mock-olive	1	502282
*	Oenothera spp.	Evening Primrose	1	508810
*	Oenothera stricta subsp. stricta	Common Evening-primrose	1	502292
	Olearia axillaris	Coast Daisy-Bush	44	502301
	Olearia ciliata var. ciliata	Fringed Daisy-bush	2	502302
	Olearia glutinosa	Sticky Daisy-bush	6	502308
	Olearia lepidophylla	Club-moss Daisy-bush	3	502311
	Olearia lirata	Snowy Daisy-bush	1	502312

	Olearia phlogopappa	Dusty Daisy-bush	7	502319
	Olearia phlogopappa subsp. co	Dusty Daisy-bush	2	504781
	Olearia ramulosa	Twiggy Daisy-bush	4	502322
	Olearia ramulosa var. ramulosa	Twiggy Daisy-bush	2	504785
	Olearia rugosa	Wrinkled Daisy-bush	1	502324
r	Olearia sp. 2	Peninsula Daisy-bush	4	502348
	Olearia spp.	Daisy Bush	14	508813
	Opercularia aspera	Coarse Stinkweed	1	502339
	Opercularia hispida	Hairy Stinkweed	1	502340
	Opercularia varia	Variable Stinkweed	5	502344
	Oplismenus hirtellus	Australian Basket-grass	1	502349
*	Opuntia spp.	Prickly Pear	1	508821
	Orchidaceae spp.	Orchid	2	507305
	Oxalis corniculata s.l.	Yellow Wood-sorrel	17	502379
	Oxalis exilis	Shade Wood-sorrel	5	502381
	Oxalis perennans	Grassland Wood-sorrel	7	502386
*	Oxalis pes-caprae	Soursob	7	502387
r	Oxalis rubens	Dune Wood-sorrel	21	502390
	Oxalis spp.	Wood Sorrel	29	508835
*	Oxalis spp. (naturalised)	Wood Sorrel	2	509287
r	Ozothamnus argophyllus	Spicy Everlasting	5	501607
	Ozothamnus ferrugineus	Tree Everlasting	7	501616
	Ozothamnus obcordatus	Grey Everlasting	2	501620
	Ozothamnus rosmarinifolius	Rosemary Everlasting	1	501624
	Ozothamnus spp.	Everlasting	1	508838
	Ozothamnus turbinatus	Coast Everlasting	30	501622
	Ornduffia reniformis	Running Marsh-flower	3	503521
	Ornduffia spp.	Marsh Flower	2	509218
*	Ornithopus compressus	Yellow Serradella	1	503912
	Orthoceras strictum	Horned Orchid	2	502370
	Pandorea pandorana subsp. pa	Wonga Vine	23	502399
*	Parapholis incurva	Coast Barb-grass	11	502418
*	Parapholis strigosa	Slender Barb-grass	5	502419
*	Paraserianthes lophantha subsp	Cape Wattle	11	500169
*	Parentucellia viscosa	Yellow Bartsia	2	502421
	Parietaria debilis s.l.	Shade Pellitory	9	502422
	Parietaria debilis s.s.	Shade Pellitory	9	505036
	Parmeliaceae spp.	Parmeliaceous lichen	2	509564
*	Paspalum dilatatum	Paspalum	21	502430
*	Paspalum distichum	Water Couch	12	502431
*	Paspalum vaginatum	Salt-water Couch	2	502701
	Patersonia fragilis	Short Purple-flag	2	502435
	Patersonia occidentalis var. occ	Long Purple-flag	1	502437
	Patersonia sericea var. sericea	Silky Purple-flag	2	504825
	Patersonia spp.	Purple Flag	2	508866
	Pelargonium australe	Austral Stork's-bill	18	502442
	Pelargonium inodorum	Kopata	1	502446
*	Pelargonium X hortorum	Zonal Pelargonium	1	505756
	Pellaea falcata s.l.	Sickle Fern	1	502449
	Pentapogon quadrifidus var. qu	Five-awned Spear-grass	8	502456

	Persicaria decipiens	Slender Knotweed	1	503919
	Persoonia juniperina	Prickly Geebung	5	502463
	Persoonia linearis	Narrow-leaf Geebung	2	502465
*	Petrorhagia dubia	Velvety Pink	1	502474
*	Phalaris aquatica	Toowoomba Canary-grass	15	502476
*	Phalaris arundinacea	Reed Canary-grass	1	502477
	Phragmites australis	Common Reed	18	502497
	Phyllangium divergens	Wiry Mitrewort	1	502209
	Phyllanthus gunnii	Shrubby Spurge	2	502500
	Phyllanthus hirtellus	Thyme Spurge	1	502501
	Phylloglossum drummondii	Pygmy Clubmoss	1	502503
*	Physalis spp.	Ground Cherry	2	508891
*	Phytolacca octandra	Red-ink Weed	3	502510
	Picris angustifolia	Native Picris	2	502512
	Picris angustifolia subsp. angus	Coast Picris	2	504397
	Pimelea humilis	Common Rice-flower	2	502523
	Pimelea linifolia	Slender Rice-flower	6	502525
	Pimelea linifolia subsp. linifolia	Slender Rice-flower	2	504819
	Pimelea serpyllifolia subsp. serp	Thyme Rice-flower	7	502530
	Pimelea spp.	Rice Flower	1	508895
*	Pinus radiata	Radiata Pine	5	502539
*	Pinus radiata var. radiata	Radiata Pine	1	505190
*	Pinus spp.	Pine	1	508896
r #	Pittosporum bicolor x undulatum	Hybrid Pittosporum	1	505795
#	Pittosporum undulatum	Sweet Pittosporum	30	502543
*	Plantago coronopus	Buck's-horn Plantain	42	502553
*	Plantago coronopus subsp. coro	Buck's-horn Plantain	4	504821
	Plantago debilis	Shade Plantain	2	502555
	Plantago hispida	Hairy Plantain	1	502560
*	Plantago lanceolata	Ribwort	47	502561
*	Plantago major	Greater Plantain	3	502562
	Plantago spp.	Plantain	4	508901
	Plantago varia	Variable Plantain	4	502566
	Platylobium formosum s.l.	Handsome Flat-pea	4	502568
	Platylobium obtusangulum	Common Flat-pea	7	502569
r	Platysace ericoides	Heath Platysace	1	502571
	Platysace lanceolata	Shrubby Platysace	3	502573
*	Poa annua s.l.	Annual Meadow-grass	15	502580
	Poa australis spp. agg.	Tussock Grass	4	502581
r	Poa billardierei	Coast Fescue	1	501361
	Poa clelandii	Noah's Ark	2	502584
	Poa labillardierei	Common Tussock-grass	14	502600
	Poa labillardierei var. labillardier	Common Tussock-grass	28	504694
	Poa morrisii	Soft Tussock-grass	10	502602
	Poa poiformis	Coast Tussock-grass	77	502605
	Poa poiformis var. poiformis	Coast Tussock-grass	13	504833
r	Poa poiformis var. ramifer	Dune Poa	14	504826
*	Poa pratensis	Kentucky Blue-grass	3	502606
	Poa sieberiana	Grey Tussock-grass	3	502608
	Poa sieberiana var. sieberiana	Grey Tussock-grass	5	504835

	Poa spp.	Tussock Grass	19	508909
	Poa tenera	Slender Tussock-grass	4	502610
*	Poa trivialis	Rough Meadow-grass	1	502611
	Poaceae spp.	Grass	2	507345
*	Poaceae spp. (naturalised)	Grass (naturalised)	1	507353
	Podolepis jaceoides s.l.	Showy/Basalt Podolepis	1	502617
	Podolepis jaceoides sensu Jean	Showy Podolepis	2	504387
*	Polycarpon tetraphyllum	Four-leaved Allseed	34	502622
*	Polygala myrtifolia	Myrtle-leaf Milkwort	3	502624
*	Polygonum aviculare s.l.	Prostrate Knotweed	4	502626
*	Polygonum aviculare s.s.	Hogweed	3	504000
*	Polypogon monspeliensis	Annual Beard-grass	14	502640
	Polystichum proliferum	Mother Shield-fern	1	502645
vu	Pomaderris apetala subsp. mari	Tasman Pomaderris	1	504717
	Pomaderris aspera	Hazel Pomaderris	2	502650
	Pomaderris elliptica var. elliptica	Smooth Pomaderris	3	502663
	Pomaderris lanigera	Woolly Pomaderris	1	502660
P	Pomaderris oraria	Bassian Pomaderris	3	502713
r	Pomaderris oraria subsp. calcic	Limestone Pomaderris	1	503946
r	Pomaderris oraria subsp. oraria	Bassian Pomaderris	2	502665
	Pomaderris paniculosa	Scurfy Pomaderris	1	502720
	Pomaderris paniculosa subsp. p	Coast Pomaderris	14	503947
	Pomaderris spp.	Pomaderris	4	508921
	Poranthera microphylla s.l.	Small Poranthera	2	502683
	Poranthera microphylla s.s.	Small Poranthera	2	507704
	Portulaca oleracea	Common Purslane	1	502684
	Potamogeton ochreatus	Blunt Pondweed	1	502690
	Potamogeton sulcatus	Furrowed Pondweed	1	505272
	Potamogeton tricarinatus Form	Floating Pondweed	1	505273
	Potamogeton tricarinatus s.l.	Floating Pondweed	1	502693
	Potamogetonaceae spp.	Pondweed	2	50267
	Prasophyllum australe	Austral Leek-orchid	1	502699
	Prasophyllum brevilabre	Short-lip Leek-orchid	3	502703
	Prasophyllum elatum	Tall Leek-orchid	2	502707
EN en L	Prasophyllum frenchii	Maroon Leek-orchid	2	502709
	Prasophyllum odoratum s.l.	Scented Leek-orchid	1	502717
	Prostanthera lasianthos	Victorian Christmas-bush	1	502743
*	Prunella vulgaris	Self-heal	4	502757
*	Prunus spp.	Prunus	1	508936
	Pteridium esculentum subsp. es	Austral Bracken	63	502777
	Pteris tremula	Tender Brake	3	502779
	Pterostylis alata s.l.	Striped Greenhood	1	502783
vu	Pterostylis alveata	Coastal Greenhood	2	503956
	Pterostylis atrans	Dark-tip Greenhood	3	502807
vu	Pterostylis coccina	Scarlet Greenhood	1	502788
	Pterostylis concinna	Trim Greenhood	1	502789
	Pterostylis curta	Blunt Greenhood	3	502791
r	Pterostylis fischii	Fisch's Greenhood	1	502795
	Pterostylis nana	Dwarf Greenhood	2	502805
	Pterostylis nutans	Nodding Greenhood	11	502806

	Pterostylis parviflora s.l.	Tiny Greenhood	1	502808
	Pterostylis pedunculata	Maroonhood	5	502810
	Pterostylis sp. aff. revoluta (Inlar	Large Autumn Greenhood	1	502814
	Pterostylis spp.	Greenhood	2	508946
	Ptychomnion aciculare	Paper Moss	4	506588
	Puccinellia spp.	Saltmarsh Grass	1	508948
	Puccinellia stricta s.l.	Australian Saltmarsh-grass	7	502834
	Puccinellia stricta s.s.	Australian Saltmarsh-grass	6	504849
	Pultenaea daphnoides	Large-leaf Bush-pea	12	502844
	Pultenaea dentata	Clustered Bush-pea	4	502846
#	Pultenaea forsythiana	Prickly Bush-pea	1	504857
	Pultenaea linophylla	Halo Bush-pea	1	502857
	Pultenaea retusa	Blunt Bush-pea	4	502870
	Pultenaea sericea	Chaffy Bush-pea	1	504862
	Pultenaea tenuifolia	Slender Bush-pea	3	502877
	Pyrorchis nigricans	Red-beaks	1	502086
	Racopilum cuspidigerum	Carpet Moss	1	506831
	Racopilum cuspidigerum var. co	Common Carpet-moss	3	506609
	Ranunculus amphitrichus	Small River Buttercup	12	502907
*	Ranunculus muricatus	Sharp Buttercup	1	502897
	Ranunculus pumilio	Ferny Small-flower Butterc	2	502905
*	Ranunculus repens	Creeping Buttercup	2	502906
	Ranunculus rivularis s.l.	River Buttercup complex	1	507384
	Ranunculus sessiliflorus	Annual Buttercup	2	502912
	Ranunculus sessiliflorus var. se	Annual Buttercup	4	504912
	Ranunculus spp.	Buttercup	1	508978
	Rhagodia candolleana subsp. ca	Seaberry Saltbush	124	502927
	Rhagodia spp.	Saltbush	3	508985
	Rhaphidorrhynchium amoenum		1	510492
	Rhytidosporum procumbens	White Marianth	1	500402
	Ricinocarpos pinifolius	Wedding Bush	1	502938
r	Roepera billardierei	Coast Twin-leaf	2	503615
*	Romulea rosea	Onion Grass	19	502942
*	Romulea rosea var. australis s.s	Common Onion-grass	2	504113
*	Rosa rubiginosa	Sweet Briar	6	502950
*	Rostraria cristata	Annual Cat's-tail	4	502054
	Rosulabryum billarderi	Common Thread-moss	4	506099
	Rosulabryum campylothecium	Sand Thread-moss	1	506102
*	Rubus anglocandicans	Common Blackberry	2	502959
*	Rubus fruticosus spp. agg.	Blackberry	25	502952
	Rubus parvifolius	Small-leaf Bramble	18	502956
	Rubus spp.	Bramble	2	508998
*	Rubus ulmifolius var. ulmifolius	Elm-leaf Blackberry	1	502962
	Rumex bidens	Mud Dock	1	502967
	Rumex brownii	Slender Dock	7	502968
*	Rumex conglomeratus	Clustered Dock	10	502969
*	Rumex crispus	Curled Dock	10	502970
*	Rumex obtusifolius subsp. obtus	Broad-leaf Dock	1	502973
*	Rumex pulcher subsp. pulcher	Fiddle Dock	1	502974
	Rumex spp.	Dock	7	509000

*	Rumex spp. (naturalised)	Dock (naturalised)	3	509286
	Ruppia maritima s.l.	Sea Tassel	1	502977
	Rytidosperma bipartitum s.s.	Leafy Wallaby-grass	2	504418
	Rytidosperma caespitosum	Common Wallaby-grass	14	500961
	Rytidosperma duttonianum	Brown-back Wallaby-grass	2	500963
	Rytidosperma geniculatum	Kneed Wallaby-grass	2	500965
	Rytidosperma laeve	Smooth Wallaby-grass	4	500967
	Rytidosperma penicillatum	Weeping Wallaby-grass	6	500974
	Rytidosperma pilosum	Velvet Wallaby-grass	7	500975
	Rytidosperma pilosum var. pilos	Velvet Wallaby-grass	7	504404
	Rytidosperma procerum	Tall Wallaby-grass	1	500976
	Rytidosperma racemosum var. r	Slender Wallaby-grass	28	500977
	Rytidosperma semiannulare	Wetland Wallaby-grass	15	500979
	Rytidosperma setaceum	Bristly Wallaby-grass	14	500980
	Rytidosperma setaceum var. se	Bristly Wallaby-grass	3	504379
	Rytidosperma sp. aff. setaceum	Wallaby Grass	1	505384
	Rytidosperma spp.	Wallaby Grass	26	508313
*	Sagina apetala	Common Pearlwort	2	502985
*	Sagina procumbens	Spreading Pearlwort	2	502987
*	Salix spp.	Willow	1	509018
r	Salsola tragus subsp. pontica	Coast Saltwort	3	505308
	Sambucus gaudichaudiana	White Elderberry	38	502999
	Samolus repens var. repens	Creeping Brookweed	60	503001
	Sanionia uncinata	Sickle-leaved Hook-moss	1	506231
	Sarcocornia blackiana	Thick-head Glasswort	4	503011
	Sarcocornia quinqueflora	Beaded Glasswort	64	503012
	Sarcocornia quinqueflora subsp	Beaded Glasswort	1	504947
	Scaevola albida	Small-fruit Fan-flower	1	503018
vu	Scaevola calendulacea	Dune Fan-flower	5	503019
	Scaevola hookeri	Creeping Fan-flower	3	503021
	Scaevola ramosissima	Hairy Fan-flower	2	503023
	Schizaea bifida s.s.	Forked Comb-fern	2	503030
	Schoenoplectus tabernaemonta	River Club-sedge	2	503038
	Schoenus apogon	Common Bog-sedge	27	503039
	Schoenus brevifolius	Zig-zag Bog-sedge	3	503041
r	Schoenus carsei	Wiry Bog-sedge	4	503043
r	Schoenus ericetorum	Heathy Bog-sedge	1	503994
	Schoenus lepidosperma	Slender Bog-sedge	2	503055
	Schoenus maschalinus	Leafy Bog-sedge	2	503048
	Schoenus nitens	Shiny Bog-sedge	28	503051
	Sebaea albidiflora	White Sebaea	3	503091
	Sebaea ovata	Yellow Sebaea	1	503092
	Scleranthus biflorus s.l.	Twin-flower Knawel	1	503060
	Selaginella gracillima	Tiny Selaginella	1	503096
	Selaginella uliginosa	Swamp Selaginella	4	503098
	Selliera radicans	Shiny Swamp-mat	44	503100
	Sematophyllum homomallum	Bronze Signal-moss	6	506661
*	Senecio angulatus	Climbing Groundsel	2	503185
	Senecio bathurstianus	Dissected Fireweed	1	504958
	Senecio biserratus	Jagged Fireweed	24	503102

*	Senecio elegans	Purple Groundsel	18	503105
	Senecio glomeratus	Annual Fireweed	35	503107
	Senecio glomeratus subsp. glom	Annual Fireweed	1	507141
	Senecio hispidulus s.l.	Rough Fireweed	4	503111
	Senecio hispidulus s.s.	Rough Fireweed	2	504959
*	Senecio jacobaea	Ragwort	9	503113
	Senecio linearifolius	Fireweed Groundsel	4	503115
	Senecio linearifolius var. linearif	Fireweed Groundsel (type v	2	505520
	Senecio minimus	Shrubby Fireweed	18	503119
	Senecio odoratus	Scented Groundsel	9	503120
	Senecio pinnatifolius	Variable Groundsel	34	503114
	Senecio pinnatifolius var. lanceo	Lance-leaf Groundsel	10	505244
	Senecio prenanthoides	Beaked Fireweed	1	503126
	Senecio quadridentatus	Cotton Fireweed	4	503124
	Senecio spathulatus s.l.	Dune Groundsel	16	503975
r	Senecio spathulatus var. latifruc	Dune Groundsel	1	505521
	Senecio spp.	Groundsel	22	509058
	Senecio tenuiflorus s.l.	Slender Fireweed	6	503129
*	Setaria parviflora	Slender Pigeon Grass	1	503133
	Sigesbeckia orientalis subsp. or	Indian Weed	1	503149
*	Silene gallica	French Catchfly	1	503151
*	Silene gallica var. gallica	French Catchfly	1	504965
*	Silene gallica var. quinquevulne	Spotted Catchfly	2	504966
*	Silybum marianum	Variegated Thistle	4	503156
*	Sinapis spp.	Mustard	1	509067
*	Sisyrinchium iridifolium	Striped Rush-leaf	1	503163
*	Sisyrinchium spp.	Sisyrinchium	1	509069
	Smilax australis	Austral Sarsaparilla	1	503166
	Solanum aviculare	Kangaroo Apple	17	503169
	Solanum laciniatum	Large Kangaroo Apple	2	503179
r	Solanum linearifolium	Mountain Kangaroo Apple	1	503181
*	Solanum linnaeanum	Apple of Sodom	6	503178
*	Solanum nigrum s.l.	Black Nightshade	17	503183
*	Solanum nigrum s.s.	Black Nightshade	6	505322
*	Solanum nodiflorum	Glossy Nightshade	1	503168
	Solanum opacum	Green-berry Nightshade	3	503184
	Solanum prinophyllum	Forest Nightshade	1	503186
	Solanum pungetium	Eastern Nightshade	2	503188
	Solanum spp.	Nightshade	9	509072
*	Solanum triflorum	Cut-leaf Nightshade	3	503192
	Solanum vescum	Gunyang	1	503193
*	Soliva sessilis	Jo Jo	1	503199
*	Sonchus asper s.l.	Rough Sow-thistle	25	503203
*	Sonchus asper s.s.	Rough Sow-thistle	9	505712
	Sonchus hydrophilus	Native Sow-thistle	3	504661
*	Sonchus oleraceus	Common Sow-thistle	86	503204
	Sonchus spp.	Sow Thistle	1	509077
*	Spartina anglica	Common Cord-grass	1	504976
*	Spergula spp.	Corn Spurrey	1	509083
	Spergularia marina s.l.	Salt Sand-spurrey	1	503217

	Spergularia media s.l.	Coast Sand-spurrey	1	503218
*	Spergularia rubra s.l.	Red Sand-spurrey	1	503219
	Spergularia tasmanica	Native Sea-spurrey	2	504666
	Sphaerolobium minus	Eastern Globe-pea	1	504725
	Sphaerolobium vimineum s.l.	Leafless Globe-pea	1	503221
	Sphaerolobium vimineum s.s.	Leafless Globe-pea	1	504978
	Sphagnum cristatum	Peat Moss	2	506670
	Spinifex sericeus	Hairy Spinifex	30	503222
*	Sporobolus africanus	Rat-tail Grass	28	503226
	Sporobolus virginicus	Salt Couch	15	503230
	Sprengelia incarnata	Pink Swamp-heath	4	503231
	Spyridium parvifolium	Dusty Miller	5	503235
*	Stachys arvensis	Stagger Weed	1	503240
	Stackhousia monogyna s.l.	Creamy Stackhousia	2	503244
k	Stackhousia spathulata	Coast Stackhousia	2	503246
*	Stellaria media	Chickweed	18	503251
	Stellaria multiflora	Rayless Starwort	1	503252
*	Stellaria pallida	Lesser Chickweed	2	503253
	Stellaria pungens	Prickly Starwort	5	503255
	Stellaria spp.	Starwort	1	509094
*	Stenotaphrum secundatum	Buffalo Grass	4	503260
	Stylidium graminifolium s.l.	Grass Triggerplant	10	503303
	Stylidium inundatum	Hundreds and Thousands	2	503304
	Stypandra glauca	Nodding Blue-lily	1	503309
	Suaeda australis	Austral Seablite	31	503312
	Swainsona lessertiifolia	Coast Swainson-pea	13	503318
*	Symphyotrichum subulatum	Aster-weed	21	500297
#	Syzygium smithii	Lilly Pilly	2	500115
*	Taraxacum officinale spp. agg.	Garden Dandelion	3	503336
	Taraxacum spp.	Dandelion	4	509122
	Tayloria octoblepharum	Dung Moss	1	506678
	Tecticornia arbuscula	Shrubby Glasswort	36	503084
	Tecticornia pergranulata subsp.	Blackseed Glasswort	2	504576
	Tetragonia implexicoma	Bower Spinach	119	503343
	Tetragonia spp.	Native Spinach	2	509126
	Tetragonia tetragonioides	New Zealand Spinach	7	503344
	Tetraria capillaris	Hair Sedge	1	503345
	Tetrarrhena juncea	Forest Wire-grass	2	503348
	Tetratheca pilosa	Hairy Pink-bells	1	503353
	Tetratheca pilosa subsp. latifolia	Hairy Pink-bells	3	504994
	Teucrium corymbosum	Forest Germander	1	503357
	Thelymitra aristata	Great Sun-orchid	1	503362
	Thelymitra flexuosa	Twisted Sun-orchid	2	503368
	Thelymitra holmesii s.l.	Blue-star Sun-orchid	1	503370
	Thelymitra holmesii s.s.	Blue-star Sun-orchid	3	507634
	Thelymitra ixioides s.l.	Spotted Sun-orchid	1	503372
	Thelymitra ixioides s.s.	Spotted Sun-orchid	1	505005
	Thelymitra media s.l.	Tall Sun-orchid	1	503379
	Thelymitra pauciflora s.l.	Slender Sun-orchid	10	503382
	Thelymitra pauciflora s.s.	Slender Sun-orchid	3	505013

	Thelymitra rubra	Salmon Sun-orchid	2	503384
	Thelymitra spp.	Sun Orchid	11	509134
en L	Thelymitra X merraniae	Merran's Sun-orchid	1	504005
	Themeda triandra	Kangaroo Grass	5	503387
*	Thinopyrum junceiforme	Sea Wheat-grass	6	500142
r	Thomasia petalocalyx	Paper Flower	1	503392
	Threlkeldia diffusa	Coast Bonefruit	9	503393
	Thuidiopsis furfurosa	Golden Weft-moss	6	506692
	Thyridia repens	Creeping Monkey-flower	15	502197
	Thysanotus patersonii	Twining Fringe-lily	3	503399
r	Tmesipteris parva	Small Fork-fern	3	503405
	Tortella cirrhata	Crisp Moss	4	506695
	Tortula antarctica	Bristly Screw-moss	3	506710
	Tortula muralis	Common Wall-moss	1	506703
	Trachymene composita var. con	Parsnip Trachymene	1	507720
*	Tribolium acutiflorum s.l.	Desmazeria	3	502547
*	Tribolium acutiflorum s.s.	Crested Desmazeria	1	505581
*	Tribolium obliterum	Desmazeria	3	505580
*	Tribolium spp.	Desmazeria	1	509157
*	Trifolium angustifolium var. ang	Narrow-leaf Clover	2	503423
*	Trifolium arvense var. arvense	Hare's-foot Clover	2	503424
*	Trifolium campestre var. campe	Hop Clover	2	503425
*	Trifolium dubium	Suckling Clover	11	503427
*	Trifolium fragiferum var. fragifer	Strawberry Clover	2	503428
*	Trifolium glomeratum	Cluster Clover	5	503429
*	Trifolium repens var. repens	White Clover	18	503435
*	Trifolium resupinatum	Shaftal Clover	1	503436
*	Trifolium resupinatum var. resu	Shaftal Clover	1	504012
*	Trifolium spp.	Clover	13	509161
*	Trifolium subterraneum	Subterranean Clover	2	503440
	Triglochin spp.	Arrowgrass	2	509162
	Triglochin striata	Streaked Arrowgrass	45	503449
	Triglochin striata (small terete le	Streaked Arrowgrass	1	505512
	Triptilodiscus pygmaeus	Common Sunray	2	501640
	Tylophora barbata	Bearded Tylophora	2	503467
	Typha domingensis	Narrow-leaf Cumbungi	6	503468
	Typha orientalis	Broad-leaf Cumbungi	3	503470
	Typha spp.	Bulrush	3	509178
*	Ulex europaeus	Gorse	40	503471
	Urtica incisa	Scrub Nettle	5	503476
*	Urtica urens	Small Nettle	4	503477
	Usnea spp.	Old Man's Beard	2	509565
*	Vellereophyton dealbatum	White Cudweed	3	503491
*	Verbascum thapsus subsp. thap	Great Mullein	2	503494
*	Verbascum virgatum	Twiggy Mullein	1	503495
	Veronica calycina	Hairy Speedwell	6	503503
	Veronica gracilis	Slender Speedwell	12	503506
	Veronica plebeia	Trailing Speedwell	11	503512
	Veronica spp.	Speedwell	1	509216
*	Vicia sativa	Common Vetch	8	503518

*	Vicia sativa subsp. nigra	Narrow-leaf Vetch	3	505053
*	Vicia sativa subsp. sativa	Common Vetch	4	505054
*	Vicia spp.	Vetch	2	509217
	Viminaria juncea	Golden Spray	1	503523
*	Vinca major	Blue Periwinkle	2	503524
	Viola betonicifolia	Showy Violet	1	503526
	Viola cleistogamoides	Hidden Violet	4	505056
	Viola hederacea sensu Entwisle	Ivy-leaf Violet	1	505058
	Viola hederacea sensu Willis (1	Ivy-leaf Violet	23	503528
*	Vulpia bromoides	Squirrel-tail Fescue	26	503544
*	Vulpia fasciculata	Dune Fescue	8	503547
*	Vulpia muralis	Wall Fescue	6	503548
*	Vulpia myuros	Rat's-tail Fescue	3	503549
*	Vulpia myuros f. megalura	Fox-tail Fescue	1	503546
*	Vulpia spp.	Fescue	11	509223
	Wahlenbergia gracilenta s.s.	Hairy Annual-bluebell	1	504124
	Wahlenbergia gracilis	Sprawling Bluebell	8	503558
	Wahlenbergia multicaulis	Branching Bluebell	2	503560
	Wahlenbergia spp.	Bluebell	8	509236
	Wahlenbergia stricta subsp. stri	Tall Bluebell	1	503559
*	Watsonia meriana	Bugle Lily	1	505861
*	Watsonia meriana var. bulbillifer	Bulbil Watsonia	2	503562
*	Watsonia spp.	Watsonia	2	509238
	Weissia controversa	Green-tufted Stubble-moss	1	506739
	Wijkia extenuata	Spear Moss	1	506745
	Wilsonia backhousei	Narrow-leaf Wilsonia	1	503573
	Wurmbea dioica subsp. dioica	Common Early Nancy	1	504082
r	Wurmbea uniflora	One-flower Early Nancy	4	503583
*	Xanthium spinosum	Bathurst Burr	1	503586
	Xanthoparmelia spp.	Foliose Lichen	3	509569
	Xanthorrhoea australis	Austral Grass-tree	5	503587
	Xanthorrhoea minor subsp. lute	Small Grass-tree	2	503588
	Xanthosia pilosa	Woolly Xanthosia	3	503592
	Xanthosia pusilla spp. agg.	Heath Xanthosia	3	503593
r	Xanthosia tasmanica	Southern Xanthosia	2	504088
	Xanthosia tridentata	Hill Xanthosia	1	503594
r	Xerochrysum papillosum	Island Everlasting	7	505425
	Xerochrysum spp.	Everlasting	2	508160
	Xyris gracilis	Slender Yellow-eye	1	503595
*	Zantedeschia aethiopica	White Arum-lily	2	503599
	Zieria arborescens subsp. arbor	Stinkwood	4	503601
	Zostera muelleri	Dwarf Grass-wrack	2	503608
	Zoysia macrantha	Prickly Couch	3	503609
	Zoysia macrantha subsp. macra	Prickly Couch	8	507230
	Zygodon menziesii	Zygodon	2	506751
		Insects		
vu L	Telicota eurychlora	Southern Sedge-darter But	1	15265
		Reptiles		

	Acritoscincus duperreyi	Eastern Three-lined Skink	12	12682
	Anepischtos maccoyi	McCoy's Skink	4	12444
	Austrelaps spp.	Australian Copperheads	2	50256
	Austrelaps superbus	Lowland Copperhead	29	12973
dd	Chelodina longicollis	Eastern Snake-necked Tur	6	5134
EN cr L	Dermochelys coriacea	Leathery Turtle	7	12013
	Drysdalia coronoides	White-lipped Snake	8	12665
	Egernia saxatilis intermedia	Black Rock Skink	9	62938
	Eulamprus heatwolei	Yellow-bellied Water Skink	14	12957
	Eulamprus spp.	Unidentified water skink	75	50255
	Intellagama lesueurii howittii	Gippsland Water Dragon	1	62919
	Lampropholis guichenoti	Pale-flecked Garden Sunsk	27	12451
	Lerista bougainvillii	Bougainville's Skink	40	12475
	Liopholis whitii GROUP	White's Skink	88	62430
en L	Morelia spilota spilota	Diamond Python	1	62968
	Niveoscincus metallicus	Metallic Skink	65	12462
	Notechis scutatus	Tiger Snake	6	12681
	Pelamis platurus	Yellow-bellied Sea Snake	3	12770
	Pseudechis porphyriacus	Red-bellied Black Snake	6	12693
	Pseudemoia entrecasteauxii	Southern Grass Skink	8	12994
	Pseudemoia spenceri	Spencer's Skink	2	12541
	Saproscincus mustelinus	Weasel Skink	15	12452
	Scincidae spp.	Unidentified skink	22	50254
	Tiliqua nigrolutea	Blotched Blue-tongued Liza	19	12578
	Tiliqua scincoides	Common Blue-tongued Liza	2	12580
	Tiliqua spp.	Unidentified blue-tongued l	1	50292
en	Varanus varius	Lace Monitor	1	12283
Amphibians				
	Crinia signifera	Common Froglet	30	13134
	Limnodynastes dumerilii	Southern Bullfrog (ssp. unk	15	13058
	Limnodynastes dumerilii dumeri	Pobblebonk Frog	1	63913
	Limnodynastes dumerilii insulari	Pobblebonk Frog	28	63914
	Limnodynastes peronii	Striped Marsh Frog	7	13061
	Limnodynastes tasmaniensis	Spotted Marsh Frog (race u	10	13063
	Litoria ewingii	Southern Brown Tree Frog	89	13182
	Litoria ewingii SOUTHERN	Southern Brown Tree Frog	3	63903
VU en L	Litoria raniformis	Growling Grass Frog	3	13207
	Litoria verreauxii (ssp. unknown	Unknown Tree Frog	33	13215
	Litoria verreauxii verreauxii	Verreaux's Tree Frog	3	63906
	Paracrinia haswelli	Haswell's Froglet	4	13103
vu	Pseudophryne semimarmorata	Southern Toadlet	19	13125
Crustaceans				
	Cyclograpsus granulosus	Purple-mottled Shore Crab	1	102828
	Engaeus cunicularius	Granular Burrowing Crayfis	2	1680
	fam. Paguridae gen. Pagurid	Hermit Crabs	9	100569
	Guinusia chabrus	Cleft-fronted Shore Crab	174	100272
	Jasus edwardsii	Red Rock Lobster	101	100270
	Nectocarcinus tuberculosus	Rough Rock Crab	18	100271

	Pagurid sp. (grey)	Right-handed hermit crab	1	100274
	Paguristes frontalis	Common Hermit Crab	3	100572
	Paguroidea spp.	Hermit crab	3	100278
	Sagmariasus verreauxi	Eastern Rock Lobster	4	100277
	Strigopagurus strigimanus	Stridulating Hermit Crab	40	100273
Mammals - terrestrial				
	Antechinus agilis	Agile Antechinus	60	11028
	Antechinus mimetes	Mainland Dusky Antechinus	7	11033
VU nt L	Antechinus minimus maritimus	Swamp Antechinus	64	11034
*	Axis porcinus	Hog Deer	8	11525
*	Canis familiaris	Dingo & Dog (feral)	1	11531
*	Capra hircus	Goat (feral)	2	11521
nt X	Cercartetus nanus	Eastern Pygmy-possum	9	11150
*	Cervus unicolor	Sambar Deer	2	11527
	Chalinolobus gouldii	Gould's Wattled Bat	42	11349
	Chalinolobus morio	Chocolate Wattled Bat	40	11351
EN en L	Dasyurus maculatus maculatus	Spot-tailed Quoll	2	11008
EN rx L	Dasyurus viverrinus	Eastern Quoll	1	11009
	Falsistrellus tasmaniensis	Eastern False Pipistrelle	1	11372
	fam. Leporidae gen. Oryctolagu	Rabbits	2	526412
	fam. Vespertilionidae gen. Eptes	House Bats	1	61810
*	Felis catus	Domestic Cat (feral)	14	11536
	Hydromys chrysogaster	Water Rat	12	11415
EN nt L	Isoodon obesulus obesulus	Southern Brown Bandicoot	2	61092
*	Lepus europaeus	European Brown Hare	6	11511
	Macropus giganteus	Eastern Grey Kangaroo	15	11265
	Macropus spp.	Kangaroo	2	50244
L	Miniopterus schreibersii GROUP	Common Bent-wing Bat	6	61341
vu L	Miniopterus schreibersii oceane	Common Bent-wing Bat (ea	3	61342
*	Mus musculus	House Mouse	29	11412
nt	Myotis macropus	Southern Myotis	1	11357
	Notamacropus rufogriseus bank	Red-necked Wallaby	3	11261
	Nyctophilus geoffroyi	Lesser Long-eared Bat	131	11335
N	Ornithorhynchus anatinus	Platypus	1	5136
*	Oryctolagus cuniculus	European Rabbit	51	11510
	Perameles nasuta	Southern Long-nosed Band	9	11097
	Peramelidae spp.	Bandicoots	1	61801
VU vu L	Petauroides volans	Southern Greater Glider	1	11133
	Petaurus australis	Yellow-bellied Glider	5	11136
	Petaurus breviceps	Sugar Glider	2	11138
vu L	Phascogale tapoatafa	Brush-tailed Phascogale	1	11017
	Phascolarctos cinereus	Koala	227	11162
	Potorous spp.	Potoroo	1	50245
VU nt L	Potorous tridactylus trisulcatus	Long-nosed Potoroo	15	11175
EN en L	Pseudomys fumeus	Smoky Mouse	1	11458
VU vu L	Pseudomys novaehollandiae	New Holland Mouse	3	11455
	Pseudocheirus peregrinus	Eastern Ring-tailed Possum	53	11129
VU vu L	Pteropus poliocephalus	Grey-headed Flying-fox	6	11280
	Rattus fuscipes	Bush Rat	143	11395

	Rattus lutreolus	Swamp Rat	19	11398
*	Rattus rattus	Black Rat	62	11408
	Rattus spp.	Rats	3	50250
dd L	Saccolaimus flaviventris	Yellow-bellied Sheathtail Ba	1	11321
nt L	Sminthopsis leucopus	White-footed Dunnart	1	11069
	Tachyglossus aculeatus	Short-beaked Echidna	93	11003
rx L	Thylogale billardierii	Rufous-bellied Pademelon	1	11235
	Trichosurus cunninghami	Mountain Brush-tailed Poss	2	11115
	Trichosurus vulpecula	Common Brush-tailed Poss	17	11113
	Vespadelus darlingtoni	Large Forest Bat	15	11381
	Vespadelus regulus	Southern Forest Bat	2	11378
	Vespadelus vulturnus	Little Forest Bat	207	11379
	Vombatus ursinus	Bare-nosed Wombat	36	11165
*	Vulpes vulpes	Red Fox	36	528552
	Wallabia bicolor	Black-tailed Wallaby	79	11242
Marine mammals				
X	Arctocephalus pusillus doriferus	Australian Fur Seal	71	11542
vu	Arctophoca forsteri	Long-nosed Fur Seal	31	11543
EN	Arctophoca tropicalis	Subantarctic Fur Seal	3	11830
	Balaenoptera acutorostrata	Common Minke Whale	1	11570
EN cr L	Balaenoptera musculus	Blue Whale	10	11567
VU dd	Balaenoptera physalus	Fin Whale	1	11569
	Caperea marginata	Pygmy Right Whale	1	11564
	Delphinus delphis	Short-beaked Common Do	49	11616
EN cr L	Eubalaena australis	Southern Right Whale	173	11561
	fam. Balaenopteridae gen. Bala	Whales	26	11828
	Globicephala melas	Long-finned Pilot Whale	1	11606
	Hydrurga leptonyx	Leopard Seal	31	11549
	Kogia breviceps	Pygmy Sperm Whale	4	11581
VU vu L	Megaptera novaeangliae austra	Southern Humpback Whale	155	11575
	Mesoplodon grayi	Gray's Beaked Whale	1	11593
	Mesoplodon layardi	Strap-toothed Whale	1	11591
VU	Mirounga leonina	Southern Elephant Seal	5	11546
VU	Neophoca cinerea	Sea-lion	3	11539
	Orcinus orca	Killer Whale	40	11600
	ord. Cetacea fam. Delphinidae	Oceanic Dolpins	3	528016
	Otariidae spp.	Eared Seals	17	50253
X	Physeter macrocephalus	Sperm Whale	3	11578
	Pseudorca crassidens	False Killer Whale	4	11603
en L	Tursiops australis	Burrunan Dolphin	5	11617
	Tursiops truncatus	Common Bottle-nosed dolp	17	11612
Marine flora				
	Acrocarpia paniculata	Brown algae	671	100300
	Acrotylus australis		62	102443
	Actinia tenebrosa	Waratah Anemone	2	102743
		Algae Algal turf	17	102811
	Amoria undulata	Benthic Volute	1	100258
k	Amphibolis antarctica	Sea Nymph	63	500207

	Amphiroa anceps		321	100805
	Amphiroa gracilis		2	100782
	Apjohnia laetevirens	Green algae	9	100521
	Areschougia spp.	Red Algae	6	50294
	Ballia callitricha		441	100370
	Botryocladia obovata		2	100710
	Bovichtus angustifrons		11	100068
*	Cakile edentula	American Sea Rocket	5	500520
*	Cakile maritima subsp. maritima	Sea Rocket	13	500521
*	Cakile spp.	Sea Rocket	4	508170
	Callophycus laxus		15	102439
	Callophyllis lambertii		4	100425
	Callophyllis rangiferina		79	100371
	Camontagnea oxyclada		1	100423
	Carpoglossum confluens	Brown algae	18	100302
	Carpomitra costata	Brown algae	95	100345
	Caulerpa brownii	Green algae	119	100351
	Caulerpa cactoides	Green algae	6	100352
	Caulerpa flexilis	Green algae	45	100353
	Caulerpa flexilis var. muelleri	Green algae	71	100369
	Caulerpa geminata	Green algae	10	100354
	Caulerpa hodkinsoniae	Green algae	5	100368
	Caulerpa longifolia	Green algae	5	100355
	Caulerpa obscura	Green algae	29	100366
	Caulerpa scalpelliformis	Green algae	19	100357
	Caulerpa simpliciuscula	Green algae	28	100358
	Caulerpa trifaria	Green algae	1	100359
	Caulocystis cephalornithos	Brown algae	19	100303
	Chaetomorpha coliformis	Green algae	2	102309
	Chaetomorpha spp.	Green Algae	11	50302
	Champia spp.	Red Algae	3	50301
	Champia viridis		1	100372
	Cheilosporum sagittatum		280	100837
	Chlanidophora microphylla	brown alga	23	100705
	Cladia aggregata	Common Coral-lichen	1	507591
	Cladia retipora	Bone Coral-lichen	1	507592
	Cladonia spp.	Candelabra Lichen	6	509562
	Cladophora spp.	Green Algae	1	50303
	Cladostephus spongiosus	Brown algae	6	100416
	Codium duthieae	Green algae	6	100523
	Codium harveyi	Green algae	1	100527
	Codium lucasii	Green algae	1	511160
	Codium pomoides	Green Algae	17	100364
	Codium spp.	Green Algae	5	50304
	Corallina officinalis		25	100518
	Corallinaceae spp.	Coralline Algae	1535	50297
	Cordylecladia furcellata		2	100407
	Craspedocarpus tenuifolius		6	102454
	Curdiea angustata		1	102322
	Cycnogeton spp.	Water Ribbons	19	503448

	Cystophora monilifera	Brown Algae	91	100309
	Cystophora moniliformis	Brown Algae	268	100310
	Cystophora platylobium		37	100311
	Cystophora retorta	Brown Algae	254	100313
	Cystophora retroflexa	Brown Algae	174	100314
	Cystophora siliquosa	Brown Algae	2	100315
	Cystophora subfarcinata	Brown Algae	27	100316
	Delisea pulchra		48	102306
	Dictymenia harveyana		2	100414
	Dictyopteris acrostichoides	Brown algae	5	100859
	Dictyopteris muelleri	Brown algae	4	100319
	Dictyota dichotoma	Brown algae	52	100320
	Dictyota diemensis	Brown algae	1	102392
	Dictyota spp.	Brown Algae	5	100507
	Dictyotaceae spp.	Brown Algae	1	50311
	Distromium flabellatum	Brown Algae	5	102405
	Distromium spp.	Brown Algae	11	50275
	Durvillaea potatorum	Brown algae	12	100321
	Echinothamnion hystrix		1	100374
	Ecklonia radiata	Brown algae	1025	100322
	Enteromorpha spp.	Tubular Green Alga	8	509555
	Erythroclonium spp.	Red Algae	3	50295
	Erythropodium hicksoni	gorgonian coral	1	102794
	Euptilota articulata		6	100410
	Exallosorus olsenii		3	102734
	fam. Dasyaceae gen. Dasya	Red Algae	2	511107
	fam. Dictyotaceae gen. Padina		2	100809
	fam. Gracilariaceae gen. Gracila	Red Algae	1	528532
	Galaxaura marginata	Red Algae	1	100529
	Gelidium asperum		10	100512
	Gelidium australe		15	100515
	Gelidium spp.	Red Algae	8	50305
	Gracilaria secundata		3	102311
	Griffithsia spp.	Red Algae	1	50277
	Halopteris spp.	Brown Algae	340	50307
	Halymenia plana		1	102432
	Hemineura frondosa		19	100376
	Homoeostrichus sinclairii	Brown algae	111	100704
	Hormosira banksii	Neptunes Necklace	30	100325
	Hypnea ramentacea		1	100377
	Jania rosea		1075	100806
	Laurencia elata		8	100448
	Laurencia filiformis		11	100593
	Laurencia spp.	Red Algae	10	50289
	Lobophora variegata	Brown algae	8	100509
	Lobospira bicuspidata	Brown algae	84	100702
	Lophurella periclados		1	102572
	Lotella rhacina		2	100008
	Macrocystis pyrifera	Brown algae	166	100330
	Mastophoropsis canaliculata		3	102458

	Melanthalia abscissa		25	102589
	Melanthalia concinna		4	100517
	Melanthalia obtusata		208	100382
	Metagoniolithon radiatum		357	100833
	Metamastophora flabellata		26	100845
	Mychodea acanthymenia		3	102573
	Nemastoma feredayae		3	100420
	Nizymenia australis		16	102447
	Notheia anomala	Brown algae	4	102411
	ord. Ceramiales fam. Ceramiac	Red Algae	1	511247
	Perithalia caudata	Brown algae	75	100332
	Peyssonnelia novaehollandiae		1	100430
	Peyssonneliaceae spp.	Red Algae	25	50309
	Phacelocarpus alatus		3	100395
	Phacelocarpus peperocarpus		556	100383
	Phaeophyceae spp.	Brown Algae	34	50310
	Phyllospora comosa	Brown algae	1676	100333
	Phyllotricha decipiens	Brown algae	22	100347
	Phyllotricha sonderi	Brown algae	65	100350
	Phyllotricha varians	Brown algae	12	100349
	Phyllotricha verruculosum	Brown algae	113	100336
	Plocamium angustum		486	100384
	Plocamium cartilagineum		50	100385
	Plocamium costatum		19	100386
	Plocamium dilatatum		226	100387
	Plocamium leptophyllum		25	100388
	Plocamium mertensii		87	100389
	Plocamium patagiatum		6	100390
	Plocamium pressianum		13	100412
	Polyopes constrictus		11	102314
	Polyopes tasmanica		2	102581
	Pterocladia lucida		149	100409
	Pterocladiella capillacea		27	102576
	Ptilonia australasica		23	100415
	Rhodopeltis australis		2	100786
	Rhodophyllis multipartita		2	102449
	Rhodophyta other thallose red a	Red Algae	259	100399
	Rhodophyta spp.	Red Algae	4	50269
	Rhodymenia australis		141	102463
	Rhodymenia leptophylla		2	102462
	Rhodymenia linearis		58	102577
	Rhodymenia obtusa		1	102465
	Rhodymenia prolificans		4	102466
	Rhodymenia spp.	Red Algae	74	50290
	Rhodymenia wilsonii		15	102579
	Rhizoclonium spp.	Filamentous Green Alga	20	509553
	Rugulopteryx okamurae	Brown algae	2	100812
	Sargassum fallax	Brown Algae	41	100334
	Sargassum lacerifolium	Brown Algae	6	100501
	Sargassum spinuligerum	Brown Algae	18	100858

	Sargassum spp.	Brown Algae	157	50291
	Sargassum vestitum	Brown Algae	29	100335
	Seirococcus axillaris	Brown algae	220	100338
	Solieria robusta		3	100799
	Sonderopelta coriacea		93	100429
	Thamnoclonium dichotomum		2	100392
	Ulva spp.		54	50272
	Xiphophora chondrophylla	Brown algae	76	100340
	Zonaria angustata	Brown algae	21	100342
	Zonaria spiralis	Brown algae	40	100842
	Zonaria spp.	Brown Algae	6	826030
	Zonaria turneriana	Brown algae	252	100343
		Fish		
	Acanthaluteres vittiger	Toothbrush Leatherjacket	164	5085
	Acanthopagrus butcheri	Black Bream	3	4918
	Achoerodus viridis	Eastern Blue Groper	6	4973
	Aetapcus maculatus	Warty Prowfish	4	100101
	Afurcagobius tamarensis	Tamar Goby	1	5018
	Aldrichetta forsteri	Yellow-eye Mullet	2	4960
	Ammotretis rostratus	Longsnouted Flounder	1	5071
	Anguilla australis	Southern Shortfin Eel	14	4651
	Aplodactylus arctidens	Marblefish	76	100048
	Aplodactylus lophodon		16	100166
	Aracana aurita	Shaw's Cowfish	17	5100
	Aracana ornata	Ornate Cowfish	6	5101
	Argyrosomus japonicus	Mulloway	1	4925
	Arripis trutta	Eastern Australian Salmon	1	4911
	Atherinosoma microstoma	Smallmouthed Hardyhead	4	4782
	Atypichthys strigatus	Mado	70	4933
	Caesioperca lepidopterus	Butterfly Perch	30	100024
	Caesioperca rasor	Barber Perch	209	100025
	Cephaloscyllium laticeps	Draughtboard Shark	13	100003
	Cheilodactylus nigripes	Magpie Perch	274	100049
	Cheilodactylus spectabilis	Banded Morwong	79	100050
	Chrysophrys auratus	Snapper	1	4920
	Conger verreauxi	Southern Conger	1	4655
	Contusus brevicaudus	Prickly Toadfish	3	5104
*	Cyprinus carpio	European Carp	2	4713
	Dactylophora nigricans	Dusky Morwong	20	4955
	Dinolestes lewini	Longfin Pike	115	100028
	Diodon nicthemerus	Globefish	54	5117
	Dotalabrus aurantiacus	Castelnau's wrasse	32	100056
	Enoplosus armatus	Old Wife	161	4938
	Eubalichthys gunnii	Gunn's Leatherjacket	31	100087
	Eupetrichthys angustipes	Snakeskin Wrasse	3	100170
	fam. Arripidae gen. Arripis	Salmon	2	4908
	fam. Sillaginidae gen. Sillaginod	Whiting	1	4890
	Gadopsis marmoratus	River Blackfish	1	4949
	Galaxias maculatus	Common Galaxias	11	4696

	Galaxias truttaceus	Spotted Galaxias	1	4693
*	Gambusia holbrooki	Eastern Gambusia	2	4771
	Genypterus tigerinus	Rock Ling	1	4761
	Girella elevata	Rock Blackfish	2	4929
	Girella tricuspidata	Luderick	6	4930
	Girella zebra	Zebra fish	130	100039
	Gnathanacanthus goetzeei	Red Velvetfish	1	100023
	Gymnothorax prasinus	Green Moray	2	100122
	Helicolenus percoides	Reef Ocean Perch	6	100019
	Heteroclinus johnstoni	Johnston's Weedfish	3	100073
	Heteroclinus perspicillatus	Common Weedfish	4	5010
	Heteroclinus tristis	Longnose Weedfish	1	100072
	Heterodontus portusjacksoni	Port Jackson Shark	9	100001
	Hyperlophus vittatus	Sandy Sprat	1	4659
	Hypoplectrodes annulatus	Blackbanded Seaperch	1	100914
	Hypoplectrodes maccullochi	Halfbanded Seaperch	2	100026
	Hypoplectrodes nigroruber	Banded Seaperch	1	100110
	Kyphosus sydneyanus	Silver Drummer	2	100038
	Latropiscis purpurissatus	Sergeant Baker	2	100179
	Liza argentea	Goldspot Mullet	1	4962
EN en L	Macquaria australasica	Macquarie Perch	2	4874
	Macquaria colonorum	Estuary Perch	3	4875
X	Macquaria novemaculeata	Australian Bass	1	4876
	Meuschenia australis	Brownstriped Leatherjacket	8	100088
	Meuschenia flavolineata	Yellowstriped Leatherjacke	88	100089
	Meuschenia freycineti	Sixspine Leatherjacket	105	100090
	Meuschenia galii	Blue-lined Leatherjacket	2	14178
	Meuschenia hippocrepis	Horse-shoe leatherjacket	88	100091
	Meuschenia scaber	Velvet Leatherjacket	1	5091
	Meuschenia trachylepis	Yellow-finned Leatherjacke	2	5090
vu L	Mugilogobius platynotus	Flatback Mangrovegoby	1	5029
	Nemadactylus douglasi		2	100168
	Nemadactylus macropterus		3	100052
	Neoodax balteatus	Little Weed Whiting	4	100063
	Notolabrus fucicola	Purple Wrasse	352	4975
	Notolabrus tetricus	Blue Throated Wrasse	471	4976
	Odax acroptilus		49	100061
	Olisthops cyanomelas	Herring Cale	364	100066
	Ophthalmolepis lineolatus	Southern Maori Wrasse	12	100111
	Osteichthyes spp.	Bony fish	19	50233
	Parablennius tasmanianus	Tasmanian Blenny	2	4990
	Parascyllium variolatum	Varied Catshark	17	100105
	Parequula melbournensis	Silverbelly	3	100033
	Parma microlepis	White-ear	33	100046
	Parma victoriae	Scalyfin	232	100047
	Pempheris multiradiata		32	100035
	Pentaceropsis recurvirostris	Longsnout boarfish	15	100044
*	Perca fluviatilis	Redfin	1	4888
	Philypnodon grandiceps	Flatheaded Gudgeon	3	5060

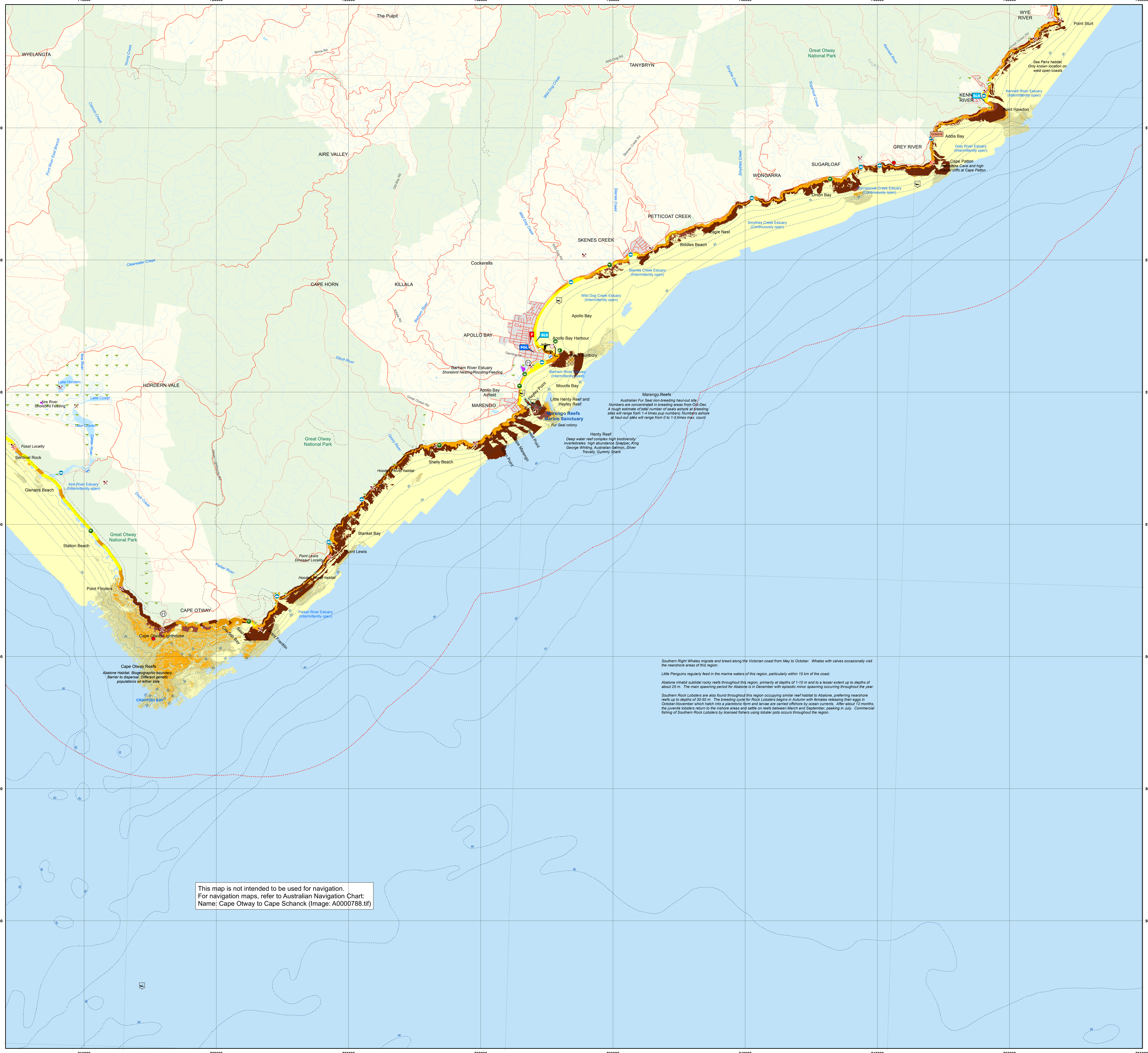
	Pictilabrus laticlavius	Senator Wrasse	163	100057
	Pseudaphritis urvillii	Tupong	2	4985
	Pseudocaranx georgianus	Silver Trevally	5	4902
	Pseudolabrus luculentus	Luculent Wrasse	2	100918
	Pseudolabrus mortonii	Rosy Wrasse	55	100059
	Pseudophycis bachus	Red Rock Cod	6	4756
	Pseudophycis barbata	Bearded Rock Cod	5	4757
	Pseudogobius sp. 9	Eastern Bluespot Goby	1	5141
	Retropinna semoni	Australian Smelt	1	4683
	Retropinna sp. 2	Eastern Australian Smelt	1	903044
*	Salmo trutta	Brown Trout	1	4680
	Scobinichthys granulatus	Rough Leatherjacket	2	5097
	Scorpaena papillosa	Southern Red Scorpionfish	4	4842
	Scorpis aequipinnis	Sea Sweep	206	4935
	Scorpis lineolata	Silver Sweep	63	100041
	Siphonognathus attenuatus	Slender Weed Whiting	4	100062
	Siphonognathus beddomei	Pencil Weed Whiting	62	100064
	Siphonognathus radiatus	Longray Weed Whiting	1	100956
	Siphonognathus tanyourus	Longtail Weed Whiting	1	100113
	Tetractenos glaber	Smooth Toadfish	18	5107
	Thyrsites atun	Barracouta	1	5064
	Tilodon sexfasciatus	Moonlighter	12	100938
*	Tinca tinca	Tench	1	528546
	Trachinops caudimaculatus	Southern Hulafish	69	100027
	Trachurus declivis	Common Jack Mackerel	2	4906
	Trachurus novaezelandiae	Yellowtail Scad	7	4905
	Trinorfolkia clarkei	Clarks Threefin	14	5000
	Upeneichthys vlamingii	Bluespotted Goatfish	59	100034
	Vincentia conspersa	Southern Cardinalfish	2	14104
Marine Invertebrates				
vu L	Apsolidium densum	Sea Cucumber 5251	1	15251
	Aulactinia veratra	anemone	1	102745
	Austrocochlea constricta	Common Periwinkle	49	102687
	Austrocochlea odontis	Checkered Periwinkle	1	102691
vu L	Bassethullia glypta	Chiton 5254	1	15254
	Bembicium melanostomum	Common Conniwink	23	102819
	Bembicium nanum	Striped-mouth Conniwink	43	102767
	Cabestana spengleri	Spengler's Triton	39	100257
	Cabestana tabulata	Ploughed Triton	3	100247
	Calliostoma (Fautor) armillatum	Jewelled Top Shell	1	102681
	Cellana tramoserica	Common Limpet	27	102761
	Cenolia tasmaniae	Feather star	17	100201
	Cenolia trichoptera	Feather star	268	100200
	Centrostephanus rodgersii	Black Sea Urchin	20	100203
	Charonia lampas	Australian Red Triton	1	100246
	Chromodoris tasmaniensis	Sea Slug	2	102353
	Chromodoris tinctoria	Sea Slug	2	102320
	Chthamalus antennatus	Six-plated Barnacle	4	102751
	Clanculus undatus	Top snail	1	102679

	Cnemidocarpa radicosa	Sea squirt	1	102496
	Cominella (Cominella) lineolata	Lineated Buccinum Whelk	2	102771
	Conus anemone	Anemone cone	3	100713
	Coscinasterias muricata	Eleven-armed Seastar	19	100209
	Cymatium (Monoplex) partheno	Hairy Triton	1	100262
	Dasyatis brevicaudata	Smooth Stingray	3	100107
	Digidentis perplexa	Sea slug	1	102326
	Echinaster arcystatus	Seastar	97	100223
	fam. Temnopleuridae gen. Amb	Sea Urchins	14	100205
	Fromia polypora	Seastar	83	100208
	Galeolaria caespitosa	tube worm	1	102747
	Goniocidaris tubaria	Thorny Sea Urchin	1	100206
	Haliotis laevigata	Green-lip Abalone	40	100240
	Haliotis rubra	Black-lip Abalone	857	100241
	Haliotis scalaris	Ridged Ear Shell	8	100252
	Heliocidaris erythrogramma	Sea urchin	318	100202
	Herdmania momus	Sea squirt	2	100617
	Holopneustes inflatus	Seagrass Sea Urchin	3	100204
	Holopneustes porossimus	Sea urchin	5	100225
	Holopneustes purpurascens	Sea urchin	5	100233
	Hypselodoris bennetti	Sea slug	4	102316
	Lunella (Subninella) undulatus	Common Warrener	237	100243
	Meridiastra calcar	Eight-armed Cushion Star	14	100221
	Meridiastra gunnii	Seastar	158	100211
	Mimachlamys asperrima	Doughboy Scallop	2	100249
	Montfortula rugosa	Cap-shaped False Limpet	4	102820
	Myliobatis australis	Southern Eagle Ray	1	4641
	Nectria macrobrachia	Seastar	161	100224
	Nectria multispina	Seastar	67	100552
	Nectria ocellata	Seastar	232	100210
	Neodoris chrysoderma	Sea slug	5	102319
	Nerita (Lisanerita) atramentosa	Black Crow Sea Snail	20	102766
	Notoacmea mayi	limpet	7	102805
	Notocypraea angustata	Brown Cowry	2	102313
	Notocypraea comptoni	Compton's Cowry	1	102591
	Onchidella patelloides		2	102776
	Parvulastra exigua	Five-armed Cushion Star	29	102517
	Patelloida alticostata	Tall-ribbed Limpet	3	102763
	Pauridia glabella/vaginata spp. a	Tiny/Yellow Star species ag	1	501754
	Pauridia vaginata var. vaginata	Yellow Star	1	504584
	Penion mandarinus	Waite's Buccinum Whelk	2	100244
	Penion maximus	Whelk	2	100245
	Pentagonaster duebeni	Vermillion Seastar	91	100213
vu L	Pentocnus bursatus	Sea Cucumber (species 52	4	15258
	Petricia vernicina	Velvet Seastar	115	100212
	Phasianella australis	Australian Pheasant Shell	1	100571
	Phasianella ventricosa	Common Pheasant Shell	4	100717
	Phasianotrochus eximius	Kelp Shell	4	102304
	Phyllopteryx taeniolatus	Common Seadragon	1	100018
vu L	Platydoris galbana	Sea slug	1	15048

	Plectaster decanus	Seastar	106	100214
	Pleuroploca australasia	Australian Horse Conch	58	100242
	Pseudonepanthia troughtoni	Seastar	82	100222
	Ranella australasia	Australian Triton	2	100253
vu L	Rhodope spp.	Marine opisthobranch	1	903743
	Sagaminopteron ornatum	bubble snail	2	102588
	Scutellastra chapmani	Chapman's Limpet	1	102760
	Scutus (Scutus) antipodes	Boat Shell	73	100266
	Sepia apama	Giant Cuttlefish	2	100251
	Sepioteuthis australis	Southern Calamari Squid	4	100261
	Siphonaria diemenensis		8	102772
	Siphonaria spp.	False Limpets	16	50421
	Tambja verconis	Sea slug	3	102321
	Tosia australis	Biscuit Star	103	100216
	Tosia magnifica	Biscuit Star	7	100215
	Uniophora granifera	Five-armed Seastar	9	100217
	Urolophus paucimaculatus	Sparsely-spotted Stingaree	2	4634
	Xenostrobus pulex	Little Black Horse Mussel	6	100282

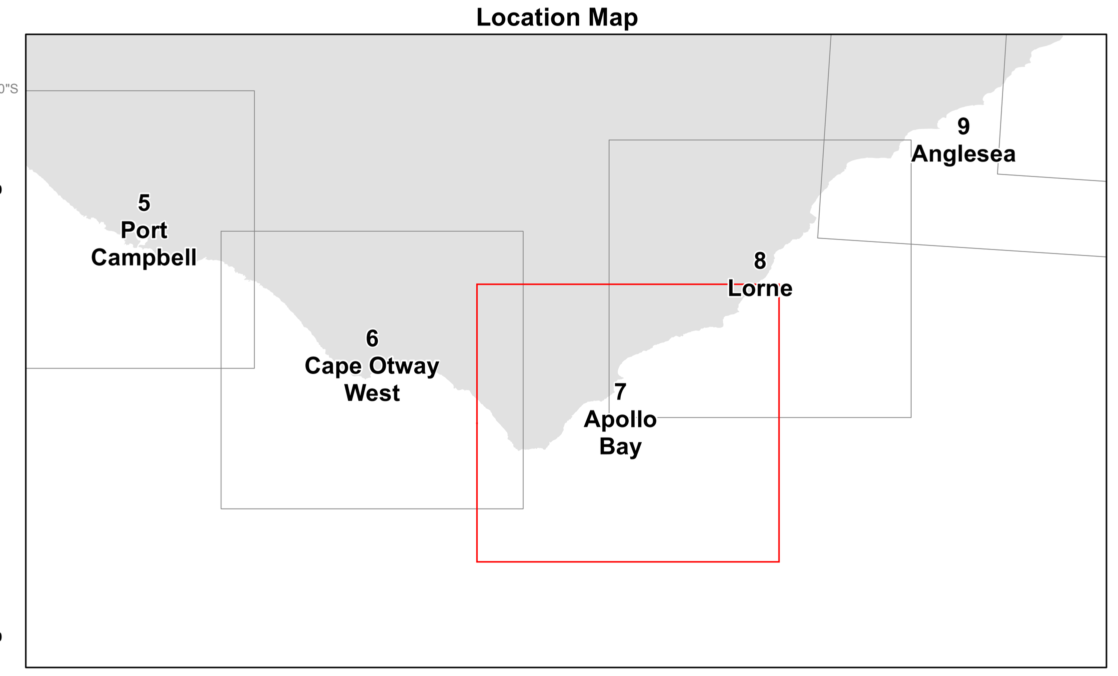
Appendix 7

Victorian Oil Spill Response Atlas (OSRA) maps



07 Apollo Bay
Oil Spill Response Atlas Map

Location Map



Legend

- Fire Station
- Lifesaving Club
- Police Station
- Estuarine Fish Habitats
- Australian Fur Seal Colonies
- Little Penguin colonies
- Hooded Plover
- Shorebird Roosting Sites
- Common Bent-wing Bat
- Shorebird Habitats
- ESTA Emergency Markers
- Boat Launch
- Boat Ramp
- Boat Slipway
- Boat Mooring
- BOM Observation Station
- Victoria - 3nm Boundary
- Coastal Protection Structure
- Shipwrecks

Geological Sites
- International, National Significance
- Regional, State, Unknown Significance
- Bathymetry
- Watercourse

Roads
- Other Roads
- Tracks
- Walking Path
- Marine National Park/Sanctuary

Inter-tidal Vegetation
- Saltmarsh

Corangamite Marine Substrate
- Reef
- Reef - patchy
- Rock platform
- Sand beach
- Sediment

Shoreline Habitat Type
- Artificial Shoreline
- Intertidal Shore Platform
- Mixed Sand Beach/Shore Platform
- Sand Beach

Coastal Types
- Intertidal Shore Platform
- Mixed Sand Beach/Shore Platform
- Sand Beach
- Sand Dunes
- Steep Shoreline (rocky cliffs/embankments)
- Subtidal Rocky Reef
- Subtidal Sandy Substrate

LiDAR Substrates
- Reef
- Reef/Sediment
- Sediment
- Water Body
- Swamp
- Parks and Reserves

Note: Symbols on the map for biological resources (bird and mammal species) are indicative of the resource being in the general vicinity only

Scale 1:50,000

0 2 4 6 8 10 Km

Acknowledgement
This map was produced with support from the Department of Environment and Primary Industries, the National Plan for Maritime Environmental Emergencies.

COORDINATES SYSTEM
Map Grid of Australia
GDA 1994 MGA Zone 54
Projection: Transverse Mercator (UTM)
Datum: GDA 1994 (AHD)

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Emergency Risk and Resilience Division
121 Exhibition Street Melbourne, Melbourne VIC
Ph: 03 8392 6505

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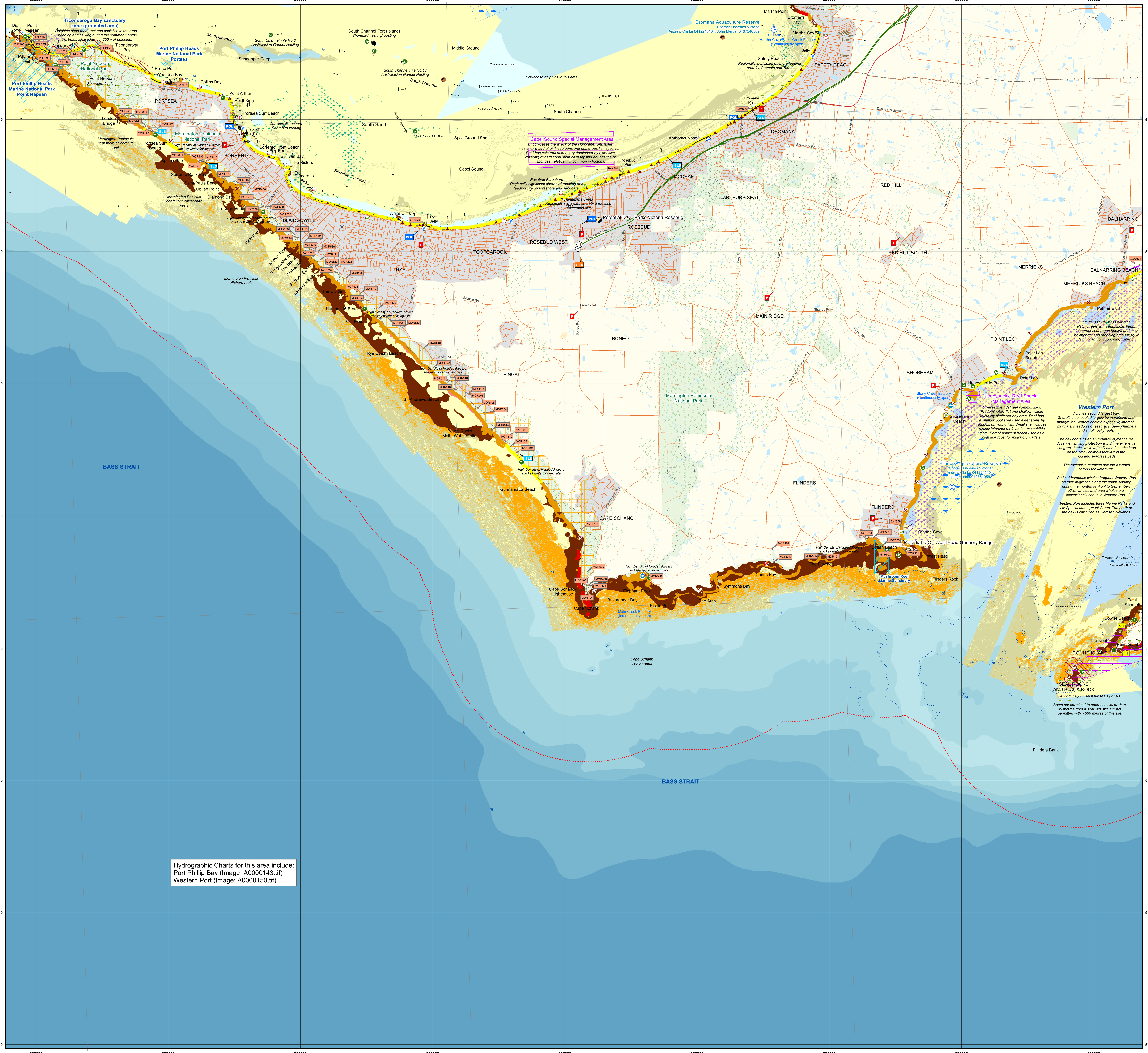
14 Mornington Peninsula South
Oil Spill Response Map



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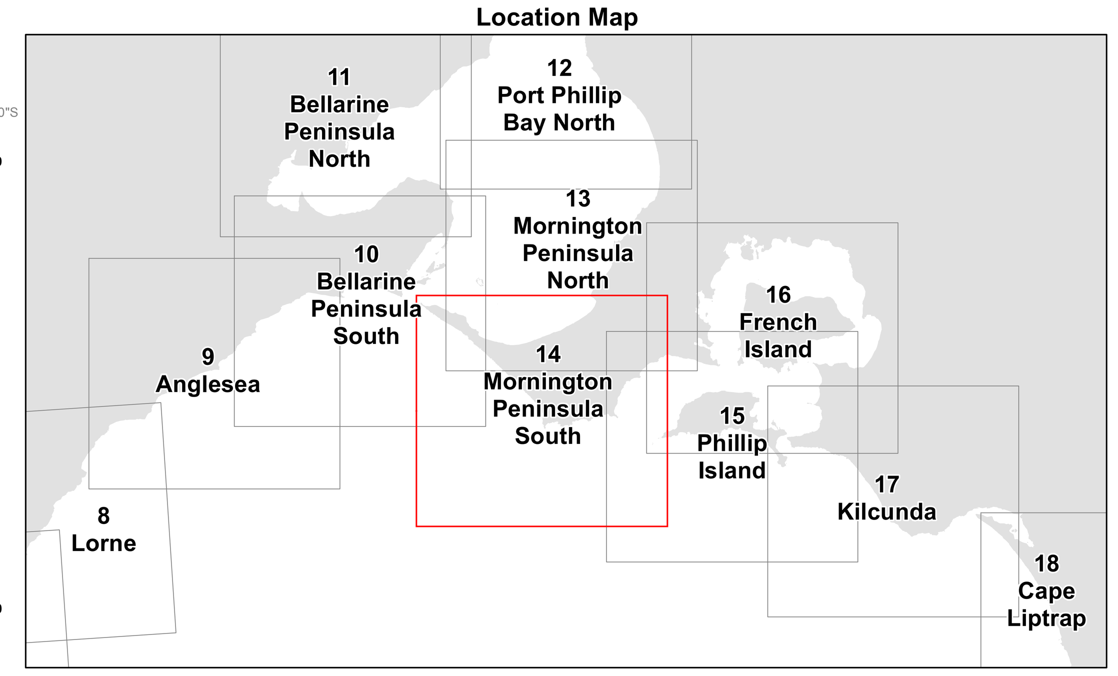

Legend

- Helipads
- Potential ICC Locations
- Fire Station
- Lifesaving Club
- Police Station
- SES Unit
- Estuarine Fish Habitats
- Australian Fur Seal Colonies
- Little Penguin Colonies
- Dolphin Habitat
- Australasian Gannet Nesting Sites
- Hooded Plover Habitat
- Shorebird Roosting Sites
- Tern Nesting Sites
- Common Bent-wing Bat Roost
- Aquaculture License Sites
- Coastal Bird Habitat
- River Entrance - Continuously Open
- River Entrance - Intermittently Open
- Beach Emergency Signs
- ESTA Emergency Markers
- Boat Launch
- Boat Ramp
- Boat Slipway
- Boat Mooring
- Breakwater
- Pier, Jetty, Wharf
- BOM Observation Station
- Navigation Aids
- Coastal Ramsar Sites in Victoria
- Victoria - 3nm Boundary
- Stormwater Drain Outlets
- Oil/Gas Facility
- Oil/Gas Pipeline

Geological Sites
- International, National Significance
- Regional, State, Unknown Significance
- Western Port Bathymetry 25k

- Freeway
- Highway
- Other Roads
- Tracks
- Walking Path
- Watercourse
- Aquaculture Reserve
- Marine Mammals Protected Area
- Marine Special Management Area
- Marine National Park/Sanctuary

Aquatic Vegetation
- Amphibolis
- Macroalgae
- Other Seagrass

Inter-tidal Vegetation
- Saltmarsh

Shoreline Habitat Type
- Artificial Shoreline
- Intertidal Shore Platform
- Mixed Cobble/Shingle Beach/Shore Platform
- Mixed Sand Beach/Shore Platform
- Sand Beach

Coastal Types
- Cobble/Shingle Beach
- Intertidal Sand Flat
- Intertidal Shore Platform
- Mixed Sand Beach/Shore Platform
- Sand Beach
- Sand Dunes
- Steep Shoreline (rocky cliffs/embankments)
- Subtidal Rocky Reef
- Subtidal Sandy Substrate
- Water Body
- Sewage Pond
- Tree Cover
- Parks and Reserves

LiDAR Substrates
- Reef
- Reef/Sediment
- Sediment

Note: Symbols on the map for biological resources (bird and mammal species) are indicative of the resource being in the general vicinity only

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0 2 4 6 8 10 Km

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Datum: GDA 1994 (AHD)

Scale
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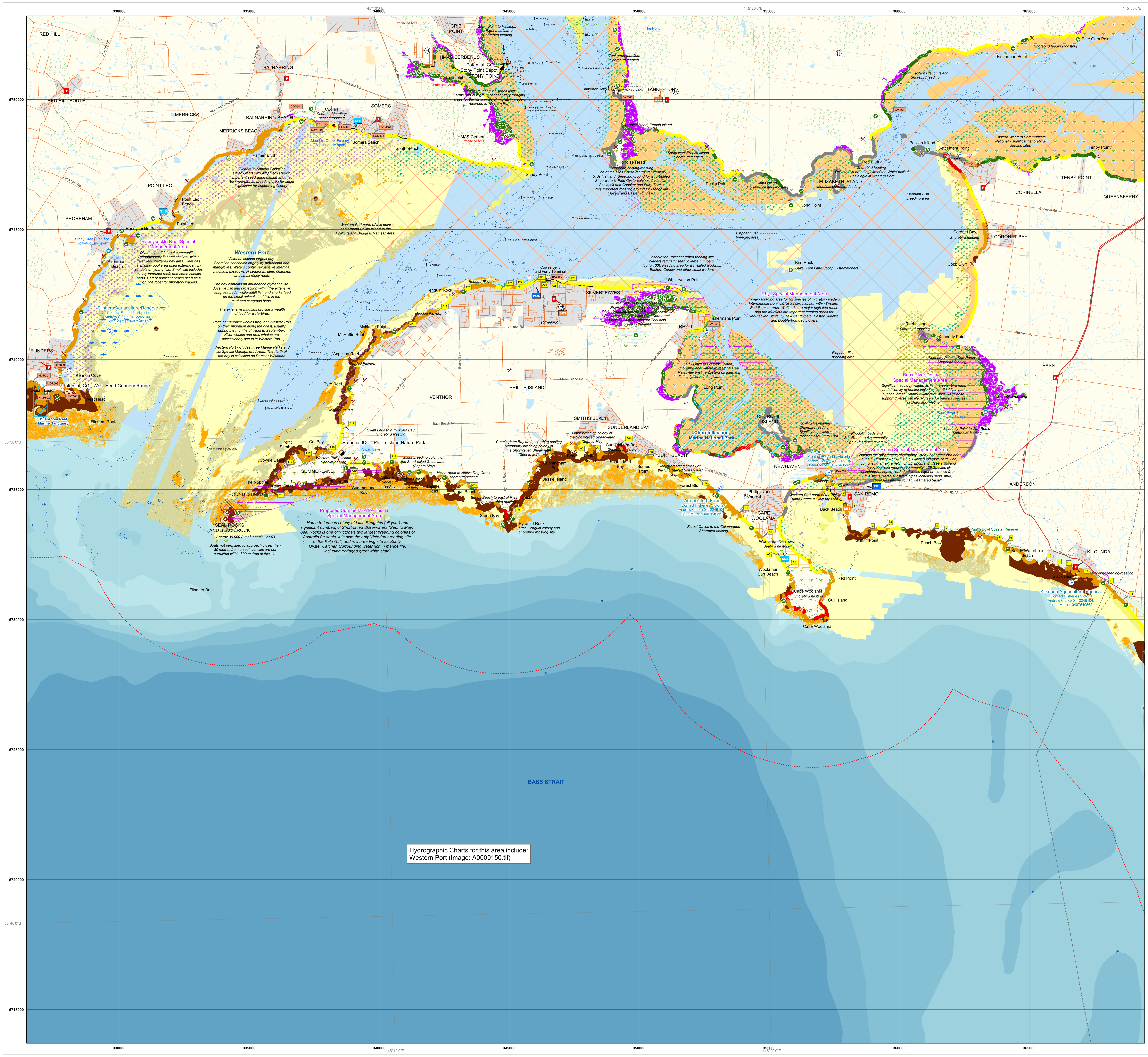
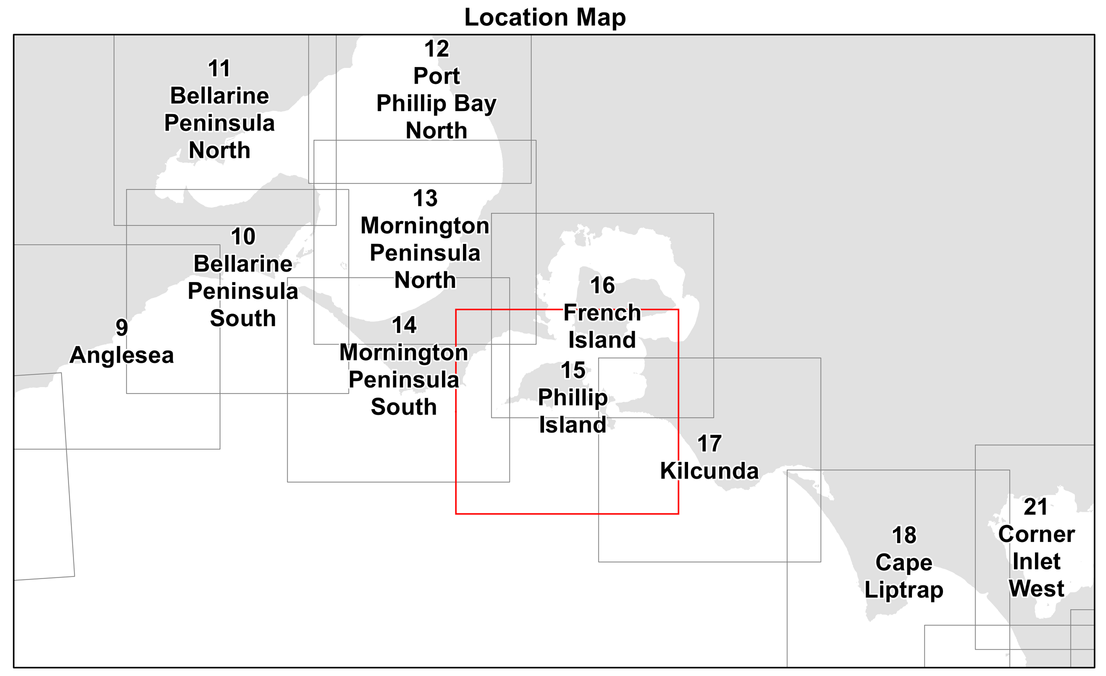
15 Phillip Island
Oil Spill Response Map



Location Map



Legend

- Helipads
- Airports and Airfields
- Potential ICC Locations
- Fire Station
- Lifesaving Club
- Police Station
- SES Unit
- Estuarine Fish Habitats
- Australian Fur Seal Colonies
- Little Penguin Colonies
- Dolphin Habitat
- Hooded Plover Habitat
- Shorebird Roosting Sites
- Tern Nesting Sites
- Aquaculture License Sites
- Coastal Bird Habitat
- River Entrance - Continuously Open
- River Entrance - Intermittently Open
- Beach Emergency Signs
- ESTA Emergency Markers
- Boat Launch
- Boat Ramp
- Boat Slipway
- Boat Mooring
- Breakwater
- Pier, Jetty, Wharf
- BOM Observation Station
- Navigation Aids
- Coastal Ramsar Sites in Victoria
- Victoria - 3nm Boundary
- Oil/Gas Pipeline

Geological Sites
- International, National Significance
- Regional, State, Unknown Significance
- Western Port Bathymetry 25k

- Highway
- Other Roads
- Tracks
- Walking Path
- Watercourse
- Aquaculture Reserve
- Marine Mammals Protected Area
- Marine Special Management Area
- Marine National Park/Sanctuary

Aquatic Vegetation
- Amphibolis
- Macroalgae
- Other Seagrass

Inter-tidal Vegetation
- Saltmarsh
- Mangrove
- Western Port Rhodolith Beds

Shoreline Habitat Type
- Artificial Shoreline
- Cobble/Shingle Beach
- Intertidal Mud-Sand Flat
- Intertidal Shore Platform
- Mangroves
- Mixed Cobble/Shingle Beach/Shore Platform
- Mixed Sand Beach/Shore Platform
- Sand Beach

Coastal Types
- Cobble/Shingle Beach
- Intertidal Mud-Sand Flat
- Intertidal Sand Flat
- Intertidal Shore Platform
- Sand Beach
- Sand Dunes
- Steep Shoreline (rocky cliffs/embankments)
- Subtidal Rocky Reef
- Subtidal Sandy Substrate
- Water Body
- Swamp
- Sewage Pond
- Tree Cover
- Parks and Reserves

LiDAR Substrates
- Reef
- Reef/Sediment
- Sediment

Note: Symbols on the map for biological resources (bird and mammal species) are indicative of the resource being in the general vicinity only

Map not suitable for navigation purposes

0 2 4 6 8 10 Km

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Projection: Transverse Mercator (UTM)
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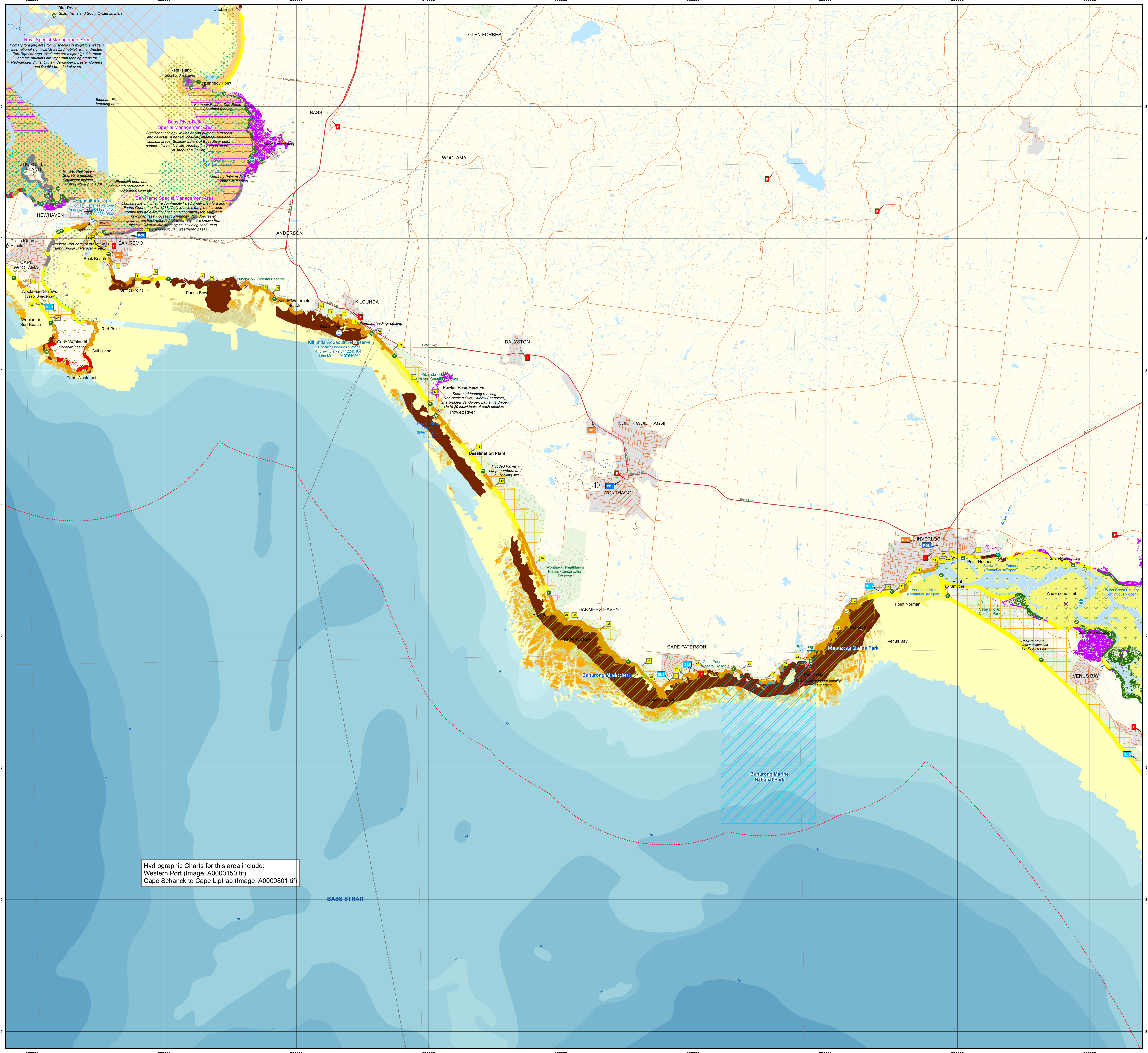
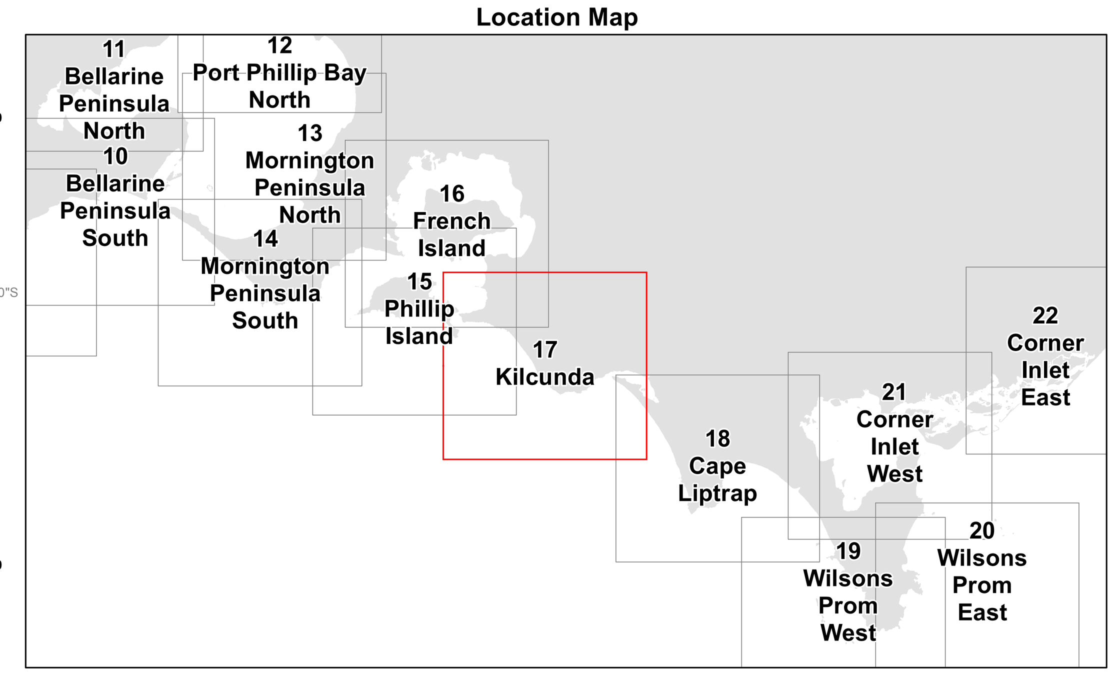
17 Kilcunda
Oil Spill Response Map



Location Map



Legend

- Helipads
- Airports and Airfields
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- Police Station
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- Estuarine Fish Habitats
- Hooded Plover Habitat
- Shorebird Roosting Sites
- Aquaculture License Sites
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- River Entrance - Intermittently Open
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- Boat Slipway
- Boat Mooring
- Breakwater
- Pier, Jetty, Wharf
- BOM Observation Station
- Coastal Ramsar Sites in Victoria
- Victoria - 3nm Boundary
- Oil/Gas Pipeline

Geological Sites
- International, National Significance
- Regional, State, Unknown Significance
- Western Port Bathymetry 25k

- Highway
- Other Roads
- Tracks
- Walking Path
- Watercourse
- Marine Special Management Area
- Marine National Park/Sanctuary
- Other Marine Park

Aquatic Vegetation
- Amphibolis
- Macroalgae
- Other Seagrass

Inter-tidal Vegetation
- Saltmarsh
- Mangrove
- Western Port Rhodolith Beds

Shoreline Habitat Type
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- Mangroves
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- Sand Beach

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0 2 4 6 8 10 Km

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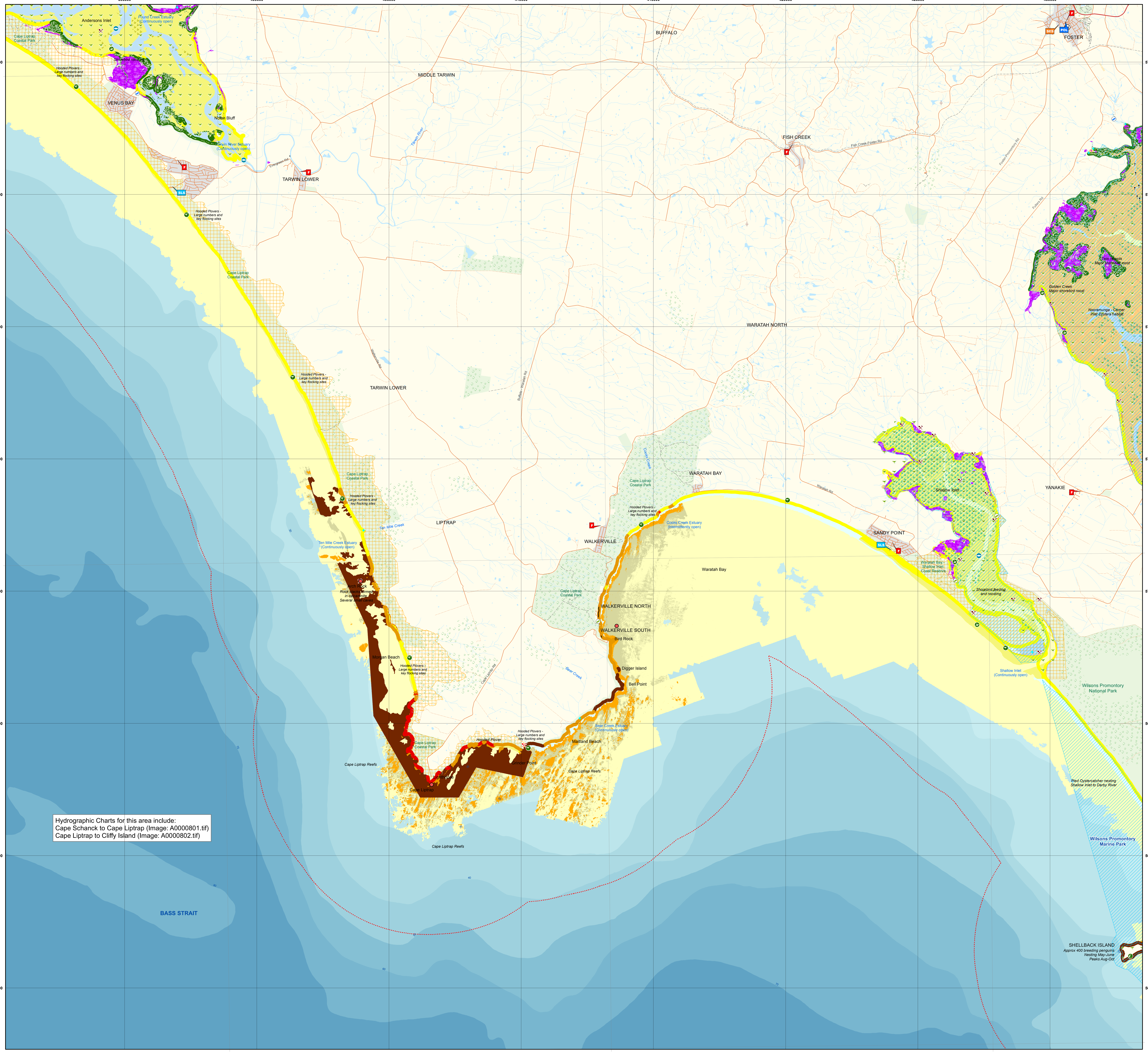
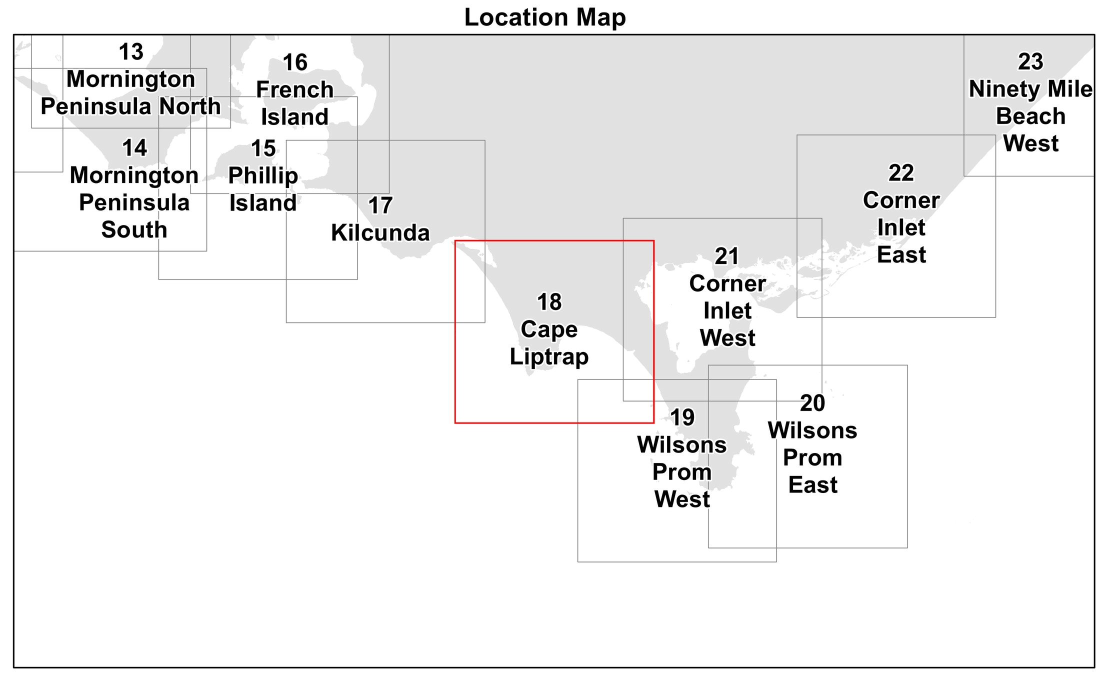


18 Cape Liptrap
Oil Spill Response Map

Location Map



Legend

- Helipads
- Fire Station
- Lifesaving Club
- Police Station
- SES Unit
- Estuarine Fish Habitats
- Little Penguin Colonies
- Hooded Plover Habitat
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- BOM Observation Station
- Coastal Ramsar Sites in Victoria
- Victoria - 3nm Boundary

Geological Sites
- International, National Significance
- Regional, State, Unknown Significance

- Highway
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- Tracks
- Walking Path
- Watercourse
- Marine National Park/Sanctuary

Aquatic Vegetation
- Macroalgae
- Other Seagrass

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- Mangrove

Shoreline Habitat Type
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- Sand Beach

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0 2 4 6 8 10 Km

Scale 1:50,000

COORDINATES SYSTEM
Map Grid of Australia
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Datum: GDA 1994 (AHD)

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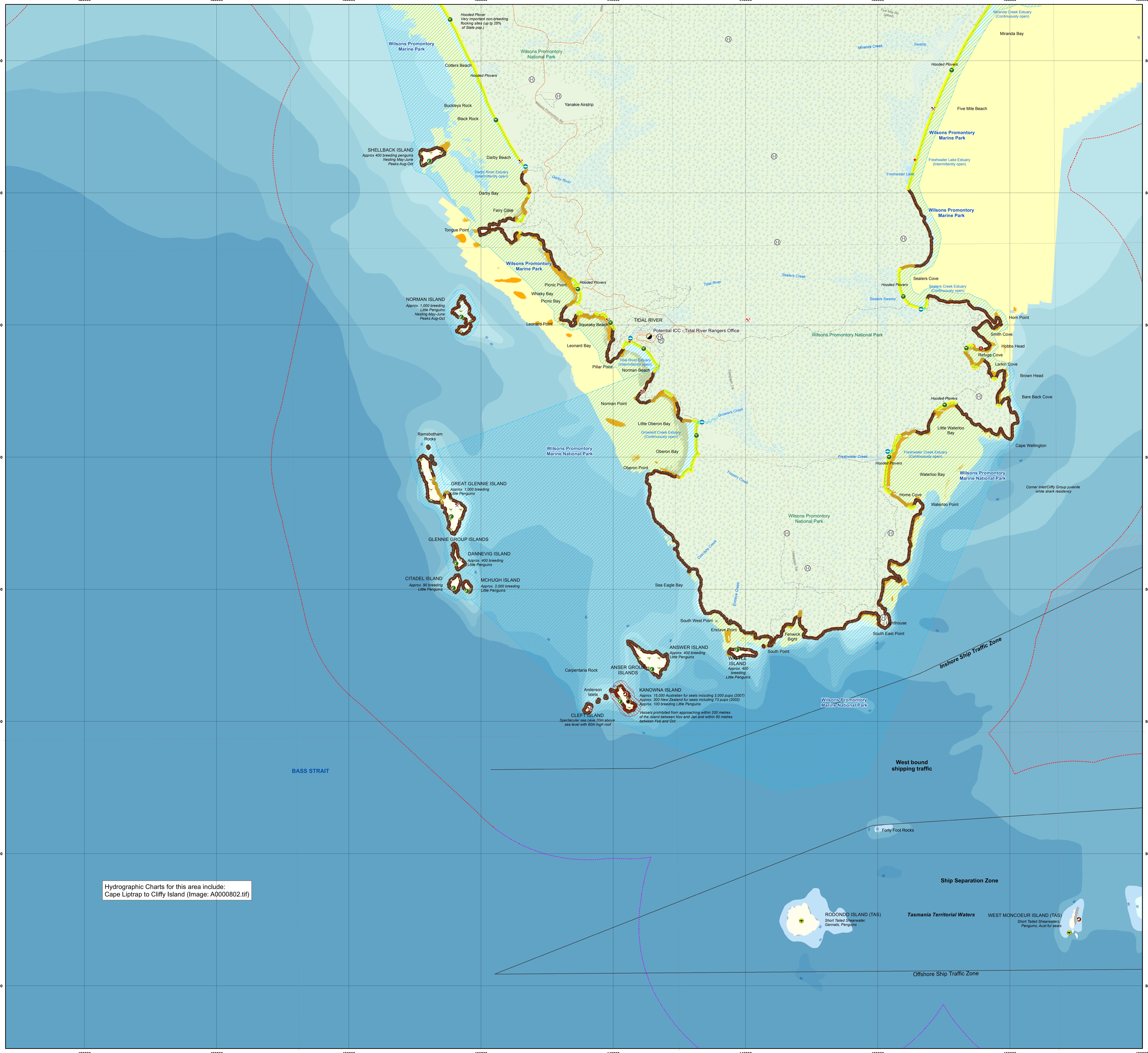
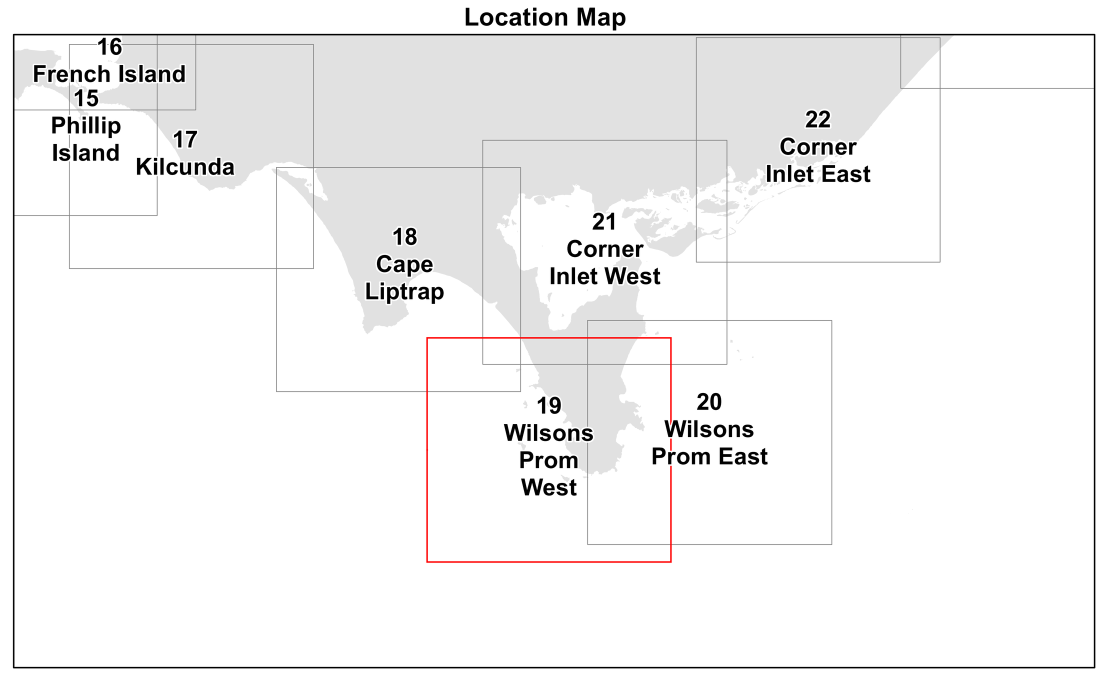
19 Wilsons Prom West
Oil Spill Response Map



Location Map



Legend

- Helipads
- Potential ICC Locations
- Estuarine Fish Habitats
- Australian Fur Seal Colonies
- NZ Fur Seal Colonies
- Little Penguin Colonies
- Hooded Plover Habitat
- Common Bent-wing Bat Roost
- Short-tailed Shearwater
- Coastal Bird Habitat
- River Entrance - Continuously Open
- River Entrance - Intermittently Open
- Boat Launch
- BOM Observation Station
- Tasmania - 3nm Boundary
- Victoria - 3nm Boundary

Geological Sites
- International, National Significance
- Regional, State, Unknown Significance

- Other Roads
- Tracks
- Walking Path
- Watercourse
- Marine Mammals Protected Area
- Commonwealth Marine Reserve
- Marine National Park/Sanctuary

Shoreline Habitat Type
- Intertidal Shore Platform
- Mixed Sand Beach/Shore Platform
- Sand Beach
- Water Body
- Swamp
- Tree Cover
- Parks and Reserves

LiDAR Substrates
- Reef
- Reef/Sediment
- Sediment

Note: Symbols on the map for biological resources (bird and mammal species) are indicative of the resource being in the general vicinity only

Map not suitable for navigation purposes

0 2 4 6 8 10 Km

COORDINATES SYSTEM
Map Grid of Australia
GDA 1994 MGA Zone 55
Projection: Transverse Mercator (UTM)
Datum: GDA 1994 (AHD)

Scale
1:50,000

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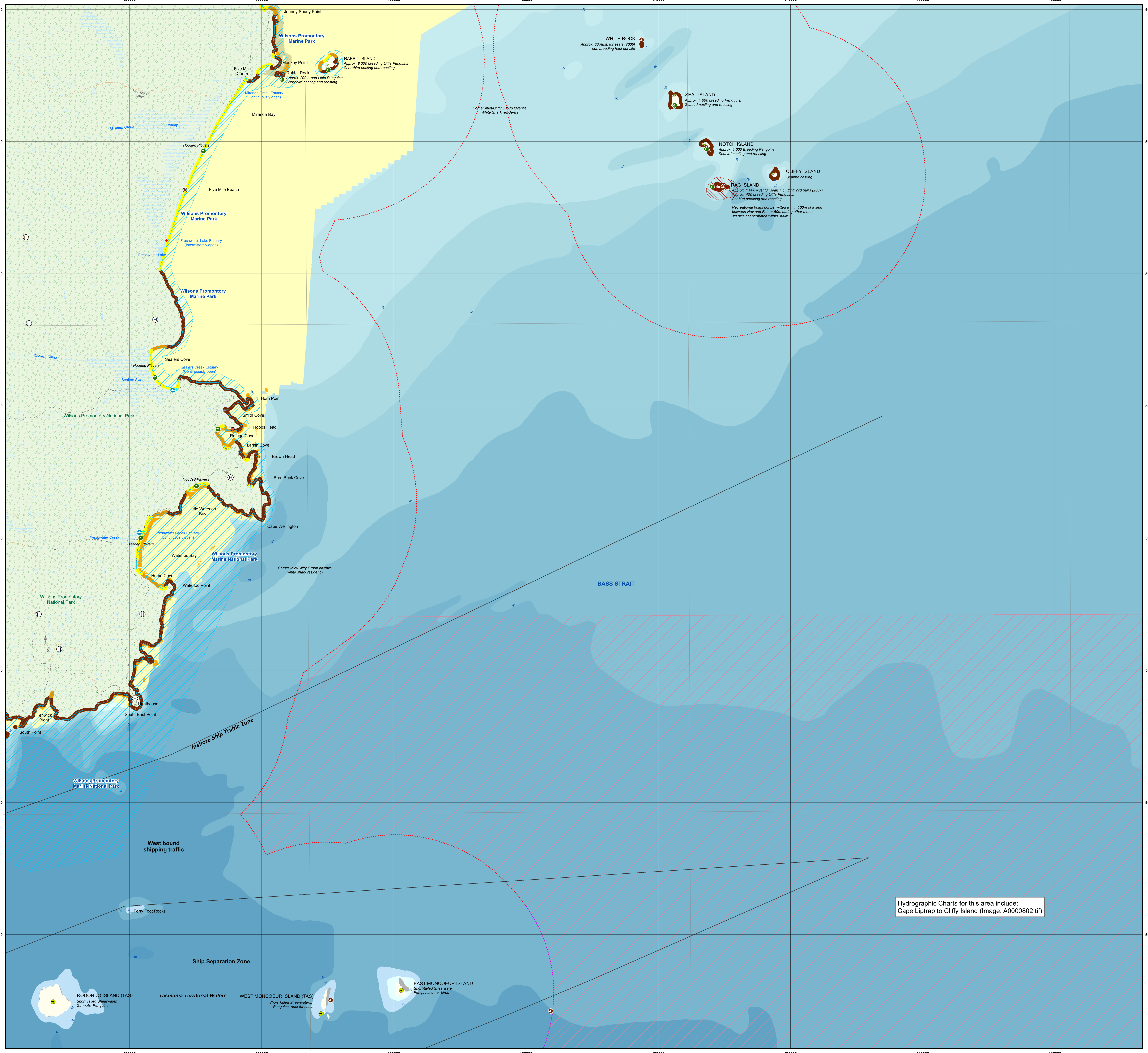
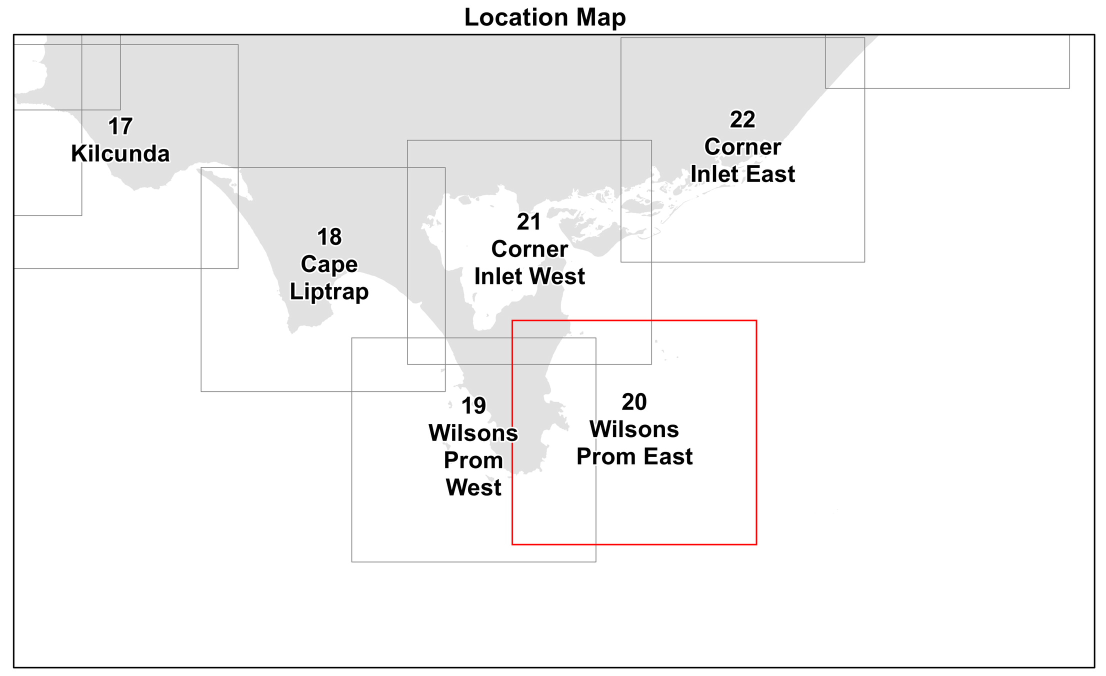
20 Wilsons Prom East
Oil Spill Response Map



Location Map



Legend

- Helipads
- Estuarine Fish Habitats
- Australian Fur Seal Colonies
- Little Penguin Colonies
- Hooded Plover Habitat
- Common Bent-wing Bat Roost
- Short-tailed Shearwater
- Coastal Bird Habitat
- River Entrance - Continuously Open
- River Entrance - Intermittently Open
- BOM Observation Station
- Tasmania - 3nm Boundary
- Victoria - 3nm Boundary

Geological Sites
- Regional, State, Unknown Significance

- Tracks
- Walking Path
- Watercourse
- Marine Mammals Protected Area
- Commonwealth Marine Reserve
- Marine National Park/Sanctuary

Inter-tidal Vegetation
- Saltmarsh

Shoreline Habitat Type
- Intertidal Shore Platform
- Mixed Sand Beach/Shore Platform
- Sand Beach
- Water Body
- Swamp
- Tree Cover
- Parks and Reserves

LiDAR Substrates
- Reef
- Reef/Sediment
- Sediment

Note: Symbols on the map for biological resources (bird and mammal species) are indicative of the resource being in the general vicinity only

Map not suitable for navigation purposes

0 2 4 6 8 10 Km

Scale 1:50,000

COORDINATES SYSTEM
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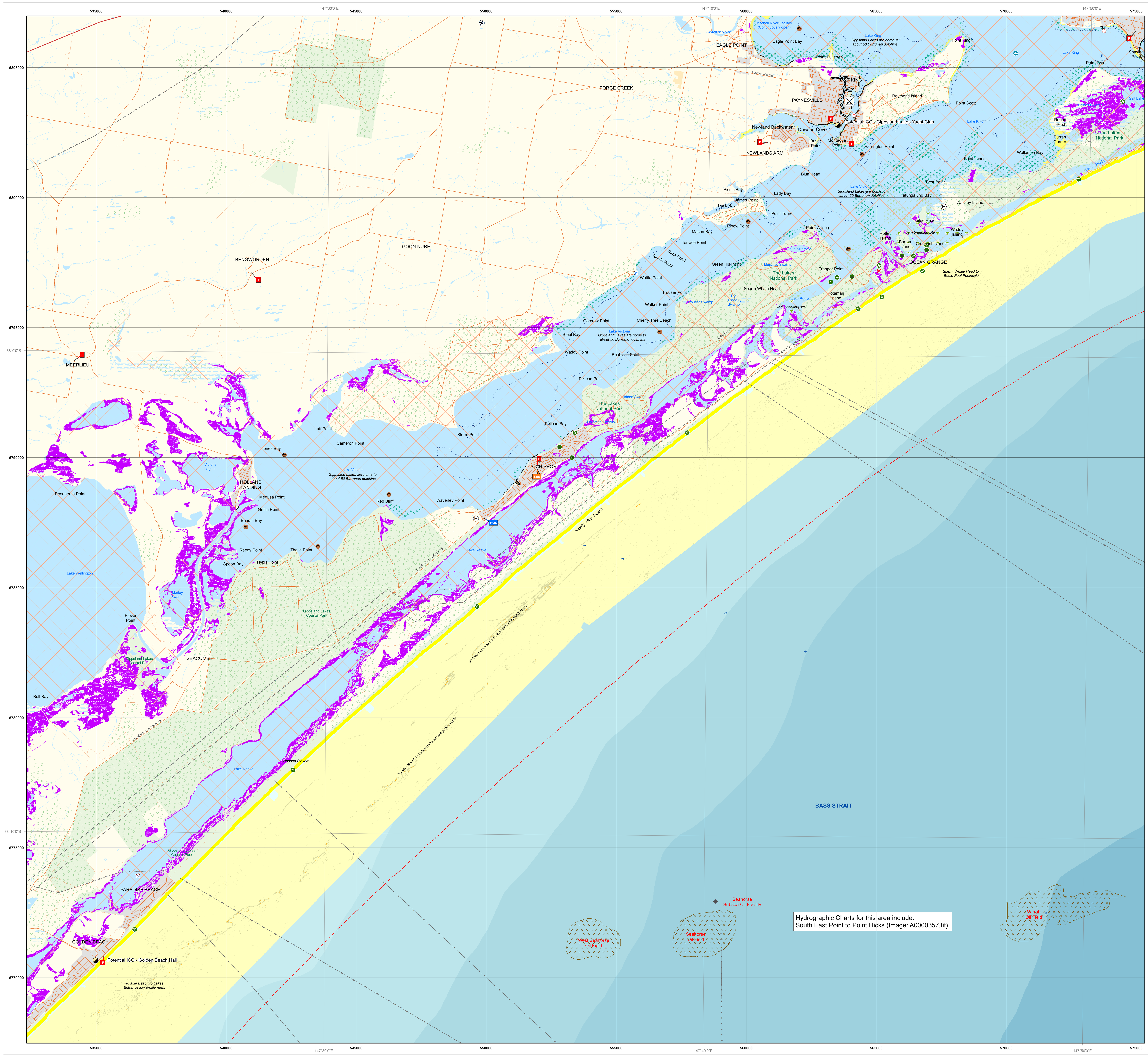
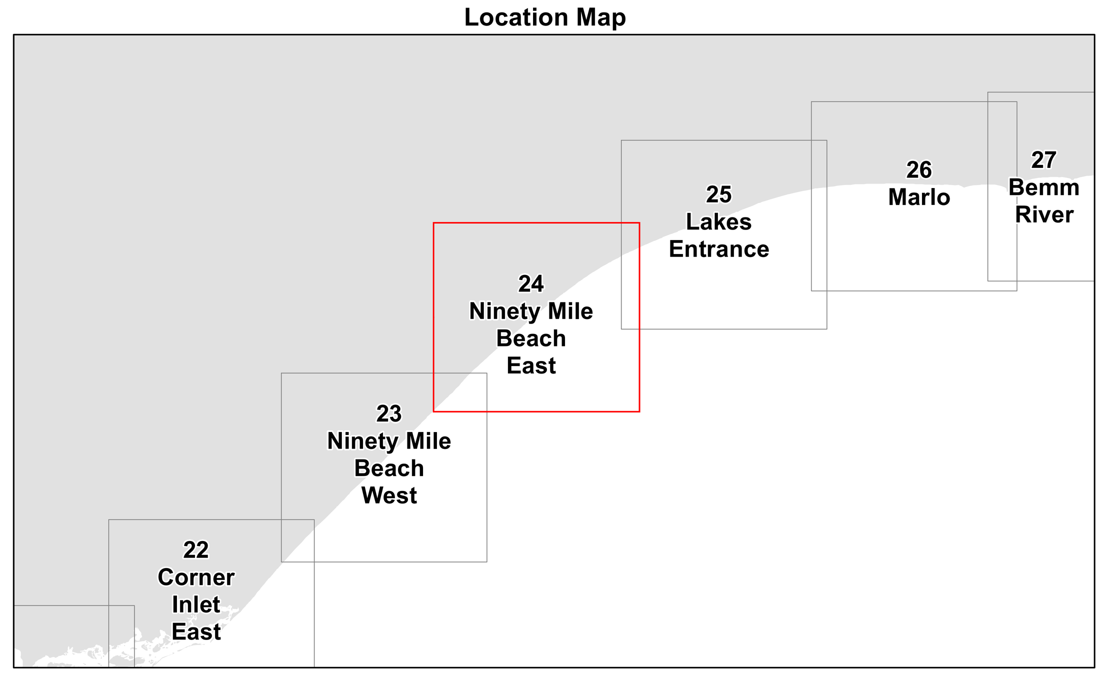
24 Ninety Mile Beach East
Oil Spill Response Map



Location Map



Legend

- Helipads
- Airports and Airfields
- Potential ICC Locations
- Marine Pollution Equipment Storage
- Fire Station
- Police Station
- SES Unit
- Estuarine Fish Habitats
- Dolphin Habitat
- Hooded Plover Habitat
- Shorebird Roosting Sites
- Tern Nesting Sites
- Coastal Bird Habitat
- Boat Launch
- Boat Ramp
- Boat Mooring
- Breakwater
- Pier, Jetty, Wharf
- Coastal Ramsar Sites in Victoria
- Victoria - 3nm Boundary
- Oil/Gas Facility
- Oil/Gas Pipeline

Geological Sites
- International, National Significance
- Regional, State, Unknown Significance

- Highway
- Other Roads
- Tracks
- Walking Path
- Watercourse

Aquatic Vegetation
- Other Seagrass
- Submerged Aquatic Vegetation

Inter-tidal Vegetation
- Saltmarsh

Shoreline Habitat Type
- Sand Beach

Gippsland Lakes Coastal Types
- Intertidal Sand Flat
- Sand Beach
- Sand Dunes
- Subtidal Sandy Substrate
- Water Body
- Swamp
- Sewage Pond
- Tree Cover
- Parks and Reserves
- Offshore Oil Field

LiDAR Substrates
- Reef
- Reef/Sediment
- Sediment

Note: Symbols on the map for biological resources (bird and mammal species) are indicative of the resource being in the general vicinity only

Map not suitable for navigation purposes

0 2 4 6 8 10 Km

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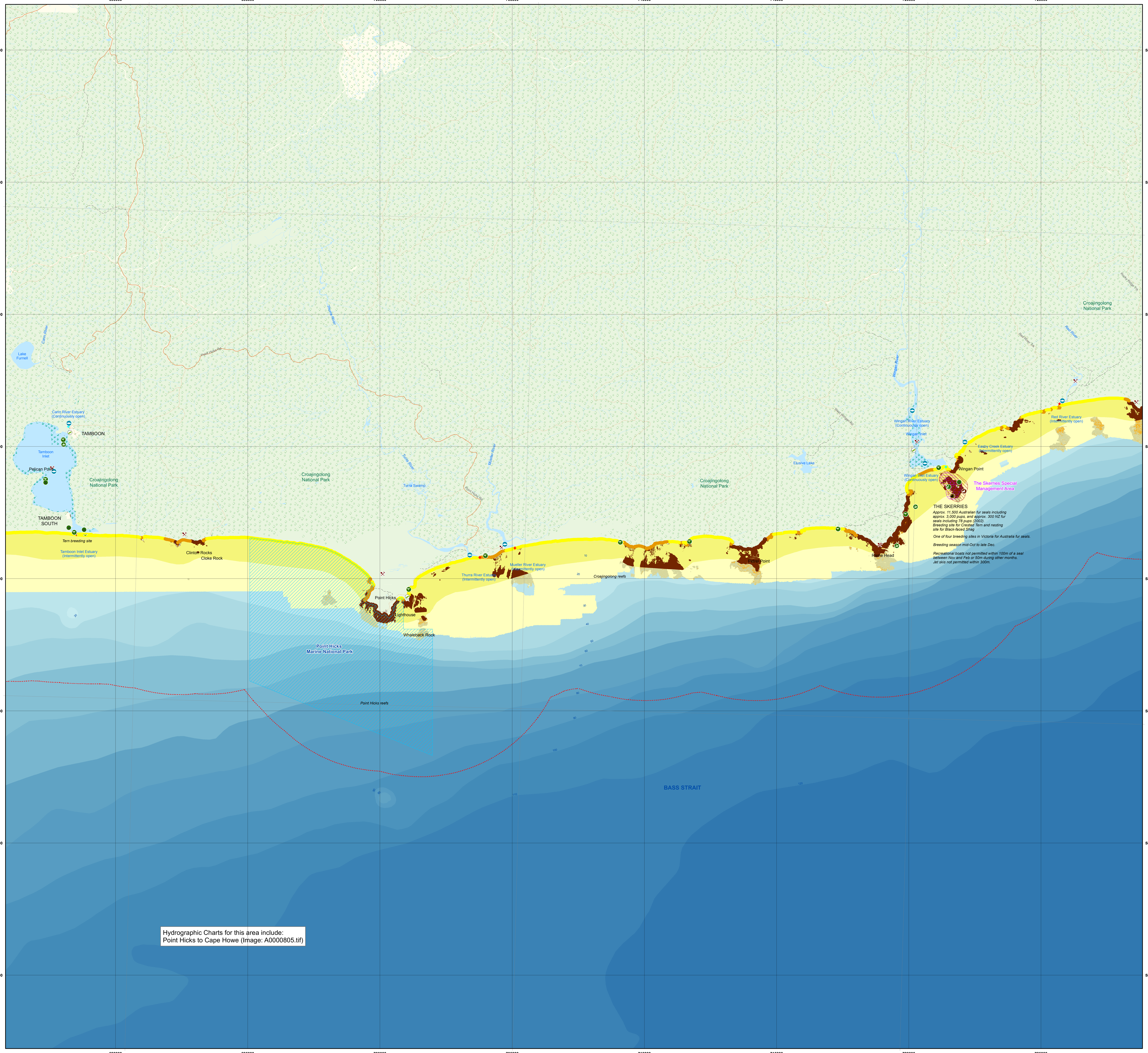
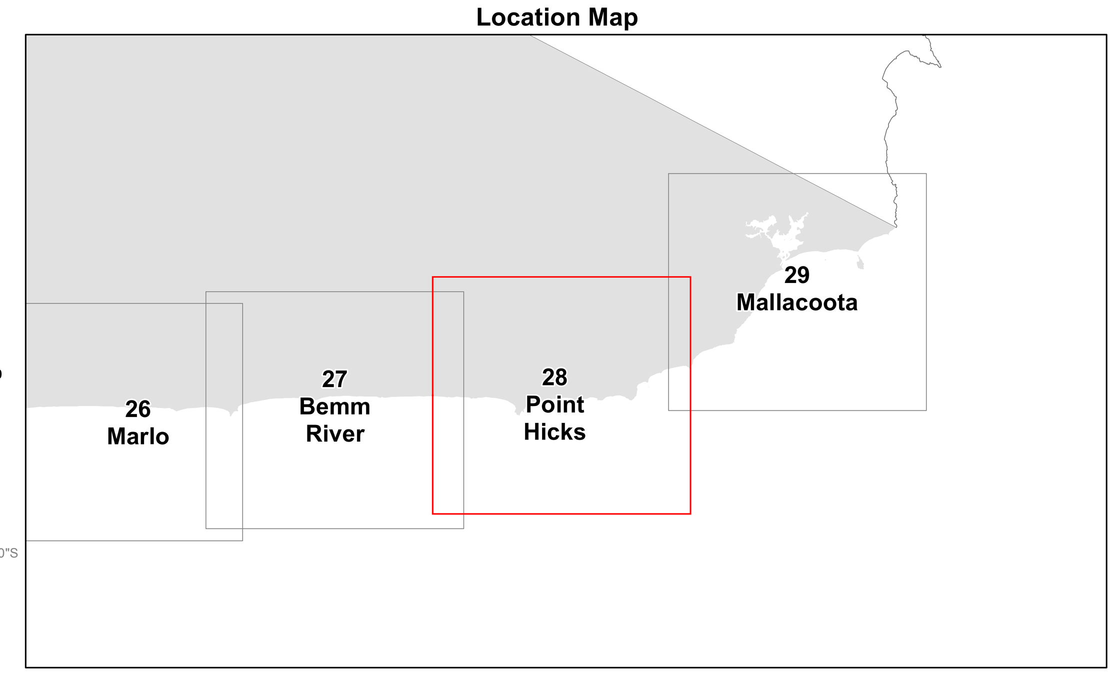
28 Point Hicks
Oil Spill Response Map



Location Map



Legend

- Estuarine Fish Habitats
- Australian Fur Seal Colonies
- NZ Fur Seal Colonies
- Little Penguin Colonies
- Hooded Plover Habitat
- Shorebird Roosting Sites
- Tern Nesting Sites
- Coastal Bird Habitat
- River Entrance - Continuously Open
- River Entrance - Intermittently Open
- Boat Launch
- Pier, Jetty, Wharf
- BOM Observation Station
- Victoria - 3nm Boundary

Geological Sites
- Regional, State, Unknown Significance

- Other Roads
- Tracks
- Walking Path
- Watercourse
- Marine Mammals Protected Area
- Marine Special Management Area
- Marine National Park/Sanctuary

Aquatic Vegetation
- Other Seagrass

Shoreline Habitat Type
- Intertidal Shore Platform
- Mixed Sand Beach/Shore Platform
- Sand Beach

East Gippsland Marine Substrate
- Reef
- Reef - patchy
- Rock platform
- Sand beach
- Sediment
- Water Body
- Swamp
- Tree Cover
- Parks and Reserves

LiDAR Substrates
- Reef
- Reef/Sediment
- Sediment

Note: Symbols on the map for biological resources (bird and mammal species) are indicative of the resource being in the general vicinity only

Map not suitable for navigation purposes

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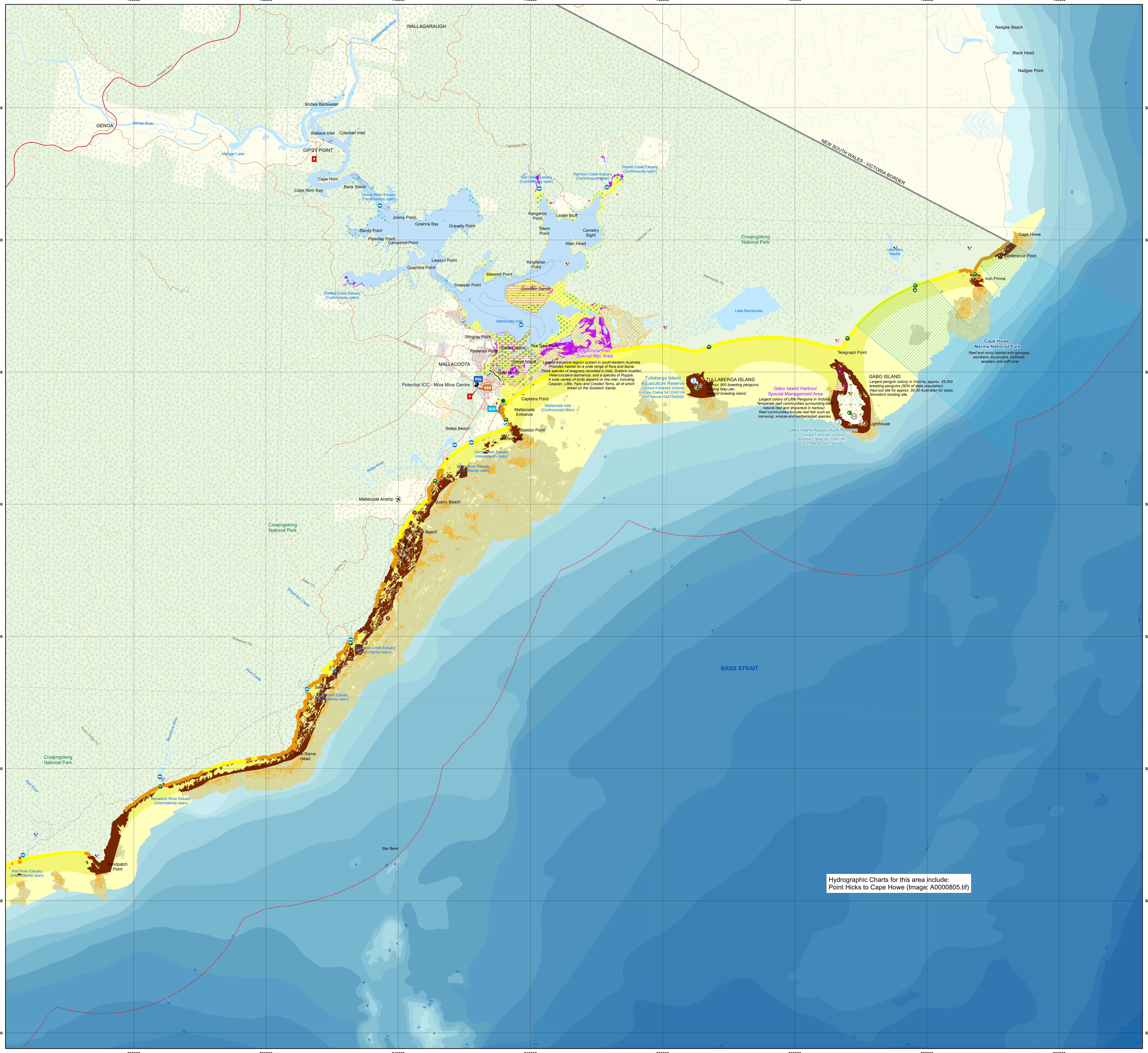
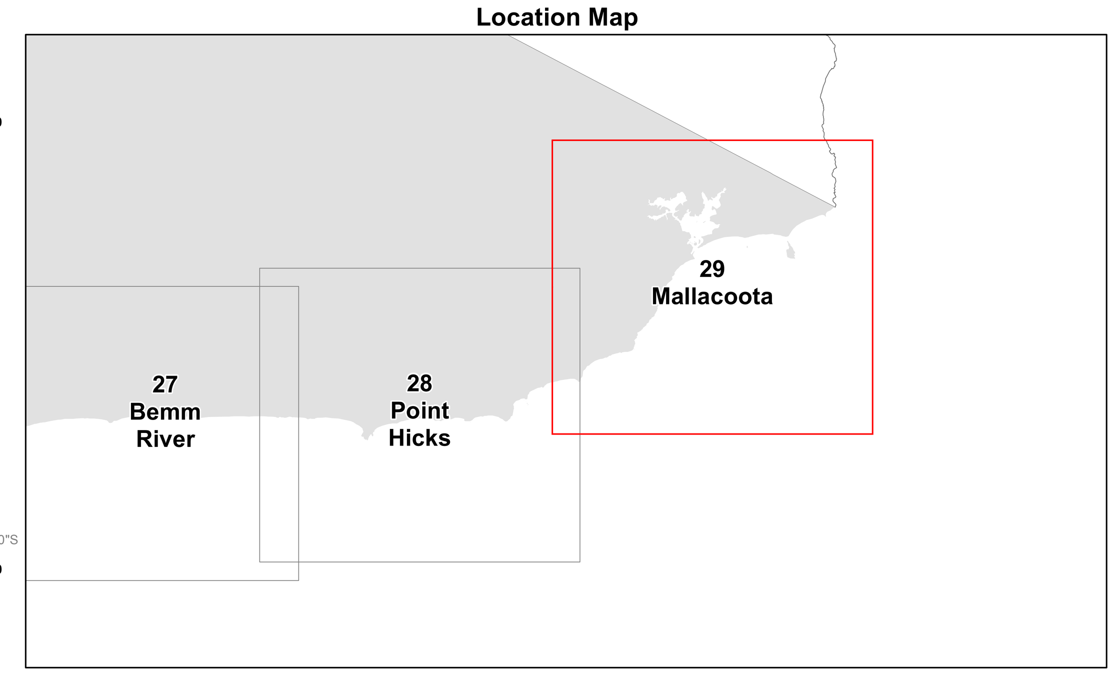


29 Mallacoota
Oil Spill Response Map

Location Map



Legend

- Helipads
- Airports and Airfields
- Potential ICC Locations
- Fire Station
- Lifesaving Club
- Police Station
- SES Unit
- Estuarine Fish Habitats
- Australian Fur Seal Colonies
- Little Penguin Colonies
- Hooded Plover Habitat
- Shorebird Roosting Sites
- Tern Nesting Sites
- Common Bent-wing Bat Roost
- Eastern Horseshoe Bat Roost
- Aquaculture License Sites
- Coastal Bird Habitat
- River Entrance - Continuously Open
- River Entrance - Intermittently Open
- Boat Launch
- Boat Ramp
- Boat Mooring
- Breakwater
- Pier, Jetty, Wharf
- BOM Observation Station
- Victoria - 3nm Boundary

Geological Sites
- International, National Significance
- Regional, State, Unknown Significance

- Highway
- Other Roads
- Tracks
- Walking Path
- Watercourse
- Marine Special Management Area
- Marine National Park/Sanctuary

Aquatic Vegetation
- Other Seagrass
- Submerged Aquatic Vegetation

Inter-tidal Vegetation
- Saltmarsh

Shoreline Habitat Type
- Intertidal Shore Platform
- Mixed Sand Beach/Shore Platform
- Sand Beach

Mallacoota Coastal Types
- Intertidal Sand Flat
- Intertidal Shore Platform
- Sand Beach
- Sand Dunes
- Subtidal Sandy Substrate

East Gippsland Marine Substrate
- Reef
- Reef - patchy
- Rock platform
- Sand beach
- Sand flat/Rock platform
- Sediment
- Water Body
- Swamp
- Sewage Pond
- Tree Cover
- Parks and Reserves

LiDAR Substrates
- Reef
- Reef/Sediment
- Sediment

Note: Symbols on the map for biological resources (bird and mammal species) are indicative of the resource being in the general vicinity only

Map not suitable for navigation purposes

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Appendix 8

Assessment of BassGas operations against the aims of approved conservation advice for Threatened Ecological Communities (TECs)

Assessment of BassGas operations against the stated aims of the Approved Conservation Advice for Giant Kelp Marine Forests of South East Australia (DSEWPC, 2012a)

The table on the following page provides an assessment of routine and non-routine operations against the stated aims of the Conservation Advice.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
1. Research Priorities		
Undertake surveys across the range of the ecological community to: i. identify sites of high conservation priority ii. gain a better understanding of its variation and dynamics in understorey algal species and associated fauna species across its range. iii. locate additional remnants and identify threatened species that may require specific conservation measures.	No impact	No impact
Support and enhance existing programs to map remnants of the ecological community.	No impact	No impact
Determine optimal management strategies for high quality remnants and support and enhance existing management programs such as state marine bioregional plans	No impact	No impact
Support ongoing research aimed at determining and managing the vulnerability of the ecological community to climate change.	No impact	No impact
Investigate the potential and efficacy of reafforestation programs or other approaches for restoration of the ecological community.	No impact	No impact
Support ongoing research and experimental trials to identify patterns of connectivity for giant kelp across the south eastern marine provinces.	No impact	No impact
Support ongoing research into effective control methods for invasive species such as *Centrostephanus rodgersii* (black sea urchin).	No impact	No impact
2. Habitat Loss, Disturbance and Modification		
Ensure that remnants that are of particularly high quality or important for connectivity are considered for inclusion in reserve tenure or other marine conservation measures.	No impact	No impact

Avoid any changes to hydrology in corresponding coastal regions that may result in changes to the natural hydrological regime, including drainage and increase or decrease in run-off, salinity, or pollution.	No impact	No impact
Monitor known remnants to identify key threats and their impacts.	No impact	No impact
Manage threats to remnants of the ecological community.	No impact	No impact
Monitor the progress of recovery, through improved mapping, estimates of extent and condition assessments of the ecological community, and effective adaptive management actions.	No impact	No impact
Liaise with local councils and State authorities to ensure new coastal development, forestry development or other activities involving substrate or vegetation disturbance in areas where the ecological community occurs downstream or in close proximity to the coastline do not adversely impact on known remnants.	No impact	No impact
Liaise with planning authorities to ensure that planning takes the protection of remnants into account, with due regard to principles for long-term conservation. This may particularly apply where the ecological community occurs in or near to coastal urban centres	No impact	No impact
Promote the need for changes in large and small scale changes in the human activities that are contributing to global climate change.	No impact	No impact
3. Invasive Species		
Manage sites to prevent introduction or further spread of new invasive exotic species, and support targeted control of existing key species which threaten the ecological community, using appropriate methods.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters	No impact
Manage shipping and aquaculture practices to minimise potential invasion of exotic species.	No impact	No impact
4. Conservation Information		
Raise public awareness about the Giant Kelp Forests South East Australia ecological community.	No impact	No impact
Establish and/or maintain liaisons with researchers and marine managers in areas which remnants occur.	No impact	No impact
Publish fact sheets and information guides about the ecological community and the implications of EPBC listing.	No impact	No impact

Assessment of BassGas operations against the stated aims of the Approved Conservation Advice for *Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria* ecological community (TSSC, 2018)

The table on the following page provides an assessment of routine and non-routine operations against the stated aims of the Conservation Advice.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
1. Climate change		
Enhance the resilience of the ecological community to the impacts of climate change by reducing other pressures.	No impact	No impact
2. Land use and associated decline in water quality		
Prevent impacts to native vegetation, fauna and substrate from any actions within, adjacent to or near the ecological community by planning for, avoiding or mitigating offsite impacts. Apply recommended buffers around the ecological community and avoid activities that could cause significant change to hydrology or water quality e.g. dredging, deposition of spoil, aquaculture facilities or major construction projects such as marinas. Wider buffers may be required where there is larger scale landscape change. Where possible, protect the inundation area of the estuaries by targeted land purchases.	No impact	No impact
3. Modification of flow regime		
Establish baseline mouth closure frequency and duration data for all estuaries within the community (see research priorities below).	No impact	No impact
Maintain the natural, three phase flow regime required for salt-wedge dynamics by allowing estuary mouths to remain open at frequencies, for durations, and with passing flows, sufficient to maintain natural or typical hydrological regime.	No impact	No impact
Ensure that surface water and ground water extraction, major riverine regulatory infrastructure (e.g. reservoirs) and other infrastructure (e.g. bridges) do not significantly alter the current hydrology of estuaries within the ecological community.	No impact	No impact
Ensure that catchment land-use changes do not significantly affect water quantity, quality and seasonality.	No impact	No impact
Minimise water quality impacts caused by run-off into rivers and estuaries, including pollution, increased nutrients (leading to eutrophication), chemical contamination, turbidity and	No impact	No impact

sedimentation by protecting buffer zones and implementing measures to reduce erosion within river catchments.		
Undertake risk assessments to identify areas of potential and active acid sulphate soils and develop and implement strategies to mitigate and manage acid flows.	No impact	No impact
3. Invasive species		
Eradicate or manage threatening weed infestations, such as willows, associated with riparian and adjacent wetland vegetation using appropriate methods.	No impact	No impact
Ensure that chemicals or other mechanisms used to eradicate weeds in the surrounding landscape do not have adverse impacts on the ecological community.	No impact	No impact
4. Disease and pathogens		
Minimise outbreaks of viruses (e.g. iridovirus in copepods) and fungal disease (e.g. Epizootic Ulcerative Syndrome or Red Spot Disease in fish) within the ecological community by maintaining optimum water quality and reducing other disturbance pressures.	No impact	No impact
5. Restore		
Implement appropriate management to improve water quality and restore natural or typical river flows with seasonal high and low flow cycles that support the periodic seasonal salt-wedge flushing and formation to build resilience of the ecological community and facilitate ecological function.	No impact	No impact
Undertake restoration of riparian and buffer zones, seagrass, Ruppia beds and other instream habitat areas (including low-flow refuges) where they have been degraded or lost.	No impact	No impact
In conjunction with appropriate research and monitoring, consider reintroduction of lost or depleted biota, including keystone species.	No impact	No impact
6. Education, information and local regulation		
Develop a communication strategy, education programs, information products and signage to help local communities, planners and managers recognise: - when the ecological community is present and why it is important to protect it; - how to appropriately support and manage the ecological community to enhance its biodiversity and ecology, including responsible management of the estuary mouth; and - responsibilities under state and local regulations and the EPBC Act.	No impact	No impact

Promote knowledge about deoxygenation, blackwater events and fish kills, including how these events impact the ecological community and strategies to mitigate these impacts (recognising that these events can also occur naturally).	No impact	No impact
Promote awareness and protection of the ecological community with relevant agencies and industries. For example with: - State and local government planning authorities (such as CMAs), to ensure that planning takes the protection of rivers and estuaries into account, with due regard to principles for long-term conservation. - Community groups, such as EstuaryWatch. EstuaryWatch groups meet regularly. Monitors take photos of the estuary mouth, record water level (AHD) and conduct water quality monitoring. This data is available to the public at www.estuarywatch.org.au. - Local councils and state authorities, to ensure water extraction, riverine regulatory infrastructure and actions undertaken within or adjacent to the ecological community, do not adversely impact the ecological community. - Landholders and farmers, to minimise water quality impacts from agricultural land use, such as pollution from chemicals and fertilisers, increased turbidity from erosion and altered hydrology. - Recreational fishers and fishing industry, to ensure that fishing practices do not adversely impact the ecological community.	No impact	No impact
7. Incentives and support		
Support opportunities for traditional owners or other members of the Indigenous community to engage with and manage the ecological community.	No impact	No impact
Encourage local participation in recovery efforts (e.g. revegetation of seagrass beds and riparian zones), removing threats and actively maintaining the ecological community. Support on-ground action and integrated management for invasive flora and fauna.	No impact	No impact
Develop coordinated incentive projects to encourage conservation and stewardship on adjacent private land and those with significant tributaries flowing into the ecological community and link with other programs and activities, especially those managed by regional catchment councils	No impact	No impact
8. Monitoring		
Install telemetry stations in estuaries that do not already have them installed to regularly capture profiles and surface measurements of physico-chemical parameters.	No impact	No impact

Undertake regular analysis of physicochemical data from estuaries within the ecological community to determine trends and opportunities to improve water quality and build resilience of the ecological community to ongoing threats.	No impact	No impact
Record and make available both discharge data and water extraction data for each estuary in the ecological community.	No impact	No impact
Monitor and record occurrences of algal blooms, blackwater events, acid flows and fish kills in a centralised database.	No impact	No impact
Monitor and record incursions of invasive species (including, but not limited to fish) across the ecological community.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters	No impact
Support the implementation of the Index of Estuary Condition and its application to the ecological community.	No impact	No impact
Undertake periodic surveys of seagrass and other macrophytes across the ecological community to assess their status.	No impact	No impact
Undertake surveys and monitoring of the composition of pelagic flora and fauna in representative estuaries across the distribution of the ecological community.	No impact	No impact
Undertake surveys to quantify recreational catches of native fish species within the ecological community to determine whether management actions are required.	No impact	No impact
Monitor changes in condition, including response to all types of management actions and use this information to increase understanding of the ecological community and inform recommendations for future management.	No impact	No impact
9. Research		
Undertake baseline assessments of a representative sub-set of the community to clarify the ecological composition of the community. Include identification of local invasive and problematic native species.	No impact	No impact
Gain a greater understanding of estuary mouth dynamics in relation to natural opening and closing behaviour versus artificial opening of the estuaries, including regular, longterm recording and analysis of related data.	No impact	No impact
Establish environmental flow requirements for each system and ensure this informs future water resource plans.	No impact	No impact

Continue to build an understanding of the biotic variation in the ecological community.	No impact	No impact
Continue to investigate the threat of disease in the ecological community, including iridovirus infection in mesozooplankton. Determine which estuaries are affected, and if possible, identify causal factors and preventative measures. Determine the levels of impact of disease on secondary productivity, food web dynamics and estuarine fish recruitment.	No impact	No impact
Develop control methods to reduce or eradicate invasive fish species in the estuaries and parent river systems of the ecological community. Undertake trials to assess effectiveness and appropriateness of control methods prior to implementation.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters	No impact
Investigate the disappearance of significant coverage of seagrass and macrophytes where these are known to occur (e.g. Hopkins estuary).	No impact	No impact
Continue to build an understanding of the risks associated with climate change, including sea level rise, increasing temperature, ocean acidification and future flood risk.	No impact	No impact
Assess the vulnerability of the ecological community to climate change and long-term drought, and investigate ways to improve resilience through threat abatement and management actions.	No impact	No impact
Determine the importance of groundwater inflow to the ecological community, particularly with regard to freshwater discharge.	No impact	No impact
10. Offsets		
Ensure that offsets are consistent with the wording and intent of the EPBC Act Environmental Offsets Policy (Commonwealth of Australia 2012), including: - 'like-for-like' principles based on meeting the overall definition of the ecological community and considering the particular species composition and other habitat and landscape features at a particular site; and - how proposed offsets will address key priority actions outlined in this Conservation Advice and any other relevant recovery plans, threat abatement plans and any other Commonwealth management plans.	No impact	No impact
Maintain (or increase) the overall quality and ecological function of the remaining extent of the ecological community and surrounding catchments and improve formal protection through a combination of the following measures: - placement of areas of the ecological community and adjacent mature vegetation in formal reserve tenure or other conservation-related land tenure for protection and management in perpetuity; and/or	No impact	No impact

- improve the condition and ecological function of salt-wedge estuaries, for example, by enhancing riverine water quality and riparian zone condition, to ensure that any offset sites add additional value to the remaining extent.

Assessment of BassGas operations against the stated aims of the Approved Conservation Advice for Subtropical and Temperate Coastal Saltmarsh (TSSC, 2013)

The table on the following page provides an assessment of routine and non-routine operations against the stated aims of the Conservation Advice.

Management Aims	Assessment of impacts of routine activities against management aims	Assessment of impacts of Level 2 or 3 hydrocarbon spill against objectives
1. Research Priorities		
Develop a methodology for calculating appropriate buffer zone sizes for Coastal Saltmarsh.	No impact	No impact
Undertake further research on Coastal Saltmarsh ecosystem function and services, for example: • 'nutrient' cycling/dynamics and energy flows • nursery function and links with coastal fisheries • 'Blue Carbon' • shoreline stabilisation and storm buffering capacity.	No impact	No impact
Research the effects of disturbances (e.g. pollution, discharge of stormwater, and recreational use) on ecological function.	No impact	No impact
Undertake surveys, encompassing a wide taxonomic range, across the national extent of the ecological community, to identify: • sites of high conservation priority • threatened species that may require specific conservation measures • areas that would most benefit from removal of tidal restriction and/or other regeneration restoration efforts.	No impact	No impact
Undertake or support analysis of the hydrological needs of the ecological community, including interactions between saltmarsh and groundwater; and modelling altered hydrological regimes.	No impact	No impact
Continue to support existing research on exotic weeds and support trials to control invasive weeds.	No impact	No impact
Identify in more detail how Coastal Saltmarsh will be impacted by future sea level rise and the potential for mitigation or adaptation at local and regional scales.	No impact	No impact
2. General		
Provide appropriate buffer zones around patches of Coastal Saltmarsh to increase resilience and make land available to accommodate landward migration of saltmarshes.	No impact	No impact

Develop a fit-for-purpose national database of Coastal Saltmarsh extent (including a comparable approach across jurisdictions) and monitor and record changes in extent.	No impact	No impact
Implement best practice standards for managing remnants on private and public lands (e.g. include 'inundation easements' as part of any foreshore redevelopment).	No impact	No impact
Monitor the progress of recovery, through improved mapping and condition assessments of Coastal Saltmarsh, and implement effective adaptive management strategies.	No impact	No impact
Liaise with planning authorities to ensure that planning decisions take into account the protection of Coastal Saltmarsh, with due regard to the need for long-term conservation.	No impact	No impact
3. Land clearing		
Avoid clearing native vegetation within Coastal Saltmarsh and its surrounds, including avoiding clearing within an appropriate buffer zone (e.g. at least 30 metres from the ecological community's boundary).	No impact	No impact
Avoid clearing native vegetation and other activities in catchment areas that may result in altered sediment delivery to the ecological community.	No impact	No impact
4. Infilling		
Avoid infilling/raising the soil profile in saltmarshes (e.g. during development projects).	No impact	No impact
Implement best practice standards and/or identify alternative construction techniques for projects which may have a land-reclamation component.	No impact	No impact
5. Altered hydrology		
Ensure that projects that lead to alterations in the hydrological characteristics of Coastal Saltmarsh areas do not occur.	No impact	No impact
Avoid constructing levees, culverts, floodgates etc. that will lead to permanent inundation or permanent tidal restriction of Coastal Saltmarsh, or that will otherwise adversely alter existing inundation/tidal regimes.	No impact	No impact
Avoid constructing outlets/drains that direct stormwater discharge into or near Coastal Saltmarsh.	No impact	No impact
Investigate options to restore natural hydrological regimes to coastal saltmarshes that have been adversely impacted and implement restoration where appropriate.	No impact	No impact
6. Invasive species - flora		

Enhance/develop and implement management plans for the control of major weed infestations (such as *Juncus acutus, Spartina, Baccharis, Limonium hyblaeum*) within the ecological community, or for emerging weed threats as they develop (e.g. the increasing number of Limonium spp. entering cultivation).	No impact	No impact
Ensure that chemicals or other mechanisms used to eradicate weeds do not have adverse impacts on saltmarsh species (including macro/micro-algae which may be particularly sensitive to some herbicides) or adverse impacts on adjacent areas such as mudflats.	No impact	No impact
7. Invasive species – fauna		
Manage shipping and aquaculture practices to minimise potential invasion of exotic macroinvertebrates, fish, meiofauna, and pathogen species; and include Coastal Saltmarsh in the sites monitored for such arrivals.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters	No impact
Avoid deliberate introductions of other invasive fauna species into the ecological community (often by members of the public) e.g. through community education.	No impact	No impact
Implement control measures to restrict the access of terrestrial invasive animals to the ecological community (e.g. fencing) and to reduce/control existing invasive populations.	No impact	No impact
8. Insect control		
Ensure that chemicals or other mechanisms used for insect control (e.g. of disease vectors/nuisance species such as mosquitoes, sandflies and midges) do not adversely impact other saltmarsh species, or those in adjacent areas (e.g. mudflat invertebrates).	No impact	No impact
Avoid further deliberate introductions of predatory mosquito fish (*Gambusia holbro*oki).	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters	No impact
Explore insect management options and their wider applicability (e.g. in Queensland runnelling has had some success, but its impacts in more species rich saltmarshes are not known).	No impact	No impact
9. Recreation		
Where practical, restrict or prevent recreational vehicle access (including bicycles) to Coastal Saltmarsh and assist through public education measures such as signs.	No impact	No impact
Implement best practise measures for constructing access tracks across Coastal Saltmarsh (e.g. use raised platforms) and ensure that access paths/tracks are not inundated at times of high tide.	No impact	No impact

Support the use of these tracks and paths (e.g. erect educational signs and information points and promote their use).		
Implement restoration activities to mitigate the impacts of recreational use, including replanting of native species as appropriate.	No impact	No impact
10. Pollution/Litter		
Implement education and management strategies around areas of Coastal Saltmarsh that discourage littering (e.g. install bins, and/or signs requesting people take their litter home, in nearby parks/carparks).	No impact	No impact
Avoid constructing outlets/drains that direct stormwater discharge or industrial effluent into or near Coastal Saltmarsh.	No impact	No impact
Where existing discharges occur investigate the feasibility and efficacy of retrofitting gross pollutant traps (GPTs).	No impact	No impact
Identify Coastal Saltmarsh as important habitat in all oil spill contingency planning at national and State levels, and monitor the application of protocols on the management of spills involving saltmarshes.	No impact	The OPEP takes into accounts risks to the shoreline and prioritises actions to reduce the spread and extent of oil towards the shoreline.
11. Eutrophication		
Implement agricultural best practise measures to minimise nutrient (e.g. nitrogen and phosphorus) run-off in Coastal Saltmarsh catchment areas.	No impact	No impact
Monitor the level of nutrient inputs into patches of the ecological community, especially those that fringe estuaries.	No impact	No impact
12. Acid sulphate soils		
Avoid disturbance of potential acid sulphate soils that may expose them to the atmosphere and may lead to the soils drying out (e.g. digging trenches or draining Coastal Saltmarsh).	No impact	No impact
Use soil testing practises to test for the presence of potential acid sulphate soils prior to any activity that may lead to drainage or disturbance.	No impact	No impact
Develop and maintain a register/s of known potential acid sulphate soil sites.	No impact	No impact
13. Evaporative salt production and mining		

Review mining tenements within coastal saltmarsh areas with a view to reducing the total area of potential mining, in particular in areas of high conservation value.	No impact	No impact
Investigate and implement alternatives to creating new solar evaporative salt production ponds in coastal saltmarshes; alternatively implement best practise strategies when identifying sites for new solar evaporative salt ponds that take into account the ecological sensitivities of the land being considered/used.	No impact	No impact
Develop and implement recovery actions for disused solar evaporative salt ponds.	No impact	No impact
14. Climate change and sea level rise		
Enhance the resilience of the ecological community to the impacts of climate change by reducing other pressures.	No impact	No impact
Investigate potential refuge/retreat areas (including buffer zones) and determine appropriate adaptation management strategies.	No impact	No impact
Expand programs such as those in a range of States (e.g. Victoria's Future Coasts Program) to cover more of the ecological community. These programs should inform and shape decision making for planning and management actions to ensure future sea level rise information is included in decisions about coastal management and development activities.	No impact	No impact
Monitor change in species composition and distribution and sediment dynamics to elucidate the effects of climate change in priority, susceptible regions (including establishment of survey lines).	No impact	No impact
15. Inappropriate fire regimes		
Ensure controlled/planned burns in areas surrounding the ecological community are not allowed to spread into the ecological community.	The EP contains control measures aimed to minimise the risk of introducing marine pests to Victorian waters	No impact
Develop and implement management practices/fire control methods in upper saltmarsh areas.	No impact	No impact
Develop and implement recovery guidelines/actions for post-fire event management.	No impact	No impact
Investigate measures that may facilitate recovery of the ecological community post-fire event, especially the recovery of fire intolerant species such as succulent chenopods.	No impact	No impact
16. Grazing		
Limit or prevent access of grazing animals to Coastal Saltmarsh (e.g. construct fences) where practicable.	No impact	No impact

Develop and implement appropriate grazing regimes for the ecological community if grazing is to continue.	No impact	No impact
Limit or prevent grazing access to recently burnt and/or recovering Coastal Saltmarsh.	No impact	No impact

Appendix 9

Yolla platform produced formation water ALARP assessment (AECOM, 2020)

AECOM Imagine it. Delivered.

Beach Energy Ltd
23-Jul-2020

Yolla-A Platform ALARP Assessment

Yolla-A Platform ALARP Assessment

Client: Beach Energy Ltd

ABN: 20 007 617 969

Prepared by

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A	13 Dec 2019	Draft for discussion	Suanna Harvey Technical Director - Environment	
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Abbreviations

Abbreviation	Detail
ALARP	As Low as Reasonably Practicable
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2018.
BAT	Best Available Technologies
BTEX	Benzene, Ethyl Benzene, Toluene, Xylene
DGV	Default Guideline Value
EIN	Environmental Improvement Notice
EP	Beach Offshore Environment Plan BassGas
FKO	Flare Knock Out drum
KO	Knock Out drum
LLGP	Lang Lang Gas Plant
LOEC	Lowest Observable Effect Concentration
MEG	Mono Ethylene Glycol
NATA	National Association of Testing Authorities
NOEC	No Observable Effect Concentration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority.
OIW	Oil in Water
OSPAR	OSPAR Commission
PFW	Produced Formation Water
PW	Produced Water
WET	Whole of Effluent Toxicity

1.0 Introduction

1.1 Background

Beach Energy Ltd (Beach) commissioned AECOM Australia Pty Ltd (AECOM) to assist it in response to an Environmental Improvement Notice (EIN) issued on the 27th August 2019, by NOPSEMA for Beach's Yolla facility. Beach is required to respond within the specified period of 120 days from the date of the notice:

The following action must be taken by the titleholder within the period specified above:

5.1. Implement produced water treatment and monitoring measures to ensure that levels of total petroleum hydrocarbons are not greater than 50 mg/L at any time, and that there is an average of less than 30 mg/L over any period of 24 hours as described in the Bass Gas Offshore Environment Plan; or

5.2. Comply with regulation 7 by any other suitable means as required to remove the threat, such as demonstrate that impacts and risks from the discharge of produced water will be reduced to a level that is acceptable and as low as reasonably practicable (ALARP).

This report has focused on addressing requirement 5.2 of the EIN.

1.2 Scope

In order to assist Beach in responding to the notice, AECOM was commissioned to undertake the following scope:

1. Whole of Effluent Toxicity (WET) assessment of Produced Formation Water (PFW) discharges from the Yolla facility with recommendations to set a risk-based guideline to be used by Operations based on current discharges
2. Any additional sampling required to achieve the above WET assessment scope (see assumptions below)
3. ALARP assessment of available technologies inclusive of the current separator system and taking into account cost benefit, fit for purpose/application on Yolla and best practice standards
4. Risk assessment of the outcome of the above study for the Yolla Environment Plan (EP) and update of the Yolla-A EP
5. Update the report based on NOPSEMA comments and Mixing Zone determination.

While these tasks have been separated and had specific deliverables, the methodology has been integrated.

The AECOM assessment was led by Dr Harry Grynberg, Technical Director – Environment with assistance from Peter Young – AECOM Marine Services Team Lead and Ian Baxter of SEAPEN Marine Environmental Services. Suanna Harvey, Technical Director – Environment of AECOM undertook technical review, and Paul Greig, Principal Environmental Scientist of AECOM was the project manager.

1.3 Methodology

1.3.1 Basis of the Methodology

The methodology was informed by the accepted approaches to assessing discharges of waste water, in this case PFW, to the surface waters of the marine environment. It is accepted that for these types of discharge situations a mixing zone has been permitted (e.g.BassGas 2014 Beach's approved EP). The mixing zone is an area within which water quality objectives may not be met but the potential impacts are considered acceptable. In order to justify the mixing zone it needs to be demonstrated the impacts have been reduced to ALARP. ALARP does not mean the lowest possible concentration.

The Australian & New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) define a mixing zone as "an explicitly defined area around an effluent discharge where some, or all, water quality objectives may not be met”. They note that “As a consequence, some community values of the water body may not be protected”. Hence, it is important to consider the environmental setting of a discharge around which a mixing zone is applied. For example, a discharge at a remote offshore location has different implications for community values than a discharge into an urban waterway that may provide a multitude of ecosystem services to local communities.

ANZG (2018) provides minimal guidance as to determining an appropriate size for a mixing zone, other than indicating that the mixing zone “should be as small as practicable”. This philosophy echoes the ALARP approach applied to health, safety and environmental risk. In regard to ‘Reasonably Practicable’ NOPSEMA (2015) notes that the following legal definition has been accepted by the Australian High Court:

‘*Reasonably practicable’ is a narrower term than ‘physically possible’ and seems to imply that a computation must be made by the owner, in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other; and that if it be shown that there is a gross disproportion between them — the risk being insignificant in relation to the sacrifice — the defendants discharge the onus on them. Moreover, this computation falls to be made by the owner at a point of time anterior to the accident*.

Whilst NOPSEMA (2015) discusses ALARP in the context of Safety Cases, it is considered that a similar assessment of ‘risk vs sacrifice’ can be applied when considering ALARP in an environmental setting.

ANZG (2018) notes that “mixing zones are regulated at the state or territory level in Australia”. Whilst it is recognised that, given its location, the discharge of produced water from the Yolla-A platform is not in waters that are regulated by the State of Victoria, it is considered relevant to adopt the approach to determining mixing zones that is espoused by the Environment Protection Authority Victoria (EPA 2010); to which ANZG (2018) refers.

The EPAV (2010) guidance includes the following:

The levels of chemical, physical and biological stressors determined for the mixing zone are used to assess impacts to water body values. This includes the level and spatial extent of impact to values from individual stressors (where they operate separately) or combined stressors (where they operate synergistically or have an additive effect on beneficial uses and values).

To account for the potential synergistic or additive effects from the various chemical components within the produced water discharge from the Yolla-A platform, it is necessary to consider the level of toxicity of the whole effluent (as determined from WET testing), rather than considering the level of toxicity of each component chemical in isolation. This is the approach that has been adopted by Beach to determine the mixing zone around the Yolla-A platform produced water discharge.

To inform the revision of the Australian & New Zealand Guidelines for Fresh and Marine Water Quality, van Dam and Chapman (2001) compiled a review of the use of Direct Toxicity Assessment (DTA), a synonym for WET testing. They considered the major benefit of DTA to be that it can be used to “assess the toxicity of waters, in which the number of unidentified components may number thousands, and their behaviour, or interactions cannot be predicted”. Through this, it “enables a greater understanding of potential impacts to aquatic environments, which in turn aids in the development of environmental protection measures”.

Van Dam and Chapman (2001) highlight that single-chemical toxicity testing is not representative of the situation in the natural environment as organisms are rarely exposed to just one toxicant. Rather, a particular chemical is typically present in combination with many other chemicals between which interactions may occur which may alter their toxicity. Subsequently, mixtures of chemicals can result in either additive toxicity, greater than additive toxicity (aka synergism), or less than additive toxicity(antagonism) (Rand 1995 in van Dam & Chapman 2001). They note that single-chemical toxicity tests do not account for such factors, and the extrapolation of these results to the assessment of potential environmental impacts therefore has a great deal of inherent uncertainty. Holdway (1992, in van Dam & Chapman 2001) notes that the toxicity of individual compounds can change with time and are often not fully known.

To overcome the limitations attendant to single-chemical toxicity testing, van Dam and Chapman (2001) indicate that it is necessary to implement DTA to provide an integrative measure of the aggregate/additive toxicity of chemicals within a mixture that accounts for interactions between component compounds. This allows more reliable predictions to be made of the potential for adverse impacts within the receiving environment (as per Waller et al. 1996; de Vlaming & Norberg-King 1999 [both in van Dam & Chapman 2001]; de Vlaming et al. 2000).

From the foregoing evidence, it is considered that it can be reasonably concluded that the application of WET/DTA testing results provides a more realistic means of defining a mixing zone boundary than does the consideration of dilutions of individual constituents of the produced water discharge from the Yolla-A platform.

For the Yolla-A platform a mixing zone has been de facto recognized, described and approved through the 2014 accepted EP (BassGas2014). The basis of the assessment for the 2014 EP was concentrations in the PFW discharge at the time compared to ANZECC guidelines, as default standards. It should be noted; however, that ANZECC guidelines (e.g. ANZG2018) are applied as “trigger values”, which, if exceeded, provide for further site specific assessments (e.g. WET testing).

The approach to assessing the impact from a discharge can be conducted as follows:

- Characterisation of the discharge in terms of constituents and their concentrations.
- Characterising the discharge regime.
- Characterisation of the receiving environment and potential sensitive receptors.
- Assessment of potential impacts through comparison of discharge concentrations with ANZG (2018) default guideline values as default standards.

Should the characteristics be lower than ANZG (2018) default guideline values, the assessment generally concludes that the discharge is acceptable.

Should the characteristics be greater than ANZG (2018) default guideline values then further investigation into potential impacts may be undertaken.

This is the approach taken in this assessment. It should be noted that ANZG (2018) default guideline values are derived from single biological species tests and single chemical species, not necessarily Australian species, often with a safety factor. These are generally conservative criteria and as noted above are trigger for further assessment. Further discussion of this aspect is provided in Section 3.1.

1.3.1.1 Specific References for methodology

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.

de Vlaming V and Norberg-King TJ. 1999. A review of single species toxicity tests: Are the tests reliable predictors of aquatic ecosystem community responses? EPA 600/R-97/11. Technical Report. U.S. Environmental Protection Agency, Duluth, MN, USA.

de Vlaming V, Connor V, DiGiorgio C, Bailey HC, Deanovic LA and Hinton DE. 2000. Application of whole effluent toxicity test procedures to ambient water quality assessment. Environmental Toxicology and Chemistry, 19, pp. 42-62.

EPA 2010, Guidance for the Determination and Assessment of Mixing Zones. Environment Protection Authority Victoria, Publication 1344, June 2010.

Holdway DA, 1992, Control of metal pollution in tropical rivers in Australia. In: Pollution in Tropical Aquatic Systems, eds DW Connell and DW Hawker, CRC Press, Boca Raton, FL, pp 231-246.

NOPSEMA 2015, ALARP. Guidance Note N -04300-GN0166, Revision 6, June 2015.

Rand GM, 1995, Fundamentals of Aquatic Toxicology. 2nd Edition. Taylor and Francis, Bristol, PA.

Van Dam R and Chapman J, 2002, Direct toxicity assessment (DTA) for water quality guidelines in Australia and New Zealand. Australasian Journal of Ecotoxicology, Jan 2002.

Waller WT, Ammann LP, Birge WJ, Dickson KL, Dorn PB, LeBlanc NE, Mount DI, Parkhurst BR,

Preston HR, Schimmel SC, Spacie A and Thursby GB, 1996, Predicting instream effects from WET tests. In: Whole Effluent Toxicity Testing: An evaluation of methods and prediction of receiving system impacts, eds DR Grothe, KL Dickson and DK Reed-Judkins, SETAC Pellston Workshop on Whole Effluent Toxicity; 1995 Sept 16-25; Pellston, MI Pensacola FL: SETAC Press. pp. 271-286.

The methodology comprised the following:

1.3.2 Document Review

Review of the documents provided by Beach including:

a. PFW monitoring data
b. any ambient marine waters monitoring data
c. the complete EP
d. the continuous oil in water (OIW) monitoring data and correlations with laboratory sampling
e. recent NOPSEMA reports and Beach responses, in particular in relation to WET testing
f. plume modelling report
g. a detailed description of the existing PFW treatment processes
h. description of chemical dosing that impacts on PFW characteristics
i. other information that Beach considered relevant.

Using the information provided, AECOM undertook the following:

- derived the characteristics of the PFW stream being discharged
- assessed the impacts based on the modelling provided
- scoped a WET testing programme
- reviewed and reported on the results of the WET testing.

1.3.3 WET testing

1.3.3.1 Use of WET Testing to Assess Wastewater Impact

The following is based on information provided in ANZG (2018) with respect to the use of trigger values and the development of site-specific criteria for impact assessment.

ANZG (2018) notes that *exceedance of the guidelines indicates that there is potential for an impact to occur (or to have occurred), but does not provide any certainty that an impact will occur (or has occurred). In areas where protection of aquatic ecosystems is a designated environmental value* (as is the case for the Yolla-A platform), *the Guidelines (ANZG 2018) recommend direct assessment of the biological community to assess whether ecosystem integrity is being maintained, threatened or compromised to a level that causes pollution. Biological indicators should therefore be used to complement the use of physical and chemical indicators for this value. These Guidelines (ANZG 2018) describe indicators for biological assessment and give guidance for determining an acceptable level of change so that the relative condition of the ecosystem can be estimated*.

Decision frameworks provide guideline trigger values (equivalent to the old guideline default values) that refer to the concentration of the chemical available for uptake by organisms. Guideline trigger values are concentrations that, if exceeded, will indicate a potential environmental problem, and so ‘trigger’ further investigation. The investigation aims to both assess whether exceedance of a trigger value will result in environmental harm and refine a guideline value, by accounting for environmental factors that can modify the effect of the chemical.

Although in some cases this will require more work (in this case the WET testing conducted), *it will result in much more realistic goals for management and therefore has the potential to reduce both costs for industry and confrontation*.

*Ultimately, it is biological measurement that will provide confirmation of the site specific guideline, so the ANZG decision scheme directs users to the option of direct toxicity assessment (DTA) if the guideline is exceeded or if there is low confidence in desktop asses*sments. WET testing is an acceptable form of DTA.

When no default trigger value is provided, where the trigger value is not applicable to a specific site, or if the chemical is one of a complex mixture, DTA is also useful. Further, DTA may provide the required link between chemical levels and biological effects or establish concentrations that are unlikely to cause adverse environmental effects. Field biological assessments can be undertaken also.

It is recommended that, *if there is any degree of complexity in the mixture interactions, proceed to DTA on the ambient waters at the site*. The PFW discharge is a complex mixture, as it has a large number of constituents at generally low concentrations.

The use of an appropriate battery of test species and chronic end-points to ascertain whether toxicity is being observed is recommended. This was the approach taken to developing the WET testing protocol for this assessment. It is recommended that *if adverse effects are observed, then initiate management action and use Toxicity Identification and Evaluation to assist in identifying the compound(s) that are causing toxicity*.

ANZG (2018) provides the following:

- *Where a chemical is to be used in an environment of particular socio- political or ecological importance, it is better to undertake toxicity testing with that chemical on species relevant to that environment.*
- *When using DTA to examine toxicity of a chemical to locally important species or, for pre-release effluents, to determine chronic effects at a range of concentrations of the chemical or effluent. For dilution, use the local reference dilution waters.*
- *Determine NOEC values for the chemical or effluent and use them for calculating site-specific guidelines. The method used for these calculations will depend on the number of data points, but use the statistical distribution method if the data requirements have been met (at least five species from four different taxonomic groups).*
- *The DTA can comprise in situ field and/or laboratory ecotoxicity tests (Chapman 1995), preferably chronic or sub-chronic tests on appropriate species using local dilution waters, satisfying all sampling, test and analysis conditions.*
- *To aid interpretation of results, analyse the chemicals concurrently with biological assessment, unless there is a biological marker of toxicity.*
- *For already existing discharges and for chemicals that have a high potential to disturb the environment, it will be necessary to measure and assess the biological health of potentially disturbed sites.*

For the WET testing reported, the chemical compositions of the samples were analysed (Table 8) and eight test species were used for ecotoxicity testing, including chronic and acute impacts (Table 9).

On this basis, the use of the WET testing to assess the toxicity of the PFW and its impacts is in line with ANZG (2018) methodology.

1.3.3.2 Background to WET testing

NOPSEMA had issued Lattice Energy (Origin Energy's conventional upstream oil and gas business; subsequently purchased by Beach) with an Environmental Improvement Notice (EIN #761), which contained an observation that the operations of the Yolla-A facility may pose a "*significant threat to the environment*". A specific concern was that "*dissolved hydrocarbons, which have been shown to cause a range of effects to marine organisms, including lethal effects, is* (sic) *being discharged to the environment at high concentrations that have not been subject to a full impact assessment."* The environment subjected to the threat was identified as the "*marine waters of the Commonwealth Marine Area in Bass Strait"* which provides habitat for species including "*fauna protected under Part 3 of the Environmental Protection and Biodiversity Conservation Act 1999*" and "*species that are important for state and commonwealth fisheries"*. It is further noted in the EIN that "*impacts from Lattice Energy* *produced formation water* (PFW) *discharges to Bass Strait water quality and environmental receptors are currently uncertain*".

To address the level of uncertainty around the potential for the PFW discharges from the Yolla-A facility to impact upon the receiving environment, AECOM recommended that Beach implement a WET testing program. This program supported the assessment of potential additive or synergistic effects that may result from the chemical constituents interacting within the PFW discharge stream that may influence stream toxicity. The results of the WET testing program were used to inform an ALARP assessment (this document) of environmental risks associated with the current PFW discharge from the Yolla-A facility.

1.3.3.3 Program Design

The following program design was aligned with similar investigations of PFW discharges implemented elsewhere within the offshore petroleum industry. The WET testing was conducted by Ecotox Services Australia (Ecotox) NATA-certified for these tests, in its Sydney laboratory. Chemical characterisation of the PFW samples was undertaken by Eurofins, NATA-certified for these analyses.

The sampling and analysis program was as follows:

- Three single, representative samples of PFW were collected, with one week between samples (the 25th September 2019, 2nd October 2019 and 10th October 2019). Samples were collected on the Yolla-A platform where the PFW stream enters the caisson for discharge overboard. The PFW discharges from the bottom of the caisson at a depth of 45 m.
- Up to 20 L of PFW was collected on each sampling occasion.
- Samples were decanted directly into laboratory-prepared amber glass bottles with Teflon-wadded lids.
- Sample bottles were triple-rinsed (i.e. filled, capped, shaken and emptied three times) with PFW prior to being completely filled, ensuring there was no headspace.
- Samples were refrigerated immediately after collection, to reduce temperature to below 4ºC.
- Immediately prior to shipment, the samples were packed (well-padded to avoid breakage) in an insulated container with ice bricks to ensure the samples reached the laboratory in a chilled state.
- Samples were accompanied by fully completed laboratory-supplied chain-of-custody documentation. This included the details of the laboratory (Eurofins) that undertook the chemical characterisation of the samples.
- Each sample was sent to the analysing laboratory, as expeditiously as possible, as soon as practicable following the chilling of the sample to below 4ºC. Sampling was aligned with helicopter flights from the platform so they were dispatched on the same day. There are no Australian Standard holding times for ecotoxicity testing of PFW samples; however, given the holding time for chemical analysis of volatile toxicants (such as hydrocarbons) is in the order of one week, this was adopted for the PFW samples.
- The second sampling of PFW was undertaken, seven days after the first sampling (2nd October 2019), and sent to the analysing laboratory.
- Laboratory reports from testing of the first PFW sample (sample chemistry and WET test results) were prepared and submitted to Beach.
- The third sampling of PFW was undertaken, seven days after the second sampling, on the 10th October 2019, and sent to the analysing laboratory. Laboratory reports from testing of the second and third PFW samples were submitted to Beach.

Taking into consideration the location of the receiving environment, and advice provided by the analysing laboratory based on their prior experience undertaking WET testing programmes for offshore oil and gas operations around Australia, the following toxicity tests were undertaken:

Acute tests:

- 96-hr acute amphipod survival using the amphipod *Allorchestes compressa*
- 96-hr fish imbalance toxicity test using Australian bass *Macqauria novemaculeata.*

- Chronic tests:
  - 72-hr marine algal growth test using *Nitzschia closterium*
  - 72-hr macroalgal germination success using *Hormosira banksii* or kelp (*Ecklonia radiata*)
  - 48-hr larval development test using the mussel *Mytilus galloprovincialis*
  - 1-hr sea urchin fertilisation success test using *Heliocidaris tuberculata*
  - 72-hr sea urchin larval development test using *Heliocidaris tuberculata*
  - 7-day marine fish imbalance and growth using Barramundi, *Lates calcarifer*.

Acute tests are assessed on the basis of mortality while chronic tests relate to impacts species growth and development that are non-lethal. The species were selected by Dr Rick Krassoi of Ecotox (NATA registered), who is considered an expert in this field. The selection was based on the understanding of the marine environment in Bass Strait and as being representative of the marine environment into which the PFW is discharged.

The toxicity testing involved preparing water samples comprising various dilutions of PFW with seawater (e.g. 1.6%, 3.1%, 6.3%, 12.5% 25% 50 % and 100%) and subjecting the test species to these concentrations for the test period duration. The test species were then assessed to determine impacts as per the tests above (e.g. larval development, fertilisation success, etc.). The results were analysed statistically to provide the following data:

- EC50 -dilution results in impact in 50% of the test species in a particular test
- EC10 -dilution results in impact in 10% of the test species in a particular test
- NOEC -no observable impact
- LOEC -lowest dilution that results in an impact to the test species in a particular test.

1.3.4 Best Practice/ALARP review (Section 4).

AECOM undertook a literature survey, utilised our local experience and consulted with AECOM international oil and gas Industry staff to identify PFW best ("good") practices for platforms located in marine environments. AECOM compared the current Yolla-A systems and impacts to reported best practice using a range of criteria. Assessment criteria included: hydrocarbon emissions, impacts, energy/greenhouse gas, other waste streams, health and safety, capital and operating costs, practicability, operations and maintenance and compliance. The qualitative assessment took into account a holistic approach, practicability and eco-efficiency.

AECOM also considered NOPSEMA guidance such as Guidance Note GN1488 Oil Pollution Risk Management, N-04300-GN0166 and other guidance, although the former is health and safety focused.

1.3.5 Risk Assessment (Section 5)

On the basis of the Best Practice/ALARP assessment and the other information collected, AECOM conducted a risk assessment using the Beach likelihood, consequence and risk rating matrices. This approach facilitates incorporation of the risk assessment outcomes into the EP.

1.4 Assessment of Hydrocarbons

One of the key aspects is understanding the various forms, analytical techniques, measurement and reporting of hydrocarbons. This also needs to be understood in the context of the historical development of compliance criteria. It is important to also note the changes in the OPGGS (Environment) Regulations from a compliance criteria basis to an ALARP basis.

In early 2014, the OPGGS(E) Regulations were modified such that the former prescriptive PFW discharge limit of 30 mg/L of OIW averaged over 24 hours (and 50 mg/L instantaneous limit) was removed in favour of assessing and managing PFW discharge impacts in the same way as other emissions and discharges. As such, other factors need to be considered, including the PFW discharge regime, chemical composition, toxicity, extent of dispersion and fate. The former regulations regarding PFW discharge did not define ‘petroleum’, but it was generally interpreted by the industry to refer to dispersed hydrocarbons (not dissolved hydrocarbons). Equipment used to remove OIW from the PFW stream is efficient at removing dispersed oil (i.e. droplets) but not dissolved oil. As such, more emphasis in recent times has been placed on the management of dissolved oils in PFW streams.

In broad terms hydrocarbons (also known as petroleum hydrocarbon or oil) can be considered to comprise of non-dissolved hydrocarbons (in the physical form of films and droplets) and dissolved hydrocarbons. The non-dissolved hydrocarbons are also known as dispersed oil (OIW) and free oil or hydrocarbons.

The non-dissolved hydrocarbons (OIW) can be measured using techniques such as OSPAR test Method 2005-15, which involves n-Hexane extraction and GCFID detection. Measurement of OIW using the OSPAR method reports analyses for hydrocarbons in the range C7-C40, including aliphatics. This is reported as Oil in Water (OIW) or dispersed oil and does not measure all hydrocarbons e.g. dissolved species such as BTEX, other aromatics, etc. (see Table 1 for explanation of aromatic and aliphatic hydrocarbons).

OIW is not total hydrocarbons. OIW criteria are not total hydrocarbon criteria. OIW plus BTEX can be called total hydrocarbons if polar organic compounds have low concentrations. This appears to be the case for the PFW at Yolla.

Total Petroleum hydrocarbons (“TPH” also called Total Recoverable Hydrocarbons [TRH] as there is an extraction part of the analytical technique) are analysed through alternate techniques based on methanol and dichloromethane extraction and GCMS analyses. These are reported by carbon chain length (e.g. C6-C9, C10-C14, C15-C28, C28-C36).

C6-C9 are carbon species (hydrocarbons) with between 6-9 carbons in the structure. In addition it is possible to analyse for specific hydrocarbon species such as Benzene, Ethyl Benzene, Toluene and Xylene (BTEX), phenols etc.

In a simplistic sense:

- C6-C9: are dissolved species including BTEX and aliphatics, some phenols, short chain chlorinated hydrocarbons
- C10-C14: are dissolved species including aromatics aliphatics, phenols, longer chain chlorinated hydrocarbons
- C14+: are mainly non-dissolved hydrocarbons (OIW) with some PAHs

Therefore OIW is generally measuring non-dissolved hydrocarbons and aliphatics.

Table 1 Description of hydrocarbon species

Oil	Description	
Dissolved oil	Dissolved oil in PFW (predominantly aliphatics, BTEX, low molecular weight PAHs and phenols) dilute readily into the receiving water and are dispersed by water currents. These compounds are bioavailable to marine organisms and biodegrade rapidly. While they may bioaccumulate at lower trophic levels, vertebrates including fish have detoxification mechanisms that break hydrocarbon compounds down. They evaporate readily if they reach the sea surface, and do not absorb strongly to suspended particles so are unlikely to be transported to the seabed.	
	Aliphatic hydrocarbons	These are carbon structures without any aromatic (ring) nucleus and are divided into alkanes, alkenes and alkynes.
	Aromatic hydrocarbons	These are carbon structures (with ring type elements) with double bonding in all positions and the carbon skeleton arrange in planar six-rings. Aromatic hydrocarbons are further divided into mono-aromatic hydrocarbons (MAHs) and polycyclic aromatic hydrocarbons (PAHs), described below.
	MAHs	These have one aromatic ring that may be alkylated. The most common compounds and those of most concern in the environment are benzene, toluene, ethyl benzene and xylene (commonly abbreviated to BTEX). BTEX compounds are more soluble in water than other hydrocarbons. PFW from gas wells usually contain higher BTEX concentrations than oil wells due to the higher aromatic content of the gas and condensate produced.
	PAHs	These are the petroleum hydrocarbons of greatest environmental concern in PFW because of their toxicity and persistence in marine waters. They exhibit a wide range of solubilities. There are typically 16 PAH compounds measured as defined by the United States Environmental Pollution Authority (see also Table 8). The most common PAHs (naphthalene, alkyl-naphthalenes, fluorene and phenanthrene) are soluble and tend to evaporate from the water.
Dispersed oil (OIW)	Oil compounds associated with oil droplets will either follow the PFW plume or be retained at certain depths in the water column depending upon their buoyancy and turbulence. Vertical turbulence generated by wind shear and wave action will mix oil droplets with diameters less than about 100 µm into the water column. These smaller droplets tend to float back to the surface only very slowly where they are repeatedly forced back into the water column. In this case, they are considered to be permanently dispersed. Once hydrocarbons have been dispersed into the water column as fine droplets, they may be removed through adsorption to particles followed by sedimentation and biodegradation.	

2.0 PFW Management and Operating Characteristics

2.1 Description of the existing PFW Management

The following is the description of the PFW system as described in the Offshore Environment Plan (OEUP-T5100-PLN-ENV-005 dated 28/05/2018, which is an internal update).

The production fluids from the wells are passed through the Production Separator where the gas is separated from the oil and water mixture. Water discharged from the Production Separator has suspended condensate droplets, which are removed via the hydro-cyclone. Dissolved gas is then removed in the Degasser, with the discharged water passing through a filter to remove any solid particulate remaining in the stream. The water is then discharged to the Dump Caisson via a liquid leg. A schematic of the Produced Water (PW) system is shown in Figure 1.

It is understood that the hydro-cyclone is not currently operational. Until 2006, the system included a BTEX stripper for removal of volatile hydrocarbons such as BTEX. The unit was oversized and considered ineffective in the context of the much lower BTEX concentrations in the PFW. The unit was removed in 2012 during the Mid Life Enhancement (MLE) construction campaign with the permission of the regulatory authorities that had been obtained in 2009.

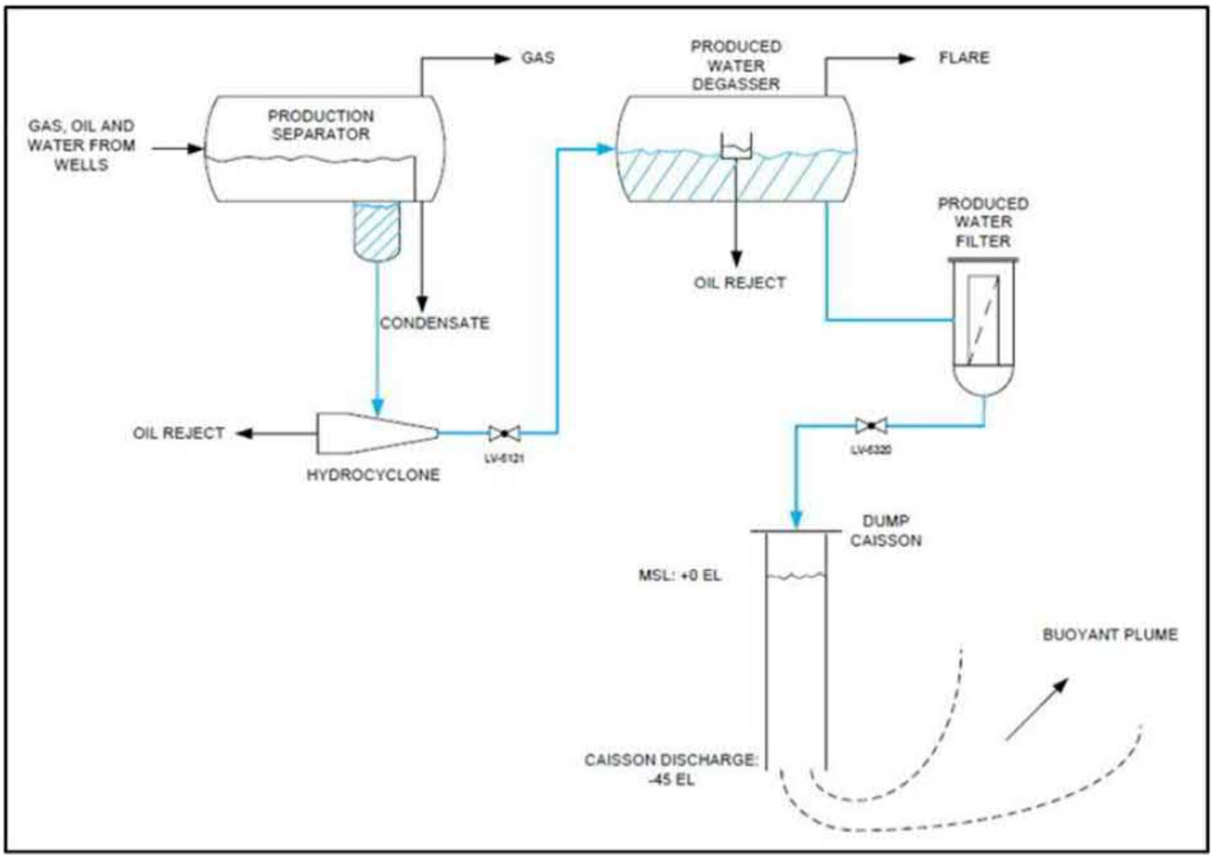

Figure 1 Schematic of Yolla-A Produced Water processing system

The Dump Caisson is constructed as part of the Platform jacket. It allows recovery of hydrocarbon liquid that may be present in the feed stream from the open drains system, produced water (PFW), or a spill. The hydrocarbon liquid is captured via gravity separation and accumulates at the top of the Caisson and can be pumped to the Flare knock out (KO) Drum. Water flows from the bottom of the Caisson at a depth of 45 m below sea level.

The segregated open drain and PFW feed to the Caisson are routed below the minimum sea water depth to ensure a liquid seal is achieved, whereby vapours can be controlled and released to a safe location via the designated atmospheric vents. The Caisson is also provided with a vent to a safe location, which is fitted with a flame arrestor.

The Dump Caisson is provided with a pneumatically operated Dump Caisson Pump to recover oil and condensate. Level indication, spared for redundancy, and alarms are also provided to assist with the operation of the Dump Caisson Pump and to provide an indication of the liquid hydrocarbon level within the Caisson. The pump has flexible connections and can deliver a nominal flow rate of 1 m^3/h from the liquid surface of the water within the Dump Caisson and pump the fluid into the Flare KO Drum for reprocessing. The pump is operated by fuel gas and can be operated remotely from the Lang Lang Gas Plant (LLGP).

2.2 PFW Monitoring

The current monitoring program is conducted through implementation of the Yolla-A PFW Sampling and Testing Maintenance Procedure (CDN/ID 10020479) is summarised in Table 2.

Table 2 Current PFW monitoring program

Monitoring program	Data Management and Action
Continuous automatic analysis of total OIW concentrations using two analysers working in parallel to ensure: • No discharge >50 mg/L at any time. • Discharges average <30 mg/L over any 24-hr period.	PFW log (stored in Bablefish) verifies continuous OIW concentration monitoring is in place.
	CMMS contains records of alarm trips for any recordings >50 mg/L.
Twice daily manual logging of the PFW OIW concentrations are undertaken by the Control Room Operator to validate analyser readings.	PFW sample log verifies continuous OIW concentration monitoring is in place.
PFW with dispersed OIW concentration >50 mg/L results in automatic shut-in to prevent overboard discharge of over-specification PFW.	CMMS records verify that over-specification water results in cessation of PFW discharge.
	Incidents of OIW concentration >50 mg/L are captured in the OMS incident register.
PFW samples are collected weekly and sent to a laboratory for testing using OSPAR methodology to validate the continuous monitoring records.	Laboratory PFW test results are available and verify weekly sampling frequency.
Comprehensive testing of the full range of chemical constituents is conducted twice a year.	OpenText records verify that twice annual testing takes place and that concentrations are within the specified ranges.
The two IMO-approved OIW Sigrist analysers are cleaned and calibrated weekly in line with the Yolla-A OIW Analyser Weekly Maintenance Procedure (CDN/ID 3972825).	CMMS records verify cleaning and calibration occurs in line with the procedure.
Sampling and modelling	
WET testing of PFW is undertaken every three years to ensure assumptions in PFW dispersion modelling remain current and establish a species protection trigger value to derive a safe dilution factor.	WET test reports (prepared to schedule 2022, 2025) are available.
PFW plume dispersion verification monitoring is undertaken every five years.	PFW plume dispersion modelling reports (prepared to schedule 2022, 2027) are available.
Trained and experienced operators manage the PFW system in accordance with Yolla-specific requirements.	CBTA training records verify operators' competency to manage the PFW system.
	All operators are inducted into the PFW training module.
Reporting	
Instances where instant dispersed OIW concentration are >30 mg/L are reported to NOPSEMA in the monthly recordable incident report.	Monthly recordable incident reports.

The management assurance procedure is summarised in Table 3.

Table 3 Summary of management assurance

Management Action	Explanation
OSPAR validation testing	Testing is conducted weekly in accordance with the CMMS. Water samples are sent to ACS Laboratories in Melbourne for testing to the OSPAR 2005-15 method for determination of dispersed oil. Depending on result, the following actions will be taken: <u>OIW Analysers <20 mg/L</u> 1 x spot check PFW sample tested weekly for dispersed oil content as per OSPAR 2005-15 test method. <u>OIW Analysers 20-30 mg/L</u> Analyser calibration checked and if confirmed accurate, PFW samples to be taken daily during this condition and tested weekly. <u>OIW Analysers >30 mg/L</u> Analyser calibration checked and if confirmed accurate, PFW production rate reduced to bring OIW content below 30 mg/L.
Online OIW analyser correlation check	Monthly Technical Monitoring Report includes review of the past month's OSPAR test results against analyser output. 3M Preventative Maintenance task scheduled for engineering team to review accuracy of the Fluorescent Units to OIW correlation.
Online OIW analyser maintenance	Calibration and routine maintenance performed weekly in accordance with the CMMS.

2.3 Operating Characteristics

2.3.1 PFW Flow Rates

In previous assessments (EP 2014, 2018) the design flow rate was nominated as 100 m^3/d; however, an increase in flow rates was anticipated, and has occurred.

Data provided in Table 4 indicates that flow rates have increased, with average daily flows above 220 m^3/d (BassGasLIMS Rev2 –SM data to July 2019).

Table 4 PFW flow rates (m^3/d)

Date	Type	Flow (m^3/day)
July-Dec 2018	Average	238.8
	Max	260
	Min	215
Jan-Dec 2019	Average	186.4
	Max	271
	Min	29

PFW Flow rates for the period 2018 - 2020 are presented in Figure 2.

Beach conducted a wireline campaign in Oct/Nov 2019, which successfully increased production. Since then the formation behaviour has certainly changed, especially for the depleting field. The field was producing large flows of PFW ~260 m^3/d before the campaign and with the Yolla 4 plug being sealed brought less formation water, now around 150-170 m^3/day only as shown in Figure 2.

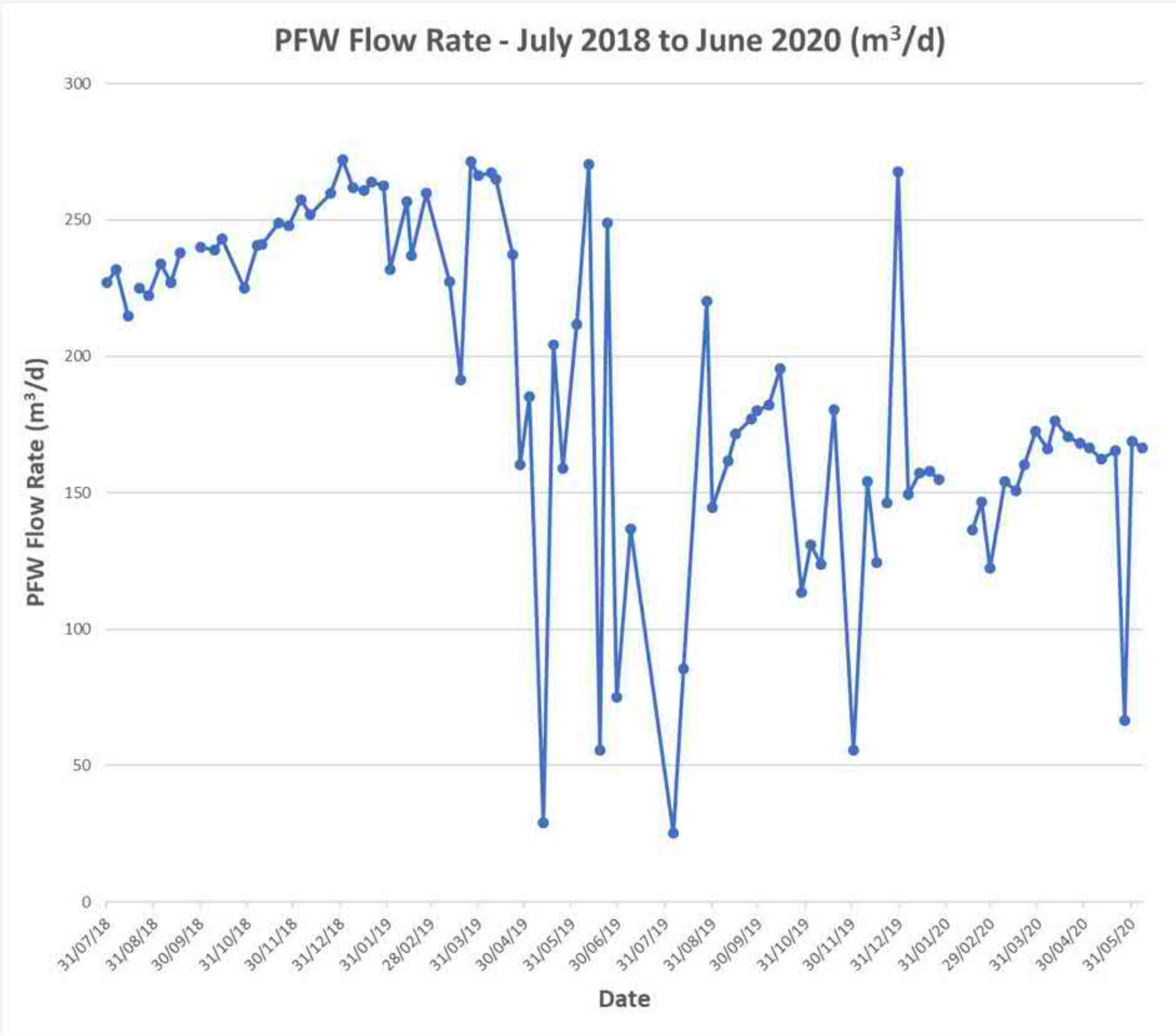

Figure 2 PFW discharge rates 2018-2020.

2.4 PFW Characteristics

Beach undertakes the following PFW monitoring:

- There are two on line OIW analysers.
- Weekly samples that are analysed for OIW and BTEX. These are analysed in a non-NATA registered laboratory, which uses OSPAR approved methods.
- twice yearly samples for comprehensive chemical analysis at a NATA registered laboratory.

2.4.1 Oil in Water Analysers

Beach has attempted to develop correlations between the OIW analysers and dispersed oil (OIW) analysed in the laboratory, as shown in Figure 3 (OIW analysers) (BassGasLIMS Rev3). The correlation is difficult to establish.

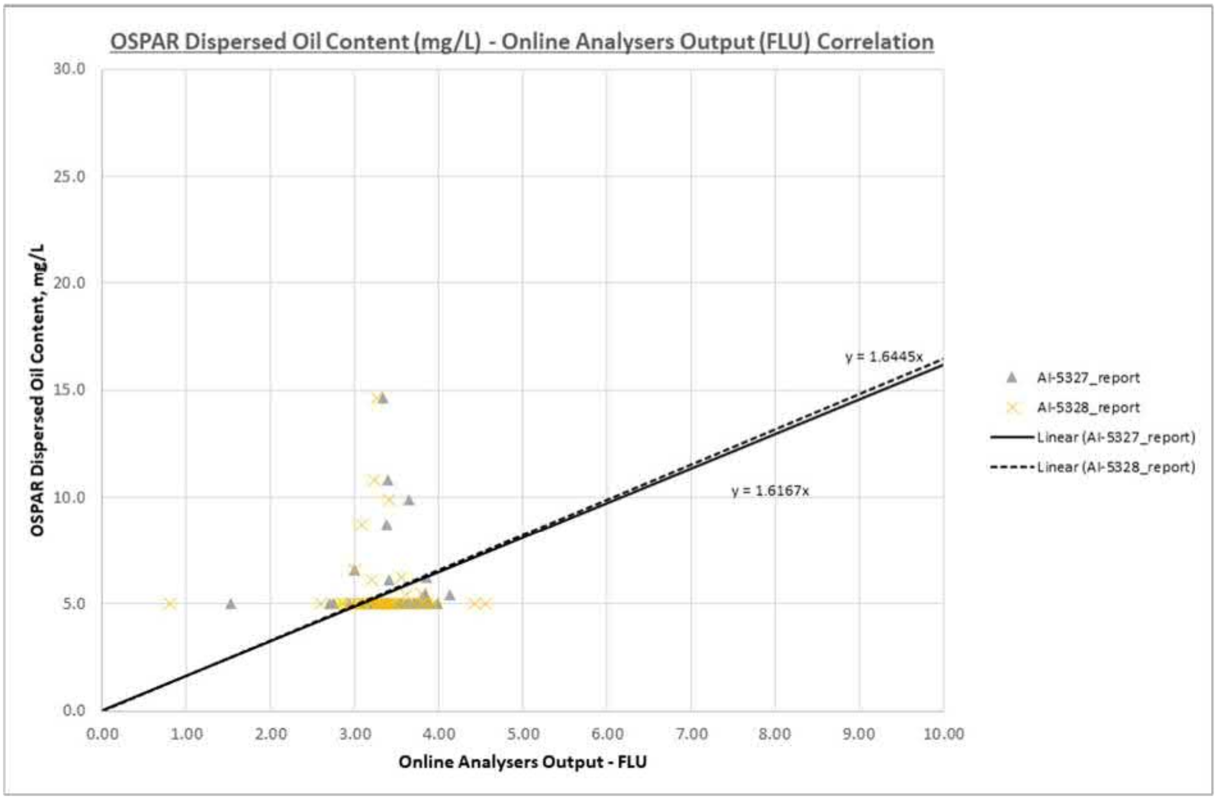

Figure 3 Correlation between OSPAR dispersed Oil and OIW analyser outputs

2.4.2 Weekly Dispersed Oil and BTEX monitoring

Table 5 shows a summary of the analytical data for the 12 months to December 2019 (BassGasLIMS Rev3).

Table 5 PFW Characterisation (ACS Laboratories non-NATA)

	BTEX (GCMS) mg/L	Dispersed Oil (OIW) mg/L	Total mg/L
Average	58	5	62
Max	126	7	131
Min	34.3	5	39.3

These data demonstrate that the existing system is efficient at removing the dispersed oil (OIW). The system complies with the former criteria of 30 mg/L dispersed oil (24 Hours) and did not exceed the maximum of 50 mg/L dispersed oil. Total Oil is the sum of dispersed oil plus BTEX. It also shows that BTEX is the most significant component of the Total .

These results do not necessarily align with the comprehensive analyses for total hydrocarbons as discussed in Section 1.4. This is discussed further below.

2.4.3 Comprehensive analyses

The comprehensive analyses were assessed in order to address whether these analyses supported the conclusions from the non-NATA analyses discussed above and whether the characteristics of PFW have changed over time.

Data were extracted from the BassGas Offshore Operations Environment Plan (EP 2014/2018), the PFW dispersion modelling (RPS 2017) and the three samples taken in September / October 2019 for the ecotoxicity testing described in Section 1.3.3.3 of this report. The results are presented in Table 6.

It appears from these data that the concentrations of barium, boron, strontium and BTEX have increased substantially. The increase in the BTEX has resulted in exceedance of both the 30 mg/L (24 hour average) and 50 mg/L (maximum) targets if these are considered total hydrocarbons. It is noted that there was a change in the criteria included in the EP (2014) from 30/50 mg/L dispersed oil to 30/50 mg/L hydrocarbons (the intent was to address dispersed hydrocarbons only). The increases in BTEX (as a total) were due to increases in individual chemical species, in some cases an almost doubling e.g. Toluene, ethyl benzene and Xylene.

The sum of the average BTEX components in Table 6 is 57 mg/L (NATA) compared to 58 mg/L (non-NATA) in Table 5. These are similar but were taken over different time periods and using different analytical laboratories. The two sets of results support the conclusion that BTEX is the significant component of the total hydrocarbons.

Comparing OIW to total petroleum hydrocarbons fractions as reported is not appropriate because of the different laboratory analytical techniques including extraction methods and the measurement method as discussed in Section 1.4. The dispersed oil analysis (OIW) is similar to what was previously called Oil and Grease and does not include volatile organics. As noted previously the OIW analysis is not a total hydrocarbon analysis.

Table 6 Comparison of historic data (Offshore Environment Plan BassGas 4 May 2014) and WET testing samples

Analyte	Historic PW (EP 2014) (mg/L)	WET Testing Samples September - October 2019 (mg/L)	
	Maximum	Average	Maximum
Aluminium	3.2	<0.05	<0.05
Arsenic	BD	0.0027	0.003
Boron	3.4	12.3	13
Barium	13	46	52
Chromium	0.001	0.001	0.001
Iron	4.3	1.02	1.2
Lead	BD	<0.0001	<0.0001
Mercury	0.029	0.0058	0.006
Manganese	0.03	0.028	0.029
Molybdenum	0.001	< 0.005	< 0.005
Nickel	0.01	< 0.001	< 0.001
Selenium	0.001	< 0.001	< 0.001
Strontium	0.81	3.1	3.1
Zinc	0.09	0.0157	0.019
Benzene	12	15	17
Toluene	14	27	30
Ethylbenzene	0.45	0.99	1.1
o-Xylene	1.6	3	3.2
m&p-Xylene	5.2	11	12
Naphthalene	1	0.167	0.36
Phenol	64	5.43	8.4
Cresols	75	16.41	26
2,4-Dimethyl Phenol	8.7	3.22	5.3
Oil & Petroleum Hydrocarbons	No data, only OIW measured	99.5 - 111.7[1]	114.2 - 127.8[1]
Glycol	criteria: 20	<20	<20

Note: [1] the range for Total Hydrocarbon arises from two analyses: Total Recoverable Hydrocarbons 1999 NEPM fractions C6-C36 and Total Recoverable Hydrocarbons 2013 NEPM fractions C6-C40

BD: below detection

As noted above there appears to have been an increase in BTEX when comparing the historic data (EP 2014) with the WET testing chemical analyses conducted in 2019/20.

The data from the comprehensive analyses for BTEX and Total Hydrocarbons are summarised in Table 7 from 2014-2019. In addition, BTEX analyses conducted by ACS (non NATA certified) following OSPAR procedures on weekly samples is shown in Figure 4.

Table 7 PFW Analyses for BTEX and Hydrocarbon Species (mg/L)

Date	Benzene	Ethyl benzene	Toluene	Xylene	Total BTEX	C6-C9 excluding BTEX	C6-C9	C10-C40	Lab
ANZG DGV 99%(mg/L)	0.5	0.005	0.18	0.625	NA	NA	NA	0.007	
1-Jan-14	7.7	NA	NA	NA	NA	NA	NA	NA	ALS
2-May-15	5.91	NA	NA	NA	NA	NA	NA	NA	ALS
2-Feb-16	5.4	NA	NA	NA	NA	NA	NA	NA	ALS
19-Jul-16	7	0.19	6.7	3	17	4.8	22	57	ALS
10-Jan-17	7.1	0.17	7.2	2.9	17.37	6.2	25	80	ALS
16-Jun-17	12	0.45	14	6.8	33.25	11.75	45	87	ALS
10-Dec-17	10	0.52	13	7.3	30.82	9.1	39.92	51	ALS
21-Jun-18	15	0.81	24	12	51.81	22	73.81	50.5	ALS
11-Dec-18	17	0.9	25	13	55.9	42	97.9	63.7	ALS
5-Aug-19	14	0.97	27	12	53.97	14	67.97	59.6	Eurofins
26-Sep-19	14	0.94	25	13	52.94	18.1	71.04	0.33	Eurofins
2-Oct-19	17	1.1	30	15	63.1	18.9	82	35	Eurofins
10-Oct-19	15	0.93	27	13	55.93	24.1	80.03	37.8	Eurofins

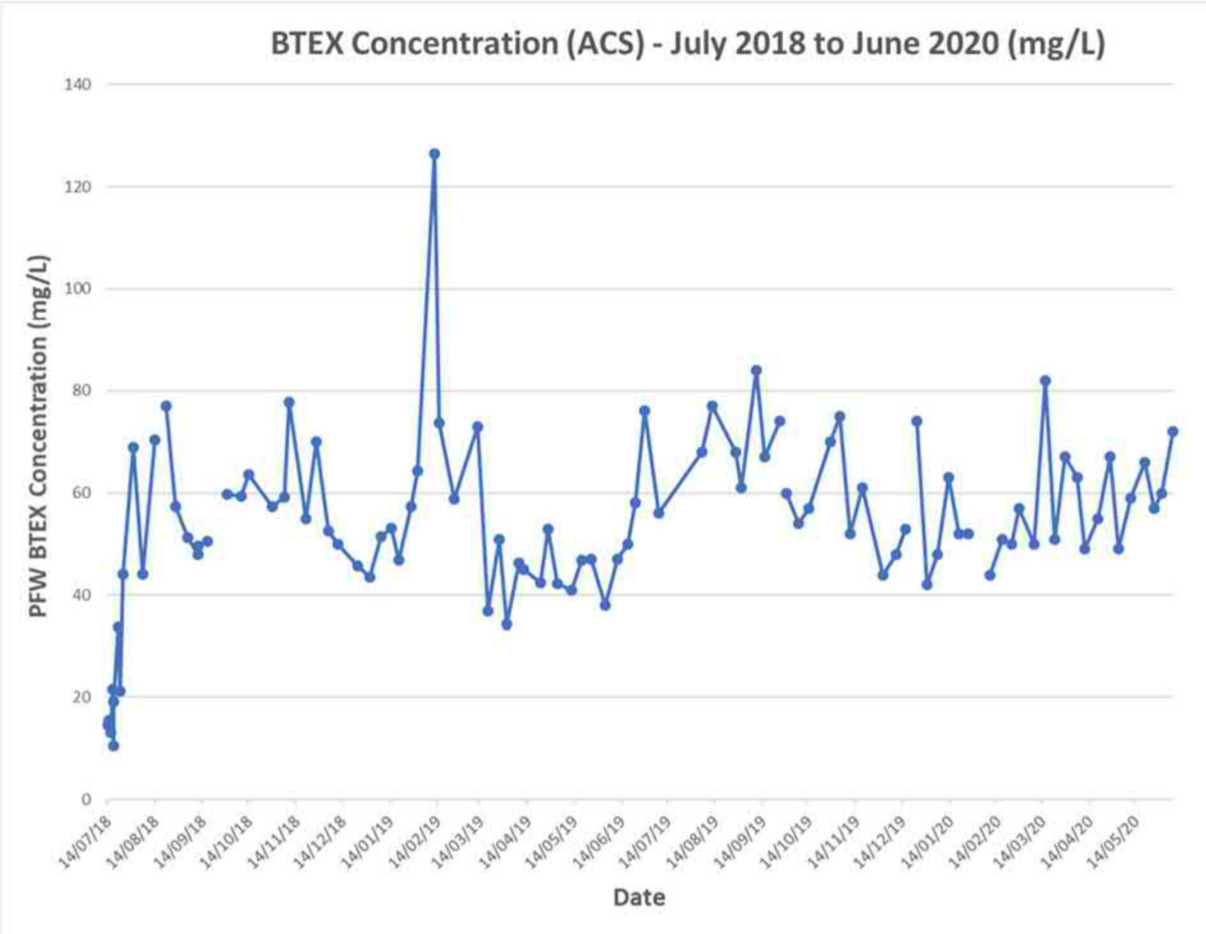

Figure 4 PFW BTEX analyses 2018-2020

Both sets of data (Table 7 and Figure 4) indicate that there has been an increase in BTEX due to an increase mainly in TEX during 2017/18. BTEX has stabilised in the 50-60 mg/L range during 2019/20. In discussion with operations staff it was advised that two new wells were brought online in 2014, which may have resulted in the increased BTEX and reduced phenols.

2.4.4 WET Testing Program

2.4.4.1 Chemical Analyses

The results of the chemical analyses of the samples are summarised in Table 8, with the laboratory reports as **Appendix A**. A comparison of the historic data (BassGas Offshore Operations Environment Plan 4 May 2014) with that from the WET testing samples is presented in Table 6.

It should be noted that there is a difference between ANZG (2018) and the ANZ Fresh and Marine Water Quality Guidelines (superseding ANZECC 2000 guidelines). While the 99% Species protection DGVs are default GLs which are set out within ANZG (2018). ANZG (2018) also provides high level advice on the determination of mixing zones but defers to State guidance as described earlier in this report, as discussed previously.

The analytical results from the three samples are compared to ANZG 99% species protection default guideline values (DGVs), and the number of dilutions required to achieve these criteria are presented in Table 8. ANZG 99% criteria can be used for defining the edge of an approved mixing zone (see Section 1.3.1). However, as discussed in Section 1.3.1, it should be noted that the DGVs are conservatively derived and take into account uncertainty in the data used to develop the guideline values . The derivation of dilution criteria from WET testing, as discussed in Section 1.3.3, is an acceptable process in accordance with ANZG 2018 and OSPAR methodology, and is more suitable for site-specific application than the adoption of the ANZG criteria.

This is consistent with the accepted approach outlined in Section 1.3.1 in which site specific whole of effluent toxicity testing is undertaken if characterisation indicates exceedance of conservative ANZG guidelines as shown in Table 8.

The retention time in the caisson is around two hours and this provides additional PFW quality improvement such as flotation of free hydrocarbon with associated skimming and potentially some volatilization. These processes would decrease the final toxicity of the PFW when comparing results from the sample point on the platform (into the caisson) and final discharge to the receiving environment (out of the caisson).

The data in Table 6 demonstrate that hydrocarbons and BTEX presently being discharged from the Yolla-A platform are higher than the historic maximum data reported; the majority of other characteristics are similar or less. Data from 2017 - 2019 provided to AECOM by Beach support this observation with respect to hydrocarbons and BTEX. The results suggest that the current PFW system is efficient in removing dispersed hydrocarbons(OIW) and the elevated total hydrocarbons are due to BTEX and other dissolved hydrocarbons.

On this basis we have determined to use the WET testing results as site-specific guideline values for the purpose of assessing the impact from the PFW and the ALARP assessment. This is an acceptable and more realistic approach based on ANZG (2018) guidelines and consistent with its approach and methodology. The samples taken are also conservatively based as there will be some improvement in PFW quality through the residence time in the Caisson before discharge to the marine environment as discussed above.

Table 8 Chemical Analyses of the Samples used for the WET Testing

Analyte	Wet Testing Samples Chemical Analyses (mg/L)							Dilutions to achieve ANZG 99% DGVs based on average	Dilutions to achieve ANZG 99% DGVs based on Max
	25-Sep	2-Oct	10-Oct	ANZG 99% DGVs	Ave	Max	Min		
Chloride	11000	9800	12000		10933	12000	9800		
Conductivity (at 25°C)	29000	29000	31000		29667	31000	29000		
Nitrate & Nitrite (as N)	< 0.05	< 0.05	< 0.05		< 0.05	< 0.05	< 0.05		
pH (at 25°C)	6.7	6.9	7.1		6.9	7.1	6.7		
Phosphate total (as P)			0.03		0.03	0.03	0.03		
Total Kjeldahl Nitrogen (as N)	27	51	34		37	51	27		
Total Nitrogen (as N)	27	51	34		37	51	27		
Total Suspended Solids Dried at 103°C	2	4.7	5.1		4	5.1	2		
Ammonia[1] (non NATA analysis)	32	32.6	31.4	0.5	32.3	32.6	32	64.6	65.2
Potassium	60	67	74		67	74	60		
BTEX									
Benzene	14	17	15	0.5	15	17	14	30.7	34.0
Ethylbenzene	0.94	1.1	0.93	0.005[2]	0.99	1.1	0.93	198.0	220.0
m&p-Xylenes	10	12	10	0.275[2]	11	12	10	38.8	43.6

Note: [1] Ammonia was analysed by Ecotox Services Australia
[2] Low Reliability DGV

Analyte	Wet Testing Samples Chemical Analyses (mg/L)							Dilutions to achieve ANZG 99% DGVs based on average	Dilutions to achieve ANZG 99% DGVs based on Max
	25-Sep	2-Oct	10-Oct	ANZG 99% DGVs	Ave	Max	Min		
o-Xylene	2.7	3.2	2.7	0.35[2]	3	3.2	2.7	8.2	9.1
Toluene	25	30	27	0.11	27	30	25	248.5	272.7
Xylenes - Total	13	15	13		14	15	13		
Total	52.94	63.1	55.93						
Glycols									
Di-Ethylene Glycol	< 20	< 20	< 20		< 20	< 20	< 20		
Ethylene glycol	< 20	< 20	< 20		< 20	< 20	< 20		
Propylene glycol	< 20	< 20	< 20		< 20	< 20	< 20		
Triethylene glycol	< 20	< 20	< 20		< 20	< 20	< 20		
Heavy Metals									
Aluminium	< 0.05	< 0.05	< 0.05		< 0.05	< 0.05	< 0.05		
Antimony	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005	< 0.005		
Arsenic	0.003	0.002	0.003		0.0027	0.003	0.002		
Barium	52	40	46		46	52	40		
Beryllium	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Boron	13	11	13		12.3	13	11		
Cadmium	< 0.0002	< 0.0002	< 0.0002	0.0007	< 0.0002	< 0.0002	< 0.0002		

Analyte	Wet Testing Samples Chemical Analyses (mg/L)							Dilutions to achieve ANZG 99% DGVs based on average	Dilutions to achieve ANZG 99% DGVs based on Max
	25-Sep	2-Oct	10-Oct	ANZG 99% DGVs	Ave	Max	Min		
Chromium	< 0.001	0.001	< 0.001	0.0077 (Cr III)	0.001	0.001	0.001		
Cobalt	< 0.001	< 0.001	< 0.001	0.000005	< 0.001	< 0.001	< 0.001	100.0	100.0
Copper		< 0.001	0.005	0.0003	0.005	0.005	0.005	16.7	16.7
Iron	1.2	1	0.86		1.02	1.2	0.86		
Lead	< 0.001	< 0.001	< 0.001	0.0022	< 0.001	< 0.001	< 0.001		
Manganese	0.029	0.028	0.028		0.028	0.029	0.028		
Mercury	0.006	0.0059	0.0054		0.0058	0.006	0.0054		
Molybdenum	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005	< 0.005		
Nickel	< 0.001	< 0.001	< 0.001	0.007	< 0.001	< 0.001	< 0.001		
Selenium	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Silver	< 0.005	< 0.005	< 0.005	0.0008	< 0.005	< 0.005	< 0.005	3.1	3.1
Strontium	3.1	3.1	3.1		3.1	3.1	3.1		
Thallium	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005	< 0.005		
Tin	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005	< 0.005		
Titanium	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005	< 0.005		
Vanadium	< 0.005	< 0.005	< 0.005	0.05	< 0.005	< 0.005	< 0.005		
Zinc	0.017	0.011	0.019	0.007	0.0157	0.019	0.011	2.2	2.7

Analyte	Wet Testing Samples Chemical Analyses (mg/L)							Dilutions to achieve ANZG 99% DGVs based on average	Dilutions to achieve ANZG 99% DGVs based on Max
	25-Sep	2-Oct	10-Oct	ANZG 99% DGVs	Ave	Max	Min		
Phenols (Halogenated)									
2.4.5-Trichlorophenol	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01		
2.4.6-Trichlorophenol	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01		
2.4-Dichlorophenol	< 0.003	< 0.003	< 0.003		< 0.003	< 0.003	< 0.003		
2.6-Dichlorophenol	< 0.003	< 0.003	< 0.003		< 0.003	< 0.003	< 0.003		
2-Chlorophenol	< 0.003	< 0.003	< 0.003		< 0.003	< 0.003	< 0.003		
4-Chloro-3-methylphenol	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01		
Pentachlorophenol	< 0.01	< 0.01	< 0.01	0.011	< 0.01	< 0.01	< 0.01		
Tetrachlorophenols - Total	< 0.03	< 0.03	< 0.03		< 0.03	< 0.03	< 0.03		
Total Halogenated Phenol	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01		
Phenols (non-Halogenated)									
2.4-Dimethylphenol	0.049	5.3	4.3		3.22	5.3	0.049		
2.4-Dinitrophenol	< 0.03	< 0.03	< 0.03		< 0.03	< 0.03	< 0.03		
2-Cyclohexyl-4.6-dinitrophenol	< 0.1	< 0.1	< 0.1		< 0.1	< 0.1	< 0.1		
2-Methyl-4.6-dinitrophenol	< 0.03	< 0.03	< 0.03		< 0.03	< 0.03	< 0.03		
2-Methylphenol (o-Cresol)	0.12	14	13		9.04	14	0.12		
2-Nitrophenol	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01		

Analyte	Wet Testing Samples Chemical Analyses (mg/L)							Dilutions to achieve ANZG 99% DGVs based on average	Dilutions to achieve ANZG 99% DGVs based on Max
	25-Sep	2-Oct	10-Oct	ANZG 99% DGVs	Ave	Max	Min		
3&4-Methylphenol (m&p-Cresol)	0.1	10	12		7.37	12	0.1		
4-Nitrophenol	< 0.03	< 0.03	< 0.03		< 0.03	< 0.03	< 0.03		
Dinoseb	< 0.1	< 0.1	< 0.1		< 0.1	< 0.1	< 0.1		
Phenol	0.19	7.7	8.4	0.27	5.43	8.4	0.19	20.1	31.1
Total Non-Halogenated Phenols	0.459	37	37.7		25.053	37.7	0.459		
Polycyclic Aromatic Hydrocarbons									
Acenaphthene	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Acenaphthylene	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Anthracene	< 0.001	< 0.001	< 0.001	0.00001[2]	< 0.001	< 0.001	< 0.001	50.0	50.0
Benz(a)anthracene	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Benzo(a)pyrene	< 0.001	< 0.001	< 0.001	0.0001[2]	< 0.001	< 0.001	< 0.001	5.0	5.0
Benzo(b&j)fluoranthene	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Benzo(g.h.i)perylene	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Benzo(k)fluoranthene	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Chrysene	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Dibenz(a.h)anthracene	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Fluoranthene	< 0.001	< 0.001	< 0.001	0.001[2]	< 0.001	< 0.001	< 0.001		

Analyte	Wet Testing Samples Chemical Analyses (mg/L)							Dilutions to achieve ANZG 99% DGVs based on average	Dilutions to achieve ANZG 99% DGVs based on Max
	25-Sep	2-Oct	10-Oct	ANZG 99% DGVs	Ave	Max	Min		
Fluorene	< 0.001	0.001	< 0.001		0.001	0.001	0.001		
Indeno(1.2.3-cd)pyrene	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Naphthalene	0.002	0.36	0.14	0.05	0.167	0.36	0.002	3.3	7.2
Phenanthrene	< 0.001	< 0.001	< 0.001	0.0006[2]	< 0.001	< 0.001	< 0.001	0.8	0.8
Pyrene	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		
Total PAH	0.002	0.361	0.14		0.168	0.361	0.002		
Total Recoverable Hydrocarbons - 1999 NEPM Fractions									
TRH C10-C14	0.33	32	32		21.44	32	0.33		
TRH C10-C36 (Total)	0.33	32.2	33	0.007[2]	21.84	33	0.33	3120.5	4714.3
TRH C15-C28	< 0.1	0.2	1		0.6	1	0.2		
TRH C29-C36	< 0.1	< 0.1	< 0.1		< 0.1	< 0.1	< 0.1		
TRH C6-C9	71	82	80		77.7	82	71		
Total Recoverable Hydrocarbons - 2013 NEPM Fractions									
Naphthalene	0.63	< 5	< 5		1.88	<5	0.63		
TRH >C10-C16	0.33	35	37		24.11	37	0.33		
TRH >C10-C16 less Naphthalene (F2)	-	35	37		36	37	35		
TRH >C10-C40 (total)	0.33	35	37.8	0.007[2]	24.4	37.8	0.33	3482.4	5400.0

Analyte	Wet Testing Samples Chemical Analyses (mg/L)							Dilutions to achieve ANZG 99% DGVs based on average	Dilutions to achieve ANZG 99% DGVs based on Max
	25-Sep	2-Oct	10-Oct	ANZG 99% DGVs	Ave	Max	Min		
TRH >C16-C34	< 0.1	< 0.1	0.8		0.8	0.8	0.8		
TRH >C34-C40	< 0.1	< 0.1	< 0.1		< 0.1	< 0.1	< 0.1		
TRH C6-C10	80	92	90		87.3	92	80		
TRH C6-C10 less BTEX (F1)	27	29	34		30	34	27		

Note: [2] Low Reliability DGV

2.4.4.2 WET Testing Results

The results of the WET testing are summarised in Table 9, with the full laboratory reports included as **Appendix B.** The results were reviewed as part of preparing this report in order to develop conservative and scientifically-based conclusions.

Firstly a No Observable Effect Concentration (NOEC) was selected as the criteria to be used. This is the dilution at which there is no impact observed on the test species during the WET tests conducted. The test species were selected as being representative of the local marine environment. As such it is reasonable to conclude that the results provide a representative assessment of the potential impacts on the receiving environment at the platform location.

Secondly the lowest NOEC value (maximum dilution) across all the species and all the samples was selected from the data in Table 9.

The results in Table 9 show a range of NOEC values that range from1.6-12.5%.

The results of the testing demonstrate that:

- a minimum No Observable Effect Concentration (NOEC) of 1.6 % (a maximum dilution of 62.5:1) would not impact these species
- a minimum Lowest Observable Effect Concentration (LOEC) of 3.1 % (a dilution of 32.3:1) could result in some impact.

The NOEC of 1.6% means that when the PFW is diluted at this ratio (1.6 parts PFW with 100 parts sea water) will have no impact on the marine environment as represented by the eight test species and three PFW samples undertaken. By the same reasoning the LOEC of 3.1% means that 3.1parts of PFW with 100 parts sea water will have some impact on the marine environment.

It is proposed that the NOEC dilution criteria derived from the whole of effluent toxicity (WET) testing should be adopted for assessment of potential impacts for the PFW discharge.

These results should be considered in comparison to the ANZG 99% DGVs shown in Table 8. It should be noted that the ANZG 99% DGVs are chronic criteria (longer term impacts) providing 99% species protection. It is proposed to use NOEC, both of which are more appropriate for site-specific application; this is consistent with ANZG methodology.

The results demonstrate that the PFW is much less toxic than inferred by a comparison to ANZG DGVs, even though the concentrations of total hydrocarbons are in excess of 100 mg/L for the second and third samples. The ANZG DGV for hydrocarbons of 0.007 mg/L is a low reliability indication (based on a relatively small data set) that predicts the need for dilutions of in excess of 3000, compared to 62.5 dilutions based on the whole of effluent toxicity (WET) testing. Similarly, toluene, ethyl benzene and cobalt are predicted to require greater than 100 dilutions inferred by comparison to ANZG DGVs.

These results need to be considered in the context of the PFW discharge mixing zone from the Yolla-A Platform as discussed in Section 3.0. No factor of safety needs to be applied to the WET testing results as eight species were tested for acute and chronic toxicity (Van & Chapman 2002).

The mixing zone is the impacted volume of water defined by the distance from the discharge point in which the dilution is less than 1.6%, i.e. the edge of the mixing zone is defined by the 1.6% dilution contour (62.5:1 dilution).

Table 9 Summary of WET Testing Results (% dilution)

Test Species	Chronic Toxicity 1-hr sea urchin fertilisation success			Chronic Toxicity 72-hr sea urchin larval development test			Chronic Toxicity 48-hr larval development test			Acute Toxicity 96-hr acute toxicity test using amphipod		
Date	**25-Sep**	**2-Oct**	**10-Oct**	**25-Sep**	**2-Oct**	**10-Oct**	**25-Sep**	**2-Oct**	**10-Oct**	**25-Sep**	**2-Oct**	**10-Oct**
EC10	1.6	2.5	3.9	3	3	8.8	2	2.3	7.4	3.4	7.9	11.1
EC50	2.4	3.8	5.7	4.8	4.1	13.9	3.4	3.9	12.3	6.6	9.2	13.9
NOEC	1.6	1.6	3.1	1.6	1.6	6.3	1.6	1.6	6.3	3.1	6.3	6.3
LOEC	3.1	3.1	6.3	3.1	3.1	12.5	3.1	3.1	12.5	6.3	12.5	12.5

Test Species	Chronic Toxicity 72-hr marine algal growth test			Chronic Toxicity 72-hr macroalgal germination success test			Acute Toxicity 96-hr fish imbalance toxicity test			Chronic Toxicity 7-day fish imbalance and biomass toxicity test		
Date	**25-Sep**	**2-Oct**	**10-Oct**	**25-Sep**	**2-Oct**	**10-Oct**	**25-Sep**	**2-Oct**	**10-Oct**	**25-Sep**	**2-Oct**	**10-Oct**
EC10	(IC10) 3.7	2	12.3	7.9	13.3	12.7	2.1	4.1	4.8	(unaffected) 2.7/ (biomass) 1.7	4.1/ 3.2	6.6/ 3.1
EC50	(IC50) 6	4	19	15.6	17.6	17.3	3.5	6.1	7.2	(unaffected) 3.2/ (biomass) 3.1	4.5/ 4.6	8.6/ 8.7
NOEC	3.1	1.6	12.5	6.3	12.5	6.3	1.6	6.3	3.1	1.6	3.1	6.3/3.1
LOEC	6.3	3.1	25	12.5	25	12	3.1	12.5	6.3	3.1	6.3	12.5/6.3

Note: *EC 10 - PFW proportion for 10% of test species impacted*
EC 50 - PFW proportion 50% of test species impacted
NOEC - PFW proportion for No Observable Effect Concentration
LOEC - PFW proportion for Lowest Observable Effect Concentration

2.4.5 Discharge Plume Modelling

The discharge of PFW at 45m below sea level results in the PFW mixing with seawater and diluting with distance from the discharge point. The mixing depends on ocean currents (speed of movement) at the time of discharge and relative densities and temperatures of the PFW and seawater. The mixture of PFW and seawater is known as a plume. In order to assess the extent of the plume and the dilution of PFW hydrodynamic modelling is undertaken. A mixing zone is an accepted mechanism for describing the extent of a plume through its impact on the marine environment. The boundary of the mixing zone is often defined by the use of ANZG DGV's at the species protection levels defined in the Victorian State Environment Protection Policy (Waters) (SEPP). For the marine waters in which the Yolla-A Platform is located, the SEPP requires a 99% protection level. For the purposes of this study site-specific GVs are defined using a NOEC as described in this report. ANZG suggest the derivation of site-specific GVs is a suitable alternative to using DGVs as they provide more relevant site specific criteria as a result of being based on the whole of effluent toxicity testing using the actual discharge (PFW) under consideration and species selected as being representative of the local marine environment.

Therefore the purpose of the plume modelling is to predict the area of potential impact associated with the plume through the predictive modelling of the dilutions of PFW that are expected to occur. Because modelling is a predictive tool Beach also proposes to undertake a marine monitoring program to confirm the plume modelling results (see **Appendix G**).

Beach has undertaken modelling of the PFW discharge plume a number of times (Worley Parsons 2009, RPS 2017). The modelling produced similar predictions of PFW dispersion. The comparison of two different modelling techniques, which gave similar results, was used as the validation method.

The following description of the modelling methodology was extracted from the RPS (2017) report.

The modelling study was carried out by firstly generating a high-resolution vertical current profile for the study area, which included the combined influence of ocean and tidal currents. Secondly, the vertical profiles for typical seasonal salinity and temperature profiles were obtained from the World Ocean Atlas. Finally, a near-field discharge model (CORMIX) was used to assess the rate of dilution (defined as the ratio of the initial concentration (at the discharge port) to the concentration at a given location based on the centreline of the plume) of the plume under static low and high current speeds for each of the three model scenarios under summer and winter conditions.

To accurately describe the variability in currents between the inshore and offshore region, a hybrid regional dataset was developed by combining deep ocean predictions obtained from HYCOM (Hybrid Coordinate Ocean Model) with surface tidal currents developed by RPS.

Tidal current data was generated using RPS's advanced ocean/coastal model, HYDROMAP. The HYDROMAP model has been thoroughly tested and verified by comparison to field measurements throughout the world over the past 32 years (Isaji & Spaulding, 1984; Isaji, et al., 2001; Zigic, et al., 2003). HYDROMAP tidal current data has been used as input to forecast (in the future) and hindcast (in the past) pollutant spills in Australian waters and forms part of the Australian National Oil Spill Emergency Response System operated by AMSA (Australian Maritime Safety Authority).

HYDROMAP employs a sophisticated sub-gridding strategy, which supports up to six levels of spatial resolution, halving the grid cell size as each level of resolution is employed. The sub-gridding allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, and/or of particular interest to a study.

The numerical solution methodology follows that of Davies (1977a and 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji and Spaulding (1984) and Isaji et al. (2001).

The ocean boundary data for the regional model was obtained from satellite measured altimetry data (TOPEX/Poseidon 8.0) which provided estimates of the eight dominant tidal constituents at a horizontal scale of approximately 0.25 degrees. The eight major tidal constituents used were K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1. Using the tidal data, time series surface heights were calculated along the open boundaries for the simulation period.

The Topex-Poseidon satellite data has a resolution of 0.25 degrees globally, with higher resolution in coastal regions, and is produced and quality controlled by NASA (National Aeronautics and Space Administration). The data capturing satellites, equipped with two altimeters capable of taking sea level measurements accurate to less than ± 5 cm, measured oceanic surface elevations (and the resultant tides) for the period 1992–2005. In total these satellites carried out 62,000 orbits of the planet. The Topex-Poseidon tidal data has been widely reported amongst the oceanographic community, being included in more than 2,100 research publications (e.g. Andersen, 1995; Ludicone et al., 1998; Matsumoto et al., 2000; Kostianoy et al., 2003; Yaremchuk & Tangdong, 2004; Qiu & Chen 2010). The Topex/Poseidon tidal data is considered suitably accurate for this study.

To ensure that tidal predictions were accurate, predicted surface elevations were compared to data from five locations situated within the study area.

Data describing the flow of ocean currents was obtained from HYCOM (Hybrid Coordinate Ocean Model, (Chassignet et al., 2007), which is operated by the HYCOM Consortium, sponsored by the Global Ocean Data Assimilation Experiment (GODAE). HYCOM is a data-assimilative, three-dimensional ocean model that is run as a hindcast (for a past period), assimilating time-varying observations of sea surface height, sea surface temperature and in-situ temperature and salinity measurements (Chassignet et al., 2009). The HYCOM predictions for drift currents are produced at a horizontal spatial resolution of approximately 8.25 km (1/12th of a degree) over the region, at a frequency of once per day. HYCOM uses isopycnal layers in the open, stratified ocean, but uses the layered continuity equation to make a dynamically smooth transition to a terrainfollowing coordinate in shallow coastal regions, and to zlevel coordinates in the mixed layer and/or unstratified seas.

For this study, the HYCOM hindcast currents were used.

The near-field mixing and dispersion of the operational discharge was simulated using the fully three-dimensional flow model in CORMIX.

CORMIX is a mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones.

CORMIX contains a series of elements for the analysis and design of conventional or toxic, single or multi-port, submerged or surface, buoyant or non-buoyant, pollutant discharges into stratified or unstratified watercourses, with emphasis on the geometry and dilution characteristics on the initial mixing zone. (Doneker, 1990; Jirka & Doneker, 1991)

CORMIX has been validated in many independent studies over the years. A list of some of these studies is provided on the CORMIX website (http://www.cormix.info/validations.php).

The current discharge rate for the Yolla-A is around 150-160 m^3/d with the maximum discharge of 300 m^3/d due to equipment constraints.

RPS modelled a range of flow rates (100 m^3/d [design case], 200 m^3/d [Typical] and 300m^3/d [Maximum]) and a range of sea current conditions. The report is included as **Appendix C**. The predicted dilutions of the PFW plume are summarised in Table 10.

The distances from the discharge point to achieve selected dilutions, based on the WET testing and modelling, are presented in Table 11. These demonstrate that the mixing zone (distance from the discharge point potentially impacted) as defined by the NOEC, is in the range 1.5-7.3 m from the discharge point across a range of flow rates and currents modelled.

Table 10 Summary of RPS modelling results – Dilution of PFW with distance from discharge point

Case	Season	Current Speed (%ile)	Maximum Distance from Discharge Point to Centreline Dilution X:1 (m)																		
			10	20	30	40	50	60	70	80	90	100	200	300	400	500	600	700	800	900	1000
Case 1 Design Operation	Summer	5th	0.2	0.4	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.5	2.7	3.7	4.6	5.4	6.2	7.0	7.8	8.5	9.2
		95th	1.2	2.2	3.0	3.6	4.2	4.8	5.3	5.8	6.3	6.7	11.0	14.9	18.4	21.8	25.1	28.4	31.6	34.8	38.0
	Winter	5th	0.2	0.4	0.6	0.7	0.9	1.0	1.1	1.2	1.4	1.5	2.6	3.6	4.5	5.3	6.1	6.8	7.6	8.3	9.0
		95th	1.2	2.2	3.0	3.6	4.2	4.7	5.2	5.7	6.2	6.7	10.9	14.6	18.0	21.2	24.3	27.3	30.1	32.9	35.6
Case 2 Typical Operation	Summer	5th	0.3	0.5	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	3.8	5.3	6.6	7.9	9.1	10.2	11.2	12.3	13.3
		95th	1.4	2.6	3.6	4.5	5.4	6.2	6.9	7.7	8.4	9.1	15.4	21.1	26.5	31.8	37.1	42.5	48.1	53.9	59.9
	Winter	5th	0.3	0.5	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.1	3.7	5.2	6.5	7.7	8.9	10.0	11.1	12.2	13.2
		95th	1.4	2.6	3.6	4.5	5.3	6.1	6.8	7.6	8.3	9.0	15.1	20.5	25.5	30.2	34.7	39.0	43.2	47.2	51.2
Case 3 Worst Case Operation	Summer	5th	0.3	0.6	0.9	1.1	1.4	1.6	1.8	2.1	2.3	2.5	4.4	6.1	7.6	9.0	10.4	11.6	12.9	14.0	15.1
		95th	1.5	2.9	4.0	5.0	6.0	6.9	7.7	8.6	9.4	10.2	17.5	24.1	30.5	36.8	43.3	49.9	56.7	63.5	70.3
	Winter	5th	0.3	0.6	0.9	1.1	1.4	1.6	1.8	2.0	2.2	2.4	4.3	5.9	7.4	8.9	10.2	11.5	12.8	14.1	15.4
		95th	1.5	2.8	3.9	4.9	5.9	6.8	7.6	8.5	9.3	10.1	17.1	23.2	28.9	34.4	39.5	44.5	49.3	54.0	58.6

Table 11 Distance from discharge point (m) to achieve the required dilutions at a range of sea water current conditions (5%ile to 95%ile)

PFW Discharge Rate	PFW %	1.6 (NOEC)	3.1 (LOEC)
	Required Dilution	62.5	32.3
Typical	200 m^3/d	1.5-6.5 m	0.9-4 m
Maximum (worst case)	300 m^3/d	1.5-7.3 m	1-4.3 m

The modelling is based on an assessment of water current speed and direction. The RPS report indicates that the predominant current direction is easterly throughout the year. RPS modelled a low current flow and a high current flow condition for summer and winter conditions. In order to take a conservative approach, the maximum discharge of 300m^3/d was assessed. Currently the discharge is around 150-160m^3/d so the extent of the plume will be less.

Figure 5 and Figure 6 show the plume in plan view for winter and summer respectively. Figure 7 shows a side view section from the south.

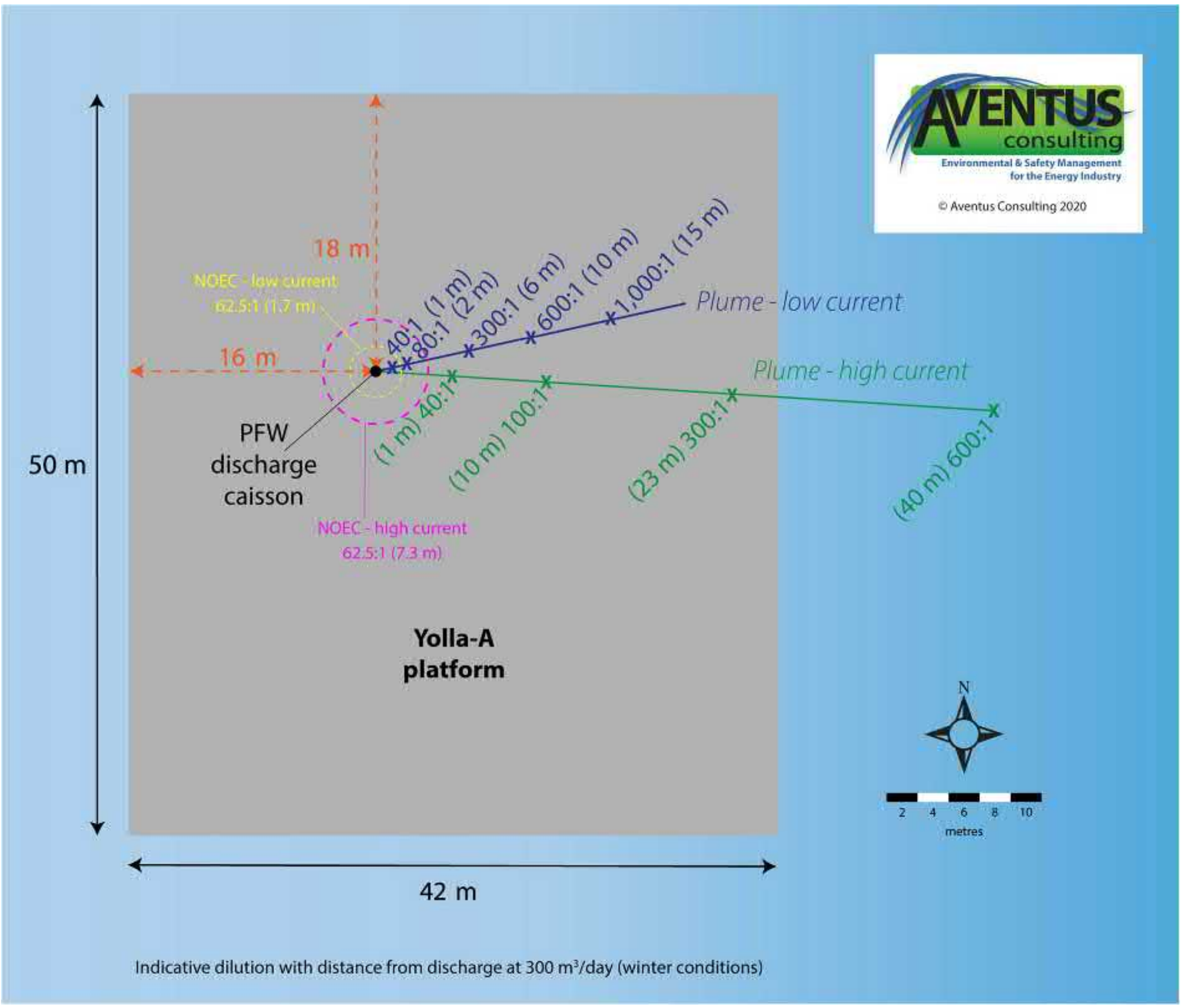

Figure 5 **Plan view of the Yolla-A Platform showing plume direction, extent and dilutions for maximum discharge 300m^3/d (Winter conditions).**

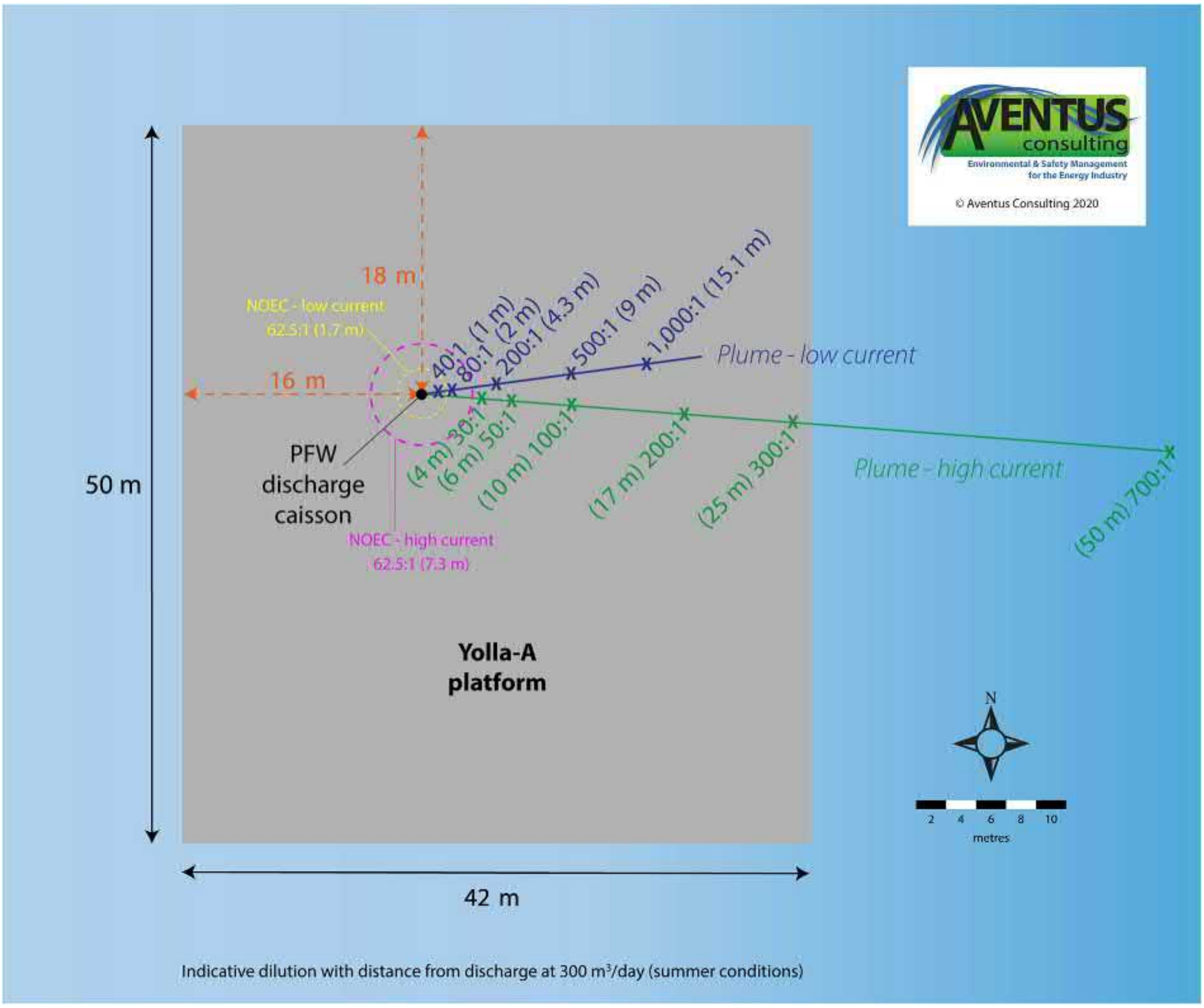

Figure 6 Plan view of the Yolla-A Platform showing plume direction, extent and dilutions for maximum discharge 300m^3/d (Summer Conditions).

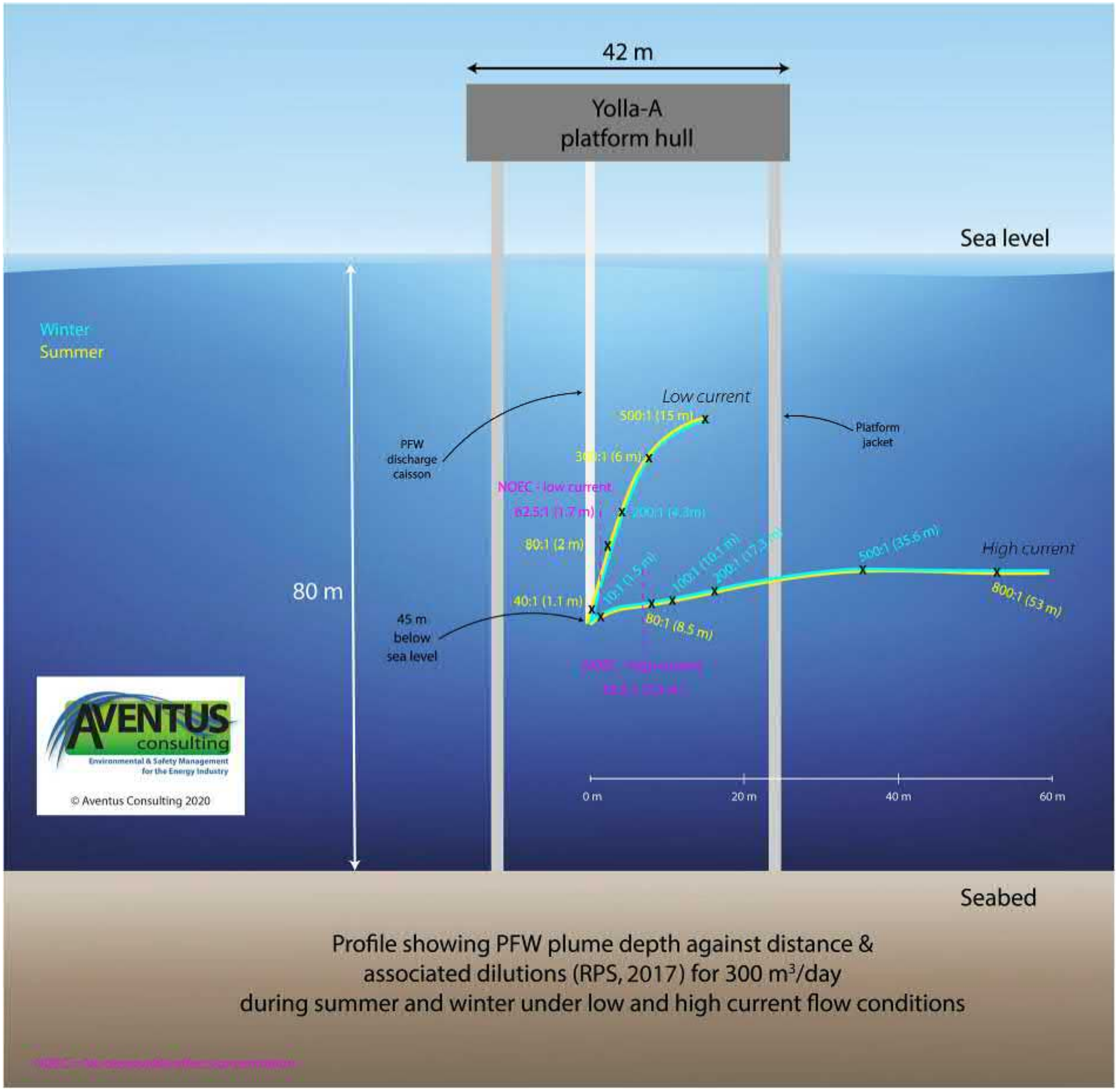

Figure 7 **Side View from south of the Yolla-A Platform showing plume direction , extent and dilutions for maximum discharge 300m^3/d (Summer and Winter conditions with high(95%ille) and low(5%ille) current flows**

The RPS modelling found that for low currents in summer and in winter the plume rises within 20-30 m of the discharge point, where as for winter and summer high currents the plume does not rise significantly. These impacts are due to the relative temperatures of the plume together with the speed of the current e.g. at low summer flows the plume is relatively warmer than the seawater and hence rises.

These diagrams demonstrate that the no observable effect (NOEC) dilution occurs within a few meters of the discharge point across all conditions. This suggests impacts may occur at only minimal extents of the modelled plume. This is because the whole of effluent toxicity testing (at 62:1 dilution) together low discharge flow (less than 300m^3/d and actually around 150-160 m^3/d) results in a low impact extent.

Beach will implement a sampling program (see **Appendix G**) to verify that the dilutions required to meet the NOEC as predicted by modelling undertaken by RPS are met within the predicted distances of the discharge.

2.4.5.1 References for RPS (2017) Report

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2.5 Summary and Conclusions

The discharge flow rates have been presented (see Figure 2 and Table 4). The current discharge rate is 150-160m^3/d and the maximum discharge is 300 m^3/d. The maximum discharge is a constraint due to equipment capacity.

The characteristics of the PFW discharge have been presented in terms of chemical constituents and whole of effluent toxicity (WET) testing. The results are summarised in Table 5 to Table 8 with respect to chemical characterisation and Table 9 for whole of effluent toxicity (WET) testing.

In summary:

- There has been an increase in BTEX and dissolved hydrocarbons compared to available historic results.
- The sample point used for characterisation of the discharge is conservative in so far as the PFW is discharged via a caisson after several hours residence in the caisson during which there is likely to be some improvement on PFW quality prior to its discharge to the sea. Therefore this assessment is conservative.
- The use of ANZG 99% DGVs over-predicts the potential impacts from the PFW as the whole of effluent testing results indicate that a No observable Effect Concentration (NOEC) is a lower dilution than dilutions based on ANZG trigger values e.g. some individual species (see Table 8) have dilution of 200 or greater (e.g. ethyl benzene and toluene).
- The approach taken to use whole of effluent toxicity (WET) testing results, rather than ANZG, to assess impacts is consistent with ANZG recommended methodology.
- The use of No Observable Effect Concentration to assess the toxicity of a wastewater stream is in line with ANZG methodology and eliminates the potential issues that can arise using single chemical toxicity data for a multi-chemical component streams.
- The discharge mixing zone could be conservatively defined (minimum NOEC of 1.6% across the eight species including chronic and acute toxicity tests and three separate samples) i.e. a maximum dilution of 62.5 to one.
- The distance to the edge of the mixing zone for a range of conditions (200-300 m^3/d, 5%-95% current ranges, summer and winter) and NOEC is predicted to be 1.5-7.3 m from the discharge point. This will be confirmed through a monitoring program.

3.0 Assessing the Impact

3.1 Background

In the 2014 accepted EP, there was discussion, in Section 6.5.5.2, of the impacts from produced water. This included an assessment of the dilution required to achieve ANZECC 99% species protection levels (Table 6.13) based on chemical constituents. Plume dispersion modelling results were also provided in Figure 6.5 for produced water discharge rates of 200 and 300 m^3/d, being typical summer and worst case. The modelling demonstrated that the dilutions required to achieve ANZECC 99% protection levels would be achieved at the plume centreline within a horizontal distance of 30 m from the discharge point.

As discussed in Section 2.4 of this report, the characteristics of the discharge have changed since that time and in particular the concentration of BTEX has increased. This has resulted in a maximum total hydrocarbon concentration of almost 130 mg/L (see Table 6 and Table 8).

As discussed in Section 1.3.1, the ANZG 2018 (superseding ANZECC 2000) guidelines are trigger levels. In accordance with ANZG, with respect to toxicants, where trigger levels are exceeded, it is appropriate to undertake site-specific assessments to develop site-specific toxicity criteria.

The approach taken by this assessment is in accordance with ANZG 2018 as discussed in Section 1.3. The results of the site-specific toxicity assessment are presented in Section 2.4.4(WET Testing Program) and align with the requirements in the EIN dated 27 August 2019. The results, as summarised in Section 2.5, demonstrate that a NOEC can be achieved with a dilution of 62.5:1. The use of whole of effluent toxicity (WET) testing aggregates the impacts from all the constituents and removes the uncertainty in interpretation of single constituent trigger values (which arises from the species used in the toxicity testing implemented to develop the trigger levels). Whole of Effluent Toxicity (WET) testing also accounts for any synergistic (increased effects of multiple chemical species being greater than the sum of individual toxicities) or antagonistic (masking) interactions between chemical constituents that are not apparent when considering a suite of individual constituent trigger values.

In order to assess the dispersion of the discharge, plume dispersion modelling was undertaken as discussed in Section 2.4.5 and shown in Figure 5 to Figure 7. The modelling program used (RPS 2017) was different to that used by Worley (2009) however as noted the results were similar.

3.2 **PFW toxicants effects in the Marine Environment**

3.2.1 Overview by Constituent

A brief overview of the potential effects on the marine environment associated with each of the toxicants which exceed detection limits in the Yolla-A Platform PFW discharge (see Table 8) for which the ANZG 2018 provides default guideline values (DGVs, which are included in Table 8 of the ALARP assessment) is as follows:

- Naphthalene – The acute toxicity of naphthalene to marine organisms is considered by Bates, Young & Sutton (1997, in Nazir et al 2008) to be 'high to moderate'. Other toxicity effects include bioaccumulation, reproduction defects, and limited growth (Nazir et al 2008). It has been shown to biodegrade in water, with half-lives ranging from about 0.8 to 43 days (Toxnet 2017a).
- Benzene – The potential for benzene to bioconcentrate[2] in aquatic organisms is considered to be low (Toxnet 2017b). It also has a low tendency to bioaccumulate; hence it is not considered likely to biomagnify though food chains (ATSDR 2007). It has high volatility and relatively low water solubility and is rapidly lost to the atmosphere from water bodies (ANZG 2018). Biodegradation has been found to vary with season (e.g. Wakeham et al 1983), but is considered by ANZG (2018) to also be rapid.

[2] Bioconcentration is the intake and retention of a substance in an organism entirely by respiration from water in aquatic ecosystems. Bioaccumulation is the intake of a chemical and its concentration in an organism by all possible means, including contact, respiration and ingestion (Alexander 1999).

- PAHs (phenanthrene, anthracene, fluoranthene and benzo(a)pyrene) - Concentrations of PAHs in marine ecosystems are generally highest in sediments, intermediate in biota and lowest in the water column (Neff 1979). Marine biota can take up PAHs via a number of routes, including dermal absorption, inhalation and consumption of contaminated prey or sediment (Meador et al. 1995). However, the persistence of these compounds in tissues and body fluids of exposed marine organisms varies depending upon the rates of uptake, metabolism and elimination (Krahn and Stein 1998, Rust et al 2004). Vertebrates, such as fish and marine mammals, quickly metabolise PAHs into more polar forms that are then excreted into urine or secreted into bile for rapid elimination via faeces (Roubal, Collier & Malins 1977, Krahn et al. 1984, Varanasi Stein & Nishimoto 1989). However, some of the PAH intermediates formed during metabolism can be more toxic, and may pose a greater health risk than the parent PAHs (Varanasi Stein & Nishimoto 1989). Fish exposed to PAHs may exhibit an array of toxic effects including genetic damage, morphological deformities, altered growth and development, decreased body size, inhibited swimming abilities and mortality (e.g. White, Robitaille & Rasmussen 1999, Incardona et al 2005). Benzo(a)pyrene has a higher molecular weight than the other three PAHs, has a greater potential to bioaccumulate and has been found to cause tumours in fish (Hawkins et al. 1990).
- Toluene – Algae seem to be more resistant to the acute effects of toluene than fish and crustaceans (Jones and Zabel 1986). Bioaccumulation in marine organisms has been found to be low, and depuration rates high (Jones and Zabel 1986). Bioconcentration in aquatic organisms is considered to be low to moderate (Toxnet 2017c). Toluene has high volatility and relatively low water solubility and is rapidly lost to the atmosphere from water bodies (ANZG 2018). Complete degradation has been observed over periods of four days (summer) and 22 days (spring) in a marine mesocosm (Wakeham et al 1983).
- Ethylbenzene – The acute toxicity of ethylbenzene to marine algae, invertebrates and fish is rated by Toxnet (2017d) as 'moderate'; there are no data reported for chronic toxicity. The potential for bioconcentration in aquatic organisms is considered low and ethylbenzene is considered to be volatile and inherently biodegradable in water under aerobic conditions (OECD 2002).
- Xylenes - Meta-, para- and ortho-xylenes are chemical isomers, with similar physicochemical properties and moderate to low toxicity (OECD 2003, Toxnet 2017e). They are inherently biodegradable under aerobic conditions and their bioaccumulation and bioconcentration potentials are considered to be relatively low (OECD 2003, Ogata et al 1984).
- Copper – adsorbed strongly by suspended material (Florence & Batley 1980 in ANZG 2018). Copper is readily accumulated by plants and animals and bioconcentration has been recorded for various species of phytoplankton, zooplankton, macrophytes, macro-invertebrates and fish (Spear & Pierce 1979 in ANZG 2018). Toxic effects occur when the rate of uptake exceeds the rates of physiological or biochemical detoxification and excretion (Rainbow 1996). Some marine invertebrates, particularly crustaceans, corals, sea anemones and bivalve molluscs, are sensitive to copper (ANZG 2018), while gastropod molluscs are more tolerant and can accumulate quite high concentrations without toxic effects (Taylor & Anstiss 1999). Marine fish appear to be relatively tolerant of copper (e.g. Denton & Burdon-Jones 1986 in ANZG 2018). Copper toxicity in algae, invertebrates and fish generally increases as salinity decreases (e.g. Stauber 1995). Precipitation of copper hydroxide reaches a maximum around pH8 (Ayres, Davis & Gietka 1994) but there is no clear relationship between pH and toxicity (ANZG 2018).
- Silver - one of the most toxic metals to aquatic life in laboratory experiments, in particular silver nitrate and silver iodide (CCREM 1987). However, in the natural environment silver is often found in less bioavailable complexes with chloride, dissolved organic carbon and sulfur-containing ligands and hence laboratory data may overestimate the toxicity of silver (Gorsuch & Purcell 1999 in ANZG 2018). The acute toxicity of silver to marine fish is considerably lower than for freshwater fish, though toxicity to most marine species increases with decreasing salinity and with elevated ammonia concentrations (Hogstrand & Wood 1998).
- Zinc – commonly forms complexes with organic matter in marine waters (Florence & Batley 1977 in ANZG 2018, Bruland 1989). Zinc is adsorbed by certain metal hydroxides (Dzombak & Morel 1990) and by suspended material; bioavailability after adsorption is variable (e.g. Vercauteren & Blust 1996). Zinc toxicity generally decreases with decreasing pH, at least up to pH 8, above which

trends are variable (e.g. Everall, Macfarlane & Sedgwick 1989, Roy & Campbell 1995). Zinc uptake and toxicity generally decreases as salinity increases (e.g. Hamilton & Buhl 1990).

- Ammonia – lost from water by volatilisation (Johnson et al 2007) and rapidly oxidised by bacteria (under aerobic conditions) into nitrite (Ward 1996). Ammonia is directly toxic to biota and can cause convulsions, coma and/or death in marine vertebrates such as fish (Randall & Tsui 2002). The toxicity of ammonia in water increases with increasing temperature and pH, but decreases with increasing salinity (ATSDR 2004). Exposure to sub-lethal ammonia stress can lead to adverse reproductive effects in fish (e.g. Armstrong et al 2015) and invertebrates (e.g. Lee et al 2013), changes in invertebrate behaviour (e.g. Montresor et al 2013, Alonso & Camargo 2014) and reduced growth in a wide range of aquatic organisms (Cheng et al 2015). Some fish species have been found to adapt to long-term sublethal ammonia concentrations by increased excretion from the body and detoxification in the brain (e.g. Kolarevic et al 2012).
- Phenol - Readily soluble in, and not expected to volatilise from, water (ANZG 2018). Phenol is expected to adsorb to suspended solids (Toxnet 2017e) but there has been no indication that it accumulates in sediment (IHCP 2006). Depuration is rapid (half-life ≤12 hours, ANZG 2018) and it is considered unlikely to bioaccumulate (e.g. Crookes & Howe 1996 in ANZG 2018, Toxnet 2017e). Toxicity to fish is considered high (Toxnet 2017e) and has been shown to increase with decreasing pH (e.g. Dalela et al. 1980 and Verma et al. 1980 in ANZG 2018).

3.2.2 Potential impacts of PFW discharge on marine life

Indirect impacts of the PFW discharge on marine life may include potential bioaccumulation, bioconcentration and/or biomagnification (i.e. increasing concentrations with increasing trophic levels) of toxicants through trophic levels. These may potentially arise from the ingestion/foraging of prey species that have established on, or are associated with, the legs and subsea infrastructure of the Yolla-A platform, particularly those established habitats/species that have been present within the PFW mixing zone for an extended period of time (i.e. they are less likely to arise in those species whose presence is of a transitory nature and not related to foraging). The level of any indirect impact would likely be localised to:

- the predator-prey relationships of those species that have interacted with, or been directly associated with, the habitat present within the PFW mixing zone; or
- the species that have inhabited the area within the zone of influence, that are more likely to have long-term exposure to those toxicants (see Table 4.0 of the Yolla-A Platform ALARP assessment).

Arnould et al (2015) investigated the use of habitat created by offshore infrastructure in Bass Strait by marine mammals and the potential benefits this infrastructure may have to certain marine ecosystems. The Australian fur seal (*Arctocephalus puillus doriferus*), is a benthic forager that feeds exclusively on demersal fish and cephalopod species over the continental shelf, with all but one of the known breeding colonies occurring within Bass Strait (Arnould et al 2015). This region is considered to be of low primary productivity (Gibbs 1992), therefore the presence of subsea infrastructure can potentially provide valuable foraging habitat. The study conducted by Arnould et al (2015) concluded that offshore infrastructure in the Bass Strait was potentially important foraging habitat for Australian fur seals, due to creation of fish habitat etc, however the study indicated that pipelines and cable routes appeared to be the most influential structures (over wells and shipwrecks), potentially providing habitat connectivity for prey species. Fur seals are often observed below the Yolla-A platform, which indicates that the associated subsea infrastructure may support suitable foraging habitat.

There is a potential for pinnipeds (seals and sea lions), specifically the Australian fur seal, to forage on species that have had a direct association with habitat within the PFW mixing zone, e.g. seals eat fish that may have eaten algae/crustaceans/molluscs that inhabit the zone of influence of the PFW mixing zone. Therefore, there is a potential that bioaccumulation or bioconcentration of toxicants within fur seals may occur.

The principal diet of most seals and sea lions consist of cephalopod molluscs and fish; unlike bivalves and suspension feeders these prey are not likely to accumulate petroleum hydrocarbons. All seals and sea lion species are assumed to have the necessary enzymes available within their systems to metabolise some petroleum fractions, while others may be deposited into fat stores. To date, no evidence of deleterious effects related to bioaccumulation of petroleum hydrocarbons has been documented (NOAA 1992).

3.2.3 Conclusion

Due to the small zone of impact associated with the PFW mixing zone, it is concluded that there is a negligible risk of the PFW having a significant impact upon the marine ecosystem within the receiving environment. It is reasonable to conclude that any impacts that may occur would be localised to those biological communities present in those habitats with long-term exposure to the PFW plume, which represent a only a very small proportion of the total available similar habitat (i.e. other platform legs or subsea infrastructure). Any indirect impacts would be localised to those species that forage on the biota within the habitats that experience long-term exposure to the PFW plume.

3.2.4 References

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3.3 Defining a mixing Zone

The SEPP (Waters) in clause 23 provides the following regarding approval of a mixing zone:

Approval of mixing zones

(1) In considering an application made in accordance with clause 21, the Authority may determine a mixing zone if the applicant can demonstrate that it is not reasonably practicable to meet the requirements of clause 21(2)(b).

(2) The Authority must not approve a mixing zone which, according to tests approved by the Authority, will result in any of the following –

(a) acute lethality at the point of discharge;

(b) chronic toxicity outside the mixing zone;

(c) risks to beneficial uses at the boundary of the mixing zone;

(d) harm to humans;

(e) harm to plants or animals;

(f) loss of aesthetic enjoyment;

(g) objectionable odour.

(3) If a mixing zone is approved, the licence holder must –

(a) monitor the impacts of the mixing zone and associated risks to beneficial uses;

and

(b) implement measures that eliminate the mixing zone, so far as reasonably practicable or, if it is not reasonably practicable to eliminate the mixing zone, to reduce the mixing zone, so far as reasonably practicable

For the produced water discharge, the mixing zone will be defined by the NOEC.

As noted above, in addressing a mixing zone there are three aspects to be considered

1. acute impacts at the discharge point (lethality);
2. chronic toxicity outside the mixing zones; and
3. risks to beneficial uses at the boundary of the mixing zone.

3.4 Impacts within the Mixing Zone

The ANZG (2018) define a mixing zone as "an explicitly defined area around an effluent discharge where some, or all, water quality objectives may not be met". They note that: "As a consequence, some community values of the water body may not be protected". Hence, it is important to consider the environmental setting of a discharge around which a mixing zone is applied. For example, a discharge at a remote offshore location (such as for Yolla-A) has different implications for community values than a discharge into an urban waterway that may provide a multitude of ecosystem services to local communities.

ANZG (2018) provides minimal guidance as to the determining an appropriate size for a mixing zone, other than indicating that: "they should be as small as practicable". This philosophy echoes the As Low As Reasonably Practicable (ALARP) approach applied to health, safety and environmental risk. The ALARP assessment is presented in Sections 5.0 and 6.0.

For this situation the water quality in the plume will be in excess of chronic criteria. This will result in potential impact on species that come in contact with the plume, which could include impaired growth including reduced fertilisation success, for sea urchins, that was assessed in a 1hour test. All the other tests ranged from 72 hours - 7 days in duration. In this time range it is considered unlikely that species would be present for that period of time within the plume (i.e. fish are mobile and are quickly likely to pass through the plume rather than reside in it).

3.5 Chronic Toxicity outside the mixing zone.

As discussed in Sections 1.3.1, 2.4.4 and 2.4.5, the extent of the mixing zone is defined in Table 10. A No Observable Effect Concentration (NOEC) criterion was used to define the extent of the mixing zone.

The following is based on the Beach risk assessment definitions presented in **Appendix E**.

The likelihood of there being chronic toxicity effects outside the mixing zone is considered remote (<1% chance of occurring within the next year). Occurrence requires exceptional circumstances and is an exceptionally unlikely event in the long-term future. The potential impact could be conservatively considered serious (moderate effects on biological or physical environment and serious short-term effect to ecosystem functions) resulting in a risk that is considered low.

3.6 Risks to beneficial uses at the boundary of the mixing zone

The risks to the beneficial uses at the boundary are considered the same as the assessment of chronic toxicity outside the mixing zone as discussed above: low.

3.7 Acute Impacts

As part of the whole of effluent (WET) testing regime two acute toxicity tests were conducted (Table 9):

- 96-hour acute toxicity test using amphipod; and
- 96-hour fish imbalance toxicity test.

The results gave a range of maximum PFW proportions that would result in acute toxicity (lethality) based on the EC50: 3.5-13.9%. It is noted that the test duration is 96 hours and that the nature of the plume is that its direction varies subject to tidal and ocean current influences. Conservatively using 3.5 % (28.5:1 dilution) as a criterion, the length of the plume would be as shown in Table 12.

Table 12 Length of plume (m) within which acute impacts occur

Parameter	Range of PFW Impacts	
	5th Percentile	95th Percentile
%PFW	3.5	3.5
Dilution	28.5	28.5
Current Speed (percentile)	5	95
Predicted plume length (m) at typical Flow (200m^3/d)	0.8	3.6
Predicted plume length (m) at maximum flow (300m^3/d)	0.9	4

The results show that the impacted plume is between 0.9 and 4 m in length. The 95th percentile current occurs for less than 5% of the time (RPS 2017).

The following is based on the Beach risk assessment terminology presented in **Appendix E**.

Given that the plume direction is variable the likelihood that species will be continuously exposed for 96 hours is considered unlikely (< 5% chance of occurring within the next year), while the potential impact is ranked as serious (moderate effects on biological or physical environment and serious short term effect to ecosystem functions) to major (offsite release contained or immediately reportable event with very serious environmental effects, such as displacement of species and partial impairment of ecosystem. Widespread medium and some long-term impact). On this basis, the risk is considered to be Medium.

3.8 Conclusions

The potential impact from the discharge of PFW from Yolla-A has been assessed through assessing the PFW discharge rate, characterisation of the discharge and hydrodynamic modelling of the discharge plume.

The results demonstrate that the discharge of PFW does not pose a credible risk of significant impact upon the quality of the waters of Bass Strait, due to the relatively low discharge flows, low toxicity and limited extent of the mixing zone around the point of discharge. This is because the extent of the plume defined by the no observable effect concentration (NOEC) is small.

4.0 ALARP Assessment

4.1 Introduction

In its guideline document *Environment plan decision making* (GL1721-Rev5 June 2018), in discussing the ALARP criterion NOPSEMA provides the following:

Sub-regulation 10A(b) requires that an EP demonstrate that the environmental impacts and risks of the activity will be reduced to as low as reasonably practicable (ALARP). The question that needs to be answered to meet this criterion is 'has the titleholder done enough to reduce the impacts and risks of the activity?' Reducing impacts and risks to ALARP is based on the concept of reasonable practicability; the weighing up of the magnitude of impact or risk reduction against the cost of that reduction[4]. In this context, a titleholder is required to implement all available control measures where the cost is not grossly disproportionate to the environmental benefit gained from implementing the control measure.

Therefore ALARP can be defined as: a level of risk that is not intolerable, and cannot be reduced further without the expenditure of costs that are grossly disproportionate to the benefit gained.

In this ALARP assessment the subject is the discharge of PFW from the Yolla-A Platform.

NOPSEMA (Article published in the Regulator, Issue 3: 2014) has provided further commentary in relation to ALARP and PFW.

The repeal of regulations 29 and 29A is a notable change brought about through the 28 February 2014 amendments to the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Environment Regulations). The Regulations previously set a limit of 30 mg/L of petroleum (averaged over 24 hours) in any produced formation water (PFW) discharged to the sea, and also outlined associated testing requirements for equipment used to monitor oil-in-water (OIW).

The 30 mg/L limit was a legacy of the former 'Schedule of Specific Requirements as to Offshore Petroleum Exploration and Production 1995', and stemmed from an engineering specification used in the Gulf of Mexico in the 1970s. This was considered to be the limit at which a visible sheen could not be observed and was as low as the available water treatment and analysis technology of the day could achieve.

Regulations 29 and 29A were prescriptive within the wider 'objective-based' context of the Environment Regulations, and were inconsistent with the principles of risk management as found in ISO 31000, especially given OIW is only one class of contaminants associated with PFW mixtures discharged to the sea.

Under the amended Environment Regulations, discharges of PFW are to be assessed and managed in the same way as other emissions and discharges from offshore petroleum facilities. That is, it needs to be demonstrated that the impacts and risks will be of an acceptable level and reduced to as low as reasonably practicable (ALARP). It should be noted that while OIW limits may remain a valid control, the risk assessment process must address all impacts and risks. It may therefore be necessary to consider a range of other factors, including the PFW discharge regime, chemical composition, toxicity, extent of dispersion and fate (including potential for accumulation in sediments and biota).

Further, the Environment Regulations also require an appropriate implementation strategy with provisions for the monitoring of emissions and discharges, and reporting arrangements to facilitate assessment of whether environmental performance outcomes and standards are being met and control measures are effective. Together, these elements of the implementation strategy aim to ensure that all reasonable action is being taken to keep the impacts and risks from the discharge of PFW acceptable and ALARP.

The Base case for this assessment is:

- the current treatment process as described in Section 2.1,
- flow rates (Section 2.3.1, Table 4 and Figure 2),
- the characteristics such as chemical composition (Table 6 to Table 8),
- the whole of effluent toxicity (WET) testing (Section 2.4.4)
- the plume characteristics (Section 2.4.5), and
- Current monitoring procedures (Section 2.2).

As noted in Section 2.4, the main residual characteristics of concern in the current discharge of PFW are BTEX and dissolved hydrocarbons in the C6-C16 range. This is because the existing treatment systems are effective in removing larger hydrocarbon species. Therefore, an assessment was conducted of best practice/industry practice PFW treatment with a focus on removal of these constituents. As part of the ALARP assessment the risk assessment presented in Section 2.5 addresses the current monitoring systems. The current monitoring systems are comparable with systems used at other industry sites. However given the challenges of continuous monitoring of total hydrocarbons faced by the oil and gas industry some improvements may be required. These are discussed in Section 5.0.

4.2 Best Practice Assessment

4.2.1 Overseas

There have been a number of reviews of PFW treatment technology, summarised as follows:

Efficiency in water use (IPIECA 2014)

This is a guidance document for the upstream oil and gas industry (on shore only). It describes technologies for oil removal generically, including separators and flotation.

Optimal Options for Treatment of Produced Water in Offshore Petroleum Platforms (Igwe et al., J Pollut Eff Cont 2013),

The article identified granular activated carbon (GAC), air stripping, membrane filtration, advanced oxidation, and biological treatment. It compares technologies and cost qualitatively as shown in Table 13.

Table 13 Comparison of technologies for PFW treatment

Method	Advantages	Disadvantages	Cost
Carbon Adsorption Modular granular activated carbon systems	Removes hydrocarbons and acid, base and neutral compounds; low energy requirements; higher through-put than other treatments (except biological); treats a broad range of contaminants; very efficient at removing high Molecular weight organics	Fouling of carbon granules is a problem; produces waste stream of carbon and backwash; requires some pre- treatment of produced water stream.	Moderate
Air stripping Packed tower with air bubbling through the produced water stream.	Removes 95% of VOCs as well as benzene, toluene, naphthalene, andphenols; H2S and ammonia can bestripped with pH adjusting;higher temperature improves removal of semi-volatiles; small size; low weight and low energy requirements	Can be fouled by oil; risk of iron and calcium scales forming; generates an off-gas waste stream that may require treatment; requires some pre-treatment of produced water stream.	Low capital and operating costs; treatment cost up to $0.10/1,000 gal plus $1.50/k gal if off-gas control by activated carbon
Membrane Filtration Nano-filtration and Reverse Osmosis Polymeric membrane.	Effective removal of particles and dispersed and emulsified oil; small footprint size, low weight and low energy requirements; high through-put rates, no chemical addition,	Not effective in removing volatiles compounds, chemical reactions can cause failure. Oil, sulfides or bacteria may foul membrane, reject may contain radioactive material	Low Operating Costs
Ultra-violet light Irradiation by UV lamps	Destroys dissolved organics and both volatile and non-volatile organic compounds, including organic biocides; does not generate additional waste stream; handles upset or high loading conditions.	Will not treat ammonia, dispersed oil, heavy metals, or salinity; relatively high energy requirements; UV lamps may become fouled; residues may be toxic if peroxide used; requires some pre-treatment of produced water stream.	Similar capital costs to chemical oxidation with ozone but operating costs lower because no waste streams.
Chemical Oxidation Ozone and/or hydrogen peroxide oxidation	Removes H2S and particulates; treats hydrocarbons, acid, base and neutral organics, volatiles and non-volatiles; low energy requirements if peroxide system used; straight forward to operate.	High energy inputs for ozone system; oil may foul catalyst; may produce sludge and toxic residues; requires some pre- treatment of produced water stream.	Moderate Operating Costs
Biological Treatment Aerobic system with fixed film bio- tower or suspended growth (e.g. deep shaft)	Treats biodegradable hydrocarbons and organic compounds, H2S, some metals and, in some conditions, ammonia; "fairly low" energy requirements; handles variable loadings, if acclimated.	Large, heavy plant required for long residence times; build-up of oil and iron hinders biological activity; aeration causes calcium scale to form; produces gas and sludge requiring treatment; requires pre-treatment of feed.	Similar capital costs to chemical oxidation with ozone but operating costs lower because no waste streams.

Of these technologies the carbon adsorption and air stripping are the most relevant to the Yolla-A operations.

Produced water from oil - A review of the main treatment technologies. (Thyara CM Nonato PhD1, Alcione A De A Alves Prof, Mauricio L Sens Prof, Ramon Lucas Dalsasso ProfJ Environ Chem Toxicol Vol 2 No 1 March 2018)

This is a high-level general review, which discusses adsorption, electrochemical, filtration and flotation technologies.

Produced water treatment technologies (E.T. Igunnu and G.Z. Chen International Journal of Low-Carbon Technologies 2014, 9, 157–177)

The article discusses a wide range of technologies, including some suitable for removal of dissolved oil and BTEX; however, it does not provide removal efficiencies.

Oil and Gas Produced Water Management and Beneficial Use in the Western United States (Bureau of Reclamation US Department of the Interior. 2011).

This article is specifically for on shore PFW; it contains a detailed review of treatment technologies. (See Table 14).

The processes identified in the table that are relevant to the Yolla-A operations include adsorption and dissolved air/gas stripping.

Other technologies that are efficient at removal of free oil (hydro-cyclones, API separators) are not applicable. Processes such as settling ponds and wetlands obviously cannot be installed on a platform.

Yolla-4 Water Clarification Trial Nalco Champion 12 February 2020

It was concluded that overall the hydrocarbon content results indicate similar performance across all products tested. Additionally, the treated results are similar to the control sample, indicating the level of hydrocarbon is at or below the threshold for chemical treatment. The results for the BTEX analyses, indicate the addition of the chemical made little to no difference when compared with the control sample. The sample containing only produced water with no condensate was significantly lower than the samples containing condensate. Similarly, the addition of WC had the same effect on the concentrations of TPH across all samples, as the treated sample results showed little to no difference compared to the control sample. On this basis it was concluded that chemical dosing would not remove BTEX.

Table 14 Comparison of organic containment and particulate removal technologies for treatment of produced water

Technology	Emerging Technology	Previously Employed for Produced Water	Overall Process Recovery (%)	Contaminants removed	Organic Matter Removal	Particulate Removal (min size removed)	Heavy Metals	Low Chemical Demand	Low Energy Demand	Minimal Maintenance	Ease of Operation	Minimal Posttreatment Requirement	Low Cost	Robustness[1]	Reliability[2]	Flexibility[3]	Mobility[4]	Modularity[5]	Waste Disposal Requreiments	Small Footprint
Biological aerated filters	No	Yes	100%	oil, nitrogen, COD, BOD	++	++	+	+++	+++	+++	+++	+	+++	+++	+++	+++	-	+	++	-
Hydroclone	No	Yes	98%	particulates	NA	5-15 um	-	+++	+	+++	+++	+++	+	+++	+++	+	+	-	++	++
Centrifuge	No	Yes	98%	particulates	NA	2 um	-	+++	+	+++	+++	+++	+	+++	+++	+	+	-	++	++
API gravity separator	No	Yes	98%	particulates	NA	150 um	-	+++	+	+++	+++	+++	+	+++	+++	+	+	-	++	++
Corrugated plate separator	No	Yes	98%	particulates	NA	40 um	-	+++	+	+++	+++	+++	+	+++	+++	+	+	-	++	++
Dissolved air/gas flotation	No	Yes	100%	TOC, oil and grease, particulates, hydrogen sulfide	+++	3-25 um	-	+++	++	++	+++	+++	++	++	+++	+	+	-	++	++
Adsorption/media filtration	No	Yes	98%	particulates, BTEX, oil, TOC, iron, manganese, heavy metals	+++	5 um	++	+++	+++	++	+++	+++	++	+++	+++	+++	+++	+++	++	++
Oxidation	No	Yes	100%	manganese, iron, sulfur, color, odor, synthetic organic compounds	++	NA	++	++	++	++	++	+++	++	+++	+++	+++	+++	+++	+++	+++
Settling pond	No	Yes	100%	particulates, iron, manganese	NA	+++	++	+++	+++	+++	+++	+++	+++	+++	+++	++	-	-	+++	-
Air stripping	No	Yes	100%	TOC, volatile organics	+++	NA	-	+++	++	++	++	+++	++	+++	+++	+	++	+	+++	++
Surfactant modified zeolite vapor phase bioreactor	Yes	Yes	95%	TOC, volatile organics	+++		++	++	+++	+++	+++	+++	ND	ND	ND	ND	ND	+++	++	++
Constructed wetlands	No	Yes	100%	TOC, dissolved organic compounds (increased calcium and slighly increased TDS)	+++	+++	++	+++	+++	+++	+++	+++	+++	+++	+++	++	-	-	+++	-
Granular activated carbon fluidized bed reactor	No	Yes	100%	TOC, volatile organics	+++	++	+++	+++	+++	++	+++	+++	+	+++	+++	+++	+++	+++	+	+++
UV disinfection	No	Yes	100%	inactivation of microbial contaminants	NA	NA	NA	+++	+	+	+++	+++	+	+	+++	+++	+++	+++	+++	+++
Ceramic MF/UF membrane	Yes	Yes	85 to 95%	particulates, dissolved (with coagulation) and suspended organics, biological contaminants	++	0.01 um	-	++	++	++	++	+++	++	+++	++	++	+++	+++	++	++
Polymeric MF/UF membrane	No	Yes	85 to 95%	particulates, dissolved (with coagulation) and suspended organics, biological contaminants	++	0.01 um	-	++	++	++	++	+++	++	+	++	++	+++	+++	++	++

Legend:	Excellent	Good	Fair	Poor

Notes:

[1]Robust: Ability of equipment to withstand harsh conditions, mechanical strength, able to accommodate multiple design criteria, failure of an individual. component does not significantly affect the overall performance

[2]Reliable: Minimal equipment downtime, technology not prone to failure and produces consistent product water quality.

[3]Mobile: Easily moved from one site to another.

[4]Flexible: Able to accommodate a wide range of water quality.

[5]Modularity: Ability to implement technology as a unit process in a treatment train, and accommodate changing influent volumes.

ND - No data

NA - Not applicable

1 bbl = 42 gallons

Treatment of Oil & Gas Produced Water (B. P. Dwyer and F. McDonald Sandia SAND2016-11532016)

The article discusses on shore systems using OWS, coagulation/settling, filtration, ozone, H_2O_2, carbon polishing and reinjection. This is a complicated treatment system used at pilot scale.

Addendum to the OSPAR Background Document Concerning Techniques for the Management of Produced Water from Offshore Installations (Publication number 162/2002) OSPAR Commission 2006.

This was not reviewed as it was updated in 2013, see below.

Background Document concerning Techniques for the Management of Produced Water from Offshore Installations. OSPAR Commission 2013 (p00602)

This document provides a detailed review of treatment technologies (refer to Table 19) and identifies BAT (Best Available Technologies); some descriptions are incomplete. The technologies presented are listed in the following table. The technologies were reviewed for suitability for removal of BTEX and dissolved hydrocarbons.

Table 15 List of technologies nominated by OSPAR

A. Preventive techniques

- Down-hole oil-water separation (DHWS)
- Down-hole gas-water separation (DHWS)
- Mechanical water shut-off
- Chemical water shut-off

B. Process integrated techniques

- Methanol recovery unit
- Glycol regeneration (incl. Drizo)
- Overhead vapour combustion (OVC)
- Macro Porous Polymer Extraction (MPPE) (partial flow)
- High pressure condensate-water separation
- Steam stripping (glycol regeneration water)
- Insulation of pipelines
- Stainless steel lines and casks
- Alternative methods of gas drying (IFPEXOL etc.)
- Labyrinth type choke valve
- Glycol overheads backflow to separator
- Degassers

C. End of pipe techniques

Conventional techniques

- Gas flotation (DGF/IGF)
- Flotation cells
- CPU compact flotation unit
- Plate separator (CPI/PPI)
- Hydrocyclone
- Axiflow cyclones
- Skimmer tank
- Centrifuge
- Disk stacked centrifuges
- Produced water re-injection (PWRI)
- Filter coalescer, incl.
  - sand filters
  - filters filled with oleophilic resins
  - etc.
- Screen coalescers
- Pall coalescers
- In-line coalescing technology (incl. Mare's Tail and PECT-F)
- Performance enhancing coalescer fiber
- FU filter unit
- Integral plate packs in three phase separators

Biological techniques

- Aerobic
- Bioreactor (anaerobic)
- Membrane bioreactor (MBR)
- Enzyme reactor
- Compost filter (glycol overhead)
- Bacterial treatment

Membrane techniques

- Micro-filtration
- Ultra-filtration
- Nano-filtration
- Membrane separator
- Reversed osmosis
- Pertraction
- Emulsion pertraction
- Electro-dialyse
- Membrane assisted affinity sorption (MAAS)

Absorption / adsorption techniques

- Absorption filter
- Granular active carbon
- Powder carbon
- Ion exchange
- Centrifugal absorption techniques
- Zeolites
- MPPE (end flow)
- MPPS
- Reusable oil adsorbent (RPA)

Stripping techniques

- Steam stripping (end flow)
- Air stripping
- Gas stripping

Evaporation

- Evaporation system
- Freezing concentration

Oxidation techniques

- O_3
- H_2O_2
- Oxidation / neutralisation / de-watering (OND)
- Vertech
- $KMnO_4$
- Natural air
- Electron beam
- Plasma
- Sonolysis
- Photo catalytic oxidation
- Low temperature hydro-thermal gasification (LTHG)

On the basis of the review of over 70 different technologies for management of PFW, the technologies that were considered potentially applicable were assessed for suitability and are listed in Table 16. There was no assessment of adsorption (e.g. activated carbon).

Table 16 Applicable technologies for PFW management

Technology	Removal of BTEX	Removal of Dissolved Hydrocarbons	BAT (OSPAR 2012)
Steam Stripping	>90%	>90%	Yes
Skimmer tank	none	none	Yes
Reinjection	100%	100%	Yes
Dissolved/Induced Gas Flotation	0-20%	0-20%	Yes
PPI/CPI	none	none	Yes
Hydro-cyclones	none	none	Yes
MPPE	>99%	>99%	not rated
Adsorption Filters	<10%	<10%	Yes

On the basis of this assessment, options for consideration for application at Yolla-A included Reinjection, Steam Stripping and MPPE. As adsorption was not assessed this was subsequently considered separately (see article by Ming Tang below). Air stripping was mentioned in Table 14, but given the experience with gas stripping this was not considered further.

Overview of Produced Water (PW) Treatment and Measurement (Ming Tang TUV SEL NEL 2014)

The presentation provided the following summary of technologies (Physico-Chemical) for removal of hydrocarbons.

Most of these absorption technologies (refer to Table 17) have not been used in full scale except for MPPE and CruSorp. The latter is a filtration process and is a polishing step. As adsorption technologies (e.g. Activated Carbon or CruSorp) have not been used in full scale, they have not been considered further in this ALARP assessment.

Table 17 Comparison of technologies by supplier

Supplier	Cetco	ET Ventures	Symons	CWSL	Veolia	Mycelx	ABS Materials
Technology	Abs.	Abs.+Ads.	Absorption	Oxidation	Abs.	Abs.	Abs
Model	CruSorp	ET#1	OPS RM25 Medium	AquaPurge	MPPE	Mycelx	PW Unit 1
Capacity	Up to 2x67 m^3/hr	2.3 m^3/hr (example not the max)	1.3 m^3/hr (example not the max)	Up to 100 m^3/hr	Up to 70 m^3/hr	66 m^3/hr	14.3 m^3/hr
Weight	2 tonnes for 2x1.2 m^3/hr; 32.3 tonnes for 67 m^3/hr	n/a		3 tonnes for 2m^3/hr or 5 tonnes for 66 m^3/hr	1.5 tonnes for 1 m^3/hr or 2 tonnes for 6m^3/hr)	770 kg for 66 m^3/hr	3.4 tonnes (only the treating equipment
Footprint	1.7x2x2.1 for 2x1.2 m^3/hr or 6.6x3x4 (60 m^3/hr capacity)	n/a	2x3x?	2x1.5x2 for 2 m^3/hr or 3x1x2 for 66 m^3/hr capacity	1x1.5x1.7 for 1 m^3/hr or 1x1.7x2 for 60 m^3/hr capacity	2.6x0.8x2.4	12.2x6.1
Removal efficiency	90% (from 100 mg/l to 10 mg/l)	99% (from 150 ppm to 1.1 ppm)	94% (from 80-180mg/l to average 5 mg/l with a maximum outlet concentration of 11 ppm	50% - 60 % (from 50 ppm to 20 ppm)	50 to 99%	96% (from 121 to less than 5 ppm)	99.9% (277 ppm to 0.1 ppm)
Applications and field trial	Several offshore, see [58]	Only trial onshore [57]	Several offshore, see [59]	A few field trials offshore and onshroe	Several offshore and onshore, see [60]	Field trial on shore, see [43]	Onshore pilot trial. Lab trials

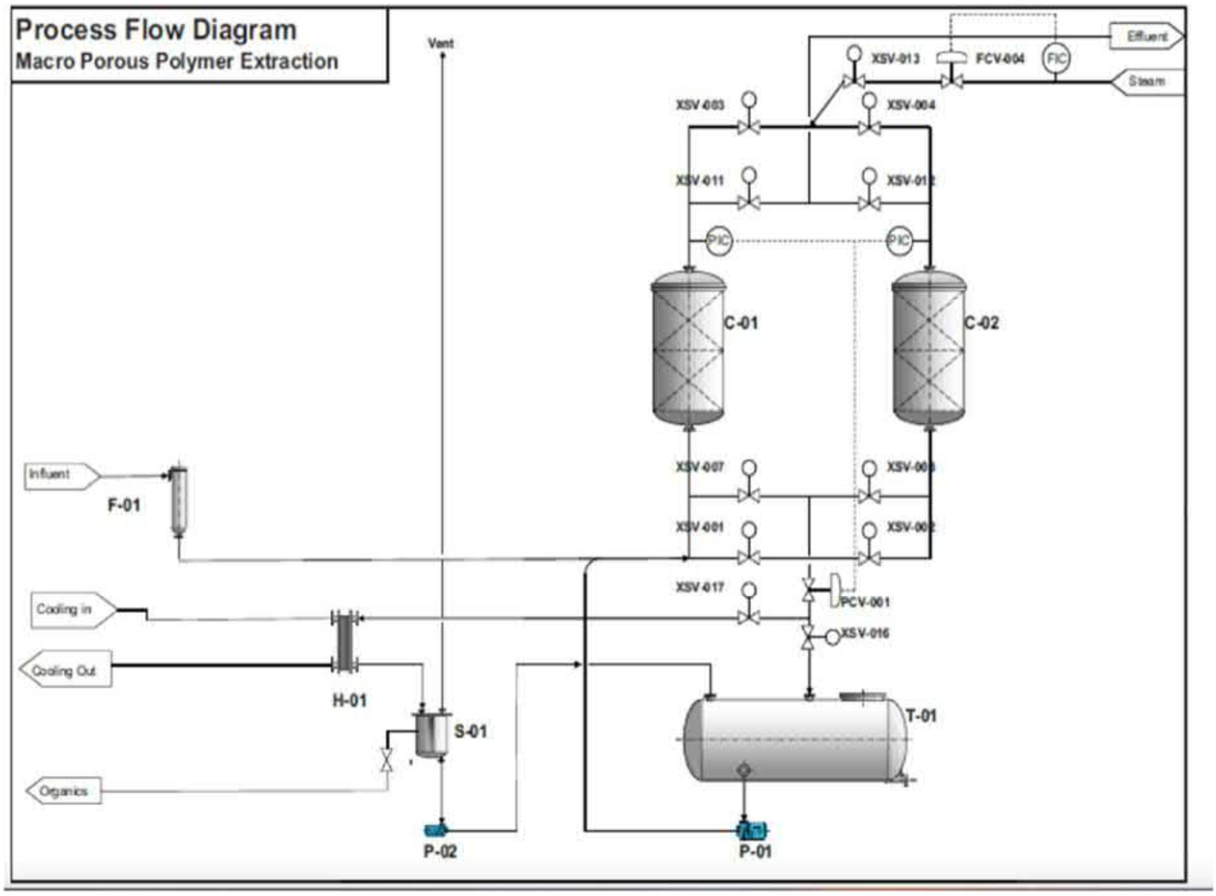
Removal of dissolved and dispersed hydrocarbons from oil and gas produced water with Macro Porous Polymer Extraction (MPPE) to reduce toxicity and allow water reuse (Dick Meijer and Chris Madin APPEA Journal 2010).

This technology (supplied by Veolia Water Solutions) has been used offshore at a number of locations. It is reported to remove (recover) dissolved hydrocarbons and BTEX to in excess of 99%. These hydrocarbons are recovered and can be re-injected with the gas/condensate stream sent on shore.

4.2.1.1 Conclusion – overseas technology review

Based on the review of overseas experience and assessment of more than 70 treatment technologies, the suitable technologies that would be considered BAT and that could enhance the removal of the dissolved hydrocarbons and BTEX are steam stripping and MPPE. OSPAR (2012) provided the following process descriptions for these options.

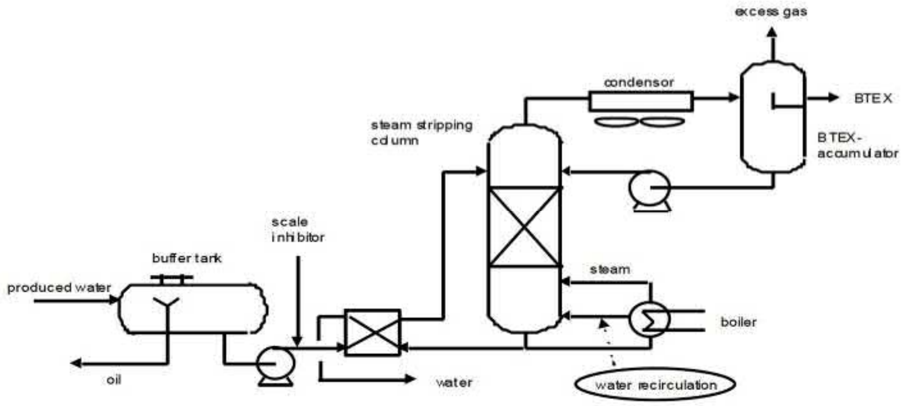
4.2.1.1.1 MPPE Information (OSPAR 2012)



	Per Unit	Minimum	Maximum
Technical details	Treatment capacity (m^3 PW per hour)	0.3-15	150
	Gross Package volume (LxWxH)	6.2 x 4 x 3 m	10 x 6 x 12 m
	Operating weight	10 ton	250 ton
Critical operational parameters		The main critical parameter is the measured outlet concentration vs. discharge limit. If this comes close to the discharge limit the MPPE material needs to be replaced. This is a very slow process (years) and can be done say on a weekly basis. The reduction performance is very stable and does not change overnight.	
Operational reliability including information on downtime		The MPPE unit is fully automatic and remote controlled and has been in operation on an unmanned platform.	

4.2.1.1.2 Steam Stripper Information (OSPAR 2012)

Process diagram



	Platform	Gas 1 (small)	Gas 2 (large)	Oil 1
Technical details	PW volume (design)	1 m^3/h	6 m^3/h	N/A
	Required area (LxWxH)	3 x 2 x 5 m	6 x 3 x 5 m	
	Mass (filled)	12 tonnes	20 tonnes	
Critical operational parameters		Since PW usually contains salts and solid particles, problems with depositions (scale) may occur in the boiler and the heat exchanger. In order to prevent concentration of salts in the boiler, it is recommended to create a slight throughput by means of a re-circulation line from the boiler to the column. The steam line must be large enough in order to allow for equal levels in boiler and column (and above the bundle of the boiler). In order to guarantee a constant throughput, a buffer tank is required. This also provides the possibility to skim off oil, avoiding disruption of the process in the column.		
Operational reliability		When the PW contains large amounts of salts, the installation will need to be shut down regularly to enable removal of salt depositions.		

The expected removal efficiency for BTEX is high: reduction from 50 mg/L to < 6 mg/L, aliphatic hydrocarbons from 30 mg/L to <3 mg/L. Removal efficiencies of >90% for dissolved oil, BTEX, benzene and PAHs.

4.2.2 PFW Management on Platforms in Australian waters

Current PFW treatment systems used on oil and gas platforms in Australian waters are summarised in Table 16 for eight different locations. This is based on a review of publicly available documents provided on the NOPSEMA web site.

Two of the systems use injection wells, the others use subsurface marine discharges similar to Yolla. Most of the sites use simple oil water separation systems; e.g. degasser with additional treatment with flotation units. Two of the sites, in addition, use MPPE.

Where nominated, the PFW discharge rates are much higher than from the Yolla-A platform, resulting in larger plumes.

The systems used on the Yolla-A platform to treat the PFW (see Section 2.1) are generally similar to most of the other platforms used in Australian Waters (Table 18). The monitoring results demonstrate that the Yolla-A system is effective in removing dispersed oil (Section 2.2). None of the other platforms report using a BTEX stripper, while two platforms use MPPE (refer Section 4.2.1.1.1 for process details).

Based on local experience it can be concluded that further consideration should be given to the options of injection wells and MPPE for management of PFW from the Yolla-A platform.

4.2.3 Best Practice Review Conclusion

Based on the review of overseas and local experience the following best practice options should be considered for the ALARP assessment:

- Reinjection wells
- A steam stripper
- MPPE.

Table 18 PFW treatment and disposal on Oil and Gas Industry platforms in Australian waters

Platform	Treatment	Discharge	Reference
Ngujima-Yin (NY) Floating Production Storage and Offloading Facility	PW treatment begins in one of two HP separators, with chemical injection, then enters a coagulation vessel and through to a hydro-cyclone unit. From the hydro-cyclone, the PW is directed through one of the PW filters continues on through to the PW degasser. The degasser is fitted with an internal oil skimming facility to remove residual oil build-up in the degasser vessel.	Injection Wells	Ngujima-Yin Floating Production Storage and Offloading Facility Operations Environment Plan Summary. Woodside, December 2018
Angel Operations	The PW system is designed to direct streams from the process areas to the PW degasser to remove dissolved gas and condensate before disposal overboard above the water line at +8 m LAT.	Marine subsurface	Angel Operations Environment Plan Summary. Woodside, December 2018
Goodwyn Alpha (GWA) Facility	The PW system directs all PW streams from the process areas to the PW degasser. Adsorbent hydrocarbon filters to remove dispersed oil from the PW stream are installed on GWA. The system is used sparingly and primarily to manage OIW upsets.	Marine subsurface	Goodwyn Alpha (GWA) Facility Operations Environment Plan Summary. Woodside, October 2018
Ichthys Project Offshore Facility	Use primary PW treatment system to reduce OIW concentrations. Use MPPE as a secondary PW treatment system. During normal operations, use of primary and secondary PW treatment systems to achieve OIW discharge, to meet ≤30 mg/L, on a rolling 24-hour average. Whether this was total hydrocarbons was not specified.	Marine subsurface	Ichthys Project Offshore Facility (Operation) Environment Plan Summary
Esso Bass Strait	PFW is separated from crude oil and then treated by dissolved gas flotation and/or hydro-cyclones to remove oil to below 30 mg/L before discharge to the ocean. Whether this was total hydrocarbons was not specified.	Marine subsurface	Esso Bass Strait Operations EMP
Prelude FLNG	Oil Water Separation and MPPE.	Marine subsurface	Prelude FLNG Environment Plan Summary. Shell
Pyrenees Operations	PFW and slops water is discharge to the sea from the Compact Flotation Unit (CFU) and Dissolved Gas Flotation unit (DGF) if not greater than an average of 30 mg/L over any rolling period of 24 hours.	Under normal operating conditions, 90% of PFW will be re-injected.	Pyrenees Operations Environment Plan (Commonwealth Summary) BHP 2019
North Rankin Complex	The PW system directs all PW streams from the process to the PW degasser to remove dissolved gas. The degasser allows mixing and provides a hold-up volume for the control of a uniform feed to the PW centrifuge(s), thus ensuring efficiency of the centrifuge is not affected by gas breakout. The system also returns water to the degasser.	Marine subsurface	North Rankin Complex Operations Environment Plan Summary. Woodside, September 2019

4.3 ALARP Assessment

Based on the best practice review discussed in Section 4.2 and an assessment of land management undertaken by Beach (BassGas Raw Gas Pipeline Feasibility Study, Worley Parsons May 2009), the below options were identified for the ALARP assessment. Two approaches were then taken to ALARP assessment, one based on the waste hierarchy and the second based on selected criteria.

- **Re-injection**

In consideration of PFW injection into a well, all four wells on Yolla-A are required for production. Therefore, it would require a new well. It would be necessary to evaluate a sub-surface structure that could accept the PFW, but may require a new well (roughly circa $A40 million excluding rig mobilisation/demobilisation cost), injection pumps and Xmas tree.

A re-injection well has other complications. There would need to be space on the platform for the additional well tie-back, which would also require a conductor (i.e. pipe in casings that goes from deck level to below seabed), hydraulic control system etc. The Xmas tree should be a substantially smaller than the existing trees given the PFW volumes involved.

- **Discharge through the pipeline for on shore management**

This option involves no separation of PFW on the platform, but discharge to the on shore BassGass facility. There would be the need for substantial chemical injection (Mono Ethylene Glycol - MEG) and corrosion inhibitors. The supply of MEG to the platform would require either a pipeline or routine delivery by boat. The PFW would be separated at the LLGP and would require on land management potentially through evaporation ponds. It would be necessary to obtain an EPA works approval as well as other approvals. This option was rejected in 2009 due to the high capital and operating cost (MEG Pipeline: $116M capital, $0.2M annual operating cost; MEG Boat delivery: $55M, capital $9.5M annual operating cost).

- **Steam stripper**

Two stripping options were considered by Advisian (Yolla Produced Water Improvement TIC estimated Dec 2019 included in **Appendix D**) - a gas stripper and a steam stripper. More details are provided in that report. The gas stripper utilises the fuel gas produced in the platform to strip volatiles from the PFW. This system was available for use from 2006-2009 but was removed due to its inefficiency for removal of BTEX. This option was not considered further in this assessment. The steam stripper comprises of a demineralised water package, a steam stripper and associated pumps, tie ins and demolition of some elements on the platform. The screening level estimated capital cost is $18.2 M, operating cost has not been estimated. The power consumption estimate is equivalent to 400 kW using fuel gas.

- **MPPE**

The MPPE system comprises of a demineralised water package and ion exchange beds, pumps, the MPPE unit, tie ins and demolition (see **Appendix D**). The screening level estimated capital cost is $15.4 M, operating cost has not been estimated. The power consumption estimate is 75 kW.

4.3.1 ALARP Assessment based on the Waste Hierarchy

The comparison of the four options based on the waste hierarchy is presented in Table 19.

Avoidance is generally considered to mean eliminating the source. In this case avoidance of discharging to the marine environment is addressed through a change in the processing / discharge regime.

The outcome of the comparison is that, based on the waste hierarchy, reinjection would be preferable, although a new injection well would be required, with an associated high cost (estimated at more than $40 M for the drilling and up to an additional $40 M for mobilisation/demobilisation). The suitability of the geological strata is yet to be confirmed.

Table 19 Assessment of the Options using the Waste Hierarchy

Criteria	Option 1 Reinjection	Option 2 Pipeline discharge	Option 3 Steam Stripping	Option 4 MPPE	Current System
Avoidance	This avoids discharge to the sea. However, it will require additional treatment and use of chemicals. It may be necessary to drill a new injection bore	This avoids discharge to the sea but requires significant additional chemical usage in terms of corrosion inhibiters. It moves management of the PFW to a land-based system	This does not avoid discharges but allows recovery of hydrocarbons	This does not avoid discharges but allows recovery of hydrocarbons	This does not avoid discharges
Reuse/Recycling	N/A	Given the saline nature of the PFW, reuse and recycling are not feasible	This does not facilitate reuse of water but recovery of some hydrocarbons	This does not facilitate reuse of water but recovery of some hydrocarbons	This does not facilitate reuse of water or recovery of some hydrocarbons
Recovery of Energy	This will require energy for pumped reinjection, and an additional injection well	N/A	This requires additional energy for steam production and pumping	This requires additional energy for steam production and pumping	N/A
Treatment	Additional treatment is required	Land based treatment and disposal would need to occur	This is a treatment option	This is a treatment option	This is a treatment option
Containment	This involves containment in the geological substrata.	N/A	N/A	N/A	N/A

4.3.2 ALARP Assessment based on Selected Criteria

The assessment of the four options against the base case (current situation) for the selected criteria is presented in Table 20.

The proposed option of reinjection and pipeline discharge would result in no discharge to the marine environment and hence is high on the waste hierarchy. The pipeline option would result in PFW disposal issues on land. The four options will increase energy consumption but are not major contributors (other than a ship-based supply of MEG to the platform in the case of the pipeline option and the steam stripping). The four options produce some minor waste streams.

The increased complexity relating to the operations increases the health and safety risk profile and increased operations and maintenance requirements. Both of these aspects should be manageable under existing systems.

Implementation timeframes are estimated in the range up to 2.5 years with possible additional time for government approvals.

In all cases, including the base case, an update of the EP will be required as well as other approvals for modifications to the platform, an injection well or EPA Works Approval for land-based modification for the pipeline option.

The capital costs are in the range of $15.4M - $55M+; operating costs have not been defined for all options.

The capacity of the platform with respect to weight and area has not been assessed for the MPPE and steam stripper options.

As noted in Table 20,the options would eliminate the impacts or reduce the mixing zone from 7 m to less than 3.5 m. Eliminating the mixing zone would cost between $55 M capital and $9.5 M annual for the pipeline options, and more than $40 M for the reinjection option, if found to be feasible.

4.4 ALARP Conclusion

Given the discussion of ALARP presented by NOPSEMA:

Reducing impacts and risks to ALARP is based on the concept of reasonable practicability; the weighing up of the magnitude of impact or risk reduction against the cost of that reduction4. In this context, a titleholder is required to implement all available control measures where the cost is not grossly disproportionate to the environmental benefit gained from implementing the control measure.

It is concluded that the cost of implementing any of the four PFW treatment options is grossly disproportionate to the environmental benefit of implementing any of four options. This is because:

- The PFW flow is relatively low (compared to other platforms) contributing to a small mixing zone of less than 10 m meaning that the mixing zone does not exit the foot print of the platform.
- The toxicity (as measured by the whole of effluent toxicity [WET] testing) can be managed with low dilutions.
- The extent of the mixing zone is very small and as such minimal impact on marine receptors is anticipated (see section 3.2.3)

Therefore, it is concluded that it has been demonstrated that the current treatment system represents an ALARP solution. The risk of impacts on the environment can be considered minimal and, therefore, acceptable.

It is noted that as part of achieving ALARP, adequate monitoring systems and adaptive management are required. The current PFW monitoring systems are described in Section 2.2. These have been assessed in Section 5.0 as part of the ALARP assessment.

Table 20 Options Assessment

Criteria	Option 1 Reinjection	Option 2 Pipeline Discharge	Option 3 Steam Stripping	Option 4 MPPE	Current System (base case)
Marine Emissions	No discharges to the marine environment	No discharges to the marine environment	Extent of mixing zone reduced by 50% or more to less than 3.5 m	Extent of mixing zone reduced by 50% or more to less than 3.5 m	Mixing zone impact (NOEC) less than 7.3 m from discharge.
Air impacts	No impact	No impact	No impact	No impact	No impact
Energy/Greenhouse Gas	Additional energy consumption/greenhouse gas emissions through drilling and additional treatment and pumping to well	Additional energy consumption/greenhouse gas emissions due to chemical dosing on platform and additional PFW management on shore (overall energy consumption not estimated in the Worley 2009 study)	Additional energy/greenhouse gas emissions (400 kW equivalent from gas usage) for treatment and steam production	Additional energy/greenhouse gas emissions (75 kW gas/electricity usage) for treatment and steam production	No additional energy/greenhouse gas emissions
Other Waste streams	Minor waste streams from additional treatment	Minor waste streams from additional treatment, plus management of MEG	No additional waste streams other than steam related blowdown	No additional waste streams other than steam related blowdown	No additional waste streams
Waste hierarchy	Eliminates/Avoids discharge to the marine environment	Eliminates/Avoids discharge to the marine environment	Enhanced Treatment of the PFW with recovery of hydrocarbons	Enhanced Treatment of the PFW with recovery of hydrocarbons	Treatment with no recovery of hydrocarbons
Health and Safety	Some additional complexity of operation unlikely to significantly change the H&S risk profile	Some additional complexity of operation unlikely to significantly change the H&S risk profile	Additional complexity with added PFW processing, including steam generation, likely to increase the H&S risk profile	Additional complexity with added PFW processing, including steam generation, likely to increase the H&S risk profile	No change in risk profile.

Criteria	Option 1 Reinjection	Option 2 Pipeline Discharge	Option 3 Steam Stripping	Option 4 MPPE	Current System (base case)
Capital cost	$40M+ (2019$), plus up to $40M for mobilisation/ demobilisation	$55-116M (2009$) depending on the MEG supply option.	$18.2M (2019$)	$15.4M (2019$)	No increase
Operating cost	Not assessed	$9.5-$0.2M (2009$) depending on the MEG supply option	Not assessed	Not assessed	No increase
Operations and Maintenance Availability	Increased operations and maintenance due to additional treatment, pumping pipeline and well	Increased operations and maintenance due to additional treatment, MEG management and on shore PFW management	Increased operations and maintenance due to additional treatment including steam generation	Increased operations and maintenance due to additional treatment including steam generation	No change in O&M activities
Licencing/approvals	Additional approvals would be required for an injection well	The EP would need to be updated and approvals for new processes required. An EPA works approval for the onshore activities would be required.	The EP would need to be updated and approvals for new processes required.	The EP would need to be updated and approvals for new processes required	No change

5.0 Risk Assessment

5.1 Methodology

The risk assessment methodology is consistent with the proposed methodology included in NOPSEMA documentation (e.g. Oil Pollution Risk Management Guidance Note Feb 2018 Doc. A382148; Environment plan content requirements Guidance note N-04750-GN1344 Revision 4 - 17 April 2019 Doc. A339814) and Beach risk management procedures (see **Appendix E**).

5.2 Establish the Context

The context of the assessment is the response to the NOPSEMA EIN issued on the 27th August 2019 and the need to update the EP. The scope of the assessment is the discharge of hydrocarbons in the PFW into the marine environment. The marine environment is described in detail in Section 5.0 (Existing Environment) of the EP. The current system for managing PFW is described in Section 2.1 of this report. Current monitoring systems are described in Section 2.2. The characteristics of the PFW are described in Section 2.4 of this report. The assessment of the current PFW treatment system and the risk of impacts from it, concluded that it represents an ALARP solution This is presented in Section 4.3 and Section 4.4. In a recent meeting NOPSEMA raised the issue of impact on marine life e.g. seals. In response AECOM prepared the memo Potential Impact of Yolla Platform PFW Discharge on Marine Life, which is included as **Appendix F** (AECOM 2019).

5.3 Risk Identification

The identified risks in relation to the impact of hydrocarbons discharged with the PFW were:

- Failure of oil water separation resulting in the increased discharge of dispersed oil.

The monitoring data indicate that the oil water separation system is effective in removing dispersed oil. The current on-line monitors appear to be adequate for assessing peak and daily average results relative to criteria. Failure of the separation systems would result in increased impact on the marine environment.

- Changes in PFW characteristics resulting in increased hydrocarbons, particularly dissolved hydrocarbons including BTEX.

In comparing historical data with data from the past 2-3 years there has been an increase in some constituents. These have the potential to change impacts on the marine environment. Current on-line monitoring does not provide this data while routine monitoring does.

- Failure of existing OIW monitoring systems to adequately monitor dispersed oil.

The current on-line monitors appear to be adequate for assessing peak and daily average results relative to criteria. If they were to fail then discharges exceeding criteria would not be identified.

- Inadequate total hydrocarbon monitoring.

Currently no routine total hydrocarbon (as TRH) monitoring occurs other than the six-monthly comprehensive analysis. The current assessment concluded that the PFW treatment systems are at ALARP and the risks of impacts are minimal and acceptable. Should the characteristics of the PFW increase (i.e. the concentration of total hydrocarbons (as TPH) increase) suddenly (which is not considered likely) there is potential for increased impacts (i.e. greater plume size). As noted previously the plume is relatively small (up to 7.3 m), an increase in size would also likely be small.

5.4 Risk Analysis, Evaluation and Treatment

The risk analysis, evaluation and treatment are presented in Table 21.

Based on the risk assessment, the key additional mitigating measures involve implementing suitable on line and/or routine total hydrocarbon monitoring systems. In addition, incorporation of triennial WET testing of the PFW to confirm the findings to date. With respect to impacts on marine life AECOM (2019) concluded:

Due to the small zone of impact associated with the PFW mixing zone, it is concluded that there is a negligible risk of the PFW having a significant impact upon the marine ecosystem within the receiving environment. It is reasonable to conclude that any impacts that may occur would be localised to those biological communities present in those habitats with long-term exposure to the PFW plume, which represent only a very small proportion of the total available similar habitat (i.e. other platform legs or subsea infrastructure). Any indirect impacts would be localised to those species that forage on the biota within the habitats that experience long-term exposure to the PFW plume.

As the risk was considered negligible the impact was not considered further.

Table 21 Risk Analysis, Evaluation and treatment

Risk Issue	Impact	Current Controls	Effectiveness of Controls	Consequence	Likeli-hood	Risk	Additional Mitigation Measures	Residual Risk
Failure of oil water separation resulting in the increased discharge of dispersed oil.	Adverse impact on the marine environment through increase in the size of the mixing zone and higher concentrations of hydrocarbons in the mixing zone. Non-compliance with the EP and regulations	Routine system maintenance, monitoring and alarms from OIW monitoring system, should the OIW monitoring exceed 20 mg/L daily sampling of PFW discharges is commenced.	Maintenance systems are considered effective, the OIW monitoring systems are problematic. There are two monitors such that redundancy is provided. The OIW systems may be adequate for monitoring dispersed oil but are not effective for total hydrocarbons. Based on the weekly monitoring data (e.g. Table 5) there have been no exceedances of 30/50 mg/L dispersed oil historically	Potential adverse impact on the marine environment, NOPSEMA Notice or Fine **Consequence: Moderate- Serious**	Unlikely	Medium	Improved Monitoring of dispersed oil	Highly unlikely/ Moderate: **Low Risk**
Undetected changes in PFW characteristics resulting in increased hydrocarbons particularly dissolved hydrocarbons including BTEX	Adverse impact on the marine environment through the increase in the size of the mixing zone and higher concentrations of hydrocarbons in the mixing zone if not detected and addressed. Non-compliance with the EP and regulations. The review included in this report	Routine monitoring of the PFW on a weekly basis (BTEX and Dispersed oil) and six-monthly comprehensive analysis	It is not a control as such. The review of this data should result in a response if necessary. e.g. re-evaluation of impact assessment and development of mitigating measures.	It is likely that dissolved hydrocarbons and BTEX increases would occur gradually rather than suddenly unless there was a significant change in operations e.g. an additional well. This type of event would be addressed through Management of Change procedures. Potential adverse impact on the marine environment, NOPSEMA Notice or Fine	Possible	Medium	Implementation of suitable on-line total hydrocarbon monitoring, weekly monitoring for total hydrocarbons (as well as BTEX and dispersed oil), triennial WET testing if triggers exceeded	Highly unlikely/ Moderate **Low risk**

Risk Issue	Impact	Current Controls	Effectiveness of Controls	Consequence	Likeli-hood	Risk	Additional Mitigation Measures	Residual Risk
	indicates that characteristics have changed with increases in BTEX in particular. However, the assessment of the impact found that it is small (mixing zone of <7.3 m)			**Consequence: Moderate**				
Failure of existing OIW monitoring systems to adequately monitor dispersed oil	Adverse impact on the marine environment through increase in the size of the mixing zone and higher concentrations of hydrocarbons in the mixing zone if not detected and addressed. Non-compliance with the EP and regulations.	Routine system maintenance, monitoring and alarms from OIW monitoring system, should the OIW monitoring exceed 20 mg/L daily sampling of PFW discharges is commenced.	The inline monitoring is maintained and are routinely calibrated. There are two monitors such that redundancy is provided. The OIW systems may be adequate for monitoring dispersed oil but are not effective for total hydrocarbons. Based on the weekly monitoring data (e.g. Table 5) there have been no exceedances of 30/50 mg/L dispersed oil historically	The lack of reliable data means that operators do not know whether the discharge complies with the requirements. Potential adverse impact on the marine environment, NOPSEMA Notice or Fine **Consequence: Moderate- Serious**	Possible	Medium	Reassessment of the suitability of the on-line monitors - if requiring replacement, implement the recommended actions. Development of an adaptive management program to respond to trigger exceedance.	Highly unlikely/ Moderate **Low risk**
Inadequate total hydrocarbon monitoring	Adverse impact on the marine environment through increase in the size of the mixing zone and higher concentrations of	Routine monitoring of the PFW on a weekly basis (BTEX and Dispersed oil) and six-monthly comprehensive analysis)	It is not a control as such. The review of this data should result in a response if necessary. e.g. re-evaluation of impact assessment. Development of mitigating measures.	The lack of reliable data means that operators do not know whether the discharge complies with the requirements potential adverse impact on the marine	Likely	Medium	Implementation of suitable on-line total Hydrocarbon Monitoring, weekly monitoring for total hydrocarbons (as well as BTEX and	Highly unlikely /Moderate **Low risk**

Risk Issue	Impact	Current Controls	Effectiveness of Controls	Consequence	Likeli-hood	Risk	Additional Mitigation Measures	Residual Risk
	hydrocarbons in the mixing zone if not detected and addressed. Non-compliance with the EP and regulations. The review included in this report indicates that characteristics have changed with increases in BTEX in particular. However, the assessment of the impact found that it is small (mixing zone of <7.3 m).			environment, NOPSEMA Notice or Fine **Consequence: Moderate**			dispersed oil), tri-annual WET testing or initiate if trigger exceeded. Development of an adaptive management program to respond to trigger exceedance	

6.0 Discussion, conclusions and recommendations

The NOPSEMA EIN indicates:

The following action must be taken by the titleholder within the period specified above:

5.1. Implement produced water treatment and monitoring measures to ensure that levels of total petroleum hydrocarbons are not greater than 50 mg/L at any time, and that there is an average of less than 30 mg/L over any period of 24 hours as described in the Bass Gas Offshore Environment Plan; or

5.2. Comply with regulation 7 by any other suitable means as required to remove the threat, such as demonstrate that impacts and risks from the discharge of produced water will be reduced to a level that is acceptable and as low as reasonably practicable (ALARP).

The following discussion, conclusions and recommendations address clause 5.2 of the NOPSEMA EIN. It is noted that the notice advises that clause 5.1 or 5.2 could be addressed to demonstrate compliance. Based on this report, clause 5.2 has been addressed fully and demonstrates compliance.

6.1 Response to Clause 5.2

The discussion of ALARP presented by NOPSEMA is as follows:

Reducing impacts and risks to ALARP is based on the concept of reasonable practicability; the weighing up of the magnitude of impact or risk reduction against the cost of that reduction. In this context, a titleholder is required to implement all available control measures where the cost is not grossly disproportionate to the environmental benefit gained from implementing the control measure.

The process for assessing Best Practice involved assessing more than 70 treatment technologies and shot listing to four applicable management options. It is concluded that the cost of implementing any of the four PFW treatment options is grossly disproportionate to the environmental benefit of implementing any of four options. This is because:

- The PFW flow is relatively low (compared to other platforms) contributing to a small mixing zone of less than 10 m from the discharge location.
- The toxicity (as measured by the whole of effluent toxicity [WET] testing) can be managed such that negligible impacts to the marine environment would be reasonably expected with low dilutions.
- the extent of the mixing zone is very small (no greater than 7.3 m based on the Whole of Effluent Toxicity testing and plume modelling) and hence the potential impact on marine life is likley to be minimal.

Therefore, it is concluded that the current treatment system represents an ALARP solution. The risk of impacts on the environment can be considered minimal and, therefore, acceptable.

The risk assessment was based on the results from the WET testing and chemical characterisation in line with ANZG guidelines.

Additional field monitoring has been recommended to provide Beach with information on the total hydrocarbons being discharged to ensure the PW discharge properties are still valid to the ALARP assessment (see also **Appendix G**).

As noted in this report and documentation from NOPSEMA, the 30 mg/L and 50 mg/L criteria derive from dispersed oil criteria (“Oil in Water” OIW). This was then adopted as *30 mg/L and 50 mg/L of petroleum using an oil in water* (OIW*) monitor*. The NOPSEMA notice and inspection report interpret this as being total hydrocarbons. The EP describes OIW as *including soluble and insoluble hydrocarbons.* NOPSEMA has also indicated (see clause 5.2 above) that ALARP needs to be demonstrated and *OIW may remain a valid control*. To date, the weekly monitoring includes BTEX and dispersed oil and the six-monthly comprehensive monitoring includes all hydrocarbons (as total petroleum hydrocarbons). As discussed in Section 1.4 OIW is not total hydrocarbon but is nHexane extractable C7-C14 based on OSPAR methodology. Total hydrocarbons based on OSPAR OIW plus

BTEX could be defined as “Total Hydrocarbons”. Total Petroleum Hydrocarbons (TPH) using the NEPM methodology includes BTEX and other aromatics.

Table 22 Comparison of weekly analyses and comprehensive analysis

	ACS (OSPAR,Non-NATA)		ALS/Eurofins (NATA)	
Date	Dispersed Oil (C7-C40) mg/L	BTEX (mg/L)	Total Hydrocarbons (C6-C36/40) (mg/L) includes BTEX	BTEX (mg/L)
5-Dec-17	6			
10-Dec-17			51	31
12-Dec-17	12			
5-Jun-18	14.6			
12-Jun-18	9		143	51.9
19-Jun-18	17.1			
5-Dec-18	5	52.5		
11-Dec-18	6.1	49.9	137	92
12-Aug-19	5	77		
15-Aug-19			135	54
27-Aug-19	5	68		
15-Sep-19	<5	67		
25-Sep-19			71.3-80.3	53
29-Sep-19	<5	60		
2-Oct-19			115-127	63.1
7-Oct-19	<5	54		
10-Oct-19			113-127	55.9

The recent results are summarised in Table 22. These results demonstrate the effectiveness of the PFW treatment system for removing dispersed oil (OIW). They also indicate that total hydrocarbons have been recorded at up to 140 mg/L.

The whole of effluent toxicity (WET) testing found that for 110-127 mg/L TPH (Sept -Oct 2019), 1.6% dilution provides a NOEC for all species tested (i.e. 1 part PFW to 62.5 parts seawater). Plume modelling has found that this results in an impacted mixing zone of up to 7.3 m from the discharge point. This methodology used to develop the mixing zone and the associated use of NOEC is consistent with ANZG methodology. Impacts within the mixing zone are at an acceptable level.

The approach used is consistent with ANZG (2018) for development of site-specific water quality criteria and with the OSPAR approach (OSPAR Commission 2012, OSPAR Recommendation 2012/5) to impact assessment. It is proposed to undertake field-testing of the plume to confirm the extent (see **Appendix G**).

In relation to impacts on marine life, due to the small zone of impact associated with the PFW mixing zone, it is concluded that there is a negligible risk of the PFW having a significant impact upon the marine ecosystem within the receiving environment.

In relation to OIW as a valid control, AECOM proposes the following to be incorporated into the EP:

- The 30 mg/L and 50 mg/L remain as a control point for OIW (OSPAR method) as currently monitored.
- Beach to implement enhanced monitoring of total hydrocarbons, either on line and/or routinely (e.g. weekly).
- The weekly testing should include monitoring for total hydrocarbons (BTEX and dispersed oil [OIW]), and TPH
- Beach to implement the additional assessments described in **Appendix G**.
- The data should be reviewed in line with monthly reporting requirements.
- Total produced water discharge not to exceed 300 m^3 per day.

In the context of the existing systems being ALARP, as discussed below, the proposed control points can address the potential risks and impacts and provide an expanded monitoring program.

The current PFW quality monitoring system control points should be modified as shown in Table 23.

Table 23 Suggested modifications to monitoring program

Monitoring program	Data Management and Action	Suggested Modifications to monitoring program	Suggested Modifications response to be incorporated into an Adaptive Management Plan
Continuous automatic analysis of total OIW concentrations using two analysers working in parallel to ensure: No discharge >50 mg/L at any time. Discharges average <30 mg/L over any 24-hr period.	PFW log (stored in Bablefish) verifies continuous OIW concentration monitoring is in place.	retain	retain
	CMMS contains records of alarm trips for any recordings >50 mg/L.	retain	retain
Twice daily manual logging of the PFW OIW concentrations are undertaken by the Control Room Operator to validate analyser readings.	PFW sample log verifies continuous OIW concentration monitoring is in place.	retain	retain
PFW with dispersed OIW concentration >50 mg/L results in automatic shut-in to prevent overboard discharge of over-specification PFW.	CMMS records verify that over-specification water results in cessation of PFW discharge.	retain	retain
	Incidents of OIW concentration >50 mg/L are captured in the OMS incident register.		
PFW samples are collected weekly and sent to a laboratory for testing using OSPAR /NATA methodology to validate the continuous monitoring records and assess potential impacts	Laboratory PFW test results are available and verify weekly sampling frequency.	Include analyses for Total Hydrocarbons (OIW plus BTEX) and TPH	If exceed 140mg/L (total hydrocarbons as TPH the maximum concentration found to date) or 80mg/L BTEX (as measured by ACS , maximum to date) resample. If results confirmed undertake WET testing and comprehensive analyses. Assess the mixing zone extent ,if greater then 25 m shut down, assess causes and rectify.
Comprehensive testing of the full range of chemical constituents is conducted twice a year.	OpenText records verify twice annual testing takes place and that concentrations are within the specified ranges.	Annual testing as monthly monitoring has been increased to include TPH. WET testing will also result in additional characterisation	If exceed 140mg/L (total hydrocarbons as TPH the maximum concentration found to date) or 80mg/L BTEX (as measured by ACS , maximum to date) resample. If

Monitoring program	Data Management and Action	Suggested Modifications to monitoring program	Suggested Modifications response to be incorporated into an Adaptive Management Plan
			results confirmed undertake WET testing and comprehensive analyses. Assess the mixing zone extent if greater than 25 m shut down, assess causes and rectify.
The two IMO-approved OIW Sigrist analysers are cleaned and calibrated weekly in line with the Yolla OIW Analyser Weekly Maintenance Procedure (CDN/ID 3972825).	CMMS records verify cleaning and calibration occurs in line with the procedure.	retain	
Sampling and modelling			
WET testing of PFW is undertaken every three years to ensure assumptions in PFW dispersion modelling remain current and establish a species protection trigger value to derive a safe dilution factor.	WET test reports (prepared to schedule – 2022, 2025) are available.	retain	Based on the WET testing results, assess the mixing zone extent if greater than 25 m shut down, assess causes and rectify.
PFW plume dispersion verification monitoring is undertaken every 5 years.	PFW plume dispersion modelling reports (prepared to schedule – 2022, 2027) are available.	retain	Based on the latest WET test results and plume assessment reassess the mixing zone if greater than 25 m shut down, assess causes and rectify.
Trained and experienced operators manage the PFW system in accordance with Yolla-specific requirements.	CBTA training records verify operators' competency to manage the PFW system.	retain	
	All operators are inducted into the PFW training module.		
Reporting			
Instances where instant dispersed OIW concentration are >30 mg/L are reported to NOPSEMA in the monthly recordable incident report.	Monthly recordable incident reports.	retain	

The management assurance (retain) is summarised in Table 24.

Table 24 Management actions

Management Action	Explanation
OSPAR validation testing	Testing is conducted weekly in accordance with the CMMS. Water samples are sent to ACS Laboratories in Melbourne for testing to the OSPAR 2005-15 method for determination of dispersed oil. Depending on result, the following actions will be taken: <u>OIW Analysers <20 mg/L</u> 1 x spot check PFW sample tested weekly for dispersed oil content as per OSPAR 2005-15 test method. <u>OIW Analysers 20-30 mg/L</u> Analyser calibration checked and if confirmed accurate, PFW samples to be taken daily during this condition and tested weekly. <u>OIW Analysers >30 mg/L</u> Analyser calibration checked and if confirmed accurate, PFW production rate reduced to bring OIW content below 30 mg/L.
Online OIW analyser correlation check	Monthly Technical Monitoring Report includes review of the past month's OSPAR test results against analyser output. 3M Preventative Maintenance task scheduled for engineering team to review accuracy of the Fluorescent Units to OIW correlation.
Online OIW analyser maintenance	Calibration and routine maintenance performed weekly in accordance with the CMMS.

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8.0 Limitations

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Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

Appendix A

Wet Test Chemical Analyses Reports

eurofins | Environment Testing

Certificate of Analysis

Beach Energy Limited
5775 South Gippsland Highway
Lang Lang
VIC 3984

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

WORLD RECOGNISED ACCREDITATION

Attention:	**Adrian Cukovski**
Report	**679568-W**
Project name	1858
Received Date	Sep 27, 2019

Client Sample ID			**Y0250919-3**
Sample Matrix			**Water**
Eurofins Sample No.			**S19-Se42146**
Date Sampled			**Sep 27, 2019**
Test/Reference	LOR	Unit	
Total Recoverable Hydrocarbons - 1999 NEPM Fractions			
TRH C6-C9	0.02	mg/L	71
TRH C10-C14	0.05	mg/L	0.33
TRH C15-C28	0.1	mg/L	< 0.1
TRH C29-C36	0.1	mg/L	< 0.1
TRH C10-C36 (Total)	0.1	mg/L	0.33
BTEX			
Benzene	0.001	mg/L	14
Toluene	0.001	mg/L	25
Ethylbenzene	0.001	mg/L	0.94
m&p-Xylenes	0.002	mg/L	10
o-Xylene	0.001	mg/L	2.7
Xylenes - Total	0.003	mg/L	13
4-Bromofluorobenzene (surr.)	1	%	89
Total Recoverable Hydrocarbons - 2013 NEPM Fractions			
Naphthalene[N02]	0.01	mg/L	0.63
TRH C6-C10	0.02	mg/L	80
TRH C6-C10 less BTEX (F1)[N04]	0.02	mg/L	27
TRH >C10-C16	0.05	mg/L	0.33
TRH >C10-C16 less Naphthalene (F2)[N01]	0.05	mg/L	-
TRH >C16-C34	0.1	mg/L	< 0.1
TRH >C34-C40	0.1	mg/L	< 0.1
TRH >C10-C40 (total)*	0.1	mg/L	0.33
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	0.001	mg/L	< 0.001
Acenaphthylene	0.001	mg/L	< 0.001
Anthracene	0.001	mg/L	< 0.001
Benz(a)anthracene	0.001	mg/L	< 0.001
Benzo(a)pyrene	0.001	mg/L	< 0.001
Benzo(b&j)fluoranthene[N07]	0.001	mg/L	< 0.001
Benzo(g.h.i)perylene	0.001	mg/L	< 0.001
Benzo(k)fluoranthene	0.001	mg/L	< 0.001
Chrysene	0.001	mg/L	< 0.001
Dibenz(a.h)anthracene	0.001	mg/L	< 0.001
Fluoranthene	0.001	mg/L	< 0.001
Fluorene	0.001	mg/L	< 0.001
Indeno(1.2.3-cd)pyrene	0.001	mg/L	< 0.001

Client Sample ID			Y0250919-3
Sample Matrix			Water
Eurofins Sample No.			S19-Se42146
Date Sampled			Sep 27, 2019
Test/Reference	LOR	Unit	
Polycyclic Aromatic Hydrocarbons			
Naphthalene	0.001	mg/L	0.002
Phenanthrene	0.001	mg/L	< 0.001
Pyrene	0.001	mg/L	< 0.001
Total PAH*	0.001	mg/L	0.002
2-Fluorobiphenyl (surr.)	1	%	107
p-Terphenyl-d14 (surr.)	1	%	119
Glycols*			
Di-Ethylene Glycol*	20	mg/L	< 20
Ethylene glycol*	20	mg/L	< 20
Propylene glycol*	20	mg/L	< 20
Triethylene glycol*	20	mg/L	< 20
Phenols (Halogenated)			
2-Chlorophenol	0.003	mg/L	< 0.003
2.4-Dichlorophenol	0.003	mg/L	< 0.003
2.4.5-Trichlorophenol	0.01	mg/L	< 0.01
2.4.6-Trichlorophenol	0.01	mg/L	< 0.01
2.6-Dichlorophenol	0.003	mg/L	< 0.003
4-Chloro-3-methylphenol	0.01	mg/L	< 0.01
Pentachlorophenol	0.01	mg/L	< 0.01
Tetrachlorophenols - Total	0.03	mg/L	< 0.03
Total Halogenated Phenol*	0.01	mg/L	< 0.01
Phenols (non-Halogenated)			
2-Cyclohexyl-4.6-dinitrophenol	0.1	mg/L	< 0.1
2-Methyl-4.6-dinitrophenol	0.03	mg/L	< 0.03
2-Methylphenol (o-Cresol)	0.003	mg/L	0.12
2-Nitrophenol	0.01	mg/L	< 0.01
2.4-Dimethylphenol	0.003	mg/L	0.049
2.4-Dinitrophenol	0.03	mg/L	< 0.03
3&4-Methylphenol (m&p-Cresol)	0.006	mg/L	0.10
4-Nitrophenol	0.03	mg/L	< 0.03
Dinoseb	0.1	mg/L	< 0.1
Phenol	0.003	mg/L	0.19
Total Non-Halogenated Phenol*	0.1	mg/L	0.459
Phenol-d6 (surr.)	1	%	48
Chloride	1	mg/L	11000
Conductivity (at 25°C)	1	uS/cm	29000
Nitrate & Nitrite (as N)	0.05	mg/L	< 0.05
pH (at 25°C)	0.1	pH Units	6.7
Total Combined Nitrogen (as N)	0.2	mg/L	27
Total Kjeldahl Nitrogen (as N)	0.2	mg/L	27
Total Suspended Solids Dried at 103–105°C	1	mg/L	2.0
Heavy Metals			
Aluminium	0.05	mg/L	< 0.05
Antimony	0.005	mg/L	< 0.005
Arsenic	0.001	mg/L	0.003
Barium	0.02	mg/L	52
Beryllium	0.001	mg/L	< 0.001
Boron	0.05	mg/L	13

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Client Sample ID			Y0250919-3
Sample Matrix			**Water**
Eurofins Sample No.			**S19-Se42146**
Date Sampled			**Sep 27, 2019**
Test/Reference	LOR	Unit	
Heavy Metals			
Cadmium	0.0002	mg/L	< 0.0002
Chromium	0.001	mg/L	< 0.001
Cobalt	0.001	mg/L	< 0.001
Iron	0.05	mg/L	1.2
Lead	0.001	mg/L	< 0.001
Manganese	0.005	mg/L	0.029
Mercury	0.0001	mg/L	0.0060
Molybdenum	0.005	mg/L	< 0.005
Nickel	0.001	mg/L	< 0.001
Selenium	0.001	mg/L	< 0.001
Silver	0.005	mg/L	< 0.005
Strontium	0.005	mg/L	3.1
Thallium	0.005	mg/L	< 0.005
Tin	0.005	mg/L	< 0.005
Titanium	0.005	mg/L	< 0.005
Vanadium	0.005	mg/L	< 0.005
Zinc	0.005	mg/L	0.017
Alkali Metals			
Potassium	0.5	mg/L	60

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Total Recoverable Hydrocarbons - 1999 NEPM Fractions	Melbourne	Oct 01, 2019	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Oct 01, 2019	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Oct 01, 2019	
- Method: LTM-ORG-2010 TRH C6-C40			
BTEX and Naphthalene			
BTEX	Melbourne	Oct 01, 2019	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Polycyclic Aromatic Hydrocarbons	Melbourne	Oct 01, 2019	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Glycols*	Melbourne	Oct 01, 2019	7 Days
- Method: GLYCOLS- US EPA SW846 METHOD 8000 GC-FID.			
Chloride	Melbourne	Oct 01, 2019	28 Days
- Method: LTM-INO-4090 Chloride by Discrete Analyser			
Conductivity (at 25°C)	Melbourne	Oct 01, 2019	28 Days
- Method: LTM-INO-4030 Conductivity			
Nitrate & Nitrite (as N)	Melbourne	Oct 01, 2019	28 Days
- Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA			
pH (at 25°C)	Melbourne	Oct 01, 2019	0 Hours
- Method: LTM-GEN-7090 pH in water by ISE			
Total Kjeldahl Nitrogen (as N)	Melbourne	Oct 01, 2019	7 Days
- Method: LTM-INO-4310 TKN in Waters & Soils by FIA			
Total Suspended Solids Dried at 103–105°C	Melbourne	Oct 01, 2019	7 Days
- Method: LTM-INO-4070 Analysis of Suspended Solids in Water by Gravimetry			
Heavy Metals	Melbourne	Oct 02, 2019	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Alkali Metals	Melbourne	Oct 01, 2019	180 Days
- Method: LTM-MET-3010 Alkali Metals S Si and P by ICP-AES			
Phenols (IWRG 621)			
Phenols (Halogenated)	Melbourne	Oct 01, 2019	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Phenols (non-Halogenated)	Melbourne	Oct 01, 2019	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			

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Project Name: 1858

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Report #: 679568
Phone: 03 5654 9103
Fax: 03 5659 0178

Received: Sep 27, 2019 3:55 PM
Due: Oct 4, 2019
Priority: 5 Day
Contact Name: Adrian Cukovski

Eurofins Analytical Services Manager : Michael Morrison

Sample Detail						Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chloride	Chromium	Cobalt	Conductivity (at 25°C)	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Nitrate & Nitrite (as N)	pH (at 25°C)	Potassium	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Total Combined Nitrogen (as N)	Total Kjeldahl Nitrogen (as N)	Total Suspended Solids Dried at 103–105°C	Vanadium	Zinc	Polycyclic Aromatic Hydrocarbons	Glycols*	Phenols (IWRG 621)	BTEX and Naphthalene	Total Recoverable Hydrocarbons
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																																									
Brisbane Laboratory - NATA Site # 20794																																									
Perth Laboratory - NATA Site # 23736																																									
External Laboratory																																									
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**																																				
1	Y0250919-3	Sep 27, 2019		Water	S19-Se42146	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Test Counts						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Environment Testing

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**ug/L:** micrograms per litre
ppm: Parts per million	**ppb:** Parts per billion	**%:** Percentage
org/100mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	mg/L	< 0.02			0.02	Pass	
TRH C10-C14	mg/L	< 0.05			0.05	Pass	
TRH C15-C28	mg/L	< 0.1			0.1	Pass	
TRH C29-C36	mg/L	< 0.1			0.1	Pass	
Method Blank							
BTEX							
Benzene	mg/L	< 0.001			0.001	Pass	
Toluene	mg/L	< 0.001			0.001	Pass	
Ethylbenzene	mg/L	< 0.001			0.001	Pass	
m&p-Xylenes	mg/L	< 0.002			0.002	Pass	
o-Xylene	mg/L	< 0.001			0.001	Pass	
Xylenes - Total	mg/L	< 0.003			0.003	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/L	< 0.01			0.01	Pass	
TRH C6-C10	mg/L	< 0.02			0.02	Pass	
TRH >C10-C16	mg/L	< 0.05			0.05	Pass	
TRH >C16-C34	mg/L	< 0.1			0.1	Pass	
TRH >C34-C40	mg/L	< 0.1			0.1	Pass	
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/L	< 0.001			0.001	Pass	
Acenaphthylene	mg/L	< 0.001			0.001	Pass	
Anthracene	mg/L	< 0.001			0.001	Pass	
Benz(a)anthracene	mg/L	< 0.001			0.001	Pass	
Benzo(a)pyrene	mg/L	< 0.001			0.001	Pass	
Benzo(b&j)fluoranthene	mg/L	< 0.001			0.001	Pass	
Benzo(g.h.i)perylene	mg/L	< 0.001			0.001	Pass	
Benzo(k)fluoranthene	mg/L	< 0.001			0.001	Pass	
Chrysene	mg/L	< 0.001			0.001	Pass	
Dibenz(a.h)anthracene	mg/L	< 0.001			0.001	Pass	
Fluoranthene	mg/L	< 0.001			0.001	Pass	
Fluorene	mg/L	< 0.001			0.001	Pass	
Indeno(1.2.3-cd)pyrene	mg/L	< 0.001			0.001	Pass	
Naphthalene	mg/L	< 0.001			0.001	Pass	
Phenanthrene	mg/L	< 0.001			0.001	Pass	
Pyrene	mg/L	< 0.001			0.001	Pass	
Method Blank							
Glycols*							
Di-Ethylene Glycol*	mg/L	< 20			20	Pass	
Ethylene glycol*	mg/L	< 20			20	Pass	
Propylene glycol*	mg/L	< 20			20	Pass	
Triethylene glycol*	mg/L	< 20			20	Pass	
Method Blank							
Phenols (Halogenated)							
2-Chlorophenol	mg/L	< 0.003			0.003	Pass	
2.4-Dichlorophenol	mg/L	< 0.003			0.003	Pass	
2.4.5-Trichlorophenol	mg/L	< 0.01			0.01	Pass	
2.4.6-Trichlorophenol	mg/L	< 0.01			0.01	Pass	
2.6-Dichlorophenol	mg/L	< 0.003			0.003	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
4-Chloro-3-methylphenol	mg/L	< 0.01			0.01	Pass	
Pentachlorophenol	mg/L	< 0.01			0.01	Pass	
Tetrachlorophenols - Total	mg/L	< 0.03			0.03	Pass	
Method Blank							
Phenols (non-Halogenated)							
2-Cyclohexyl-4.6-dinitrophenol	mg/L	< 0.1			0.1	Pass	
2-Methyl-4.6-dinitrophenol	mg/L	< 0.03			0.03	Pass	
2-Methylphenol (o-Cresol)	mg/L	< 0.003			0.003	Pass	
2-Nitrophenol	mg/L	< 0.01			0.01	Pass	
2.4-Dimethylphenol	mg/L	< 0.003			0.003	Pass	
2.4-Dinitrophenol	mg/L	< 0.03			0.03	Pass	
3&4-Methylphenol (m&p-Cresol)	mg/L	< 0.006			0.006	Pass	
4-Nitrophenol	mg/L	< 0.03			0.03	Pass	
Dinoseb	mg/L	< 0.1			0.1	Pass	
Phenol	mg/L	< 0.003			0.003	Pass	
Method Blank							
Chloride	mg/L	< 1			1	Pass	
Nitrate & Nitrite (as N)	mg/L	< 0.05			0.05	Pass	
Total Kjeldahl Nitrogen (as N)	mg/L	< 0.2			0.2	Pass	
Total Suspended Solids Dried at 103–105°C	mg/L	< 1			1	Pass	
Method Blank							
Heavy Metals							
Aluminium	mg/L	< 0.05			0.05	Pass	
Antimony	mg/L	< 0.005			0.005	Pass	
Arsenic	mg/L	< 0.001			0.001	Pass	
Barium	mg/L	< 0.02			0.02	Pass	
Beryllium	mg/L	< 0.001			0.001	Pass	
Boron	mg/L	< 0.05			0.05	Pass	
Cadmium	mg/L	< 0.0002			0.0002	Pass	
Chromium	mg/L	< 0.001			0.001	Pass	
Cobalt	mg/L	< 0.001			0.001	Pass	
Iron	mg/L	< 0.05			0.05	Pass	
Lead	mg/L	< 0.001			0.001	Pass	
Manganese	mg/L	< 0.005			0.005	Pass	
Mercury	mg/L	< 0.0001			0.0001	Pass	
Molybdenum	mg/L	< 0.005			0.005	Pass	
Nickel	mg/L	< 0.001			0.001	Pass	
Selenium	mg/L	< 0.001			0.001	Pass	
Silver	mg/L	< 0.005			0.005	Pass	
Strontium	mg/L	< 0.005			0.005	Pass	
Thallium	mg/L	< 0.005			0.005	Pass	
Tin	mg/L	< 0.005			0.005	Pass	
Titanium	mg/L	< 0.005			0.005	Pass	
Vanadium	mg/L	< 0.005			0.005	Pass	
Zinc	mg/L	< 0.005			0.005	Pass	
Method Blank							
Alkali Metals							
Potassium	mg/L	< 0.5			0.5	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	%	91			70-130	Pass	
TRH C10-C14	%	77			70-130	Pass	
LCS - % Recovery							
BTEX							

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Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Benzene	%	93			70-130	Pass	
Toluene	%	87			70-130	Pass	
Ethylbenzene	%	88			70-130	Pass	
m&p-Xylenes	%	86			70-130	Pass	
Xylenes - Total	%	87			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	86			70-130	Pass	
TRH C6-C10	%	91			70-130	Pass	
TRH >C10-C16	%	72			70-130	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	81			70-130	Pass	
Acenaphthylene	%	85			70-130	Pass	
Anthracene	%	95			70-130	Pass	
Benz(a)anthracene	%	75			70-130	Pass	
Benzo(a)pyrene	%	79			70-130	Pass	
Benzo(b&j)fluoranthene	%	80			70-130	Pass	
Benzo(g.h.i)perylene	%	77			70-130	Pass	
Benzo(k)fluoranthene	%	88			70-130	Pass	
Chrysene	%	82			70-130	Pass	
Dibenz(a.h)anthracene	%	72			70-130	Pass	
Fluoranthene	%	89			70-130	Pass	
Fluorene	%	85			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	76			70-130	Pass	
Naphthalene	%	83			70-130	Pass	
Phenanthrene	%	93			70-130	Pass	
Pyrene	%	97			70-130	Pass	
LCS - % Recovery							
Glycols*							
Ethylene glycol*	%	77			70-130	Pass	
Propylene glycol*	%	88			70-130	Pass	
LCS - % Recovery							
Phenols (Halogenated)							
2-Chlorophenol	%	92			30-130	Pass	
2.4-Dichlorophenol	%	88			30-130	Pass	
2.4.5-Trichlorophenol	%	107			30-130	Pass	
2.4.6-Trichlorophenol	%	117			30-130	Pass	
2.6-Dichlorophenol	%	94			30-130	Pass	
4-Chloro-3-methylphenol	%	89			30-130	Pass	
Pentachlorophenol	%	90			30-130	Pass	
Tetrachlorophenols - Total	%	88			30-130	Pass	
LCS - % Recovery							
Phenols (non-Halogenated)							
2-Cyclohexyl-4.6-dinitrophenol	%	62			30-130	Pass	
2-Methyl-4.6-dinitrophenol	%	80			30-130	Pass	
2-Methylphenol (o-Cresol)	%	101			30-130	Pass	
2-Nitrophenol	%	99			30-130	Pass	
2.4-Dimethylphenol	%	113			30-130	Pass	
2.4-Dinitrophenol	%	43			30-130	Pass	
3&4-Methylphenol (m&p-Cresol)	%	83			30-130	Pass	
4-Nitrophenol	%	51			30-130	Pass	
Dinoseb	%	106			30-130	Pass	
Phenol	%	59			30-130	Pass	
LCS - % Recovery							

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Chloride			%	73			70-130	Pass	
Nitrate & Nitrite (as N)			%	102			70-130	Pass	
Total Kjeldahl Nitrogen (as N)			%	91			70-130	Pass	
Total Suspended Solids Dried at 103–105°C			%	93			70-130	Pass	
LCS - % Recovery									
Heavy Metals									
Aluminium			%	105			80-120	Pass	
Antimony			%	102			80-120	Pass	
Arsenic			%	101			80-120	Pass	
Barium			%	101			80-120	Pass	
Beryllium			%	106			80-120	Pass	
Boron			%	104			80-120	Pass	
Cadmium			%	99			80-120	Pass	
Chromium			%	99			80-120	Pass	
Cobalt			%	103			80-120	Pass	
Iron			%	102			80-120	Pass	
Lead			%	103			80-120	Pass	
Manganese			%	103			80-120	Pass	
Mercury			%	98			75-125	Pass	
Molybdenum			%	101			80-120	Pass	
Nickel			%	102			80-120	Pass	
Selenium			%	100			80-120	Pass	
Silver			%	98			80-120	Pass	
Strontium			%	102			80-120	Pass	
Thallium			%	100			80-120	Pass	
Tin			%	102			80-120	Pass	
Titanium			%	99			80-120	Pass	
Vanadium			%	100			80-120	Pass	
Zinc			%	102			80-120	Pass	
LCS - % Recovery									
Alkali Metals									
Potassium			%	96			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1					
TRH C6-C9	S19-Se40921	NCP	%	91			70-130	Pass	
TRH C10-C14	M19-Se42608	NCP	%	78			70-130	Pass	
Spike - % Recovery									
BTEX				Result 1					
Benzene	S19-Se40921	NCP	%	88			70-130	Pass	
Toluene	S19-Se40921	NCP	%	86			70-130	Pass	
Ethylbenzene	S19-Se40921	NCP	%	86			70-130	Pass	
m&p-Xylenes	S19-Se40921	NCP	%	82			70-130	Pass	
o-Xylene	S19-Se40921	NCP	%	86			70-130	Pass	
Xylenes - Total	S19-Se40921	NCP	%	83			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
Naphthalene	S19-Se40921	NCP	%	86			70-130	Pass	
TRH C6-C10	S19-Se40921	NCP	%	92			70-130	Pass	
TRH >C10-C16	M19-Se42608	NCP	%	71			70-130	Pass	
Spike - % Recovery									
				Result 1					
Chloride	M19-Se42641	NCP	%	103			70-130	Pass	
Nitrate & Nitrite (as N)	M19-Se42266	NCP	%	103			70-130	Pass	

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Environment Testing

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
Heavy Metals				Result 1					
Boron	M19-Oc03140	NCP	%	81			75-125	Pass	
Spike - % Recovery									
Alkali Metals				Result 1					
Potassium	S19-Se42146	CP	%	115			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C6-C9	W19-Se41107	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
TRH C10-C14	M19-Se42607	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
TRH C15-C28	M19-Se42607	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
TRH C29-C36	M19-Se42607	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
BTEX				Result 1	Result 2	RPD			
Benzene	W19-Se41107	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Toluene	W19-Se41107	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Ethylbenzene	W19-Se41107	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
m&p-Xylenes	W19-Se41107	NCP	mg/L	< 0.002	< 0.002	<1	30%	Pass	
o-Xylene	W19-Se41107	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Xylenes - Total	W19-Se41107	NCP	mg/L	< 0.003	< 0.003	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
Naphthalene	W19-Se41107	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
TRH C6-C10	W19-Se41107	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
TRH >C10-C16	M19-Se42607	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
TRH >C16-C34	M19-Se42607	NCP	mg/L	< 0.1		<1	30%	Pass	
TRH >C34-C40	M19-Se42607	NCP	mg/L	< 0.1		<1	30%	Pass	
Duplicate									
Glycols*				Result 1	Result 2	RPD			
Di-Ethylene Glycol*	M19-Se36023	NCP	mg/L	< 20	< 20	<1	30%	Pass	
Ethylene glycol*	M19-Se36023	NCP	mg/L	< 20	< 20	<1	30%	Pass	
Propylene glycol*	M19-Se36023	NCP	mg/L	< 20	< 20	<1	30%	Pass	
Triethylene glycol*	M19-Se36023	NCP	mg/L	< 20	< 20	<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Chloride	P19-Se40555	NCP	mg/L	140	140	2.0	30%	Pass	
Conductivity (at 25°C)	N19-Se40057	NCP	uS/cm	280	290	1.0	30%	Pass	
Nitrate & Nitrite (as N)	M19-Se42266	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
pH (at 25°C)	N19-Se40057	NCP	pH Units	8.0	7.9	pass	30%	Pass	
Total Suspended Solids Dried at 103–105°C	M19-Se39441	NCP	mg/L	140	130	9.0	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Boron	M19-Oc03140	NCP	mg/L	0.17	0.15	12	30%	Pass	
Duplicate									
Alkali Metals				Result 1	Result 2	RPD			
Potassium	S19-Se42146	CP	mg/L	60	63	6.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N01	F2 is determined by arithmetically subtracting the "naphthalene" value from the ">C10-C16" value. The naphthalene value used in this calculation is obtained from volatiles (Purge & Trap analysis).
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
N04	F1 is determined by arithmetically subtracting the "Total BTEX" value from the "C6-C10" value. The "Total BTEX" value is obtained by summing the concentrations of BTEX analytes. The "C6-C10" value is obtained by quantitating against a standard of mixed aromatic/aliphatic analytes.
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs

Authorised By

Michael Morrison	Analytical Services Manager
Emily Rosenberg	Senior Analyst-Metal (VIC)
Harry Bacalis	Senior Analyst-Volatile (VIC)
Joseph Edouard	Senior Analyst-Organic (VIC)
Julie Kay	Senior Analyst-Inorganic (VIC)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Certificate of Analysis

Environment Testing

Beach Energy Limited
5775 South Gippsland Highway
Lang Lang
VIC 3984

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **Shane Reynolds**

Report	**680827-W**
Project name	ADRIAN CUKOVSKI
Received Date	Oct 04, 2019

Client Sample ID			**Y0021019**
Sample Matrix			**Water**
Eurofins Sample No.			**S19-Oc07916**
Date Sampled			**Oct 03, 2019**
Test/Reference	LOR	Unit	
Total Recoverable Hydrocarbons - 1999 NEPM Fractions			
TRH C6-C9	0.02	mg/L	82
TRH C10-C14	0.05	mg/L	32
TRH C15-C28	0.1	mg/L	0.2
TRH C29-C36	0.1	mg/L	< 0.1
TRH C10-C36 (Total)	0.1	mg/L	32.2
BTEX			
Benzene	0.001	mg/L	17
Toluene	0.001	mg/L	30
Ethylbenzene	0.001	mg/L	1.1
m&p-Xylenes	0.002	mg/L	12
o-Xylene	0.001	mg/L	3.2
Xylenes - Total	0.003	mg/L	15
4-Bromofluorobenzene (surr.)	1	%	132
Total Recoverable Hydrocarbons - 2013 NEPM Fractions			
Naphthalene[N02]	0.01	mg/L	< 5
TRH C6-C10	0.02	mg/L	92
TRH C6-C10 less BTEX (F1)[N04]	0.02	mg/L	29
TRH >C10-C16	0.05	mg/L	35
TRH >C10-C16 less Naphthalene (F2)[N01]	0.05	mg/L	35
TRH >C16-C34	0.1	mg/L	< 0.1
TRH >C34-C40	0.1	mg/L	< 0.1
TRH >C10-C40 (total)*	0.1	mg/L	35
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	0.001	mg/L	< 0.001
Acenaphthylene	0.001	mg/L	< 0.001
Anthracene	0.001	mg/L	< 0.001
Benz(a)anthracene	0.001	mg/L	< 0.001
Benzo(a)pyrene	0.001	mg/L	< 0.001
Benzo(b&j)fluoranthene[N07]	0.001	mg/L	< 0.001
Benzo(g.h.i)perylene	0.001	mg/L	< 0.001
Benzo(k)fluoranthene	0.001	mg/L	< 0.001
Chrysene	0.001	mg/L	< 0.001
Dibenz(a.h)anthracene	0.001	mg/L	< 0.001
Fluoranthene	0.001	mg/L	< 0.001
Fluorene	0.001	mg/L	0.001
Indeno(1.2.3-cd)pyrene	0.001	mg/L	< 0.001

Client Sample ID			Y0021019
Sample Matrix			Water
Eurofins Sample No.			S19-Oc07916
Date Sampled			Oct 03, 2019
Test/Reference	LOR	Unit	
Polycyclic Aromatic Hydrocarbons			
Naphthalene	0.001	mg/L	0.36
Phenanthrene	0.001	mg/L	< 0.001
Pyrene	0.001	mg/L	< 0.001
Total PAH*	0.001	mg/L	0.361
2-Fluorobiphenyl (surr.)	1	%	76
p-Terphenyl-d14 (surr.)	1	%	85
Glycols*			
Di-Ethylene Glycol*	20	mg/L	< 20
Ethylene glycol*	20	mg/L	< 20
Propylene glycol*	20	mg/L	< 20
Triethylene glycol*	20	mg/L	< 20
Phenols (Halogenated)			
2-Chlorophenol	0.003	mg/L	< 0.003
2.4-Dichlorophenol	0.003	mg/L	< 0.003
2.4.5-Trichlorophenol	0.01	mg/L	< 0.01
2.4.6-Trichlorophenol	0.01	mg/L	< 0.01
2.6-Dichlorophenol	0.003	mg/L	< 0.003
4-Chloro-3-methylphenol	0.01	mg/L	< 0.01
Pentachlorophenol	0.01	mg/L	< 0.01
Tetrachlorophenols - Total	0.03	mg/L	< 0.03
Total Halogenated Phenol*	0.01	mg/L	< 0.01
Phenols (non-Halogenated)			
2-Cyclohexyl-4.6-dinitrophenol	0.1	mg/L	< 0.1
2-Methyl-4.6-dinitrophenol	0.03	mg/L	< 0.03
2-Methylphenol (o-Cresol)	0.003	mg/L	14
2-Nitrophenol	0.01	mg/L	< 0.01
2.4-Dimethylphenol	0.003	mg/L	5.3
2.4-Dinitrophenol	0.03	mg/L	< 0.03
3&4-Methylphenol (m&p-Cresol)	0.006	mg/L	10
4-Nitrophenol	0.03	mg/L	< 0.03
Dinoseb	0.1	mg/L	< 0.1
Phenol	0.003	mg/L	7.7
Total Non-Halogenated Phenol*	0.1	mg/L	37
Phenol-d6 (surr.)	1	%	47
Chloride	1	mg/L	9800
Conductivity (at 25°C)	10	uS/cm	29000
Nitrate & Nitrite (as N)	0.05	mg/L	< 0.05
pH (at 25°C)	0.1	pH Units	6.9
Total Kjeldahl Nitrogen (as N)	0.2	mg/L	51
Total Nitrogen (as N)	0.2	mg/L	51
Total Suspended Solids Dried at 103–105°C	1	mg/L	4.7
Heavy Metals			
Aluminium	0.05	mg/L	< 0.05
Antimony	0.005	mg/L	< 0.005
Arsenic	0.001	mg/L	0.002
Barium	0.02	mg/L	40
Beryllium	0.001	mg/L	< 0.001
Boron	0.05	mg/L	11

Client Sample ID			Y0021019
Sample Matrix			**Water**
Eurofins Sample No.			**S19-Oc07916**
Date Sampled			**Oct 03, 2019**
Test/Reference	LOR	Unit	
Heavy Metals			
Cadmium	0.0002	mg/L	< 0.0002
Chromium	0.001	mg/L	0.001
Cobalt	0.001	mg/L	< 0.001
Copper	0.001	mg/L	< 0.001
Iron	0.05	mg/L	1.0
Lead	0.001	mg/L	< 0.001
Manganese	0.005	mg/L	0.028
Mercury	0.0001	mg/L	0.0059
Molybdenum	0.005	mg/L	< 0.005
Nickel	0.001	mg/L	< 0.001
Selenium	0.001	mg/L	< 0.001
Silver	0.005	mg/L	< 0.005
Strontium	0.005	mg/L	3.1
Thallium	0.005	mg/L	< 0.005
Tin	0.005	mg/L	< 0.005
Titanium	0.005	mg/L	< 0.005
Vanadium	0.005	mg/L	< 0.005
Zinc	0.005	mg/L	0.011
Alkali Metals			
Potassium	0.5	mg/L	67

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Eurofins | mgt Suite B1			
Total Recoverable Hydrocarbons - 1999 NEPM Fractions	Melbourne	Oct 07, 2019	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
BTEX	Melbourne	Oct 07, 2019	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Oct 07, 2019	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Oct 07, 2019	
- Method: LTM-ORG-2010 TRH C6-C40			
Polycyclic Aromatic Hydrocarbons	Melbourne	Oct 07, 2019	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Glycols*	Melbourne	Oct 07, 2019	7 Days
- Method: GLYCOLS- US EPA SW846 METHOD 8000 GC-FID.			
Chloride	Melbourne	Oct 07, 2019	28 Days
- Method: LTM-INO-4090 Chloride by Discrete Analyser			
Conductivity (at 25°C)	Melbourne	Oct 07, 2019	28 Days
- Method: LTM-INO-4030 Conductivity			
pH (at 25°C)	Melbourne	Oct 07, 2019	0 Hours
- Method: LTM-GEN-7090 pH in water by ISE			
Total Suspended Solids Dried at 103–105°C	Melbourne	Oct 07, 2019	7 Days
- Method: LTM-INO-4070 Analysis of Suspended Solids in Water by Gravimetry			
Heavy Metals	Melbourne	Oct 08, 2019	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Alkali Metals	Melbourne	Oct 07, 2019	180 Days
- Method: LTM-MET-3010 Alkali Metals S Si and P by ICP-AES			
Phenols (IWRG 621)			
Phenols (Halogenated)	Melbourne	Oct 07, 2019	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Phenols (non-Halogenated)	Melbourne	Oct 07, 2019	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Total Nitrogen Set (as N)			
Nitrate & Nitrite (as N)	Melbourne	Oct 07, 2019	28 Days
- Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA			
Total Kjeldahl Nitrogen (as N)	Melbourne	Oct 07, 2019	7 Days
- Method: LTM-INO-4310 TKN in Waters & Soils by FIA			

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Site # 23736

Company Name:	Beach Energy Limited	**Order No.:**	BE00016911	**Received:**	Oct 4, 2019 1:54 PM
Address:	5775 South Gippsland Highway Lang Lang VIC 3984	**Report #:**	680827	**Due:**	Oct 14, 2019
		Phone:	03 5654 9103	**Priority:**	5 Day
		Fax:	03 5659 0178	**Contact Name:**	Shane Reynolds
Project Name:	ADRIAN CUKOVSKI				

Eurofins Analytical Services Manager : Michael Morrison

Sample Detail						Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chloride	Chromium	Cobalt	Conductivity (at 25°C)	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	pH (at 25°C)	Potassium	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Total Suspended Solids Dried at 103–105°C	Vanadium	Zinc	Polycyclic Aromatic Hydrocarbons	Glycols*	Phenols (IWRG 621)	Total Nitrogen Set (as N)	Eurofins | mgt Suite B1
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																																							
Brisbane Laboratory - NATA Site # 20794																																							
Perth Laboratory - NATA Site # 23736																																							
External Laboratory																																							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**																																		
1	Y0021019	Oct 03, 2019		Water	S19-Oc07916	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Test Counts						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**ug/L:** micrograms per litre
ppm: Parts per million	**ppb:** Parts per billion	**%:** Percentage
org/100mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	mg/L	< 0.02			0.02	Pass	
TRH C10-C14	mg/L	< 0.05			0.05	Pass	
TRH C15-C28	mg/L	< 0.1			0.1	Pass	
TRH C29-C36	mg/L	< 0.1			0.1	Pass	
Method Blank							
BTEX							
Benzene	mg/L	< 0.001			0.001	Pass	
Toluene	mg/L	< 0.001			0.001	Pass	
Ethylbenzene	mg/L	< 0.001			0.001	Pass	
m&p-Xylenes	mg/L	< 0.002			0.002	Pass	
o-Xylene	mg/L	< 0.001			0.001	Pass	
Xylenes - Total	mg/L	< 0.003			0.003	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/L	< 0.01			0.01	Pass	
TRH C6-C10	mg/L	< 0.02			0.02	Pass	
TRH >C10-C16	mg/L	< 0.05			0.05	Pass	
TRH >C16-C34	mg/L	< 0.1			0.1	Pass	
TRH >C34-C40	mg/L	< 0.1			0.1	Pass	
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/L	< 0.001			0.001	Pass	
Acenaphthylene	mg/L	< 0.001			0.001	Pass	
Anthracene	mg/L	< 0.001			0.001	Pass	
Benz(a)anthracene	mg/L	< 0.001			0.001	Pass	
Benzo(a)pyrene	mg/L	< 0.001			0.001	Pass	
Benzo(b&j)fluoranthene	mg/L	< 0.001			0.001	Pass	
Benzo(g.h.i)perylene	mg/L	< 0.001			0.001	Pass	
Benzo(k)fluoranthene	mg/L	< 0.001			0.001	Pass	
Chrysene	mg/L	< 0.001			0.001	Pass	
Dibenz(a.h)anthracene	mg/L	< 0.001			0.001	Pass	
Fluoranthene	mg/L	< 0.001			0.001	Pass	
Fluorene	mg/L	< 0.001			0.001	Pass	
Indeno(1.2.3-cd)pyrene	mg/L	< 0.001			0.001	Pass	
Naphthalene	mg/L	< 0.001			0.001	Pass	
Phenanthrene	mg/L	< 0.001			0.001	Pass	
Pyrene	mg/L	< 0.001			0.001	Pass	
Method Blank							
Glycols*							
Di-Ethylene Glycol*	mg/L	< 20			20	Pass	
Ethylene glycol*	mg/L	< 20			20	Pass	
Propylene glycol*	mg/L	< 20			20	Pass	
Triethylene glycol*	mg/L	< 20			20	Pass	
Method Blank							
Phenols (Halogenated)							
2-Chlorophenol	mg/L	< 0.003			0.003	Pass	
2.4-Dichlorophenol	mg/L	< 0.003			0.003	Pass	
2.4.5-Trichlorophenol	mg/L	< 0.01			0.01	Pass	
2.4.6-Trichlorophenol	mg/L	< 0.01			0.01	Pass	
2.6-Dichlorophenol	mg/L	< 0.003			0.003	Pass	

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Environment Testing

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
4-Chloro-3-methylphenol	mg/L	< 0.01			0.01	Pass	
Pentachlorophenol	mg/L	< 0.01			0.01	Pass	
Tetrachlorophenols - Total	mg/L	< 0.03			0.03	Pass	
Method Blank							
Phenols (non-Halogenated)							
2-Cyclohexyl-4.6-dinitrophenol	mg/L	< 0.1			0.1	Pass	
2-Methyl-4.6-dinitrophenol	mg/L	< 0.03			0.03	Pass	
2-Nitrophenol	mg/L	< 0.01			0.01	Pass	
2.4-Dinitrophenol	mg/L	< 0.03			0.03	Pass	
4-Nitrophenol	mg/L	< 0.03			0.03	Pass	
Dinoseb	mg/L	< 0.1			0.1	Pass	
Method Blank							
Chloride	mg/L	< 1			1	Pass	
Conductivity (at 25°C)	uS/cm	< 10			10	Pass	
Nitrate & Nitrite (as N)	mg/L	< 0.05			0.05	Pass	
Total Kjeldahl Nitrogen (as N)	mg/L	< 0.2			0.2	Pass	
Total Suspended Solids Dried at 103–105°C	mg/L	< 1			1	Pass	
Method Blank							
Heavy Metals							
Aluminium	mg/L	< 0.05			0.05	Pass	
Antimony	mg/L	< 0.005			0.005	Pass	
Arsenic	mg/L	< 0.001			0.001	Pass	
Barium	mg/L	< 0.02			0.02	Pass	
Beryllium	mg/L	< 0.001			0.001	Pass	
Boron	mg/L	< 0.05			0.05	Pass	
Cadmium	mg/L	< 0.0002			0.0002	Pass	
Chromium	mg/L	< 0.001			0.001	Pass	
Cobalt	mg/L	< 0.001			0.001	Pass	
Copper	mg/L	< 0.001			0.001	Pass	
Iron	mg/L	< 0.05			0.05	Pass	
Lead	mg/L	< 0.001			0.001	Pass	
Manganese	mg/L	< 0.005			0.005	Pass	
Mercury	mg/L	< 0.0001			0.0001	Pass	
Molybdenum	mg/L	< 0.005			0.005	Pass	
Nickel	mg/L	< 0.001			0.001	Pass	
Selenium	mg/L	< 0.001			0.001	Pass	
Silver	mg/L	< 0.005			0.005	Pass	
Strontium	mg/L	< 0.005			0.005	Pass	
Thallium	mg/L	< 0.005			0.005	Pass	
Tin	mg/L	< 0.005			0.005	Pass	
Titanium	mg/L	< 0.005			0.005	Pass	
Vanadium	mg/L	< 0.005			0.005	Pass	
Zinc	mg/L	< 0.005			0.005	Pass	
Method Blank							
Alkali Metals							
Potassium	mg/L	< 0.5			0.5	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	%	97			70-130	Pass	
TRH C10-C14	%	121			70-130	Pass	
LCS - % Recovery							
BTEX							
Benzene	%	96			70-130	Pass	
Toluene	%	94			70-130	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Ethylbenzene	%	94			70-130	Pass	
m&p-Xylenes	%	95			70-130	Pass	
Xylenes - Total	%	94			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	99			70-130	Pass	
TRH C6-C10	%	97			70-130	Pass	
TRH >C10-C16	%	110			70-130	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	99			70-130	Pass	
Acenaphthylene	%	93			70-130	Pass	
Anthracene	%	87			70-130	Pass	
Benz(a)anthracene	%	88			70-130	Pass	
Benzo(a)pyrene	%	73			70-130	Pass	
Benzo(b&j)fluoranthene	%	100			70-130	Pass	
Benzo(g.h.i)perylene	%	74			70-130	Pass	
Benzo(k)fluoranthene	%	88			70-130	Pass	
Chrysene	%	88			70-130	Pass	
Dibenz(a.h)anthracene	%	87			70-130	Pass	
Fluoranthene	%	99			70-130	Pass	
Fluorene	%	106			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	88			70-130	Pass	
Naphthalene	%	103			70-130	Pass	
Phenanthrene	%	97			70-130	Pass	
Pyrene	%	102			70-130	Pass	
LCS - % Recovery							
Glycols*							
Ethylene glycol*	%	103			70-130	Pass	
Propylene glycol*	%	106			70-130	Pass	
LCS - % Recovery							
Phenols (Halogenated)							
2-Chlorophenol	%	90			30-130	Pass	
2.4-Dichlorophenol	%	58			30-130	Pass	
2.4.5-Trichlorophenol	%	66			30-130	Pass	
2.4.6-Trichlorophenol	%	73			30-130	Pass	
2.6-Dichlorophenol	%	100			30-130	Pass	
4-Chloro-3-methylphenol	%	49			30-130	Pass	
Pentachlorophenol	%	41			30-130	Pass	
Tetrachlorophenols - Total	%	61			30-130	Pass	
LCS - % Recovery							
Phenols (non-Halogenated)							
2-Cyclohexyl-4.6-dinitrophenol	%	64			30-130	Pass	
2-Methyl-4.6-dinitrophenol	%	77			30-130	Pass	
2-Nitrophenol	%	82			30-130	Pass	
2.4-Dinitrophenol	%	40			30-130	Pass	
4-Nitrophenol	%	123			30-130	Pass	
Dinoseb	%	95			30-130	Pass	
LCS - % Recovery							
Chloride	%	116			70-130	Pass	
Conductivity (at 25°C)	%	101			70-130	Pass	
Nitrate & Nitrite (as N)	%	95			70-130	Pass	
Total Kjeldahl Nitrogen (as N)	%	85			70-130	Pass	
Total Suspended Solids Dried at 103–105°C	%	116			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
LCS - % Recovery									
Heavy Metals									
Aluminium			%	104			80-120	Pass	
Antimony			%	97			80-120	Pass	
Arsenic			%	93			80-120	Pass	
Barium			%	103			80-120	Pass	
Beryllium			%	102			80-120	Pass	
Boron			%	90			80-120	Pass	
Cadmium			%	98			80-120	Pass	
Chromium			%	96			80-120	Pass	
Cobalt			%	93			80-120	Pass	
Copper			%	87			80-120	Pass	
Iron			%	94			80-120	Pass	
Lead			%	94			80-120	Pass	
Manganese			%	97			80-120	Pass	
Mercury			%	90			75-125	Pass	
Molybdenum			%	93			80-120	Pass	
Nickel			%	93			80-120	Pass	
Selenium			%	100			80-120	Pass	
Silver			%	90			80-120	Pass	
Strontium			%	99			80-120	Pass	
Thallium			%	90			80-120	Pass	
Tin			%	96			80-120	Pass	
Titanium			%	98			80-120	Pass	
Vanadium			%	97			80-120	Pass	
Zinc			%	85			80-120	Pass	
LCS - % Recovery									
Alkali Metals									
Potassium			%	103			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1					
TRH C6-C9	M19-Oc09876	NCP	%	110			70-130	Pass	
TRH C10-C14	M19-Oc15416	NCP	%	85			70-130	Pass	
Spike - % Recovery									
BTEX				Result 1					
Benzene	M19-Oc09876	NCP	%	109			70-130	Pass	
Toluene	M19-Oc09876	NCP	%	105			70-130	Pass	
Ethylbenzene	M19-Oc09876	NCP	%	110			70-130	Pass	
m&p-Xylenes	M19-Oc09876	NCP	%	107			70-130	Pass	
o-Xylene	M19-Oc09876	NCP	%	105			70-130	Pass	
Xylenes - Total	M19-Oc09876	NCP	%	106			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
Naphthalene	M19-Oc09876	NCP	%	100			70-130	Pass	
TRH C6-C10	M19-Oc09876	NCP	%	109			70-130	Pass	
TRH >C10-C16	M19-Oc15416	NCP	%	80			70-130	Pass	
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	M19-Se38500	NCP	%	127			70-130	Pass	
Acenaphthylene	M19-Se38500	NCP	%	125			70-130	Pass	
Anthracene	M19-Se38500	NCP	%	79			70-130	Pass	
Benz(a)anthracene	M19-Se38500	NCP	%	87			70-130	Pass	
Benzo(a)pyrene	M19-Se38500	NCP	%	102			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Benzo(b&j)fluoranthene	M19-Se38500	NCP	%	122			70-130	Pass	
Benzo(g.h.i)perylene	M19-Se38500	NCP	%	112			70-130	Pass	
Benzo(k)fluoranthene	M19-Se38500	NCP	%	126			70-130	Pass	
Chrysene	M19-Se38500	NCP	%	97			70-130	Pass	
Dibenz(a.h)anthracene	M19-Se38500	NCP	%	113			70-130	Pass	
Fluoranthene	M19-Se38500	NCP	%	125			70-130	Pass	
Fluorene	M19-Se38500	NCP	%	112			70-130	Pass	
Indeno(1.2.3-cd)pyrene	M19-Se38500	NCP	%	94			70-130	Pass	
Naphthalene	M19-Se38500	NCP	%	122			70-130	Pass	
Phenanthrene	M19-Se38500	NCP	%	123			70-130	Pass	
Pyrene	M19-Se38500	NCP	%	127			70-130	Pass	
Spike - % Recovery									
Phenols (Halogenated)				Result 1					
2-Chlorophenol	M19-Se38500	NCP	%	116			30-130	Pass	
2.4-Dichlorophenol	M19-Se38500	NCP	%	103			30-130	Pass	
2.4.5-Trichlorophenol	M19-Se38500	NCP	%	120			30-130	Pass	
2.4.6-Trichlorophenol	M19-Se38500	NCP	%	96			30-130	Pass	
2.6-Dichlorophenol	M19-Se38500	NCP	%	98			30-130	Pass	
4-Chloro-3-methylphenol	M19-Se38500	NCP	%	111			30-130	Pass	
Pentachlorophenol	M19-Se38500	NCP	%	95			30-130	Pass	
Tetrachlorophenols - Total	M19-Se38500	NCP	%	97			30-130	Pass	
Spike - % Recovery									
Phenols (non-Halogenated)				Result 1					
2-Cyclohexyl-4.6-dinitrophenol	M19-Se38500	NCP	%	91			30-130	Pass	
2-Methyl-4.6-dinitrophenol	M19-Se38500	NCP	%	69			30-130	Pass	
2-Nitrophenol	M19-Se38500	NCP	%	120			30-130	Pass	
2.4-Dinitrophenol	M19-Se38500	NCP	%	35			30-130	Pass	
Dinoseb	M19-Se38500	NCP	%	90			30-130	Pass	
Spike - % Recovery									
				Result 1					
Chloride	P19-Oc05832	NCP	%	70			70-130	Pass	
Nitrate & Nitrite (as N)	M19-Oc14161	NCP	%	100			70-130	Pass	
Total Kjeldahl Nitrogen (as N)	M19-Oc10062	NCP	%	84			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Aluminium	M19-Oc12418	NCP	%	112			75-125	Pass	
Antimony	M19-Oc12418	NCP	%	100			70-130	Pass	
Arsenic	M19-Oc12418	NCP	%	98			75-125	Pass	
Barium	M19-Oc12418	NCP	%	100			75-125	Pass	
Beryllium	M19-Oc12418	NCP	%	103			75-125	Pass	
Boron	M19-Oc12418	NCP	%	104			75-125	Pass	
Cadmium	M19-Oc12418	NCP	%	96			75-125	Pass	
Chromium	M19-Oc12418	NCP	%	101			75-125	Pass	
Cobalt	M19-Oc12418	NCP	%	101			75-125	Pass	
Copper	M19-Oc12418	NCP	%	94			75-125	Pass	
Iron	M19-Oc12418	NCP	%	102			75-125	Pass	
Lead	M19-Oc12418	NCP	%	98			75-125	Pass	
Manganese	M19-Oc12418	NCP	%	103			75-125	Pass	
Mercury	M19-Oc12418	NCP	%	87			70-130	Pass	
Molybdenum	M19-Oc12418	NCP	%	99			75-125	Pass	
Nickel	M19-Oc12418	NCP	%	100			75-125	Pass	
Selenium	M19-Oc12418	NCP	%	102			75-125	Pass	
Silver	M19-Oc12418	NCP	%	96			75-125	Pass	
Strontium	M19-Oc12418	NCP	%	101			75-125	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Thallium	M19-Oc12418	NCP	%	89			75-125	Pass	
Tin	M19-Oc12418	NCP	%	100			75-125	Pass	
Titanium	M19-Oc12418	NCP	%	101			75-125	Pass	
Vanadium	M19-Oc12418	NCP	%	101			75-125	Pass	
Zinc	M19-Oc12418	NCP	%	97			75-125	Pass	
Spike - % Recovery									
Alkali Metals				Result 1					
Potassium	S19-Oc07916	CP	%	119			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C6-C9	M19-Oc10323	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
TRH C10-C14	N19-Oc13992	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
TRH C15-C28	N19-Oc13992	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
TRH C29-C36	N19-Oc13992	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
BTEX				Result 1	Result 2	RPD			
Benzene	M19-Oc10323	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Toluene	M19-Oc10323	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Ethylbenzene	M19-Oc10323	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
m&p-Xylenes	M19-Oc10323	NCP	mg/L	< 0.002	< 0.002	<1	30%	Pass	
o-Xylene	M19-Oc10323	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Xylenes - Total	M19-Oc10323	NCP	mg/L	< 0.003	< 0.003	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
Naphthalene	M19-Oc10323	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
TRH C6-C10	M19-Oc10323	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
TRH >C10-C16	N19-Oc13992	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
TRH >C16-C34	N19-Oc13992	NCP	mg/L	< 0.1		<1	30%	Pass	
TRH >C34-C40	N19-Oc13992	NCP	mg/L	< 0.1		<1	30%	Pass	
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Acenaphthylene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Anthracene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benz(a)anthracene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(a)pyrene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(b&j)fluoranthene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(g.h.i)perylene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(k)fluoranthene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Chrysene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Dibenz(a.h)anthracene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Fluoranthene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Fluorene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Naphthalene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Phenanthrene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Pyrene	M19-Oc02904	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Duplicate									
Glycols*				Result 1	Result 2	RPD			
Di-Ethylene Glycol*	S19-Oc07916	CP	mg/L	< 20	< 20	<1	30%	Pass	
Ethylene glycol*	S19-Oc07916	CP	mg/L	< 20	< 20	<1	30%	Pass	
Propylene glycol*	S19-Oc07916	CP	mg/L	< 20	< 20	<1	30%	Pass	
Triethylene glycol*	S19-Oc07916	CP	mg/L	< 20	< 20	<1	30%	Pass	

Duplicate									
Phenols (Halogenated)				Result 1	Result 2	RPD			
2-Chlorophenol	M19-Oc02904	NCP	mg/L	< 0.003	< 0.003	<1	30%	Pass	
2.4-Dichlorophenol	M19-Oc02904	NCP	mg/L	< 0.003	< 0.003	<1	30%	Pass	
2.4.5-Trichlorophenol	M19-Oc02904	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
2.4.6-Trichlorophenol	M19-Oc02904	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
2.6-Dichlorophenol	M19-Oc02904	NCP	mg/L	< 0.003	< 0.003	<1	30%	Pass	
4-Chloro-3-methylphenol	M19-Oc02904	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
Pentachlorophenol	M19-Oc02904	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
Tetrachlorophenols - Total	M19-Oc02904	NCP	mg/L	< 0.03	< 0.03	<1	30%	Pass	
Duplicate									
Phenols (non-Halogenated)				Result 1	Result 2	RPD			
2-Cyclohexyl-4.6-dinitrophenol	M19-Oc02904	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
2-Methyl-4.6-dinitrophenol	M19-Oc02904	NCP	mg/L	< 0.03	< 0.03	<1	30%	Pass	
2-Nitrophenol	M19-Oc02904	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
2.4-Dinitrophenol	M19-Oc02904	NCP	mg/L	< 0.03	< 0.03	<1	30%	Pass	
4-Nitrophenol	M19-Oc02904	NCP	mg/L	< 0.03	< 0.03	<1	30%	Pass	
Dinoseb	M19-Oc02904	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Chloride	P19-Oc05831	NCP	mg/L	390	520	27	30%	Pass	
Conductivity (at 25°C)	M19-Oc08930	NCP	uS/cm	210	210	1.0	30%	Pass	
Nitrate & Nitrite (as N)	M19-Oc14161	NCP	mg/L	0.13	0.12	6.0	30%	Pass	
pH (at 25°C)	M19-Oc08930	NCP	pH Units	7.8	7.7	pass	30%	Pass	
Total Kjeldahl Nitrogen (as N)	M19-Oc10005	NCP	mg/L	110	100	6.6	30%	Pass	
Total Suspended Solids Dried at 103–105°C	M19-Oc10005	NCP	mg/L	510	530	4.0	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Aluminium	M19-Oc12418	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Antimony	M19-Oc12418	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Arsenic	M19-Oc12418	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Barium	M19-Oc12418	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
Beryllium	M19-Oc12418	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Boron	M19-Oc12418	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Cadmium	M19-Oc12418	NCP	mg/L	< 0.0002	< 0.0002	<1	30%	Pass	
Chromium	M19-Oc12418	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Cobalt	M19-Oc12418	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Copper	M19-Oc12418	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Iron	M19-Oc12418	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Lead	M19-Oc12418	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Manganese	M19-Oc12418	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Mercury	M19-Oc12418	NCP	mg/L	< 0.0001	< 0.0001	<1	30%	Pass	
Molybdenum	M19-Oc12418	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Nickel	M19-Oc12418	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Selenium	M19-Oc12418	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Silver	M19-Oc12418	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Strontium	M19-Oc12418	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Thallium	M19-Oc12418	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Tin	M19-Oc12418	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Titanium	M19-Oc12418	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Vanadium	M19-Oc12418	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Zinc	M19-Oc12418	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Duplicate									
Alkali Metals				Result 1	Result 2	RPD			
Potassium	S19-Oc07916	CP	mg/L	67	62	7.0	30%	Pass	

eurofins | Environment Testing

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N01	F2 is determined by arithmetically subtracting the "naphthalene" value from the ">C10-C16" value. The naphthalene value used in this calculation is obtained from volatiles (Purge & Trap analysis).
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
N04	F1 is determined by arithmetically subtracting the "Total BTEX" value from the "C6-C10" value. The "Total BTEX" value is obtained by summing the concentrations of BTEX analytes. The "C6-C10" value is obtained by quantitating against a standard of mixed aromatic/aliphatic analytes.
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs

Authorised By

Michael Morrison	Analytical Services Manager
Emily Rosenberg	Senior Analyst-Metal (VIC)
Harry Bacalis	Senior Analyst-Volatile (VIC)
Joseph Edouard	Senior Analyst-Organic (VIC)
Julie Kay	Senior Analyst-Inorganic (VIC)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Beach Energy Limited
5775 South Gippsland Highway
Lang Lang
VIC 3984

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **Adrian Cukovski**

Report **681835-W**
Project name PRODUCED WATER A15327 DISCHARGE
Received Date Oct 10, 2019

Client Sample ID			**A1-5327**
Sample Matrix			**Water**
Eurofins Sample No.			**S19-Oc15765**
Date Sampled			**Oct 10, 2019**
Test/Reference	LOR	Unit	
Total Recoverable Hydrocarbons - 1999 NEPM Fractions			
TRH C6-C9	0.02	mg/L	80
TRH C10-C14	0.05	mg/L	32
TRH C15-C28	0.1	mg/L	1.0
TRH C29-C36	0.1	mg/L	< 0.1
TRH C10-C36 (Total)	0.1	mg/L	33
BTEX			
Benzene	0.001	mg/L	15
Toluene	0.001	mg/L	27
Ethylbenzene	0.001	mg/L	0.93
m&p-Xylenes	0.002	mg/L	10
o-Xylene	0.001	mg/L	2.7
Xylenes - Total	0.003	mg/L	13
4-Bromofluorobenzene (surr.)	1	%	105
Total Recoverable Hydrocarbons - 2013 NEPM Fractions			
Naphthalene[N02]	0.01	mg/L	< 5
TRH C6-C10	0.02	mg/L	90
TRH C6-C10 less BTEX (F1)[N04]	0.02	mg/L	34
TRH >C10-C16	0.05	mg/L	37
TRH >C10-C16 less Naphthalene (F2)[N01]	0.05	mg/L	37
TRH >C16-C34	0.1	mg/L	0.8
TRH >C34-C40	0.1	mg/L	< 0.1
TRH >C10-C40 (total)*	0.1	mg/L	37.8
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	0.001	mg/L	< 0.001
Acenaphthylene	0.001	mg/L	< 0.001
Anthracene	0.001	mg/L	< 0.001
Benz(a)anthracene	0.001	mg/L	< 0.001
Benzo(a)pyrene	0.001	mg/L	< 0.001
Benzo(b&j)fluoranthene[N07]	0.001	mg/L	< 0.001
Benzo(g.h.i)perylene	0.001	mg/L	< 0.001
Benzo(k)fluoranthene	0.001	mg/L	< 0.001
Chrysene	0.001	mg/L	< 0.001
Dibenz(a.h)anthracene	0.001	mg/L	< 0.001
Fluoranthene	0.001	mg/L	< 0.001
Fluorene	0.001	mg/L	< 0.001
Indeno(1.2.3-cd)pyrene	0.001	mg/L	< 0.001

Client Sample ID			A1-5327
Sample Matrix			**Water**
Eurofins Sample No.			**S19-Oc15765**
Date Sampled			Oct 10, 2019
Test/Reference	LOR	Unit	
Polycyclic Aromatic Hydrocarbons			
Naphthalene	0.001	mg/L	0.14
Phenanthrene	0.001	mg/L	< 0.001
Pyrene	0.001	mg/L	< 0.001
Total PAH*	0.001	mg/L	0.14
2-Fluorobiphenyl (surr.)	1	%	63
p-Terphenyl-d14 (surr.)	1	%	65
Glycols*			
Di-Ethylene Glycol*	20	mg/L	< 20
Ethylene glycol*	20	mg/L	< 20
Propylene glycol*	20	mg/L	< 20
Triethylene glycol*	20	mg/L	< 20
Phenols (Halogenated)			
2-Chlorophenol	0.003	mg/L	< 0.003
2.4-Dichlorophenol	0.003	mg/L	< 0.003
2.4.5-Trichlorophenol	0.01	mg/L	< 0.01
2.4.6-Trichlorophenol	0.01	mg/L	< 0.01
2.6-Dichlorophenol	0.003	mg/L	< 0.003
4-Chloro-3-methylphenol	0.01	mg/L	< 0.01
Pentachlorophenol	0.01	mg/L	< 0.01
Tetrachlorophenols - Total	0.03	mg/L	< 0.03
Total Halogenated Phenol*	0.01	mg/L	< 0.01
Phenols (non-Halogenated)			
2-Cyclohexyl-4.6-dinitrophenol	0.1	mg/L	< 0.1
2-Methyl-4.6-dinitrophenol	0.03	mg/L	< 0.03
2-Methylphenol (o-Cresol)	0.003	mg/L	13
2-Nitrophenol	0.01	mg/L	< 0.01
2.4-Dimethylphenol	0.003	mg/L	4.3
2.4-Dinitrophenol	0.03	mg/L	< 0.03
3&4-Methylphenol (m&p-Cresol)	0.006	mg/L	12
4-Nitrophenol	0.03	mg/L	< 0.03
Dinoseb	0.1	mg/L	< 0.1
Phenol	0.003	mg/L	8.4
Total Non-Halogenated Phenol*	0.1	mg/L	37.7
Phenol-d6 (surr.)	1	%	37
Chloride	1	mg/L	12000
Conductivity (at 25°C)	10	uS/cm	31000
Nitrate & Nitrite (as N)	0.05	mg/L	< 0.05
pH (at 25°C)	0.1	pH Units	7.1
Phosphate total (as P)	0.01	mg/L	0.03
Total Combined Nitrogen (as N)	0.2	mg/L	34
Total Kjeldahl Nitrogen (as N)	0.2	mg/L	34
Total Suspended Solids Dried at 103–105°C	1	mg/L	5.1
Heavy Metals			
Aluminium	0.05	mg/L	< 0.05
Antimony	0.005	mg/L	< 0.005
Arsenic	0.001	mg/L	0.003
Barium	0.02	mg/L	46
Beryllium	0.001	mg/L	< 0.001

Client Sample ID			A1-5327
Sample Matrix			Water
Eurofins Sample No.			S19-Oc15765
Date Sampled			Oct 10, 2019
Test/Reference	LOR	Unit	
Heavy Metals			
Boron	0.05	mg/L	13
Cadmium	0.0002	mg/L	< 0.0002
Chromium	0.001	mg/L	< 0.001
Cobalt	0.001	mg/L	< 0.001
Copper	0.001	mg/L	0.005
Iron	0.05	mg/L	0.86
Lead	0.001	mg/L	< 0.001
Manganese	0.005	mg/L	0.028
Mercury	0.0001	mg/L	0.0054
Molybdenum	0.005	mg/L	< 0.005
Nickel	0.001	mg/L	< 0.001
Selenium	0.001	mg/L	< 0.001
Silver	0.005	mg/L	< 0.005
Strontium	0.005	mg/L	3.1
Thallium	0.005	mg/L	< 0.005
Tin	0.005	mg/L	< 0.005
Titanium	0.005	mg/L	< 0.005
Vanadium	0.005	mg/L	< 0.005
Zinc	0.005	mg/L	0.019
Alkali Metals			
Potassium	0.5	mg/L	74

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Total Recoverable Hydrocarbons - 1999 NEPM Fractions	Melbourne	Oct 14, 2019	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Oct 14, 2019	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Oct 14, 2019	
- Method: LTM-ORG-2010 TRH C6-C40			
BTEX and Naphthalene			
BTEX	Melbourne	Oct 14, 2019	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Polycyclic Aromatic Hydrocarbons	Melbourne	Oct 14, 2019	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Glycols*	Melbourne	Oct 14, 2019	7 Days
- Method: GLYCOLS- US EPA SW846 METHOD 8000 GC-FID.			
Chloride	Melbourne	Oct 14, 2019	28 Days
- Method: LTM-INO-4090 Chloride by Discrete Analyser			
Conductivity (at 25°C)	Melbourne	Oct 14, 2019	28 Days
- Method: LTM-INO-4030 Conductivity			
Nitrate & Nitrite (as N)	Melbourne	Oct 17, 2019	28 Days
- Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA			
pH (at 25°C)	Melbourne	Oct 14, 2019	0 Hours
- Method: LTM-GEN-7090 pH in water by ISE			
Phosphate total (as P)	Melbourne	Oct 14, 2019	28 Days
- Method: APHA 4500-P E. Phosphorus			
Total Kjeldahl Nitrogen (as N)	Melbourne	Oct 14, 2019	7 Days
- Method: LTM-INO-4310 TKN in Waters & Soils by FIA			
Total Suspended Solids Dried at 103–105°C	Melbourne	Oct 14, 2019	7 Days
- Method: LTM-INO-4070 Analysis of Suspended Solids in Water by Gravimetry			
Heavy Metals	Melbourne	Oct 15, 2019	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Metals M8	Melbourne	Oct 15, 2019	180 Days
- Method:			
Alkali Metals	Melbourne	Oct 14, 2019	180 Days
- Method: LTM-MET-3010 Alkali Metals S Si and P by ICP-AES			
Phenols (IWRG 621)			
Phenols (Halogenated)	Melbourne	Oct 14, 2019	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Phenols (non-Halogenated)	Melbourne	Oct 14, 2019	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			

Company Name:	Beach Energy Limited	**Order No.:**	PO# BE 00016911
Address:	5775 South Gippsland Highway Lang Lang VIC 3984	**Report #:**	681835
		Phone:	03 5654 9103
		Fax:	03 5659 0178
Project Name:	PRODUCED WATER A15327 DISCHARGE	**Received:**	Oct 10, 2019 11:12 AM
		Due:	Oct 17, 2019
		Priority:	5 Day
		Contact Name:	Adrian Cukovski

Eurofins Analytical Services Manager : Michael Morrison

Sample Detail						Aluminium	Antimony	Barium	Beryllium	Boron	Chloride	Cobalt	Conductivity (at 25°C)	Iron	Manganese	Molybdenum	Nitrate & Nitrite (as N)	pH (at 25°C)	Phosphate total (as P)	Potassium	Selenium	Silver	Strontium	Thallium	Tin	Titanium	Total Combined Nitrogen (as N)	Total Kjeldahl Nitrogen (as N)	Total Suspended Solids Dried at 103–105°C	Vanadium	Polycyclic Aromatic Hydrocarbons	Glycols*	Metals M8	Phenols (IWRG 621)	BTEX and Naphthalene	Total Recoverable Hydrocarbons
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																																				
Brisbane Laboratory - NATA Site # 20794																																				
Perth Laboratory - NATA Site # 23736																																				
External Laboratory																																				
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**																															
1	A1-5327	Oct 10, 2019		Water	S19-Oc15765	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Test Counts						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**ug/L:** micrograms per litre
ppm: Parts per million	**ppb:** Parts per billion	**%:** Percentage
org/100mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	mg/L	< 0.02			0.02	Pass	
TRH C10-C14	mg/L	< 0.05			0.05	Pass	
TRH C15-C28	mg/L	< 0.1			0.1	Pass	
TRH C29-C36	mg/L	< 0.1			0.1	Pass	
Method Blank							
BTEX							
Benzene	mg/L	< 0.001			0.001	Pass	
Toluene	mg/L	< 0.001			0.001	Pass	
Ethylbenzene	mg/L	< 0.001			0.001	Pass	
m&p-Xylenes	mg/L	< 0.002			0.002	Pass	
o-Xylene	mg/L	< 0.001			0.001	Pass	
Xylenes - Total	mg/L	< 0.003			0.003	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/L	< 0.01			0.01	Pass	
TRH C6-C10	mg/L	< 0.02			0.02	Pass	
TRH >C10-C16	mg/L	< 0.05			0.05	Pass	
TRH >C16-C34	mg/L	< 0.1			0.1	Pass	
TRH >C34-C40	mg/L	< 0.1			0.1	Pass	
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/L	< 0.001			0.001	Pass	
Acenaphthylene	mg/L	< 0.001			0.001	Pass	
Anthracene	mg/L	< 0.001			0.001	Pass	
Benz(a)anthracene	mg/L	< 0.001			0.001	Pass	
Benzo(a)pyrene	mg/L	< 0.001			0.001	Pass	
Benzo(b&j)fluoranthene	mg/L	< 0.001			0.001	Pass	
Benzo(g.h.i)perylene	mg/L	< 0.001			0.001	Pass	
Benzo(k)fluoranthene	mg/L	< 0.001			0.001	Pass	
Chrysene	mg/L	< 0.001			0.001	Pass	
Dibenz(a.h)anthracene	mg/L	< 0.001			0.001	Pass	
Fluoranthene	mg/L	< 0.001			0.001	Pass	
Fluorene	mg/L	< 0.001			0.001	Pass	
Indeno(1.2.3-cd)pyrene	mg/L	< 0.001			0.001	Pass	
Naphthalene	mg/L	< 0.001			0.001	Pass	
Phenanthrene	mg/L	< 0.001			0.001	Pass	
Pyrene	mg/L	< 0.001			0.001	Pass	
Method Blank							
Glycols*							
Di-Ethylene Glycol*	mg/L	< 20			20	Pass	
Ethylene glycol*	mg/L	< 20			20	Pass	
Propylene glycol*	mg/L	< 20			20	Pass	
Triethylene glycol*	mg/L	< 20			20	Pass	
Method Blank							
Phenols (Halogenated)							
2-Chlorophenol	mg/L	< 0.003			0.003	Pass	
2.4-Dichlorophenol	mg/L	< 0.003			0.003	Pass	
2.4.5-Trichlorophenol	mg/L	< 0.01			0.01	Pass	
2.4.6-Trichlorophenol	mg/L	< 0.01			0.01	Pass	
2.6-Dichlorophenol	mg/L	< 0.003			0.003	Pass	

eurofins Environment Testing

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
4-Chloro-3-methylphenol	mg/L	< 0.01			0.01	Pass	
Pentachlorophenol	mg/L	< 0.01			0.01	Pass	
Tetrachlorophenols - Total	mg/L	< 0.03			0.03	Pass	
Method Blank							
Phenols (non-Halogenated)							
2-Cyclohexyl-4.6-dinitrophenol	mg/L	< 0.1			0.1	Pass	
2-Methyl-4.6-dinitrophenol	mg/L	< 0.03			0.03	Pass	
2-Nitrophenol	mg/L	< 0.01			0.01	Pass	
2.4-Dinitrophenol	mg/L	< 0.03			0.03	Pass	
4-Nitrophenol	mg/L	< 0.03			0.03	Pass	
Dinoseb	mg/L	< 0.1			0.1	Pass	
Method Blank							
Chloride	mg/L	< 1			1	Pass	
Conductivity (at 25°C)	uS/cm	< 10			10	Pass	
Nitrate & Nitrite (as N)	mg/L	< 0.05			0.05	Pass	
Phosphate total (as P)	mg/L	< 0.01			0.01	Pass	
Total Kjeldahl Nitrogen (as N)	mg/L	< 0.2			0.2	Pass	
Total Suspended Solids Dried at 103–105°C	mg/L	< 1			1	Pass	
Method Blank							
Heavy Metals							
Aluminium	mg/L	< 0.05			0.05	Pass	
Antimony	mg/L	< 0.005			0.005	Pass	
Arsenic	mg/L	< 0.001			0.001	Pass	
Barium	mg/L	< 0.02			0.02	Pass	
Beryllium	mg/L	< 0.001			0.001	Pass	
Boron	mg/L	< 0.05			0.05	Pass	
Cadmium	mg/L	< 0.0002			0.0002	Pass	
Chromium	mg/L	< 0.001			0.001	Pass	
Cobalt	mg/L	< 0.001			0.001	Pass	
Copper	mg/L	< 0.001			0.001	Pass	
Iron	mg/L	< 0.05			0.05	Pass	
Lead	mg/L	< 0.001			0.001	Pass	
Manganese	mg/L	< 0.005			0.005	Pass	
Mercury	mg/L	< 0.0001			0.0001	Pass	
Molybdenum	mg/L	< 0.005			0.005	Pass	
Nickel	mg/L	< 0.001			0.001	Pass	
Selenium	mg/L	< 0.001			0.001	Pass	
Silver	mg/L	< 0.005			0.005	Pass	
Strontium	mg/L	< 0.005			0.005	Pass	
Thallium	mg/L	< 0.005			0.005	Pass	
Tin	mg/L	< 0.005			0.005	Pass	
Titanium	mg/L	< 0.005			0.005	Pass	
Vanadium	mg/L	< 0.005			0.005	Pass	
Zinc	mg/L	< 0.005			0.005	Pass	
Method Blank							
Alkali Metals							
Potassium	mg/L	< 0.5			0.5	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	%	113			70-130	Pass	
TRH C10-C14	%	119			70-130	Pass	
LCS - % Recovery							
BTEX							
Benzene	%	109			70-130	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Toluene	%	112			70-130	Pass	
Ethylbenzene	%	117			70-130	Pass	
m&p-Xylenes	%	111			70-130	Pass	
Xylenes - Total	%	112			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	106			70-130	Pass	
TRH C6-C10	%	116			70-130	Pass	
TRH >C10-C16	%	112			70-130	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	99			70-130	Pass	
Acenaphthylene	%	94			70-130	Pass	
Anthracene	%	64			70-130	Fail	Q08
Benz(a)anthracene	%	81			70-130	Pass	
Benzo(a)pyrene	%	89			70-130	Pass	
Benzo(b&j)fluoranthene	%	93			70-130	Pass	
Benzo(g.h.i)perylene	%	112			70-130	Pass	
Benzo(k)fluoranthene	%	102			70-130	Pass	
Chrysene	%	98			70-130	Pass	
Dibenz(a.h)anthracene	%	121			70-130	Pass	
Fluoranthene	%	98			70-130	Pass	
Fluorene	%	99			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	105			70-130	Pass	
Naphthalene	%	98			70-130	Pass	
Phenanthrene	%	96			70-130	Pass	
Pyrene	%	99			70-130	Pass	
LCS - % Recovery							
Glycols*							
Ethylene glycol*	%	119			70-130	Pass	
Propylene glycol*	%	108			70-130	Pass	
LCS - % Recovery							
Phenols (Halogenated)							
2-Chlorophenol	%	87			30-130	Pass	
2.4-Dichlorophenol	%	78			30-130	Pass	
2.4.5-Trichlorophenol	%	63			30-130	Pass	
2.4.6-Trichlorophenol	%	78			30-130	Pass	
2.6-Dichlorophenol	%	90			30-130	Pass	
4-Chloro-3-methylphenol	%	72			30-130	Pass	
Pentachlorophenol	%	50			30-130	Pass	
Tetrachlorophenols - Total	%	90			30-130	Pass	
LCS - % Recovery							
Phenols (non-Halogenated)							
2-Cyclohexyl-4.6-dinitrophenol	%	55			30-130	Pass	
2-Methyl-4.6-dinitrophenol	%	61			30-130	Pass	
2-Nitrophenol	%	83			30-130	Pass	
2.4-Dinitrophenol	%	31			30-130	Pass	
4-Nitrophenol	%	35			30-130	Pass	
Dinoseb	%	51			30-130	Pass	
LCS - % Recovery							
Chloride	%	103			70-130	Pass	
Conductivity (at 25°C)	%	101			70-130	Pass	
Nitrate & Nitrite (as N)	%	98			70-130	Pass	
Phosphate total (as P)	%	100			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Total Kjeldahl Nitrogen (as N)			%	91			70-130	Pass	
Total Suspended Solids Dried at 103–105°C			%	100			70-130	Pass	
LCS - % Recovery									
Heavy Metals									
Aluminium			%	115			80-120	Pass	
Antimony			%	104			80-120	Pass	
Arsenic			%	93			80-120	Pass	
Barium			%	106			80-120	Pass	
Beryllium			%	99			80-120	Pass	
Boron			%	119			80-120	Pass	
Cadmium			%	92			80-120	Pass	
Chromium			%	88			80-120	Pass	
Cobalt			%	103			80-120	Pass	
Copper			%	89			80-120	Pass	
Iron			%	103			80-120	Pass	
Lead			%	88			80-120	Pass	
Manganese			%	108			80-120	Pass	
Mercury			%	91			75-125	Pass	
Molybdenum			%	98			80-120	Pass	
Nickel			%	90			80-120	Pass	
Selenium			%	108			80-120	Pass	
Silver			%	106			80-120	Pass	
Strontium			%	107			80-120	Pass	
Thallium			%	93			80-120	Pass	
Tin			%	103			80-120	Pass	
Titanium			%	104			80-120	Pass	
Vanadium			%	102			80-120	Pass	
Zinc			%	97			80-120	Pass	
LCS - % Recovery									
Alkali Metals									
Potassium			%	103			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1					
TRH C10-C14	M19-Oc17905	NCP	%	96			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
TRH >C10-C16	M19-Oc17905	NCP	%	87			70-130	Pass	
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	B19-Oc15953	NCP	%	75			70-130	Pass	
Acenaphthylene	B19-Oc15953	NCP	%	73			70-130	Pass	
Anthracene	B19-Oc15953	NCP	%	92			70-130	Pass	
Benz(a)anthracene	B19-Oc15953	NCP	%	99			70-130	Pass	
Benzo(a)pyrene	B19-Oc15953	NCP	%	75			70-130	Pass	
Benzo(b&j)fluoranthene	B19-Oc15953	NCP	%	78			70-130	Pass	
Benzo(g.h.i)perylene	B19-Oc15953	NCP	%	84			70-130	Pass	
Benzo(k)fluoranthene	B19-Oc15953	NCP	%	85			70-130	Pass	
Chrysene	B19-Oc15953	NCP	%	87			70-130	Pass	
Dibenz(a.h)anthracene	B19-Oc15953	NCP	%	79			70-130	Pass	
Fluoranthene	B19-Oc15953	NCP	%	72			70-130	Pass	
Fluorene	B19-Oc15953	NCP	%	77			70-130	Pass	
Indeno(1.2.3-cd)pyrene	B19-Oc15953	NCP	%	87			70-130	Pass	
Naphthalene	B19-Oc15953	NCP	%	82			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Phenanthrene	B19-Oc15953	NCP	%	71			70-130	Pass	
Pyrene	B19-Oc15953	NCP	%	75			70-130	Pass	
Spike - % Recovery									
Phenols (Halogenated)				Result 1					
2-Chlorophenol	B19-Oc15953	NCP	%	103			30-130	Pass	
2.4-Dichlorophenol	B19-Oc15953	NCP	%	83			30-130	Pass	
2.4.5-Trichlorophenol	B19-Oc15953	NCP	%	64			30-130	Pass	
2.4.6-Trichlorophenol	B19-Oc15953	NCP	%	81			30-130	Pass	
2.6-Dichlorophenol	B19-Oc15953	NCP	%	108			30-130	Pass	
4-Chloro-3-methylphenol	B19-Oc15953	NCP	%	73			30-130	Pass	
Pentachlorophenol	B19-Oc15953	NCP	%	47			30-130	Pass	
Tetrachlorophenols - Total	B19-Oc15953	NCP	%	93			30-130	Pass	
Spike - % Recovery									
Phenols (non-Halogenated)				Result 1					
2-Cyclohexyl-4.6-dinitrophenol	P19-Oc05826	NCP	%	114			30-130	Pass	
2-Methyl-4.6-dinitrophenol	M19-Oc19408	NCP	%	58			30-130	Pass	
2-Nitrophenol	B19-Oc15953	NCP	%	93			30-130	Pass	
2.4-Dinitrophenol	P19-Oc05826	NCP	%	112			30-130	Pass	
4-Nitrophenol	P19-Oc05826	NCP	%	72			30-130	Pass	
Dinoseb	M19-Oc19408	NCP	%	60			30-130	Pass	
Spike - % Recovery									
				Result 1					
Chloride	M19-Oc13756	NCP	%	103			70-130	Pass	
Nitrate & Nitrite (as N)	M19-Oc20348	NCP	%	101			70-130	Pass	
Phosphate total (as P)	M19-Oc16057	NCP	%	88			70-130	Pass	
Total Kjeldahl Nitrogen (as N)	M19-Oc22243	NCP	%	98			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Aluminium	M19-Oc16016	NCP	%	124			75-125	Pass	
Antimony	M19-Oc16016	NCP	%	97			70-130	Pass	
Arsenic	M19-Oc16016	NCP	%	97			75-125	Pass	
Barium	M19-Oc16016	NCP	%	108			75-125	Pass	
Beryllium	M19-Oc16016	NCP	%	94			75-125	Pass	
Boron	M19-Oc16098	NCP	%	117			75-125	Pass	
Cadmium	M19-Oc16016	NCP	%	102			75-125	Pass	
Chromium	M19-Oc16016	NCP	%	96			75-125	Pass	
Cobalt	M19-Oc16016	NCP	%	98			75-125	Pass	
Copper	M19-Oc16016	NCP	%	138			75-125	Fail	Q08
Iron	M19-Oc16016	NCP	%	112			75-125	Pass	
Lead	M19-Oc16016	NCP	%	96			75-125	Pass	
Manganese	M19-Oc16016	NCP	%	113			75-125	Pass	
Molybdenum	M19-Oc16016	NCP	%	96			75-125	Pass	
Nickel	M19-Oc16016	NCP	%	97			75-125	Pass	
Selenium	M19-Oc16016	NCP	%	97			75-125	Pass	
Silver	M19-Oc16016	NCP	%	90			75-125	Pass	
Strontium	M19-Oc16016	NCP	%	130			75-125	Fail	Q08
Thallium	M19-Oc16016	NCP	%	84			75-125	Pass	
Tin	M19-Oc16016	NCP	%	97			75-125	Pass	
Titanium	M19-Oc16016	NCP	%	101			75-125	Pass	
Vanadium	M19-Oc16016	NCP	%	98			75-125	Pass	
Zinc	M19-Oc16016	NCP	%	107			75-125	Pass	
Spike - % Recovery									
Alkali Metals				Result 1					
Potassium	M19-Oc15760	NCP	%	94			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C10-C14	S19-Oc13529	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
TRH C15-C28	S19-Oc13529	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
TRH C29-C36	S19-Oc13529	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
TRH >C10-C16	S19-Oc13529	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
TRH >C16-C34	S19-Oc13529	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
TRH >C34-C40	S19-Oc13529	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Acenaphthylene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Anthracene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benz(a)anthracene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(a)pyrene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(b&j)fluoranthene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(g.h.i)perylene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(k)fluoranthene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Chrysene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Dibenz(a.h)anthracene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Fluoranthene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Fluorene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Naphthalene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Phenanthrene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Pyrene	B19-Oc15952	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Duplicate									
Glycols*				Result 1	Result 2	RPD			
Di-Ethylene Glycol*	S19-Oc15765	CP	mg/L	< 20	< 20	<1	30%	Pass	
Ethylene glycol*	S19-Oc15765	CP	mg/L	< 20	< 20	<1	30%	Pass	
Propylene glycol*	S19-Oc15765	CP	mg/L	< 20	< 20	<1	30%	Pass	
Triethylene glycol*	S19-Oc15765	CP	mg/L	< 20	< 20	<1	30%	Pass	
Duplicate									
Phenols (Halogenated)				Result 1	Result 2	RPD			
2-Chlorophenol	B19-Oc15952	NCP	mg/L	< 0.003	< 0.003	<1	30%	Pass	
2.4-Dichlorophenol	B19-Oc15952	NCP	mg/L	< 0.003	< 0.003	<1	30%	Pass	
2.4.5-Trichlorophenol	B19-Oc15952	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
2.4.6-Trichlorophenol	B19-Oc15952	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
2.6-Dichlorophenol	B19-Oc15952	NCP	mg/L	< 0.003	< 0.003	<1	30%	Pass	
4-Chloro-3-methylphenol	B19-Oc15952	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
Pentachlorophenol	B19-Oc15952	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
Tetrachlorophenols - Total	B19-Oc15952	NCP	mg/L	< 0.03	< 0.03	<1	30%	Pass	
Duplicate									
Phenols (non-Halogenated)				Result 1	Result 2	RPD			
2-Cyclohexyl-4.6-dinitrophenol	B19-Oc15952	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
2-Methyl-4.6-dinitrophenol	B19-Oc15952	NCP	mg/L	< 0.03	< 0.03	<1	30%	Pass	
2-Nitrophenol	B19-Oc15952	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
2.4-Dinitrophenol	B19-Oc15952	NCP	mg/L	< 0.03	< 0.03	<1	30%	Pass	
4-Nitrophenol	B19-Oc15952	NCP	mg/L	< 0.03	< 0.03	<1	30%	Pass	
Dinoseb	B19-Oc15952	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	

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Duplicate									
				Result 1	Result 2	RPD			
Chloride	M19-Oc15757	NCP	mg/L	1800	1900	4.0	30%	Pass	
Conductivity (at 25°C)	M19-Oc17733	NCP	uS/cm	3300	3300	1.0	30%	Pass	
Nitrate & Nitrite (as N)	M19-Oc20348	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
pH (at 25°C)	M19-Oc17733	NCP	pH Units	8.3	8.4	pass	30%	Pass	
Phosphate total (as P)	M19-Oc16052	NCP	mg/L	0.14	0.14	<1	30%	Pass	
Total Kjeldahl Nitrogen (as N)	M19-Oc14326	NCP	mg/L	36	40	9.7	30%	Pass	
Total Suspended Solids Dried at 103–105°C	M19-Oc23892	NCP	mg/L	140	130	3.0	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Aluminium	M19-Oc16016	NCP	mg/L	0.34	0.34	1.0	30%	Pass	
Antimony	M19-Oc16016	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Arsenic	M19-Oc16016	NCP	mg/L	0.001	0.001	4.0	30%	Pass	
Barium	M19-Oc16016	NCP	mg/L	0.02	0.02	3.0	30%	Pass	
Beryllium	M19-Oc16016	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Boron	M19-Oc16098	NCP	mg/L	< 0.5	< 0.5	<1	30%	Pass	
Cadmium	M19-Oc16016	NCP	mg/L	0.0015	0.0015	4.0	30%	Pass	
Chromium	M19-Oc16016	NCP	mg/L	0.002	0.002	2.0	30%	Pass	
Cobalt	M19-Oc16016	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Copper	M19-Oc16016	NCP	mg/L	0.11	0.11	1.0	30%	Pass	
Iron	M19-Oc16016	NCP	mg/L	0.33	0.34	3.0	30%	Pass	
Lead	M19-Oc16016	NCP	mg/L	0.005	0.005	1.0	30%	Pass	
Manganese	M19-Oc16016	NCP	mg/L	0.030	0.032	7.0	30%	Pass	
Molybdenum	M19-Oc16016	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Nickel	M19-Oc16016	NCP	mg/L	0.002	0.002	6.0	30%	Pass	
Selenium	M19-Oc16016	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Silver	M19-Oc16016	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Strontium	M19-Oc16016	NCP	mg/L	0.075	0.074	1.0	30%	Pass	
Thallium	M19-Oc16016	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Tin	M19-Oc16016	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Titanium	M19-Oc16016	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Vanadium	M19-Oc16016	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Zinc	M19-Oc16016	NCP	mg/L	0.030	0.031	3.0	30%	Pass	
Duplicate									
Alkali Metals				Result 1	Result 2	RPD			
Potassium	M19-Oc15760	NCP	mg/L	380	380	1.0	30%	Pass	

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Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N01	F2 is determined by arithmetically subtracting the "naphthalene" value from the ">C10-C16" value. The naphthalene value used in this calculation is obtained from volatiles (Purge & Trap analysis).
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
N04	F1 is determined by arithmetically subtracting the "Total BTEX" value from the "C6-C10" value. The "Total BTEX" value is obtained by summing the concentrations of BTEX analytes. The "C6-C10" value is obtained by quantitating against a standard of mixed aromatic/aliphatic analytes.
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs
Q08	The matrix spike recovery is outside of the recommended acceptance criteria. An acceptable recovery was obtained for the laboratory control sample indicating a sample matrix interference.

Authorised By

Michael Morrison	Analytical Services Manager
Emily Rosenberg	Senior Analyst-Metal (VIC)
Harry Bacalis	Senior Analyst-Volatile (VIC)
Joseph Edouard	Senior Analyst-Organic (VIC)
Julie Kay	Senior Analyst-Inorganic (VIC)

Glenn Jackson

General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Appendix B

Wet Test Eco-testing Reports

Toxicity Assessment of Produced Formation Water from the BASGAS Yolla Facility

Beach Energy Ltd

Test Report

October 2019

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Toxicity Test Report: TR1858/1

Accredited for compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 25 September 2019 26 September 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9252	Y0250919	Produced Formation Water, pH 6.3*, salinity 17.3 ‰*, total ammonia 32.0mg/L*. Sample received at 12ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	1-hr sea urchin fertilisation success test using *Heliocidaris tuberculata*
Test Protocol:	ESA SOP 104 (ESA 2014), based on USEPA (2002) and Simon and Laginestra (1996)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Field collected from South Maroubra, NSW.
Test Initiated:	27 September 2019 at 1810h

Sample 9252: *Y0250919*		*Vacant*	*Vacant*
Concentration (%)	**% Fertilised Eggs (Mean ± SD)**		
FSW Control	92.0 ± 1.8		
ASW Control	92.5 ± 1.7		
1.6	87.8 ± 5.6		
3.1	12.8 ± 9.5 *		
6.3	2.0 ± 1.4 *		
12.5	0.0 ± 0.0		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		
EC10 = 1.6%** **EC50 = 2.4% **** **NOEC = 1.6%** **LOEC = 3.1%**			

*Significantly lower percentage fertilised eggs compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)
** The 95% Confidence limits are not reliable.

Toxicity Test Report: TR1858/1

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % fertilised eggs	≥70.0%	92.0%	Yes
Reference Toxicant within cusum chart limits	48.7-66.6µg Cu/L	56.9µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 11 October 2019

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

ESA (2014) ESA SOP 104 - *Sea Urchin Fertilisation Success Test*. Issue No. 13. Ecotox Services Australasia, Sydney NSW.

Simon, J. and Laginestra, E.(1997) Bioassay for testing sublethal toxicity in effluents, using gametes of sea urchin *Heliocidaris tuberculata*. National Pulp Mills Research Program Technical Report No. 20. CSIRO, Canberra ACT

USEPA (2002) Short-term methods for measuring the chronic toxicity of effluents and receiving waters to marine and estuarine organisms. Third Edition. United States Environmental Protection Agency, Office of Water, Washington DC, EPA-821-R-02-014.

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Toxicity Test Report: TR1858/2

Accredited for compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 25 September 2019 26 September 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9252	Y0250919	Produced Formation Water, pH 6.3*, salinity 17.3 ‰*, total ammonia 32.0mg/L*. Sample received at 12ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	72-hr sea urchin larval development test using *Heliocidaris tuberculata*
Test Protocol:	ESA SOP 105 (ESA 2016), based on APHA (1998), Simon and Laginestra (1996) and Doyle *et al*. (2003)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Field collected from South Maroubra, NSW.
Test Initiated:	27 September 2019 at 1730h

Sample:

Concentration (%)	**% Normal larvae (Mean ± SD)**	*Vacant*	*Vacant*
FSW Control	95.3 ± 2.2		
ASW Control	96.0 ± 2.6		
1.6	96.3 ± 1.7		
3.1	84.0 ± 4.7 *		
6.3	25.5 ± 10.3 *		
12.5	0.0 ± 0.0		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		

72-hr EC10 = 3.0 (2.78-3.22)%
72-hr EC50 = 4.9 (4.66-5.08)%
NOEC = 1.6%
LOEC = 3.1%

*Significantly lower percentage of normally developed larvae compared with the FSW Control (Dunnett's Test, 1-tailed, P=0.05)

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QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % normal larvae	≥70.0%	95.3%	Yes
Reference Toxicant within cusum chart limits	9.6-13.6µg Cu/L	11.5µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 11 October 2019

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

APHA (1998) Method 8810 D. Echinoderm Embryo Development Test. In Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association and the Water Environment Federation, USA.

Doyle, C.J., Pablo, F., Lim, R.P. and Hyne, R.V. (2003) Assessment of metal toxicity in sediment pore water from Lake Macquarie, Australia. *Arch. Environ. Contam. Toxicology*, 44(3): 343-350.

ESA (2016) *ESA SOP 105 - Sea Urchin Larval Development Test*. Issue No. 11. Ecotox Services Australasia, Sydney NSW.

Simon, J. and Laginestra, E.(1997) Bioassay for testing sublethal toxicity in effluents, using gametes of sea urchin *Heliocidaris tuberculata*. National Pulp Mills Research Program Technical Report No. 20. CSIRO, Canberra, ACT.

Toxicity Test Report: TR1858/3

Accredited for compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 25 September 2019 26 September 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9252	Y0250919	Produced Formation Water, pH 6.3*, salinity 17.3 ‰*, total ammonia 32.0mg/L*. Sample received at 12ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	48-hr larval development test using the mussel *Mytilus galloprovincialis*
Test Protocol:	ESA SOP 106 (ESA 2016), based on APHA (1998) and USEPA (1996)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	The test was extended to 72hr
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Farm-reared, Mercury Passage, TAS
Test Initiated:	27 September 2019 at 1830 h

Sample 9252: *Y0250919*

Concentration (%)	**% Normal larvae (Mean ± SD)**	*Vacant*	*Vacant*
FSW Control	78.3 ± 4.0		
ASW Control	76.5 ± 3.4		
1.6	80.3 ± 4.4		
3.1	48.0 ± 8.8 *		
6.3	0.0 ± 0.0		
12.5	0.0 ± 0.0		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		

72-hr EC10 =2.0 (1.87-2.21)%
72-hr EC50 =3.4 (3.28-3.50)%
NOEC = 1.6%
LOEC = 3.1%

*Significantly lower percentage of normally developed larvae compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

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Toxicity Test Report: TR1858/3

QA/QC Parameter	Criterion	This Test	Criterion met?
FSW Control mean % normal	≥70%	78.3%	Yes
Reference Toxicant within cusum chart limits	7.5-15.3µg Cu/L	9.3µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 11 October 2019

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

APHA (1998) *Standard Methods for the Examination of Water and Wastewate*r. 20th Ed. American Public Health Association, American Water Works Association and the Water Environment Federation, Washington, DC, USA.

ESA (2016) *Bivalve Larval Development Test*. Issue No. 15. Ecotox Services Australasia, Sydney, NSW

USEPA (1996) *Bivalve acute toxicity test (embryo larval) OPPTS 850.1055. Ecological Effects Test Guidelines.* United States Environmental Protection Agency. Prevention, Pesticides and Toxic Substances. EPA/712/C-96/137.

Toxicity Test Report: TR1858/4

Performed in compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 25 September 2019 26 September 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9252	Y0250919	Produced Formation Water, pH 6.3, salinity 17.3 ‰, total ammonia 32.0mg/L. Sample received at 12ºC in apparent good condition.

Test Performed:	96-hr acute toxicity test using the amphipod *Allorchestes compressa*
Test Protocol:	ESA SOP 108 (ESA 2017), based on USEPA (2002) and Department of Transport and Communications (1990)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	In-house culture, originally sourced from Queenscliff, VIC
Test Initiated:	27 September 2019 at 1630h

Sample 9252: Y0250919

Concentration (%)	**% Unaffected (Mean ± SD)**
FSW Control	100 ± 0.0
ASW Control	100 ± 0.0
1.6	100 ± 0.0
3.1	90.0 ± 20.0
6.3	60.0 ± 16.3 *
12.5	10.0 ± 11.6 *
25	0.0 ± 0.0
50	0.0 ± 0.0
100	0.0 ± 0.0

96-hr EC10 = 3.4(2.27-4.39)%
96-hr EC50 = 6.6 (5.41-8.19)%
NOEC = 3.1%
LOEC = 6.3%

Vacant

Vacant

*Significantly lower percent unaffected compared with the ASW Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)

Toxicity Test Report: TR1858/4

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % unaffected	≥90.0%	100%	Yes
Reference Toxicant within cusum chart limits	0.6-8.4mg SDS/L	3.6mg SDS/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 11 October 2019

Results are based on the samples in the condition as received by ESA.
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Citations:

Department of Transport and Communications (1990) Guidelines for Acceptance of Oil Spill Dispersants in Australian Waters. Pollution Prevention Section, Department of Transport and Communications, Canberra ACT.

ESA (2017) SOP 108 – *Amphipod Acute Toxicity Test*. Issue No 10. Ecotox Services Australia, Sydney, NSW.

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth Edition. United States Environmental Protection Agency, Office of Research and Development, Washington DC, EPA/600/4-90/027F.

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Toxicity Test Report: TR1858/5

Performed in compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 25 September 2019 26 September 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9252	Y0250919	Produced Formation Water, pH 6.3, salinity 17.3 ‰, total ammonia 32.0mg/L. Sample received at 12ºC in apparent good condition.

Test Performed:	72-hr marine algal growth test using *Nitzschia closterium*
Test Protocol:	ESA SOP 110 (ESA 2016), based on Stauber *et al*. (1994)
Test Temperature:	The test was performed at 21±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was filtered to 0.45µm and serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	In-house culture, originally sourced from CSIRO Microalgae Supply Service, TAS
Test Initiated:	27 September 2019 at 1930h

Sample 9252: *Y0250919*		*Vacant*	*Vacant*
Concentration (%)	**Cell Yield (Mean number of cells/mL x10^4 ± SD)**		
FSW Control	18.1 ± 1.0		
ASW Control	16.7 ± 0.6		
1.6	19.0 ± 1.3		
3.1	18.3 ± 1.8		
6.3	8.2 ± 1.8 *		
12.5	2.6 ± 1.4 *		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		
72-hr IC10 = 3.7 (3.33-3.80)% **72-hr IC50 = 6.0 (5.43-6.93)%** **NOEC = 3.1%** **LOEC = 6.3%**			

*Significantly lower cell yield compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

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Toxicity Test Report: TR1858/5

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean cell density	≥16.0x10^4 cells/mL	19.1x10^4 cells/mL	Yes
Control coefficient of variation	<20%	5.5%	Yes
Reference Toxicant within cusum chart limits	3.0-9.3µg Cu/L	4.8µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 11 October 2019

Results are based on the samples in the condition as received by ESA.
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Citations:

ESA (2016) SOP 110 – *Marine Algal Growth Test*. Issue No. 12. Ecotox Services Australasia, Sydney NSW

Stauber, J.L., Tsai, J., Vaughan, G.T., Peterson, S.M. and Brockbank, C.I. (1994) Algae as indicators of toxicity of the effluent from bleached eucalypt kraft pulp mills. National Pulp Mills Research Program, Technical Report No. 3. CSIRO, Canberra, ACT

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Toxicity Test Report: TR1858/6

Performed in compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 25 September 2019 26 September 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9252	Y0250919	Produced Formation Water, pH 6.3, salinity 17.3‰, total ammonia 32.0mg/L. Sample received at 12ºC in apparent good condition.

Test Performed:	72-hr macroalgal germination success test using *Hormosira banksii*
Test Protocol:	ESA SOP 116 (ESA 2014), based on Kevekordes and Clayton (1996) and Gunthorpe *et al*. (1997)
Test Temperature:	The test was performed at 18±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Field collected from Bilgola, NSW.
Test Initiated:	27 September 2019 at 1930h

Sample 9252: *Y0250919*		*Vacant*	*Vacant*
Concentration (%)	**% Germination (Mean ± SD)**		
FSW Control	95.5 ± 2.7		
ASW Control	95.8 ± 2.5		
1.6	94.8 ± 3.0		
3.1	95.5 ± 2.1		
6.3	93.5 ± 2.1		
12.5	57.5 ± 11.8 *		
25	24.0 ± 11.5 *		
50	0.0 ± 0.0		
100	0.0 ± 0.0		
72-hr EC10 = 7.9 (5.58-9.79)% **72-hr EC50 = 15.6 (13.3-18.1)%** **NOEC = 6.3%** **LOEC = 12.5%**			

*Significantly lower percentage of germinated zygotes compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

Toxicity Test Report: TR1858/6

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % germination	≥70.0%	95.5%	Yes
Reference Toxicant within cusum chart limits	104.9-276.5µg Cu/L	181.7µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 11 October 2019

Results are based on the samples in the condition as received by ESA.
This document shall not be reproduced except in full.

Citations:

ESA (2014) *SOP 116 – Macroalgal Germination Success Test*. Issue No. 13. Ecotox Services Australasia, Sydney.

Gunthorpe L, Nottage M, Palmer D, and Wu R (1997) *Testing for Sublethal Toxicity Using Gametes of Hormosira banksii: protocol*. National Pulp Mills Research Program Technical Report No. 22, CSIRO, Canberra.

Kevekordes K and Clayton MN (1996) Using developing embryos of *Hormosira banksii* (Phaeophyta) as a marine bioassay system. *International Journal of Plant Science*, 157: 582-585.

Toxicity Test Report: TR1858/7

Performed in compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 25 September 2019 26 September 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9252	Y0250919	Produced Formation Water, pH 6.3, salinity 17.3‰, total ammonia 32.0mg/L. Sample received at 12ºC in apparent good condition.

Test Performed:	96-hr fish imbalance toxicity test using the Bass *Macqauria novemaculeata.*
Test Protocol:	ESA SOP 117 (ESA 2016), based on USEPA (2002)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample
Source of Test Organisms:	In-house cultures
Test Initiated:	27 September 2019 at 1900h

Sample 9252: *Y0250919*

Concentration (%)	**% Unaffected (Mean ± SD)**
FSW Control	90.0 ± 11.6
ASW Control	90.0 ± 11.6
1.6	90.0 ± 11.6
3.1	60.0 ± 16.3 *
6.3	0.0 ± 0.0
12.5	0.0 ± 0.0
25	0.0 ± 0.0
50	0.0 ± 0.0
100	0.0 ± 0.0

96-hr IC10 = 2.1%**
96-hr EC50 = 3.5 (3.04-4.06)%
NOEC = 1.6%
LOEC = 3.1%

Vacant

Vacant

*Significantly lower percentage of unaffected larval fish compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)
** The 95% Confidence Limits are not reliable.

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Toxicity Test Report: TR1858/7

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % unaffected	≥80.0%	90.0%	Yes
Reference Toxicant within cusum chart limits	76.3-2555.9µg Cu/L	607.5µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 11 October 2019

Results are based on the samples in the condition as received by ESA.
This document shall not be reproduced except in full.

Citations:

ESA (2016) SOP 117 –*Freshwater and Marine Fish Imbalance Test*. Issue No 12. Ecotox Services Australasia, Sydney, NSW

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth edition EPA-821-R-02-012. United States Environmental Protection Agency, Office of Research and Development, Washington FC, USA

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Toxicity Test Report: TR1858/8

Performed in compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 25 September 2019 26 September 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9252	Y0250919	Produced Formation Water, pH 6.3, salinity 17.3‰, total ammonia 32.0mg/L. Sample received at 12ºC in apparent good condition.

Test Performed:	7-day fish imbalance and biomass toxicity test using barramundi *Lates calcarifer*
Test Protocol:	ESA SOP 122 (ESA 2017), based on USEPA (2002)
Test Temperature:	The test was performed at 25±2°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Hatchery reared, SA
Size of Test Organisms:	23mm
Test Initiated:	27 September 2019 at 1930h

Sample 9252: *Y0250919*

Concentration (%)	**% Unaffected (Mean ± SD)**		**Concentration (%)**	**Biomass, mg (Mean ± SD)**	
FSW Control	100 ± 0.0		FSW Control	22.4 ± 1.9	
ASW Control	100 ± 0.0		ASW Control	22.1 ± 2.5	
1.6	100 ± 0.0		1.6	20.6 ± 1.6	
3.1	55.0 ± 10.0	*	3.1	10.8 ± 1.8	**
6.3	0.0 ± 0.0		6.3	0.0 ± 0.0	
12.5	0.0 ± 0.0		12.5	0.0 ± 0.0	
25	0.0 ± 0.0		25	0.0 ± 0.0	
50	0.0 ± 0.0		50	0.0 ± 0.0	
100	0.0 ± 0.0		100	0.0 ± 0.0	

7 day EC10 (unaffected) = 2.7 (2.62-2.76)%
7 day EC50 (unaffected) = 3.2 (2.79-3.78)%
NOEC = 1.6%
LOEC = 3.1%

7 day IC10 (biomass) = 1.7%***
7 day IC50 (biomass) =3.1 (2.69-3.67) %
NOEC = 1.6%
LOEC = 3.1%

*Significantly lower percentage of unaffected larval fish compared with the ASW Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)
**Significantly lower fish biomass compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)
***The 95% Confidence Limits are not reliable

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Toxicity Test Report: TR1858/8

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % unaffected	$\geq$80.0%	100%	Yes
Control mean growth	$\geq$20% of initial weight	-	No*
Reference Toxicant within cusum chart limits	10.7-114.8mg NH_4^+/L	46.3mg NH_4^+/L	Yes

*fish available for testing at 27 September were older and at a relatively lower growth phase than with younger fish

Test Report Authorised by: Dr Rick Krassoi, Director on 11 October 2019

Results are based on the samples in the condition as received by ESA. This document shall not be reproduced except in full.

Citations:

ESA (2017) SOP 122 –*7-day Fish Imbalance and Growth Test*. Issue No 6. Ecotox Services Australasia, Sydney, NSW

USEPA (2002) Short-term methods for estimating the chronic toxicity of effluents and receiving waters to marine and estuarine organisms. Third edition EPA-821-R-02-014. United States Environmental Protection Agency, Office of Research and Development, Washington FC, USA

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Chain-of-Custody Documentation

Datasheet ID: 601.2
Last Revised: 21 September 2018

Sample Receipt Notification

Attention : Peter Young

Client : AECOM Australia Pty Ltd
Level 6, 3 Forrest Place
Perth WA 6849

Email : peter.young@aecom.com
Telephone : 08 6208 0000
Facsimile :

Date : 2/10/2019

Re : Receipt of Samples **Pages : 2**

ESA Project : PR1858 ☑ For Review ☐ Additional Documentation Required - Please Respond

Sample Delivery Details

Completed Chain of Custody accompanied samples:	**YES**
Samples received in apparent good condition and correctly bottled:	**YES**
Security seals on sample bottles and esky intact:	**YES**

Date samples received : 26/10/2019
Time samples received : 8:45
No. of samples received : 1
Sample matrix : Aqueous
Sample temperature : 11-15°C

Comments : 4 x 2.5L sample received at 12oC in apparent good condition

Contact Details

Projects Manager : Dr Rick Krassoi
Telephone : 61 2 9420 9481
Facsimile : 61 2 9420 9484
Email : rkrassoi@ecotox.com.au

Please contact customer services officer for all queries or issues regarding samples

Note that the chain-of-custody provides definitive information on the tests to be performed

Ecotox Services Australia
ABN 95619426201
Unit 27, 2 Chaplin Drive
Lane Cove NSW 2066 Australia

Phone : 61 2 9420 9481
Fax : 61 2 9420 9484
Email : info@ecotox.com.au

Datasheet ID 601.1
Last Revised 20 September 2018

Chain-of-Custody / Service Request Form

ecotox SERVICES AUSTRALIA

Customer

Contact Name

Phone

Email

Ship To

Attention

(please provide an email address for sample receipt notification)

Sampled by D M'LACHLAN

12°C

0925+

Sample Date (day/month/year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance)	Comments / Instructions
25/09/2019	08 10	Y0250919 - 1		1 x 2.5L	/ / / / / /	
"	"	Y0250919 - 2		1 x 2.5L	/ / / / / /	
"	"	Y0250919 - 3		1 x 2.5L	/ / / / / /	
"	"	Y0250919 - 4		1 x 2.5L	/ / / / / /	

Comments / Instructions

Note that testing will be delayed if an incomplete chain of custody is received

- Additional treatment of samples (i.e. spiking)
- Sub-contracted services (i.e. chemical analyses)
- Dilutions required (if different than 100% down to 6.25%)
- Sample holding time restriction (if applicable)
- Sample used for litigation (if applicable)

Note: An MSDS must be attached if Available

ESA Project Number: PR 1858

1) Released By	Date	2) Received By	Date	3) Released By	Date	4) Received By	Date
D M'LACHLAN	25/9/19	[signature]	26/9/19				
Of	Time 08 30	Of ESA	Time 0845	Of	Time	Of	Time

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

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Phone 61 2 9420-9481 Fax 61 2 9420-9484 info@ecotox.com.au

Statistical Printouts for the Sea Urchin Fertilisation Test

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	27/09/2019 17:30	Test ID:	PR1858/12	Sample ID:	Y0250919
End Date:	30/09/2019 19:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9400	0.9300	0.9800	0.9600
ASW Control	0.9500	0.9300	0.9900	0.9700
1.6	0.9400	0.9700	0.9600	0.9800
3.1	0.7900	0.8500	0.9000	0.8200
6.3	0.3600	0.1200	0.3000	0.2400
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.9525	0.9922	1.3562	1.3030	1.4289	4.120	4					
ASW Control	0.9600	1.0000	1.3789	1.3030	1.4706	5.232	4	*			16	400
1.6	0.9625	1.0026	1.3796	1.3233	1.4289	3.240	4	-0.012	2.290	0.1332	15	400
*3.1	0.8400	0.8750	1.1624	1.0948	1.2490	5.681	4	3.723	2.290	0.1332	64	400
*6.3	0.2550	0.2656	0.5222	0.3537	0.6435	23.840	4	14.729	2.290	0.1332	298	400
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.975273	0.887	-0.42954	0.482187
Bartlett's Test indicates equal variances (p = 0.41)	2.877388	11.34487		
The control means are not significantly different (p = 0.64)	0.498347	2.446912		

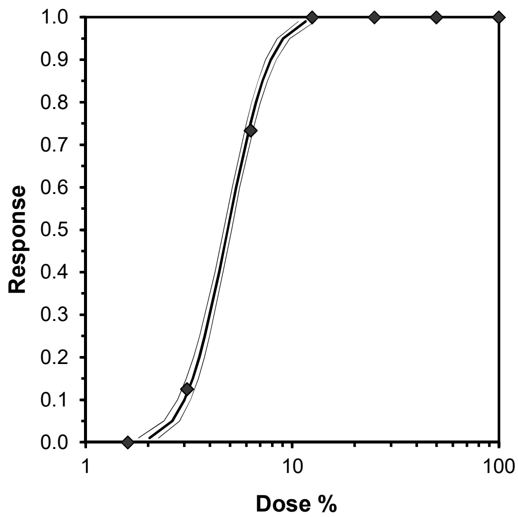
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	0.065634	0.068111	0.657642	0.006766	1.1E-08	3, 12
Treatments vs ASW Control										

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits	
Slope	6.149576	0.334514	5.493928	6.805223
Intercept	0.773331	0.245685	0.291789	1.254874
TSCR	0.039185	0.007027	0.025411	0.052959

Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
0.04	3.589738	11.0705	0.61	0.687311	0.162613	4

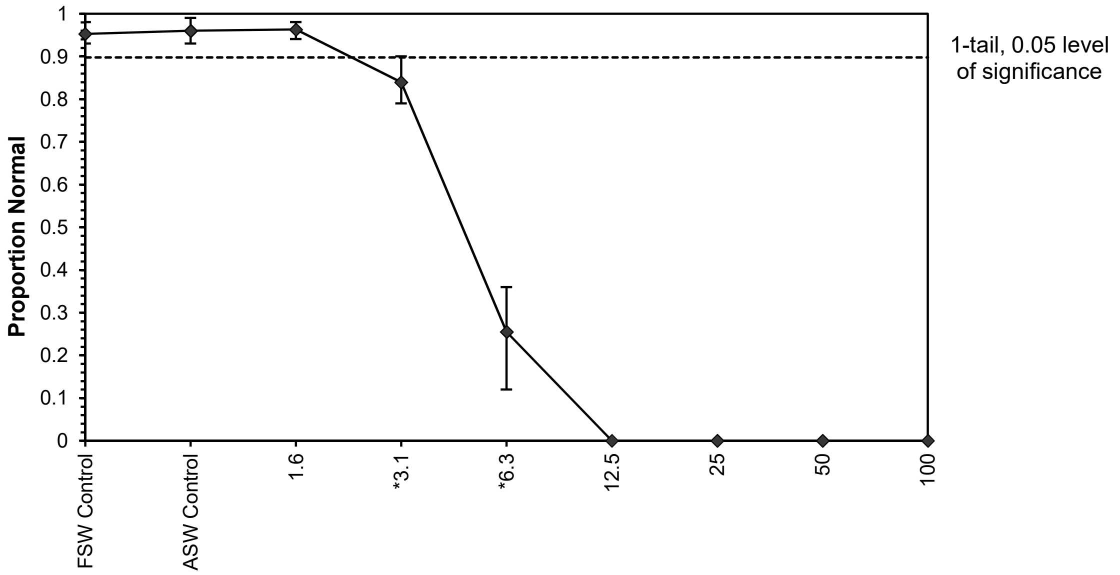
Point	Probits	%	95% Fiducial Limits	
EC01	2.674	2.03712	1.801262	2.253447
EC05	3.355	2.629277	2.390429	2.845354
EC10	3.718	3.012408	2.777552	3.224509
EC15	3.964	3.301971	3.07203	3.51023
EC20	4.158	3.55183	3.326811	3.756811
EC25	4.326	3.781202	3.560788	3.983656
EC40	4.747	4.427037	4.216199	4.628583
EC50	5.000	4.867552	4.656595	5.077419
EC60	5.253	5.351901	5.131327	5.582442
EC75	5.674	6.266013	5.997911	6.570449
EC80	5.842	6.670664	6.370831	7.020684
EC85	6.036	7.175431	6.828854	7.591264
EC90	6.282	7.865156	7.444511	8.384187
EC95	6.645	9.011248	8.448203	9.728514
EC99	7.326	11.63067	10.68178	12.89303



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	27/09/2019 17:30	Test ID:	PR1858/12	Sample ID:	Y0250919
End Date:	30/09/2019 19:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	27/09/2019 17:30	Test ID:	PR1858/12	Sample ID:	Y0250919
End Date:	30/09/2019 19:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Conc-%	Parameter	Auxiliary Data Summary Mean	Min	Max	SD	CV%	N
FSW Control	% Normal	95.25	93.00	98.00	2.22	1.56	4
ASW Control		96.00	93.00	99.00	2.58	1.67	4
1.6		96.25	94.00	98.00	1.71	1.36	4
3.1		84.00	79.00	90.00	4.69	2.58	4
6.3		25.50	12.00	36.00	10.25	12.55	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.80	35.80	35.80	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.80	35.80	35.80	0.00	0.00	1
3.1		35.80	35.80	35.80	0.00	0.00	1
6.3		35.70	35.70	35.70	0.00	0.00	1
12.5		35.70	35.70	35.70	0.00	0.00	1
25		35.70	35.70	35.70	0.00	0.00	1
50		35.70	35.70	35.70	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	DO %	99.60	99.60	99.60	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		102.10	102.10	102.10	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		100.00	100.00	100.00	0.00	0.00	1
12.5		100.40	100.40	100.40	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		93.10	93.10	93.10	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1

Statistical Printouts for the Sea Urchin Larval Development Test

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	27/09/2019 17:30	Test ID:	PR1858/12	Sample ID:	Y0250919
End Date:	30/09/2019 19:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9400	0.9300	0.9800	0.9600
ASW Control	0.9500	0.9300	0.9900	0.9700
1.6	0.9400	0.9700	0.9600	0.9800
3.1	0.7900	0.8500	0.9000	0.8200
6.3	0.3600	0.1200	0.3000	0.2400
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.9525	0.9922	1.3562	1.3030	1.4289	4.120	4					
ASW Control	0.9600	1.0000	1.3789	1.3030	1.4706	5.232	4	*			16	400
1.6	0.9625	1.0026	1.3796	1.3233	1.4289	3.240	4	-0.012	2.290	0.1332	15	400
*3.1	0.8400	0.8750	1.1624	1.0948	1.2490	5.681	4	3.723	2.290	0.1332	64	400
*6.3	0.2550	0.2656	0.5222	0.3537	0.6435	23.840	4	14.729	2.290	0.1332	298	400
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.975273	0.887	-0.42954	0.482187
Bartlett's Test indicates equal variances (p = 0.41)	2.877388	11.34487		
The control means are not significantly different (p = 0.64)	0.498347	2.446912		

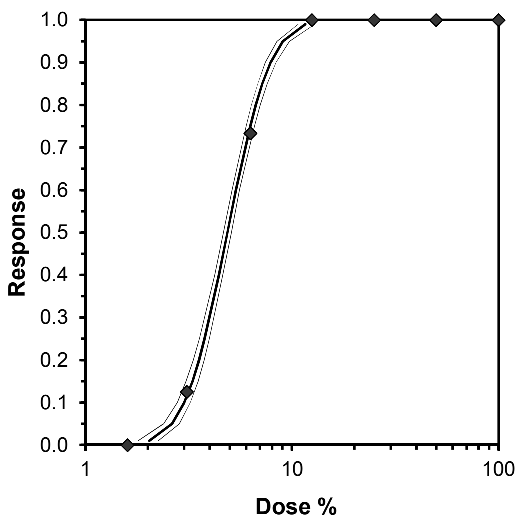
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	0.065634	0.068111	0.657642	0.006766	1.1E-08	3, 12
Treatments vs ASW Control										

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits	
Slope	6.149576	0.334514	5.493928	6.805223
Intercept	0.773331	0.245685	0.291789	1.254874
TSCR	0.039185	0.007027	0.025411	0.052959

Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
0.04	3.589738	11.0705	0.61	0.687311	0.162613	4

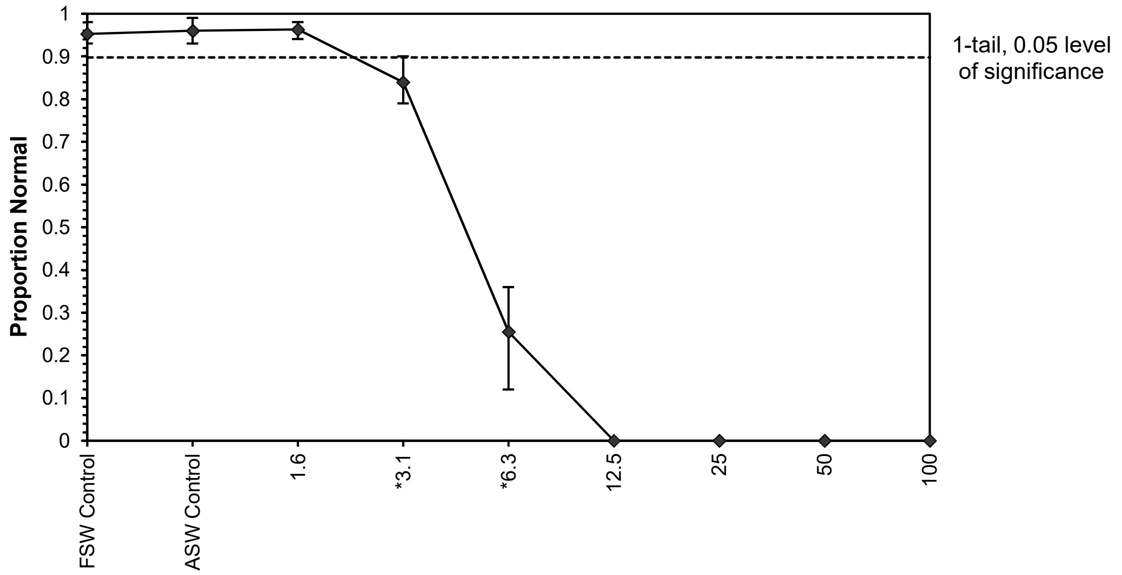
Point	Probits	%	95% Fiducial Limits	
EC01	2.674	2.03712	1.801262	2.253447
EC05	3.355	2.629277	2.390429	2.845354
EC10	3.718	3.012408	2.777552	3.224509
EC15	3.964	3.301971	3.07203	3.51023
EC20	4.158	3.55183	3.326811	3.756811
EC25	4.326	3.781202	3.560788	3.983656
EC40	4.747	4.427037	4.216199	4.628583
EC50	5.000	4.867552	4.656595	5.077419
EC60	5.253	5.351901	5.131327	5.582442
EC75	5.674	6.266013	5.997911	6.570449
EC80	5.842	6.670664	6.370831	7.020684
EC85	6.036	7.175431	6.828854	7.591264
EC90	6.282	7.865156	7.444511	8.384187
EC95	6.645	9.011248	8.448203	9.728514
EC99	7.326	11.63067	10.68178	12.89303



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	27/09/2019 17:30	Test ID:	PR1858/12	Sample ID:	Y0250919
End Date:	30/09/2019 19:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	27/09/2019 17:30	Test ID:	PR1858/12	Sample ID:	Y0250919
End Date:	30/09/2019 19:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	% Normal	95.25	93.00	98.00	2.22	1.56	4
ASW Control		96.00	93.00	99.00	2.58	1.67	4
1.6		96.25	94.00	98.00	1.71	1.36	4
3.1		84.00	79.00	90.00	4.69	2.58	4
6.3		25.50	12.00	36.00	10.25	12.55	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.80	35.80	35.80	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.80	35.80	35.80	0.00	0.00	1
3.1		35.80	35.80	35.80	0.00	0.00	1
6.3		35.70	35.70	35.70	0.00	0.00	1
12.5		35.70	35.70	35.70	0.00	0.00	1
25		35.70	35.70	35.70	0.00	0.00	1
50		35.70	35.70	35.70	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	DO %	99.60	99.60	99.60	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		102.10	102.10	102.10	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		100.00	100.00	100.00	0.00	0.00	1
12.5		100.40	100.40	100.40	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		93.10	93.10	93.10	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1

Statistical Printouts for the Mussel Toxicity Tests

Bivalve Acute Toxicity Tests-Proportion Normal

Start Date:	27/09/2019 18:30	Test ID:	PR1858/15	Sample ID:	Y0250919
End Date:	30/09/2019 18:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
FSW Control	0.7400	0.8300	0.8000	0.7600
ASW Control	0.7500	0.8100	0.7300	0.7700
1.6	0.7400	0.8400	0.8100	0.8200
3.1	0.4600	0.3900	0.4700	0.6000
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

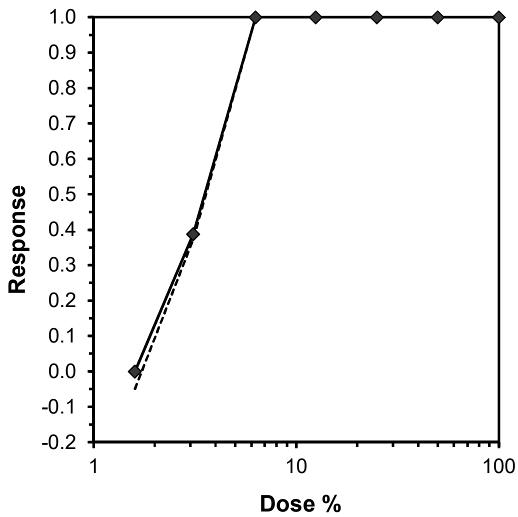
			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.7825	1.0229	1.0869	1.0357	1.1458	4.535	4					
ASW Control	0.7650	1.0000	1.0655	1.0244	1.1198	3.830	4	*			94	400
1.6	0.8025	1.0490	1.1119	1.0357	1.1593	4.799	4	-1.024	2.180	0.0987	79	400
*3.1	0.4800	0.6275	0.7653	0.6745	0.8861	11.522	4	6.633	2.180	0.0987	208	400
6.3	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.97222	0.859	0.428236	0.615081
Bartlett's Test indicates equal variances (p = 0.44)	1.627575	9.21034		
The control means are not significantly different (p = 0.53)	0.668304	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	0.088191	0.115181	0.141556	0.004096	6.0E-05	2, 9
Treatments vs ASW Control										

Trimmed Spearman-Karber

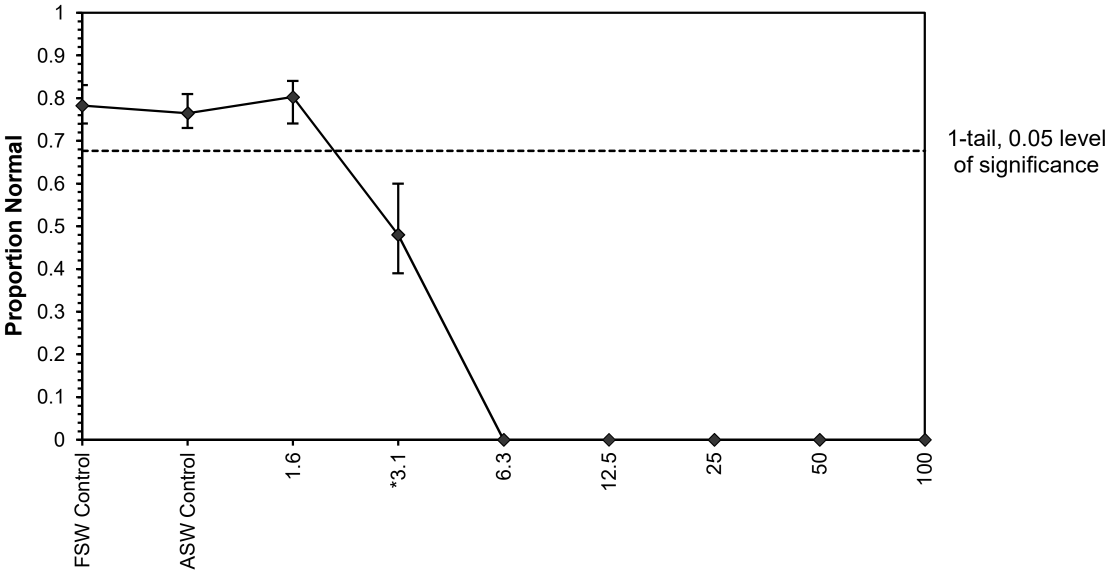
Trim Level	EC50	95% CL	
0.0%	3.3885	3.2773	3.5036
5.0%	3.4105	3.2858	3.5400
10.0%	3.4323	3.2895	3.5813
20.0%	3.4747	3.2733	3.6886
Auto-0.0%	3.3885	3.2773	3.5036



Bivalve Acute Toxicity Tests-Proportion Normal

Start Date:	27/09/2019 18:30	Test ID:	PR1858/15	Sample ID:	Y0250919
End Date:	30/09/2019 18:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Dose-Response Plot



Bivalve Acute Toxicity Tests-Proportion Normal

Start Date:	27/09/2019 18:30	Test ID:	PR1858/15	Sample ID:	Y0250919
End Date:	30/09/2019 18:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	Parameter	Auxiliary Data Summary Mean	Min	Max	SD	CV%	N
FSW Control	% Normal	78.25	74.00	83.00	4.03	2.57	4
ASW Control		76.50	73.00	81.00	3.42	2.42	4
1.6		80.25	74.00	84.00	4.35	2.60	4
3.1		48.00	39.00	60.00	8.76	6.16	4
6.3		0.00	0.00	0.00	0.00		4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.80	35.80	35.80	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.80	35.80	35.80	0.00	0.00	1
3.1		35.80	35.80	35.80	0.00	0.00	1
6.3		35.70	35.70	35.70	0.00	0.00	1
12.5		35.70	35.70	35.70	0.00	0.00	1
25		35.70	35.70	35.70	0.00	0.00	1
50		35.70	35.70	35.70	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	DO %	99.60	99.60	99.60	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		102.10	102.10	102.10	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		100.00	100.00	100.00	0.00	0.00	1
12.5		100.40	100.40	100.40	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		93.10	93.10	93.10	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1

Bivalve Acute Toxicity Tests-Proportion Normal

Start Date:	27/09/2019 18:30	Test ID:	PR1858/15	Sample ID:	Y0250919
End Date:	30/09/2019 18:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
FSW Control	0.7400	0.8300	0.8000	0.7600
ASW Control	0.7500	0.8100	0.7300	0.7700
1.6	0.7400	0.8400	0.8100	0.8200
3.1	0.4600	0.3900	0.4700	0.6000
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

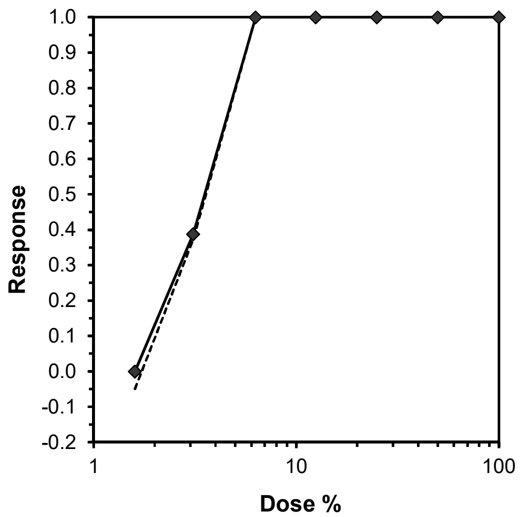
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.7825	1.0229	1.0869	1.0357	1.1458	4.535	4					
ASW Control	0.7650	1.0000	1.0655	1.0244	1.1198	3.830	4	*			0.7838	1.0000
1.6	0.8025	1.0490	1.1119	1.0357	1.1593	4.799	4	-1.024	2.180	0.0987	0.7838	1.0000
*3.1	0.4800	0.6275	0.7653	0.6745	0.8861	11.522	4	6.633	2.180	0.0987	0.4800	0.6124
6.3	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.97222	0.859	0.428236	0.615081
Bartlett's Test indicates equal variances (p = 0.44)	1.627575	9.21034		
The control means are not significantly different (p = 0.53)	0.668304	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	0.088191	0.115181	0.141556	0.004096	6.0E-05	2, 9
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	1.7956	0.0668	1.7268	1.9051	-10.9184
IC10	1.9850	0.0560	1.8688	2.2077	0.3615
IC15	2.1715	0.0825	1.9964	2.5128	0.9785
IC20	2.3581	0.1116	2.1214	2.8245	1.1568
IC25	2.5471	0.1401	2.2395	3.1471	1.0250
IC40	3.1101	0.1053	2.6353	3.2456	-1.0027
IC50	3.1942	0.0411	3.0657	3.3281	0.1532



Statistical Printouts for the Acute *Allorchestes* Toxicity Test

Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	27/09/2019 16:30	Test ID:	PR1858/02	Sample ID:	Y0250919
End Date:	1/10/2019 16:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	0.6000
6.3	0.6000	0.8000	0.6000	0.4000
12.5	0.0000	0.2000	0.2000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		0	20
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
3.1	0.9000	0.9000	1.2305	0.8861	1.3453	18.660	4	16.00	10.00	2	20
*6.3	0.6000	0.6000	0.8910	0.6847	1.1071	19.366	4	10.00	10.00	8	20
*12.5	0.1000	0.1000	0.3446	0.2255	0.4636	39.900	4	10.00	10.00	18	20
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20

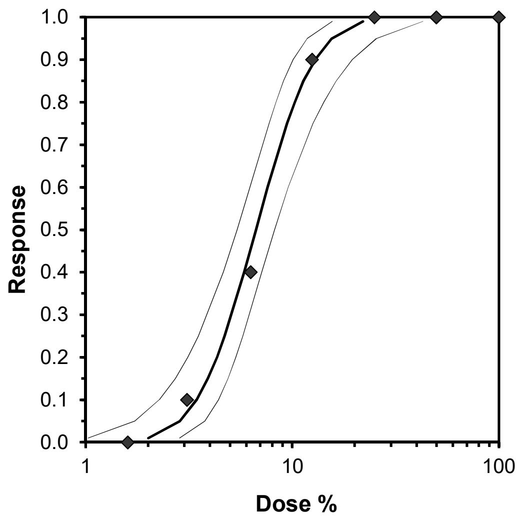
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.874764	0.905	-1.01023	1.925233
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	3.1	6.3	4.419276	32.25806
Treatments vs ASW Control				

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	4.476347	0.779411	2.948702	6.003993	0	0.752017	11.0705	0.98	0.823407	0.223396	3
Intercept	1.314144	0.671174	-0.00136	2.629645							
TSCR											

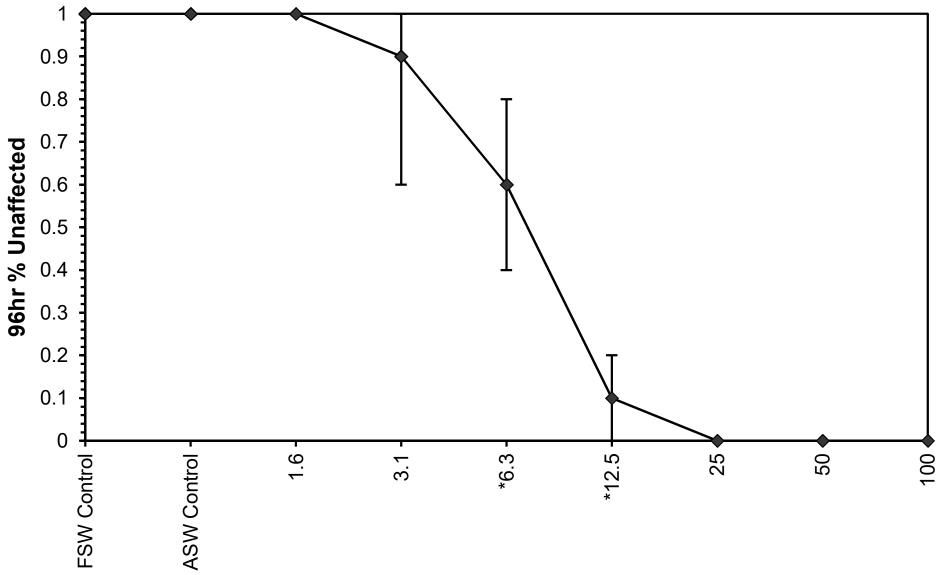
Point	Probits	%	95% Fiducial Limits	
EC01	2.674	2.012376	1.034186	2.85415
EC05	3.355	2.857278	1.733282	3.765561
EC10	3.718	3.444395	2.271134	4.387061
EC15	3.964	3.907252	2.716143	4.87997
EC20	4.158	4.319085	3.122326	5.326055
EC25	4.326	4.706828	3.509488	5.756475
EC40	4.747	5.845344	4.639124	7.111008
EC50	5.000	6.658968	5.410339	8.189498
EC60	5.253	7.585842	6.234193	9.545884
EC75	5.674	9.420751	7.706435	12.60984
EC80	5.842	10.26649	8.330809	14.17074
EC85	6.036	11.3486	9.093906	16.28708
EC90	6.282	12.87363	10.11726	19.4753
EC95	6.645	15.51891	11.78891	25.51472
EC99	7.326	22.03458	15.55582	42.75583



Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	27/09/2019 16:30	Test ID:	PR1858/02	Sample ID:	Y0250919
End Date:	1/10/2019 16:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

Dose-Response Plot



Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	27/09/2019 16:30	Test ID:	PR1858/02	Sample ID:	Y0250919
End Date:	1/10/2019 16:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Non-immobilised	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		90.00	60.00	100.00	20.00	4.97	4
6.3		60.00	40.00	80.00	16.33	6.74	4
12.5		10.00	0.00	20.00	11.55	33.98	4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	DO %	99.60	99.60	99.60	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		102.10	102.10	102.10	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		100.00	100.00	100.00	0.00	0.00	1
12.5		100.40	100.40	100.40	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		93.10	93.10	93.10	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1
FSW Control	Salinity ppt	35.80	35.80	35.80	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.80	35.80	35.80	0.00	0.00	1
3.1		35.80	35.80	35.80	0.00	0.00	1
6.3		35.70	35.70	35.70	0.00	0.00	1
12.5		35.70	35.70	35.70	0.00	0.00	1
25		35.70	35.70	35.70	0.00	0.00	1
50		35.70	35.70	35.70	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1

Statistical Printouts for the *Nitzschia* Growth Inhibition Tests

Microalgal Cell Yield-Cell Yield

Start Date:	27/09/2019 19:30	Test ID:	PR1858/07	Sample ID:	Y0250919
End Date:	1/10/2019 19:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 110	Test Species:	NC-Nitzschia closterium
Comments:					

Conc-%	1	2	3	4	5	6	7	8
FSW Control	18.314	17.014	19.514	17.614	16.614	19.014	17.814	18.614
ASW Control	17.314	16.614	16.814	15.914				
1.6	18.614	19.014	17.714	20.714				
3.1	21.014	17.314	17.814	17.114				
6.3	8.114	5.914	10.114	8.714				
12.5	2.214	4.314	2.914	1.014				
25	0.000	0.000	0.000	0.000				
50	0.000	0.000	0.000	0.000				
100	0.000	0.000	0.000	0.000				

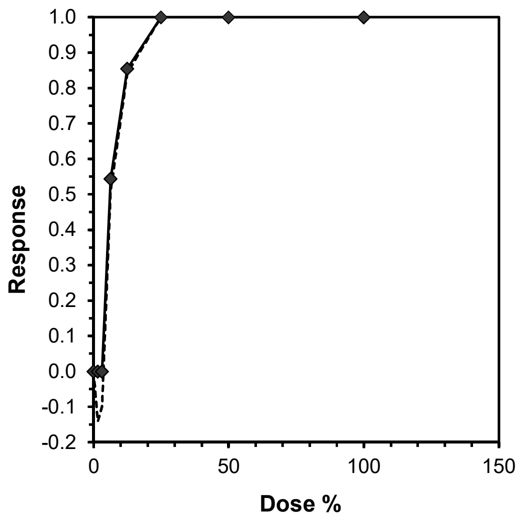
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	18.064	1.0840	18.064	16.614	19.514	5.472	8					
ASW Control	16.664	1.0000	16.664	15.914	17.314	3.482	4	*			17.997	1.0000
1.6	19.014	1.1410	19.014	17.714	20.714	6.611	4	-2.327	2.360	2.383	17.997	1.0000
3.1	18.314	1.0990	18.314	17.114	21.014	9.959	4	-1.634	2.360	2.383	17.997	1.0000
*6.3	8.214	0.4929	8.214	5.914	10.114	21.273	4	8.368	2.360	2.383	8.214	0.4564
*12.5	2.614	0.1569	2.614	1.014	4.314	52.734	4	13.914	2.360	2.383	2.614	0.1452
25	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
50	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
100	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.970155	0.905	0.427505	-0.08268
Bartlett's Test indicates equal variances (p = 0.51)	3.267247	13.2767		
The control means are significantly different (p = 0.03)	2.580344	2.228139		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	3.1	6.3	4.419276	32.25806	2.383094	0.143009	208.6	2.039333	1.1E-10	4, 15
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

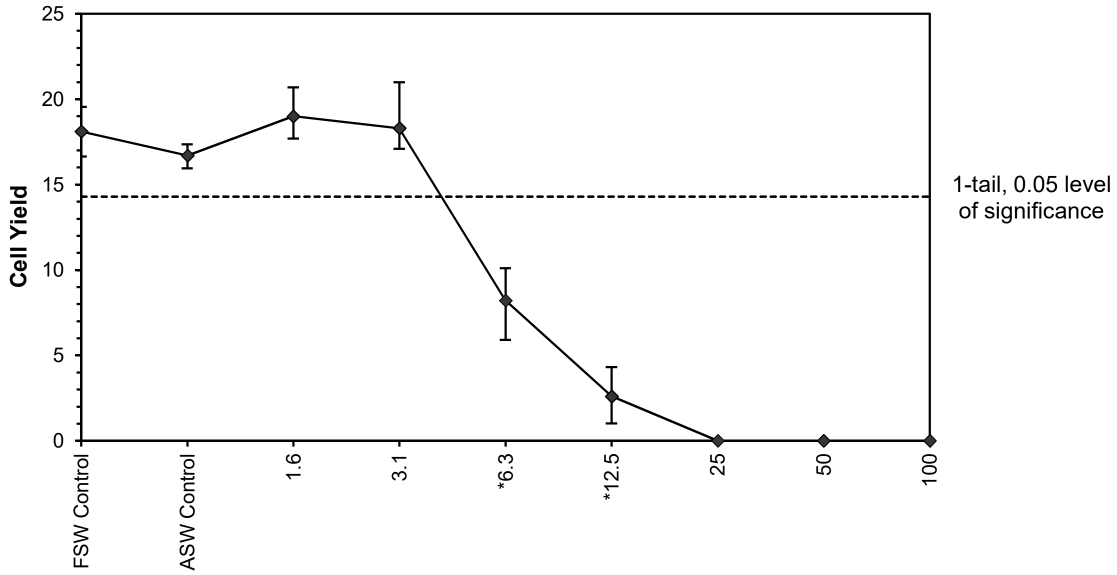
Point	%	SD	95% CL(Exp)		Skew
IC05	3.3943	0.0843	2.9935	3.4479	-1.8951
IC10	3.6887	0.0779	3.3296	3.8001	-1.1331
IC15	3.9830	0.0832	3.6401	4.1536	-0.6121
IC20	4.2773	0.0953	3.9400	4.5055	-0.2673
IC25	4.5717	0.1121	4.2001	4.8608	-0.0793
IC40	5.4547	0.1757	4.9306	5.9203	0.1581
IC50	6.0433	0.2582	5.4339	6.9275	0.8476



Microalgal Cell Yield-Cell Yield

Start Date:	27/09/2019 19:30	Test ID:	PR1858/07	Sample ID:	Y0250919
End Date:	1/10/2019 19:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 110	Test Species:	NC-Nitzschia closterium
Comments:					

Dose-Response Plot



Microalgal Cell Yield-Cell Yield

Start Date:	27/09/2019 19:30	Test ID:	PR1858/07	Sample ID:	Y0250919
End Date:	1/10/2019 19:30	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 110	Test Species:	NC-Nitzschia closterium
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	Cell Yield	18.06	16.61	19.51	0.99	5.50	8
ASW Control		16.66	15.91	17.31	0.58	4.57	4
1.6		19.01	17.71	20.71	1.26	5.90	4
3.1		18.31	17.11	21.01	1.82	7.37	4
6.3		8.21	5.91	10.11	1.75	16.09	4
12.5		2.61	1.01	4.31	1.38	44.92	4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.80	35.80	35.80	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.80	35.80	35.80	0.00	0.00	1
3.1		35.80	35.80	35.80	0.00	0.00	1
6.3		35.70	35.70	35.70	0.00	0.00	1
12.5		35.70	35.70	35.70	0.00	0.00	1
25		35.70	35.70	35.70	0.00	0.00	1
50		35.70	35.70	35.70	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1

Statistical Printouts for the Acute *Hormosira* Cell Germination Test

Macroalgal Germination Success Test-Proportion Germinated

Start Date:	27/09/2019 19:30	Test ID:	PR1858/03	Sample ID:	Y0250919
End Date:	30/09/2019 19:00	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 116	Test Species:	HB-Hormosira banksii
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9500	0.9800	0.9200	0.9700
ASW Control	0.9600	0.9500	0.9300	0.9900
1.6	0.9600	0.9100	0.9400	0.9800
3.1	0.9600	0.9300	0.9800	0.9500
6.3	0.9400	0.9100	0.9600	0.9300
12.5	0.6500	0.4100	0.6700	0.5700
25	0.3900	0.1200	0.1900	0.2600
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.9550	0.9974	1.3637	1.2840	1.4289	4.643	4					
ASW Control	0.9575	1.0000	1.3721	1.3030	1.4706	5.188	4	*			17	400
1.6	0.9475	0.9896	1.3469	1.2661	1.4289	5.129	4	0.401	2.410	0.1513	21	400
3.1	0.9550	0.9974	1.3617	1.3030	1.4289	3.860	4	0.166	2.410	0.1513	18	400
6.3	0.9350	0.9765	1.3155	1.2661	1.3694	3.274	4	0.902	2.410	0.1513	26	400
*12.5	0.5750	0.6005	0.8618	0.6949	0.9589	13.905	4	8.129	2.410	0.1513	170	400
*25	0.2400	0.2507	0.5036	0.3537	0.6745	26.989	4	13.835	2.410	0.1513	304	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.981601	0.916	-0.09971	0.299336
Bartlett's Test indicates equal variances (p = 0.38)	5.275941	15.08627		
The control means are not significantly different (p = 0.87)	0.175539	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	6.3	12.5	8.87412	15.87302	0.078607	0.081794	0.526421	0.007882	5.5E-11	5, 18
Treatments vs ASW Control										

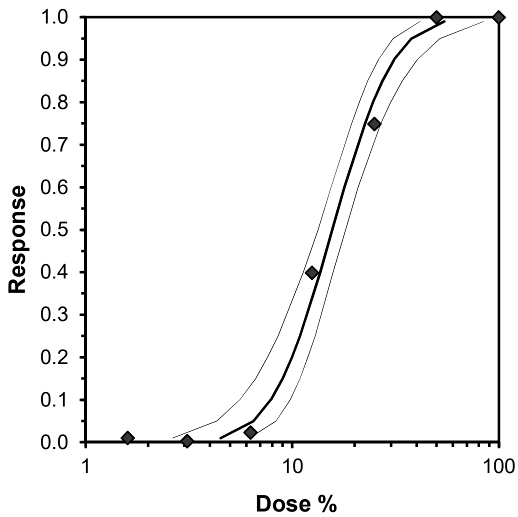
Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits	
Slope	4.301535	0.44916	3.146931	5.456138
Intercept	-0.1379	0.565265	-1.59096	1.315165
TSCR	0.044103	0.012778	0.011255	0.07695

Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
0.0425	23.77123	11.0705	2.4E-04	1.194433	0.232475	5

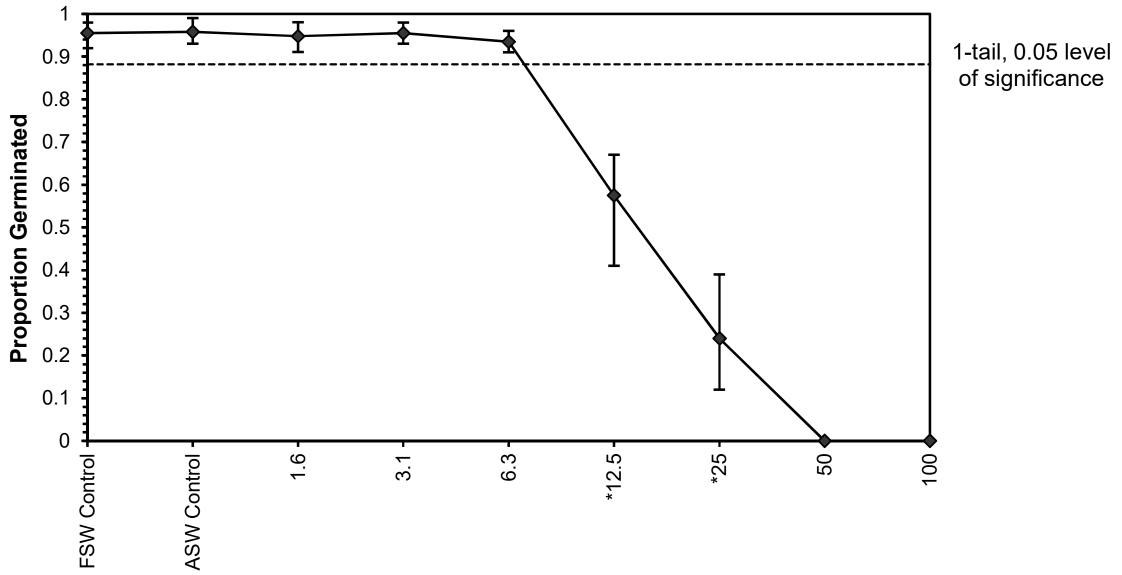
Point	Probits	%	95% Fiducial Limits	
EC01	2.674	4.504174	2.641494	6.197175
EC05	3.355	6.487026	4.311699	8.334077
EC10	3.718	7.879603	5.584404	9.785016
EC15	3.964	8.984383	6.637686	10.9229
EC20	4.158	9.971884	7.603767	11.93814
EC25	4.326	10.90514	8.53209	12.90182
EC40	4.747	13.66269	11.30799	15.82467
EC50	5.000	15.64708	13.2775	18.05275
EC60	5.253	17.91968	15.44643	20.786
EC75	5.674	22.45098	19.42831	26.86441
EC80	5.842	24.55214	21.13958	29.94037
EC85	6.036	27.25074	23.244	34.09206
EC90	6.282	31.07149	26.0878	40.30351
EC95	6.645	37.74165	30.78708	51.93311
EC99	7.326	54.35649	41.60597	84.35676

Significant heterogeneity detected (p = 2.40E-04)



Macroalgal Germination Success Test-Proportion Germinated					
Start Date:	27/09/2019 19:30	Test ID:	PR1858/03	Sample ID:	Y0250919
End Date:	30/09/2019 19:00	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 116	Test Species:	HB-Hormosira banksii
Comments:					

Dose-Response Plot



Macroalgal Germination Success Test-Proportion Germinated

Start Date:	27/09/2019 19:30	Test ID:	PR1858/03	Sample ID:	Y0250919
End Date:	30/09/2019 19:00	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 116	Test Species:	HB-Hormosira banksii
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	Germination, %	95.50	92.00	98.00	2.65	1.70	4
ASW Control		95.75	93.00	99.00	2.50	1.65	4
1.6		94.75	91.00	98.00	2.99	1.82	4
3.1		95.50	93.00	98.00	2.08	1.51	4
6.3		93.50	91.00	96.00	2.08	1.54	4
12.5		57.50	41.00	67.00	11.82	5.98	4
25		24.00	12.00	39.00	11.52	14.14	4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.80	35.80	35.80	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.80	35.80	35.80	0.00	0.00	1
3.1		35.80	35.80	35.80	0.00	0.00	1
6.3		35.70	35.70	35.70	0.00	0.00	1
12.5		35.70	35.70	35.70	0.00	0.00	1
25		35.70	35.70	35.70	0.00	0.00	1
50		35.70	35.70	35.70	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	DO %	99.60	99.60	99.60	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		102.10	102.10	102.10	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		100.00	100.00	100.00	0.00	0.00	1
12.5		100.40	100.40	100.40	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		93.10	93.10	93.10	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1

Statistical Printouts for the Larval Fish Imbalance Tests

Fish Acute Toxicity Test-96 hr Unaffected

Start Date:	27/09/2019 19:00	Test ID:	PR1858/06	Sample ID:	Y0250919
End Date:	1/10/2019 19:00	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 117	Test Species:	MN-Macquaria novemaculeata
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	0.8000	0.8000	1.0000
ASW Control	1.0000	0.8000	0.8000	1.0000
1.6	0.8000	0.8000	1.0000	1.0000
3.1	0.6000	0.6000	0.8000	0.4000
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

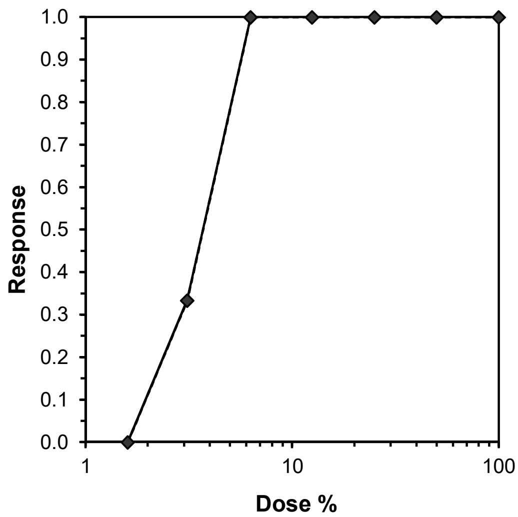
			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.9000	1.0000	1.2262	1.1071	1.3453	11.212	4					
ASW Control	0.9000	1.0000	1.2262	1.1071	1.3453	11.212	4	*			2	20
1.6	0.9000	1.0000	1.2262	1.1071	1.3453	11.212	4	0.000	2.180	0.2314	2	20
*3.1	0.6000	0.6667	0.8910	0.6847	1.1071	19.366	4	3.159	2.180	0.2314	8	20
6.3	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				20	20
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				20	20
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				20	20
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				20	20
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				20	20

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.895444	0.859	0.057516	-1.43497
Bartlett's Test indicates equal variances (p = 0.91)	0.187668	9.21034		
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	0.182504	0.206012	0.149821	0.022526	0.016848	2, 9
Treatments vs ASW Control										

Trimmed Spearman-Karber

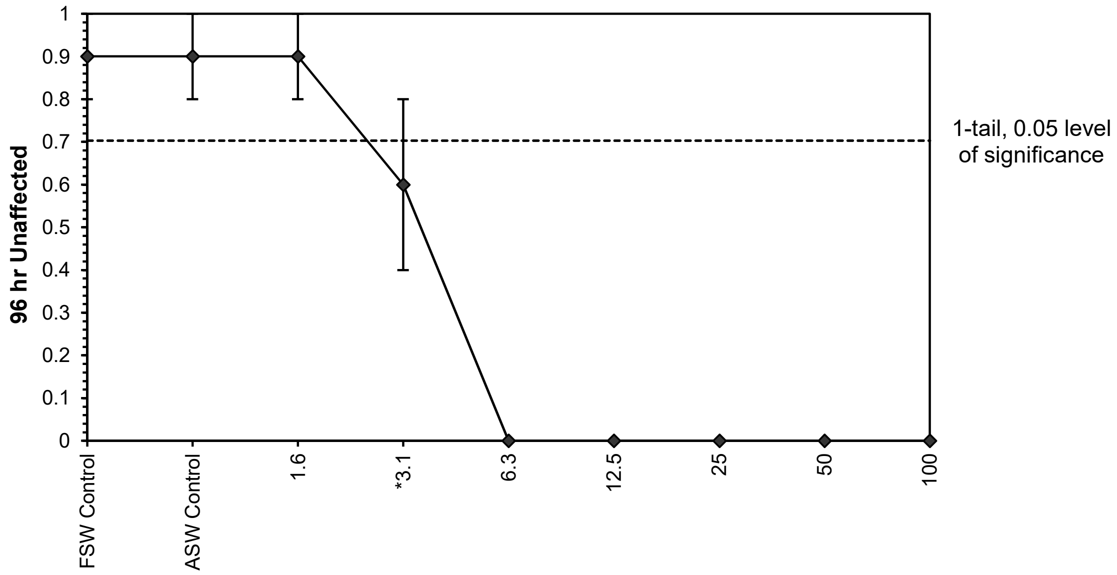
Trim Level	EC50	95% CL	
0.0%	3.5168	3.0437	4.0634
5.0%	3.5524	3.0218	4.1763
10.0%	3.5872	2.9774	4.3219
20.0%	3.6512	2.7833	4.7896
Auto-0.0%	3.5168	3.0437	4.0634



Fish Acute Toxicity Test-96 hr Unaffected

Start Date:	27/09/2019 19:00	Test ID:	PR1858/06	Sample ID:	Y0250919
End Date:	1/10/2019 19:00	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 117	Test Species:	MN-Macquaria novemaculeata
Comments:					

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Fish Acute Toxicity Test-96 hr Unaffected

Start Date:	27/09/2019 19:00	Test ID:	PR1858/06	Sample ID:	Y0250919
End Date:	1/10/2019 19:00	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 117	Test Species:	MN-Macquaria novemaculeata
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% unaffected	90.00	80.00	100.00	11.55	3.78	4
ASW Control		90.00	80.00	100.00	11.55	3.78	4
1.6		90.00	80.00	100.00	11.55	3.78	4
3.1		60.00	40.00	80.00	16.33	6.74	4
6.3		0.00	0.00	0.00	0.00		4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.80	35.80	35.80	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.80	35.80	35.80	0.00	0.00	1
3.1		35.80	35.80	35.80	0.00	0.00	1
6.3		35.70	35.70	35.70	0.00	0.00	1
12.5		35.70	35.70	35.70	0.00	0.00	1
25		35.70	35.70	35.70	0.00	0.00	1
50		35.70	35.70	35.70	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	DO %	99.60	99.60	99.60	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		102.10	102.10	102.10	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		100.00	100.00	100.00	0.00	0.00	1
12.5		100.40	100.40	100.40	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		93.10	93.10	93.10	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1

Fish Acute Toxicity Test-96 hr Unaffected

Start Date:	27/09/2019 19:00	Test ID:	PR1858/06	Sample ID:	Y0250919
End Date:	1/10/2019 19:00	Lab ID:	9252	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 117	Test Species:	MN-Macquaria novemaculeata
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	0.8000	0.8000	1.0000
ASW Control	1.0000	0.8000	0.8000	1.0000
1.6	0.8000	0.8000	1.0000	1.0000
3.1	0.6000	0.6000	0.8000	0.4000
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

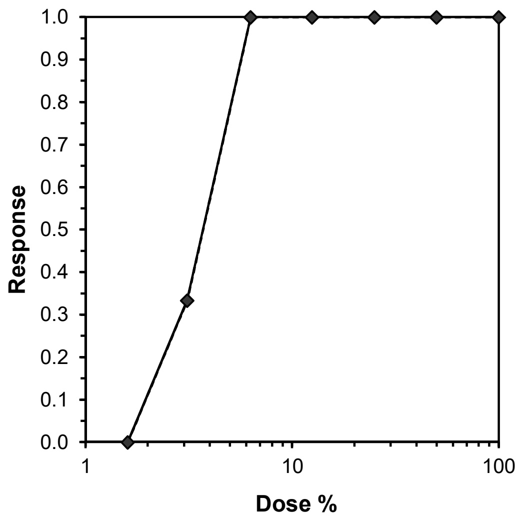
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.9000	1.0000	1.2262	1.1071	1.3453	11.212	4					
ASW Control	0.9000	1.0000	1.2262	1.1071	1.3453	11.212	4		*		0.9000	1.0000
1.6	0.9000	1.0000	1.2262	1.1071	1.3453	11.212	4	0.000	2.180	0.2314	0.9000	1.0000
*3.1	0.6000	0.6667	0.8910	0.6847	1.1071	19.366	4	3.159	2.180	0.2314	0.6000	0.6667
6.3	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.895444	0.859	0.057516	-1.43497
Bartlett's Test indicates equal variances (p = 0.91)	0.187668	9.21034		
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	0.182504	0.206012	0.149821	0.022526	0.016848	2, 9
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	1.8951	0.4157	0.0000	2.2252	-0.9916
IC10	2.1439	0.3236	0.8814	2.8397	-0.4616
IC15	2.3670	0.3059	1.0202	3.1809	-0.2162
IC20	2.5750	0.2961	1.4886	3.4503	-0.2842
IC25	2.7745	0.2697	1.7863	3.4026	-0.3367
IC40	3.1607	0.1279	2.5292	3.3745	-1.5697
IC50	3.2518	0.0790	3.0065	3.4562	-0.6610



Statistical Printouts for the 7-d Larval Fish Growth Inhibition Tests

Fish Growth Test-7 Day Unaffected

Start Date:	27/09/2019 19:30	Test ID:	PR1858/11	Sample ID:	Y0250919
End Date:	4/10/2019 19:30	Lab ID:	9252	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	0.6000	0.6000	0.4000	0.6000
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

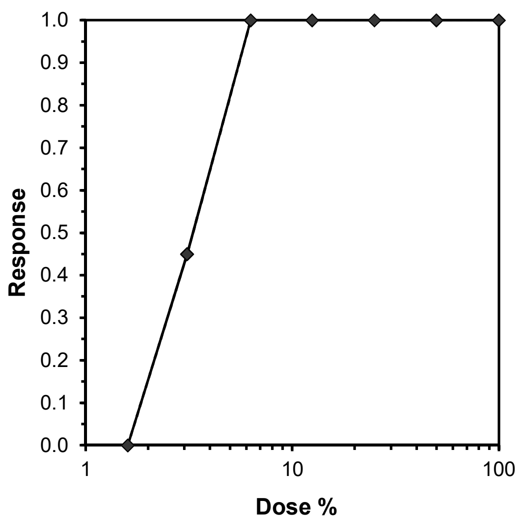
			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		0	20
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	11.00	0	20
*3.1	0.5500	0.5500	0.8357	0.6847	0.8861	12.047	4	10.00	11.00	9	20
6.3	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.633513	0.859	-2.29783	7.088889
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	1.6	3.1	2.227106	62.5
Treatments vs ASW Control				

Trimmed Spearman-Karber

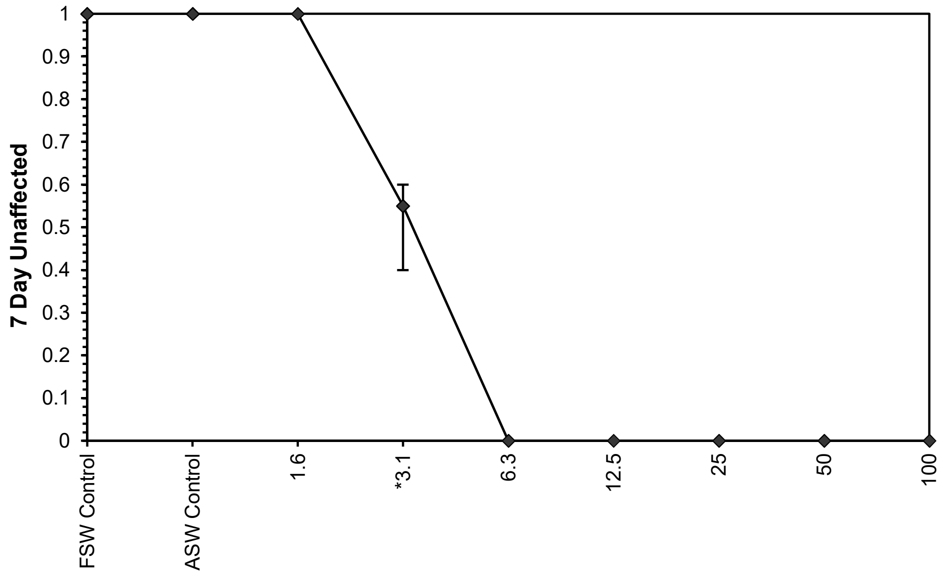
Trim Level	EC50	95% CL	
0.0%	3.2466	2.7875	3.7813
5.0%	3.2538	2.7460	3.8556
10.0%	3.2611	2.6918	3.9508
20.0%	3.2755	2.5232	4.2521
Auto-0.0%	3.2466	2.7875	3.7813



Fish Growth Test-7 Day Unaffected

Start Date:	27/09/2019 19:30	Test ID:	PR1858/11	Sample ID:	Y0250919
End Date:	4/10/2019 19:30	Lab ID:	9252	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Dose-Response Plot



Fish Growth Test-7 Day Unaffected

Start Date:	27/09/2019 19:30	Test ID:	PR1858/11	Sample ID:	Y0250919
End Date:	4/10/2019 19:30	Lab ID:	9252	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Un-affected	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		55.00	40.00	60.00	10.00	5.75	4
6.3		0.00	0.00	0.00	0.00		4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	Biomass	22.40	20.18	24.20	1.89	6.13	4
ASW Control		22.09	19.94	24.38	2.46	7.10	4
1.6		20.58	18.98	22.16	1.57	6.10	4
3.1		10.83	8.06	11.80	1.84	12.54	4
6.3		0.00	0.00	0.00	0.00		4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity	35.80	35.80	35.80	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.80	35.80	35.80	0.00	0.00	1
3.1		35.80	35.80	35.80	0.00	0.00	1
6.3		35.70	35.70	35.70	0.00	0.00	1
12.5		35.70	35.70	35.70	0.00	0.00	1
25		35.70	35.70	35.70	0.00	0.00	1
50		35.70	35.70	35.70	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	% DO	99.60	99.60	99.60	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		102.10	102.10	102.10	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		100.00	100.00	100.00	0.00	0.00	1
12.5		100.40	100.40	100.40	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		93.10	93.10	93.10	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1

Fish Growth Test-7 Day Unaffected

Start Date:	27/09/2019 19:30	Test ID:	PR1858/11	Sample ID:	Y0250919
End Date:	4/10/2019 19:30	Lab ID:	9252	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	0.6000	0.6000	0.4000	0.6000
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

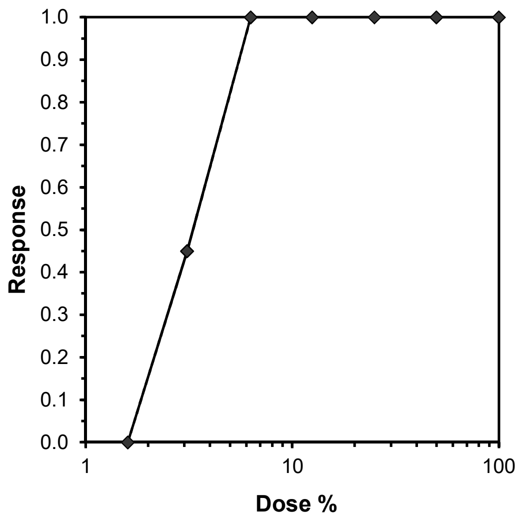
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		1.0000	1.0000
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	11.00	1.0000	1.0000
*3.1	0.5500	0.5500	0.8357	0.6847	0.8861	12.047	4	10.00	11.00	0.5500	0.5500
6.3	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.633513	0.859	-2.29783	7.088889
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	1.6	3.1	2.227106	62.5
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	2.5690	0.0224	2.4923	2.6112	-0.5832
IC10	2.7064	0.0260	2.6174	2.7555	-0.5813
IC15	2.7941	0.0284	2.6970	2.8477	-0.5801
IC20	2.8615	0.0303	2.7581	2.9186	-0.5792
IC25	2.9180	0.0318	2.8094	2.9781	-0.5785
IC40	3.0578	0.0358	2.9357	3.1253	-0.5768
IC50	3.1507	0.0432	3.0061	3.2311	-0.5273



Fish Growth Test-7 day Biomass

Start Date:	27/09/2019 19:30	Test ID:	PR1858/11	Sample ID:	Y0250919
End Date:	4/10/2019 19:30	Lab ID:	9252	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	23.700	24.200	20.180	21.500
ASW Control	19.980	19.940	24.060	24.380
1.6	21.680	22.160	19.500	18.980
3.1	11.800	11.740	8.060	11.700
6.3	0.000	0.000	0.000	0.000
12.5	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000
50	0.000	0.000	0.000	0.000
100	0.000	0.000	0.000	0.000

			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	22.395	1.0138	22.395	20.180	24.200	8.420	4					
ASW Control	22.090	1.0000	22.090	19.940	24.380	11.150	4	*			22.090	1.0000
1.6	20.580	0.9316	20.580	18.980	22.160	7.648	4	1.070	2.180	3.076	20.580	0.9316
*3.1	10.825	0.4900	10.825	8.060	11.800	17.033	4	7.984	2.180	3.076	10.825	0.4900
6.3	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
12.5	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
25	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
50	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
100	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000

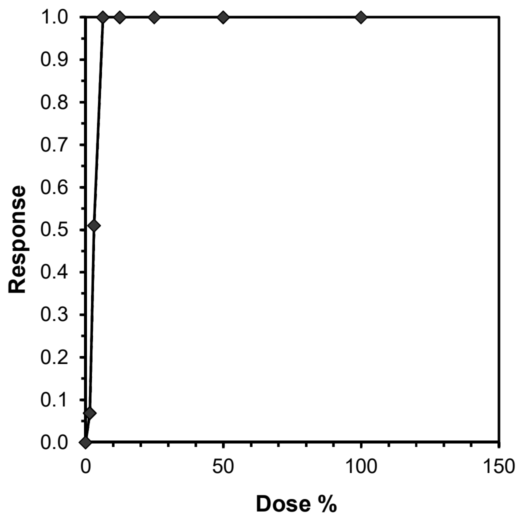
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.882251	0.859	-0.34393	-1.65716
Bartlett's Test indicates equal variances (p = 0.76)	0.551451	9.21034		
The control means are not significantly different (p = 0.85)	0.196645	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	3.075745	0.139237	149.5602	3.981233	4.3E-05	2, 9
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05*	1.1703	0.4380	0.0597	2.1276	-0.1603
IC10	1.7075	0.2517	0.4993	2.0752	-1.4779
IC15	1.8773	0.1593	1.1592	2.2431	-1.0802
IC20	2.0472	0.1365	1.5410	2.4110	-0.5000
IC25	2.2170	0.1298	1.7899	2.5792	-0.3700
IC40	2.7265	0.1259	2.3538	3.0930	0.0248
IC50	3.0662	0.1740	2.6876	3.6711	0.5220

* indicates IC estimate less than the lowest concentration



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SERVICES AUSTRALIA

Toxicity Assessment of Produced Formation Water from the BASGAS Yolla Facility

Beach Energy Ltd

Test Report- Round 2

October 2019

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ECOTOX SERVICES AUSTRALIA PTY LIMITED
ABN 95 619 426 201

NATA
WORLD RECOGNISED ACCREDITATION

Toxicity Test Report: TR1858/9

Accredited for compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 2 October 2019 3 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9259	Y0021019	Produced Formation Water, pH 6.5*, salinity 17.7 ‰*, total ammonia 32.6mg/L*. Sample received at 12ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	1-hr sea urchin fertilisation success test using *Heliocidaris tuberculata*
Test Protocol:	ESA SOP 104 (ESA 2014), based on USEPA (2002) and Simon and Laginestra (1996)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Field collected from South Maroubra, NSW.
Test Initiated:	08 October 2019 at 1420h

Sample 9259: *Y0021019*

Concentration (%)	**% Fertilised Eggs (Mean ± SD)**	*Vacant*	*Vacant*
FSW Control	95.3 ± 1.7		
ASW Control	94.5 ± 1.3		
1.6	94.8 ± 1.5		
3.1	75.5 ± 13.3 *		
6.3	0.0 ± 0.0		
12.5	0.0 ± 0.0		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		

IC10 = 2.5 (2.09-3.30)%
EC50 = 3.8 (3.74-3.96)%
NOEC = 1.6%
LOEC = 3.1%

*Significantly lower percentage fertilised eggs compared with the ASW Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)

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Toxicity Test Report: TR1858/9

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % fertilised eggs	≥70.0%	95.3%	Yes
Reference Toxicant within cusum chart limits	48.6-66.5µg Cu/L	55.2µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 October 2019

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

This document shall not be reproduced except in full.

Citations:

ESA (2014) ESA SOP 104 - *Sea Urchin Fertilisation Success Test*. Issue No. 13. Ecotox Services Australasia, Sydney NSW.

Simon, J. and Laginestra, E.(1997) Bioassay for testing sublethal toxicity in effluents, using gametes of sea urchin *Heliocidaris tuberculata*. National Pulp Mills Research Program Technical Report No. 20. CSIRO, Canberra ACT

USEPA (2002) Short-term methods for measuring the chronic toxicity of effluents and receiving waters to marine and estuarine organisms. Third Edition. United States Environmental Protection Agency, Office of Water, Washington DC, EPA-821-R-02-014.

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Toxicity Test Report: TR1858/10

Accredited for compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 2 October 2019 3 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9259	Y0021019	Produced Formation Water, pH 6.5*, salinity 17.7 ‰*, total ammonia 32.6mg/L*. Sample received at 12ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	72-hr sea urchin larval development test using *Heliocidaris tuberculata*
Test Protocol:	ESA SOP 105 (ESA 2016), based on APHA (1998), Simon and Laginestra (1996) and Doyle *et al*. (2003)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Field collected from South Maroubra, NSW.
Test Initiated:	08 October 2019 at 1400h

Sample 9259: *Y0021019*		*Vacant*	*Vacant*
Concentration (%)	**% Normal larvae (Mean ± SD)**		
FSW Control	94.0 ± 3.4		
ASW Control	96.3 ± 1.0		
1.6	95.0 ± 1.8		
3.1	85.5 ± 9.0 *		
6.3	0.0 ± 0.0		
12.5	0.0 ± 0.0		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		
72-hr EC10 = 3.0 (2.23-3.41)% **72-hr EC50 = 4.1 (4.01-4.20)%** **NOEC = 1.6%** **LOEC = 3.1%**			

*Significantly lower percentage of normally developed larvae compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

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Toxicity Test Report: TR1858/10

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % normal larvae	≥70.0%	94.0%	Yes
Reference Toxicant within cusum chart limits	9.6-13.6µg Cu/L	11.1µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 October 2019

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

APHA (1998) Method 8810 D. Echinoderm Embryo Development Test. In Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association and the Water Environment Federation, USA.

Doyle, C.J., Pablo, F., Lim, R.P. and Hyne, R.V. (2003) Assessment of metal toxicity in sediment pore water from Lake Macquarie, Australia. *Arch. Environ. Contam. Toxicology*, 44(3): 343-350.

ESA (2016) *ESA SOP 105 - Sea Urchin Larval Development Test*. Issue No. 11. Ecotox Services Australasia, Sydney NSW.

Simon, J. and Laginestra, E.(1997) Bioassay for testing sublethal toxicity in effluents, using gametes of sea urchin *Heliocidaris tuberculata*. National Pulp Mills Research Program Technical Report No. 20. CSIRO, Canberra, ACT.

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Toxicity Test Report: TR1858/11

Accredited for compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 2 October 2019 3 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9259	Y0021019	Produced Formation Water, pH 6.5*, salinity 17.7 ‰*, total ammonia 32.6mg/L*. Sample received at 12ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	48-hr larval development test using the mussel *Mytilus galloprovincialis*
Test Protocol:	ESA SOP 106 (ESA 2016), based on APHA (1998) and USEPA (1996)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	The test was extended to 72hr
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Farm-reared, Mercury Passage, TAS
Test Initiated:	04 October 2019 at 1600 h

Sample 9259: *Y0021019*

Concentration (%)	**% Normal larvae (Mean ± SD)**
FSW Control	78.8 ± 1.7
ASW Control	80.3 ± 3.3
1.6	81.0 ± 3.6
3.1	64.5 ± 10.2 *
6.3	0.0 ± 0.0
12.5	0.0 ± 0.0
25	0.0 ± 0.0
50	0.0 ± 0.0
100	0.0 ± 0.0

72-hr EC10 =2.3 (1.80-3.57)%
72-hr EC50 =3.9 (3.75-3.96)%
NOEC = 1.6%
LOEC = 3.1%

Vacant

Vacant

*Significantly lower percentage of normally developed larvae compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

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Toxicity Test Report: TR1858/11

QA/QC Parameter	Criterion	This Test	Criterion met?
FSW Control mean % normal	≥70%	78.8%	Yes
Reference Toxicant within cusum chart limits	7.5-15.3µg Cu/L	10.4µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 October 2019

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

APHA (1998) *Standard Methods for the Examination of Water and Wastewater*. 20th Ed. American Public Health Association, American Water Works Association and the Water Environment Federation, Washington, DC, USA.

ESA (2016) *Bivalve Larval Development Test*. Issue No. 15. Ecotox Services Australasia, Sydney, NSW

USEPA (1996) *Bivalve acute toxicity test (embryo larval) OPPTS 850.1055. Ecological Effects Test Guidelines.* United States Environmental Protection Agency. Prevention, Pesticides and Toxic Substances. EPA/712/C-96/137.

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Toxicity Test Report: TR1858/12

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 2 October 2019 3 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9259	Y0021019	Produced Formation Water, pH 6.5*, salinity 17.7 ‰*, total ammonia 32.6mg/L*. Sample received at 12ºC* in apparent good condition.

Test Performed:	96-hr acute toxicity test using the amphipod *Allorchestes compressa*
Test Protocol:	ESA SOP 108 (ESA 2017), based on USEPA (2002) and Department of Transport and Communications (1990)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	In-house culture, originally sourced from Queenscliff, VIC
Test Initiated:	04 October 2019 at 1830h

Sample 9259: *Y0021019*		*Vacant*	*Vacant*
Concentration (%)	**% Unaffected (Mean ± SD)**		
FSW Control	100 ± 0.0		
ASW Control	95.0 ± 10.0		
1.6	100 ± 0.0		
3.1	100 ± 0.0		
6.3	100 ± 0.0		
12.5	5.0 ± 10.0 *		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		
96-hr EC10 = 7.9 (6.35-10.73)% **96-hr EC50 = 9.2 (8.59-9.83)%** **NOEC = 6.3%** **LOEC = 12.5%**			

*Significantly lower percent unaffected compared with the ASW Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)

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Toxicity Test Report: TR1858/12

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % unaffected	≥90.0%	100%	Yes
Reference Toxicant within cusum chart limits	0.5-8.6mg SDS/L	3.3mg SDS/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 October 2019

Results are based on the samples in the condition as received by ESA.
This document shall not be reproduced except in full.

Citations:

Department of Transport and Communications (1990) Guidelines for Acceptance of Oil Spill Dispersants in Australian Waters. Pollution Prevention Section, Department of Transport and Communications, Canberra ACT.

ESA (2017) SOP 108 – *Amphipod Acute Toxicity Test*. Issue No 10. Ecotox Services Australia, Sydney, NSW.

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth Edition. United States Environmental Protection Agency, Office of Research and Development, Washington DC, EPA/600/4-90/027F.

Toxicity Test Report: TR1858/13

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 2 October 2019 3 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9259	Y0021019	Produced Formation Water, pH 6.5*, salinity 17.7 ‰*, total ammonia 32.6mg/L*. Sample received at 12ºC* in apparent good condition.

Test Performed:	72-hr marine algal growth test using *Nitzschia closterium*
Test Protocol:	ESA SOP 110 (ESA 2016), based on Stauber *et al*. (1994)
Test Temperature:	The test was performed at 21±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was filtered to 0.45µm and serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	In-house culture, originally sourced from CSIRO Microalgae Supply Service, TAS
Test Initiated:	04 october 2019 at 1630h

Sample 9259: *Y0021019*		*Vacant*	*Vacant*
Concentration (%)	**Cell Yield (Mean number of cells/mL x10⁴ ± SD)**		
FSW Control	16.6 ± 0.9		
ASW Control	15.8 ± 0.8		
1.6	16.6 ± 1.0		
3.1	10.7 ± 1.9 *		
6.3	1.1 ± 1.4 *		
12.5	0.0 ± 0.0		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		

72-hr IC10 = 2.0 (1.89-2.32%
72-hr IC50 = 4.0 (3.31-4.54)%
NOEC = 1.6%
LOEC = 3.1%

*Significantly lower cell yield compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean cell density	≥16.0x10^4 cells/mL	17.7x10^4 cells/mL	Yes
Control coefficient of variation	<20%	5.3%	Yes
Reference Toxicant within cusum chart limits	3.1-9.2µg Cu/L	6.2µg Cu/L	Yes

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Toxicity Test Report: TR1858/13

Test Report Authorised by: Dr Rick Krassoi, Director on 25 October 2019

Results are based on the samples in the condition as received by ESA.
This document shall not be reproduced except in full.

Citations:

ESA (2016) SOP 110 – *Marine Algal Growth Test*. Issue No. 12. Ecotox Services Australasia, Sydney NSW

Stauber, J.L., Tsai, J., Vaughan, G.T., Peterson, S.M. and Brockbank, C.I. (1994) Algae as indicators of toxicity of the effluent from bleached eucalypt kraft pulp mills. National Pulp Mills Research Program, Technical Report No. 3. CSIRO, Canberra, ACT

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Toxicity Test Report: TR1858/14

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 2 October 2019 3 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9259	Y0021019	Produced Formation Water, pH 6.5*, salinity 17.7 ‰*, total ammonia 32.6mg/L*. Sample received at 12ºC* in apparent good condition.

Test Performed:	72-hr macroalgal germination success test using *Hormosira banksii*
Test Protocol:	ESA SOP 116 (ESA 2014), based on Kevekordes and Clayton (1996) and Gunthorpe *et al*. (1997)
Test Temperature:	The test was performed at 18±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Field collected from Bilgola, NSW.
Test Initiated:	04 October 2019 at 1630h

Sample 9259: *Y0021019*		*Vacant*	*Vacant*
Concentration (%)	**% Germination (Mean ± SD)**		
FSW Control	94.0 ± 1.8		
ASW Control	93.0 ± 3.2		
1.6	93.3 ± 2.5		
3.1	92.8 ± 1.7		
6.3	92.5 ± 2.1		
12.5	87.3 ± 6.4		
25	4.8 ± 2.8 *		
50	0.0 ± 0.0		
100	0.0 ± 0.0		
72-hr EC10 = 13.3 (12.37-14.03)% **72-hr EC50 = 17.6 (16.76-18.24)%** **NOEC = 12.5%** **LOEC = 25%**			

*Significantly lower percentage of germinated zygotes compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

Toxicity Test Report: TR1858/14

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % germination	≥70.0%	94.0%	Yes
Reference Toxicant within cusum chart limits	110.1-266.95µg Cu/L	168.3µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 October 2019

Results are based on the samples in the condition as received by ESA.

Citations:

ESA (2014) *SOP 116 – Macroalgal Germination Success Test*. Issue No. 13. Ecotox Services Australasia, Sydney.

Gunthorpe L, Nottage M, Palmer D, and Wu R (1997) *Testing for Sublethal Toxicity Using Gametes of Hormosira banksii: protocol*. National Pulp Mills Research Program Technical Report No. 22, CSIRO, Canberra.

Kevekordes K and Clayton MN (1996) Using developing embryos of *Hormosira banksii* (Phaeophyta) as a marine bioassay system. *International Journal of Plant Science*, 157: 582-585.

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Toxicity Test Report: TR1858/15

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 2 October 2019 3 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	Sample Name:	Sample Description:
9259	Y0021019	Produced Formation Water, pH 6.5*, salinity 17.7 ‰*, total ammonia 32.6mg/L*. Sample received at 12ºC* in apparent good condition.

Test Performed:	96-hr fish imbalance toxicity test using the Bass Macqauria novemaculeata.
Test Protocol:	ESA SOP 117 (ESA 2016), based on USEPA (2002)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample
Source of Test Organisms:	In-house cultures
Test Initiated:	03 October 2019 at 1700h

Sample 9259: *Y0021019*

Concentration (%)	% Unaffected (Mean ± SD)
FSW Control	90.0 ± 11.6
ASW Control	95.0 ± 10.0
1.6	95.0 ± 10.0
3.1	95.0 ± 10.0
6.3	45.0 ± 25.2
12.5	0.0 ± 0.0
25	0.0 ± 0.0
50	0.0 ± 0.0
100	0.0 ± 0.0

96-hr IC10 = 4.1%*
96-hr EC50 = 6.1 (5.26-7.18)%
NOEC =6.3%
LOEC = 12.5%

Vacant

Vacant

**\ The 95% Confidence Limits are not reliable.

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % unaffected	>80.0%	90.0%	Yes
Reference Toxicant within cusum chart limits	85.9-2437.6µg Cu/L	606.2µg Cu/L	Yes

Toxicity Test Report: TR1858/15

Test Report Authorised by: Dr Rick Krassoi, Director on 25 October 2019

Results are based on the samples in the condition as received by ESA.
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Citations:

ESA (2016) SOP 117 –*Freshwater and Marine Fish Imbalance Test*. Issue No 12. Ecotox Services Australasia, Sydney, NSW

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth edition EPA-821-R-02-012. United States Environmental Protection Agency, Office of Research and Development, Washington FC, USA

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Toxicity Test Report: TR1858/8

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 2 October 2019 3 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9259	Y0021019	Produced Formation Water, pH 6.5*, salinity 17.7 ‰*, total ammonia 32.6mg/L*. Sample received at 12ºC* in apparent good condition.

Test Performed:	7-day fish imbalance and biomass toxicity test using barramundi *Lates calcarifer*
Test Protocol:	ESA SOP 122 (ESA 2017), based on USEPA (2002)
Test Temperature:	The test was performed at 25±2°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Hatchery reared, SA
Size of Test Organisms:	12-15mm
Test Initiated:	04 October 2019 at 1800h

Sample 9259: *Y0021019*

Concentration (%)	**% Unaffected (Mean ± SD)**	**Biomass, mg (Mean ± SD)**
FSW Control	100 ± 0.0	16.8 ± 1.0
ASW Control	100 ± 0.0	17.6 ± 1.8
1.6	100 ± 0.0	17.8 ± 1.0
3.1	100 ± 0.0	16.4 ± 0.9
6.3	0.0 ± 0.0	0.0 ± 0.0
12.5	0.0 ± 0.0	0.0 ± 0.0
25	0.0 ± 0.0	0.0 ± 0.0
50	0.0 ± 0.0	0.0 ± 0.0
100	0.0 ± 0.0	0.0 ± 0.0

7 day IC10 (unaffected) = 4.1%*
7 day IC50 (unaffected) = 4.5%*
NOEC = 3.1%
LOEC = 6.3%

7 day IC10 (biomass) = 3.2 (0.98-3.52)%
7 day IC50 (biomass) =4.6 (4.30-4.75) %
NOEC = 3.1%
LOEC = 6.3%

*The 95% Confidence Limits are not available

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Toxicity Test Report: TR1858/8

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % unaffected	≥80.0%	100%	Yes
Control mean growth	≥20% of initial weight	-	No
Reference Toxicant within cusum chart limits	10.7-114.8mg NH_4^+/L	46.3mg NH_4^+/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 October 2019

Results are based on the samples in the condition as received by ESA. This document shall not be reproduced except in full.

Citations:

ESA (2017) SOP 122 –*7-day Fish Imbalance and Growth Test*. Issue No 6. Ecotox Services Australasia, Sydney, NSW

USEPA (2002) Short-term methods for estimating the chronic toxicity of effluents and receiving waters to marine and estuarine organisms. Third edition EPA-821-R-02-014. United States Environmental Protection Agency, Office of Research and Development, Washington FC, USA

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Chain-of-Custody Documentation

Datasheet ID: 601.2
Last Revised: 21 September 2018

Sample Receipt Notification

Attention : Peter Young

Client : AECOM Australia Pty Ltd
Level 6, 3 Forrest Place
Perth WA 6849

Email : peter.young@aecom.com
Telephone : 08 6208 0000
Facsimile :

Date : 8/10/2019

Re : Receipt of Samples **Pages :** **2**

ESA Project : PR1858 ☑ For Review ☐ Additional Documentation Required - Please Respond

Sample Delivery Details

Completed Chain of Custody accompanied samples:	**YES**
Samples received in apparent good condition and correctly bottled:	**YES**
Security seals on sample bottles and esky intact:	**YES**

Date samples received : 3/10/2019
Time samples received : 10:30
No. of samples received : 1
Sample matrix : Aqueous
Sample temperature : 6-10°C

Comments : 4 x 2.5L sample received at 9oC in apparent good condition

Contact Details

Projects Manager : Dr Rick Krassoi
Telephone : 61 2 9420 9481
Facsimile : 61 2 9420 9484
Email : rkrassoi@ecotox.com.au

Please contact customer services officer for all queries or issues regarding samples

Note that the chain-of-custody provides definitive information on the tests to be performed

Chain-of-Custody / Service Request Form

Datasheet ID: 601.1
Last Revised: 20 September 2018

ecotox SERVICES AUSTRALIA

Customer: Search Energy
Contact Name: Adrian Cukovski
Phone:
Email: Adrian.cukovski@searchenergy.com.au (please provide an email address for sample receipt notification)
Sampled by: D.MCLACHLAN

Ship To: Ecotox Services Aust
Attention: Rich Kritsch

Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab. composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance): 96 h Allorchestes Acute / 96 h Barra FIT	72 h Nitzschia / 72 h Hormosira	48 h Mussel / 1 h Sea urchin fert.	72 h Sea urchin dev.	7 d FIT & Growth	Sub-sampling for Ecotox	Comments / Instructions
2/10/19	06:00	Y0021019-1	Grab	4 x 25L	/	/	/	/	/	/	
"	06:00	Y0021019-2	"	"	/	/	/	/	/	/	
"	06:00	Y0021019-3	"	"	/	/	/	/	/	/	
"	06:00	Y0021019-4	"	"	/	/	/	/	/	/	

Comments / Instructions

Note that testing will be delayed if an incomplete chain of custody is received

- Additional treatment of samples (i.e. spiking)
- Sub-contracted services (i.e. chemical analyses)
- Dilutions required (if different than 100% down to 6.25%)
- Sample holding time restriction (if applicable)
- Sample used for litigation (if applicable)

Note: An MSDS must be attached if Available

ESA Project Number: PR 18558

9°C

9259

1) Released By: D.McLachlan	Date: 2/10/19	2) Received By: [signature]	Date: 3/10/19	3) Released By:	Date:	4) Received By:	Date:
Of: Yolla	Time: 12:00	Of: ESA	Time: 1030	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

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Phone: 61 2 9420-9481 Fax 61 2 9420-9484 info@ecotox.com.au

Page 1 of 1

Statistical Printouts for the Sea Urchin Fertilisation Test

Sea Urchin Fertilisation Test-Proportion Fertilised

Start Date:	8/10/2019 14:20	Test ID:	PR1858/109	Sample ID:	Y0021019
End Date:	8/10/2019 15:40	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 104	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9500	0.9600	0.9300	0.9700
ASW Control	0.9500	0.9400	0.9300	0.9600
1.6	0.9400	0.9600	0.9300	0.9600
3.1	0.8600	0.7900	0.8100	0.5600
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

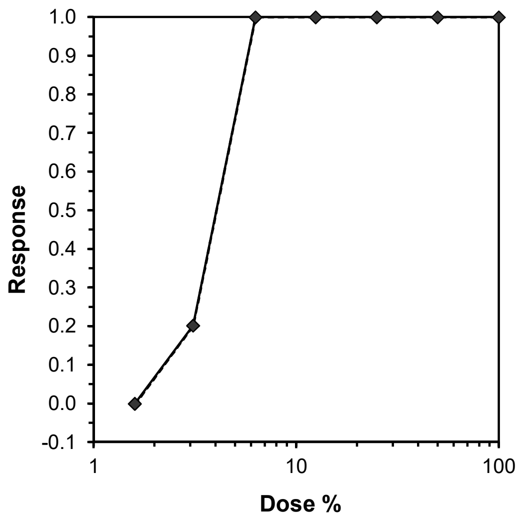
			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
FSW Control	0.9525	1.0079	1.3536	1.3030	1.3967	2.935	4				
ASW Control	0.9450	1.0000	1.3353	1.3030	1.3694	2.140	4	*		22	400
1.6	0.9475	1.0026	1.3413	1.3030	1.3694	2.499	4	19.00	11.00	21	400
*3.1	0.7550	0.7989	1.0618	0.8455	1.1873	14.070	4	10.00	11.00	98	400
6.3	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.838216	0.859	-1.60666	4.802703
Bartlett's Test indicates equal variances (p = 0.01)	8.495721	9.21034		
The control means are not significantly different (p = 0.48)	0.749736	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	1.6	3.1	2.227106	62.5
Treatments vs ASW Control				

Trimmed Spearman-Karber

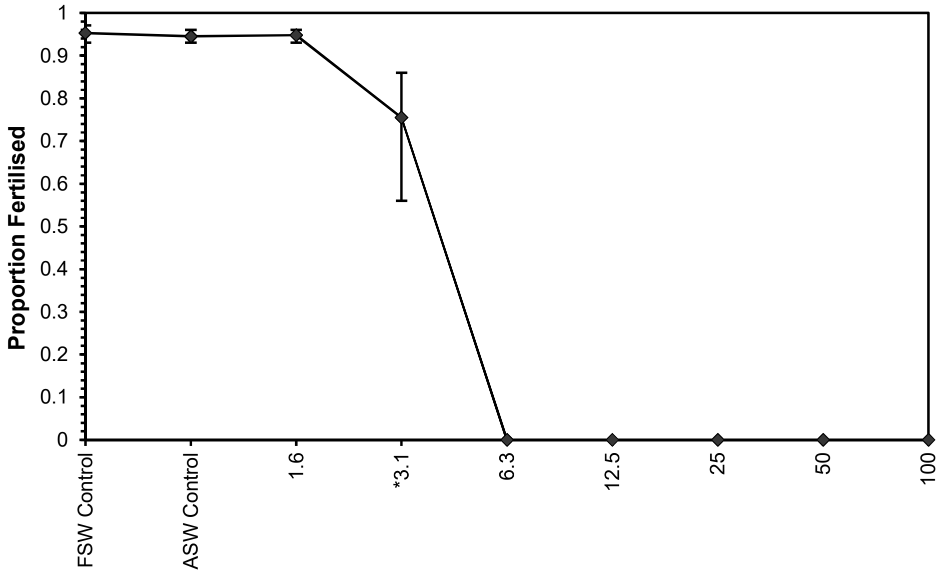
Trim Level	EC50	95% CL	
0.0%	3.8477	3.7432	3.9550
5.0%	3.9177	3.7966	4.0428
10.0%	3.9774	3.8284	4.1322
20.0%	4.0396	3.7814	4.3154
Auto-0.0%	3.8477	3.7432	3.9550



Sea Urchin Fertilisation Test-Proportion Fertilised

Start Date:	8/10/2019 14:20	Test ID:	PR1858/109	Sample ID:	Y0021019
End Date:	8/10/2019 15:40	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 104	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Dose-Response Plot



Sea Urchin Fertilisation Test-Proportion Fertilised

Start Date:	8/10/2019 14:20	Test ID:	PR1858/109	Sample ID:	Y0021019
End Date:	8/10/2019 15:40	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 104	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	% Fertilised	95.25	93.00	97.00	1.71	1.37	4
ASW Control		94.50	93.00	96.00	1.29	1.20	4
1.6		94.75	93.00	96.00	1.50	1.29	4
3.1		75.50	56.00	86.00	13.33	4.84	4
6.3		0.00	0.00	0.00	0.00		4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.20	8.20	8.20	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
FSW Control	Salinity ppt	35.90	35.90	35.90	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.90	35.90	35.90	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	DO %	99.30	99.30	99.30	0.00	0.00	1
ASW Control		99.40	99.40	99.40	0.00	0.00	1
1.6		98.90	98.90	98.90	0.00	0.00	1
3.1		99.70	99.70	99.70	0.00	0.00	1
6.3		99.50	99.50	99.50	0.00	0.00	1
12.5		99.50	99.50	99.50	0.00	0.00	1
25		99.90	99.90	99.90	0.00	0.00	1
50		89.10	89.10	89.10	0.00	0.00	1
100		69.30	69.30	69.30	0.00	0.00	1

Sea Urchin Fertilisation Test-Proportion Fertilised

Start Date:	8/10/2019 14:20	Test ID:	PR1858/109	Sample ID:	Y0021019
End Date:	8/10/2019 15:40	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 104	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9500	0.9600	0.9300	0.9700
ASW Control	0.9500	0.9400	0.9300	0.9600
1.6	0.9400	0.9600	0.9300	0.9600
3.1	0.8600	0.7900	0.8100	0.5600
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

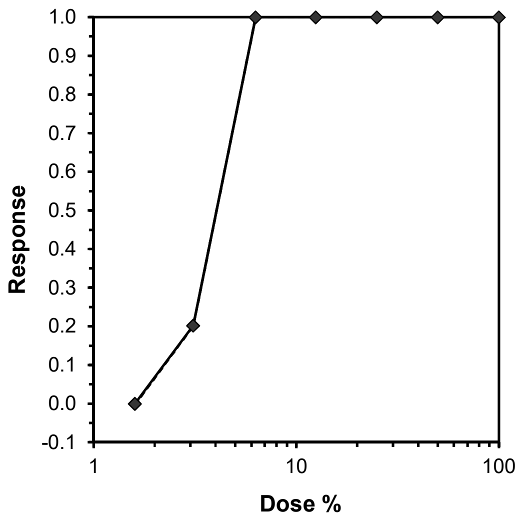
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	0.9525	1.0079	1.3536	1.3030	1.3967	2.935	4				
ASW Control	0.9450	1.0000	1.3353	1.3030	1.3694	2.140	4	*		0.9463	1.0000
1.6	0.9475	1.0026	1.3413	1.3030	1.3694	2.499	4	19.00	11.00	0.9463	1.0000
*3.1	0.7550	0.7989	1.0618	0.8455	1.1873	14.070	4	10.00	11.00	0.7550	0.7979
6.3	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.838216	0.859	-1.60666	4.802703
Bartlett's Test indicates equal variances (p = 0.01)	8.495721	9.21034		
The control means are not significantly different (p = 0.48)	0.749736	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	1.6	3.1	2.227106	62.5
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	2.1079	0.1141	1.8191	2.5561	0.8421
IC10	2.4849	0.2024	2.0934	3.2951	0.7723
IC15	2.8027	0.2176	2.2448	3.3722	0.0347
IC20	3.0884	0.1629	2.3634	3.3012	-0.9995
IC25	3.1533	0.1083	2.5887	3.3508	-1.4413
IC40	3.2999	0.0666	3.0669	3.4938	-0.2953
IC50	3.3921	0.0649	3.1638	3.5829	-0.2576



Statistical Printouts for the Sea Urchin Larval Development Test

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	8/10/2019 14:00	Test ID:	PR1858/109	Sample ID:	Y0021019
End Date:	11/10/2019 14:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9800	0.9000	0.9300	0.9500
ASW Control	0.9700	0.9600	0.9500	0.9700
1.6	0.9600	0.9400	0.9300	0.9700
3.1	0.9500	0.7600	0.8000	0.9100
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

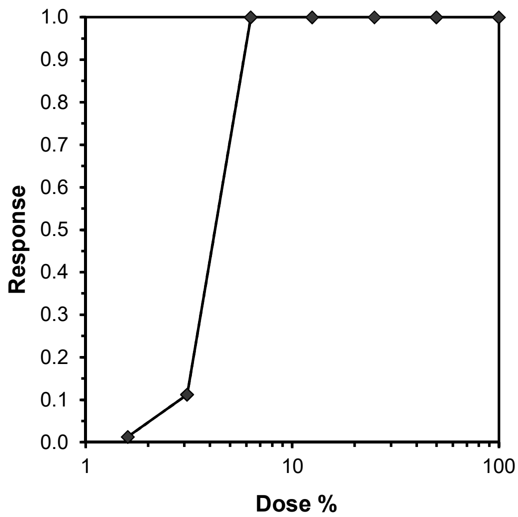
			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.9400	0.9766	1.3316	1.2490	1.4289	5.701	4					
ASW Control	0.9625	1.0000	1.3770	1.3453	1.3967	1.799	4	*			15	400
1.6	0.9500	0.9870	1.3481	1.3030	1.3967	3.165	4	0.496	2.180	0.1271	20	400
*3.1	0.8550	0.8883	1.1943	1.0588	1.3453	11.223	4	3.133	2.180	0.1271	58	400
6.3	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.980881	0.859	0.172766	0.813745
Bartlett's Test indicates equal variances (p = 0.03)	7.189846	9.21034		
The control means are not significantly different (p = 0.30)	1.13899	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	0.062402	0.064805	0.038577	0.0068	0.025469	2, 9
Treatments vs ASW Control										

Trimmed Spearman-Karber

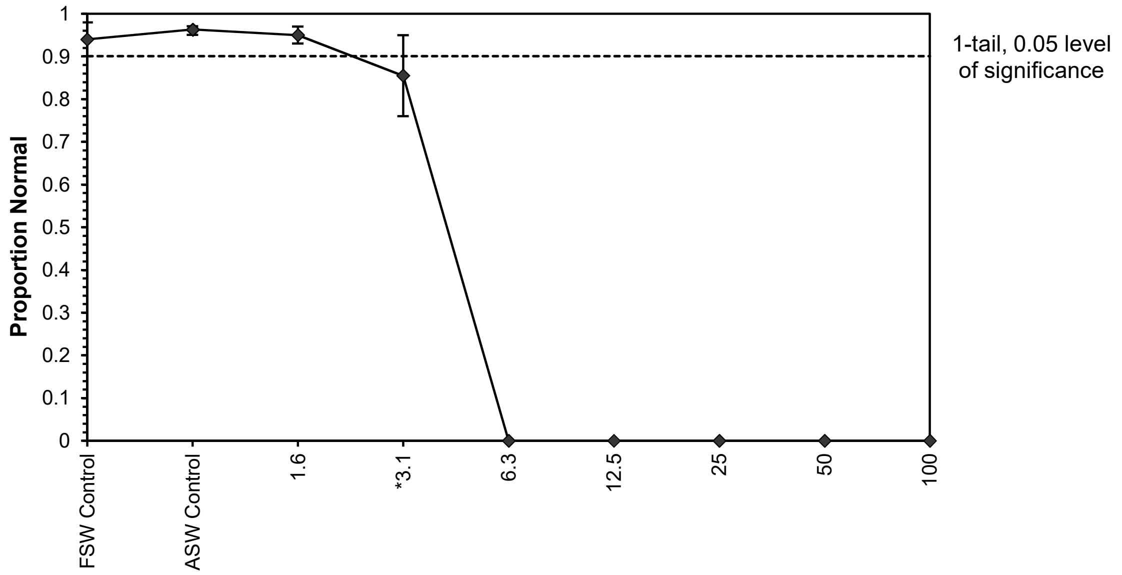
Trim Level	EC50	95% CL	
0.0%			
5.0%	4.1742	4.0686	4.2825
10.0%	4.2245	4.0713	4.3834
20.0%	4.2266	4.1672	4.2868
Auto-1.3%	4.1036	4.0124	4.1970



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	8/10/2019 14:00	Test ID:	PR1858/109	Sample ID:	Y0021019
End Date:	11/10/2019 14:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Dose-Response Plot



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	8/10/2019 14:00	Test ID:	PR1858/109	Sample ID:	Y0021019
End Date:	11/10/2019 14:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Normal	94.00	90.00	98.00	3.37	1.95	4
ASW Control		96.25	95.00	97.00	0.96	1.02	4
1.6		95.00	93.00	97.00	1.83	1.42	4
3.1		85.50	76.00	95.00	8.96	3.50	4
6.3		0.00	0.00	0.00	0.00		4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.20	8.20	8.20	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
FSW Control	Salinity ppt	35.90	35.90	35.90	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.90	35.90	35.90	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	DO %	99.30	99.30	99.30	0.00	0.00	1
ASW Control		99.40	99.40	99.40	0.00	0.00	1
1.6		98.90	98.90	98.90	0.00	0.00	1
3.1		99.70	99.70	99.70	0.00	0.00	1
6.3		99.50	99.50	99.50	0.00	0.00	1
12.5		99.50	99.50	99.50	0.00	0.00	1
25		99.90	99.90	99.90	0.00	0.00	1
50		89.10	89.10	89.10	0.00	0.00	1
100		69.30	69.30	69.30	0.00	0.00	1

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	8/10/2019 14:00	Test ID:	PR1858/109	Sample ID:	Y0021019
End Date:	11/10/2019 14:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9800	0.9000	0.9300	0.9500
ASW Control	0.9700	0.9600	0.9500	0.9700
1.6	0.9600	0.9400	0.9300	0.9700
3.1	0.9500	0.7600	0.8000	0.9100
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

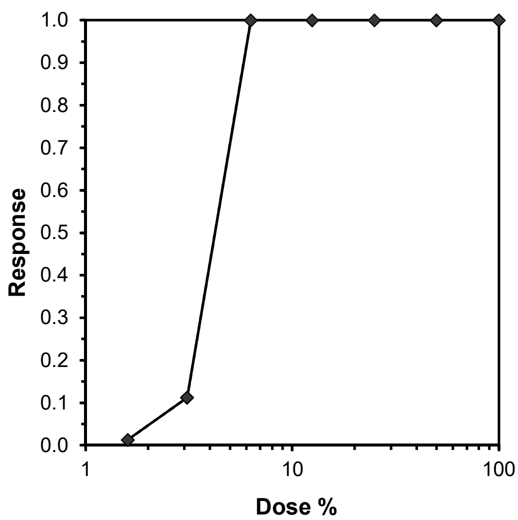
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.9400	0.9766	1.3316	1.2490	1.4289	5.701	4					
ASW Control	0.9625	1.0000	1.3770	1.3453	1.3967	1.799	4	*			0.9625	1.0000
1.6	0.9500	0.9870	1.3481	1.3030	1.3967	3.165	4	0.496	2.180	0.1271	0.9500	0.9870
*3.1	0.8550	0.8883	1.1943	1.0588	1.3453	11.223	4	3.133	2.180	0.1271	0.8550	0.8883
6.3	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.980881	0.859	0.172766	0.813745
Bartlett's Test indicates equal variances (p = 0.03)	7.189846	9.21034		
The control means are not significantly different (p = 0.30)	1.13899	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	0.062402	0.064805	0.038577	0.0068	0.025469	2, 9
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	2.2537	0.3023	1.7635	3.6583	1.0843
IC10	2.9529	0.2325	2.2269	3.4099	-0.5090
IC15	3.1587	0.0989	2.7158	3.4119	-1.5479
IC20	3.2237	0.0656	3.0634	3.4755	0.2179
IC25	3.2806	0.0640	3.1226	3.5305	0.3031
IC40	3.4272	0.0620	3.2749	3.6710	0.3035
IC50	3.5182	0.0607	3.3694	3.7574	0.3031



Statistical Printouts for the Mussel Toxicity Tests

Bivalve Acute Toxicity Tests-Proportion Normal

Start Date:	4/10/2019 16:00	Test ID:	PR1858/104	Sample ID:	Y0021019
End Date:	7/10/2019 16:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 103	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
FSW Control	0.7900	0.8100	0.7800	0.7700
ASW Control	0.8000	0.8400	0.8100	0.7600
1.6	0.7600	0.8400	0.8100	0.8300
3.1	0.6400	0.7900	0.5900	0.5600
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

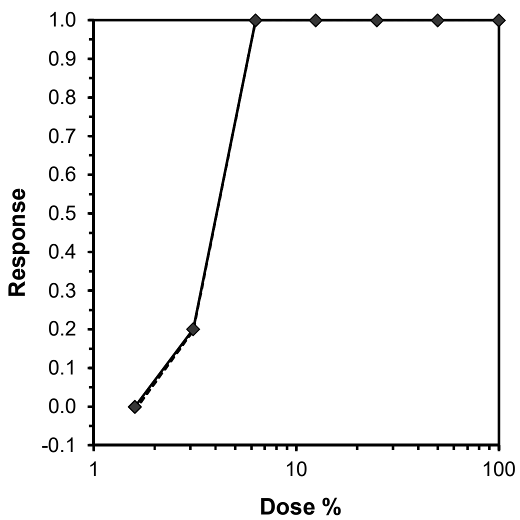
			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.7875	0.9813	1.0919	1.0706	1.1198	1.924	4					
ASW Control	0.8025	1.0000	1.1113	1.0588	1.1593	3.727	4	*			79	400
1.6	0.8100	1.0093	1.1209	1.0588	1.1593	3.972	4	-0.187	2.180	0.1128	76	400
*3.1	0.6450	0.8037	0.9359	0.8455	1.0948	11.879	4	3.390	2.180	0.1128	142	400
6.3	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.91614	0.859	1.075696	2.106456
Bartlett's Test indicates equal variances (p = 0.18)	3.381894	9.21034		
The control means are not significantly different (p = 0.44)	0.832105	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	0.096583	0.120237	0.043396	0.005352	0.009694	2, 9
Treatments vs ASW Control										

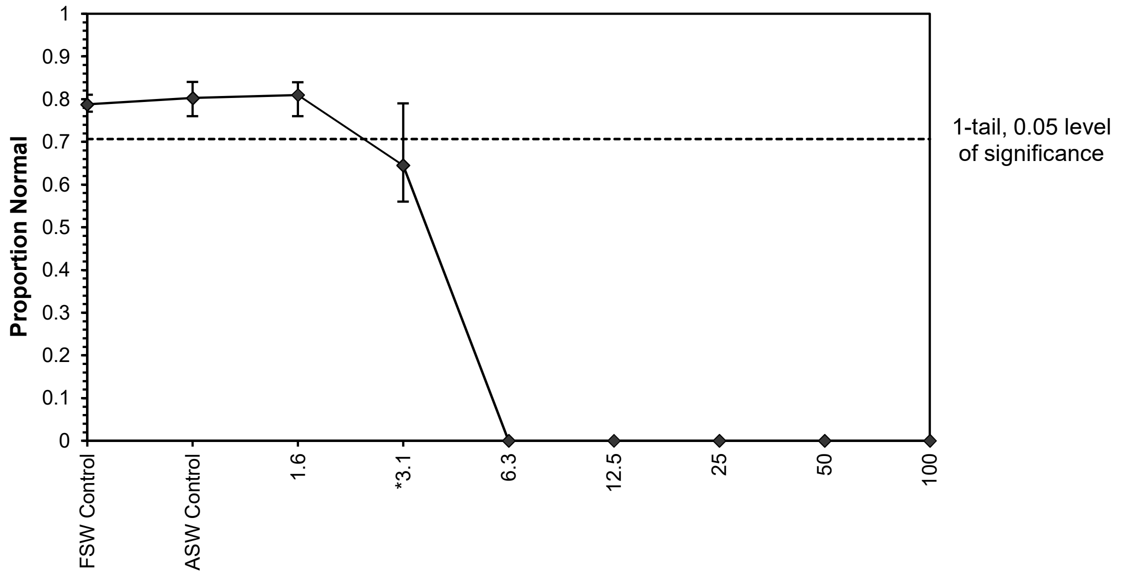
Trimmed Spearman-Karber

Trim Level	EC50	95% CL	
0.0%	3.8533	3.7491	3.9603
5.0%	3.9239	3.8029	4.0487
10.0%	3.9837	3.8347	4.1385
20.0%	4.0444	3.9558	4.1350
Auto-0.0%	3.8533	3.7491	3.9603



Bivalve Acute Toxicity Tests-Proportion Normal					
Start Date:	4/10/2019 16:00	Test ID:	PR1858/104	Sample ID:	Y0021019
End Date:	7/10/2019 16:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 103	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Dose-Response Plot



Bivalve Acute Toxicity Tests-Proportion Normal

Start Date:	4/10/2019 16:00	Test ID:	PR1858/104	Sample ID:	Y0021019
End Date:	7/10/2019 16:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 103	Test Species:	MG-Mytilus galloprovincialis
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Normal	78.75	77.00	81.00	1.71	1.66	4
ASW Control		80.25	76.00	84.00	3.30	2.27	4
1.6		81.00	76.00	84.00	3.56	2.33	4
3.1		64.50	56.00	79.00	10.21	4.96	4
6.3		0.00	0.00	0.00	0.00		4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
FSW Control	Salinity ppt	36.90	36.90	36.90	0.00	0.00	1
ASW Control		35.40	35.40	35.40	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	DO %	99.30	99.30	99.30	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		99.60	99.60	99.60	0.00	0.00	1
3.1		99.50	99.50	99.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		99.70	99.70	99.70	0.00	0.00	1
25		98.10	98.10	98.10	0.00	0.00	1
50		84.60	84.60	84.60	0.00	0.00	1
100		72.00	72.00	72.00	0.00	0.00	1

Bivalve Acute Toxicity Tests-Proportion Normal

Start Date:	4/10/2019 16:00	Test ID:	PR1858/104	Sample ID:	Y0021019
End Date:	7/10/2019 16:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 103	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
FSW Control	0.7900	0.8100	0.7800	0.7700
ASW Control	0.8000	0.8400	0.8100	0.7600
1.6	0.7600	0.8400	0.8100	0.8300
3.1	0.6400	0.7900	0.5900	0.5600
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

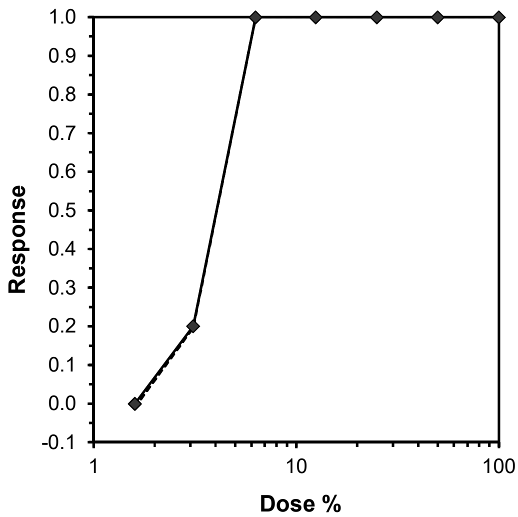
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.7875	0.9813	1.0919	1.0706	1.1198	1.924	4					
ASW Control	0.8025	1.0000	1.1113	1.0588	1.1593	3.727	4	*			0.8063	1.0000
1.6	0.8100	1.0093	1.1209	1.0588	1.1593	3.972	4	-0.187	2.180	0.1128	0.8063	1.0000
*3.1	0.6450	0.8037	0.9359	0.8455	1.0948	11.879	4	3.390	2.180	0.1128	0.6450	0.8000
6.3	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
12.5	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.91614	0.859	1.075696	2.106456
Bartlett's Test indicates equal variances (p = 0.18)	3.381894	9.21034		
The control means are not significantly different (p = 0.44)	0.832105	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	0.096583	0.120237	0.043396	0.005352	0.009694	2, 9
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	1.9671	0.1809	1.5409	2.5694	0.4629
IC10	2.3356	0.2611	1.7986	3.5670	1.1566
IC15	2.7114	0.2681	2.0993	3.4161	0.3344
IC20	3.1000	0.1873	2.3245	3.2529	-0.6488
IC25	3.1417	0.0865	2.7349	3.2947	-1.2942
IC40	3.2628	0.0444	3.1507	3.4147	0.3545
IC50	3.3457	0.0435	3.2374	3.4952	0.3551



Statistical Printouts for the Acute *Allorchestes* Toxicity Test

Amphipod Acute Toxicity Test-96hr % Unaffected					
Start Date:	4/10/2019 18:30	Test ID:	PR1858/108	Sample ID:	Y0021019
End Date:	8/10/2019 18:30	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	0.8000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	0.2000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

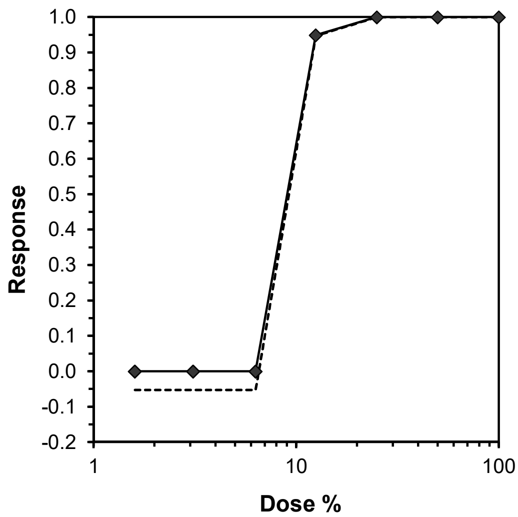
			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
FSW Control	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4				
ASW Control	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	*		1	20
1.6	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0	20
3.1	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0	20
6.3	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0	20
*12.5	0.0500	0.0526	0.2850	0.2255	0.4636	41.771	4	10.00	10.00	19	20
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.811293	0.905	-4.3E-14	4.066993
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 0.36)	1	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Trimmed Spearman-Karber

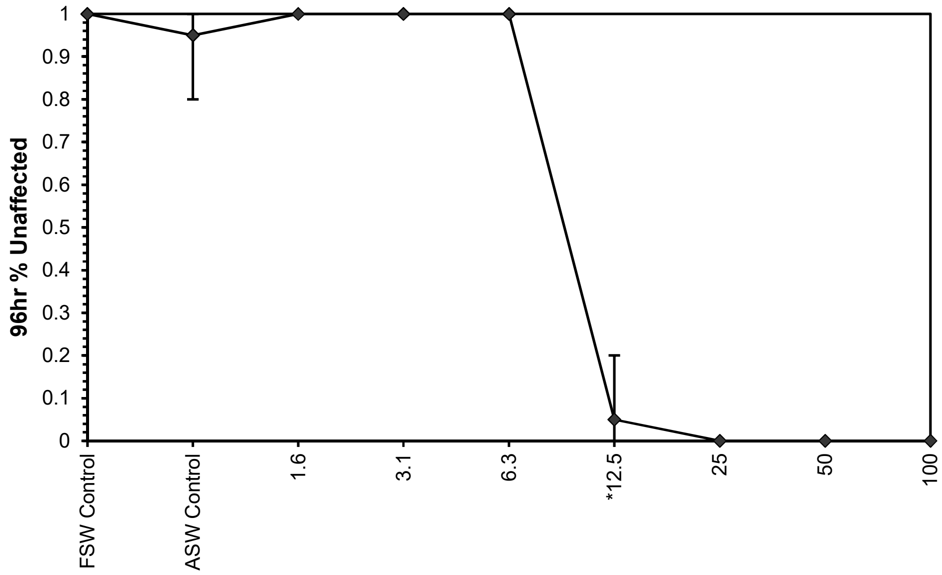
Trim Level	EC50	95% CL	
0.0%	9.1892	8.5888	9.8316
5.0%	9.0378	8.6976	9.3912
10.0%	9.0378	8.7071	9.3809
20.0%	9.0378	8.7071	9.3809
Auto-0.0%	9.1892	8.5888	9.8316



Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	4/10/2019 18:30	Test ID:	PR1858/108	Sample ID:	Y0021019
End Date:	8/10/2019 18:30	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

Dose-Response Plot



Amphipod Acute Toxicity Test-96hr % Unaffected					
Start Date:	4/10/2019 18:30	Test ID:	PR1858/108	Sample ID:	Y0021019
End Date:	8/10/2019 18:30	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	% Non-immobilised	100.00	100.00	100.00	0.00	0.00	4
ASW Control		95.00	80.00	100.00	10.00	3.33	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		100.00	100.00	100.00	0.00	0.00	4
6.3		100.00	100.00	100.00	0.00	0.00	4
12.5		5.00	0.00	20.00	10.00	63.25	4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
FSW Control	DO %	99.30	99.30	99.30	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		99.60	99.60	99.60	0.00	0.00	1
3.1		99.50	99.50	99.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		99.70	99.70	99.70	0.00	0.00	1
25		98.10	98.10	98.10	0.00	0.00	1
50		84.60	84.60	84.60	0.00	0.00	1
100		72.00	72.00	72.00	0.00	0.00	1
FSW Control	Salinity ppt	36.90	36.90	36.90	0.00	0.00	1
ASW Control		35.40	35.40	35.40	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1

Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	4/10/2019 18:30	Test ID:	PR1858/108	Sample ID:	Y0021019
End Date:	8/10/2019 18:30	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	0.8000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	0.2000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

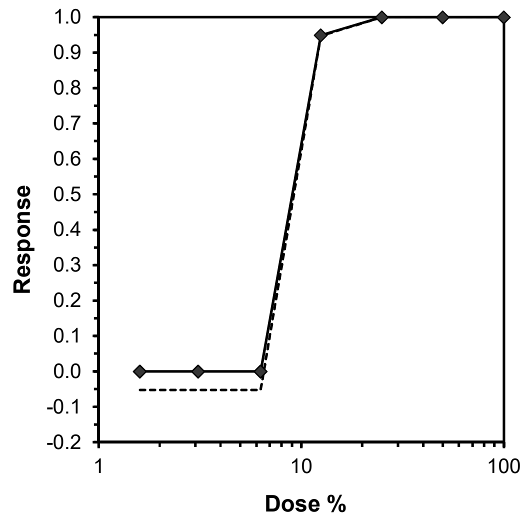
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4				
ASW Control	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	*		0.9875	1.0000
1.6	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9875	1.0000
3.1	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9875	1.0000
6.3	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9875	1.0000
*12.5	0.0500	0.0526	0.2850	0.2255	0.4636	41.771	4	10.00	10.00	0.0500	0.0506
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.811293	0.905	-4.3E-14	4.066993
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 0.36)	1	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

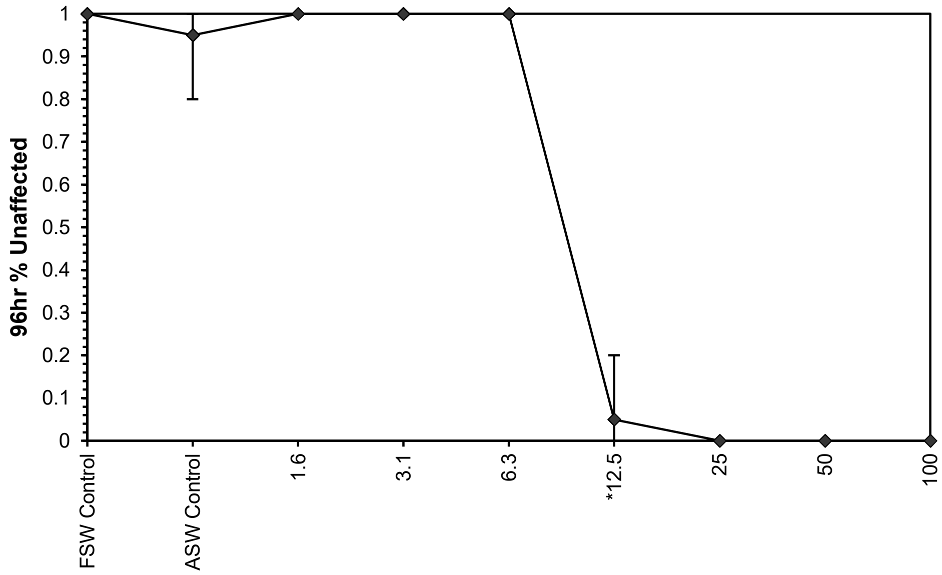
Point	%	SD	95% CL(Exp)		Skew
IC05	7.3866	0.8671	6.2975	10.3402	0.7131
IC10	7.8507	0.8948	6.3541	10.7345	0.5631
IC15	8.1722	0.9114	6.4007	10.9719	0.4202
IC20	8.4291	0.9264	6.4397	11.1489	0.2870
IC25	8.6502	0.9415	6.4736	11.2945	0.1633
IC40	9.2135	0.9922	6.5588	11.6449	-0.1592
IC50	9.5622	1.0336	6.6092	11.8505	-0.3403



Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	4/10/2019 18:30	Test ID:	PR1858/108	Sample ID:	Y0021019
End Date:	8/10/2019 18:30	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	4/10/2019 18:30	Test ID:	PR1858/108	Sample ID:	Y0021019
End Date:	8/10/2019 18:30	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Non-immobilised	100.00	100.00	100.00	0.00	0.00	4
ASW Control		95.00	80.00	100.00	10.00	3.33	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		100.00	100.00	100.00	0.00	0.00	4
6.3		100.00	100.00	100.00	0.00	0.00	4
12.5		5.00	0.00	20.00	10.00	63.25	4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
FSW Control	DO %	99.30	99.30	99.30	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		99.60	99.60	99.60	0.00	0.00	1
3.1		99.50	99.50	99.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		99.70	99.70	99.70	0.00	0.00	1
25		98.10	98.10	98.10	0.00	0.00	1
50		84.60	84.60	84.60	0.00	0.00	1
100		72.00	72.00	72.00	0.00	0.00	1
FSW Control	Salinity ppt	36.90	36.90	36.90	0.00	0.00	1
ASW Control		35.40	35.40	35.40	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1

Statistical Printouts for the *Nitzschia* Growth Inhibition Tests

Microalgal Cell Yield-Cell Yield

Start Date:	4/10/2019 16:30	Test ID:	PR1858/102	Sample ID:	Y0021019
End Date:	7/10/2019 17:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 110	Test Species:	NC-Nitzschia closterium
Comments:					

Conc-%	1	2	3	4	5	6	7	8
FSW Control	16.994	16.560	15.260	17.210	15.585	16.452	17.969	17.102
ASW Control	15.369	14.935	16.777	15.910				
1.6	16.344	17.860	15.585	16.452				
3.1	8.219	11.360	10.494	12.769				
6.3	0.000	1.394	0.000	3.019				
12.5	0.000	0.000	0.000	0.000				
25	0.000	0.000	0.000	0.000				
50	0.000	0.000	0.000	0.000				
100	0.000	0.000	0.000	0.000				

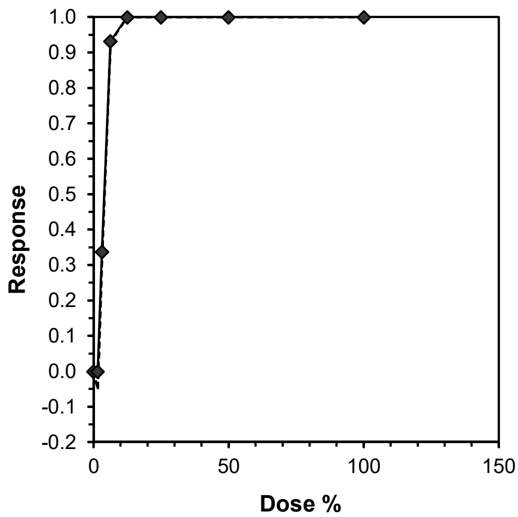
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	16.642	1.0568	16.642	15.260	17.969	5.320	8					
ASW Control	15.748	1.0000	15.748	14.935	16.777	5.040	4	*			16.154	1.0000
1.6	16.560	1.0516	16.560	15.585	17.860	5.728	4	-0.855	2.290	2.177	16.154	1.0000
*3.1	10.710	0.6801	10.710	8.219	12.769	17.809	4	5.299	2.290	2.177	10.710	0.6630
*6.3	1.103	0.0700	1.103	0.000	3.019	130.194	4	15.405	2.290	2.177	1.103	0.0683
12.5	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
25	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
50	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
100	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.971959	0.887	-0.01546	0.029112
Bartlett's Test indicates equal variances (p = 0.49)	2.424579	11.34487		
The control means are not significantly different (p = 0.12)	1.699361	2.228139		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	1.6	3.1	2.227106	62.5	2.177035	0.138244	201.9835	1.807548	4.9E-09	3, 12
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

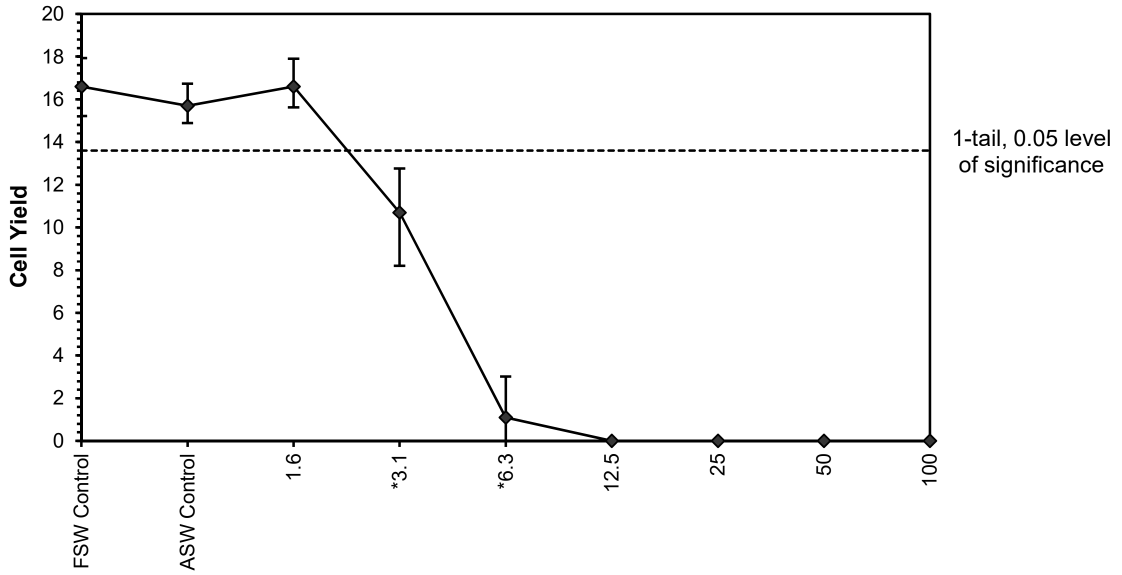
Point	%	SD	95% CL(Exp)		Skew
IC05	1.8226	0.0445	1.7147	1.9580	-1.5970
IC10	2.0451	0.0709	1.8906	2.3161	0.5371
IC15	2.2677	0.1038	2.0359	2.6741	0.6902
IC20	2.4902	0.1382	2.1812	3.0321	0.7386
IC25	2.7128	0.1700	2.3266	3.3674	0.6835
IC40	3.4390	0.2288	2.7656	4.0806	-0.0785
IC50	3.9771	0.2087	3.3138	4.5373	-0.2787



Microalgal Cell Yield-Cell Yield

Start Date:	4/10/2019 16:30	Test ID:	PR1858/102	Sample ID:	Y0021019
End Date:	7/10/2019 17:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 110	Test Species:	NC-Nitzschia closterium
Comments:					

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Microalgal Cell Yield-Cell Yield

Start Date:	4/10/2019 16:30	Test ID:	PR1858/102	Sample ID:	Y0021019
End Date:	7/10/2019 17:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 110	Test Species:	NC-Nitzschia closterium
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	Cell Yield	16.64	15.26	17.97	0.89	5.65	8
ASW Control		15.75	14.94	16.78	0.79	5.66	4
1.6		16.56	15.59	17.86	0.95	5.88	4
3.1		10.71	8.22	12.77	1.91	12.89	4
6.3		1.10	0.00	3.02	1.44	108.64	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	2
ASW Control		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
FSW Control	Salinity ppt	36.90	36.90	36.90	1.06	2.85	2
ASW Control		35.40	35.40	35.40	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1

Statistical Printouts for the Acute *Hormosira* Cell Germination Test

Macroalgal Germination Success Test-Proportion Germinated

Start Date:	4/10/2019 16:30	Test ID:	PR1858/107	Sample ID:	Y0021019
End Date:	8/10/2019 16:30	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 116	Test Species:	HB-Hormosira banksii
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9500	0.9300	0.9600	0.9200
ASW Control	0.9700	0.9000	0.9100	0.9400
1.6	0.9400	0.9600	0.9300	0.9000
3.1	0.9200	0.9500	0.9100	0.9300
6.3	0.9200	0.9500	0.9300	0.9000
12.5	0.7900	0.8600	0.9400	0.9000
25	0.0300	0.0800	0.0600	0.0200
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.9400	1.0108	1.3254	1.2840	1.3694	2.937	4					
ASW Control	0.9300	1.0000	1.3088	1.2490	1.3967	5.094	4	*			28	400
1.6	0.9325	1.0027	1.3112	1.2490	1.3694	3.805	4	-0.055	2.410	0.1066	27	400
3.1	0.9275	0.9973	1.2996	1.2661	1.3453	2.614	4	0.208	2.410	0.1066	29	400
6.3	0.9250	0.9946	1.2954	1.2490	1.3453	3.096	4	0.304	2.410	0.1066	30	400
12.5	0.8725	0.9382	1.2136	1.0948	1.3233	7.976	4	2.153	2.410	0.1066	51	400
*25	0.0475	0.0511	0.2126	0.1419	0.2868	31.205	4	24.790	2.410	0.1066	381	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400

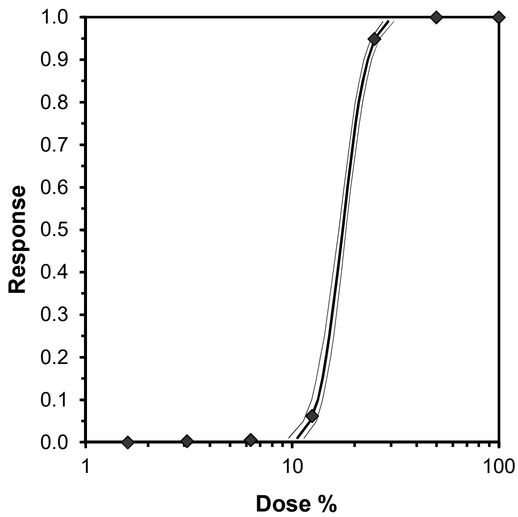
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.990604	0.916	0.038641	-0.27548
Bartlett's Test indicates equal variances (p = 0.57)	3.828166	15.08627		
The control means are not significantly different (p = 0.68)	0.431366	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	12.5	25	17.67767	8	0.062717	0.067227	0.773125	0.003911	4.5E-15	5, 18
Treatments vs ASW Control										

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	10.57689	0.637561	9.327272	11.82651	0.07	0.179704	11.0705	1	1.243463	0.094546	5
Intercept	-8.15197	0.829675	-9.77813	-6.5258							
TSCR	0.07125	0.006431	0.058645	0.083855							

Point	Probits	%	95% Fiducial Limits	
EC01	2.674	10.55641	9.597342	11.40222
EC05	3.355	12.24471	11.32893	13.0509
EC10	3.718	13.25248	12.37001	14.03231
EC15	3.964	13.97887	13.12206	14.74019
EC20	4.158	14.58448	13.7492	15.33156
EC25	4.326	15.1249	14.30833	15.86081
EC40	4.747	16.57714	15.80406	17.29447
EC50	5.000	17.51711	16.76281	18.23531
EC60	5.253	18.51038	17.76405	19.24429
EC75	5.674	20.28769	19.51739	21.09522
EC80	5.842	21.03944	20.24301	21.89683
EC85	6.036	21.95093	21.11037	22.88333
EC90	6.282	23.15409	22.23614	24.20815
EC95	6.645	25.05973	23.98164	26.3519
EC99	7.326	29.06758	27.54548	30.9977



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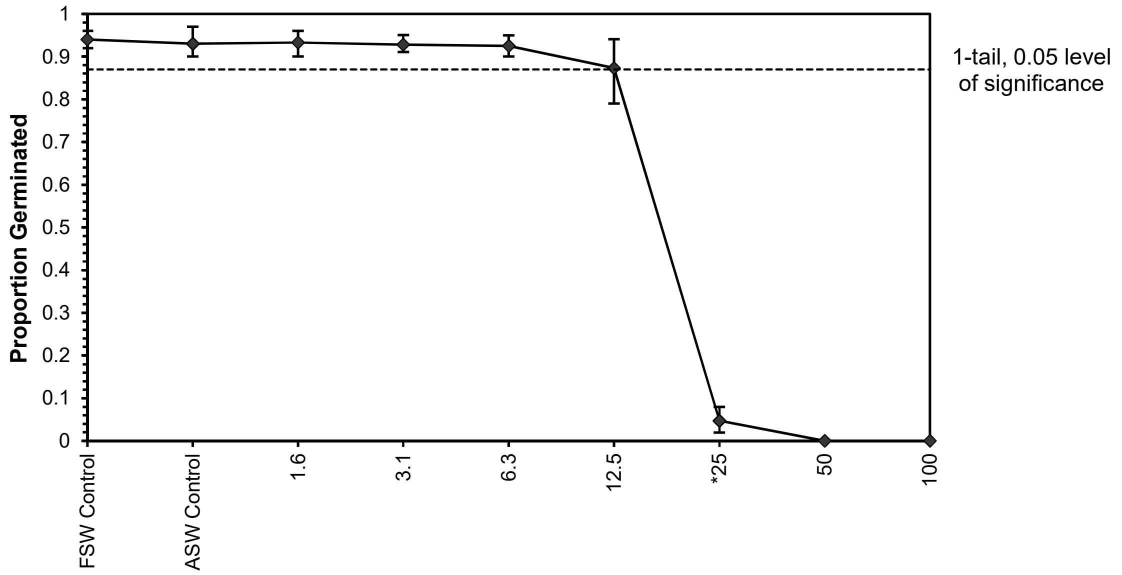
Macroalgal Germination Success Test-Proportion Germinated

Start Date:	4/10/2019 16:30	Test ID:	PR1858/107	Sample ID:	Y0021019
End Date:	8/10/2019 16:30	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 116	Test Species:	HB-Hormosira banksii
Comments:					

Dose-Response Plot



Macroalgal Germination Success Test-Proportion Germinated

Start Date:	4/10/2019 16:30	Test ID:	PR1858/107	Sample ID:	Y0021019
End Date:	8/10/2019 16:30	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 116	Test Species:	HB-Hormosira banksii
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	Germination, %	94.00	92.00	96.00	1.83	1.44	4
ASW Control		93.00	90.00	97.00	3.16	1.91	4
1.6		93.25	90.00	96.00	2.50	1.70	4
3.1		92.75	91.00	95.00	1.71	1.41	4
6.3		92.50	90.00	95.00	2.08	1.56	4
12.5		87.25	79.00	94.00	6.40	2.90	4
25		4.75	2.00	8.00	2.75	34.94	4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
FSW Control	Salinity ppt	36.90	36.90	36.90	0.00	0.00	1
ASW Control		35.40	35.40	35.40	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	DO %	99.30	99.30	99.30	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		99.60	99.60	99.60	0.00	0.00	1
3.1		99.50	99.50	99.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		99.70	99.70	99.70	0.00	0.00	1
25		98.10	98.10	98.10	0.00	0.00	1
50		84.60	84.60	84.60	0.00	0.00	1
100		72.00	72.00	72.00	0.00	0.00	1

Statistical Printouts for the Larval Fish Imbalance Tests

Fish Imbalance Test-96 hr Unaffected					
Start Date:	3/10/2019 17:00	Test ID:	PR1858/101	Sample ID:	Y0021019
End Date:	7/10/2019 17:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 117	Test Species:	AB-Macquaria novemaculeata
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	0.8000	0.8000	1.0000
ASW Control	1.0000	0.8000	1.0000	1.0000
1.6	1.0000	1.0000	0.8000	1.0000
3.1	0.8000	1.0000	1.0000	1.0000
6.3	0.8000	0.4000	0.4000	0.2000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

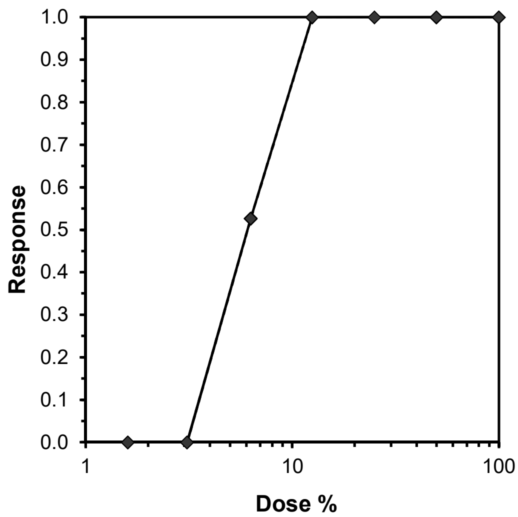
			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
FSW Control	0.9000	0.9474	1.2262	1.1071	1.3453	11.212	4				
ASW Control	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	*		1	20
1.6	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	18.00	10.00	1	20
3.1	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	18.00	10.00	1	20
6.3	0.4500	0.4737	0.7351	0.4636	1.1071	36.604	4	10.50	10.00	11	20
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.835925	0.887	0.351483	1.528959
Bartlett's Test indicates equal variances (p = 0.37)	3.147714	11.34487		
The control means are not significantly different (p = 0.54)	0.654654	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Trimmed Spearman-Karber

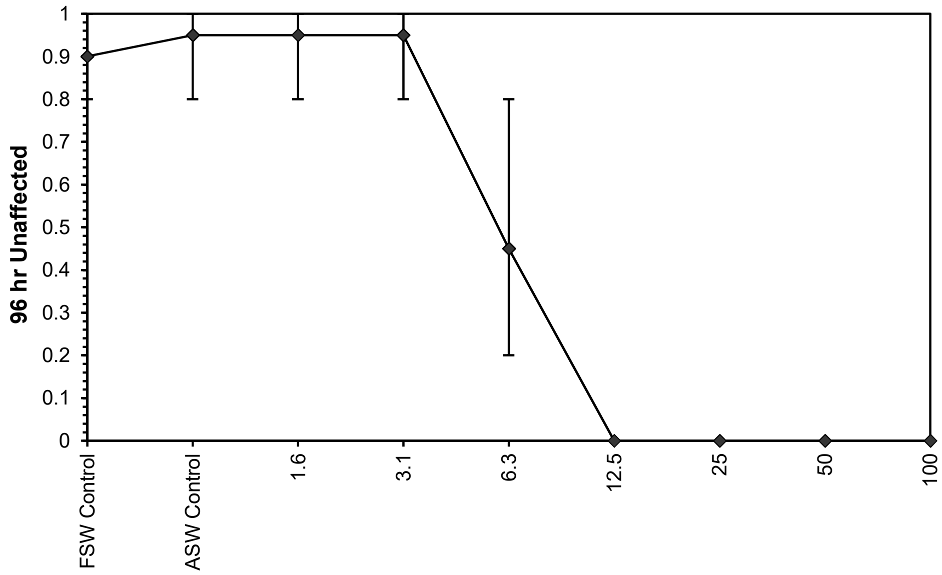
Trim Level	EC50	95% CL	
0.0%	6.1485	5.2621	7.1842
5.0%	6.1409	5.1663	7.2994
10.0%	6.1334	5.0523	7.4458
20.0%	6.1183	4.7374	7.9016
Auto-0.0%	6.1485	5.2621	7.1842



Fish Imbalance Test-96 hr Unaffected

Start Date:	3/10/2019 17:00	Test ID:	PR1858/101	Sample ID:	Y0021019
End Date:	7/10/2019 17:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 117	Test Species:	AB-Macquaria novemaculeata
Comments:					

Dose-Response Plot



Fish Imbalance Test-96 hr Unaffected

Start Date:	3/10/2019 17:00	Test ID:	PR1858/101	Sample ID:	Y0021019
End Date:	7/10/2019 17:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 117	Test Species:	AB-Macquaria novemaculeata
Comments:					

Conc-%	Parameter	Auxiliary Data Summary					
		Mean	Min	Max	SD	CV%	N
FSW Control	% unaffected	90.00	80.00	100.00	11.55	3.78	4
ASW Control		95.00	80.00	100.00	10.00	3.33	4
1.6		95.00	80.00	100.00	10.00	3.33	4
3.1		95.00	80.00	100.00	10.00	3.33	4
6.3		45.00	20.00	80.00	25.17	11.15	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
FSW Control	Salinity ppt	36.90	36.90	36.90	0.00	0.00	1
ASW Control		35.40	35.40	35.40	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	DO %	99.30	99.30	99.30	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		99.60	99.60	99.60	0.00	0.00	1
3.1		99.50	99.50	99.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		99.70	99.70	99.70	0.00	0.00	1
25		98.10	98.10	98.10	0.00	0.00	1
50		84.60	84.60	84.60	0.00	0.00	1
100		72.00	72.00	72.00	0.00	0.00	1

Fish Imbalance Test-96 hr Unaffected

Start Date:	3/10/2019 17:00	Test ID:	PR1858/101	Sample ID:	Y0021019
End Date:	7/10/2019 17:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 117	Test Species:	AB-Macquaria novemaculeata
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	0.8000	0.8000	1.0000
ASW Control	1.0000	0.8000	1.0000	1.0000
1.6	1.0000	1.0000	0.8000	1.0000
3.1	0.8000	1.0000	1.0000	1.0000
6.3	0.8000	0.4000	0.4000	0.2000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

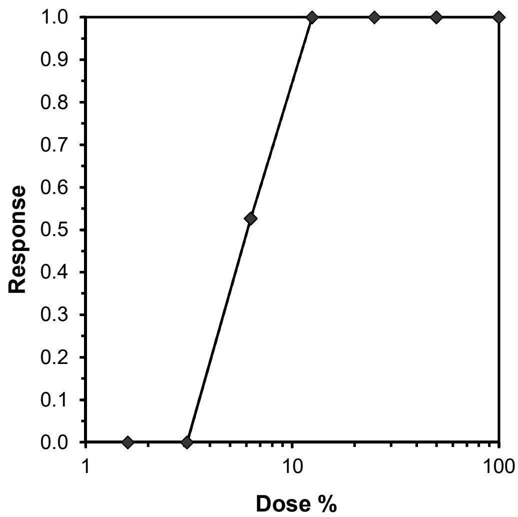
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	0.9000	0.9474	1.2262	1.1071	1.3453	11.212	4				
ASW Control	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	*		0.9500	1.0000
1.6	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	18.00	10.00	0.9500	1.0000
3.1	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	18.00	10.00	0.9500	1.0000
6.3	0.4500	0.4737	0.7351	0.4636	1.1071	36.604	4	10.50	10.00	0.4500	0.4737
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.835925	0.887	0.351483	1.528959
Bartlett's Test indicates equal variances (p = 0.37)	3.147714	11.34487		
The control means are not significantly different (p = 0.54)	0.654654	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	3.6781	0.9144	0.0000	5.9060	-0.6436
IC10	4.0815	0.6744	1.4566	6.1294	-0.4518
IC15	4.4090	0.5479	2.3146	6.2321	0.4305
IC20	4.6953	0.5263	2.9463	6.3223	0.3390
IC25	4.9572	0.5140	3.4978	6.7261	0.4404
IC40	5.6817	0.4782	4.4137	6.9915	0.1725
IC50	6.1665	0.4013	4.7351	7.0016	-0.3281



Statistical Printouts for the 7-d Larval Fish Growth Inhibition Tests

Fish Growth Test-7 Day Unaffected

Start Date:	4/10/2019 18:00	Test ID:	PR1858/111	Sample ID:	Y0021019
End Date:	11/10/2019 18:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	0.0000	0.0000	0.0000	0.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

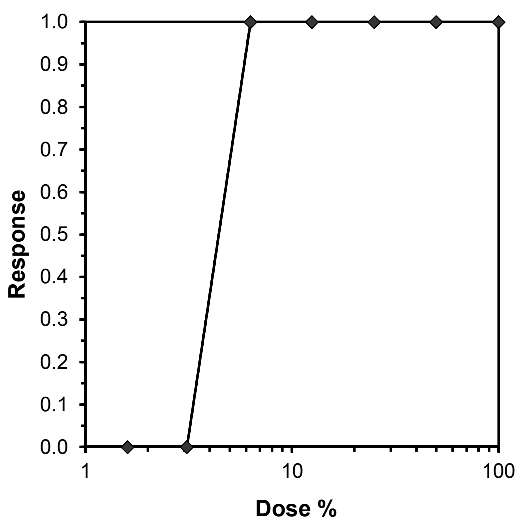
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		1.0000	1.0000
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	11.00	1.0000	1.0000
3.1	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	11.00	1.0000	1.0000
6.3	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	1	0.859		
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	3.1	6.3	4.419276	32.25806
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

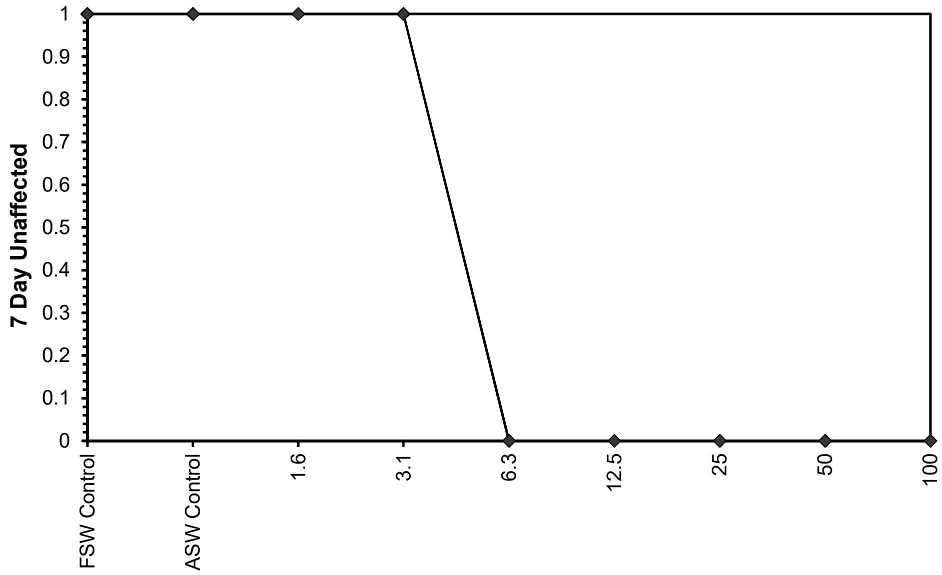
Point	%	SD	95% CL(Exp)		Skew
IC05	3.9889	0.0000	3.9889	3.9889	1.0076
IC10	4.1070	0.0000	4.1070	4.1070	-1.0076
IC15	4.1816	0.0000	4.1816	4.1816	-1.0076
IC20	4.2384	0.0000	4.2384	4.2384	1.0076
IC25	4.2858	0.0000	4.2858	4.2858	#DIV/0!
IC40	4.4018	0.0000	4.4018	4.4018	1.0076
IC50	4.4708	0.0000	4.4708	4.4708	-1.0076



Fish Growth Test-7 Day Unaffected

Start Date:	4/10/2019 18:00	Test ID:	PR1858/111	Sample ID:	Y0021019
End Date:	11/10/2019 18:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Dose-Response Plot



Fish Growth Test-7 Day Unaffected

Start Date:	4/10/2019 18:00	Test ID:	PR1858/111	Sample ID:	Y0021019
End Date:	11/10/2019 18:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
		Auxiliary Data Summary					
FSW Control	% Un-affected	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		100.00	100.00	100.00	0.00	0.00	4
6.3		0.00	0.00	0.00	0.00		4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	Biomass	16.81	15.76	18.20	1.04	6.06	4
ASW Control		17.64	15.98	19.98	1.76	7.52	4
1.6		17.75	16.54	18.74	0.99	5.61	4
3.1		0.00	0.00	0.00	0.00		4
6.3		0.00	0.00	0.00	0.00		4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
FSW Control	Salinity	36.90	36.90	36.90	0.00	0.00	1
ASW Control		35.40	35.40	35.40	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.60	35.60	35.60	0.00	0.00	1
FSW Control	% DO	99.30	99.30	99.30	0.00	0.00	1
ASW Control		98.00	98.00	98.00	0.00	0.00	1
1.6		99.60	99.60	99.60	0.00	0.00	1
3.1		99.50	99.50	99.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		99.70	99.70	99.70	0.00	0.00	1
25		98.10	98.10	98.10	0.00	0.00	1
50		84.60	84.60	84.60	0.00	0.00	1
100		72.00	72.00	72.00	0.00	0.00	1

Fish Growth Test-7 day Biomass

Start Date:	4/10/2019 18:00	Test ID:	PR1858/111	Sample ID:	Y0021019
End Date:	11/10/2019 18:00	Lab ID:	9259	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	EPAM 94	Test Species:	MI
Comments:					

Conc-%	1	2	3	4
FSW Control	16.900	18.200	15.760	16.380
ASW Control	19.980	17.940	15.980	16.660
1.6	18.740	17.360	16.540	18.340
3.1	17.820	15.880	16.080	15.980
6.3	0.000	0.000	0.000	0.000
12.5	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000
50	0.000	0.000	0.000	0.000
100	0.000	0.000	0.000	0.000

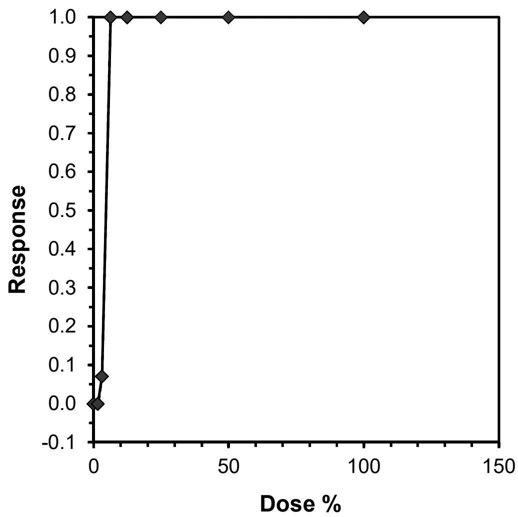
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	16.810	0.9529	16.810	15.760	18.200	6.170	4					
ASW Control	17.640	1.0000	17.640	15.980	19.980	9.971	4	*			17.693	1.0000
1.6	17.745	1.0060	17.745	16.540	18.740	5.583	4	-0.116	2.180	1.976	17.693	1.0000
3.1	16.440	0.9320	16.440	15.880	17.820	5.618	4	1.324	2.180	1.976	16.440	0.9292
6.3	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
12.5	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
25	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
50	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
100	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.959799	0.859	0.631592	-0.06225
Bartlett's Test indicates equal variances (p = 0.50)	1.404235	9.21034		
The control means are not significantly different (p = 0.45)	0.812931	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	3.1	6.3	4.419276	32.25806	1.975752	0.112004	2.1027	1.642789	0.324187	2, 9
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	2.6594	0.6349	0.0000	3.5814	-0.6979
IC10	3.2006	0.3678	0.9839	3.5147	-2.2527
IC15	3.3728	0.1343	2.7574	3.6695	-1.2580
IC20	3.5450	0.1103	3.1021	3.8242	-0.3437
IC25	3.7172	0.1034	3.3019	3.9789	-0.3437
IC40	4.2337	0.0827	3.9016	4.4431	-0.3437
IC50	4.5781	0.0690	4.3013	4.7526	-0.3437



Toxicity Assessment of Produced Formation Water from the BASGAS Yolla Facility

Beach Energy Ltd

Test Report- Round 3

October 2019

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www.ecotox.com.au
ECOTOX SERVICES AUSTRALIA PTY LIMITED
ABN 95 619 426 201

Toxicity Test Report: TR1858/17

Accredited for compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 9 October 2019 10 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	Sample Name:	Sample Description:
9262	A1-5327	Produced Formation Water, pH 6.9*, salinity 18.5 ‰*, total ammonia 31.4 mg/L*. Sample received at 14ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	1-hr sea urchin fertilisation success test using *Heliocidaris tuberculata*
Test Protocol:	ESA SOP 104 (ESA 2014), based on USEPA (2002) and Simon and Laginestra (1996)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Field collected from South Maroubra, NSW.
Test Initiated:	10 October 2019 at 1010h

Sample 9262: *A1-5327*

Concentration (%)	% Fertilised Eggs (Mean ± SD)	*Vacant*	*Vacant*
FSW Control	94.5 ± 1.3		
ASW Control	92.3 ± 2.6		
1.6	94.8 ± 1.7		
3.1	95.3 ± 1.7		
6.3	35.3 ± 8.5 *		
12.5	0.0 ± 0.0		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		

IC10 = 3.9 (3.77-4.07)%
EC50 = 5.7 (5.55-5.94)%
NOEC = 3.1%
LOEC = 6.3%

*Significantly lower percentage fertilised eggs compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

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Toxicity Test Report: TR1858/17

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % fertilised eggs	≥70.0%	94.5%	Yes
Reference Toxicant within cusum chart limits	48.7-66.5µg Cu/L	56.2µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 16 November 2019

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

ESA (2014) ESA SOP 104 - *Sea Urchin Fertilisation Success Test*. Issue No. 13. Ecotox Services Australasia, Sydney NSW.

Simon, J. and Laginestra, E.(1997) Bioassay for testing sublethal toxicity in effluents, using gametes of sea urchin *Heliocidaris tuberculata*. National Pulp Mills Research Program Technical Report No. 20. CSIRO, Canberra ACT

USEPA (2002) Short-term methods for measuring the chronic toxicity of effluents and receiving waters to marine and estuarine organisms. Third Edition. United States Environmental Protection Agency, Office of Water, Washington DC, EPA-821-R-02-014.

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Toxicity Test Report: TR1858/18

Accredited for compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 9 October 2019 10 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9262	A1-5327	Produced Formation Water, pH 6.9*, salinity 18.5 ‰*, total ammonia 31.4 mg/L *. Sample received at 14ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	72-hr sea urchin larval development test using *Heliocidaris tuberculata*
Test Protocol:	ESA SOP 105 (ESA 2016), based on APHA (1998), Simon and Laginestra (1996) and Doyle *et al*. (2003)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Field collected from South Maroubra, NSW.
Test Initiated:	10 October 2019 at 1030h

Sample 9262: *A1-5327*		*Vacant*	*Vacant*
Concentration (%)	**% Normal larvae (Mean ± SD)**		
FSW Control	95.3 ± 2.2		
ASW Control	96.0 ± 1.8		
1.6	95.8 ± 1.7		
3.1	95.8 ± 2.2		
6.3	95.5 ± 2.4		
12.5	62.5 ± 9.0 *		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		
72-hr EC10 = 8.8 (7.73-9.70)% **72-hr EC50 = 13.9 (13.41-14.34)%** **NOEC = 6.3%** **LOEC = 12.5%**			

*Significantly lower percentage of normally developed larvae compared with the ASW Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)

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Toxicity Test Report: TR1858/18

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % normal larvae	≥70.0%	95.3%	Yes
Reference Toxicant within cusum chart limits	10.4-12.3µg Cu/L	11.3µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 16 November 2019

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

APHA (1998) Method 8810 D. Echinoderm Embryo Development Test. In Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association and the Water Environment Federation, USA.

Doyle, C.J., Pablo, F., Lim, R.P. and Hyne, R.V. (2003) Assessment of metal toxicity in sediment pore water from Lake Macquarie, Australia. *Arch. Environ. Contam. Toxicology*, 44(3): 343-350.

ESA (2016) *ESA SOP 105 - Sea Urchin Larval Development Test*. Issue No. 11. Ecotox Services Australasia, Sydney NSW.

Simon, J. and Laginestra, E.(1997) Bioassay for testing sublethal toxicity in effluents, using gametes of sea urchin *Heliocidaris tuberculata*. National Pulp Mills Research Program Technical Report No. 20. CSIRO, Canberra, ACT.

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NATA WORLD RECOGNISED ACCREDITATION

ecotox SERVICES AUSTRALIA

Toxicity Test Report: TR1858/19

Accredited for compliance with ISO/IEC 17025 - Testing

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 9 October 2019 10 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	Sample Name:	Sample Description:
9262	A1-5327	Produced Formation Water, pH 6.9*, salinity 18.5 ‰*, total ammonia 31.4 mg/L *. Sample received at 14ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	48-hr larval development test using the mussel *Mytilus galloprovincialis*
Test Protocol:	ESA SOP 106 (ESA 2016), based on APHA (1998) and USEPA (1996)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	The test was extended to 72hr
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Farm-reared, Mercury Passage, TAS
Test Initiated:	10 October 2019 at 1230 h

Sample 9262: *A1-5327*

Concentration (%)	% Normal larvae (Mean ± SD)
FSW Control	76.8 ± 3.3
ASW Control	74.3 ± 3.0
1.6	79.3 ± 3.4
3.1	78.0 ± 2.6
6.3	77.5 ± 2.7
12.5	37.0 ± 9.4 *
25	0.0 ± 0.0
50	0.0 ± 0.0
100	0.0 ± 0.0

72-hr EC10 =7.4 (6.85-7.80)%
72-hr EC50 =12.3 (11.93-12.78)%
NOEC = 6.3%
LOEC = 12.5%

Vacant

Vacant

*Significantly lower percentage of normally developed larvae compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

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Toxicity Test Report: TR1858/19 (Page 2 of 2)

QA/QC Parameter	Criterion	This Test	Criterion met?
FSW Control mean % normal	≥70%	76.8%	Yes
Reference Toxicant within cusum chart limits	7.6-14.7µg Cu/L	10.4µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 16 November 2019

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

This document shall not be reproduced except in full.

Citations:

APHA (1998) *Standard Methods for the Examination of Water and Wastewater*. 20th Ed. American Public Health Association, American Water Works Association and the Water Environment Federation, Washington, DC, USA.

ESA (2016) *Bivalve Larval Development Test*. Issue No. 15. Ecotox Services Australasia, Sydney, NSW

USEPA (1996) *Bivalve acute toxicity test (embryo larval) OPPTS 850.1055. Ecological Effects Test Guidelines.* United States Environmental Protection Agency. Prevention, Pesticides and Toxic Substances. EPA/712/C-96/137.

Toxicity Test Report: TR1820/20

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 9 October 2019 10 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9262	A1-5327	Produced Formation Water, pH 6.9, salinity 18.5 ‰, total ammonia 31.4 mg/L. Sample received at 14° in apparent good condition.

Test Performed:	96-hr acute toxicity test using the amphipod *Allorchestes compressa*
Test Protocol:	ESA SOP 108 (ESA 2017), based on USEPA (2002) and Department of Transport and Communications (1990)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	In-house culture, originally sourced from Queenscliff, VIC
Test Initiated:	22 October 2019 at 1530h

Sample 9262: *A1-5327*		*Vacant*	*Vacant*
Concentration (%)	**% Unaffected (Mean ± SD)**		
FSW Control	100 ± 0.0		
ASW Control	100 ± 0.0		
1.6	100 ± 0.0		
3.1	100 ± 0.0		
6.3	100 ± 0.0		
12.5	65.0 ± 10.0 *		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		
96-hr IC10 = 11.1 (10.8-11.6)% **96-hr EC50 = 13.9 (12.0-16.1)%** **NOEC = 6.3%** **LOEC = 12.5%**			

*Significantly lower percent unaffected compared with the ASW Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % unaffected	≥90.0%	100%	Yes
Reference Toxicant within cusum chart limits	0.6-9.0mg SDS/L	3.1mg SDS/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 16 November 2019

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Toxicity Test Report: TR1820/20

Citations:

Department of Transport and Communications (1990) Guidelines for Acceptance of Oil Spill Dispersants in Australian Waters. Pollution Prevention Section, Department of Transport and Communications, Canberra ACT.

ESA (2017) SOP 108 – *Amphipod Acute Toxicity Test*. Issue No 10. Ecotox Services Australia, Sydney, NSW.

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth Edition. United States Environmental Protection Agency, Office of Research and Development, Washington DC, EPA/600/4-90/027F.

Toxicity Test Report: TR1858/21

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 9 October 2019 10 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9262	A1-5327	Produced Formation Water, pH 6.9, salinity 18.5 ‰, total ammonia 31.4 mg/L. Sample received at 14° in apparent good condition.

Test Performed:	72-hr marine algal growth test using *Nitzschia closterium*
Test Protocol:	ESA SOP 110 (ESA 2016), based on Stauber *et al*. (1994)
Test Temperature:	The test was performed at 21±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was filtered to 0.45µm and serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	In-house culture, originally sourced from CSIRO Microalgae Supply Service, TAS
Test Initiated:	22 October 2019 at 1430h

Sample 9262: *A1-5327*

Concentration (%)	**Cell Yield (Mean number of cells/mL $x10^4 \pm$ SD)**	*Vacant*	*Vacant*
FSW Control	15.9 ± 0.9		
ASW Control	15.0 ± 1.1		
1.6	16.2 ± 0.7		
3.1	15.5 ± 1.6		
6.3	16.1 ± 0.8		
12.5	14.1 ± 1.2		
25	2.2 ± 2.3 *		
50	0.0 ± 0.0		
100	0.0 ± 0.0		

72-hr IC10 = 12.3 (8.33-13.88)%
72-hr IC50 = 19.0 (17.46-21.01)%
NOEC = 12.5%
LOEC = 25%

*Significantly lower cell yield compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

QA/QC Parameter	**Criterion**	**This Test**	**Criterion met?**
Control mean cell density	≥16.0x10^4 cells/mL	16.9x10^4 cells/mL	Yes
Control coefficient of variation	<20%	5.5%	Yes
Reference Toxicant within cusum chart limits	3.2-9.2µg Cu/L	5.2µg Cu/L	Yes

Toxicity Test Report: TR1858/21

Test Report Authorised by: Dr Rick Krassoi, Director on 16 November 2019

Results are based on the samples in the condition as received by ESA.
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Citations:

ESA (2016) SOP 110 – *Marine Algal Growth Test*. Issue No. 12. Ecotox Services Australasia, Sydney NSW

Stauber, J.L., Tsai, J., Vaughan, G.T., Peterson, S.M. and Brockbank, C.I. (1994) Algae as indicators of toxicity of the effluent from bleached eucalypt kraft pulp mills. National Pulp Mills Research Program, Technical Report No. 3. CSIRO, Canberra, ACT

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Toxicity Test Report: TR1858/22

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 9 October 2019 10 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9262	A1-5327	Produced Formation Water, pH 6.9, salinity 18.5 ‰, total ammonia 31.4 mg/L. Sample received at 14º in apparent good condition.

Test Performed:	72-hr macroalgal germination success test using *Hormosira banksii*
Test Protocol:	ESA SOP 116 (ESA 2014), based on Kevekordes and Clayton (1996) and Gunthorpe *et al*. (1997)
Test Temperature:	The test was performed at 18±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Field collected from Bilgola, NSW.
Test Initiated:	10 October 2019 at 1330h

Sample 9262*: A1-5327*

Concentration (%)	**% Germination (Mean ± SD)**	*Vacant*	*Vacant*
FSW Control	97.3 ± 1.0		
ASW Control	97.0 ± 2.5		
1.6	97.3 ± 1.0		
3.1	96.5 ± 1.3		
6.3	98.3 ± 1.7		
12.5	88.8 ± 5.4 *		
25	5.5 ± 3.4 *		
50	0.0 ± 0.0		
100	0.0 ± 0.0		

72-hr EC10 = 12.7 (10.17-13.86)%
72-hr EC50 = 17.3 (16.88-17.75)%
NOEC = 6.3%
LOEC = 12.5%

*Significantly lower percentage of germinated zygotes compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

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Toxicity Test Report: TR1858/22

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % germination	≥70.0%	97.3%	Yes
Reference Toxicant within cusum chart limits	118.5-257.9µg Cu/L	184.3µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 16 November 2019

Results are based on the samples in the condition as received by ESA.
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Citations:

ESA (2014) *SOP 116 – Macroalgal Germination Success Test*. Issue No. 13. Ecotox Services Australasia, Sydney.

Gunthorpe L, Nottage M, Palmer D, and Wu R (1997) *Testing for Sublethal Toxicity Using Gametes of Hormosira banksii: protocol*. National Pulp Mills Research Program Technical Report No. 22, CSIRO, Canberra.

Kevekordes K and Clayton MN (1996) Using developing embryos of *Hormosira banksii* (Phaeophyta) as a marine bioassay system. *International Journal of Plant Science*, 157: 582-585.

Toxicity Test Report: TR1858/23

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 9 October 2019 10 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9262	A1-5327	Produced Formation Water, pH 6.9, salinity 18.5 ‰, total ammonia 31.4 mg/L. Sample received at 14° in apparent good condition.

Test Performed:	96-hr fish imbalance toxicity test using the Barramundi *Lates calcarifer*
Test Protocol:	ESA SOP 117 (ESA 2016), based on USEPA (2002)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample
Source of Test Organisms:	In-house cultures
Test Initiated:	22 October 2019 at 1430h

Sample 9262: *A1-5327*		*Vacant*	*Vacant*
Concentration (%)	**% Unaffected (Mean ± SD)**		
FSW Control	100 ± 0.0		
ASW Control	100 ± 0.0		
1.6	100 ± 0.0		
3.1	100 ± 0.0		
6.3	65.0 ± 19.2 *		
12.5	5.0 ± 10.0 *		
25	0.0 ± 0.0		
50	0.0 ± 0.0		
100	0.0 ± 0.0		

96-hr IC10 = 4.8 (3.26-5.76)%
96-hr EC50 = 7.2 (6.09-8.58)%
NOEC =3.1%
LOEC = 6.3%

QA/QC Parameter	**Criterion**	**This Test**	**Criterion met?**
Control mean % unaffected	≥80.0%	100%	Yes
Reference Toxicant within cusum chart limits	10.7-117.39µg Cu/L	36.5µg Cu/L	Yes

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Toxicity Test Report: TR1858/23

Test Report Authorised by: Dr Rick Krassoi, Director on 16 November 2019

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Citations:

ESA (2016) SOP 117 –*Freshwater and Marine Fish Imbalance Test*. Issue No 12. Ecotox Services Australasia, Sydney, NSW

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth edition EPA-821-R-02-012. United States Environmental Protection Agency, Office of Research and Development, Washington FC, USA

Toxicity Test Report: TR1858/24

Client:	Beach Energy Ltd GPO Box 175 Adelaide SA 5002	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1858 9 October 2019 10 October 2019
Attention:	Adrian Cukovski / John Peel	**Sampled By:**	Client
Client Ref:	BE00020689	**ESA Quote #:**	PR1858_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
9262	A1-5327	Produced Formation Water, pH 6.9, salinity 18.5 ‰, total ammonia 31.4 mg/L. Sample received at 14º in apparent good condition.

Test Performed:	7-day fish imbalance and biomass toxicity test using barramundi *Lates calcarifer*
Test Protocol:	ESA SOP 122 (ESA 2017), based on USEPA (2002)
Test Temperature:	The test was performed at 25±2°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	Hatchery reared, SA
Age of Test Organisms:	-
Test Initiated:	22 October 2019 at 1430h

Sample 9262: *A1-5327*

Concentration (%)	**% Unaffected (Mean ± SD)**
FSW Control	100 ± 0.0
ASW Control	100 ± 0.0
1.6	100 ± 0.0
3.1	100 ± 0.0
6.3	95.0 ± 10.0
12.5	0.0 ± 0.0
25	0.0 ± 0.0
50	0.0 ± 0.0
100	0.0 ± 0.0

7 day IC10 (unaffected) = 6.6 (5.72-9.21)%
7 day IC50 (unaffected) = 8.6 (8.01-9.17)%
NOEC = 6.3%
LOEC = 12.5%

Sample 9262: *A1-5327*

Concentration (%)	**Biomass, mg (Mean ± SD)**	
FSW Control	23.1 ± 0.8	
ASW Control	22.6 ± 0.7	
1.6	23.4 ± 2.0	
3.1	20.6 ± 0.6	
6.3	18.7 ± 1.9	*
12.5	0.0 ± 0.0	
25	0.0 ± 0.0	
50	0.0 ± 0.0	
100	0.0 ± 0.0	

7 day IC10 (biomass) = 3.1 (2.40-5.92)%
7 day IC50 (biomass) = 8.7 (8.08-9.12) %
NOEC = 3.1%
LOEC = 6.3%

*Significantly lower fish biomass compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

Toxicity Test Report: TR1858/24

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % unaffected	$\geq$80.0%	100%	Yes
Control mean growth	$\geq$20% of initial weight	17.1%	No*
Reference Toxicant within cusum chart limits	10.7-117.4mg NH_4^+/L	36.5mg NH_4^+/L	Yes

*fish available for testing at 22 October were older and at a relatively lower growth phase than with younger fish

Test Report Authorised by: Dr Rick Krassoi, Director on 16 November 2019

Results are based on the samples in the condition as received by ESA. This document shall not be reproduced except in full.

Citations:

ESA (2017) SOP 122 –*7-day Fish Imbalance and Growth Test*. Issue No 6. Ecotox Services Australasia, Sydney, NSW

USEPA (2002) Short-term methods for estimating the chronic toxicity of effluents and receiving waters to marine and estuarine organisms. Third edition EPA-821-R-02-014. United States Environmental Protection Agency, Office of Research and Development, Washington FC, USA

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Chain-of-Custody Documentation

Datasheet ID: 601.2
Last Revised: 21 September 2018

Sample Receipt Notification

Attention : Peter Young

Client : AECOM Australia Pty Ltd
Level 6, 3 Forrest Place
Perth WA 6849

Email : peter.young@aecom.com
Telephone : 08 6208 0000
Facsimile :

Date : 10/10/2019

Re : Receipt of Samples **Pages : 2**

ESA Project : PR1858 ☑ For Review ☐ Additional Documentation Required - Please Respond

Sample Delivery Details

Completed Chain of Custody accompanied samples:	**YES**
Samples received in apparent good condition and correctly bottled:	**YES**
Security seals on sample bottles and esky intact:	**YES**

Date samples received : 10/10/2019
Time samples received : 8:30
No. of samples received : 1
Sample matrix : Aqueous
Sample temperature : 11-15°C

Comments : 4 x 2.5L sample received at 14oC in apparent good condition

Contact Details

Projects Manager : Dr Rick Krassoi
Telephone : 61 2 9420 9481
Facsimile : 61 2 9420 9484
Email : rkrassoi@ecotox.com.au

Please contact customer services officer for all queries or issues regarding samples

Note that the chain-of-custody provides definitive information on the tests to be performed

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Chain-of-Custody / Service Request Form

Datasheet ID: 601.1
Last Revised: 20 September 2018

ecotox SERVICES AUSTRALIA

Customer: Search Energy
Contact Name: Adrian Cukovski
Phone:
Email: Adrian.cukovski@searchenergy.com.au (please provide an email address for sample receipt notification)
Sampled by: Rob McFadyen

Ship To: Ecotox Services Aust
Attention: Rizh Krassoi

1400

Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance): 96 h Allivibrio Acute / 96 h Bass FIT	72 h Nitzschia / 72 h Heracuslia	48 h Ceriodaphnia / 1 h Sea urchin Fert.	72 h Sea urchin [illegible]	7 d FIT & Growth	Salt - Sampling for Ecotox	Comments / Instructions
9-10-19	0600	Yolla-A, A1-5327	Grab	4 x 25L	/	/	/	/	/	/	

a262

Comments / Instructions:

Note that testing will be delayed if an incomplete chain of custody is received

- Additional treatment of samples (i.e. spiking)
- Sub-contracted services (i.e. chemical analyses)
- Dilutions required (if different than 100% down to 6.25%)
- Sample holding time restriction (if applicable)
- Sample used for litigation (if applicable)

Note: An MSDS must be attached if Available

ESA Project Number: PR 1858

1) Released By: [signature]	Date: 9-10-19	2) Received By: [signature]	Date: 10/10/19	3) Released By:	Date:	4) Received By:	Date:
Of:	Time:	Of: ESA	Time: 0830	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

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Statistical Printouts for the Sea Urchin Fertilisation Test

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	10/10/2019 10:30	Test ID:	PR1858/03	Sample ID:	A1-5327
End Date:	13/10/2019 10:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9400	0.9600	0.9800	0.9300
ASW Control	0.9700	0.9500	0.9400	0.9800
1.6	0.9400	0.9600	0.9800	0.9500
3.1	0.9300	0.9700	0.9500	0.9800
6.3	0.9700	0.9800	0.9400	0.9300
12.5	0.7600	0.5900	0.5700	0.5800
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

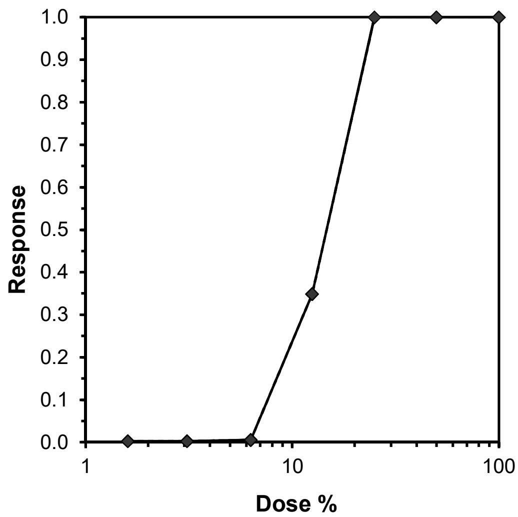
			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
FSW Control	0.9525	0.9922	1.3562	1.3030	1.4289	4.120	4				
ASW Control	0.9600	1.0000	1.3736	1.3233	1.4289	3.497	4	*		16	400
1.6	0.9575	0.9974	1.3667	1.3233	1.4289	3.330	4	17.50	10.00	17	400
3.1	0.9575	0.9974	1.3685	1.3030	1.4289	4.062	4	17.50	10.00	17	400
6.3	0.9550	0.9948	1.3630	1.3030	1.4289	4.371	4	16.50	10.00	18	400
*12.5	0.6250	0.6510	0.9140	0.8556	1.0588	10.600	4	10.00	10.00	150	400
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.89649	0.905	0.91037	0.373947
Bartlett's Test indicates equal variances (p = 0.70)	2.205322	13.2767		
The control means are not significantly different (p = 0.65)	0.471764	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Trimmed Spearman-Karber

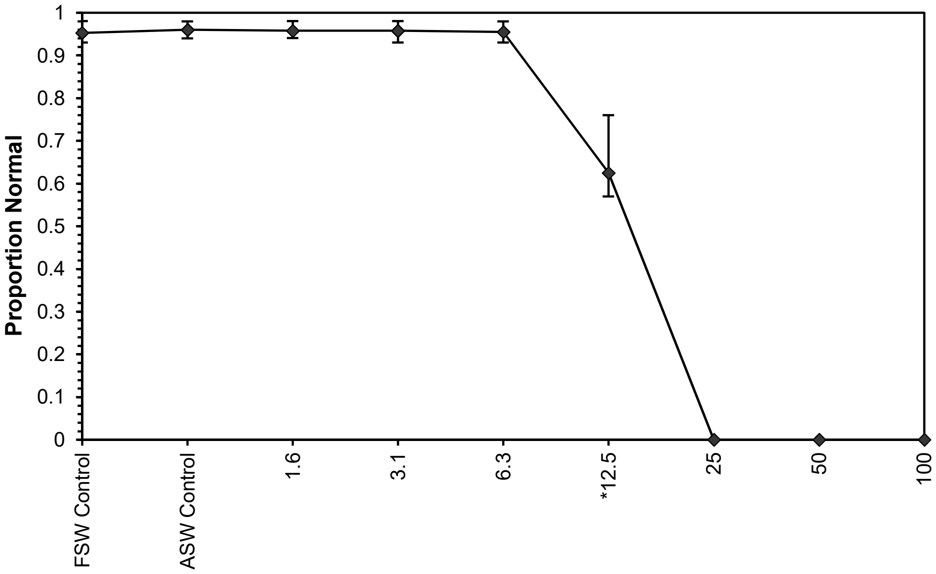
Trim Level	EC50	95% CL	
0.0%			
5.0%	14.019	13.513	14.544
10.0%	14.162	13.577	14.772
20.0%	14.431	13.578	15.337
Auto-0.3%	13.869	13.412	14.340



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	10/10/2019 10:30	Test ID:	PR1858/03	Sample ID:	A1-5327
End Date:	13/10/2019 10:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Dose-Response Plot



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	10/10/2019 10:30	Test ID:	PR1858/03	Sample ID:	A1-5327
End Date:	13/10/2019 10:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Normal	95.25	93.00	98.00	2.22	1.56	4
ASW Control		96.00	94.00	98.00	1.83	1.41	4
1.6		95.75	94.00	98.00	1.71	1.36	4
3.1		95.75	93.00	98.00	2.22	1.56	4
6.3		95.50	93.00	98.00	2.38	1.62	4
12.5		62.50	57.00	76.00	9.04	4.81	4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.90	35.90	35.90	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.80	35.80	35.80	0.00	0.00	1
FSW Control	DO %	99.70	99.70	99.70	0.00	0.00	1
ASW Control		97.60	97.60	97.60	0.00	0.00	1
1.6		99.50	99.50	99.50	0.00	0.00	1
3.1		99.70	99.70	99.70	0.00	0.00	1
6.3		99.10	99.10	99.10	0.00	0.00	1
12.5		99.60	99.60	99.60	0.00	0.00	1
25		98.90	98.90	98.90	0.00	0.00	1
50		84.60	84.60	84.60	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	10/10/2019 10:30	Test ID:	PR1858/03	Sample ID:	A1-5327
End Date:	13/10/2019 10:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9400	0.9600	0.9800	0.9300
ASW Control	0.9700	0.9500	0.9400	0.9800
1.6	0.9400	0.9600	0.9800	0.9500
3.1	0.9300	0.9700	0.9500	0.9800
6.3	0.9700	0.9800	0.9400	0.9300
12.5	0.7600	0.5900	0.5700	0.5800
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

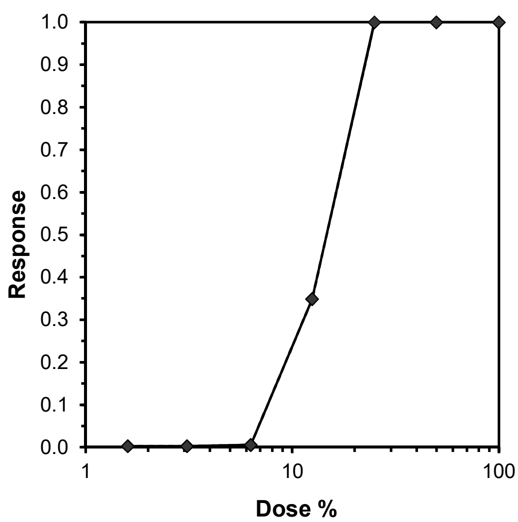
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	0.9525	0.9922	1.3562	1.3030	1.4289	4.120	4				
ASW Control	0.9600	1.0000	1.3736	1.3233	1.4289	3.497	4	*		0.9600	1.0000
1.6	0.9575	0.9974	1.3667	1.3233	1.4289	3.330	4	17.50	10.00	0.9575	0.9974
3.1	0.9575	0.9974	1.3685	1.3030	1.4289	4.062	4	17.50	10.00	0.9575	0.9974
6.3	0.9550	0.9948	1.3630	1.3030	1.4289	4.371	4	16.50	10.00	0.9550	0.9948
*12.5	0.6250	0.6510	0.9140	0.8556	1.0588	10.600	4	10.00	10.00	0.6250	0.6510
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution ($p <= 0.05$)	0.89649	0.905	0.91037	0.373947
Bartlett's Test indicates equal variances ($p = 0.70$)	2.205322	13.2767		
The control means are not significantly different ($p = 0.65$)	0.471764	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	7.680	0.296	6.557	8.225	-0.3105
IC10	8.770	0.313	7.728	9.704	0.4079
IC15	9.657	0.370	8.645	10.965	1.0192
IC20	10.437	0.446	9.415	12.083	1.3913
IC25	11.157	0.488	10.100	13.220	1.0515
IC40	12.687	0.168	12.281	13.279	0.7576
IC50	13.049	0.160	12.724	13.631	0.8966



Statistical Printouts for the Sea Urchin Larval Development Test

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	10/10/2019 10:30	Test ID:	PR1858/03	Sample ID:	A1-5327
End Date:	13/10/2019 10:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9400	0.9600	0.9800	0.9300
ASW Control	0.9700	0.9500	0.9400	0.9800
1.6	0.9400	0.9600	0.9800	0.9500
3.1	0.9300	0.9700	0.9500	0.9800
6.3	0.9700	0.9800	0.9400	0.9300
12.5	0.7600	0.5900	0.5700	0.5800
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

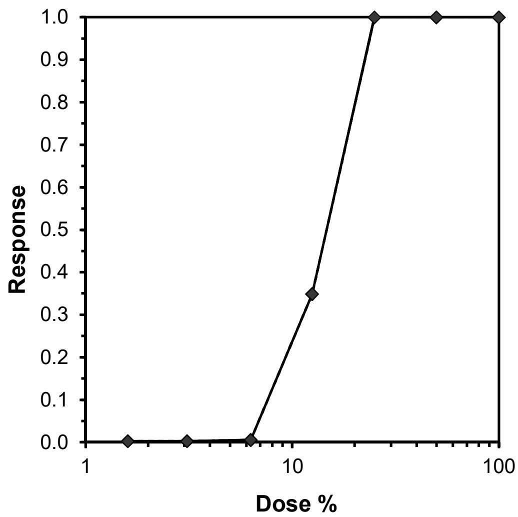
			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
FSW Control	0.9525	0.9922	1.3562	1.3030	1.4289	4.120	4				
ASW Control	0.9600	1.0000	1.3736	1.3233	1.4289	3.497	4	*		16	400
1.6	0.9575	0.9974	1.3667	1.3233	1.4289	3.330	4	17.50	10.00	17	400
3.1	0.9575	0.9974	1.3685	1.3030	1.4289	4.062	4	17.50	10.00	17	400
6.3	0.9550	0.9948	1.3630	1.3030	1.4289	4.371	4	16.50	10.00	18	400
*12.5	0.6250	0.6510	0.9140	0.8556	1.0588	10.600	4	10.00	10.00	150	400
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.89649	0.905	0.91037	0.373947
Bartlett's Test indicates equal variances (p = 0.70)	2.205322	13.2767		
The control means are not significantly different (p = 0.65)	0.471764	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

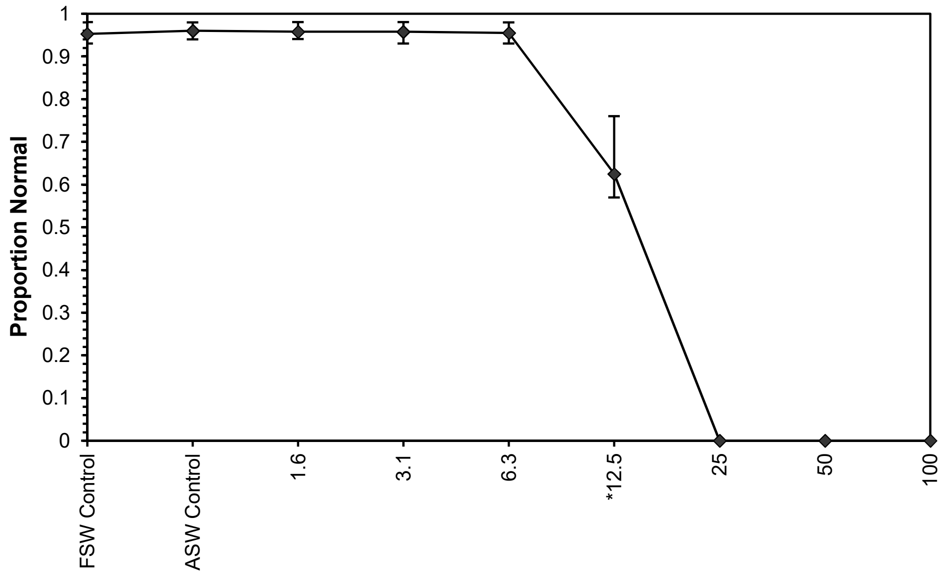
Trimmed Spearman-Karber

Trim Level	EC50	95% CL	
0.0%			
5.0%	14.019	13.513	14.544
10.0%	14.162	13.577	14.772
20.0%	14.431	13.578	15.337
Auto-0.3%	13.869	13.412	14.340



Sea Urchin Larval Development Test-Proportion Normal					
Start Date:	10/10/2019 10:30	Test ID: PR1858/03		Sample ID:	A1-5327
End Date:	13/10/2019 10:30	Lab ID: 9262		Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol: ESA 105		Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Dose-Response Plot



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	10/10/2019 10:30	Test ID:	PR1858/03	Sample ID:	A1-5327
End Date:	13/10/2019 10:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Normal	95.25	93.00	98.00	2.22	1.56	4
ASW Control		96.00	94.00	98.00	1.83	1.41	4
1.6		95.75	94.00	98.00	1.71	1.36	4
3.1		95.75	93.00	98.00	2.22	1.56	4
6.3		95.50	93.00	98.00	2.38	1.62	4
12.5		62.50	57.00	76.00	9.04	4.81	4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.90	35.90	35.90	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.80	35.80	35.80	0.00	0.00	1
FSW Control	DO %	99.70	99.70	99.70	0.00	0.00	1
ASW Control		97.60	97.60	97.60	0.00	0.00	1
1.6		99.50	99.50	99.50	0.00	0.00	1
3.1		99.70	99.70	99.70	0.00	0.00	1
6.3		99.10	99.10	99.10	0.00	0.00	1
12.5		99.60	99.60	99.60	0.00	0.00	1
25		98.90	98.90	98.90	0.00	0.00	1
50		84.60	84.60	84.60	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	10/10/2019 10:30	Test ID:	PR1858/03	Sample ID:	A1-5327
End Date:	13/10/2019 10:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 105	Test Species:	-HELIOCIDARIS TUBERCULATA
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9400	0.9600	0.9800	0.9300
ASW Control	0.9700	0.9500	0.9400	0.9800
1.6	0.9400	0.9600	0.9800	0.9500
3.1	0.9300	0.9700	0.9500	0.9800
6.3	0.9700	0.9800	0.9400	0.9300
12.5	0.7600	0.5900	0.5700	0.5800
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

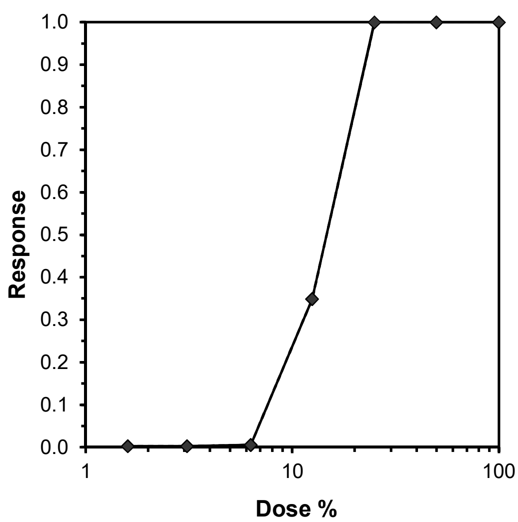
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	0.9525	0.9922	1.3562	1.3030	1.4289	4.120	4				
ASW Control	0.9600	1.0000	1.3736	1.3233	1.4289	3.497	4	*		0.9600	1.0000
1.6	0.9575	0.9974	1.3667	1.3233	1.4289	3.330	4	17.50	10.00	0.9575	0.9974
3.1	0.9575	0.9974	1.3685	1.3030	1.4289	4.062	4	17.50	10.00	0.9575	0.9974
6.3	0.9550	0.9948	1.3630	1.3030	1.4289	4.371	4	16.50	10.00	0.9550	0.9948
*12.5	0.6250	0.6510	0.9140	0.8556	1.0588	10.600	4	10.00	10.00	0.6250	0.6510
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.89649	0.905	0.91037	0.373947
Bartlett's Test indicates equal variances (p = 0.70)	2.205322	13.2767		
The control means are not significantly different (p = 0.65)	0.471764	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	7.680	0.296	6.557	8.225	-0.3105
IC10	8.770	0.313	7.728	9.704	0.4079
IC15	9.657	0.370	8.645	10.965	1.0192
IC20	10.437	0.446	9.415	12.083	1.3913
IC25	11.157	0.488	10.100	13.220	1.0515
IC40	12.687	0.168	12.281	13.279	0.7576
IC50	13.049	0.160	12.724	13.631	0.8966



Statistical Printouts for the Mussel Toxicity Tests

Bivalve Acute Toxicity Tests-Proportion Normal

Start Date:	10/10/2019 12:30	Test ID:	PR1858/06	Sample ID:	A1-5327
End Date:	13/10/2019 12:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
FSW Control	0.7600	0.8100	0.7700	0.7300
ASW Control	0.7100	0.7300	0.7800	0.7500
1.6	0.7800	0.8400	0.7900	0.7600
3.1	0.7500	0.8100	0.7900	0.7700
6.3	0.7800	0.7600	0.7500	0.8100
12.5	0.2700	0.3100	0.4600	0.4400
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

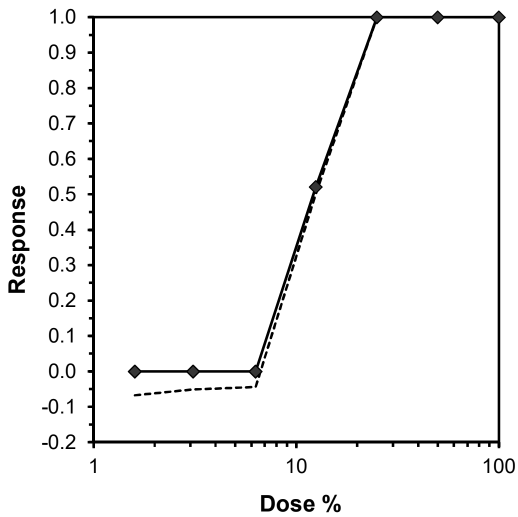
			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.7675	1.0337	1.0684	1.0244	1.1198	3.694	4					
ASW Control	0.7425	1.0000	1.0391	1.0021	1.0826	3.306	4	*			103	400
1.6	0.7925	1.0673	1.0989	1.0588	1.1593	3.909	4	-1.559	2.360	0.0905	83	400
3.1	0.7800	1.0505	1.0831	1.0472	1.1198	2.883	4	-1.148	2.360	0.0905	88	400
6.3	0.7750	1.0438	1.0771	1.0472	1.1198	2.974	4	-0.992	2.360	0.0905	90	400
*12.5	0.3700	0.4983	0.6519	0.5464	0.7454	15.086	4	10.100	2.360	0.0905	252	400
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.979874	0.905	0.018979	0.115837
Bartlett's Test indicates equal variances (p = 0.18)	6.202708	13.2767		
The control means are not significantly different (p = 0.31)	1.120964	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	6.3	12.5	8.87412	15.87302	0.082617	0.111203	0.144838	0.00294	1.9E-08	4, 15
Treatments vs ASW Control										

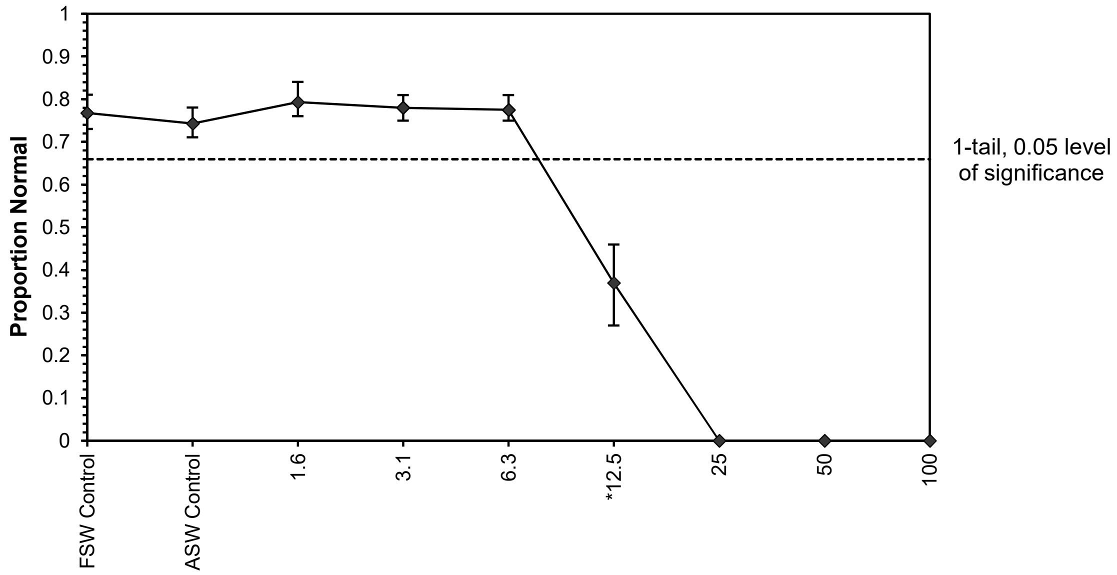
Trimmed Spearman-Karber

Trim Level	EC50	95% CL	
0.0%	12.345	11.927	12.777
5.0%	12.324	11.862	12.804
10.0%	12.304	11.788	12.843
20.0%	12.264	11.589	12.977
Auto-0.0%	12.345	11.927	12.777



Bivalve Acute Toxicity Tests-Proportion Normal					
Start Date:	10/10/2019 12:30	Test ID:	PR1858/06	Sample ID:	A1-5327
End Date:	13/10/2019 12:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Dose-Response Plot



Bivalve Acute Toxicity Tests-Proportion Normal					
Start Date:	10/10/2019 12:30	Test ID:	PR1858/06	Sample ID:	A1-5327
End Date:	13/10/2019 12:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	% Normal	76.75	73.00	81.00	3.30	2.37	4
ASW Control		74.25	71.00	78.00	2.99	2.33	4
1.6		79.25	76.00	84.00	3.40	2.33	4
3.1		78.00	75.00	81.00	2.58	2.06	4
6.3		77.50	75.00	81.00	2.65	2.10	4
12.5		37.00	27.00	46.00	9.42	8.29	4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.90	35.90	35.90	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.80	35.80	35.80	0.00	0.00	1
FSW Control	DO %	99.70	99.70	99.70	0.00	0.00	1
ASW Control		97.60	97.60	97.60	0.00	0.00	1
1.6		99.50	99.50	99.50	0.00	0.00	1
3.1		99.70	99.70	99.70	0.00	0.00	1
6.3		99.10	99.10	99.10	0.00	0.00	1
12.5		99.60	99.60	99.60	0.00	0.00	1
25		98.90	98.90	98.90	0.00	0.00	1
50		84.60	84.60	84.60	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1

Bivalve Acute Toxicity Tests-Proportion Normal

Start Date:	10/10/2019 12:30	Test ID:	PR1858/06	Sample ID:	A1-5327
End Date:	13/10/2019 12:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 106	Test Species:	MG-Mytilus galloprovincialis
Comments:					

Conc-%	1	2	3	4
FSW Control	0.7600	0.8100	0.7700	0.7300
ASW Control	0.7100	0.7300	0.7800	0.7500
1.6	0.7800	0.8400	0.7900	0.7600
3.1	0.7500	0.8100	0.7900	0.7700
6.3	0.7800	0.7600	0.7500	0.8100
12.5	0.2700	0.3100	0.4600	0.4400
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

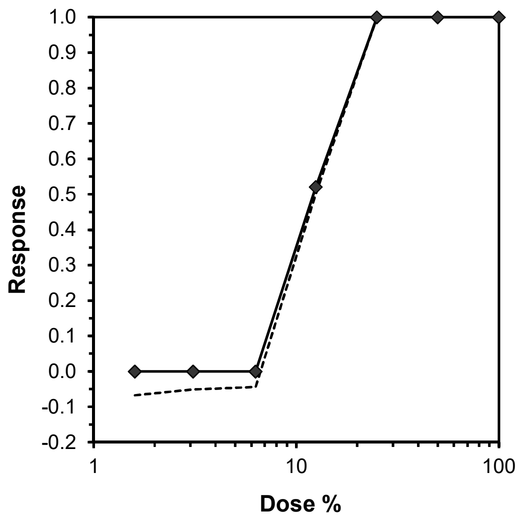
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.7675	1.0337	1.0684	1.0244	1.1198	3.694	4					
ASW Control	0.7425	1.0000	1.0391	1.0021	1.0826	3.306	4	*			0.7725	1.0000
1.6	0.7925	1.0673	1.0989	1.0588	1.1593	3.909	4	-1.559	2.360	0.0905	0.7725	1.0000
3.1	0.7800	1.0505	1.0831	1.0472	1.1198	2.883	4	-1.148	2.360	0.0905	0.7725	1.0000
6.3	0.7750	1.0438	1.0771	1.0472	1.1198	2.974	4	-0.992	2.360	0.0905	0.7725	1.0000
*12.5	0.3700	0.4983	0.6519	0.5464	0.7454	15.086	4	10.100	2.360	0.0905	0.3700	0.4790
25	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.979874	0.905	0.018979	0.115837
Bartlett's Test indicates equal variances (p = 0.18)	6.202708	13.2767		
The control means are not significantly different (p = 0.31)	1.120964	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	6.3	12.5	8.87412	15.87302	0.082617	0.111203	0.144838	0.00294	1.9E-08	4, 15
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	6.852	0.101	6.358	7.035	-0.5888
IC10	7.392	0.137	6.852	7.803	0.1359
IC15	7.927	0.190	7.255	8.596	0.4035
IC20	8.465	0.254	7.675	9.405	0.5073
IC25	9.014	0.325	8.071	10.231	0.5609
IC40	10.792	0.587	9.285	13.051	0.6458
IC50	12.177	0.545	10.209	13.116	-0.4472



Statistical Printouts for the Acute *Allorchestes* Toxicity Test

Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	22/10/2019 15:30	Test ID:	PR1858/10	Sample ID:	A1-5327
End Date:	26/10/2019 15:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	0.6000	0.8000	0.6000	0.6000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

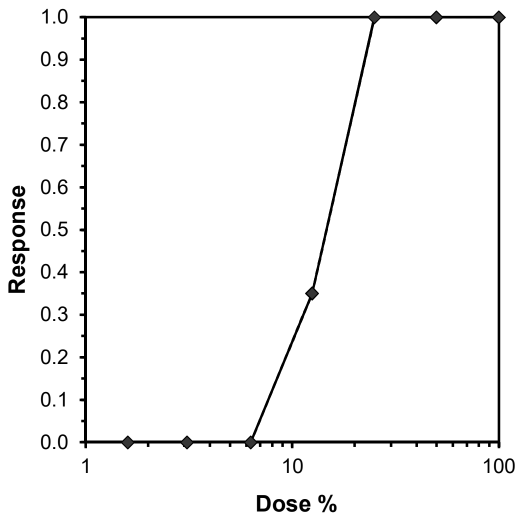
			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		0	20
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
3.1	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
6.3	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
*12.5	0.6500	0.6500	0.9413	0.8861	1.1071	11.742	4	10.00	10.00	7	20
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.508902	0.905	2.796235	11.6732
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Trimmed Spearman-Karber

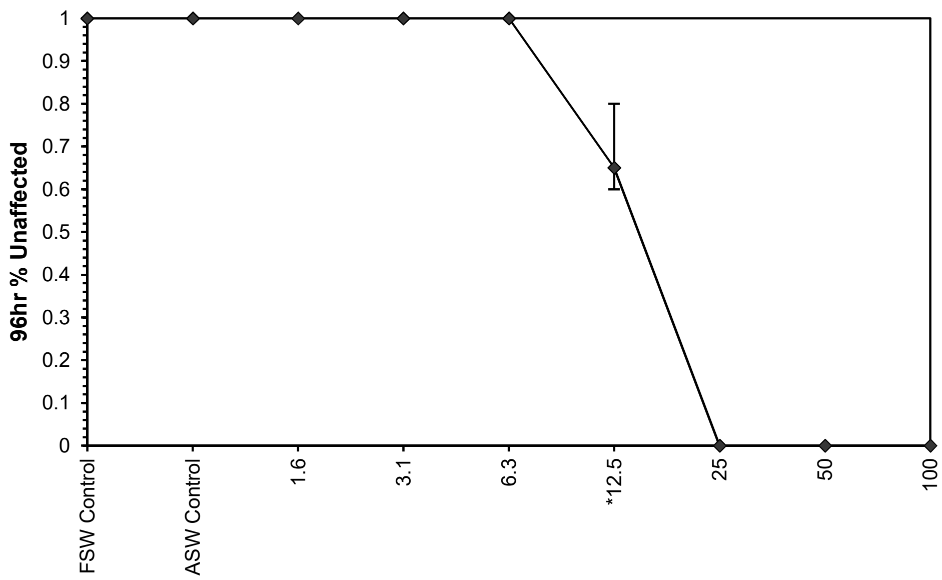
Trim Level	EC50	95% CL	
0.0%	13.889	11.990	16.088
5.0%	14.029	11.901	16.537
10.0%	14.166	11.726	17.114
20.0%	14.425	10.978	18.955
Auto-0.0%	13.889	11.990	16.088



Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	22/10/2019 15:30	Test ID:	PR1858/10	Sample ID:	A1-5327
End Date:	26/10/2019 15:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

Dose-Response Plot



Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	22/10/2019 15:30	Test ID:	PR1858/10	Sample ID:	A1-5327
End Date:	26/10/2019 15:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Non-immobilised	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		100.00	100.00	100.00	0.00	0.00	4
6.3		100.00	100.00	100.00	0.00	0.00	4
12.5		65.00	60.00	80.00	10.00	4.87	4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
FSW Control	DO %	99.20	99.20	99.20	0.00	0.00	1
ASW Control		94.20	94.20	94.20	0.00	0.00	1
1.6		99.60	99.60	99.60	0.00	0.00	1
3.1		99.20	99.20	99.20	0.00	0.00	1
6.3		98.00	98.00	98.00	0.00	0.00	1
12.5		99.30	99.30	99.30	0.00	0.00	1
25		98.60	98.60	98.60	0.00	0.00	1
50		84.10	84.10	84.10	0.00	0.00	1
100		79.30	79.30	79.30	0.00	0.00	1
FSW Control	Salinity ppt	36.00	36.00	36.00	0.00	0.00	1
ASW Control		35.70	35.70	35.70	0.00	0.00	1
1.6		36.00	36.00	36.00	0.00	0.00	1
3.1		36.00	36.00	36.00	0.00	0.00	1
6.3		36.00	36.00	36.00	0.00	0.00	1
12.5		36.00	36.00	36.00	0.00	0.00	1
25		36.00	36.00	36.00	0.00	0.00	1
50		36.00	36.00	36.00	0.00	0.00	1
100		35.80	35.80	35.80	0.00	0.00	1

Amphipod Acute Toxicity Test-96hr % Unaffected

Start Date:	22/10/2019 15:30	Test ID:	PR1858/10	Sample ID:	A1-5327
End Date:	26/10/2019 15:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 108	Test Species:	AC-Allorchestes compressa
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	0.6000	0.8000	0.6000	0.6000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

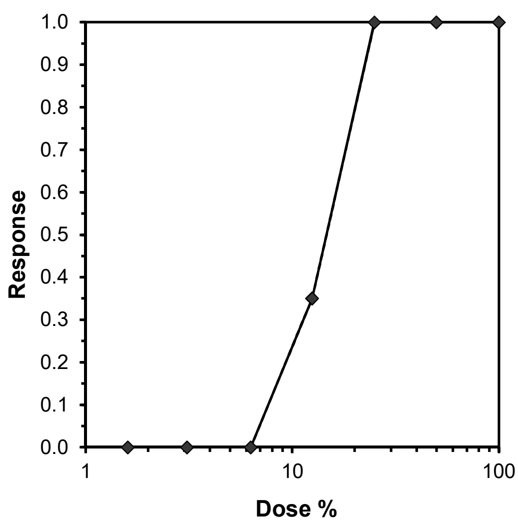
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		1.0000	1.0000
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
3.1	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
6.3	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
*12.5	0.6500	0.6500	0.9413	0.8861	1.1071	11.742	4	10.00	10.00	0.6500	0.6500
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.508902	0.905	2.796235	11.6732
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	10.430	0.113	10.233	10.922	0.6357
IC10	11.058	0.133	10.825	11.639	0.6380
IC15	11.464	0.147	11.207	12.105	0.6395
IC20	11.779	0.158	11.503	12.467	0.6406
IC25	12.045	0.167	11.753	12.773	0.6416
IC40	12.694	0.166	12.384	13.357	0.4839
IC50	13.069	0.163	12.764	13.721	0.4830



Statistical Printouts for the *Nitzschia* Growth Inhibition Tests

Microalgal Cell Yield-Cell Yield									
Start Date:	22/10/2019 14:30	Test ID:	PR1858/11		Sample ID:		A1-5327		
End Date:	25/10/2019 14:30	Lab ID:	9262		Sample Type:		PFW-Produced Formation Water		
Sample Date:		Protocol:	ESA 110		Test Species:		NC-Nitzschia closterium		
Comments:									

Conc-%	1	2	3	4	5	6	7	8
FSW Control	16.763	15.563	16.863	14.463	15.963	14.863	16.363	16.263
ASW Control	14.763	13.563	15.763	15.763				
1.6	16.563	15.363	16.863	15.963				
3.1	16.263	14.763	13.663	17.163				
6.3	16.563	16.863	14.963	15.863				
12.5	13.463	13.963	13.063	15.763				
25	5.463	0.163	0.903	2.063				
50	0.000	0.000	0.000	0.000				
100	0.000	0.000	0.000	0.000				

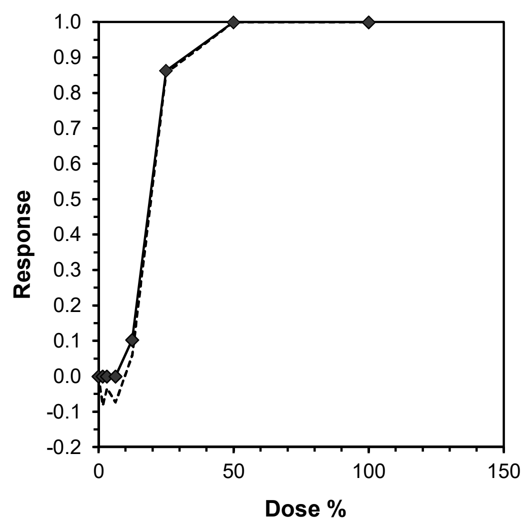
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	15.888	1.0618	15.888	14.463	16.863	5.464	8					
ASW Control	14.963	1.0000	14.963	13.563	15.763	6.988	4	*			15.669	1.0000
1.6	16.188	1.0819	16.188	15.363	16.863	4.109	4	-1.247	2.410	2.368	15.669	1.0000
3.1	15.463	1.0334	15.463	13.663	17.163	10.061	4	-0.509	2.410	2.368	15.669	1.0000
6.3	16.063	1.0735	16.063	14.963	16.863	5.258	4	-1.120	2.410	2.368	15.669	1.0000
12.5	14.063	0.9399	14.063	13.063	15.763	8.474	4	0.916	2.410	2.368	14.063	0.8975
*25	2.148	0.1435	2.148	0.163	5.463	109.152	4	13.043	2.410	2.368	2.148	0.1371
50	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
100	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.958622	0.916	0.688967	0.89182
Bartlett's Test indicates equal variances (p = 0.36)	5.505599	15.08627		
The control means are not significantly different (p = 0.13)	1.633112	2.228139		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	12.5	25	17.67767	8	2.367933	0.158256	118.5836	1.930789	1.1E-10	5, 18
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

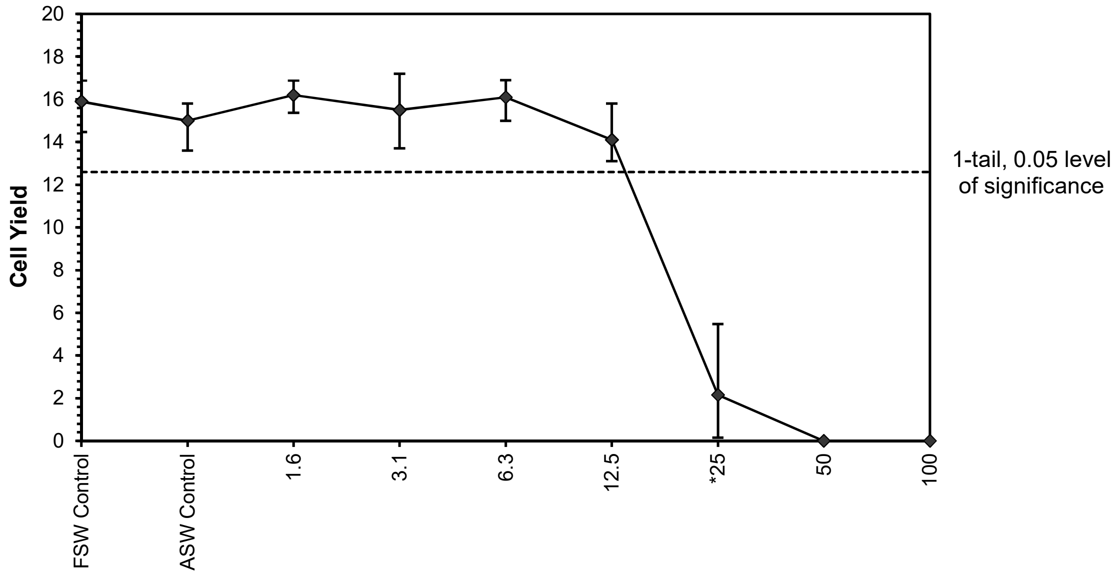
Point	%	SD	95% CL(Exp)		Skew
IC05	9.324	1.595	4.966	14.219	-0.7465
IC10	12.348	1.105	8.325	13.878	-0.2383
IC15	13.281	0.566	11.506	14.673	-0.0083
IC20	14.103	0.510	12.737	15.539	0.5533
IC25	14.924	0.505	13.615	16.409	0.6795
IC40	17.390	0.565	15.933	18.952	0.7747
IC50	19.034	0.654	17.457	21.013	0.7583



Microalgal Cell Yield-Cell Yield

Start Date:	22/10/2019 14:30	Test ID:	PR1858/11	Sample ID:	A1-5327
End Date:	25/10/2019 14:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 110	Test Species:	NC-Nitzschia closterium
Comments:					

Dose-Response Plot



Microalgal Cell Yield-Cell Yield

Start Date:	22/10/2019 14:30	Test ID:	PR1858/11	Sample ID:	A1-5327
End Date:	25/10/2019 14:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 110	Test Species:	NC-Nitzschia closterium
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	Cell Yield	15.89	14.46	16.86	0.87	5.86	8
ASW Control		14.96	13.56	15.76	1.05	6.83	4
1.6		16.19	15.36	16.86	0.67	5.04	4
3.1		15.46	13.66	17.16	1.56	8.07	4
6.3		16.06	14.96	16.86	0.84	5.72	4
12.5		14.06	13.06	15.76	1.19	7.76	4
25		2.15	0.16	5.46	2.34	71.29	4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
FSW Control	Salinity ppt	36.00	36.00	36.00	0.00	0.00	1
ASW Control		35.70	35.70	35.70	0.00	0.00	1
1.6		36.00	36.00	36.00	0.00	0.00	1
3.1		36.00	36.00	36.00	0.00	0.00	1
6.3		36.00	36.00	36.00	0.00	0.00	1
12.5		36.00	36.00	36.00	0.00	0.00	1
25		36.00	36.00	36.00	0.00	0.00	1
50		36.00	36.00	36.00	0.00	0.00	1
100		35.80	35.80	35.80	0.00	0.00	1

Statistical Printouts for the Acute *Hormosira* Cell Germination Test

Macroalgal Germination Success Test-Proportion Germinated					
Start Date:	10/10/2019 13:30	Test ID:	PR1858/07	Sample ID:	A1-5327
End Date:	13/10/2019 13:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 116	Test Species:	HB-Hormosira banksii
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9800	0.9600	0.9700	0.9800
ASW Control	0.9400	0.9900	0.9600	0.9900
1.6	0.9800	0.9600	0.9800	0.9700
3.1	0.9600	0.9800	0.9500	0.9700
6.3	0.9900	0.9600	1.0000	0.9800
12.5	0.8100	0.9300	0.8900	0.9200
25	0.0400	0.0600	0.1000	0.0200
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

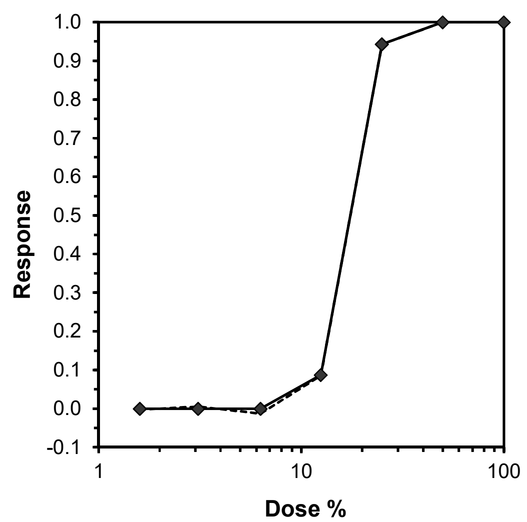
			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.9725	1.0026	1.4060	1.3694	1.4289	2.042	4					
ASW Control	0.9700	1.0000	1.4085	1.3233	1.4706	5.265	4	*			12	400
1.6	0.9725	1.0026	1.4060	1.3694	1.4289	2.042	4	0.056	2.410	0.1084	11	400
3.1	0.9650	0.9948	1.3851	1.3453	1.4289	2.598	4	0.521	2.410	0.1084	14	400
6.3	0.9825	1.0129	1.4474	1.3694	1.5208	4.432	4	-0.866	2.410	0.1084	7	400
*12.5	0.8875	0.9149	1.2349	1.1198	1.3030	6.664	4	3.861	2.410	0.1084	45	400
*25	0.0550	0.0567	0.2281	0.1419	0.3218	33.281	4	26.248	2.410	0.1084	378	400
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				400	400

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.968111	0.916	-0.31998	-0.64273
Bartlett's Test indicates equal variances (p = 0.54)	4.080333	15.08627		
The control means are not significantly different (p = 0.95)	0.063348	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	6.3	12.5	8.87412	15.87302	0.045383	0.0466	0.900647	0.004045	1.6E-15	5, 18
Treatments vs ASW Control										

Trimmed Spearman-Karber

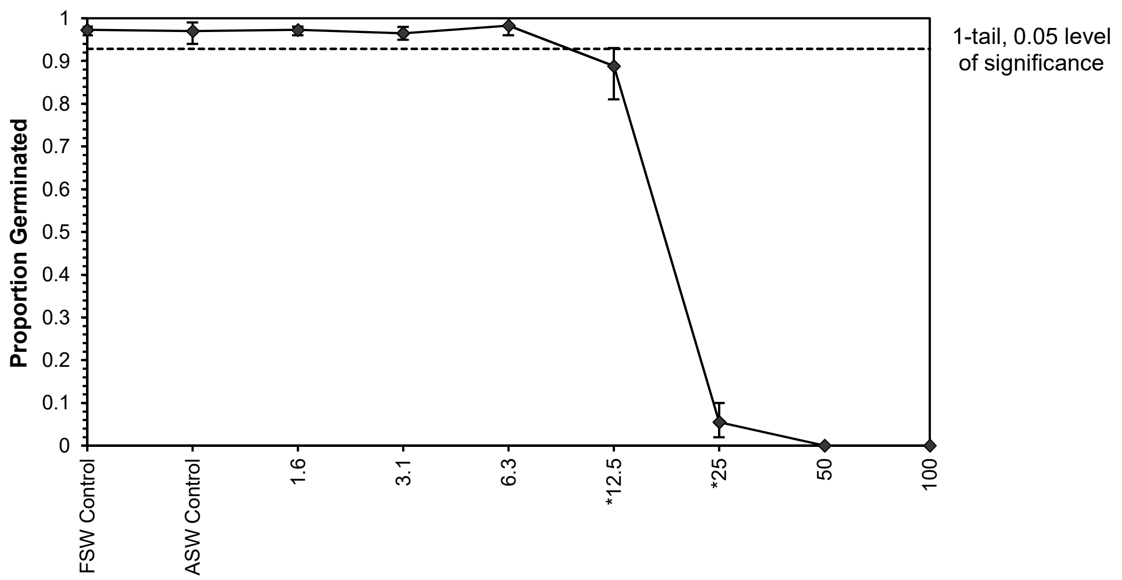
Trim Level	EC50	95% CL	
0.0%	17.310	16.879	17.752
5.0%	17.368	17.005	17.738
10.0%	17.458	17.200	17.720
20.0%	17.458	17.200	17.720
Auto-0.0%	17.310	16.879	17.752



Macroalgal Germination Success Test-Proportion Germinated

Start Date:	10/10/2019 13:30	Test ID:	PR1858/07	Sample ID:	A1-5327
End Date:	13/10/2019 13:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 116	Test Species:	HB-Hormosira banksii
Comments:					

Dose-Response Plot



Macroalgal Germination Success Test-Proportion Germinated

Start Date:	10/10/2019 13:30	Test ID:	PR1858/07	Sample ID:	A1-5327
End Date:	13/10/2019 13:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 116	Test Species:	HB-Hormosira banksii
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	Germination, %	97.25	96.00	98.00	0.96	1.01	4
ASW Control		97.00	94.00	99.00	2.45	1.61	4
1.6		97.25	96.00	98.00	0.96	1.01	4
3.1		96.50	95.00	98.00	1.29	1.18	4
6.3		98.25	96.00	100.00	1.71	1.33	4
12.5		88.75	81.00	93.00	5.44	2.63	4
25		5.50	2.00	10.00	3.42	33.60	4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.90	35.90	35.90	0.00	0.00	1
ASW Control		35.50	35.50	35.50	0.00	0.00	1
1.6		35.90	35.90	35.90	0.00	0.00	1
3.1		35.90	35.90	35.90	0.00	0.00	1
6.3		35.90	35.90	35.90	0.00	0.00	1
12.5		35.90	35.90	35.90	0.00	0.00	1
25		35.80	35.80	35.80	0.00	0.00	1
50		35.80	35.80	35.80	0.00	0.00	1
100		35.80	35.80	35.80	0.00	0.00	1
FSW Control	DO %	99.70	99.70	99.70	0.00	0.00	1
ASW Control		97.60	97.60	97.60	0.00	0.00	1
1.6		99.50	99.50	99.50	0.00	0.00	1
3.1		99.70	99.70	99.70	0.00	0.00	1
6.3		99.10	99.10	99.10	0.00	0.00	1
12.5		99.60	99.60	99.60	0.00	0.00	1
25		98.90	98.90	98.90	0.00	0.00	1
50		84.60	84.60	84.60	0.00	0.00	1
100		80.20	80.20	80.20	0.00	0.00	1

Macroalgal Germination Success Test-Proportion Germinated

Start Date:	10/10/2019 13:30	Test ID:	PR1858/07	Sample ID:	A1-5327
End Date:	13/10/2019 13:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 116	Test Species:	HB-Hormosira banksii
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9800	0.9600	0.9700	0.9800
ASW Control	0.9400	0.9900	0.9600	0.9900
1.6	0.9800	0.9600	0.9800	0.9700
3.1	0.9600	0.9800	0.9500	0.9700
6.3	0.9900	0.9600	1.0000	0.9800
12.5	0.8100	0.9300	0.8900	0.9200
25	0.0400	0.0600	0.1000	0.0200
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

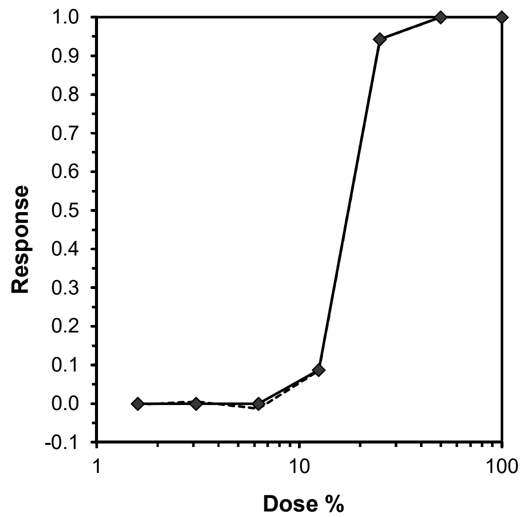
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.9725	1.0026	1.4060	1.3694	1.4289	2.042	4					
ASW Control	0.9700	1.0000	1.4085	1.3233	1.4706	5.265	4	*			0.9725	1.0000
1.6	0.9725	1.0026	1.4060	1.3694	1.4289	2.042	4	0.056	2.410	0.1084	0.9725	1.0000
3.1	0.9650	0.9948	1.3851	1.3453	1.4289	2.598	4	0.521	2.410	0.1084	0.9725	1.0000
6.3	0.9825	1.0129	1.4474	1.3694	1.5208	4.432	4	-0.866	2.410	0.1084	0.9725	1.0000
*12.5	0.8875	0.9149	1.2349	1.1198	1.3030	6.664	4	3.861	2.410	0.1084	0.8875	0.9126
*25	0.0550	0.0567	0.2281	0.1419	0.3218	33.281	4	26.248	2.410	0.1084	0.0550	0.0566
50	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000
100	0.0000	0.0000	0.0500	0.0500	0.0500	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.968111	0.916	-0.31998	-0.64273
Bartlett's Test indicates equal variances (p = 0.54)	4.080333	15.08627		
The control means are not significantly different (p = 0.95)	0.063348	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	6.3	12.5	8.87412	15.87302	0.045383	0.0466	0.900647	0.004045	1.6E-15	5, 18
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	10.315	0.942	8.232	13.852	0.6791
IC10	12.713	0.646	10.172	13.857	-0.5679
IC15	13.439	0.429	12.141	14.574	-0.0023
IC20	14.045	0.418	12.790	15.220	0.0216
IC25	14.581	0.411	13.300	15.724	0.0335
IC40	16.004	0.408	14.639	17.152	0.0041
IC50	16.918	0.421	15.586	18.171	-0.0635



Statistical Printouts for the Larval Fish Imbalance Tests

Fish Imbalance Test-96 hr Unaffected

Start Date:	22/10/2019 16:00	Test ID:	PR1858/14	Sample ID:	A1-5327
End Date:	26/10/2019 14:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 112	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	0.6000	0.4000	0.8000	0.8000
12.5	0.2000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		0	20
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
3.1	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
*6.3	0.6500	0.6500	0.9463	0.6847	1.1071	21.467	4	10.00	10.00	7	20
*12.5	0.0500	0.0500	0.2850	0.2255	0.4636	41.771	4	10.00	10.00	19	20
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20

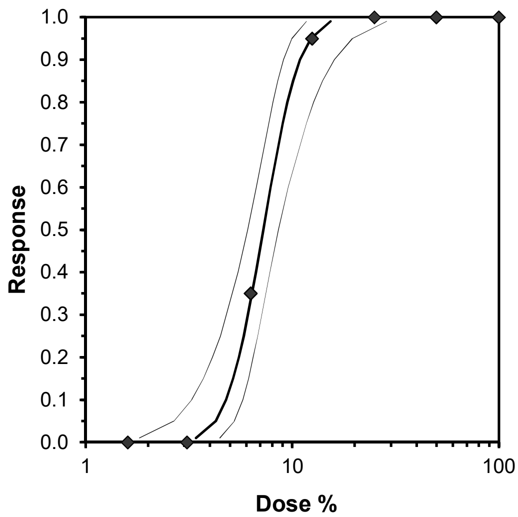
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.772021	0.905	-0.337	3.142347
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	3.1	6.3	4.419276	32.25806
Treatments vs ASW Control				

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	7.171209	1.622143	3.991809	10.35061	0	0.124313	11.0705	1	0.858989	0.139447	4
Intercept	-1.15999	1.415627	-3.93462	1.614642							
TSCR											

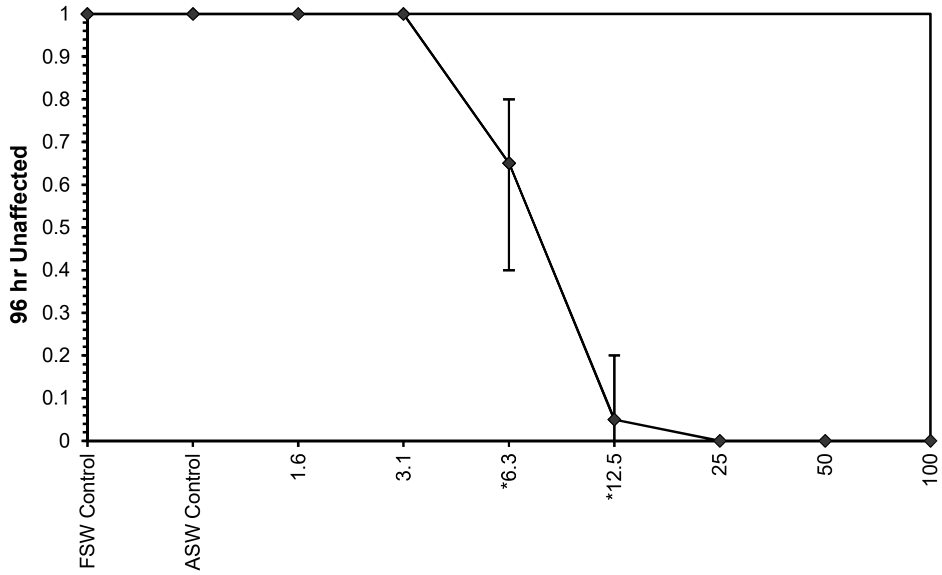
Point	Probits	%	95% Fiducial Limits	
EC01	2.674	3.424425	1.823373	4.459235
EC05	3.355	4.262061	2.668168	5.253962
EC10	3.718	4.789397	3.255165	5.757561
EC15	3.964	5.181574	3.711936	6.141831
EC20	4.158	5.516042	4.110225	6.481224
EC25	4.326	5.820141	4.475316	6.80322
EC40	4.747	6.662855	5.467963	7.796544
EC50	5.000	7.22751	6.086886	8.575823
EC60	5.253	7.840019	6.697982	9.542679
EC75	5.674	8.975196	7.679833	11.65338
EC80	5.842	9.469998	8.062462	12.68679
EC85	6.036	10.08128	8.508998	14.04641
EC90	6.282	10.90678	9.077873	16.01571
EC95	6.645	12.25626	9.949011	19.53719
EC99	7.326	15.25421	11.72327	28.58626



Fish Imbalance Test-96 hr Unaffected

Start Date:	22/10/2019 16:00	Test ID:	PR1858/14	Sample ID:	A1-5327
End Date:	26/10/2019 14:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 112	Test Species:	LT-Lates calcarifer
Comments:					

Dose-Response Plot



Fish Imbalance Test-96 hr Unaffected

Start Date:	22/10/2019 16:00	Test ID:	PR1858/14	Sample ID:	A1-5327
End Date:	26/10/2019 14:00	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 112	Test Species:	LT-Lates calcarifer
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% unaffected	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		100.00	100.00	100.00	0.00	0.00	4
6.3		65.00	40.00	80.00	19.15	6.73	4
12.5		5.00	0.00	20.00	10.00	63.25	4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
FSW Control	Salinity ppt	36.00	36.00	36.00	0.00	0.00	1
ASW Control		35.70	35.70	35.70	0.00	0.00	1
1.6		36.00	36.00	36.00	0.00	0.00	1
3.1		36.00	36.00	36.00	0.00	0.00	1
6.3		36.00	36.00	36.00	0.00	0.00	1
12.5		36.00	36.00	36.00	0.00	0.00	1
25		36.00	36.00	36.00	0.00	0.00	1
50		36.00	36.00	36.00	0.00	0.00	1
100		35.80	35.80	35.80	0.00	0.00	1
FSW Control	DO %	99.20	99.20	99.20	0.00	0.00	1
ASW Control		94.20	94.20	94.20	0.00	0.00	1
1.6		99.60	99.60	99.60	0.00	0.00	1
3.1		99.20	99.20	99.20	0.00	0.00	1
6.3		98.00	98.00	98.00	0.00	0.00	1
12.5		99.30	99.30	99.30	0.00	0.00	1
25		98.60	98.60	98.60	0.00	0.00	1
50		84.10	84.10	84.10	0.00	0.00	1
100		79.30	79.30	79.30	0.00	0.00	1

Statistical Printouts for the 7-d Larval Fish Growth Inhibition Tests

Fish Growth Test-7 Day Unaffected

Start Date:	22/10/2019 14:30	Test ID:	PR1858/15	Sample ID:	A1-5327
End Date:	29/10/2019 14:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	0.8000	1.0000	1.0000	1.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

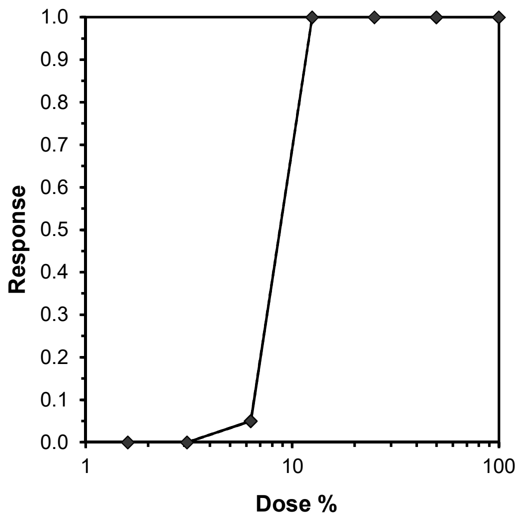
			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		0	20
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
3.1	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
6.3	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	1	20
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.564851	0.887	-2.55551	9.368132
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Trimmed Spearman-Karber

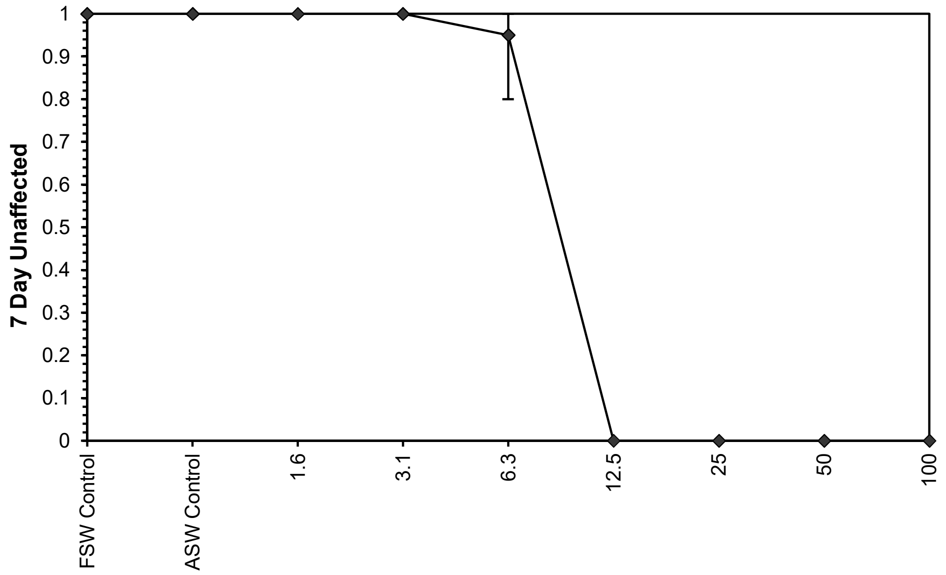
Trim Level	EC50	95% CL	
0.0%	8.5701	8.0071	9.1727
5.0%	8.7155	8.3990	9.0440
10.0%	8.7155	8.3990	9.0440
20.0%	8.7155	8.3990	9.0440
Auto-0.0%	8.5701	8.0071	9.1727



Fish Growth Test-7 Day Unaffected

Start Date:	22/10/2019 14:30	Test ID:	PR1858/15	Sample ID:	A1-5327
End Date:	29/10/2019 14:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Dose-Response Plot



Fish Growth Test-7 Day Unaffected

Start Date:	22/10/2019 14:30	Test ID:	PR1858/15	Sample ID:	A1-5327
End Date:	29/10/2019 14:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	% Un-affected	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		100.00	100.00	100.00	0.00	0.00	4
6.3		95.00	80.00	100.00	10.00	3.33	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	Biomass	23.06	22.16	24.14	0.82	3.92	4
ASW Control		22.62	21.74	23.26	0.70	3.69	4
1.6		23.38	21.24	26.14	2.04	6.10	4
3.1		20.64	20.12	21.56	0.63	3.85	4
6.3		18.72	16.02	19.94	1.86	7.28	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
FSW Control	Salinity	36.00	36.00	36.00	0.00	0.00	1
ASW Control		35.70	35.70	35.70	0.00	0.00	1
1.6		36.00	36.00	36.00	0.00	0.00	1
3.1		36.00	36.00	36.00	0.00	0.00	1
6.3		36.00	36.00	36.00	0.00	0.00	1
12.5		36.00	36.00	36.00	0.00	0.00	1
25		36.00	36.00	36.00	0.00	0.00	1
50		36.00	36.00	36.00	0.00	0.00	1
100		35.80	35.80	35.80	0.00	0.00	1
FSW Control	% DO	99.20	99.20	99.20	0.00	0.00	1
ASW Control		94.20	94.20	94.20	0.00	0.00	1
1.6		99.60	99.60	99.60	0.00	0.00	1
3.1		99.20	99.20	99.20	0.00	0.00	1
6.3		98.00	98.00	98.00	0.00	0.00	1
12.5		99.30	99.30	99.30	0.00	0.00	1
25		98.60	98.60	98.60	0.00	0.00	1
50		84.10	84.10	84.10	0.00	0.00	1
100		79.30	79.30	79.30	0.00	0.00	1

Fish Growth Test-7 Day Unaffected					
Start Date:	22/10/2019 14:30	Test ID:	PR1858/15	Sample ID:	A1-5327
End Date:	29/10/2019 14:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	0.8000	1.0000	1.0000	1.0000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

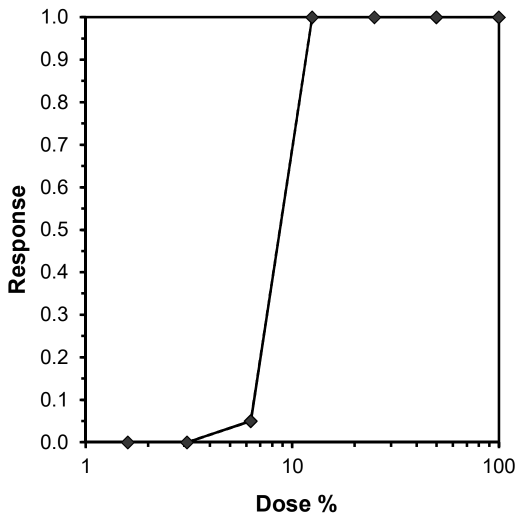
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		1.0000	1.0000
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
3.1	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
6.3	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	0.9500	0.9500
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.564851	0.887	-2.55551	9.368132
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	6.3000	0.9048	5.2589	9.0169	0.6816
IC10	6.5812	0.8405	5.7217	9.2117	0.7437
IC15	6.7607	0.8178	6.0236	9.3337	0.7586
IC20	6.8986	0.8037	6.1716	9.4262	0.7579
IC25	7.0144	0.7916	6.2962	9.5031	0.7574
IC40	7.3004	0.7606	6.6052	9.6898	0.7560
IC50	7.4724	0.7414	6.7920	9.8001	0.7552



Fish Growth Test-7 day Biomass					
Start Date:	22/10/2019 14:30	Test ID:	PR1858/15	Sample ID:	A1-5327
End Date:	29/10/2019 14:30	Lab ID:	9262	Sample Type:	PFW-Produced Formation Water
Sample Date:		Protocol:	ESA 122	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	24.140	23.000	22.940	22.160
ASW Control	23.080	23.260	21.740	22.380
1.6	26.140	22.940	23.180	21.240
3.1	20.120	21.560	20.460	20.420
6.3	16.020	18.960	19.940	19.940
12.5	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000
50	0.000	0.000	0.000	0.000
100	0.000	0.000	0.000	0.000

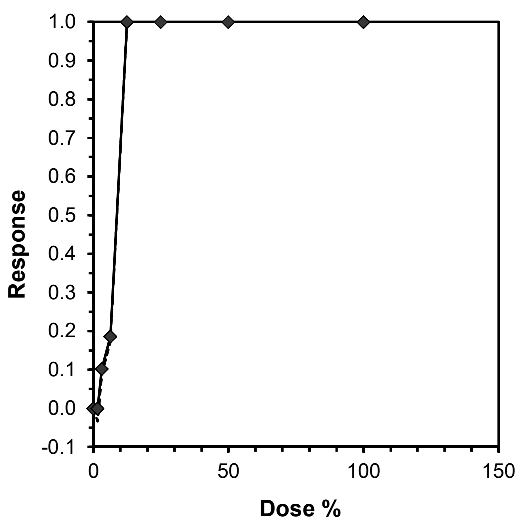
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	23.060	1.0197	23.060	22.160	24.140	3.536	4					
ASW Control	22.615	1.0000	22.615	21.740	23.260	3.077	4	*			22.995	1.0000
1.6	23.375	1.0336	23.375	21.240	26.140	8.708	4	-0.739	2.290	2.356	22.995	1.0000
3.1	20.640	0.9127	20.640	20.120	21.560	3.061	4	1.920	2.290	2.356	20.640	0.8976
*6.3	18.715	0.8275	18.715	16.020	19.940	9.912	4	3.791	2.290	2.356	18.715	0.8139
12.5	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
25	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
50	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000
100	0.000	0.0000	0.000	0.000	0.000	0.000	4				0.000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.956336	0.887	-0.14716	1.088529
Bartlett's Test indicates equal variances (p = 0.16)	5.23149	11.34487		
The control means are not significantly different (p = 0.44)	0.83023	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	3.1	6.3	4.419276	32.25806	2.356109	0.104183	17.52989	2.117142	0.002973	3, 12
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	2.3323	0.1792	1.8219	2.8954	0.3291
IC10	3.0646	0.5357	2.4006	5.9172	1.6593
IC15	4.9190	0.9476	2.4558	7.4254	0.0603
IC20	6.4057	0.5624	3.8844	7.0995	-1.1757
IC25	6.7866	0.3070	5.6365	7.4370	-1.1526
IC40	7.9293	0.2191	7.1906	8.4496	-0.5149
IC50	8.6910	0.1826	8.0755	9.1247	-0.5149



Appendix C

RPS 2017 Plume Modelling Report

YOLLA PLATFORM – BASS STRAIT

Produced Water Dispersion Near-Field Modelling

Prepared for ***Lattice Energy***

28 NOVEMBER 2017

Prepared by:

RPS

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Version / Date: Rev 1 | 28/11/2017

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Document Status

Version	Purpose of Document	Orig	Review	Review Date
Rev A	Draft for internal review	Nathan Benfer	Ryan Dunn	15/11/2017
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Approval for Issue

Name	Signature	Date
Nathan Benfer	Nathan	28/11/2017
Ben Leitinger - BassGas Senior Operations Engineer		
Kamran Zaheer - Engineering, Reliability & Maintenance Manager		

Contents

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Executive Summary

Background

Lattice Energy Pty Ltd (Lattice) operates the Yolla Platform which is located within the production license T/L1 and is approximately 100 km offshore from mainland Victoria in the Bass Strait.

As part of Lattice's due diligence, they have commissioned RPS to assess the fate of produced water (PW) being operationally discharged from the Yolla Platform. Recent debottlenecking upgrades to the produced water system has increase the maximum discharge rate, therefore Lattice requested RPS to assess a range of operational states; i) Design, ii) Typical and iii) Worst Case.

The rates of discharge for these three cases were 100 m^3/day, 200 m^3/day and 300 m^3/day, which represented the original PW design flow rate, expected operation post-debottlenecking, and worst-case (end of field life, large amounts of PW production) operation scenarios, respectively. All scenarios were modelled as single port discharge through the bottom of the discharge caisson.

Methodology

The modelling study was carried out by firstly generating a high resolution vertical current profile for the study area, which included the combined influence of ocean and tidal currents. Secondly, the vertical profiles for typical seasonal salinity and temperature profiles were obtained from the World Ocean Atlas. Finally, a near-field discharge model (CORMIX) was used to assess the rate of dilution (defined as the ratio of the initial concentration (at the discharge port) to the concentration at a given location based on the centreline of the plume) of the plume under static low and high current speeds for each of the three model scenarios under summer and winter conditions.

Key Findings

Near-field Modelling

- The furthest distance for any plume to reach 1000:1 dilution was 70 m, for Case 3 – Worst Case Operation scenario (300 m^3/day) under summer conditions with high current speeds.
- Plumes released during summer conditions required a greater distance before reaching 1,000:1 dilution, in comparison to plumes released during winter.
- Plumes released during low current speed conditions rose higher in the water column and travelled less horizontally than plumes released in high current speed conditions for all three flow rates modelled under summer and winter conditions.

1.0 Introduction

Lattice Energy Pty Ltd (Lattice) operates the Yolla Platform which is located within the production license T/L1 and is approximately 100 km offshore from mainland Victoria in the Bass Strait.

As part of Lattice's due diligence, they have commissioned RPS to assess the fate of produced water (PW) being operationally discharged from the Yolla Platform. Recent debottlenecking upgrades to the produced water system has increase the maximum discharge rate, therefore Lattice requested RPS to assess a range of operational states; i) Design, ii) Typical and iii) Worst Case.

The rates of discharge for these three cases were 100 m^3/day, 200 m^3/day and 300 m^3/day, which represented the original PW design flow rate, expected operation post-debottlenecking, and worst-case (end of field life, large amounts of PW production) operation scenarios, respectively. All scenarios were modelled as single port discharge through the bottom of the discharge caisson.

Table 1 Location of the release site used for the dispersion modelling assessment.

Release Site	Latitude	Longitude	Water Depth (m)
Yolla Platform	39° 50' 39.5" S	145° 49' 5.9" E	80

1.1 Scope of work

The physical mixing of the PW stream can be separated into two distinct zones: (a) near-field; and (b) far-field. The limits of the near-field zone are defined by the area where the levels of mixing and dilution are controlled by the plume's initial jet momentum and the buoyancy flux, resulting from the density difference. When the plume encounters a boundary such as the water surface, or loses its buoyancy, the near-field mixing is complete, and the far-field mixing begins.

Therefore, to accurately determine the dilution of the discharge and the mixing zones, the effect of near-field dynamics need to be considered first.

The scope of work included the following components:

1. Generate a 5-year 3-dimensional current data set (2012-2016) that included the combined influence of ocean and tidal currents;
2. Generate seasonal vertical profiles of salinity and water temperature at the release site; and
3. Simulate the near field-mixing and dilution zone using the three-dimensional near-field model (CORMIX) under static low and high current speeds for each of the three model scenarios under summer and winter conditions.

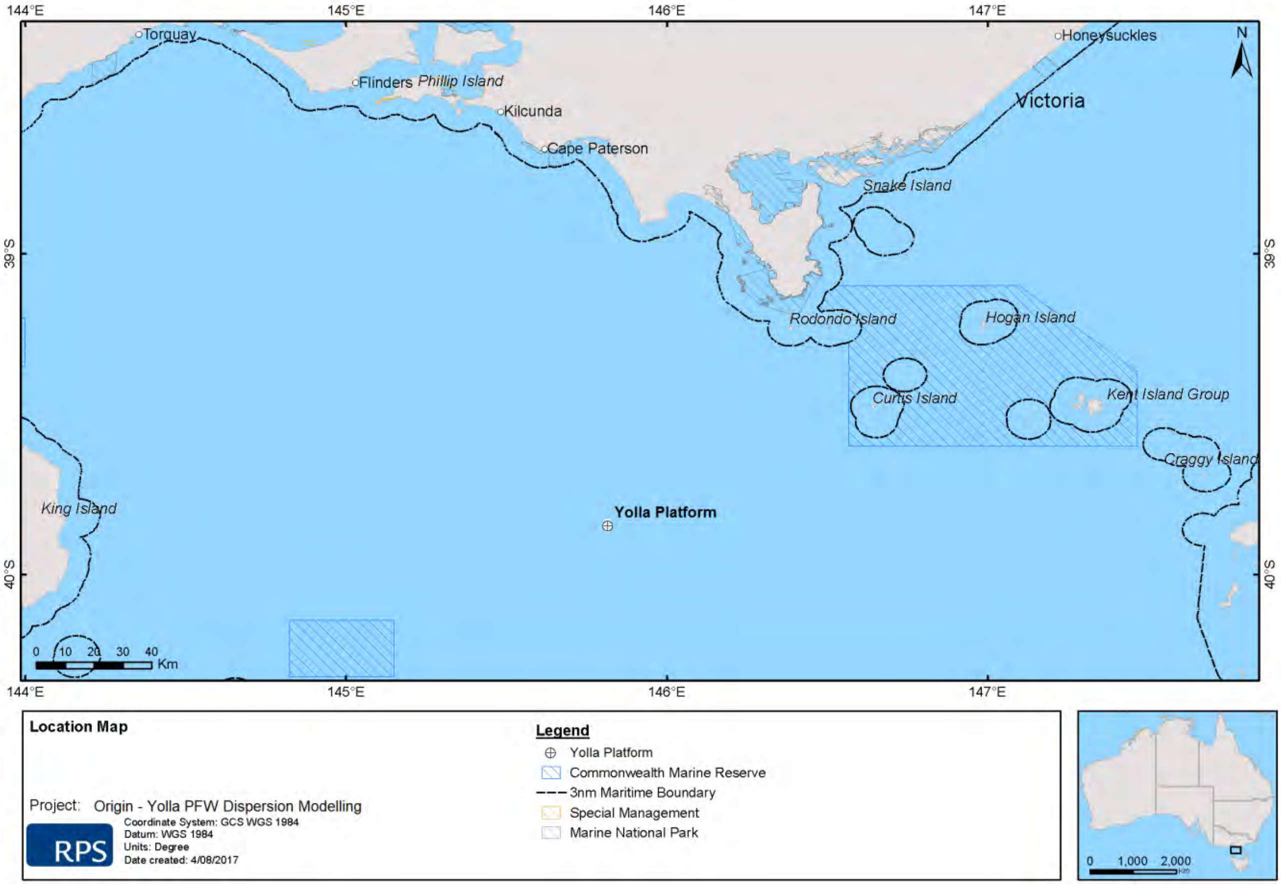

Figure 1 Location of the Yolla Platform used in the dispersion modelling study.

2.0 Discharge Characteristics

The PW stream, consists of both PW and water of condensation, is discharged vertically downwards through a discharge caisson at a depth of 45 meters below mean sea level (MSL). The depth of the surrounding water is approximately 80 m.

The PW discharge properties, are summarised in Table 2. The PW plume is slightly hotter (1°C above ambient at 45 m below MSL) and less saline than the receiving waters, resulting in a positively buoyant plume.

Table 2 Summary of the modelled discharge parameters used to simulate the discharges at Yolla.

Component	Design Operation	Typical Operation	Worst Case Operation
Flow rate (m^3/d)	100	200	300
Temperature (°C)	13.784 – 16.760	13.784 – 16.760	13.784 – 16.760
Salinity (PSU)	0.14	11.9	14.7
Diameter of discharge pipe (m)	0.73		
Depth of discharge (m)	45		
Pipe orientation	Downward		

2.1 Produced Water Contaminants Assessed

Lattice has provided a list of measured contaminant levels and trigger values for 99% species protection (Table 3), which were adopted as part of this study.

As shown, the majority of the contaminants require a dilution factor of less than 75.

Contaminants of concern include mercury, phenol, glycol and oil and petroleum hydrocarbons, all of which require dilutions greater than 100 to reach the 99% species protection.

For conservatism the discharge was assessed to a maximum dilution of 1000:1.

Table 3 Summary of produced water contaminants and trigger values

Component	Max recorded produced water concentration (µg/L)	99% Species protection trigger value (µg/L)	Required dilution factor to achieve 99% trigger value
Aluminium	3,200	27*	119
Arsenic	BD	1	-
Boron	3,400	90*	38
Barium	13,000	NL	-
Chromium	1	0.14	7.1
Iron	4,300	ID	-
Lead	BD	1	-
Mercury	29	0.1	290
Manganese	30	1200*	NR (<1)
Molydenum	1	ID	-
Nickel	10	7	1.4
Selenium	1	5*	NR (<1)
Strontium	810	NL	-
Zinc	90	7	12.9
Benzene	12,000	500	24
Toluene	14,000	110*	127
Ethylbenzene	450	50*	90
o-Xylene	1,600	200*	8
m&p-Xylene	5,200	50*	104
Napthalene	1,000	50	20
Phenol	64,000	270	237
Cresols	75,000	NL	-
2,4-Dimethyl Phenol	8,700	NL	-
Oil & Petroleum Hydrocarbons	<30,000 (current discharge limit)	70	428
Glycol	2 vol% (20,000,000 µg/L)	50,000^	400

^ = Guideline for working limits only, insufficient data to determine level of species protection
* = Taken from data for 99% species protection in fresh water systems ANZECC
BD = Historical testing shows these contaminants are below the limit of detection of 0.001 mg/L
ID = Insufficient data to determine a trigger value for marine or freshwater environment
NL = Component not listed in ANZECC guidelines
NR = Dilution not required, below ANZECC guideline concentration at point of discharge

3.0 Currents

Bass Strait is a body of water separating Tasmania from the southern Australian mainland, specifically the state of Victoria. The strait is a relatively shallow area off the continental shelf, connecting the southeast Indian Ocean with the Tasman Sea. Currents within the straight are driven by tides, winds, incident continental shelf waves and density driven flows. High winds and strong tidal currents are frequent within the area (Jones, 1980).

The varied geography and bathymetry of the region, in addition to the forcing of the south-eastern Indian Ocean and local meteorology lead to complex shelf and slope circulation patterns (Middleton & Bye, 2007). Figure 2 displays seasonal current trends within the Bass Strait. During winter there is a strong eastward water flow due to the strengthening of the South Australian Current (fed by the Leeuwin Current in the Northwest Shelf), which bifurcates with one extension moving though the Bass Strait, and another forming the Zeehan Current off western Tasmania (Sandery & Kampf 2007). During summer, water flow reverses off Tasmania, King Island and the Otway Basin travelling eastward, as the coastal current develops due to south-easterly winds.

To accurately describe the variability in currents between the inshore and offshore region, a hybrid regional dataset was developed by combining deep ocean predictions obtained from HYCOM (Hybrid Coordinate Ocean Model) with surface tidal currents developed by RPS. The following sections provide a summary of the hybrid regional data set.

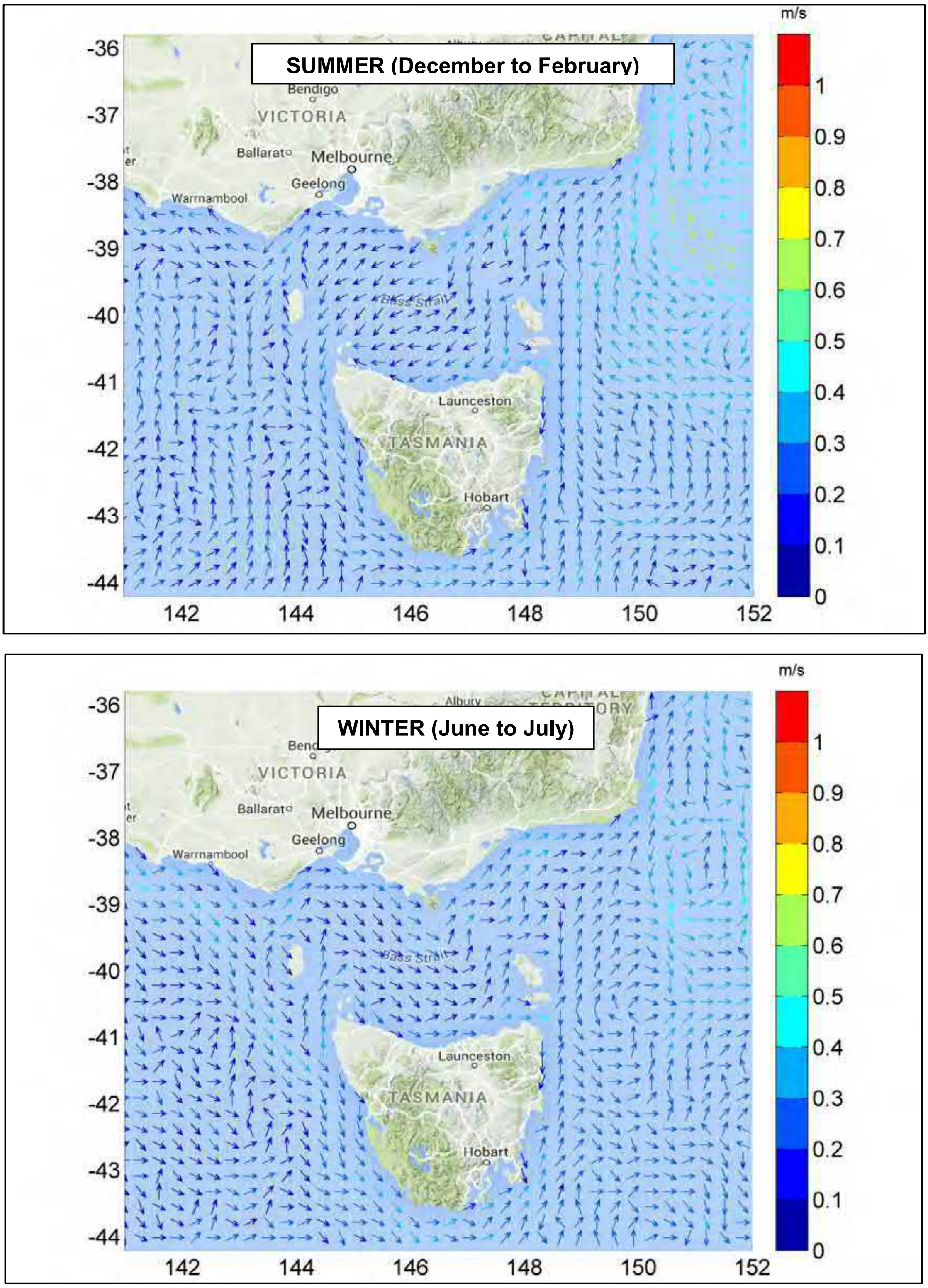

Figure 2 HYCOM averaged seasonal surface drift currents during summer and winter.

3.1 Tidal Currents

Tidal current data was generated using RPS's advanced ocean/coastal model, HYDROMAP. The HYDROMAP model has been thoroughly tested and verified by comparison to field measurements throughout the world over the past 32 years (Isaji & Spaulding, 1984; Isaji, et al., 2001; Zigic, et al., 2003). HYDROMAP tidal current data has been used as input to forecast (in the future) and hindcast (in the past) pollutant spills in Australian waters and forms part of the Australian National Oil Spill Emergency Response System operated by AMSA (Australian Maritime Safety Authority).

HYDROMAP employs a sophisticated sub-gridding strategy, which supports up to six levels of spatial resolution, halving the grid cell size as each level of resolution is employed. The sub-gridding allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, and/or of particular interest to a study.

The numerical solution methodology follows that of Davies (1977a and 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji and Spaulding (1984) and Isaji et al. (2001).

3.1.1 Grid Setup

RPS has a global tidal model with global coverage. The model is sub-gridded to a resolution of 500 m for shallow and coastal regions, starting from an offshore (or deep water) resolution of 8 km. The finer grids are progressively allocated in a step-wise fashion to more accurately resolve flows along the coastline, around islands and over regions with more complex bathymetry. Figure 3 shows the tidal model grid covering the study domain.

A combination of datasets were used and merged to describe the shape of the seabed within the grid domain (Figure 4). These included spot depths and contours which were digitised from nautical charts released by the hydrographic offices as well as Geoscience Australia database and depths extracted from the Shuttle Radar Topography Mission (SRTM30_PLUS) Plus dataset (see Becker et al., 2009).

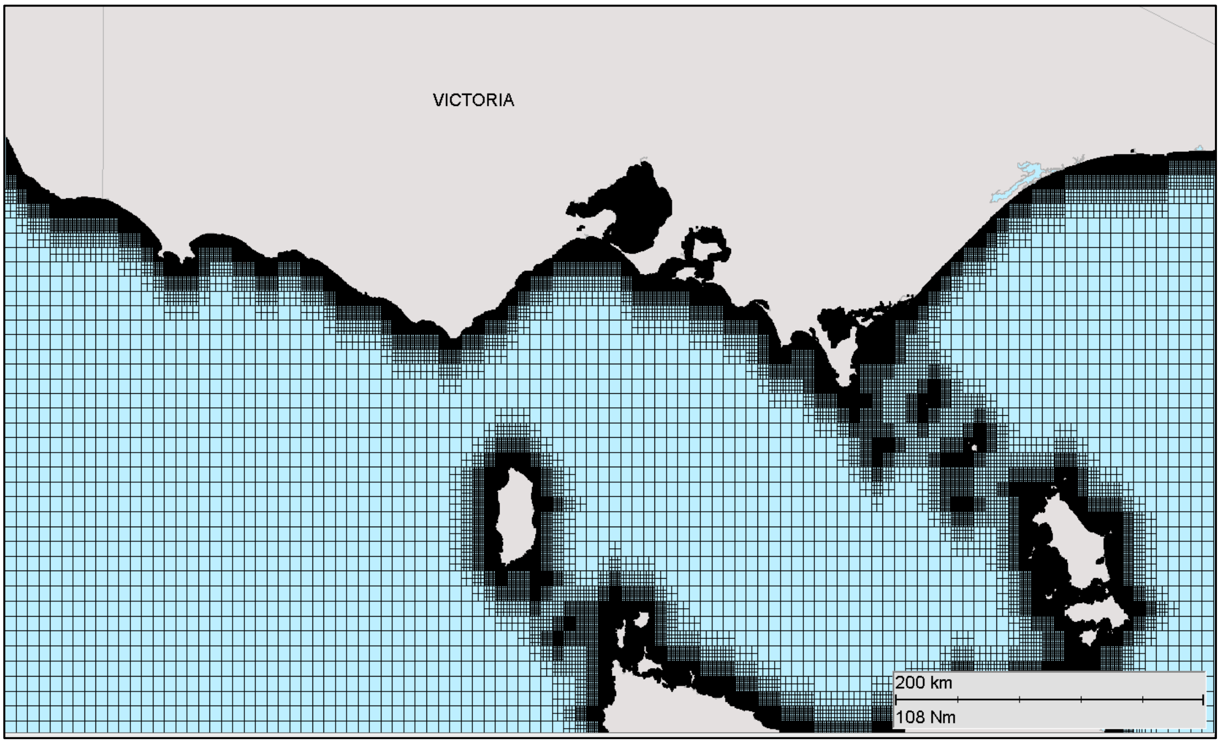

Figure 3 Sample of the model grid used to generate the tidal currents for the study region. Higher resolution areas are shown by the denser mesh.

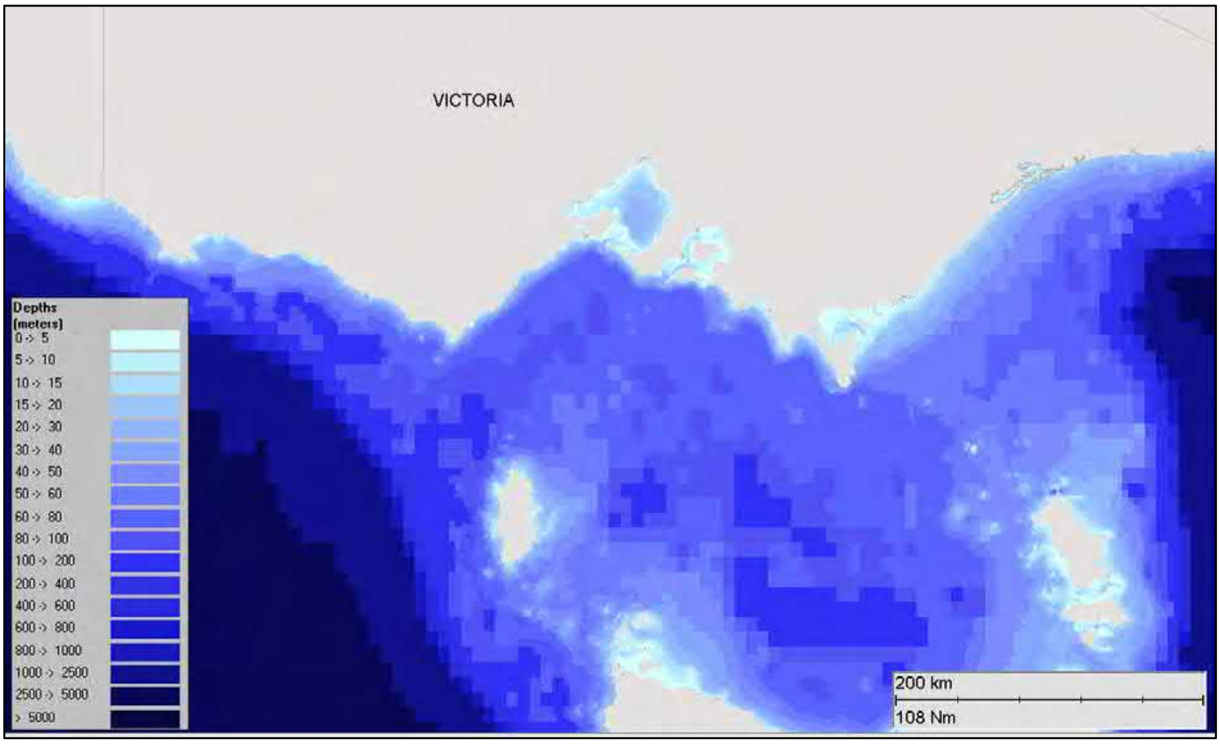

Figure 4 Bathymetry defined throughout the tidal model domain.

3.1.2 Tidal Conditions

The ocean boundary data for the regional model was obtained from satellite measured altimetry data (TOPEX/Poseidon 8.0) which provided estimates of the eight dominant tidal constituents at a horizontal scale of approximately 0.25 degrees. The eight major tidal constituents used were K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1. Using the tidal data, time series surface heights were calculated along the open boundaries for the simulation period.

The Topex-Poseidon satellite data has a resolution of 0.25 degrees globally, with higher resolution in coastal regions, and is produced and quality controlled by NASA (National Aeronautics and Space Administration). The data capturing satellites, equipped with two altimeters capable of taking sea level measurements accurate to less than ± 5 cm, measured oceanic surface elevations (and the resultant tides) for the period 1992–2005. In total these satellites carried out 62,000 orbits of the planet. The Topex-Poseidon tidal data has been widely reported amongst the oceanographic community, being included in more than 2,100 research publications (e.g. Andersen, 1995; Ludicone et al., 1998; Matsumoto et al., 2000; Kostianoy et al., 2003; Yaremchuk & Tangdong, 2004; Qiu & Chen 2010). The Topex/Poseidon tidal data is considered suitably accurate for this study.

3.1.3 Surface Elevation Validation

To ensure that tidal predictions were accurate, predicted surface elevations were compared to data from five locations situated within the study area (Figure 5).

Figure 6 and Figure 7 illustrate comparisons of the predicted and observed surface elevations for each location for January 2014. As shown on the graph, the model accurately reproduced the phase and amplitudes throughout the spring and neap tidal cycles.

To provide a statistical measure of the model’s performance, the Index of Agreement (IOA – Willmott, 1981) and the Mean Absolute Error (MAE – Willmott, 1982; Willmott & Matsuura, 2005) were used.

The MAE is the average of the absolute values of the difference between the model-predicted (P) and observed (O) variables. It is a more natural measure of the average error and more readily understood (Willmott & Matsuura, 2005).

$$MAE = N^{-1}\sum_{i=1}^{N}|P_i - O_i|$$

The Index of Agreement (IOA) is determined by:

$$IOA = 1 - \frac{\sum|X_{model} - X_{obs}|^2}{\sum(|X_{model} - \overline{X_{obs}}| + |X_{obs} - \overline{X_{obs}}|)^2}$$

Where: X represents the variable being compared and the time mean of that variable. A perfect agreement exists between the model and field observations if the index gives an agreement value of 1 and complete disagreement will produce an index measure of 0 (Wilmott, 1981). Willmott et al. (1985) also suggests that values meaningfully larger than 0.5 represent good model performance. Clearly, a greater IOA and lower MAE represent a better model performance.

Table 4 Statistical comparison between the observed and HYDROMAP predicted surface elevations. shows the IOA and MAE values for the selected locations.

Figure 8 shows a screenshot of the predicted tidal current vectors within the Otway Basin.

Table 4 Statistical comparison between the observed and HYDROMAP predicted surface elevations.

Tide Station	IOA	MAE (m)
Gabo Island	0.98	0.08
Port MacDonnell	0.98	0.05
Port Welshpool	0.92	0.30
Portland	0.97	0.07
Stack Island	0.96	0.22

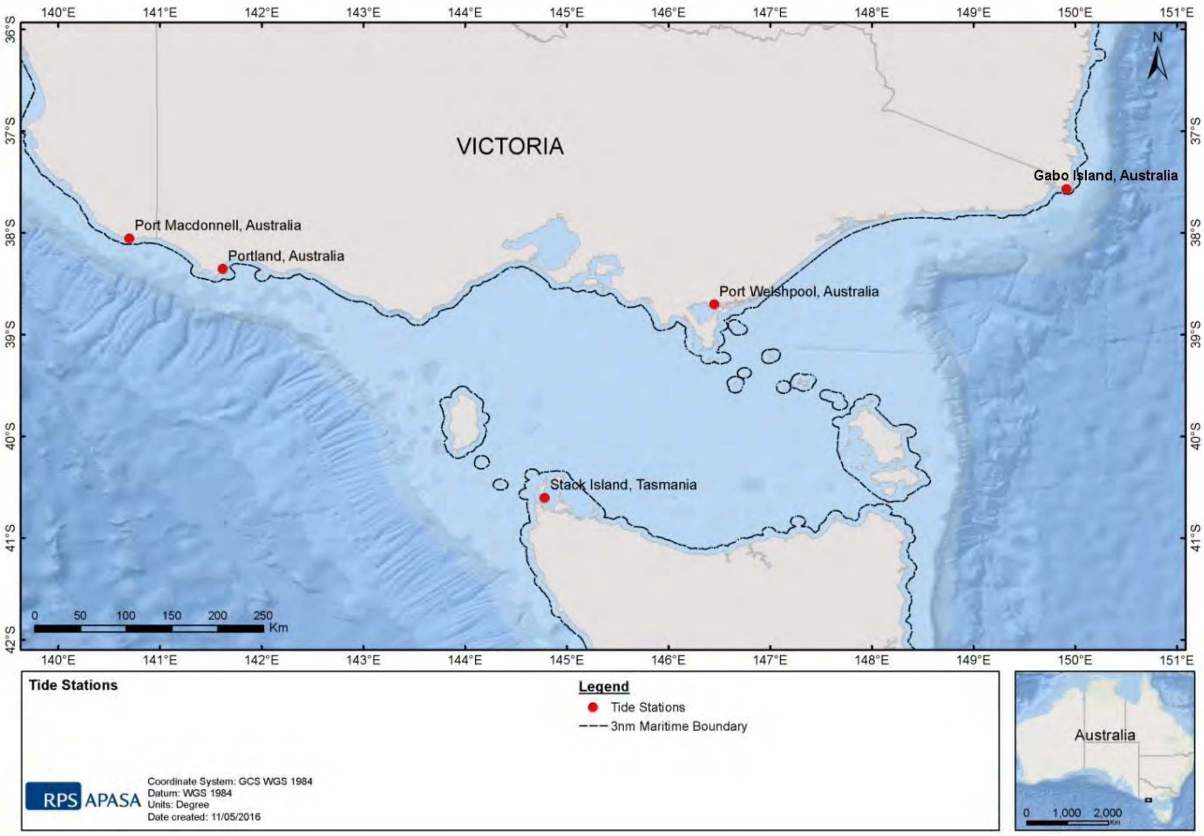

Figure 5 Location of the tide stations used in the surface elevation validation.

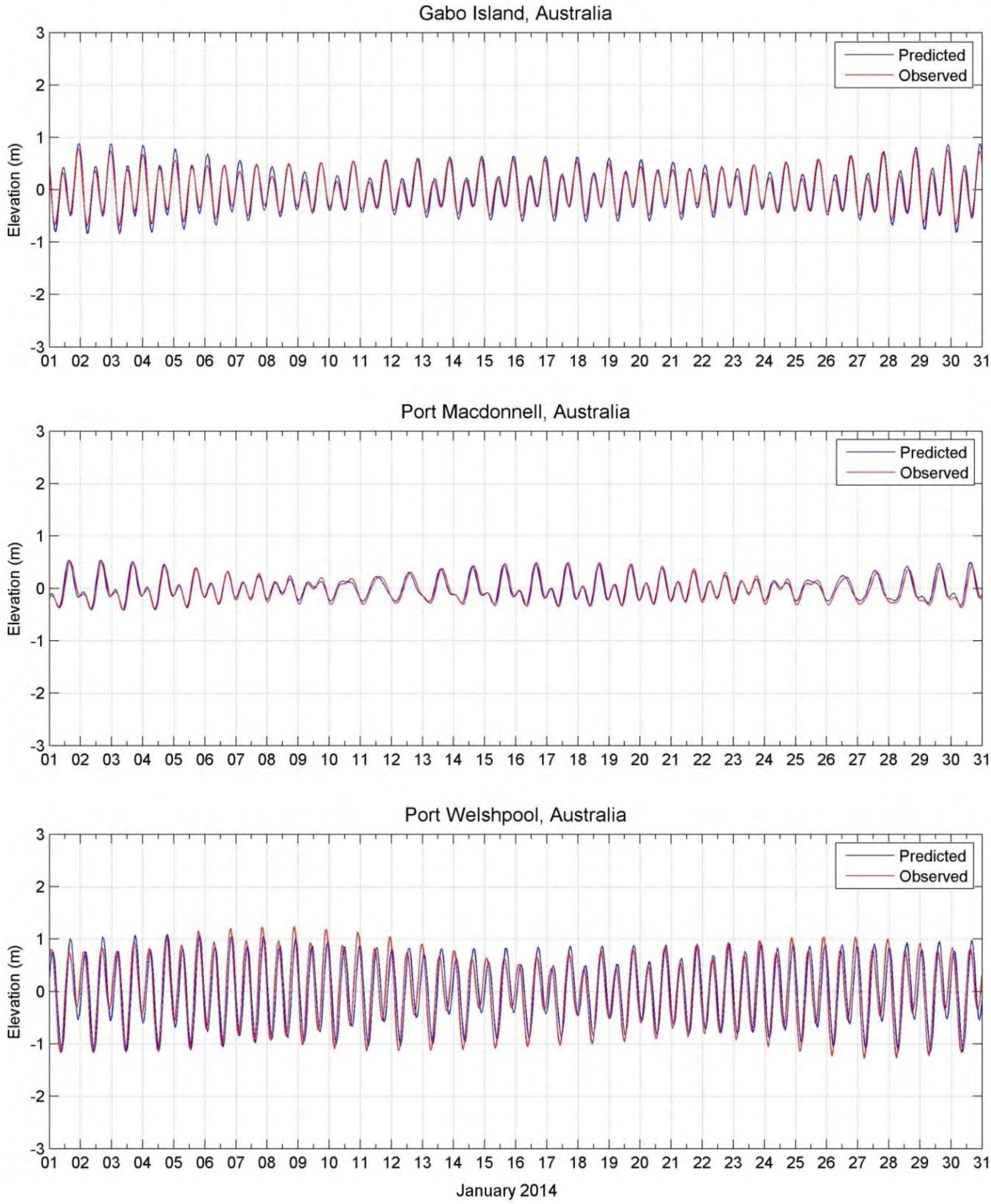

Figure 6 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation at tidal stations Gabo Island (upper image), Port MacDonnell (middle image) and Port Welshpool (lower image).

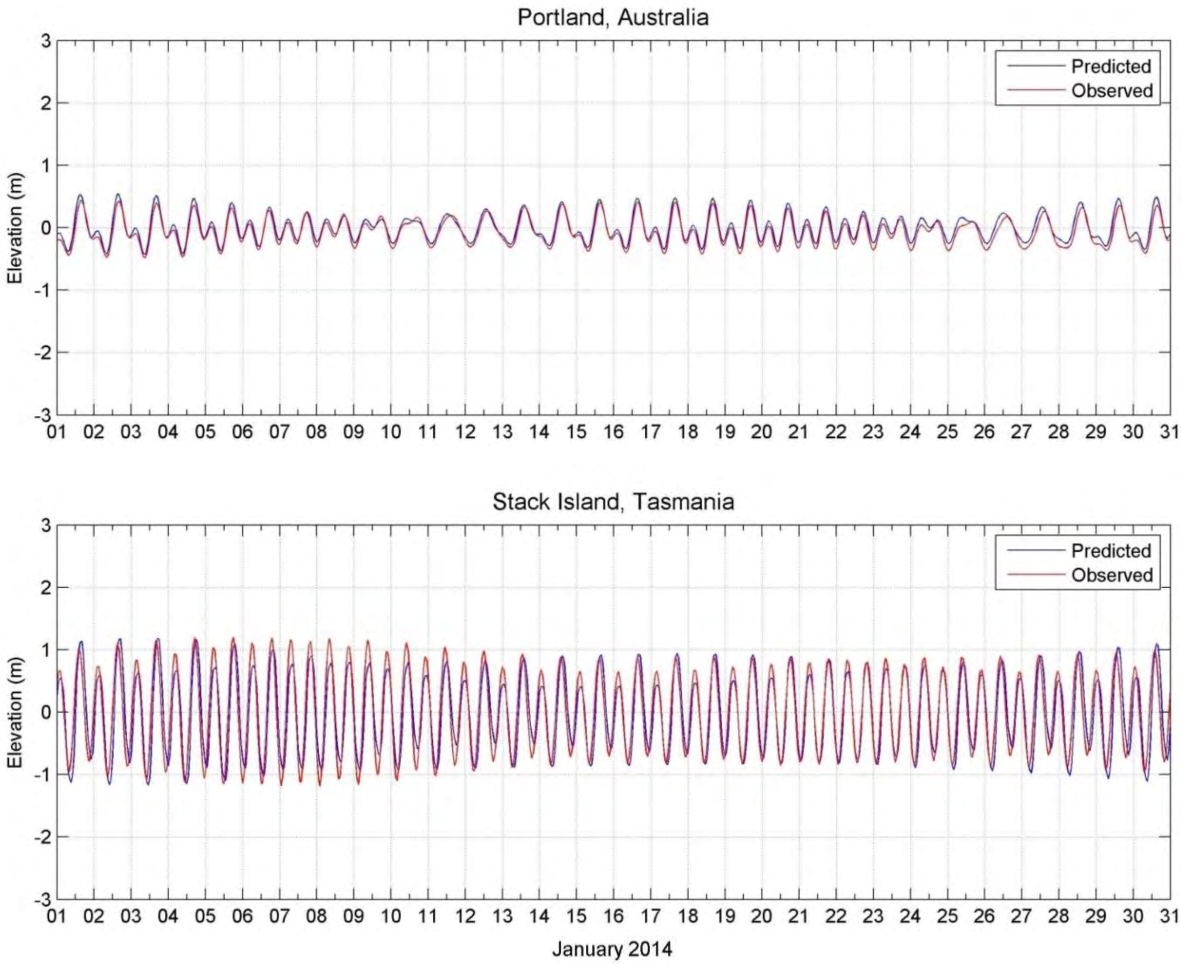

Figure 7 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation at tidal stations Portland (upper image) and Stack Island (lower image).

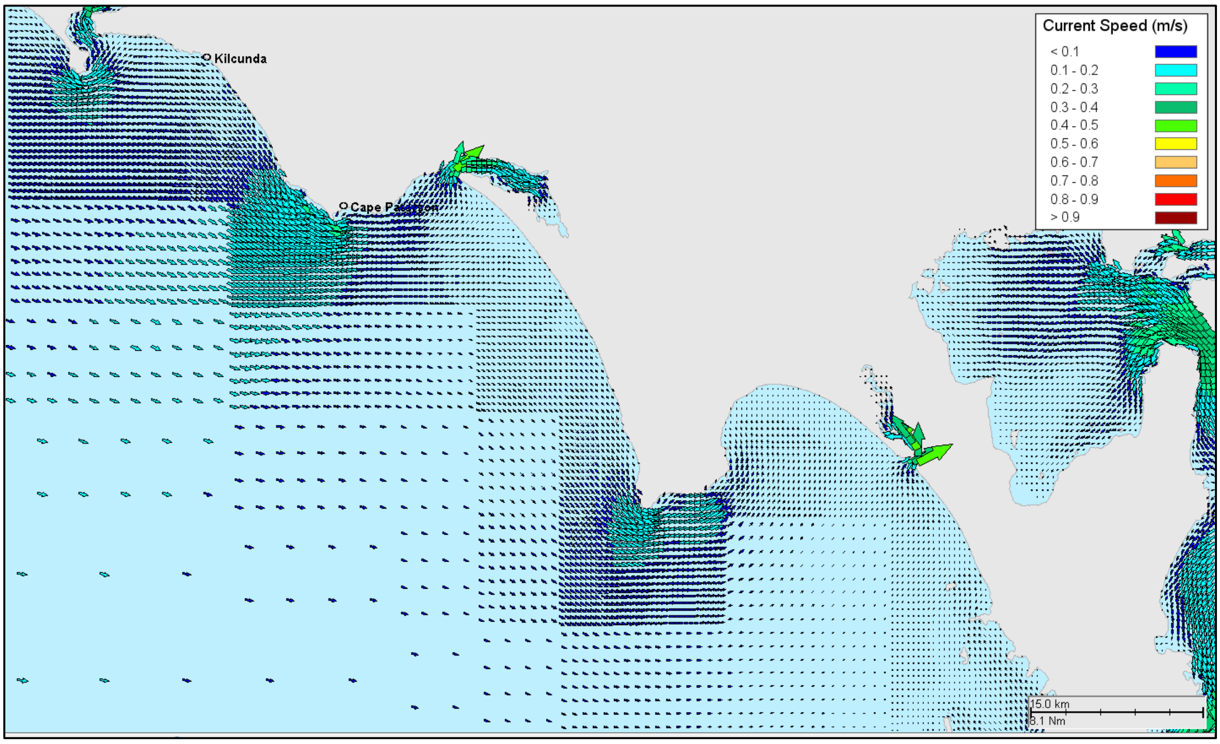

Figure 8 Snapshot of the predicted tidal current vectors. Note the density of the tidal vectors vary with the grid resolution, particularly along the coastline and around the islands and sholas. Colourations of individual vectors indicate current speed.

3.2 Ocean Currents

Data describing the flow of ocean currents was obtained from HYCOM (Hybrid Coordinate Ocean Model, (Chassignet et al., 2007), which is operated by the HYCOM Consortium, sponsored by the Global Ocean Data Assimilation Experiment (GODAE). HYCOM is a data-assimilative, three-dimensional ocean model that is run as a hindcast (for a past period), assimilating time-varying observations of sea surface height, sea surface temperature and in-situ temperature and salinity measurements (Chassignet et al., 2009). The HYCOM predictions for drift currents are produced at a horizontal spatial resolution of approximately 8.25 km (1/12th of a degree) over the region, at a frequency of once per day. HYCOM uses isopycnal layers in the open, stratified ocean, but uses the layered continuity equation to make a dynamically smooth transition to a terrain-following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or unstratified seas.

For this study, the HYCOM hindcast currents were obtained used. Figure 9 shows an example modelled surface ocean currents (HYCOM) during the study period.

Figure 10 and Figure 11 show the monthly and total current rose distributions resulting from the combination of HYCOM ocean current data and HYDROMAP tidal data nearby the Yolla release site.

Note the convention for defining current direction is the direction the current flows towards, which is used to reference current direction throughout this report. Each branch of the rose represents the currents flowing to that direction, with north to the top of the diagram. Sixteen directions are used. The branches are divided into segments of different colour, which represent the current speed ranges for each direction. Speed intervals of

0.1 m/s are predominantly used in these current roses. The length of each coloured segment is relative to the proportion of currents flowing within the corresponding speed and direction.

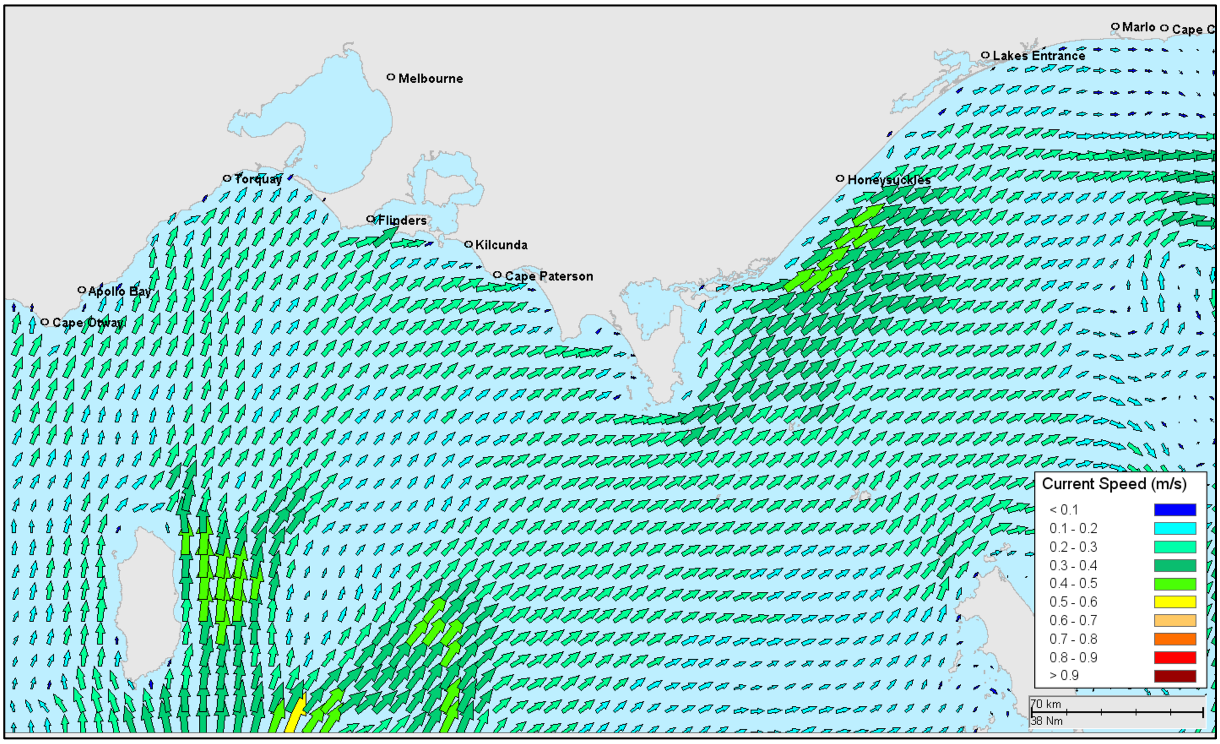

Figure 9 Modelled surface ocean currents presented for the 1st May 2012. Derived from the HYCOM ocean hindcast model. The colours of the vectors indicate current speed in m/s.

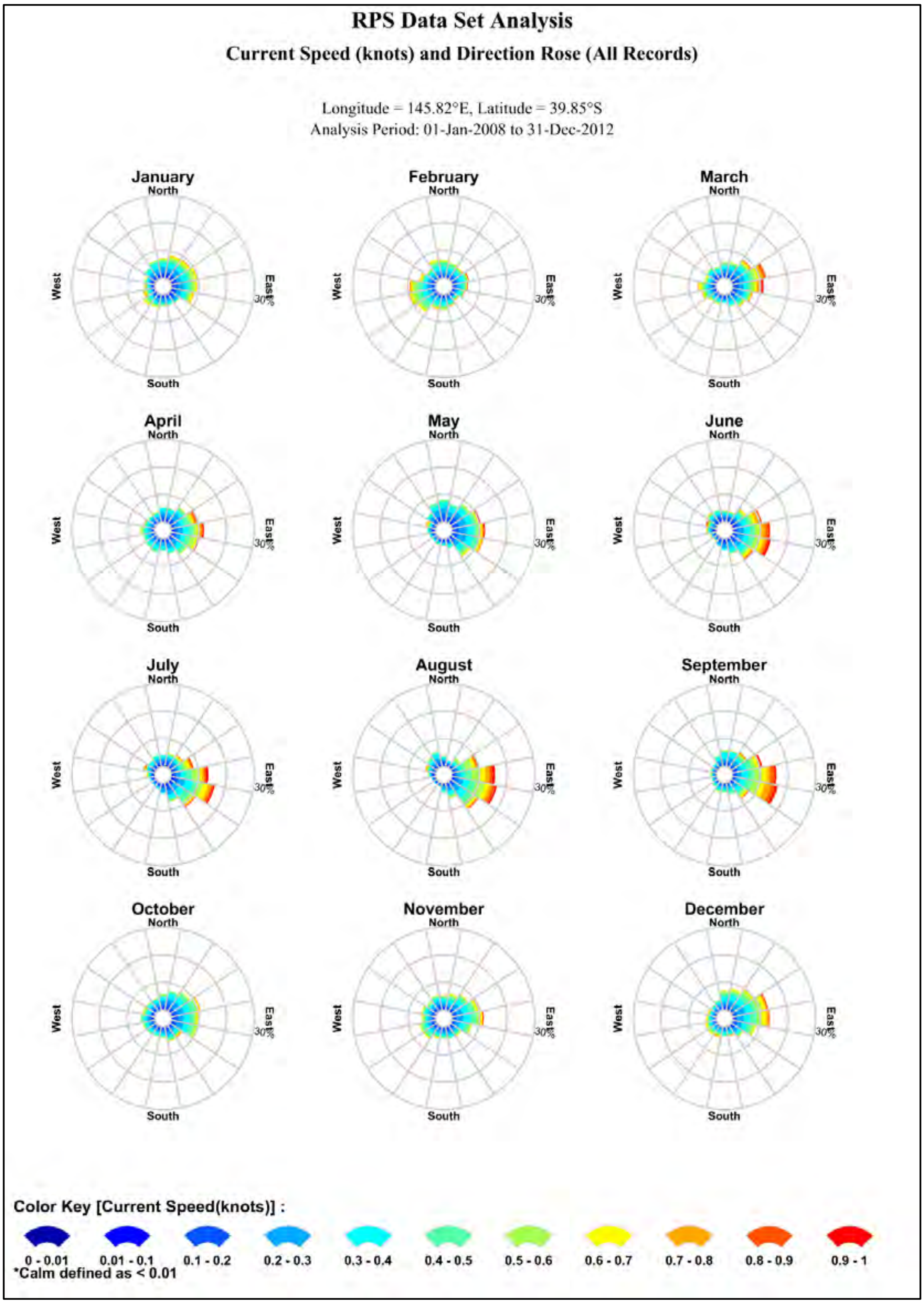

Figure 10 Monthly surface current rose plots nearby the Yolla release site (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2008–2012 (inclusive). The colour key shows the current magnitude (m/s), the compass direction provides the current direction flowing TOWARDS and the length of the wedge gives the percentage of the record for a particular speed and direction combination.

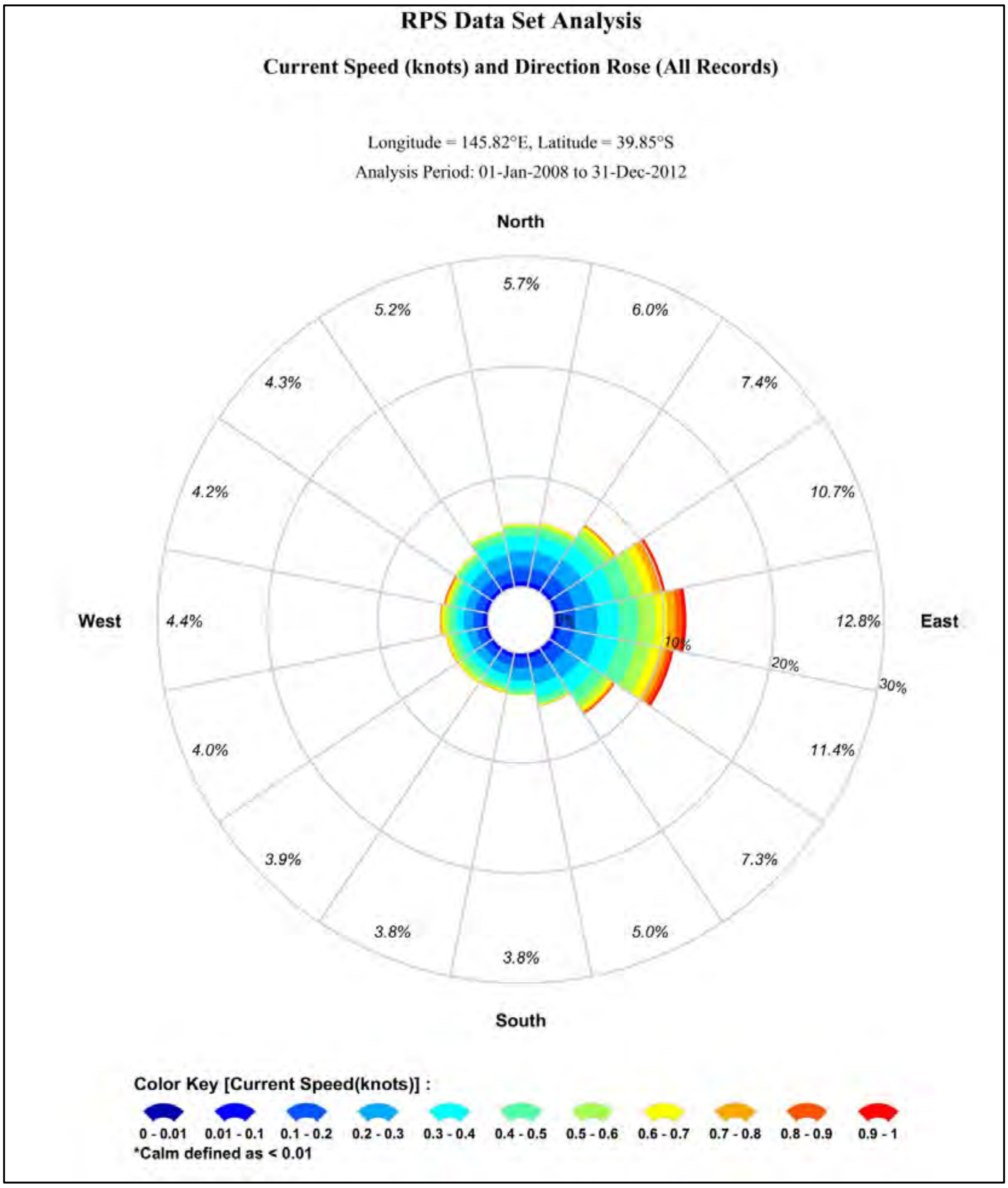

Figure 11 Modelled total surface current rose plot nearby the Yolla release site (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2008–2012 (inclusive). The colour key shows the current magnitude (m/s), the compass direction provides the current direction flowing TOWARDS and the length of the wedge gives the percentage of the record for a particular speed and direction combination.

4.0 Modelling Methods

4.1 Description of Models

4.1.1 Near-Field Model

The near-field mixing and dispersion of the operational discharge was simulated using the fully three-dimensional flow model in CORMIX.

CORMIX is a mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones.

CORMIX contains a series of elements for the analysis and design of conventional or toxic, single or multi-port, submerged or surface, buoyant or nonbuoyant, pollutant discharges into stratified or unstratified watercourses, with emphasis on the geometry and dilution characteristics on the initial mixing zone. (Doneker, 1990; Jirka & Doneker, 1991)

CORMIX has been validated in many independent studies over the years. A list of some of these studies is provided on the CORMIX website (http://www.cormix.info/validations.php).

4.2 Near-Field Model Setup

4.2.1 Ambient Environmental Conditions

Inputs for the ambient environmental conditions included a vertical profile of salinity and water temperature, along with static current speeds and general direction. The salinity and water temperature and profiles are important to accurately account for buoyancy of the diluting plume, whilst the current speeds influence the intensity of initial mixing and the deflection of the PW plume. These inputs are described below.

4.2.1.1 Ambient Temperature and Salinity

Table 5 shows the seasonal water temperature and salinity levels at varying depths from 0 to 50 m at the release site. The data was sourced from the World Ocean Atlas 2013 database produced by the National Oceanographic Data Centre (National Oceanic and Atmospheric Administration) and its co-located World Data Center for Oceanography (see Levitus et al., 2013).

Seasonal water temperature profiles show a 2–4 ^{o}C difference between the summer and winter conditions. The temperature ranged from 14.74 to 17.79^{o}C during the summer season and 12.78 to 13.11^{o}C during the winter season. Alternatively, salinity values demonstrate greater consistency across the seasons and depth range. Salinity values during the summer season ranged from 35.36 to 35.52 PSU and 35.49 to 35.61 PSU during the winter season.

Table 5 Seasonal temperature and salinity profile adjacent at the release site.

Season	Depth (m)	Temperature (°C)	Salinity (PSU)
Summer	0	18.05	35.36
	10	17.79	35.41
	20	17.55	35.44
	30	17.36	35.44
	40	16.78	35.44
	50	14.74	35.52
Winter	0	13.11	35.49
	10	13.07	35.57
	20	13.02	35.58
	30	12.81	35.60
	40	12.79	35.61
	50	12.78	35.61

4.2.1.2 Ambient Currents

The 5-year current dataset was analysed to determine the 5th and 95th percentile current speeds as input into the near-field model, representative of low and high current speeds, respectively.

Table 6 presents the 5th and 95th percentiles of current speeds through the water column, which produce contrasting dilution and advection cases:

- 5th percentile current speed: low current speed, low dilution and slow advection;
- 95th percentile current speed: high current speed, high dilution and rapid advection to nearby areas.

The 5th and 95th percentile values are referenced as low and high current speeds throughout the remainder of the report, respectively.

Table 6 Adopted ambient current conditions.

Depth (m)	5th Percentile or low current speed (m/s)	95th Percentile or high current speed (m/s)
0	0.042	0.390
10	0.030	0.254
20	0.028	0.227
30	0.027	0.224
40	0.026	0.218
50	0.026	0.212

5.0 Results

5.1 Near-Field Modelling Results

Table 7 presents a summary of the near-field plume results for each of the three cases for summer and winter conditions under low and high current speed conditions.

Figure 12 to Figure 14 show the trajectory of the plume through the water column as the current transport it away from the discharge point.

The furthest distance for any plume to reach 1000:1 dilution was 70 m, for the Case 3 – Worst Case Operation scenario (300 m^3/day) under summer conditions with high current speed.

Plumes released during summer conditions required a greater distance before reaching 1,000:1 dilution, in comparison to plumes released during winter.

Plumes released during low current speed conditions rose higher in the water column and travelled less horizontally than plumes released in high current speed conditions for all three flow rates modelled under summer and winter conditions.

Table 7 Maximum horizontal distance from the discharge point that centreline dilution (X:1) was predicted to travel.

Case	Season	Current Speed (%ile)	Maximum Distance from Discharge Point to Centreline Dilution X:1 (m)																		
			10	20	30	40	50	60	70	80	90	100	200	300	400	500	600	700	800	900	1000
Case 1 Design Operation	Summer	5th	0.2	0.4	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.5	2.7	3.7	4.6	5.4	6.2	7.0	7.8	8.5	9.2
		95th	1.2	2.2	3.0	3.6	4.2	4.8	5.3	5.8	6.3	6.7	11.0	14.9	18.4	21.8	25.1	28.4	31.6	34.8	38.0
	Winter	5th	0.2	0.4	0.6	0.7	0.9	1.0	1.1	1.2	1.4	1.5	2.6	3.6	4.5	5.3	6.1	6.8	7.6	8.3	9.0
		95th	1.2	2.2	3.0	3.6	4.2	4.7	5.2	5.7	6.2	6.7	10.9	14.6	18.0	21.2	24.3	27.3	30.1	32.9	35.6
Case 2 Typical Operation	Summer	5th	0.3	0.5	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	3.8	5.3	6.6	7.9	9.1	10.2	11.2	12.3	13.3
		95th	1.4	2.6	3.6	4.5	5.4	6.2	6.9	7.7	8.4	9.1	15.4	21.1	26.5	31.8	37.1	42.5	48.1	53.9	59.9
	Winter	5th	0.3	0.5	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.1	3.7	5.2	6.5	7.7	8.9	10.0	11.1	12.2	13.2
		95th	1.4	2.6	3.6	4.5	5.3	6.1	6.8	7.6	8.3	9.0	15.1	20.5	25.5	30.2	34.7	39.0	43.2	47.2	51.2
Case 3 Worst Case Operation	Summer	5th	0.3	0.6	0.9	1.1	1.4	1.6	1.8	2.1	2.3	2.5	4.4	6.1	7.6	9.0	10.4	11.6	12.9	14.0	15.1
		95th	1.5	2.9	4.0	5.0	6.0	6.9	7.7	8.6	9.4	10.2	17.5	24.1	30.5	36.8	43.3	49.9	56.7	63.5	70.3
	Winter	5th	0.3	0.6	0.9	1.1	1.4	1.6	1.8	2.0	2.2	2.4	4.3	5.9	7.4	8.9	10.2	11.5	12.8	14.1	15.4
		95th	1.5	2.8	3.9	4.9	5.9	6.8	7.6	8.5	9.3	10.1	17.1	23.2	28.9	34.4	39.5	44.5	49.3	54.0	58.6

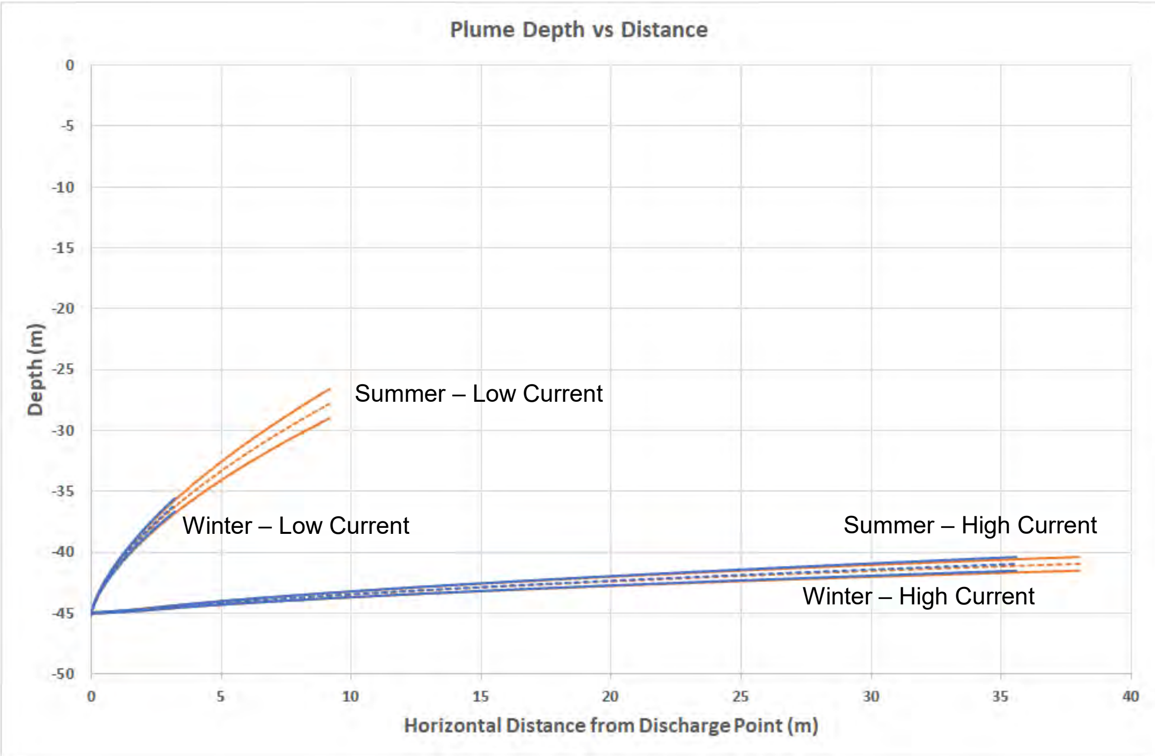

Figure 12 Plume depth versus distance for Case 1 Design Operation (100 m^3/day flow) for summer and winter under low and high current flow conditions.

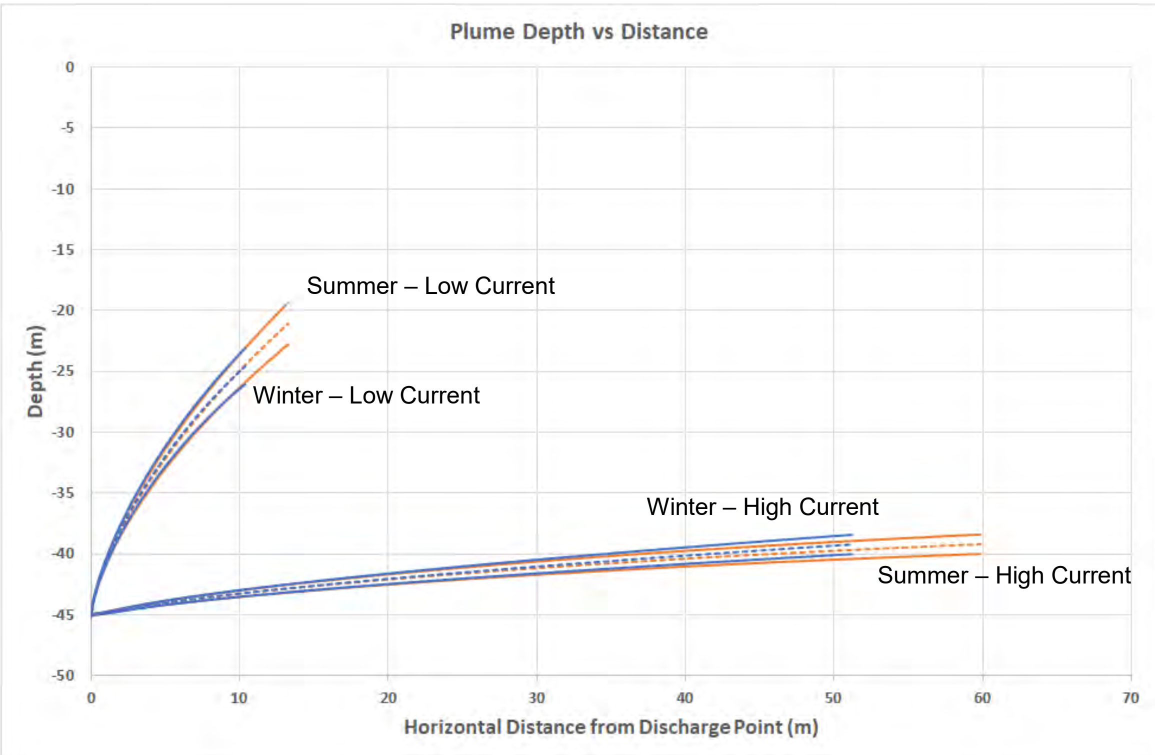

Figure 13 Plume depth versus distance for Case 2 Typical Operation (200 m^3/day flow) for summer and winter under low and high current flow conditions.

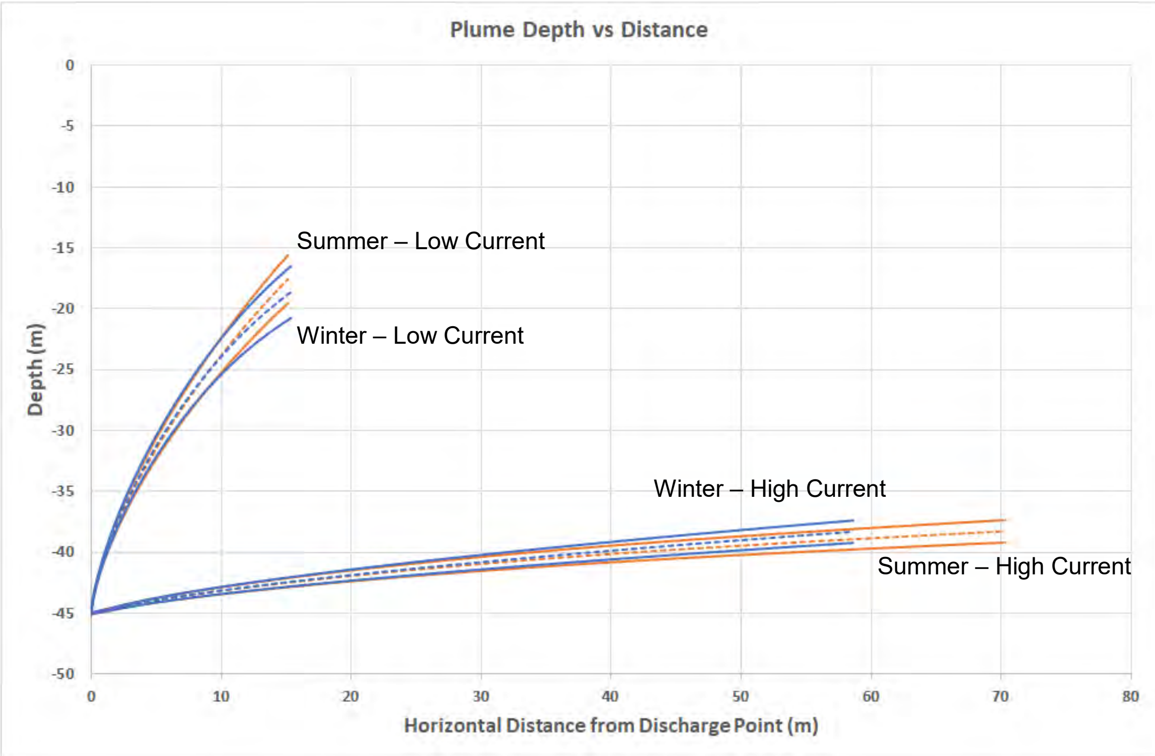

Figure 14 Plume depth versus distance for Case 3 Worst-Case Operation (300 m^3/day flow) for summer and winter under low and high current flow conditions.

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Appendix D

Advisian Report 2019

Yolla Produced Water Improvements

TIC estimates

Beach Energy

11-December-2019

411010-00050-GE-REP-0001

Advisian
Worley Group

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PROJECT 411010-00050-GE-REP-0001: Yolla Produced Water Improvements - TIC estimates

Rev	Description	Author	Review	Advisian approval	Revision date	Client approval	Approval date
0	Issued for Use	R. George	S. Henzell S. Henzell	C. Adinolfi	11-Dec-19		

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Executive summary

Due to changes in legislation regarding the allowable oil-in-water content of water discharge overboard, Beach energy are reviewing options to improve the capability of the Produced Water (PW) Treatment system on the Yolla platform.

Beach energy identified 3 options and commissioned Advisian to perform a high level (+/- 50%) Total Installed Cost (TIC) estimated of these options. To generate the costs, assumptions had to be made regarding where equipment would be installed and the adequacy of existing utilities. These assumptions are critical to the cost estimate and given that the platform has limited spare weight, layout and utilities these assumptions have the potential to escalate the costs by +100% or more if invalid. A thorough review and validation of the assumptions should be conducted in the next project phase.

A cost comparison of the 3 options is shown in Figure 0-1 with further details below.

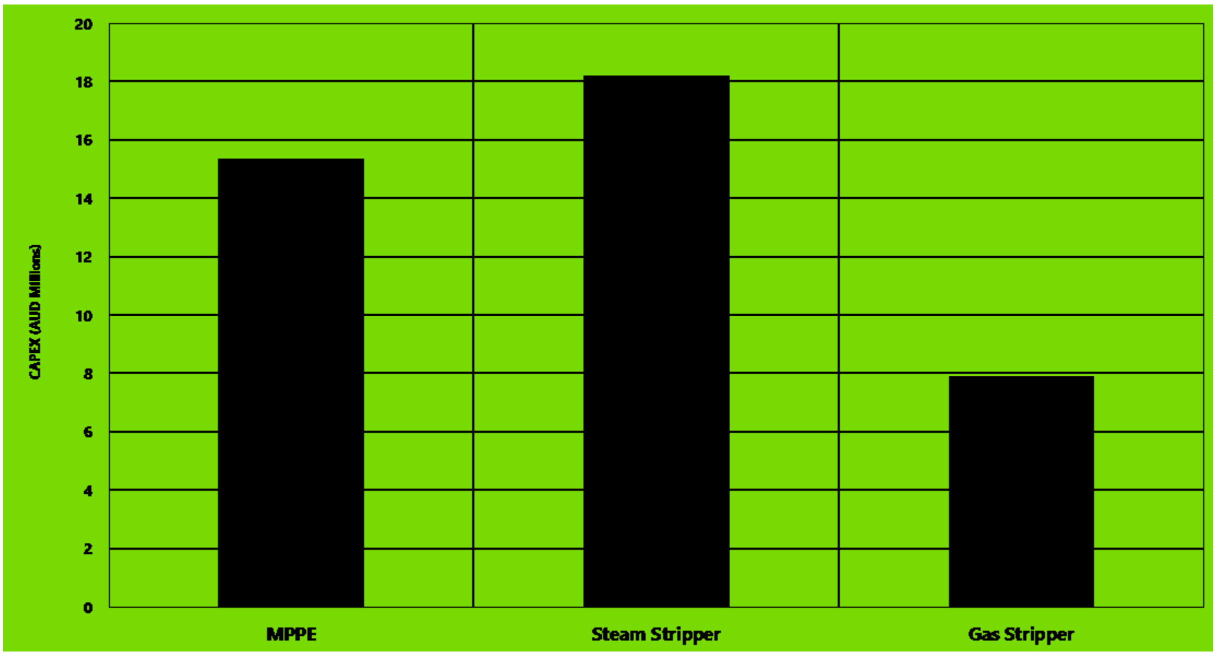

Figure 0-1: Total Installed Cost Comparison of the 3 options

Mono Porous Polymer Extraction (MPPE) Unit

The MPPE unit removes the hydrocarbons by running the produced water through a media filled extraction column. Two columns are installed in a duty/regeneration arrangement with steam being used to regenerate the offline column. The hydrocarbon laden steam is condensed, and the two liquid phases separated with the water recycled back into the produced water stream and the hydrocarbons sent to the flare drum.

The MPPE unit is provided as a single package containing the columns, condenser, separator, pumps and electric steam boiler. An offtake of Reverse Osmosis (RO) treated water (available on Yolla) will be passed through an Ion Exchange (IX) unit to create demineralised water to feed to the steam boiler.

It is envisaged that the MPPE will be installed where the current Produced Water Filters are located (with the filters demolished) and the IX unit installed near the existing RO units.

The total installed cost is **AUD$15.4M**

Steam Stripping Unit

The Steam Stripping unit removes the hydrocarbons by contacting the produced water with steam inside a packed column. The hydrocarbon laden steam is condensed with the water recycled in the column and the hydrocarbon/BTEX vapour stream sent to flare.

The steam stripper package consists of a single package containing the column, buffer tank, condenser, BTEX accumulator, pumps and steam boiler. The steam rate required (~420 kg/h) is to too great for the existing RO units, therefore a new demineralised water package needs to be installed to produce the Boiler Feed Water (BFW). The duty of the steam boiler of 400 kW is too great for the existing Yolla power gen sets and hence a fired heater using fuel gas would be installed. The existing seawater lift pumps and fuel gas conditioning units are considered to have adequate capacity to not required modifications.

It is envisaged that the Steam Stripping Unit will be installed where the current Produced Water Filters are located (with the filters demolished) and the demineralised water package to be installed near the existing RO units or if too large to be located close to the steam boiler.

The total installed cost is **AUD $18.2M**

Gas Stripping Unit

The Gas stripping unit option consists of reinstalling a gas stripping column similar to what was originally installed on Yolla. In this option hydrocarbons are removed by contacting the produced water with fuel gas. The leaving fuel gas is sent to flare.

It is envisaged that the Gas Stripper will be installed next to the current Produced Water Filters i.e. filters not demolished in this case. This is similar to the original installation; however, the base of the column will need to be installed on the top deck.

The total installed cost is **AUD $7.9M**

RECOMMENDATION

The gas stripping unit is the cheapest of the options but given the operating experience with the previous column underperforming there is the risk that the technology would not meet the more stringent specification. The MPPE option is cheaper than the steam stripper and has less impact on the water handling (RO units) due to the lower amount of steam required. The MPPE options therefore would be the preferred option at this stage. The issue with this option (and all options) is ensuring the equipment fits within existing constraints of the platform. This study has made the assumption that only minor brownfield work is required to locate and install the necessary package however if major works such as jacket strengthening is required then the costs provided could escalate by 100% or more.

FURTHER WORK

There are several feasibility issues that have not been addressed in this preliminary study that must be investigated.

- Weight limits for Yolla
- Constructability
    - Downtime e.g. while filters are demolished, tie-ins made
    - Manning limits
    - Brownfield works e.g. demolition work required.
- Utility limits / Capacity
    - Power – capacity of existing gen sets
    - Fuel gas requirements (supply to the steam boiler)
    - Water handling (seawater lift, RO units)
- Impact on operations including greater surveillance and operator intervention
- Chemical consumption e.g. MPPE media and chemicals for BFW generation
- Time to implement
    - Site surveys
    - Analysis and design
    - Procurement
    - Installation
    - Hook-up and commissioning

In the next project phase the following activities should occur;

- Confirm with MPPE vendor the impact on size, weight, cost of replacing the plate and frame condenser with an ACHE
- Confirm that based on operating experience and contacting the RO vendor that the existing units could operate without modification for the additional load required for steam generation for the MPPE option.
- Confirm details of the steam stripping package for the full produced water rate (300 m^3/d), including confirmation of steam rate and boiler duty required. If boiler duty is below 200 kW, there's the potential to use an electric boiler and stay within the existing capacity of the gen sets.

- Contact vendors to confirm details on the ion exchange for the MPPE option and demineralised water generation package for the Steam Stripper option
- More detailed analysis of layout and where equipment could be installed for all options.
- Develop a detailed project execution schedule for each of the options.

1 Introduction

The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) has recently revised the allowable oil content in water specification for discharge overboard. This change in regulations means that the produced water treatment system on the Yolla platform will require upgrades.

The facility is to handle a maximum of 300 m^3/d (12.5 m^3/h) of produced water and remove all hydrocarbons (free and dissolved) to no more than 10 mg/L.

Beach Energy has performed an initial assessment and identified three (3) treatment options;

1. Macro Porous Polymer Extraction (MPPE) Unit
2. Stream Stripping Unit
3. Gas Stripping Unit

Beach Energy has commissioned Advisian to perform a high level Total Installed Cost (TIC) estimate of the three options.

The cost estimates have been developed based on the preliminary assessment information provided by Beach Energy for each option (Appendix A). The project is in pre-concept and Advisian has not performed any engineering design/analysis on the identified options other than to assess the necessary works associated with each option to determine the TIC.

As advised in the Beach Energy scope of work document, the following work is excluded;

1. No allowance for Owner's costs
2. No assessment for layout
3. No assessment of existing platform spare weight capacity
4. No estimate for duration of platform outage to install

Although layout is noted as an exclusion, Advisian has performed a brief look at potential locations for where the equipment could be installed at a high level to generate the construction costs associated with each option - Refer to section 5.

The costing has been prepared using in-house cost engineering experience and standard Advisian spreadsheets. The estimating sheets allow for material procurement and construction activities which are added to give the total direct cost. Allowances are added for engineering, project management, design growth and unknowns. These costs have then combined and summarised to build up costs for each option. These cost estimates are for screening purposes only with an estimate range of +/- 50%.

2 Macro Porous Polymer Extraction (MPPE)

Beach Energy has provided a quotation for the MPPE unit has from vendor Veolia (Appendix B).

Figure 2-1 shows a sketch of the proposed works associated with installing a MPPE package with further description below.

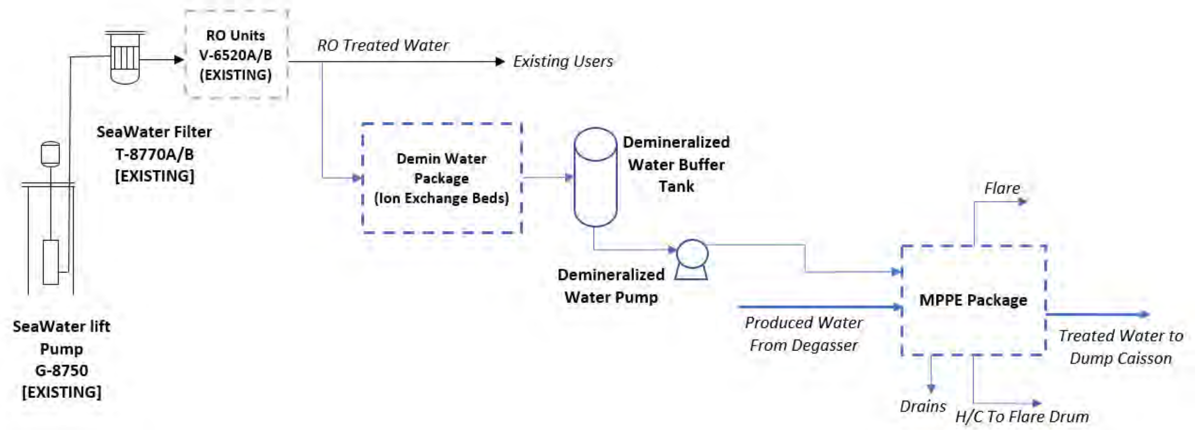

Figure 2-1: Sketch for MPPE Option

- MPPE Package
  - Veolia will provide a skid package that contains the processing equipment (cartridge filter, extraction/regeneration columns, stream generator, condenser, separator, water tank, return water pump and hydrocarbons pump).

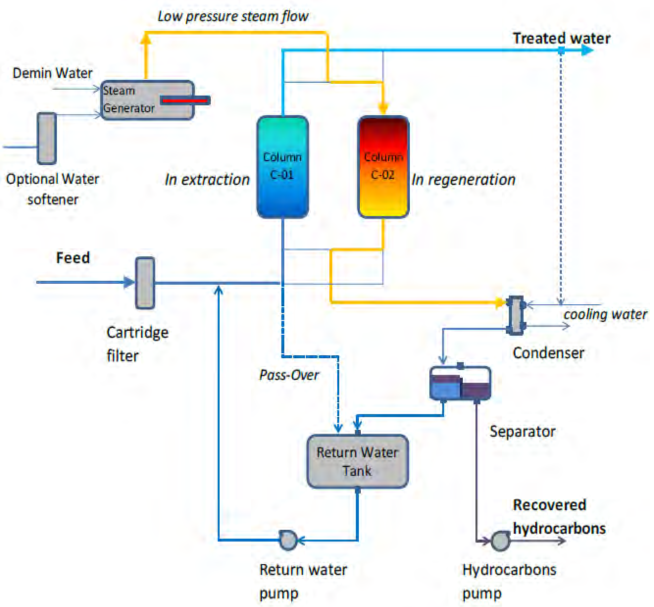

Figure 2-2: MPPE Package

- The MPPE package has dimensions and weight of:
    - L x W x H: 6.1m x 2.5m x 3.7m
    - Weight: 12 t
- It is recommended that the cooling medium for the steam condenser change from cooling water to air i.e. installation of an Air Cooled Heat Exchanger (ACHE) in place of the plate and frame exchanger proposed by Veolia. For Yolla the use of air is preferred to water for the following reasons;
    - If raw seawater is used (supply taken from downstream of the existing seawater filters, but upstream of the RO units) there is the high risk of the condenser scaling and fouling due to exchanger operating above 100°C and the water containing salts and minerals.
    - If treated utility water is used additional RO units would be required as the required cooling water rate is 1m^3/h whereas the RO units have a combined capacity of 0.76 m^3/h (0.38 m^3/h each).

  The condenser needs to achieve a temperature of approximately 40°C to condense all hydrocarbons and water which given the ambient temperature at Yolla would be feasible with an ACHE. The inclusion of the ACHE also removes the tie-in to the existing water system and associated new piping, valves, instruments and fittings.

  For the cost estimate no change has been made to the quote provided by Veolia, but NO allowance has been made for modifications necessary to provide cooling water.

- Demineralised water package / Ion exchange (IX) beds
    - Steam is required to regenerate and strip the extracted hydrocarbons from the MPPE columns. The steam generator is part of the MPPE package provided by Veolia but the water to the generator must come from the platform and must be of Boiler Feed Water (BFW) or demineralised water quality. Veolia advise that the steam generator requires 91 L/h [~2 m^3/d] of water at a specification of 0.5 German hardness (~9 ppm or mg/L $CaCO_3$).
    - The existing Yolla RO units (duty/standby) have a capacity of 760 L/h (0.38m^3/h each) and can produce water with a total hardness of <20mg/L $CaCO_3$. The required 91 L/h is about 12% of the total capacity of the units and hence no upgrade to the RO units is expected, but additional processing of the RO treated water is required. For this option it is assumed that an offtake of the RO treated water will flow through a set of ion exchanger (resin) chambers to generate demineralised water at the necessary hardness specification.
    - It has also been assumed that a small demineralised buffer tank (2m^3 i.e. 1 day reserve) and pump (2 m^3/d) will be installed (close to the MPPE package boiler) to ensure constant supply to the boiler.

- Hydrocarbon Return Pump
  - The Veolia quote states that the hydrocarbon return pump is an optional equipment item as they assume the oil can gravity flow to the drains. A cost allowance for a <1 kW pump to return hydrocarbon to flare KO drum has been made.
- Demolition
  - It is assumed that the existing Produced Water Filters will be demolished and the MPPE installed in its location. It is assumed that the ion exchange will be installed close to the existing RO units (Refer section 5). The Demin Water buffer tank will be located close to the MPPE.
- Piping Tie-ins include;
  - PW tie-in between PW filters and dump caisson (3") to install MPPE package
  - Tie-in to water system to install demineralised water package (1")
  - Tie-in to flare header (2")
  - Tie-in to Liquids return header to flare knock out drum (2")
  - Tie-ins to closed drains header (2")
- Power generation
  - The installed power for the steam boiler is 66 kW, the other electrical items i.e. pump, lighting, tracing & instruments is estimated at 3 kW, the addition of the ACHE fan motor would be < 5 kW and the hydrocarbon return pump would add <1 kW.
  - The demineralised water package (ion exchange beds) is assumed to have negligible power consumption. The demineralised water pump motor would be < 1kW.
  - Total additional power consumption for MPPE is estimated at ~75 kW. As advised by Beach energy there is approximately a spare 200 kW available to still fit comfortably within the existing rated gen sets.
- Control Systems
  - Works are required to the substations to incorporate and make provisions for the operating and control systems of the MPPE package into the DCS/ESD. Veolia have indicated 32 instruments as part of their package and it is estimated there will be another 8 for the BFW supply.
- Other utilities
  - It is assumed all other utilities e. nitrogen for purging and instrument air have adequate capacity and do not require upgrades other than allowing for the necessary tie-ins.

3 Steam Stripping Package

Preliminary information regarding the steam stripping option has been provided by Beach energy (Appendix A).

Figure 2-1 shows a sketch of the proposed works associated with installing a stream stripper unit with further description below.

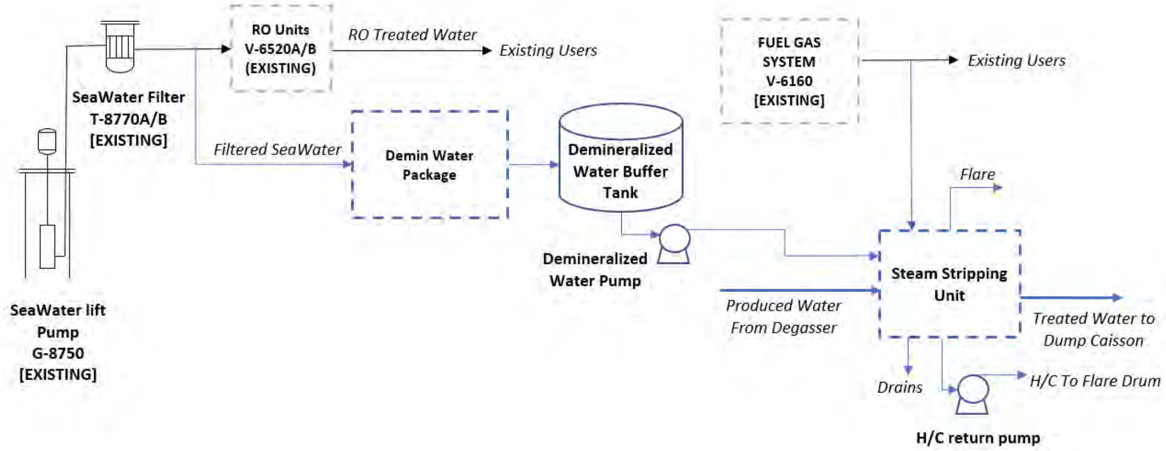

Figure 3-1: Sketch for Steam Stripping option

- Steam stripper package
    - o The steam stripper package includes; buffer tank, PW booster pump, cross exchanger, stripping column, overheads condenser, BTEX accumulator, reflux pump and steam boiler.

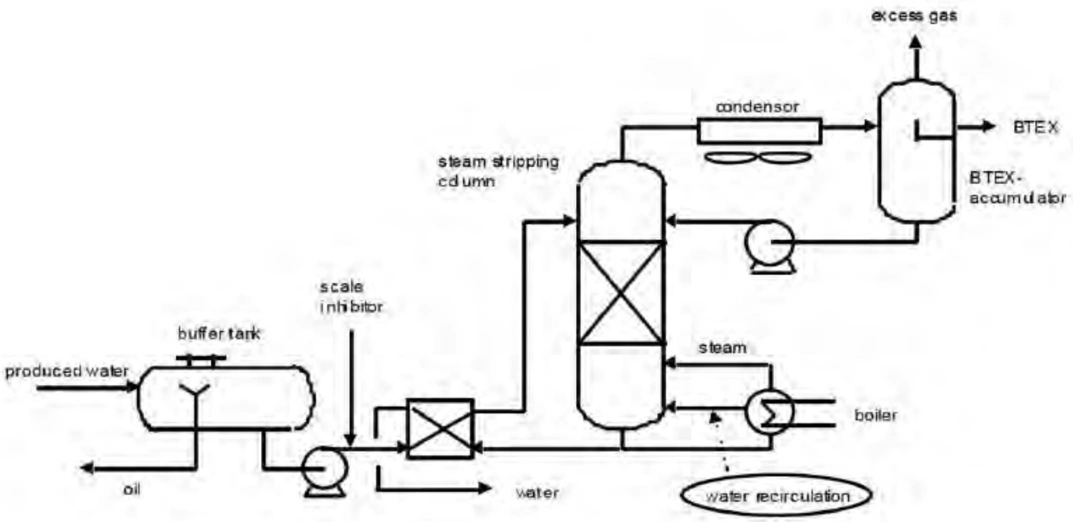

Figure 3-2: Steam stripping unit

o Scaling from the available data provided the estimated dimensions and weight of the steam unit is

  - L x W x H: 7.2m x 3.3m x 5m
  - Weight: 23 t

- BFW / demineralised water package

  o Figure 3-2 indicates that some treated produced water flow is recirculated to the boiler to generate the steam. This study has assumed all the necessary steam is generated from demineralised water.

  o The required BFW rate is estimated on a ratio of 1:30 to produced water feed. At a design rate of 300m^3/d (12.5 m^3/h) his equates to 10m^3/d (0.42m^3/h) or ~420 kg/h of steam required.

  o Allowing a margin, a demineralised water package of 0.5m^3/h has been allowed. This would equate to about 55% of the existing RO unit's capacity. This has the potential to overload the units and risk the supply of potable water to the accommodation block. Therefore, a new demineralised water package would be installed upstream of the existing RO units / downstream of the Seawater filters.

  o The existing sealift pump has a capacity of 12m^3/h with a discharge pressure of 1000 kPag. It is assumed it has spare capacity to supply the additional 0.5m^3/h through the demineralised water package to the buffer tank without modification.

  o It has also been assumed that a demineralised buffer tank (~12m^3 i.e. 1 day reserve) and pump (0.5 m^3/h) will be installed (close to the MPPE package boiler) to ensure constant supply to the boiler.

  o The total installed electrical power required to generate this steam is estimated at 400 kW. This is too large for the existing gen sets to provided (only ~200 kW available) hence a fired (gas fuelled) boiler is required. The fuel gas required is approximately 50 kg/h which is considered within the capacity of the existing fuel gas system [capacity >3,000 kg/h] therefore no upgrade to the fuel gas system has been made.

- Hydrocarbon Return Pump

  o A cost allowance for a 1 kW pump to return hydrocarbon from the buffer tank to the flare KO drum has been made.

- Demolition

  o It is assumed that the existing Produced water filters will be demolished, and the steam stripper package installed in its location. It is assumed that the demineralised water package will be installed close to the existing RO units (Refer section 5), however if there is inadequate space it may need to be located next to the stripper unit. The Demin Water buffer tank will be located close to the Stripper package.

- Piping Tie-ins include;
    - PW tie-in between PW filters and dump caisson (3") to install steam stripper package
    - Tie-in to water system to install Demineralised water package (1")
    - Tie-in to Liquids return header to flare knock out drum (2")
    - Tie-in to the fuel gas supply system (2")
    - Tie-in to flare header (3")
    - Tie-ins to closed drains header (2")
- Power generation
    - As stated above the assumption is the steam boiler with be fired and not electric. The other power users i.e. water supply pump, condenser fan, reflux pump along with lighting, instruments etc is expected to be <10 kW.
    - The demineralised water package will have negligible power consumption. Associated chemical injection Pulsation pumps will likely be air driven. The demineralised water pump motor will be <1 kW.
    - Total additional power consumption for steam stripper is estimated at ~10 kW. As advised by Beach energy there is approximately a spare 200 kW available to still fit comfortably within the existing rated gen sets.
- Control Systems

    Works are required to the substations to incorporate and make provisions for the operating and control systems of the steam stripper package into the DCS/ESD. It is estimated that there will be about 25 instruments in total.
- Other utilities
    - It is assumed all other utilities e.g. nitrogen for purging and instrument air have adequate capacity and do not require upgrades other than allowing for the necessary tie-ins.

4 Gas Stripping Unit

For the gas stripping unit it is assumed that the previous gas stripping column arrangement will be re-instated. Works involved are:

- Installation of the gas stripping column
    - 0.4m ID x 10.6 F/F
    - Weight 1.6t [Column = 1.4t, internals 0.2t]

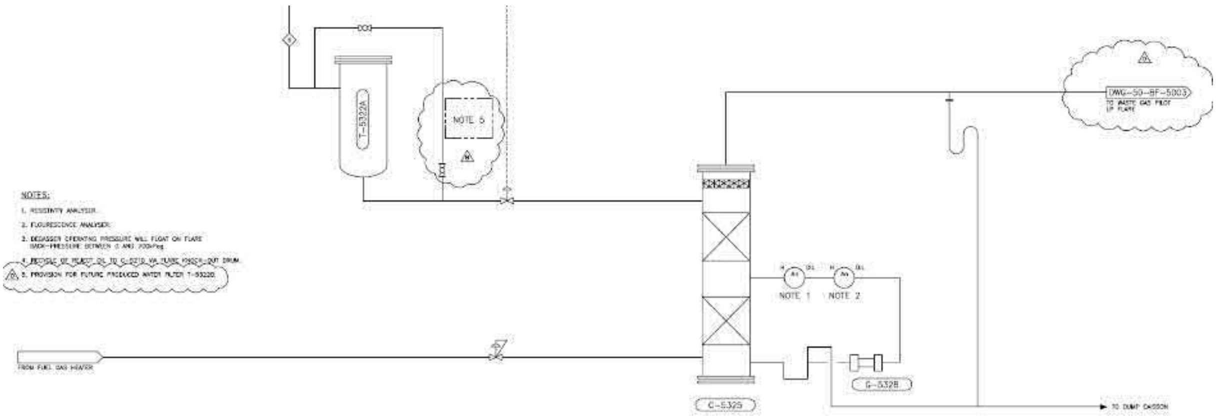

Figure 4-1: Original PW Stripper (with fuel gas)

- Fuel Gas System
    - As this is a re-instatement of the original design and an additional fuel gas conditioning unit has been installed to support the booster compressor, it is assumed there is adequate fuel gas supply capacity and no upgrade required.
- Tie-ins
    - Tie-in between PW filters and dump caisson (3")
        - PW sample show in Figure 4-1 is to remain in current position close to dump caisson and to not be reconnected to the column.
    - Tie-in to the fuel gas system (2")
    - Tie-in to the flare header (3")
    - Tie-in the drains header (2")
- Demolition
    - For this option is assumed that the existing Produced water filters will NOT be demolished and that the stripper column be installed next to the filters on the upper deck.

- Power generation
  - No additional power uses to be added as part of this option.
- Control Systems
  - Works are required to the substations to incorporate and make provisions for the operating and control systems of the steam stripper package into the DCS/ESD. It is estimated there'll be 8 instruments to connect.
- Other utilities
  - It is assumed all other utilities e.g. nitrogen for purging and instrument air have adequate capacity and do not require upgrades other than allowing for the necessary tie-ins.

5 Layout

Layout was listed as an exclusion in the Scope of Work and has not been investigated in any detail, however the location of the equipment does have a significant bearing on the cost of construction. Therefore, a brief review of the Yolla layout drawings and 3D model has been performed to make assumptions of where the equipment could be located. The locations proposed have been shown in Figure 5-1 and has formed the basis for the cost of construction. The feasibility of using these locations requires a more thorough investigation.

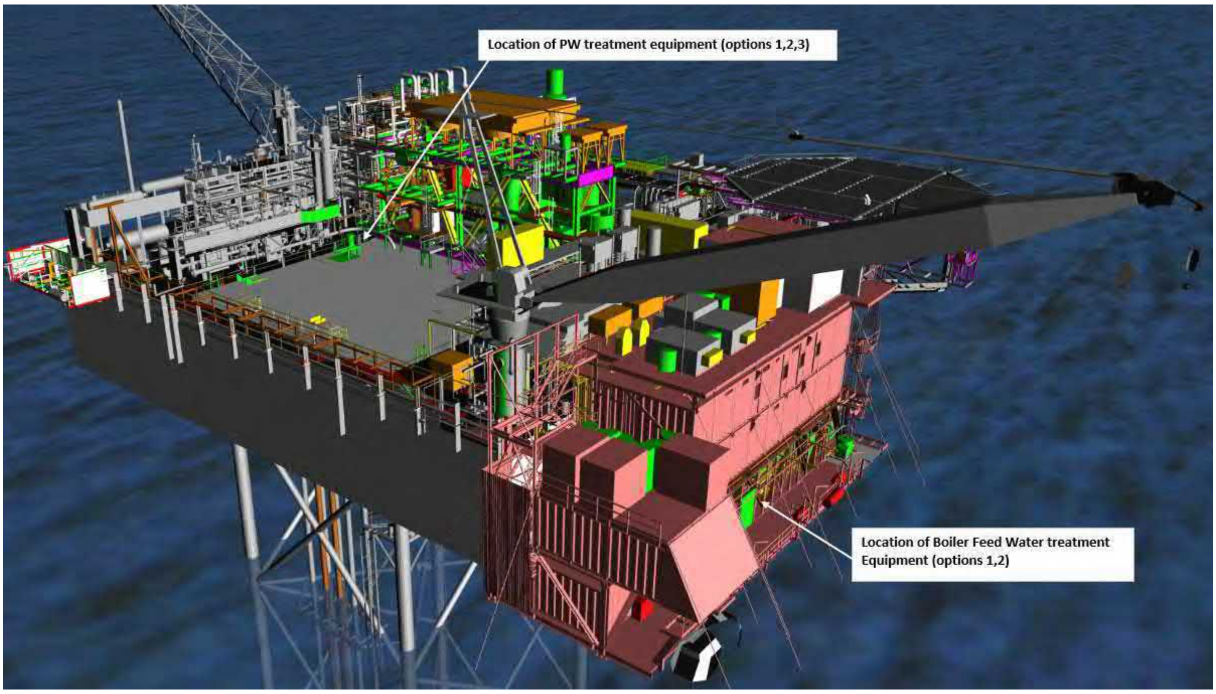

Figure 5-1: Potential Equipment Locations

5.1 Main processing equipment

For this assessment it has been assumed that for either of the 3 options the main equipment items i.e. MPPE package, the Steam stripper package or the gas stripper column would be installed on the main deck area where the current produced water filter and chemical injection skid are installed. These items would need to be removed/relocated as required.

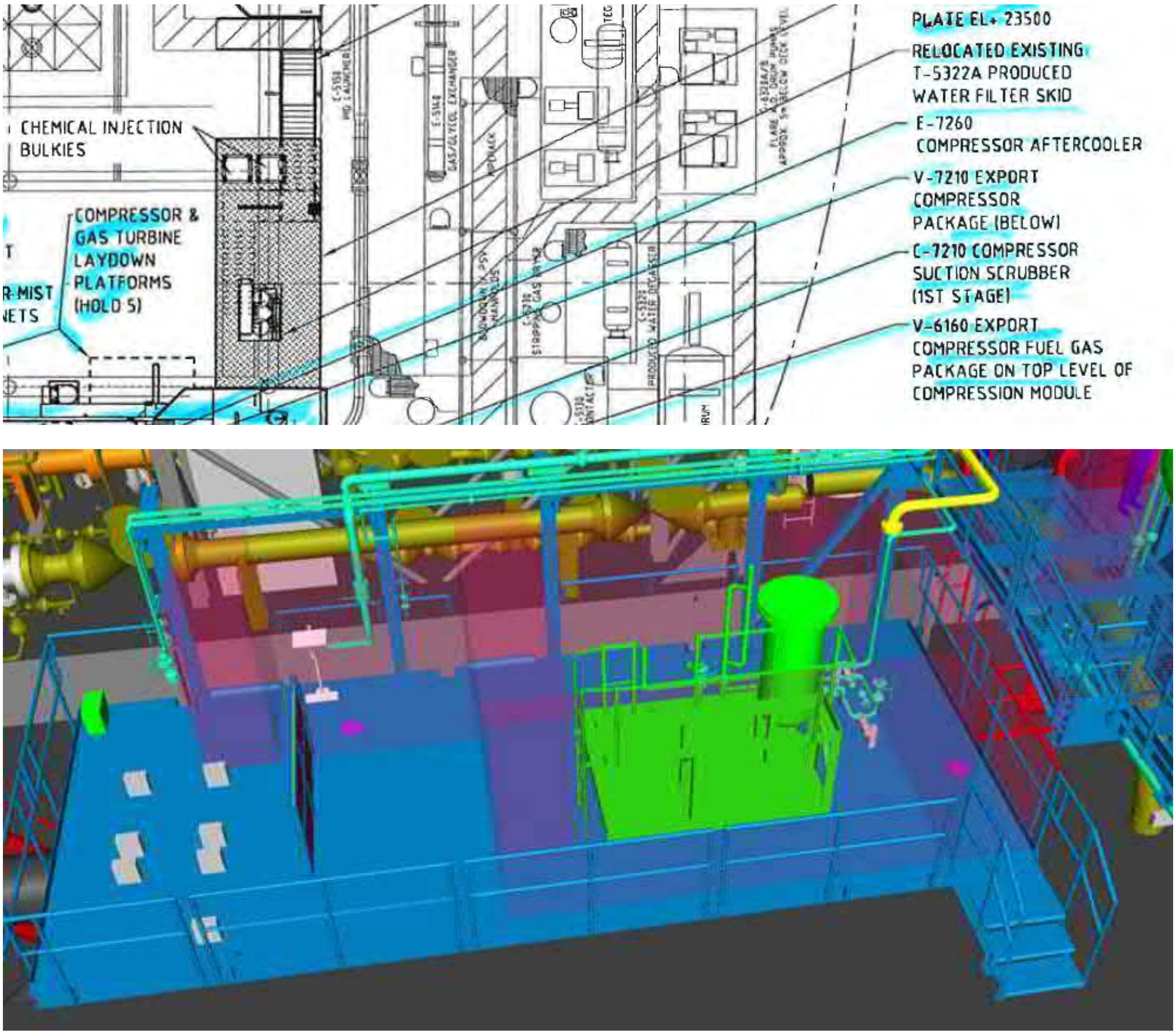

Figure 5-2: Existing PW Filters

5.2 Demineralised water generation equipment

For the options that require steam i.e. the MPPE and steam stripper option, the equipment required for pre-treating the boiler feed water is assumed to be installed on the accommodation utilities level where the existing water utilities (RO units, freshwater tanks, sea water filters etc.) are installed. It is assumed that relocation of some of these items may be required in order to fit the new equipment items in. For the steam stripping option, the demineralised water package may not fit into this location and alternatively it too would need on the upper deck close to the steam stripping package.

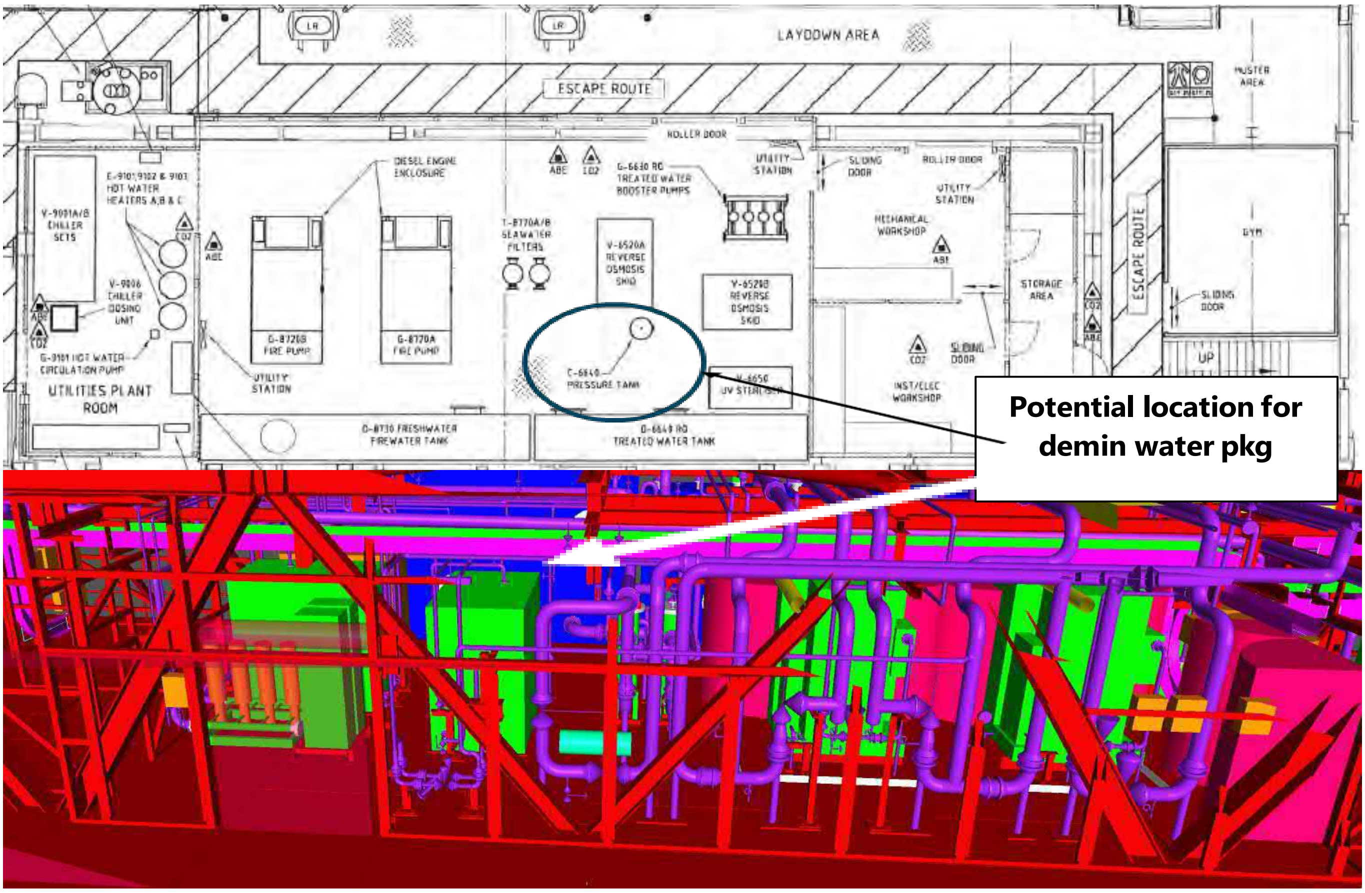

Figure 5-3: Existing water handling facilities

6 Cost Estimates

A summary of the cost estimates is provided in Table 6-1 with full costing spreadsheets provided in Appendix C. Estimates have been prepared for three cases:

- MPPE
- Steam Stripper
- Gas Stripper

The estimated CAPEX ranges from $18.2 million for the Steam stripper option to $7.9 million for the gas stripper option. These estimates are P50 estimates including a 30% to 40% contingency, the P50 cost is the most likely cost that has an equal probability of being underrun or overrun.

The estimate has been prepared using budget quotes from previous work for the MPPE and steam stripper equipment, other equipment is estimated using historical metrics escalated to todays costs. Bulks have been generated using bulk weight factors. All installation costs have been estimated by task allowing a crew size, duration and productivity factor for each activity. The procurement, fabrication and installation give the total direct costs.

Allowances have been added for design growth, engineering, project management and insurance as a percentage of direct costs. A 30% contingency is added to the bottom line to allow for unknowns.

Table 6-1: Total Installed Cost (TIC) Summary

AUD ($Millions)	MPPE	STEAM STRIPPER	GAS STRIPPER
Equipment Costs	1.92	2.42	0.19
Bulks	0.14	0.23	0.03
Mobilisation / Demobilisation	0.54	0.54	0.54
Construction	4.80	5.71	2.88
Engineering / Project Management	2.60	2.99	1.52
Allowances	0.52	0.64	0.16
Contingency	4.84	5.69	2.57
TOTAL INSTALLED COST	**15.4**	**18.2**	**7.9**

Advisian
Worley Group

beach

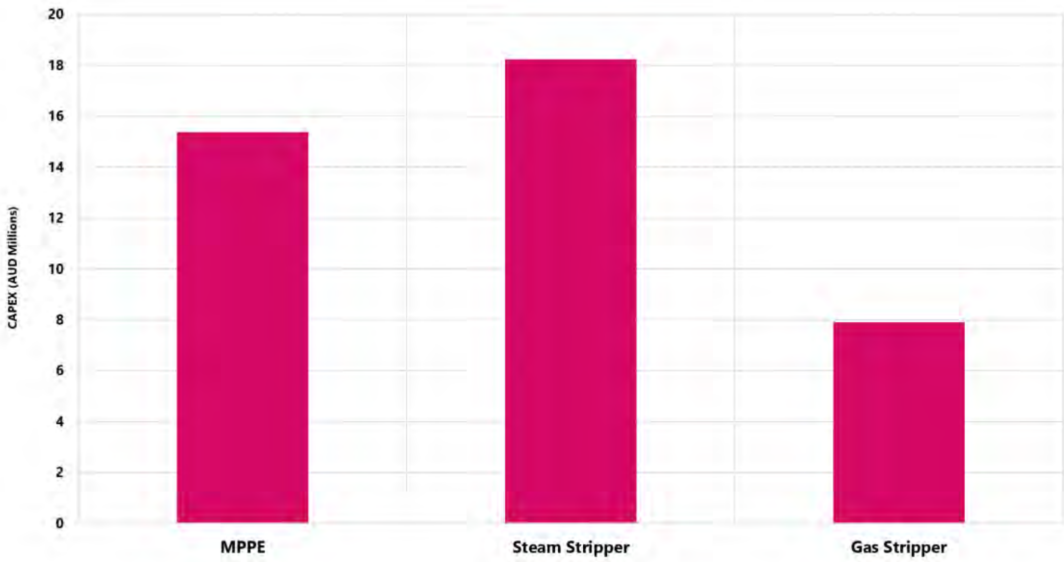

Figure 6-1 CAPEX by option

The Gas Stripper is the least expensive as it requires the least amount of equipment to install. However, as the original gas stripper was removed from Yolla, additional investigation is required to confirm that the new column would be able to meet the necessary specification.

The Steam Stripper is the most expensive due to the size and quantity of the processing equipment to install and requires the most steam. This option would have the most difficulty in finding the necessary layout, especially trying to fit the new demineralised water package close to the existing water handling facilities.

The MPPE option is less than the steam stripper however does make the assumption that condenser could be replaced with an air cooler. If cooling water is required, then modifications to the water handling system would be required i.e. installation of a demineralised water package which would make the costs fairly similar to the steam stripper option.

The following basis has been used for this study;

- All costs in 2019 AUD
- Exchange rate of 1 Euro = 1.62 AUD [spot rate at 6-December-2019]
- An all-inclusive Labour rate of $280 / hr consisting of overheads, transport, accommodation, food, tools and consumables.
- A productivity factor of 50% or 60% has been applied to offshore works.
- No owners' costs have been allowed
- Assumes the utilities are adequate except where specifically specified for each option.

- Assumes demolition work is minimal i.e. removal of filters and existing water handling equipment.
- Allowances have been added as a % of costs
    - Freight at 8% of equipment and bulks procurement
    - Spares at 5% of equipment procurement
    - Insurance and certification at 3% of total direct costs
    - Design growth at 3% of total direct costs
    - Engineering at 8% of fabrication costs and 20% of offshore costs
    - Project Management at 10% of fabrication costs and 25% of offshore costs
    - Contingency at 30% of fabrication costs and 40% of offshore costs

7 References

1. Origin, Yolla PFD, Produced Water Degasser, DWG-50-BF-5005 Rev 0
2. Origin, Yolla UFD, Water Handling System, DWG-50-BF-6601-2P, Rev P1
3. Origin, Yolla P&ID, Produced Water Stripper, DWG-50-BP-5305 Rev 1
4. FEGL/Origin, FD101-4 RO Watermakers, UV Sterilizer Package, Manufacturing Record Book (MRB), T-5150-40-RP-B002-906, Rev 0
5. GLP Plant, Produced Water Degasser Stripper C-5325, Manufacturing Data Record (MDR), 35101304-BG000502-007, Rev A

Appendix A
Scope of Work

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21 November 2019

Project to Determine TIC of a Produced Water Treatment Facility on Yolla Platform

SCOPE OF WORK

Beach Energy require an indicative estimate to perform works associated with generating a total installed cost to modify Yolla platform with a facility to remediate the produced water system. The project is at pre-concept stage only and only requires indicative estimates against each option.

Use in-house cost engineering experience and/or industry cost estimating software for an offshore facility. Allowances to include engineering design, procurement, construction, construction management and commissioning.

Design Basis

Facility will handle up to design maximum of 300m3/day of produced water.

Target to reduce total hydrocarbons (free and dissolved) to no more than 10 mg/litre. Currently typically about 80 mg/litre comprising mostly dissolved BTEX.

Three treatment options have been identified:

(1) MPPE Unit
(2) Steam Stripping Unit
(3) Gas Stripping Unit

Schedule

Target by close of business Friday, 13th December 2019

Deliverable

Cover note and a spreadsheet outlining indicative costs for each option.

OPTIONS:

(1) MPPE Unit

A quotation and sizing/weight for a Macro Porous Polymer Extraction (MPPE) unit has been requested from a vendor Veolia. Quote expected by start of week of 25-Nov which will include steam generation capacity. This estimate will be forwarded as soon as it is available.

Allowance for utility/process connections include power supply, treated water supply, cooling, flare/drains:

- Allow for some substation works, expect to have adequate capacity from existing gensets.
- Allow for cooling water mods from downstream of filters and return line to dump caisson. Assume existing seawater pump has adequate spare capacity.

- Allow for some upgrade to water supply ex RO units, and chemical injection eg BFW treatment Assume produced water can gravity flow from existing Degassing Vessel.
- Allow for pump to deliver recovered hydrocarbons to Flare KO Drum
- Allowance for integration into DCS/ESD systems.
- Scale up estimated weight from package estimate from vendor. Factor weight for piping and connections.

(2) Steam Stripping Unit

Attached document provides 2012 estimates for a steam stripping unit. Consider a factored cost based on capacity, year and location, and for duplex vs carbon steel.

Allowance for utility/process connections include power supply, treated water supply, cooling, flare/drains:

- Allow for some substation works, expect to have adequate capacity from existing gensets.
- Assume doubling the size of the existing seawater pump.
- Allow for some upgrade to water supply ex RO units, and chemical injection eg BFW treatment Note: Indicative water/steam ratio of approx. 30-40:1. Assume 30:1, therefore steam rate from 10m3/hr of feed water. Allow for 8MW gas fired steam boiler. Allow for upgrade of fuel gas facility.
- Assume produced water can gravity flow from existing Degassing Vessel.
- Allow for pump to deliver recovered hydrocarbons to Flare KO Drum.
- Allowance for integration into DCS/ESD systems.
- Scale up estimated weight from package estimate from vendor. Factor weight for piping and connections.

Clarified in email with Richard Walls (03-Dec-19) that this should have been per day not hour making boiler duty ~400kW [Email attached at end of SoW]

(3) Gas Stripping Unit

Assume a Gas Stripping Column similar to what was removed from Yolla a few years ago. Refer attached historical P&ID.

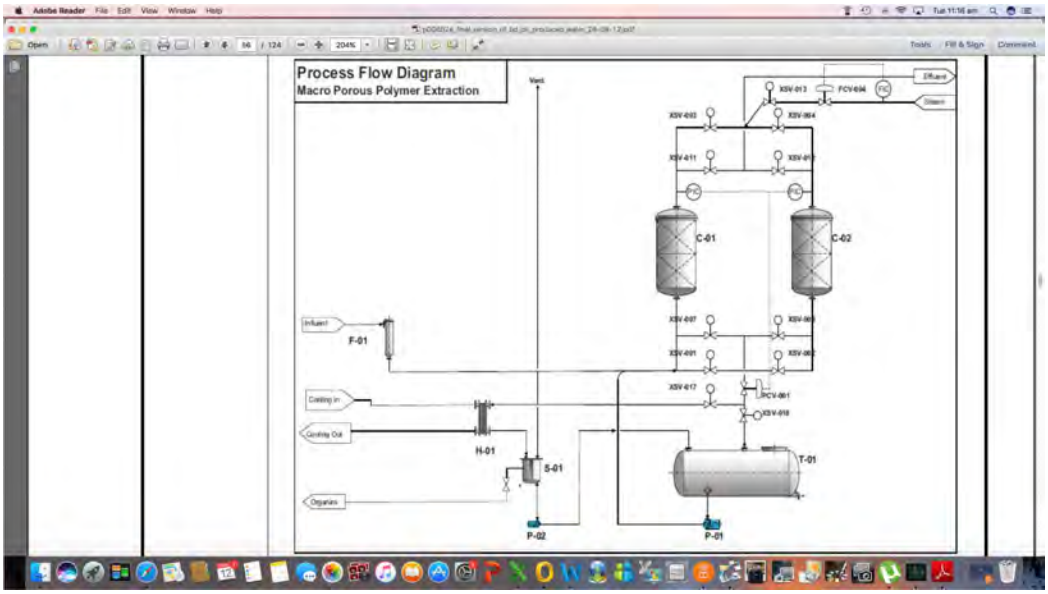
Allowance for utility/process connections include flare/drains:

- Allowance to have validation of the design and process guarantee.
- Allowance for integration into DCS/ESD systems.
- Use estimated package weight from previous design. Factor weight for piping and connections.

Exclusions:

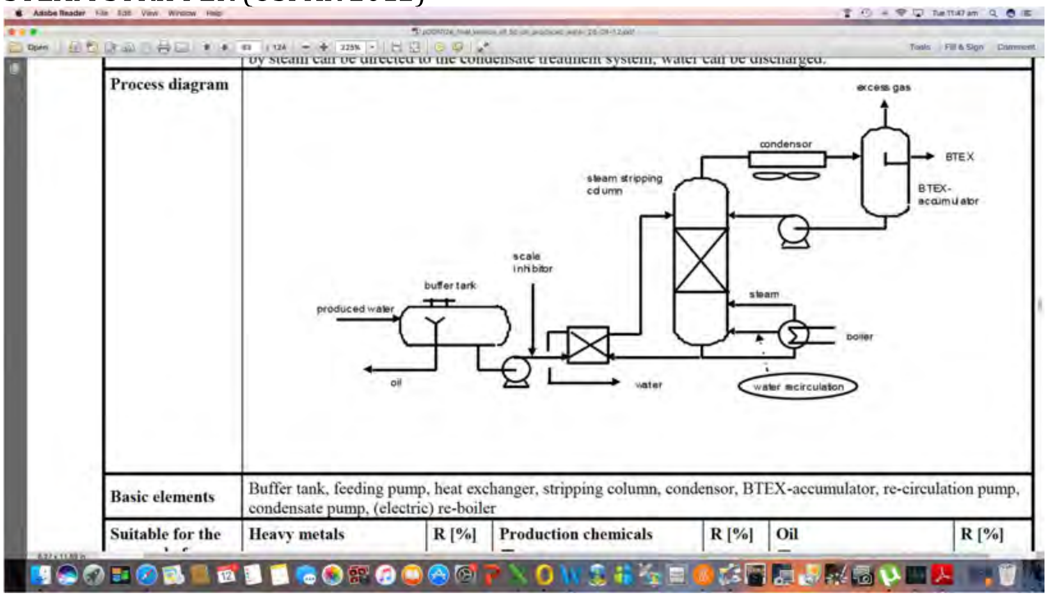
1. No allowance for Owner's costs.
2. No assessment for layout
3. No assessment of existing platform spare weight capacity.
4. No estimate for duration of platform outage to install.

MPPE Information (OSPAR 2012)



	Per Unit	Minimum	Maximum
Technical details	Treatment capacity (m3 produced water per hour)	0,3-15	150
	Gross Package volume (LxWxH)	6,2 x 4 x 3 m	10 x 6 x 12
	Operating weight	10 ton	250 ton
	CAPEX (€)	1 000 000 (2012)	10 000 000
	OPEX (€/year)	50 000 (2012)	250 000
	Cost per m3 produced water(€/m3)	0,60 (2012)	0,24
Critical operational parameters		The main critical parameter is the measured outlet concentration vs. discharge limit. If this comes close to the discharge limit the MPPE material needs to be replaced. This is a very slow process (Years) and can be done say on a weekly basis. The reduction performance is very stable and does not change overnight.	
Operational reliability incl. information on downtime		-The MPPE unit is fully automatic and remote controlled and has been in operation on an unmanned platform	

STEAM STRIPPER (OSPAR 2012)



by steam can be directed to the condensate treatment system, water can be discharged.

Process diagram						
Basic elements	Buffer tank, feeding pump, heat exchanger, stripping column, condensor, BTEX-accumulator, re-circulation pump, condensate pump, (electric) re-boiler					
Suitable for the	**Heavy metals**	**R [%]**	**Production chemicals**	**R [%]**	**Oil**	**R [%]**

Technical details	Platform	Gas 1 (small)	Gas 2 (large)	Oil 1
	Produced water volume (design)	1 m3/h	6 m3/h	n.a.
	Required area (LxWxH)	3 x 2 x 5 m	6 x 3 x 5 m	
	Mass (filled)	12 tonnes	20 tonnes	

Critical operational parameters

Since produced water usually contains salts and solid particles, problems with depositions (scale) may occur in the boiler and the heat exchanger. In order to prevent concentration of salts in the boiler, it is recommended to create a slight throughput by means of a re-circulation line from the boiler to the column. The steam line must be large enough in order to allow for equal levels in boiler and column (and above the bundle of the boiler). In order to guarantee a constant throughput, a buffer tank is required. This also provides the possibility to skim off oil, avoiding disruption of the process in the column.

Operational reliability

When the produced water contains large amounts of salts, the installation will need to be shut down regularly to enable removal of salt depositions.

The expected removal efficiency for BTEX is high: reduction from 50 mg/l to < 6 mg/l, aliphatic hydrocarbons from 30 mg/l to < 3 mg/l . Removal efficiencies of >90% for Dissolved oil, BETX, benzene and PAHs.

Costs	Investment costs (CAPEX) [€] 2012		Exploitation costs (OPEX) [€ / year]	
	present	new	present	new
gas platform, small	670 000	560 000	238 000	169 200
gas platform, large	990 000	840 000	401 400	276 900
oil platform	n.a.	n.a.	n.a.	n.a.

Appendix B
Vendor (Veolia) MPPE Quote

Proposal for Offshore Produced Water Treatment

For: Beach Energy
End-user: Beach Energy
Melbourne Australia

MPP project: M-199B
Revision: A
Date: 21-11-2019

Disclaimer

Veolia offers this service for free and warrants that the bid is based in accordance with generally accepted professional practices, supplier information and to the best of our Knowledge and without obligations. In no event shall Veolia Water Technologies Techno Center Netherlands B.V. be held liable for any damages, claims, demands, suits, causes of action, losses, costs, expenses and/or liabilities, regardless of whether such liability arises out of breach of contract, guarantee or warranty, tort, product liability, indemnity, contribution, strict liability or any other legal theory .

Revision	Date	Status	Issued by	Checked by
A	21-11-2019	Budget	JBK	JBO

Legal Entity: Veolia Water Technologies Techno Center Netherlands B.V. (Part of Veolia Water Technologies)
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Contents

1. Executive Summary

A proven safe, robust and one-step solution to efficiently remove dispersed & dissolved Hydrocarbons and Mercury from Produced Water.

Beach Energy has requested Veolia Water Technologies Techno Center Netherlands B.V. to provide preliminary budget proposal including design, sizing and weight information for a MPPE unit treating Gas Produced Water from an existing Offshore Platform.
We have based our Technical proposal on the received website inquiry data and communication by phone.

The present Technical proposal accounts for general O&G specifications in terms of engineering, quality, inspection and documentation, but some deviations on HFE requirements with regards to spacing and accessibility might be applicable mainly due to the fact that the unit has been contained in a 20' Sea container.

We are investigating the option for long term rental of the unit through our local Australian office.

Veolia has been supplying on- and offshore MPPE units for Gas Produced Water since 1994. MPPE Technology treats the Gas Produced Water on for instance for Shell Prelude, Inpex Ichthys, Equinor Kollsnes, Shell Ormen Lange and Woodside Pluto.

1.1 Veolia's Solution to the Key Projects Requirements

Key Project Requirement	Veolia's MPPE System Solution
Achieve the required Effluent quality	Yes
Treat a maximum inlet flow rate of 12.5 m3/h	Yes
Ability to maintain removal efficiency independent of Feed concentration	Yes
Ability to handle emulsions that maybe present	Yes
Ability to remove Mercury if present	Yes, removal rate 90% - 98%
Most compact solution possible	Yes, the Sea container version is the most compact and easy to install solution. However an open skid mounted unit may also be offered.
Value added benefits of Veolia's solution	• *Full recovery of hydrocarbons for sale* • *Fully regenerable system providing certainty of OPEX costs & performance irrespective of influent hydrocarbon levels* • *Proven performance to handle slugs of oil or increased BTEX levels as seen in LNG related wastewater as high as 2500 mg/l*
Performance impact due to motion	No impact

MPPE Features & Benefits

MPPE Features	Benefits to the Project
1. Very High Separation Performance	• MPPE technology removes dissolved and dispersed hydrocarbons with high reduction factor (any removal rate from 80% to 99.99%). • Reduction factor independent of inlet concentration. I.e. the design is made for a certain reduction rate. So when designed for 99% removal 100 ppm will be reduced to 1 ppm and 500 ppm to 5 ppm.
2. Robust, No Fouling	• No interference from dissolved iron, heavy metals, surfactants, salt and polar compounds, and no scaling • No biological fouling because of periodic in situ regeneration by steam
3. Reliable and Easy Operation	• Fully automated operation. NO operator intervention required for adjusting of settings or on-site controls. • No special equipment requiring dedicated maintenance.
4. Flexible Operation	• Turndown ratio up to 10%. • Higher Feed concentrations can be treated at lower flow rates. For example, if the feed concentration is 50% higher, effluent requirements can still be maintained with only a 10% lower flow. At lower feed concentrations, higher flows can be treated while still meeting the effluent demand. • Immediate performance at start up • Batch wise operation possible
5. Compact Equipment	• MPPE offers a Single unit treatment. Compared to existing technologies, the unit is compact with a small footprint.
6. No Chemicals uses No Sludge produced	• NO Chemicals required, thus NO HSE issues, NO logistics, NO dosing tweaking required and NO Chemical sludge produced requiring storage and dewatering. • Removed hydrocarbons are recovered almost 100% pure and may be reused (blended). Thus no waste.
7. Performance Guarantee during Operational Life	• The MPPE media performance is guaranteed through the Performance Guarantee Service Contract
8. Environmental Benefits	• Long lifetime of media. Normally 2-4 years. Spent media are collected by Veolia, cleaned and refilled with extraction fluid to be reused. • Low energy consumption • Low noise • No off-gas produced

1.2 Conclusion & Next Steps

We trust that we have supplied you with sufficient information and look forward to discuss further possibilities with you in detail.

Veolia is available to answer any questions you may have regarding this proposal and are excited at the prospect of working with Beach Energy on this project.
If this budget proposal is of further commercial interest, we would welcome the opportunity to present this proposal through tele- or videoconferencing and discuss the next steps along with their timing.

We would like to inform you that Veolia Water is the Number 1 water treatment company in the world. Veolia Water Technologies as part of Veolia Water is able to deliver you the whole portfolio of water treatment technologies to treat your wastewater, produced water, process water and groundwater.

1.3 Point of contact:

Sales Manager: Jan Bart Kok
Phone: Office +31 318 664010
Direct +31 318 664006
Mobile +31 6 51335419
Email: janbart.kok@veolia.com

2. Commercial

2.1 Budget Estimate (CAPEX)

The CAPEX price is given for the engineering, manufacturing, equipment delivery, tests and inspection, optional functional duration test and services for a MPPE unit as described in following paragraphs. The MPPE material is supplied through the PGS contract (see 2.3.1).

For the Base Case, i.e. **including** Return Tank and Return Pump:

€ 1,000,000.- (One Million Euro)

2.2 Operational expenditures

2.2.1 OPEX

The annual operating expenditures consist of:

- A fixed annual fee for a Performance Guarantee & related Service (PGS) Contract
- Utility costs
- Operation and maintenance costs

Note that the recovered Hydrocarbons have a market value (equivalent to condensates) and can be considered as a revenue.

2.2.2 Performance Guarantee & related Service Contract (PGS)

An MPPE unit is delivered with an operational lifetime Performance Guarantee with related services, meaning that VWT Techno Center Netherlands B.V guarantees the Intermediate and Hydrocarbons removal efficiency over the lifetime of the MPPE unit.
This removal efficiency guarantee is covered in the Performance Guarantee and related Services (PGS) Contract. The PGS contract includes supply, replacement and return of the MPPE material, operations support, service and periodic control, access to new developments (process, automation etc.).

The fixed annual PGS fee, is independent of the number of MPPE exchanges per year and the performance guarantee is valid for the total operational lifetime of the MPPE unit.
At lower influent concentrations it is possible to run the unit at higher capacity (higher flow) while still meeting effluent requirements.
At higher influent concentrations than design it is possible to meet the effluent criteria at lower flows.
These conditions are all within the performance guarantee at no higher operational costs.

The PGS contract will be closed with the End user (owner and operator) and includes the following:

- MPPE material supply / exchange / return
- Columns internals inspection
- Performance guarantee during lifetime operation
- Performance control and optimization (based on remote control facility)
- Operations support by remote control and local support
- Access to new developments / improvements

Annual Fee: **€ 45,000 (Forty Five Thousand Euro)**

2.3 Value recovered Hydrocarbons (profits)

The recovered Hydrocarbons have a market value (assumed 65 $/barrel). Based on design Feed conditions and design removal rates the annual recovery is approximately **150 barrels per year i.e. $10,000 per year.**

2.4 Price

The price is based on the complete and undivided delivery.
Value Added Tax or similar fiscal imposition, any taxes such as withholding taxes which are in force or which may be introduced by the government, is not included in any price indicated in this proposal.

2.5 Delivery conditions

2.5.1 Delivery type

The delivery is FCA Workshop according to Incoterms 2017. Workshop location may be The Netherlands, Middle East or Asia. Location can only be fixed in during EPC, after contract award.

2.5.2 Time of Delivery

Under normal conditions the expected delivery time FCA Workshop is 12 months from PO acceptance.

3. Process Design

The design has been based on Feed flow rate and concentrations of Dispersed & Dissolved HC's and BTEX as specified.

3.1 Design conditions and Separation performance

FEED CONDITIONS			
Parameter	**Unit**	**Value**	**Remark**
Design Flow rate ~~max~~ for ~~separation~~ performance guarantee.	m3/h	12,5	Note 1
Feed pressure at flow	barg	1 - 5	
Temperature	C	<40	Note 2
Inlet composition			
Dispersed Hydrocarbons	mg/l	<40	Assumed to be present as C11-C16
Dissolved Hydrocarbons (aliphatic)	mg/l	<100	Assumed to be present as C6-C10
BTEX	mg/l	<60	
Total	mg/l	**<200**	
Hg	mg/l	N/A	Note 4
PAHs	mg/l	N/A	No information provided, note 5
NPDs	mg/l	N/A	
Corrosion & Scale Inhibitors	mg/l	N/A	

DISCHARGE DATA			
Parameter	**Unit**	**Value**	**Remark**
Dispersed Hydrocarbons	mg/l	<5	
BTEX	mg/l	<5	
Total HC	**mg/l**	**<10**	
PAHs removal rate	Removal	>99%	Expected removal
NPDs removal rate	Removal	>99%	Expected removal
Temperature increase	C	2-3	Estimate
Flow rate outlet	m^3/h	0- 112%	Every hour: 7 min zero flow Remaining time at 112% inlet flow.
Pressure at flow (approx..)	mwc	12	

Notes:

1) Maximum flowrate

Hydraulic flow rate limitations are set by the pipe sizes used. Veolia allows for a maximum velocity in the pipe of 2.5 m/s. In this offer a pipe size of 2" is used allowing a maximum Feed Flow rate of approximately 15 m3/h (but at reduced removal efficiency).

2) Temperature

For the technology to be efficient the Feed temperature needs to be below 50 degC and preferably below 40degC.

3) Inlet concentration of hydrocarbons

It should be noted that the values for BTEX are low compared to what we see in other references. We have assumed that the C11-C16 is predominantly present as dispersed phase. The C6-C10 will be partly dispersed and partly dissolved.

4) Mercury removal

No information has been provided on the Hg level in the produced water, nor information on maximum discharge level is given.

In benchmark studies of current MPPE units a structural removal of total Mercury content of 80-99% has been observed. This phenomenon has been studied and Hg removal can be guaranteed at 90% for dissolved Hg, either metallic or ionic. Particulate Hg or Hg chemically bound to organic molecules are excluded from this guarantee.

5) Removal of other constituents

This MPPE process design is based on the dissolved & dispersed aliphatics and BTEX. Other extractable compounds like PAHs, NPDs (and partly field chemicals like corrosion/scale inhibitors) will also be removed. In principle a Zero Harmful Discharge to the Environment will be achieved.

4. General Process Description

The extraction process itself is a batch process but by using two columns, one in extractioj mode and one in regeneration mode, the process can be made continuous. This however requires a process sequence that will create an internal recycle which can be dealt with in two ways: (i) include a Return Tank, or (ii) make use of a projected feed tank or off-spec tank. The latter reduces the number of equipment and decreases the size and the weight of the MPPE unit, but does require the MPPE unit to be above and close to the projected tank. The two options are described below:

4.1 Description including a Return Tank

A Macro Porous Polymer Extraction (MPPE) unit consists of two columns, containing a packed bed of MPPE material. One Column is in extraction mode, the other in regeneration (figure 1). The MPPE media contain an immobilized extraction fluid that enables the extraction of hydrocarbons from the Feed water.

A cartridge filter protects the media from incidental off-spec solids. The MPPE-column C-01 is in operation and fed in up flow direction (blue line) . Column C-02 is in regeneration (yellow) and is heated up with Low-pressure steam. The temperature of around 102 C in the Bed is maintained for approximately 30 minutes. The extracted hydrocarbons contained in the media are forced out into the steam vapor. The vapor condenses in two phases – a water and a hydrocarbon phase - in a water cooled condenser. Density differences between the condensed phases allow a final separation of hydrocarbons and water in the Separator.

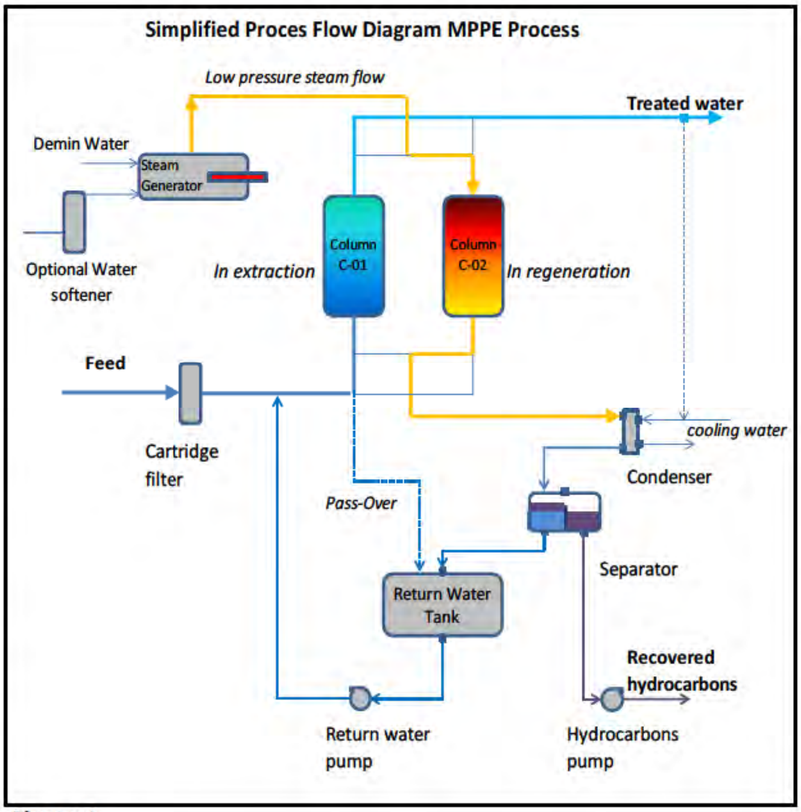


Figure 1

When the regeneration has completed (normally 1 hour) the operation of the Columns is switched. The hot regenerated Column C-02 is fed with Feed Water which is led to the Column C-01 to be regenerated. This so-called Pass-over enables cooling down of the regenerated Column and pre-heating of the Column to be regenerated. As the Pass-over Water coming from the Column is hot and containing elevated levels of hydrocarbons it cannot be discharged. The pass-over Water is led to the Water Return Tank and gradually fed back with the Feed Water over the next operational phase. The switching of Columns does <u>not</u> interrupt the Feed. The discharge of treated water is interrupted for several minutes during the Pass-over step.

The process is fully automated, flow rate adjusted and requires no Operator intervention. The process has a Turn-down ratio up to 10% of the design flow rate. The process operates at very low noise levels.

Description of the No Return Tank option

The so-called Return water is required to buffer the drain (so-called Pass-over step) from the MPPE Columns during the Regeneration step. The buffered water is contaminated with HC from the Columns and is pumped by the Return Water Pump back to the Feed line of the MPPE Unit within one Regeneration cycle. The Return Water Tank (with related pumps and piping) can be deleted in case there is an external Buffer Tank available positioned below the MPPE unit (to allow gravity flow) and that has the option of pumping to the Feed of the MPPE unit. The Buffer Tank may either be an existing upstream Buffer Tank from which the Feed is pumped to the MPPE Unit or for instance Off-Spec Tank that has the option of pumping to the Feed line of the MPPE Unit (see figure 2).

The major advantage is the deletion of one floor (that holds the Return Tank and pumps) in the Base case unit resulting in a major weight, height and cost reduction.

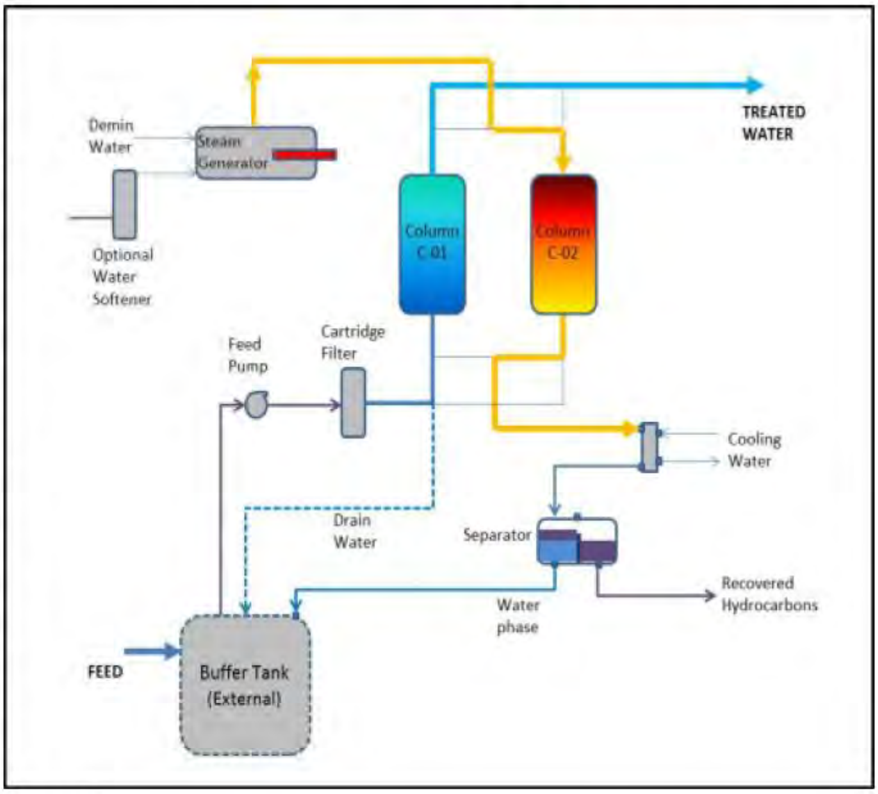


Figure 2

The following requirements apply for this option:

- Buffer Tank (upstream) Tank should be below and near to MPPE Unit to allow for gravity drain from MPPE Columns.
- Buffer Tank Feed pumps allow for approximately 4 m3/h additional flow rate on top of the design Feed Flow rate. Preferably VSD controlled to limit the Flow Control Valve pressure drop.

The following process consequences should be noted:

- The drain from the columns will be during approximately 3-15 minutes and has a temperature that is equivalent to the Feed temperature. However the last approximately 0.2 m3 will have a temperature of 95 C.
- The drain from the Columns may hold dispersed HC that may float in the Buffer tank. It is advised to have a skimming option in the Tank (something that is normally considered for this type of Tanks)

5. Design Assumptions and Considerations

The following assumptions and considerations have been used in the design:

1. **Build type**
   We have proposed a **containerized MPPE Unit**. The Unit will be supplied with all piping, electrical and I/O connections at battery limits. The on-site works for deck connection, connection of (external) piping, electrical and I/O cabling is by Client or third party local Contractor. Veolia will provide Supervisor for on-site support.

2. **Pre-treatment**
   A standard Cartridge type pre-filter is included for preventive reasons. As a default we assume that TSS content is low and particles are small in the Feed and that no continuous TSS removal is required. In existing MPPE units treating offshore Gas/Condensate produced water TSS is no issue and typical lifetime of the cartridges is 6-12 months.

3. **Material of construction**
   The material of construction for piping and vessels Duplex SS due to salt and sea environment and high design temperature of certain parts.

4. **Redundancy <u>OPTIONS</u>**
   - Cartridge Filters
     Cartridge Filters are supplied as 1 duty + 1 standby preventing a unit shutdown when filters are exchanged.

   - Condenser
     Condenser plates may foul depending on Feed and Cooling water composition. Generally the cleaning/inspection frequency is every 1-4 years. Redundant Condensers will allow for uninterrupted operations.

   - BTEX/Recovered Hydrocarbon pumps
     The BTEX/RHC pump discharges the Recovered Hydrocarbons from the Separator tank. The Separator Tank has a typical buffer capacity for Hydrocarbons of several days, allowing for repair/maintenance of the BTEX/RHC pump.

   - Water Return Pumps
     The Water Return Pump recycles the condensed steam and back-flow water into the Feed of the Unit. Discontinuation of operation can only be allowed for several minutes and does not allow for repair or maintenance works.

   - Redundant Extraction capacity
     Generally the efficiency loss of the MPPE media is very gradual. A required exchange of the media can be predicted months ahead. A media exchange requires a total stop of the operations. An additional set of 2 columns can be included as a warehouse (onshore/offshore) spare option for quick exchange (less than one working day). This however requires sufficient lay down area and access by crane with around 2 tons lifting capacity.

5. **Nitrogen/Fuel gas Blanketing option**
   Small volumes of "breathing" off-gas due to level variations in the Return Water Tank and the Separator are vented at a high point of the unit as default.
   Some environmental regulation may not allow breathing to the air. Connection to a venting, blanketing and/or flare system may be required and can be offered as an option.

6. **Specifications**
   We have accounted for typical O&G specifications in terms of required design & engineering, quality & inspection and documentation standards. However some specific Company requirements may lead to major design, lay-out or equipment changes that will impact price and supply time.

7. **Zoning**
   We have assumed that the Unit is placed in a Zone 2 area

8. **Control**
   The default supply consists of instrument cabling to Junction boxes on unit edge. Power cabling to be installed by client (separate cable trays are included in scope).
   Functional description as basis for programming of Client (central) control is included.

6. Unit properties and Utilities

6.1 Estimated Sizing & Weight

For typical GA please refer to Attachment 1, dimensions and weights are listed below

Base Case:
Estimated MPPE Unit sizing: 6.1 x 2.5 x 3.7 m (L x W x H) excluding external stairs and ladders
Estimated Weight: Empty 12 tons
Wet (max.) 15 tons

6.2 Estimated Utilities Consumption

Estimated Utilities Consumption below are based on Design conditions as listed in previous paragraph

Cooling water consumption Condenser (design conditions)	m3/y	5.762
Assuming Cooling water temp. 25 C; max. temp. increase 15 C	m3/h	1
Feed water Steam Boiler (design conditions)	m3/y	494
Feed water quality should be better than 0.5 German hardness	l/h	91
Annual steam consumption (LP: 110C; 1.5 bar abs.)	ton/y	449
Peak Steam flow rate	kg/h	82
Electrical consumption: eg. pumps, lighting, tracing, instruments	kWh/y	25.448
Electrical consumption Steam Generator	kWh/y	203
Installed Power Steam Boiler	kW	66

7. Scope of Supply

7.1 Engineering services

Following major Engineering services are included:

Item	Remark
Project Management and Detailed Engineering incl: • Project Management • Structural analysis and design, • MPPE Process design • Pipe stress analysis • Thermal & Mechanical design of exchanger(s), • Mechanical design of equipment • Assembly of equipment, piping and MPPE skid (at Veolia Workshop) • Inspections Equipment and at works Veolia workshop • Packing	
Participation and technical support at - Kick-Off meeting (1 meetings of 2 days) - Progress meetings (max 2 meetings of 2 days), - HAZOP (1 meeting of max 2 days), - 30% 3D, 60% 3D and 90% 3D meetings (each meeting of max 2 days) - Bi-weekly engineering conference (video or telephone)	
DCC and Documentation/certification as per Veolia standard	
MPPE Polymer first fill	Not included but part of the Performance Guarantee & Services Contract with End-user
Functional Test MPPE unit, incl software validation	Optional
Vendor assistance onshore and/or offshore, e.g. Pre-Commissioning, Commissioning, SAT and Ready For Start Up (RFSU)	Optional
Training for Company operations and maintenance personnel at Company Site or other nominated venue	Optional

7.2 Functional duration test with water prior to shipment

Once completed, the MPPE unit will be fully functional tested including automatic extraction regeneration cycles. Apart from testing all equipment, this functional testing makes it also possible to "debug" the automation program (possibly made by client based on narratives supplied by MPP Systems). The functional test can be executed in the presence of End user/Contractor after which the MPPE unit is then "Plug and Play" ready for delivery.

7.3 Spare parts for commissioning and Start up

Commissioning and start up spare parts based on a standard list and included.

7.4 Referenced Documents and Standards

No Technical specifications and requirements have been forwarded by the Client at this stage.
We have assumed "general" Oil & Gas specifications for budget estimate purposes.

7.5 Equipment supply

All Equipment will be mounted in and on a 20' Sea container. The attached typical PFD (Attachment 2) shows the main Equipment, Valves and Instrumentation. Attachment 1 shows a typical layout.

Item	MOC	#	Remark
EQUIPMENT			
Inlet Filter	Duplex	1	Atmospheric with lid
MPPE Columns	Duplex	2	FV-9 barg
Separator	Duplex	1	FV-9 barg
HC Pump	Duplex	-	Optional; assumed gravity flow from separator
Steam Generator	Duplex	1	electrical
Condenser	Duplex plates,	1	FV-9 barg, CS frame
Return Water Tank	Duplex	1	FV-9 barg *(not in No Return Tank option)*
Return Water Pump	Duplex	1	Magnetic Type *(not in No Return Tank option)*
PIPING			
Piping	Duplex	1	ASME
Insulation; certain part of piping + vessels	Mineral wool + alu cladding	1	CINI Guidelines
Overpressure safety on steam gen	Duplex	1	
Drains and vents		1	Connected to main header prior TP
Positive isolation by MV only		1	
Sample connections	Duplex	2	Feed Water, Effluent Water
STRUCTURAL			
Structural Steel	SS	1	steel base, support structures, platforms, stairs, ladders, walkways, handrails, pinned construction/ positioning
Grating	Galvanised CS	1	20mm ball proof (by Hilti assembly)
INSTRUMENTS			
Temperature transmitters		4	
Pressure transmitters		8	
Level transmitters		3	
Flow transmitters		2	
Control Valves		2	
Automated ON/OFF Valves		13	
Instrumentation tubing	SS316	incl.	
Manual Valves		34	
E&I cabling		incl.	Power & instrument cables segregated
Cable trays		incl.	
Cables supports		incl.	
Cables wired to junction boxes at package edge		incl.	
Earthing system	Cu-cable	incl.	
PROCESS CONTROL			
Software Control MPPE process		-	Base offer: control by Client control system. Optional PLC + HMI, incl software license
MARKING			
ATEX		incl.	
CE Marking		incl.	
Fluid tagging		incl.	As per Client spec
Name plates for E&I		incl.	As per Client spec
Name plates for equipment		incl.	As per Client spec
Name plates for Vessels		incl.	As per Client spec

7.6 Preferred suppliers

Item	Vendor
Mechanical	
Steel structure, vessels, piping, assembly	Yard in China, South East Asia, Middle East or Europe may be selected
Valves	
Automated Ball Valves	Pentair
Check valves	Pentair
Control Valves	Samson
Manual Valves	Eriks
Pumps	
Return Water Pump	Flowserve, Sulzer, Dickow
Hydrocarbon Transfer Pump	Axflow; SPX Flow, Dickow
Condensor	Alfa Laval, Tranter, Kelvion, ITM
Safety relief Valves	Tyco, Pentair
Instruments	Endress+Hauser or equivalent

8. MPPE Process : Characterstics & Proven Experience

8.1 MPPE Flexibility and Robustness

- High reduction factor.
- Reduction factor independent of inlet concentration.
- Robust against water environment (salt, methanol, glycols, corrosion inhibitors, scale inhibitors, H2S scavengers, demulsifiers, defoamers and dissolved (heavy) metals).
- Predictable performance.
- Flow/inlet concentration flexibility:
  - 10% lower flow than design: 50% higher inlet concentration possible.
  - lower inlet concentration: higher flow possible.
- Capacity flexibility: turn up / down ratio e.g. 0 to 150% of design capacity (depending on hydraulic constraints).
- Batch wise operation possible, immediate performance after start up.
- Separated hydrocarbons are practically 100% pure ready for (re)use.
- No waste stream, no air emission, low noise.
- 100% water and hydrocarbon recovery.

8.2 MPPE Experience, Reliability and Performance
(OIL & GAS, LNG, Chemical, Pharmaceutical, Coatings, Electronics Industry)

Introduction

The MPPE Technology is a relatively new Innovative Technology and therefore generally not described in text books and being taught at Schools and Universities. For potential new users, not familiar and experienced with this technology, it is often difficult to evaluate and predict the reliability, robustness, separation and operation performance. Therefore this summary has been prepared to get a quick impression. Further information/analyses can be received on request.

General Performance predictability and experience

MPPE is basically a liquid – liquid Extraction Technology where the extraction liquid is immobilized in an Macro Porous Polymer.
The MPPE separation performance for dissolved and dispersed hydrocarbons is independent of the influent concentration (law of physics) and therefore separation effectiveness is maintained at influent levels from ppb levels to thousands of ppm and higher.
The MPPE process is mathematically described, computer modeled and tested, so the performance predictability of any design is practically 100%.
All installed MPPE units (> 30) have reached their predicted performance.
Various business concepts (Design & Build, Operation and Maintenance or Design, Build, Finance and Maintenance) have been applied.

Gas / Condensate / LNG Produced water (BTEX, PAHs, Aliphatics)

- In Offshore Produced Water treatment of Gas/Condensate/LNG production a more than 50 years of accumulated experience (TOTAL, NAM (SHELL/EXXON), STATOIL) has been built up with good separation performance and operational experience.
- On 3 offshore platforms, MPPE units have been installed without prior testing and are operating successfully now since 2002 (99% removal of 600-900 ppm of dispersed and dissolved hydrocarbons, BTEX, PAHs, Aliphatics).
- The oldest MPPE unit (ELF/TOTAL/VERMILION in Harlingen) is operating successfully since 1994 on offshore produced water (gas/condensate) with a > 99.9% removal of 2,000 to 3,000 ppm dissolved and dispersed hydrocarbons.
- Environmental Impact Factor reductions of 95 to 99% (removal of toxic contents of produced water) were reported (HYDRO / STATOIL) for gas/condensate produced water.
- HYDRO/SHELL ORMEN LANGE Norway (NORSOK specifications) offshore gas/condensate field, aiming at zero harmful discharge (startup 2008).
- WOODSIDE PLUTO LNG Australia, (startup 2011).
- SHELL PRELUDE Australia, first Floating LNG (startup 2018).
- INPEX ICHTHYS LNG Australia, MPPE on FPSO (startup 2018)

Waste water (CHCs, BTEX, PAHs, Aliphatics, THT)
For waste water treatment a more than 45 years of accumulated experience has been built up in Europe and the USA (PHILIPS, DUPONT, TOTAL, ALBEMARLE, GAZ DE FRANCE, AKZO NOBEL) with removal at 99% levels or higher.
In five projects the MPPE units were installed without prior testing and have shown performances as predicted/designed.

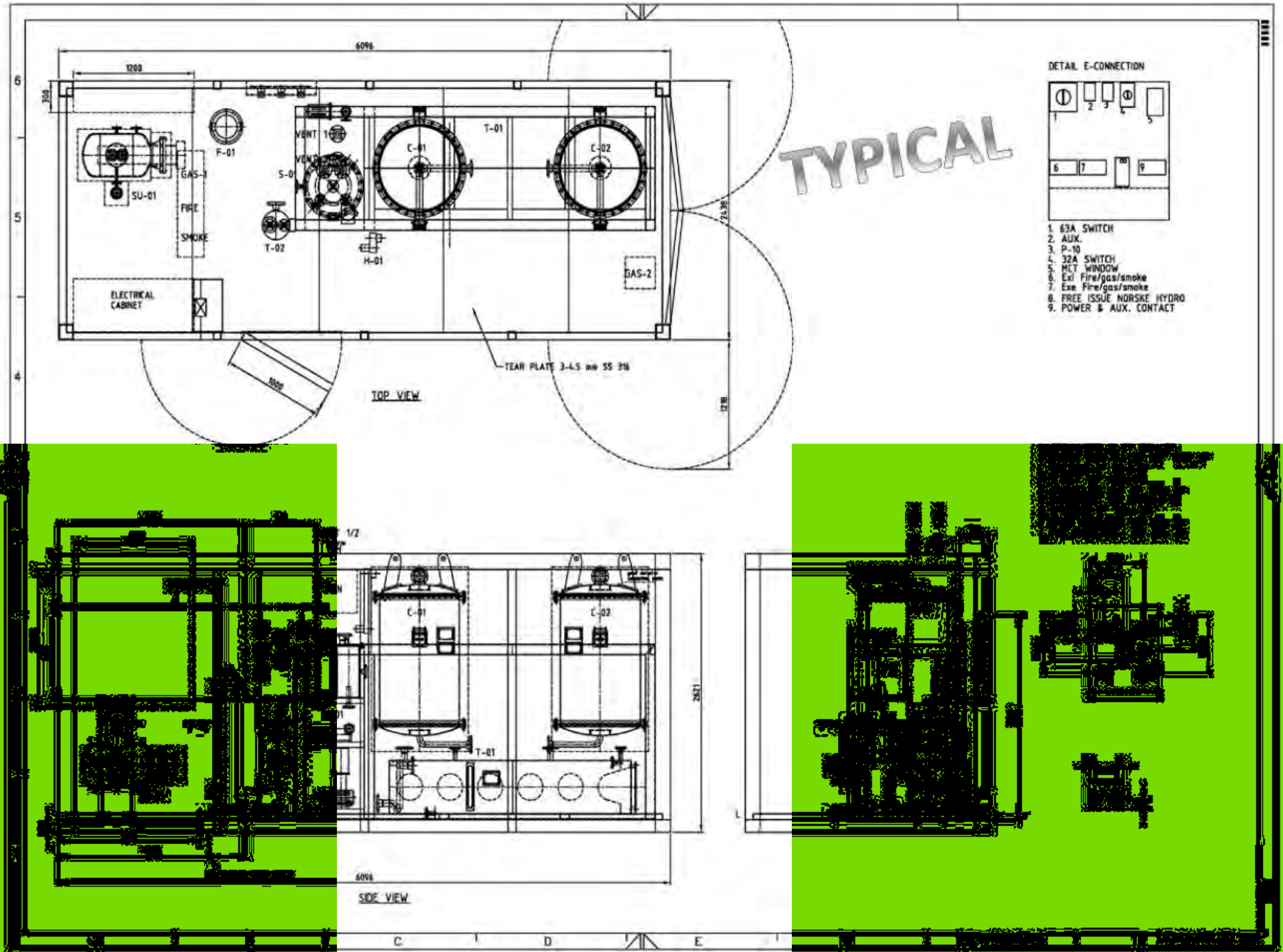
8.3 References

Unit	Flow rate m3/hr (6)	Composition (1)	Inlet mg/l (ppm)	Outlet mg/l (ppm)
The Netherlands				
Vermilion (Total) (Harlingen) Offshore Gas (3)	4-6	Al, Ar	2000-3000	< 0.5
Allied Signal, Weert	0.2	CFHC, CHC	5	< 0.010
Akzo Nobel Industrial Fibers, Arnhem	25	Solvesso	400	< 0.050
LBC Rotterdam bv; Groupe Fimalac	15/0.1	CHC, Ar	5/2000	≤ 0.1
Shell/Exxon (NAM B.V.), Offshore Gas Produced water, k15A	3-5	Al, Ar, PAH	Hundreds	> 90% removal
Shell/Exxon (NAM B.V.), Offshore Gas Produced water k15B	3-5	Al, Ar, PAH	Hundreds	> 90% removal
Total F15A Offshore Gas Produced water	3	Al, Ar, PAH	700-950	> 90% removal
Germany				
Philips Bildröhrenfabrik, Aachen	5	Ar	500	< 0.05
France				
Gaz de France	3	THT	75	< 0.5
Synthexim Calais (3)	6	Ar, CHC, COD	1400 – 11000	> 99.9% removal
Norway				
Statoil/Shell, Ormen Lange Offshore Gas Produced water (5)	68	Al, Ar, PAH	600-1300	>99% removal
Statoil Kollsnes Offshore Gas PW (5)	20	Al, Ar, PAH	240	>99% removal
Offshore Atlantic StatoilHydro Åsgard Å(2)	3	Ar, PAH	70-80	> 98% removal
Offshore Atlantic StatoilHydro Troll B (2)	9	Al, Ar, PAH	15-25	95-99% removal
United States of America				
Akzo Nobel Resins, Louisville	3	Ar	150	< 0.05
Akzo Nobel Resins, East St. Louis	3	Ar	150	< 0.05
Northeast Chemical Manufacturer	16	CHC	225	< 0.2
Total Fina Elf, Houston	3	Ar	150	< 0.05
Total Fina Elf, Milwaukee	3	Ar	150	< 0.05
Midwestern Chemical Manufacturer	10	Ar, CHC	300	< 0.03
Albemarle Tyrone	6	Ar, CHC	800	< 1
Western Refining	114	Al, Ar	200-260	<0.5
Rest of World				
Offshore South China Sea (2)	3	Al, Ar	200-500	> 99% removal
Woodside Pluto LNG Australia (5)	40	Al, Ar, PAH	Hundreds	> 99% removal
Shell Floating LNG Prelude, Australia (5)	140	Al,Ar, PAH	Hundreds	> 99% removal
Inpex Ichthys FPSO offshore, Australia (5)	180	Al,Ar,PAH	1150	> 99% removal

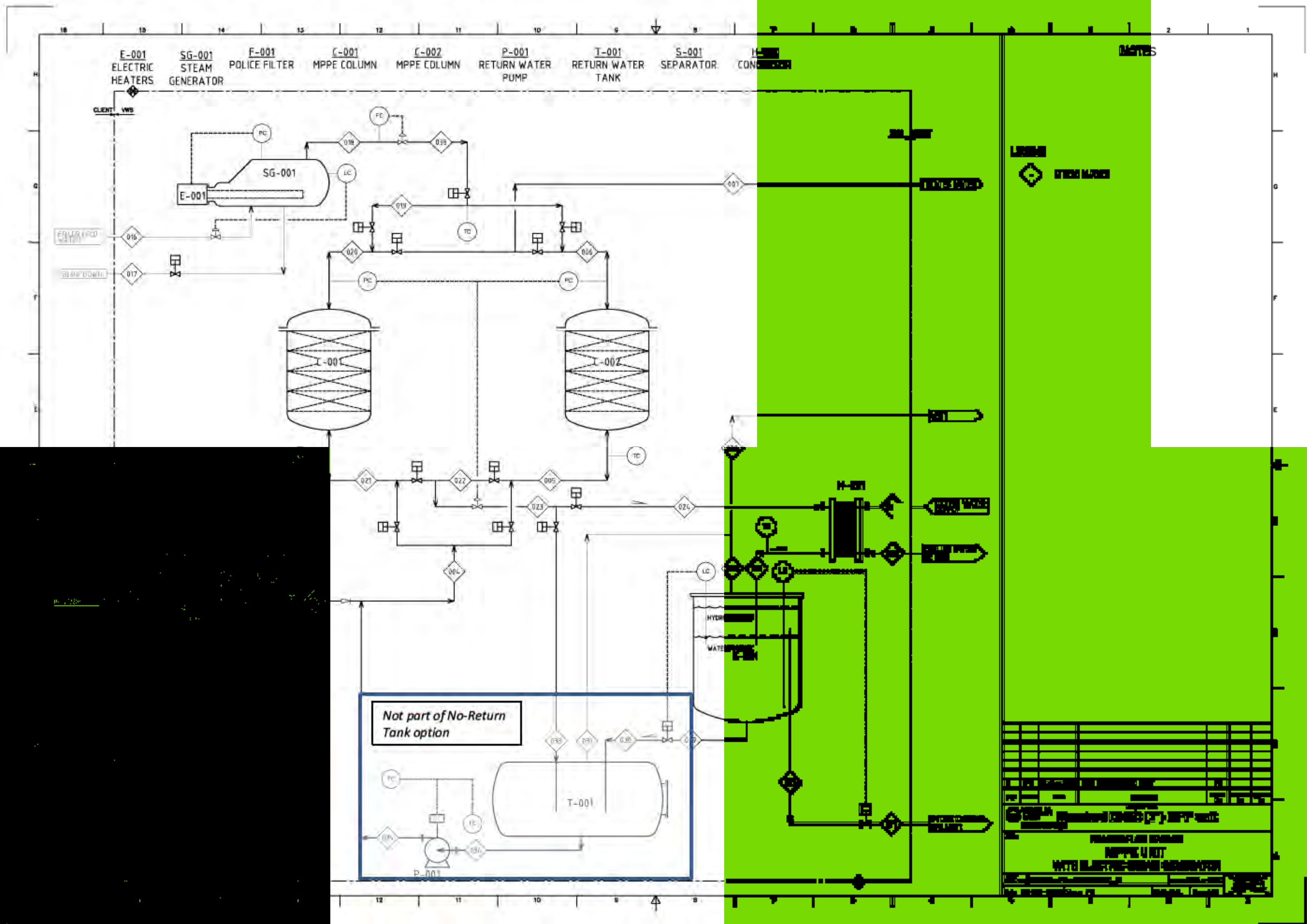
(1) AL: Aliphatics – Ar: Aromatics – PAH: PolyAromatic Hydrocarbons – CHC: Chlorinated Hydrocarbons
(2) Long duration test
(3) Combined groundwater and process water
(4) Combined with biotreatment
(5) MEG-Regen upstream
(6) 1m3/hr = 4.4 gpm

Attachment 1: Typical Container Lay-out

NOTES: *Model shown below is a typical 20"Sea container unit. Our current offering have higher columns that protrude through the container roof and are covered by a roof extension approx. 1 m height.*



Attachment 2: Typical PFD for Redundant Columns MPPE unit



Attachment 3: Case sheets

Veolia MPPE Technology TOTAL F 15A Offshore - NL

Offshore Gas Produced Water treatment- Unmanned Operation

Operational since 2002
- Robust against salt, surfactants, Corrosion inhibitors
- Fulfilling TOTAL's environmental goal beyond present legal requirements

Challenge
- Unmanned operation
- Remote control
- Practically no space on existing platform
- Dissolved/dispersed toxic content removal for Zero Harmful Discharge

The MPPE process

MPPE stands for Macro Porous Polymer Extraction. Polymer beads contain a specific immobilized extraction liquid. Hydrocarbon contaminated water is passed through a column packed with MPPE particles. The hydrocarbons are extracted from the water at any designed efficiency up to 99.999%. The MPPE particles can simply be regenerated by heating with steam. The removed hydrocarbons are recovered as an almost 100% pure product. No other waste stream is created. No chemicals requires, no off gasses produced.

Performance

MPPE removes:
- Dispersed oil (aliphatics) > 99%
- Dissolved and dispersed aromatics (BTEX) >99%
- Poly Aromatics (PAHs) >99.5%

MPPE Unit capacity 5 m3/h
- Built in container
- Hanging 50% outside platform
- Fully integrated including
  - steamboiler
  - water maker
- No waste stream

MPP & TiPSS Technologies
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www.mpptechnology.com & www.tipsstechnology.com

Veolia MPPE Technology NAM K15A Offshore - NL

Offshore Gas Produced Water treatment-

Operational since 2002
- Robust against salt, surfactants, Corrosion inhibitors
- Fulfilling NAM's environmental goal beyond present legal requirements

Challenge
- Remote control
- Practically no space on existing platform
- Dissolved/dispersed toxic content removal for Zero Harmful Discharge

The MPPE process

MPPE stands for Macro Porous Polymer Extraction. Polymer beads contain a specific immobilized extraction liquid. Hydrocarbon contaminated water is passed through a column packed with MPPE particles. The hydrocarbons are extracted from the water at any designed efficiency up to 99.999%. The MPPE particles can simply be regenerated by heating with steam. The removed hydrocarbons are recovered as an almost 100% pure product. No other waste stream is created. No chemicals requires, no off gasses produced.

Performance

MPPE removes:
- Dispersed oil (aliphatics) <30 ppm
- Dissolved and dispersed aromatics (BTEX) >90%
- Poly Aromatics (PAHs) >99%

MPPE Unit capacity 4.2 m3/h
- Built in container
- Placed on Top deck
- Including steam boiler
- No waste stream

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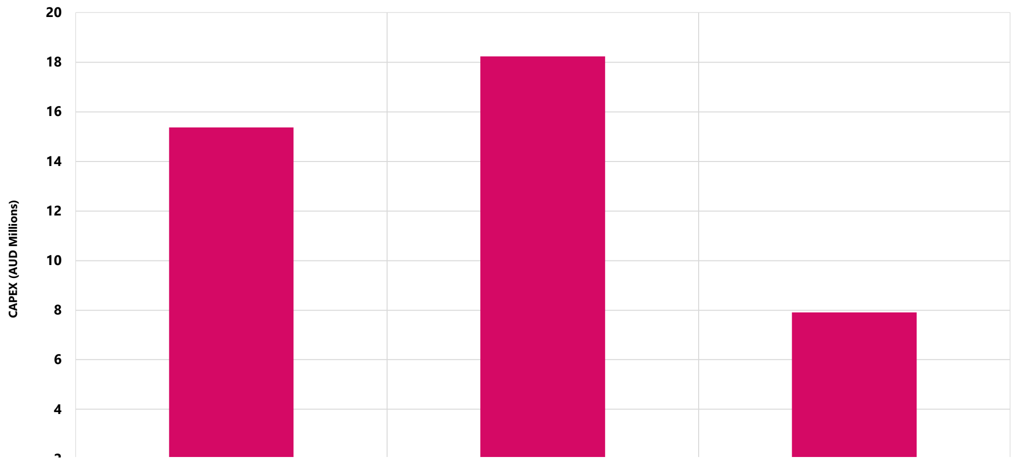
Appendix C
Cost Estimates

Client	Beach Energy		
Calc. No.	411010-00050		
Prepared	Antony Perri	Rev.	0
Checked	Richard George	Date:	11/12/19

Yolla Water Handling Upgrade
Cost Estimates Summary
Cost Summary

COST COMPONENT	DEVELOPMENT OPTIONS														
(All in AUD Millions unless indicated	MPPE	Steam Stripper	Gas Stripper	0	0	0	0	0	0	0	0	0	0	0	0
Offshore Facility															
Offshore Mobilisation	15.4	18.2	7.9												
TOTAL DEVELOPMENT COST (P50)	15	18	8												
P10 -30%	11	13	6												
P90 +40%	22	26	11												



Client	Beach Energy		
Calc. No.	411010-00050		
Prepared	Antony Perri	**Rev.**	0
Checked	Richard George	**Date:**	11/12/19

Yolla Water Handling Upgrade
Cost Estimates Summary
Building Blocks Summary

COST COMPONENT (All in AUD Millions unless indicated otherwise)	METRIC				MOB. / DEMOB.	PROCUREMENT		CONSTRUCTION				ALLOWANCES					CONT.	TOTAL				
						Equip.	Bulks	Fab.	Load-Out & Trans.	Install.	Hook-Up & Comm.	Eng.	PM	Freight	Spares	Ins. & Cert.			MPPE	Steam Stripper	Gas Stripper	
Offshore Mobilisation	**Inst. Dur. (days)**	**Len (km)**	**Dia. (in)**	**$k/in/km**																		
MPPE Macro Porous Polymer Extraction					0.54	1.92	0.14	0.47	0.11	4.10	0.13	1.16	1.45	0.16	0.09	0.27	4.84	15.36	15.4			
Steam Stripper					0.54	2.43	0.23	0.82	0.12	4.53	0.24	1.33	1.66	0.21	0.12	0.32	5.69	18.23		18.2		
Gas Stripper					0.54	0.19	0.03	0.14	0.10	2.61	0.03	0.68	0.85	0.01	0.01	0.14	2.57	7.91			7.9	
																		Subtotal	**15.4**	**18.2**	**7.9**	
																		Subtotal				

TOTAL DEVELOPMENT COST (P50)	**15**	**18**	**8**	
P10 - 30%	11	13	6	
P90 + 40%	22	26	11	

Client	Beach Energy		
Calc. No.	411010-00050		
Prepared	Antony Perri	**Rev.**	0
Checked	Richard George	**Date:**	11/12/19

Yolla Water Handling Upgrade

Offshore Facility

MPPE Macro Porous Polymer Extraction

Offshore Facility Parameters

Type	Water Handling	Pre-Fabrication Location	VIC	Installation by	Heavy Lift Vessel
Capacity		Site Location	VIC	Method	Lift Installed

Topsides - Equipment / Bulks and Installation

Equipment Description	Structure Type	Piping Material	Number	Sizing Parameter	Unit	$/Unit	$/Item	t/Item	$	t	Equip. Type	Electrical		Instrument		Piping		Structural	
												Factor	Weight	Factor	Weight	Factor	Weight	Factor	Weight
Water Treatment System																			
New MPPE Package	Modules, topsides	CS	1	1,000,000	Euro	1.62	1,620,000	12.0	1,620,000	12.0	Skids	0.03	0.4	0.06	0.7	0.15	1.8	0.00	0.0
Hydrocarbon Return Pump	Modules, topsides	CS	1	2	m3/d		25,000	1.0	25,000	0.2	Pumps	0.14	0.0	0.44	0.1	1.50	0.3	0.00	0.0
Demin water tank	Modules, topsides	CS	1	2	m3		30,000	1.0	30,000	1.0	Tanks/Storage	0.05	0.1	0.05	0.1	0.70	0.7	1.15	2.1
Demin water package / Ion Exchange	Modules, topsides	CS	1	2	m3/d		150,000	1.5	150,000	1.5	Skids	0.03	0.0	0.06	0.1	0.15	0.2	1.15	2.1
Demin water pump	Modules, topsides	CS	1	2	m3/d		25,000	1.0	25,000	1.0	Pumps	0.14	0.1	0.44	0.4	1.50	1.5	1.15	3.5
Bulks Procurement & Fabrication																			
Structure	Modules, topsides				t														0.0
Installation aids	Modules, topsides				t														0.0
Rigging	Modules, topsides				t														0.0
CS pipe	Modules, topsides	CS			t												0.0		
CRA Pipe	Modules, topsides	SS			t												0.0		
					t														
Building	Modules, topsides	CS	1																
Subtotals									**1,850,000**	**16**			**1**		**1**		**5**		**8**

Summary Description	Unit	Equipment	Elec.	Inst.	Piping			Structure	Bulks Subtotals	equip + bulks
					CS	CRA	CS/CRA			
Unit cost	$/t	117,834	25,000	40,000	12,000	18,000	25,000	1,500		
Productivity	hrs/t	25	600	600	300	400	450	120		
% spent in Fabyard	Factor	100%	100%	100%	100%	100%	100%	100%		
Productivity Factor	Factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
Labour rate	$/hr	120	120	120	120	120	120	120		
Hours to install	**hrs**	**393**	**374**	**833**	**1,358**	**0**	**0**	**930**	**3,494**	**3,887**
Weight	**t**	**16**	**1**	**1**	**5**	**0**	**0**	**8**	**14**	**30**
Procurement	**$**	**1,850,000**	**15,575**	**55,520**	**54,300**	**0**	**0**	**11,627**	**137,022**	**1,987,022**
Installation	**$**	**47,100**	**44,856**	**99,936**	**162,900**	**0**	**0**	**111,614**	**419,306**	**466,406**

Miscellaneous	Weight (t)	Length (m)	Breadth (m)	Area.	Unit	$/Unit	$
					m2	10,000	
					m2	10,000	
Subtotal Miscellaneous	**0**						**0**

Seafastening & Load-Out	Factor	Unit	Weight	Unit	$/Unit	$
Total Topside Weight			30	t		
Seafastening Materials (as % of Total Topside Weight)	5.0%	-	1	t	1,800	2,699
Seafastening Fabrication	120	hrs/t	1	t	35	6,297
Load-Out on vessel			1	each	25,000	25,000
Subtotal Seafastening & Load-Out						**33,996**

Transportation	Distance (nm	peed (knots	Duration	Unit	$/Unit	$
Standby at wharf			0.25	days	35,000	8,750
Transport to site	200	10	0.8	days	35,000	29,167
standby at site			0.25	days	35,000	8,750
Return to fab yard	200	10	0.8	days	35,000	29,167
Fuel			35	days	0	
Subtotal Transportation						**75,833**

Installation		Duration	Unit	$/Unit	$
Set up at site			days	300,000	
Lift skid 1			days	300,000	
Lift skid 2			days	300,000	
Total Duration		0.0	days		
Equipment & weather downtime	25%	0.0	days	300,000	
Subtotal Installation					**0**

Hook-Up and Commissioning	Qty.	Unit	Factor	Unit	Duration	Unit	$/Unit	$
Total Topside Weight	30	t						
Hook up				hrs/t	0	hours	280	
Pre-Commissioning			10	hrs/t	300	hours	420	125,945
Hook up Barge	8	crew	12	hrs/day		days	150,000	
Total Duration					0.0	days		
Equipment & weather downtime				25%	0.0	days	150,000	
Subtotal Hook-Up and Commissioning								**125,945**

Advisian

Client	Beach Energy		
Calc. No.	411010-00050		
Prepared	Antony Perri	Rev.	0
Checked	Richard George	Date:	11/12/19

Yolla Water Handling Upgrade

Offshore Facility

MPPE Macro Porous Polymer Extraction

Standard Rates for Offshore Work				
Labours				
	Offshore Labour	280	$/hr	inclusive of tools, consumables, accommodation, food and helicopter transfers
	Hours per day	12	hrs	
Productivity Factors				
	Works in protected location	80.0%	effective % of time	
	Field work on platform	60.0%	effective % of time	
	Field work in exposed location, shutdown work	50.0%	effective % of time	

Mobilisation Crew and Equipment	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Mobilise/demob crew to platform, training, induction etc.	16	crew	3	100.0%	576	280	161,280	
Clear deck/work area	8	crew	3	60.0%	480	280	134,400	
Install workshop/stores/office	8	crew	4	60.0%	640	280	179,200	
Tie in power/comms to temporary buildings	3	crew	4	60.0%	240	280	67,200	
Subtotal Mobilisation Crew and Equipment					**1,936**		**542,080**	

Hire Equipment	Qty.	Unit	Duration	Unit	$/week	$	Comment(s) / Remark(s)
Office/stores containers	1	each	26	weeks	200	5,200	
Mobile workshop	1	each	26	weeks	1,000	26,000	
Scrap/transport Containers	4	each	26	weeks	100	10,400	
Scaffolding	200	m2	26	weeks	5	26,000	
Accommodation vessel			0	days	150,000		Flotel if required for additional POB
Additional escape craft							If required for additional POB
Subtotal Hire Equipment						**67,600**	

Scaffold, Rigging and Construction Aids	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Scaffold deck area	5	crew	10	60.0%	1,000	280	280,000	
Demolish scaffolding	5	crew	5	60.0%	500	280	140,000	
		crew	2	60.0%		280		
		crew	1	60.0%		280		
		crew	3	60.0%		280		
Subtotal Scaffold, Rigging and Construction Aids					**1,500**		**420,000**	

Crane Upgrade		Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Service existing crane		3	people	2	60.0%	120	280	**33,600**	Service existing crane
Spares		1	lot				10,000	**10,000**	
Temporary Crane	Install temporary crane		people		60.0%		280		
	hire temporary crane		weeks				10,000		
	remove temporary crane		people		60.0%		280		
	Subtotal							**0**	
Upgrade existing crane	Purchase crane upgrade equipment		each				10,000		
	Crane upgrade construction	10	people		60.0%		280		
	Subtotal							**0**	
Subtotal Crane Upgrade						**120**		**43,600**	

Demolition	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Isolate existing water equipment	8	crew	1	60.0%	160	280	44,800	
Remove existing water handling equipment	8	crew	3	60.0%	480	280	134,400	
Remove redundant piping	8	crew	5	60.0%	800	280	224,000	
Remove filters	8	crew	2	60.0%	320	280	89,600	
Clear structure	8	crew	1	60.0%	160	280	44,800	
Paint touch up	3	crew	2	60.0%	120	280	33,600	
Subtotal Demolition					**2,040**		**571,200**	

Building and HVAC	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
		crew		60.0%		280		
		crew		60.0%		280		
		crew		60.0%		280		
		crew		60.0%		280		
Subtotal Building and HVAC					**0**		**0**	

Equipment Installation	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Lift in MPPE Container	8	crew	1	60.0%	160	280	44,800	
Rig in Demin water unit	5	crew	4	60.0%	400	280	112,000	
Lift in demin water tank	8	crew	1	60.0%	160	280	44,800	
		crew		60.0%		280		
		crew		60.0%		280		
Subtotal Equipment Installation					**720**		**201,600**	

Structure	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Secure MPPE skid	5	crew	3	60.0%	300	280	84,000	
Secure demin water tank	5	crew	2	60.0%	200	280	56,000	
Secure and install supports for demin water maker	5	crew	2	60.0%	200	280	56,000	
		crew		60.0%		280		
		crew		60.0%		280		
Paint touch up	3	crew	2	60.0%	120	280	33,600	
NDT for structural work	2	crew	1	80.0%	30	280	8,400	
Subtotal Structure					**850**		**238,000**	

Piping	dia	length	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Piping tie in #1 Produced water inlet	3	5	5	crew	1	50.0%	120	280	33,600	Shut down required
Piping tie in #2 to Produced water to dump caisson	3	5	5	crew	1	50.0%	120	280	33,600	Shut down required
Piping tie in #3 to flare header	2	20	5	crew	3	50.0%	360	280	100,800	Shut down required
Piping tie in #4 to liquids to flare drum	2	20	5	crew	3	50.0%	360	280	100,800	
Piping tie in #5 to drains	2	20	5	crew	3	50.0%	360	280	100,800	
Piping tie in # 6 RO unit to demin water maker	1	80	5	crew	7	50.0%	840	280	235,200	
Piping Run from demin maker to tank	1	5	3	crew	1	50.0%	72	280	20,160	
Piping run from demin tank to demin pump	1	2	1	crew	1	50.0%	24	280	6,720	
Piping tie in # 7 Demin water tank to MPPE	1	5	3	crew	1	50.0%	72	280	20,160	
Leak test piping systems			3	crew	2	60.0%	120	280	33,600	
Paint touch up			3	crew	3	60.0%	180	280	50,400	
Subtotal Piping							**2,628**		**735,840**	

Electrical	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Power supply to demin water skid	3	crew	7	50.0%	504	280	141,120	Local shut down required
Power supply to MPPE	3	crew	7	80.0%	315	280	88,200	
MCC mods in SG room	3	crew	4	60.0%	240	280	67,200	
Testing and precommissioning	3	crew	3	60.0%	180	280	50,400	
Subtotal Electrical					**1,239**		**346,920**	

Advisian

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Yolla Water Handling Upgrade

Offshore Facility

MPPE Macro Porous Polymer Extraction

Instrumentation	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Run cables from Ins room to local panel	150	m	0.10	60.0%	300	280	84,000	allow approx. 1 hr per m
Install field instruments & cable	40	instruments	1.00	60.0%	800	280	224,000	allow 12 hrs per instrument
Install tubing, chem injection	0	m	0.16	60.0%		280		allow 2 hrs per m
Instrument hook up to skid	40	instruments	0.25	60.0%	200	280	56,000	allow 3 hrs per instrument
Testing and precomm 100 loop checks	80	loops	0.10	60.0%	160	280	44,800	Allow 1 hour per loop
Testing and precomm new to existing system	3	crew	2	60.0%	120	280	33,600	
Install Fire and Gas detectors	1	instruments	1	60.0%	20	280	5,600	allow 1 day per instrument
Subtotal Instrumentation					**1,600**		**448,000**	

Safety and Risk	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
New manual alarm		no		60.0%		280		
Fire fighting, portable extinguishers	3	no	0	60.0%	6	280	1,680	
Fire fighting, fixed hose reel		no		60.0%		280		
safety shower		no		60.0%		280		
Comms PA station		no		60.0%		280		
Subtotal Safety and Risk					**6**		**1,680**	

Support Vessels / Helicopters	#Trip/Week	Time/Trip	Unit	Weeks	hrs	$/hr	$	Comment(s) / Remark(s)
Helicopter additional flights, urgent freight etc.	1	2	hrs	21	42	3,500	147,455	
Supply boat for equipment	1	1	days	21	21	45,000	947,925	
Subtotal Support Vessels / Helicopters							**1,095,380**	

Summaries

Fabrication Costs Summary			
Direct Procurement & Fabrication Costs			
Equipment Procurement		1,850,000	
Bulks Procurement		137,022	
Equipment Installation		47,100	
Bulks Fabrication		419,306	
Miscellaneous		0	
Subtotal Direct Costs		**2,453,428**	
Installation Costs Summary			
Direct Transport & Installation Costs			
Seafastening & Load-Out		33,996	
Transportation		75,833	
Installation		0	
Hook-Up and Commissioning		125,945	
Subtotal Direct Costs		**235,775**	
Allowances			***Applied to:***
Freight	8.0%	158,962	*Equipment & Bulks Procurement*
Spares	5.0%	92,500	*Equipment Procurement*
Insurance	2.5%	67,230	*Subtotal Direct Costs*
Certification	0.5%	12,897	*Subtotal Direct Costs*
Engineering	8.0%	215,136	*Subtotal Direct Costs*
Contractors Project Management	10.0%	268,920	*Subtotal Direct Costs*
Design Growth	10.0%	245,343	*Subtotal Procurement & Fabrication Costs*
Subtotal Allowances		**1,060,988**	
Fabrication Cost		**3,750,191**	
Contingency	30.0%	**1,125,057**	
Total Fabrication Cost		**4,875,248**	

Tie-In Costs Summary			hours	$
Direct Costs			**hours**	**$**
Mobilisation Crew and Equipment			1,936	542,080
Hire Equipment			0	67,600
Scaffold, Rigging and Construction Aids			1,500	420,000
Crane Upgrade			120	43,600
Demolition			2,040	571,200
Building and HVAC			0	0
Equipment Installation			720	201,600
Structure			850	238,000
Piping			2,628	735,840
Electrical			1,239	346,920
Instrumentation			1,600	448,000
Safety and Risk			6	1,680
Support Vessels / Helicopters			0	1,095,380
Notes:				
- Crew Size	*10*			
- uration (no contingency)	*105*	*days*		
- Duration (with contingency)	*21*	*weeks*		
Subtotal Direct Costs			**12,639**	**4,711,900**
Allowances				
Insurance			3.0%	141,357
Certification			1.0%	47,119
Engineering			20.0%	942,380
Project Management			25.0%	1,177,975
Design Growth			10.0%	471,190
Subtotal Allowances				**2,780,021**
Contingency			40.0%	**2,996,768**
Total Tie-In Cost				**10,488,689**

Overall Summary		
Direct Costs		
Mobilisation / Demobilisation		542,080
Equipment Procurement		1,917,600
Bulks Procurement		137,022
Fabrication		466,406
Load-Out & Transport		109,829
Installation		4,102,220
Hook-Up & Commissioning		125,945
Subtotal Direct Costs		**7,401,103**
Allowances		
Engineering		1,157,516
Project Management		1,446,895
Freight		158,962
Spares		92,500
Insurace & Certification		268,603
Subtotal Allowances		**3,124,476**
Contingency		**4,838,358**
Total Cost		**15,363,937**
Lower Bound P10-	30.0%	10,754,756
Upper Bound P90+	40.0%	21,509,512
Owners Cost	0.0%	**0**

Weights Summary

	equip	I&E	Pipe	Struct	uildings/mis	Total
Raw weight	16	2	5	8	0	30
Factored	19	2	5	9	0	36
%	52%	7%	15%	26%	0%	100%
Weight growth factor	20.0%					

Hours Summary Fabrication

	equip	I&E	Pipe	Struct		Total	Crew size	Hours/week	Duration
Hours	393	1,207	1,358	930		3,887			
Factored	393	1,207	1,358	930		3,887	60	60	1
%	10%	31%	35%	24%	0%	100%			
Growth factor	25.0%								

Hours Summary Offshore

	Prelims	Demolition	Buildings	equip	I&E	Pipe	Struct	HUC	Total	Crew size	Hours/week	Duration
Hours	3,556	2,040	0	720	2,839	2,628	850	300	7,337			
Factored	4,445	2,550	0	900	3,549	3,285	1,063	375	9,171	30	84	4
%	48%	28%	0%	10%	39%	36%	12%	4%	100%			
Growth factor	25.0%											

Advisian

Client	Beach Energy		
Calc. No.	411010-00050		
Prepared	Antony Perri	Rev.	0
Checked	Richard George	Date:	11/12/19

Yolla Water Handling Upgrade

Offshore Facility

Steam Stripper

Offshore Facility Parameters

Type	Water Handling	Pre-Fabrication Location	VIC	Installation by	Heavy Lift Vessel
Capacity		Site Location	VIC	Method	Lift Installed

Topsides - Equipment / Bulks and Installation

Equipment Description	Structure Type	Piping Material	Number	Sizing Parameter	Unit	$/Unit	$/Item	t/Item	$	t	Equip. Type	Electrical Factor	Electrical Weight	Instrument Factor	Instrument Weight	Piping Factor	Piping Weight	Structural Factor	Structural Weight
Water Treatment System																			
Steam Stripper Package	Modules, topsides	CS	1	1,200,000	Euro	1.62	1,944,000	23.0	1,944,000	23.0	Skids	0.03	0.7	0.06	1.4	0.15	3.5	0.00	0.0
Hydrocarbon Return Pump	Modules, topsides	CS	1	2	m3/d		25,000	0.5	25,000	0.2	Pumps	0.14	0.0	0.44	0.1	1.50	0.3	0.00	0.0
Demin water tank	Modules, topsides	CS	1	12	m3		60,000	2.0	60,000	2.0	Tanks/Storage	0.05	0.1	0.05	0.1	0.70	1.4	1.15	4.1
New Demin water skid	Modules, topsides	CS	1	12	m3/d		300,000	5.0	300,000	5.0	Skids	0.03	0.2	0.06	0.3	0.15	0.8	1.15	7.1
Demin water pump	Modules, topsides	CS	1	12	m3/d		30,000	1.0	30,000	1.0	Pumps	0.14	0.1	0.44	0.4	1.50	1.5	1.15	3.5
Bulks Procurement & Fabrication																			
Structure	Modules, topsides				t														0.0
Installation aids	Modules, topsides				t														0.0
Rigging	Modules, topsides				t														0.0
CS pipe	Modules, topsides	CS			t												0.0		
CRA Pipe	Modules, topsides	SS			t												0.0		
					t														
Building	Modules, topsides	CS	1																
Subtotals									**2,359,000**	**31**			**1**		**2**		**7**		**15**

Summary Description	Unit	Equipment	Elec.	Inst.	Piping CS	Piping CRA	Piping CS/CRA	Structure	Bulks Subtotals	equip + bulks
Unit cost	$/t	75,609	25,000	40,000	12,000	18,000	25,000	1,500		
Productivity	hrs/t	25	600	600	300	400	450	120		
% spent in Fabyard	Factor	100%	100%	100%	100%	100%	100%	100%		
Productivity Factor	Factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
Labour rate	$/hr	120	120	120	120	120	120	120		
Hours to install	**hrs**	**780**	**665**	**1,385**	**2,220**	**0**	**0**	**1,777**	**6,047**	**6,827**
Weight	**t**	**31**	**1**	**2**	**7**	**0**	**0**	**15**	**26**	**57**
Procurement	**$**	**2,359,000**	**27,700**	**92,320**	**88,800**	**0**	**0**	**22,218**	**231,038**	**2,590,038**
Installation	**$**	**93,600**	**79,776**	**166,176**	**266,400**	**0**	**0**	**213,293**	**725,645**	**819,245**

Miscellaneous	Weight (t)	Length (m)	Breadth (m)	Area.	Unit	$/Unit	$
					m2	10,000	
					m2	10,000	
Subtotal Miscellaneous	**0**						**0**

Seafastening & Load-Out	Factor	Unit	Weight	Unit	$/Unit	$
Total Topside Weight			57	t		
Seafastening Materials (as % of Total Topside Weight)	5.0%	-	3	t	1,800	5,115
Seafastening Fabrication	120	hrs/t	3	t	35	11,934
Load-Out on vessel			1	each	25,000	25,000
Subtotal Seafastening & Load-Out						**42,048**

Transportation	Distance (nm	peed (knots	Duration	Unit	$/Unit	$
Standby at wharf			0.25	days	35,000	8,750
Transport to site	200	10	0.8	days	35,000	29,167
standby at site			0.25	days	35,000	8,750
Return to fab yard	200	10	0.8	days	35,000	29,167
Fuel			35	days	0	
Subtotal Transportation						**75,833**

Installation		Duration	Unit	$/Unit	$
Set up at site			days	300,000	
Lift skid 1			days	300,000	
Lift skid 2			days	300,000	
Total Duration		0.0	days		
Equipment & weather downtime	25%	0.0	days	300,000	
Subtotal Installation					**0**

Hook-Up and Commissioning	Qty.	Unit	Factor	Unit	Duration	Unit	$/Unit	$
Total Topside Weight	57	t						
Hook up				hrs/t	0	hours	280	
Pre-Commissioning			10	hrs/t	568	hours	420	238,678
Hook up Barge	8	crew	12	hrs/day		days	150,000	
Total Duration					0.0	days		
Equipment & weather downtime				25%	0.0	days	150,000	
Subtotal Hook-Up and Commissioning								**238,678**

Client	Beach Energy			
Calc. No.	411010-00050			
Prepared	Antony Perri	**Rev.**	0	
Checked	Richard George	**Date:**	11/12/19	

Yolla Water Handling Upgrade
Offshore Facility
Steam Stripper

Standard Rates for Offshore Work			
Labours			
	Offshore Labour	280 $/hr	inclusive of tools, consumables, accommodation, food and helicopter transfers
	Hours per day	12 hrs	
Productivity Factors			
	Works in protected location	80.0% effective % of time	
	Field work on platform	60.0% effective % of time	
	Field work in exposed location, shutdown work	50.0% effective % of time	

Mobilisation Crew and Equipment	**Qty.**	**Unit**	**days**	**Productivity**	**hrs**	**$/hr**	**$**	**Comment(s) / Remark(s)**
Mobilise/demob crew to platform, training, induction etc.	16	crew	3	100.0%	576	280	161,280	
Clear deck/work area	8	crew	3	60.0%	480	280	134,400	
Install workshop/stores/office	8	crew	4	60.0%	640	280	179,200	
Tie in power/comms to temporary buildings	3	crew	4	60.0%	240	280	67,200	
Subtotal Mobilisation Crew and Equipment					**1,936**		**542,080**	

Hire Equipment	**Qty.**	**Unit**	**Duration**	**Unit**	**$/week**	**$**	**Comment(s) / Remark(s)**
Office/stores containers	1	each	26	weeks	200	5,200	
Mobile workshop	1	each	26	weeks	1,000	26,000	
Scrap/transport Containers	4	each	26	weeks	100	10,400	
Scaffolding	200	m2	26	weeks	5	26,000	
Accommodation vessel			0	days	150,000		Flotel if required for additional POB
Additional escape craft							If required for additional POB
Subtotal Hire Equipment						**67,600**	

Scaffold, Rigging and Construction Aids	**Qty.**	**Unit**	**days**	**Productivity**	**hrs**	**$/hr**	**$**	**Comment(s) / Remark(s)**
Scaffold deck area	5	crew	10	60.0%	1,000	280	280,000	
Demolish scaffolding	5	crew	5	60.0%	500	280	140,000	
		crew	2	60.0%		280		
		crew	1	60.0%		280		
		crew	3	60.0%		280		
Subtotal Scaffold, Rigging and Construction Aids					**1,500**		**420,000**	

Crane Upgrade		**Qty.**	**Unit**	**days**	**Productivity**	**hrs**	**$/hr**	**$**	**Comment(s) / Remark(s)**
Service existing crane		3	people	2	60.0%	120	280	**33,600**	Service existing crane
Spares		1	lot				10,000	**10,000**	
Temporary Crane	Install temporary crane		people		60.0%		280		
	hire temporary crane		weeks				10,000		
	remove temporary crane		people		60.0%		280		
	Subtotal							**0**	
Upgrade existing crane	Purchase crane upgrade equipment		each				10,000		
	Crane upgrade construction	10	people		60.0%		280		
	Subtotal							**0**	
Subtotal Crane Upgrade						**120**		**43,600**	

Demolition	**Qty.**	**Unit**	**days**	**Productivity**	**hrs**	**$/hr**	**$**	**Comment(s) / Remark(s)**
Isolate existing water equipment	8	crew	1	60.0%	160	280	44,800	
Remove existing water handling equipment	8	crew	3	60.0%	480	280	134,400	
Remove redundant piping	8	crew	5	60.0%	800	280	224,000	
Remove filters	8	crew	2	60.0%	320	280	89,600	
Clear structure	8	crew	1	60.0%	160	280	44,800	
Paint touch up	3	crew	2	60.0%	120	280	33,600	
Subtotal Demolition					**2,040**		**571,200**	

Building and HVAC	**Qty.**	**Unit**	**days**	**Productivity**	**hrs**	**$/hr**	**$**	**Comment(s) / Remark(s)**
		crew		60.0%		280		
		crew		60.0%		280		
		crew		60.0%		280		
		crew		60.0%		280		
Subtotal Building and HVAC					**0**		**0**	

Equipment Installation	**Qty.**	**Unit**	**days**	**Productivity**	**hrs**	**$/hr**	**$**	**Comment(s) / Remark(s)**
Lift in Steam stripper	8	crew	2	60.0%	320	280	89,600	
Rig in Demin water unit	5	crew	6	60.0%	600	280	168,000	
Lift in demin water tank	8	crew	1	60.0%	160	280	44,800	
Install pump	5	crew	3	60.0%	300	280	84,000	
		crew		60.0%		280		
Subtotal Equipment Installation					**1,380**		**386,400**	

Structure	**Qty.**	**Unit**	**days**	**Productivity**	**hrs**	**$/hr**	**$**	**Comment(s) / Remark(s)**
Secure steam stripper skid	5	crew	3	60.0%	300	280	84,000	
Secure demin water tank	5	crew	2	60.0%	200	280	56,000	
Secure and install supports for demin water maker	5	crew	3	60.0%	300	280	84,000	
		crew		60.0%		280		
		crew		60.0%		280		
Paint touch up	3	crew	2	60.0%	120	280	33,600	
NDT for structural work	2	crew	1	80.0%	30	280	8,400	
Subtotal Structure					**950**		**266,000**	

Advisian

Client	Beach Energy
Calc. No.	411010-00050
Prepared	Antony Perri
Rev.	0
Checked	Richard George
Date:	11/12/19

Yolla Water Handling Upgrade

Offshore Facility

Steam Stripper

Piping	dia	length	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Piping tie in #1 Produced water inlet	3	5	5	crew	1	50.0%	120	280	33,600	Shut down required
Piping tie in #2 to Produced water to dump caisson	3	5	5	crew	1	50.0%	120	280	33,600	Shut down required
Piping tie in #3 to flare header	3	20	5	crew	3	50.0%	360	280	100,800	Shut down required
Piping tie in #4 to liquids to flare drum	2	20	5	crew	3	50.0%	360	280	100,800	
Piping tie in #5 to drains	2	20	5	crew	3	50.0%	360	280	100,800	
Piping tie in # 6 to demin water maker	1	80	5	crew	7	50.0%	840	280	235,200	
Piping Run from demin maker to tank	1	5	3	crew	1	50.0%	72	280	20,160	
Piping tie in # 7 Demin water tank to steam stripper	1	5	3	crew	1	50.0%	72	280	20,160	
Piping tie in # 8 Fuel gas supply	2	30	5	crew	4	50.0%	480	280	134,400	
Piping to pump	1	20	3	crew	2	50.0%	144	280	40,320	
Leak test piping systems			3	crew	2	60.0%	120	280	33,600	
Paint touch up			3	crew	3	60.0%	180	280	50,400	
Subtotal Piping							**3,228**		**903,840**	

Electrical	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Power supply to demin water skid	3	crew	7	50.0%	504	280	141,120	Local shut down required
Power supply to steam stripper	3	crew	7	80.0%	315	280	88,200	
Power supply to pump	3	crew	4	80.0%	180	280	50,400	
MCC mods in SG room	3	crew	5	60.0%	300	280	84,000	
Testing and precommissioning	3	crew	3	60.0%	180	280	50,400	
Subtotal Electrical					**1,479**		**414,120**	

Instrumentation	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Run cables from Ins room to local panel	150	m	0.10	60.0%	300	280	84,000	allow approx. 1 hr per m
Install field instruments & cable	25	instruments	1	60.0%	500	280	140,000	allow 12 hrs per instrument
Install tubing, chem injection	0	m	0.16	60.0%		280		allow 2 hrs per m
Instrument hook up to skid	25	instruments	0.25	60.0%	125	280	35,000	allow 3 hrs per instrument
Testing and precomm 100 loop checks	50	loops	0.10	60.0%	100	280	28,000	Allow 1 hour per loop
Testing and precomm new to existing system	3	crew	2	60.0%	120	280	33,600	
Install Fire and Gas detectors	1	instruments	1	60.0%	20	280	5,600	allow 1 day per instrument
Subtotal Instrumentation					**1,165**		**326,200**	

Safety and Risk	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
New manual alarm		no		60.0%		280		
Fire fighting, portable extinguishers	3	no	0	60.0%	6	280	1,680	
Fire fighting, fixed hose reel		no		60.0%		280		
safety shower		no		60.0%		280		
Comms PA station		no		60.0%		280		
Subtotal Safety and Risk					**6**		**1,680**	

Support Vessels / Helicopters	#Trip/Week	Time/Trip	Unit	Weeks	hrs	$/hr	$	Comment(s) / Remark(s)
Helicopter additional flights, urgent freight etc.	1	2	hrs	23	46	3,500	161,047	
Supply boat for equipment	1	1	days	23	23	45,000	1,035,300	
Subtotal Support Vessels / Helicopters							**1,196,347**	

Summaries

Fabrication Costs Summary			
Direct Procurement & Fabrication Costs			
Equipment Procurement		2,359,000	
Bulks Procurement		231,038	
Equipment Installation		93,600	
Bulks Fabrication		725,645	
Miscellaneous		0	
Subtotal Direct Costs		**3,409,283**	
Installation Costs Summary			
Direct Transport & Installation Costs			
Seafastening & Load-Out		42,048	
Transportation		75,833	
Installation		0	
Hook-Up and Commissioning		238,678	
Subtotal Direct Costs		**356,559**	
Allowances			***Applied to:***
Freight	8.0%	207,203	*Equipment & Bulks Procurement*
Spares	5.0%	117,950	*Equipment Procurement*
Insurance	2.5%	94,146	*Subtotal Direct Costs*
Certification	0.5%	18,240	*Subtotal Direct Costs*
Engineering	8.0%	301,267	*Subtotal Direct Costs*
Contractors Project Management	10.0%	376,584	*Subtotal Direct Costs*
Design Growth	10.0%	340,928	*Subtotal Procurement & Fabrication Costs*
Subtotal Allowances		**1,456,319**	
Fabrication Cost		**5,222,161**	
Contingency	30.0%	**1,566,648**	
Total Fabrication Cost		**6,788,809**	

Tie-In Costs Summary			hours	$
Direct Costs			**hours**	**$**
Mobilisation Crew and Equipment			1,936	542,080
Hire Equipment			0	67,600
Scaffold, Rigging and Construction Aids			1,500	420,000
Crane Upgrade			120	43,600
Demolition			2,040	571,200
Building and HVAC			0	0
Equipment Installation			1,380	386,400
Structure			950	266,000
Piping			3,228	903,840
Electrical			1,479	414,120
Instrumentation			1,165	326,200
Safety and Risk			6	1,680
Support Vessels / Helicopters			0	1,196,347
Notes:				
- *Crew Size*	*10*			
- *uration (no contingency)*	*115*	*days*		
- *Duration (with contingency)*	*23*	*weeks*		
Subtotal Direct Costs			**13,804**	**5,139,067**
Allowances				
Insurance			3.0%	154,172
Certification			1.0%	51,391
Engineering			20.0%	1,027,813
Project Management			25.0%	1,284,767
Design Growth			10.0%	513,907
Subtotal Allowances				**3,032,049**
Contingency			40.0%	**3,268,446**
Total Tie-In Cost				**11,439,562**

Overall Summary		
Direct Costs		
Mobilisation / Demobilisation		542,080
Equipment Procurement		2,426,600
Bulks Procurement		231,038
Fabrication		819,245
Load-Out & Transport		117,882
Installation		4,529,387
Hook-Up & Commissioning		238,678
Subtotal Direct Costs		**8,904,909**
Allowances		
Engineering		1,329,081
Project Management		1,661,351
Freight		207,203
Spares		117,950
Insurace & Certification		317,949
Subtotal Allowances		**3,633,533**
Contingency		**5,689,930**
Total Cost		**18,228,372**
Lower Bound P10-	30.0%	12,759,860
Upper Bound P90+	40.0%	25,519,720
Owners Cost	0.0%	**0**

Weights Summary	equip	I&E	Pipe	Struct	uildings/mis	Total
Raw weight	31	3	7	15	0	57
Factored	37	4	9	18	0	68
%	55%	6%	13%	26%	0%	100%
Weight growth factor	20.0%					

Hours Summary Fabrication	equip	I&E	Pipe	Struct		Total	Crew size	Hours/week	Duration
Hours	780	2,050	2,220	1,777		6,827			
Factored	780	2,050	2,220	1,777		6,827	60	60	2
%	11%	30%	33%	26%	0%	100%			
Growth factor	25.0%								

Hours Summary Offshore	Prelims	Demolition	Buildings	equip	I&E	Pipe	Struct	HUC	Total	Crew size	Hours/week	Duration
Hours	3,556	2,040	0	1,380	2,644	3,228	950	568	8,770			
Factored	4,445	2,550	0	1,725	3,305	4,035	1,188	710	10,963	30	84	4
%	41%	23%	0%	16%	30%	37%	11%	6%	100%			
Growth factor	25.0%											

Advisian

Client	Beach Energy
Calc. No.	411010-00050
Prepared	Antony Perri	Rev.	0
Checked	Richard George	Date:	11/12/19

Yolla Water Handling Upgrade

Offshore Facility

Gas Stripper

Offshore Facility Parameters

Type	Water Handling	Pre-Fabrication Location	VIC	Installation by	Heavy Lift Vessel
Capacity		Site Location	VIC	Method	Lift Installed

Topsides - Equipment / Bulks and Installation

Equipment Description	Structure Type	Piping Material	Number	Sizing Parameter	Unit	$/Unit	$/Item	t/Item	$	t	Equip. Type	Electrical Factor	Electrical Weight	Instrument Factor	Instrument Weight	Piping Factor	Piping Weight	Structural Factor	Structural Weight
Water Treatment System																			
Gas Stripper column	Modules, topsides	CS	1	1.4	t	30,000	42,000	1.4	42,000	1.4	Columns	0.05	0.1	0.12	0.2	0.70	1.0	1.15	3.0
Column internals	Modules, topsides	CS	1				100,000	0.5	100,000	0.5	Columns	0.05	0.0	0.12	0.1	0.70	0.4	1.15	1.1
Bulks Procurement & Fabrication																			
Structure	Modules, topsides				t														0.0
Installation aids	Modules, topsides				t														0.0
Rigging	Modules, topsides				t														0.0
CS pipe	Modules, topsides	CS			t												0.0		
CRA Pipe	Modules, topsides	SS			t												0.0		
					t														
Building	Modules, topsides	CS	1																
Subtotals									**142,000**	**2**			**0**		**0**		**1**		**4**

Summary Description	Unit	Equipment	Elec.	Inst.	Piping CS	Piping CRA	Piping CS/CRA	Structure	Bulks Subtotals	equip + bulks
Unit cost	$/t	74,737	25,000	40,000	12,000	18,000	25,000	1,500		
Productivity	hrs/t	25	600	600	300	400	450	120		
% spent in Fabyard	Factor	100%	100%	100%	100%	100%	100%	100%		
Productivity Factor	Factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
Labour rate	$/hr	120	120	120	120	120	120	120		
Hours to install	**hrs**	**48**	**57**	**137**	**399**	**0**	**0**	**490**	**1,083**	**1,131**
Weight	**t**	**2**	**0**	**0**	**1**	**0**	**0**	**4**	**6**	**8**
Procurement	**$**	**142,000**	**2,375**	**9,120**	**15,960**	**0**	**0**	**6,129**	**33,584**	**175,584**
Installation	**$**	**5,700**	**6,840**	**16,416**	**47,880**	**0**	**0**	**58,838**	**129,974**	**135,674**

Miscellaneous	Weight (t)	Length (m)	Breadth (m)	Area.	Unit	$/Unit	$
					m2	10,000	
					m2	10,000	
Subtotal Miscellaneous	**0**						**0**

Seafastening & Load-Out	Factor	Unit	Weight	Unit	$/Unit	$
Total Topside Weight			8	t		
Seafastening Materials (as % of Total Topside Weight)	5.0%	-	0	t	1,800	688
Seafastening Fabrication	120	hrs/t	0	t	35	1,604
Load-Out on vessel			1	each	25,000	25,000
Subtotal Seafastening & Load-Out						**27,292**

Transportation	Distance (nm	peed (knots	Duration	Unit	$/Unit	$
Standby at wharf			0.25	days	35,000	8,750
Transport to site	200	10	0.8	days	35,000	29,167
standby at site			0.25	days	35,000	8,750
Return to fab yard	200	10	0.8	days	35,000	29,167
Fuel			35	days	0	
Subtotal Transportation						**75,833**

Installation		Duration	Unit	$/Unit	$
Set up at site			days	300,000	
Lift skid 1			days	300,000	
Lift skid 2			days	300,000	
Total Duration		0.0	days		
Equipment & weather downtime	25%	0.0	days	300,000	
Subtotal Installation					**0**

Hook-Up and Commissioning	Qty.	Unit	Factor	Unit	Duration	Unit	$/Unit	$
Total Topside Weight	8	t						
Hook up				hrs/t	0	hours	280	
Pre-Commissioning			10	hrs/t	76	hours	420	32,084
Hook up Barge	8	crew	12	hrs/day		days	150,000	
Total Duration					0.0	days		
Equipment & weather downtime				25%	0.0	days	150,000	
Subtotal Hook-Up and Commissioning								**32,084**

Advisian

Client	Beach Energy		
Calc. No.	411010-00050		
Prepared	Antony Perri	Rev.	0
Checked	Richard George	Date:	11/12/19

Yolla Water Handling Upgrade
Offshore Facility
Gas Stripper

Standard Rates for Offshore Work			
Labours			
	Offshore Labour	280 $/hr	inclusive of tools, consumables, accommodation, food and helicopter transfers
	Hours per day	12 hrs	
Productivity Factors			
	Works in protected location	80.0% effective % of time	
	Field work on platform	60.0% effective % of time	
	Field work in exposed location, shutdown work	50.0% effective % of time	

Mobilisation Crew and Equipment	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Mobilise/demob crew to platform, training, induction etc.	16	crew	3	100.0%	576	280	161,280	
Clear deck/work area	8	crew	3	60.0%	480	280	134,400	
Install workshop/stores/office	8	crew	4	60.0%	640	280	179,200	
Tie in power/comms to temporary buildings	3	crew	4	60.0%	240	280	67,200	
Subtotal Mobilisation Crew and Equipment					**1,936**		**542,080**	

Hire Equipment	Qty.	Unit	Duration	Unit	$/week	$	Comment(s) / Remark(s)
Office/stores containers	1	each	20	weeks	200	4,000	
Mobile workshop	1	each	20	weeks	1,000	20,000	
Scrap/transport Containers	4	each	20	weeks	100	8,000	
Scaffolding	200	m2	20	weeks	5	20,000	
Accommodation vessel			0	days	150,000		Flotel if required for additional POB
Additional escape craft							If required for additional POB
Subtotal Hire Equipment						**52,000**	

Scaffold, Rigging and Construction Aids	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Scaffold deck area	5	crew	10	60.0%	1,000	280	280,000	
Demolish scaffolding	5	crew	5	60.0%	500	280	140,000	
		crew	2	60.0%		280		
		crew	1	60.0%		280		
		crew	3	60.0%		280		
Subtotal Scaffold, Rigging and Construction Aids					**1,500**		**420,000**	

Crane Upgrade		Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Service existing crane		3	people	2	60.0%	120	280	**33,600**	Service existing crane
Spares		1	lot				10,000	**10,000**	
Temporary Crane	Install temporary crane		people		60.0%		280		
	hire temporary crane		weeks				10,000		
	remove temporary crane		people		60.0%		280		
	Subtotal							**0**	
Upgrade existing crane	Purchase crane upgrade equipment		each				10,000		
	Crane upgrade construction	10	people		60.0%		280		
	Subtotal							**0**	
Subtotal Crane Upgrade						**120**		**43,600**	

Demolition	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Isolate existing water equipment	8	crew	1	60.0%	160	280	44,800	
Remove existing water handling equipment	8	crew	3	60.0%	480	280	134,400	
Remove redundant piping	8	crew	5	60.0%	800	280	224,000	
Clear structure	8	crew	1	60.0%	160	280	44,800	
Paint touch up	3	crew	2	60.0%	120	280	33,600	
Subtotal Demolition					**1,720**		**481,600**	

Building and HVAC	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
		crew		60.0%		280		
		crew		60.0%		280		
		crew		60.0%		280		
		crew		60.0%		280		
Subtotal Building and HVAC					**0**		**0**	

Equipment Installation	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Lift in Gas Stripper Column	8	crew	1	60.0%	160	280	44,800	
		crew		60.0%		280		
		crew		60.0%		280		
		crew		60.0%		280		
		crew		60.0%		280		
Subtotal Equipment Installation					**160**		**44,800**	

Structure	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Secure Gas stripper column	5	crew	7	60.0%	700	280	196,000	
		crew		60.0%		280		
		crew		60.0%		280		
Paint touch up	3	crew	1	60.0%	60	280	16,800	
NDT for structural work	2	crew	1	80.0%	30	280	8,400	
Subtotal Structure					**790**		**221,200**	

Advisian

Client	Beach Energy				
Calc. No.	411010-00050				
Prepared	Antony Perri	**Rev.**	0		
Checked	Richard George	**Date:**	11/12/19		

Yolla Water Handling Upgrade

Offshore Facility

Gas Stripper

Piping	dia	length	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Piping tie in #1 Produced water inlet	3	5	5	crew	1	50.0%	120	280	33,600	Shut down required
Piping tie in #2 to Produced water to dump caisson	3	5	5	crew	1	50.0%	120	280	33,600	Shut down required
Piping tie in #3 to flare header	2	20	5	crew	3	50.0%	360	280	100,800	Shut down required
Piping tie in #5 to drains	2	20	5	crew	3	50.0%	360	280	100,800	
Piping tie in # 6 Fuel gas to column	2	30	5	crew	4	50.0%	480	280	134,400	
Leak test piping systems			3	crew	2	60.0%	120	280	33,600	
Paint touch up			3	crew	3	60.0%	180	280	50,400	
Subtotal Piping							**1,740**		**487,200**	

Electrical	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
		crew		50.0%		280		Local shut down required
		crew		80.0%		280		
		crew		60.0%		280		
Testing and precommissioning	3	crew	3	60.0%	180	280	50,400	
Subtotal Electrical					**180**		**50,400**	

Instrumentation	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
Run cables from Ins room to local panel	100	m	0.10	60.0%	200	280	56,000	allow approx. 1 hr per m
Install field instruments & cable	5	instruments	1	60.0%	100	280	28,000	allow 12 hrs per instrument
Install tubing, chem injection	0	m	0.16	60.0%		280		allow 2 hrs per m
Instrument hook up to skid	5	instruments	0.25	60.0%	25	280	7,000	allow 3 hrs per instrument
Testing and precomm 100 loop checks	10	loops	0.10	60.0%	20	280	5,600	Allow 1 hour per loop
Testing and precomm new to existing system	3	crew	1	60.0%	60	280	16,800	
Install Fire and Gas detectors	1	instruments	1	60.0%	20	280	5,600	allow 1 day per instrument
Subtotal Instrumentation					**425**		**119,000**	

Safety and Risk	Qty.	Unit	days	Productivity	hrs	$/hr	$	Comment(s) / Remark(s)
New manual alarm		no		60.0%		280		
Fire fighting, portable extinguishers	3	no	0	60.0%	6	280	1,680	
Fire fighting, fixed hose reel		no		60.0%		280		
safety shower		no		60.0%		280		
Comms PA station		no		60.0%		280		
Subtotal Safety and Risk					**6**		**1,680**	

Support Vessels / Helicopters	#Trip/Week	Time/Trip	Unit	Weeks	hrs	$/hr	$	Comment(s) / Remark(s)
Helicopter additional flights, urgent freight etc.	1	2	hrs	14	29	3,500	100,065	
Supply boat for equipment	1	1	days	14	14	45,000	643,275	
Subtotal Support Vessels / Helicopters							**743,340**	

Summaries

Fabrication Costs Summary			
Direct Procurement & Fabrication Costs			
Equipment Procurement		142,000	
Bulks Procurement		33,584	
Equipment Installation		5,700	
Bulks Fabrication		129,974	
Miscellaneous		0	
Subtotal Direct Costs		**311,258**	
Installation Costs Summary			
Direct Transport & Installation Costs			
Seafastening & Load-Out		27,292	
Transportation		75,833	
Installation		0	
Hook-Up and Commissioning		32,084	
Subtotal Direct Costs		**135,209**	
Allowances			***Applied to:***
Freight	8.0%	14,047	*Equipment & Bulks Procurement*
Spares	5.0%	7,100	*Equipment Procurement*
Insurance	2.5%	11,162	*Subtotal Direct Costs*
Certification	0.5%	1,717	*Subtotal Direct Costs*
Engineering	8.0%	35,717	*Subtotal Direct Costs*
Contractors Project Management	10.0%	44,647	*Subtotal Direct Costs*
Design Growth	10.0%	31,126	*Subtotal Procurement & Fabrication Costs*
Subtotal Allowances		**145,515**	
Fabrication Cost		**591,981**	
Contingency	30.0%	**177,594**	
Total Fabrication Cost		**769,575**	

Tie-In Costs Summary				
Direct Costs			**hours**	**$**
Mobilisation Crew and Equipment			1,936	542,080
Hire Equipment			0	52,000
Scaffold, Rigging and Construction Aids			1,500	420,000
Crane Upgrade			120	43,600
Demolition			1,720	481,600
Building and HVAC			0	0
Equipment Installation			160	44,800
Structure			790	221,200
Piping			1,740	487,200
Electrical			180	50,400
Instrumentation			425	119,000
Safety and Risk			6	1,680
Support Vessels / Helicopters			0	743,340
Notes:				
- *Crew Size*	*10*			
- *uration (no contingency)*	*71*	*days*		
- *Duration (with contingency)*	*14*	*weeks*		
Subtotal Direct Costs			**8,577**	**3,206,900**
Allowances				
Insurance			3.0%	96,207
Certification			1.0%	32,069
Engineering			20.0%	641,380
Project Management			25.0%	801,725
Design Growth			10.0%	320,690
Subtotal Allowances				**1,892,071**
Contingency			40.0%	**2,039,588**
Total Tie-In Cost				**7,138,559**

Overall Summary		
Direct Costs		
Mobilisation / Demobilisation		542,080
Equipment Procurement		194,000
Bulks Procurement		33,584
Fabrication		135,674
Load-Out & Transport		103,125
Installation		2,612,820
Hook-Up & Commissioning		32,084
Subtotal Direct Costs		**3,653,366**
Allowances		
Engineering		677,097
Project Management		846,372
Freight		14,047
Spares		7,100
Insurace & Certification		141,154
Subtotal Allowances		**1,685,770**
Contingency		**2,568,998**
Total Cost		**7,908,135**
Lower Bound P10-	30.0%	5,535,694
Upper Bound P90+	40.0%	11,071,389
Owners Cost	0.0%	**0**

Weights Summary	equip	I&E	Pipe	Struct	uildings/mis	Total
Raw weight	2	0	1	4	0	8
Factored	2	0	2	5	0	9
%	25%	4%	17%	53%	0%	100%
Weight growth factor	20.0%					

Hours Summary Fabrication	equip	I&E	Pipe	Struct		Total	Crew size	Hours/week	Duration
Hours	48	194	399	490		1,131			
Factored	48	194	399	490		1,131	60	60	0
%	4%	17%	35%	43%	0%	100%			
Growth factor	25.0%								

Hours Summary Offshore	Prelims	Demolition	Buildings	equip	I&E	Pipe	Struct	HUC	Total	Crew size	Hours/week	Duration
Hours	3,556	1,720	0	160	605	1,740	790	76	3,371			
Factored	4,445	2,150	0	200	756	2,175	988	95	4,214	30	84	2
%	105%	51%	0%	5%	18%	52%	23%	2%	100%			
Growth factor	25.0%											

Appendix E

Beach Risk Assessment Guidance

Risk Rating Toolkit

Risk Matrix Instruction

Step A
Identify and describe the risk as follows: "(something happens) leading to outcomes expressed in terms of impact on objectives).

Step B
Assess the potential exposure (maximum credible impact on Lattice Energy arising from a risk without regards for controls).

Step C
Identify existing controls, and assess their effectiveness.

Step D
Identify the consequence rating (1-6) corresponding to the maximum credible impact across the Consequence Categories (may be more than one), given the existing controls and their effectiveness.

Step E
Identify the Likelihood of occurrence ("remote" through to "almost certain") of those consequences at that level, taking into account the current controls and their effectiveness.

Step F
Determine the Level of Risk (Low, medium, High, Severe, Extreme) based on the intersection of the Consequence rating and Likelihood.

Step G
Determine and action (e.g. Risk treatment) and escalation required based on the Level of Risk.

Control Effectiveness

Rating	Explanation
Fully Effective (100%)	Controls are well designed for the risk, largely prevent the risk from eventuating, and address the root causes. The controls are operating effectively and are reliable at all times. Nothing more to be done except review and monitor the existing controls.
Substantially Effective (75%)	Most controls are designed correctly and are in place and effective. Some more work needs to be done to improve operating effectiveness of the controls, or there are doubts about operational effectiveness and reliability.
Partially Effective (50%)	While the design of controls may be largely correct in that they treat most of the root causes of the risk, they are not currently very effective. There may be an over reliance on reactive controls.
Largely ineffective (25%)	Significant control gaps. Either controls do not treat root cause or they do not operate effectively at all. Controls, if they exist, are just reactive.
None (0%)	Virtually no credible control. There is little to no confidence that any degree of control is being achieved due to poor control design and/or very limited operational effectiveness of controls.

Risk Management Action

Level of risk	Action required	Escalation and Approval of Treatment Plans	Acceptance authority
EXTREME	Risk treatment Plan must be in place immediately Risk reviewed monthly by Risk owner	Exco for review and approval of the treatment plan	Exco
SEVERE	Risk treatment must be considered Risk reviewed monthly by Risk owner	Exco for review and approval of associated treatment plan (if applicable)	Exco
HIGH	Risk treatment must be considered Risk reviewed twice per year by Risk owner	Project / Operations Manager for review and approval of associated treatment plan (if applicable)	Exco direct report (Exco -1)
MEDIUM	Risk treatment may be considered Risk reviewed annually by Risk owner	Project / Operations Manager	Exco direct report (Exco -1)
LOW	No risk treatment required Risk reviewed annually by Risk owner	Facilities Manager / Operations Superintendent	Exco Direct report – reports (Exco -2)

Risk Matrix

CONSEQUENCE CATEGORIES	Impact to Lattice or contracting personnel	Natural environment	Community damage/ impact/ social/ cultural heritage	Financial impact (e.g. due to loss of revenue, business	Damage to reputation, services interruption, customer interruption	Breach of law or criminal prosecution or civil action (e.g. OHS, environment, industrial relations, trade practices, industry acts)	LIKELIHOOD					
							1 REMOTE	2 HIGHLY UNLIKELY	3 UNLIKELY	4 POSSIBLE	5 LIKELY	6 ALMOST CERTAIN
							<1% chance of occurring within the next year. Occurrence requires exceptional circumstances exceptionally unlikely event in the long-term future only occur as a 100-year event.	>1% chance of occurring within the next year May occur but not anticipated could occur years to decades.	>5% chance of occurring within the next year May occur but not for a while could occur within a few years.	>10% chance of occurring within the next year May occur shortly but a distinct probability it wont could occur within months to years.	>50% chance of occurring within the next year Balance of probability will occur could occur within weeks to months.	99% chance of occurring within the next year impact is occurring now could occur within days to weeks.
6 CATASTROPHIC	Multiple fatalities >4 or severe irreversible disability to large group of people (>10).	Long term destruction of highly significant ecosystem or very significant effects on endangered species or habitats.	Multiple community fatalities, complete breakdown of social order, irreparable damage of highly valued items or structures of great cultural significance.	EBIT: impact, loss or deterioration from expectation greater than $100m. CASH FLOW: severe cash flow crisis, unable to source funds.	Negative international or prolonged national media (e.g. 2 weeks). continued severe degradation of services to customers > 1 month or > 10,000 customer days.	Potential jail terms for executives and or very high fines for the company. Prolonged multiple litigations.	HIGH	HIGH	SEVERE	SEVERE	EXTREME	EXTREME
5 CRITICAL	1-3 fatalities or serious irreversible disability (>30%) to multiple persons (<10).	Major offsite release or spill, significant impact on highly valued species or habitats to the point of eradication or impairment of the ecosystem. Widespread long-term impact.	Community fatality. Significant breakdown of social order. Ongoing serious social issue. Major irreparable damage to highly valuable structures/ items of cultural significance.	EBIT: impact, loss or deterioration from expectation greater than $30m but less than $100m. CASH FLOW: severe cash flow crisis, difficulty to source funds. Probable credit rating downgrade.	Negative media national for 2 days or more. Significant public outcry. severe degradation of services to customers up to 1 month or >5,000 customer days	Very significant fines and prosecutions. Multiple prosecution and fines.	MEDIUM	MEDIUM	HIGH	SEVERE	SEVERE	EXTREME
4 MAJOR	Serious permanent injury/ illness or moderate irreversible disability (<30%) to one or more persons.	Offsite release contained or immediately reportable event with very serious Environmental effects, such as displacement of species and partial impairment of ecosystem. Widespread medium and some long-term impact.	Serious injury to member of the community, Widespread social impacts. Significant damage to items of cultural significance.	EBIT: impact, loss or deterioration from expectation greater than $3m but less than $30m. CASH FLOW: Loss of flexibility and/or increase in cost to source funds. Market explanation required.	Negative national media for 1 day. Individual customers or segments disadvantaged up to 1 week. Customer interruption >500 customer days. NGO adverse attention.	Major breach of regulation and significant prosecution including class actions.	MEDIUM	MEDIUM	MEDIUM	HIGH	SEVERE	SEVERE
3 SERIOUS	Serious reversible/ temporary injury/illness (e.g. lost time >5 days or hospitalisation or alternate/Restricted Duties > 1 month).	Moderate effects on biological or physical environment and serious short term effect to ecosystem functions.	Media attention and heightened concerns by local community and criticism by NGOs. Ongoing social issues. Permanent damage to items of cultural significance.	EBIT: impact, loss or deterioration from expectation greater than $0.3m but less than $3m. CASH FLOW: Material impact to cash flow.	Negative state media. Heightened concern from local community. Service interruption up to 1 day or > 10 customer days. Criticism by NGOs.	Serious breach of law/regulation with investigation or report to authority with possible prosecution. Performance infringement notice (Pin).	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH	SEVERE
2 MODERATE	Reversible temporary injury/illness requiring Medical treatment (e.g. lost time <5 days or alternate/Restricted Duties for < 1 month).	Event contained within site. Minor short term damage to area of limited significance. Short term effects but not affecting ecosystem functions.	Medical treatment injury to a member of the community, Minor adverse local public or media attention and complaints. Minor medium term social impact on local population, mostly repairable.	EBIT: impact or loss greater than $30k but less than $0.3m. CASH FLOW: impact to project or business unit cash flow.	Public concern restricted to local complaints Negative local media. Internal escalation to senior management. Few hours service interruption. Adverse local public attention.	Breach of law/regulation or non-compliance. Minor legal issues, minor litigation possible.	LOW	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH
1 MINOR	Injury/illness requiring Medical treatment (no lost time, no alternate/ Restricted Duties), First aid, Report only.	Minor consequence, local response. No lasting effects. Low level impacts on biological and physical environment to an area of low significance.	Public concern restricted to local complaints, low level repairable damage to common place structures.	EBIT: impact or loss greater than $3k but less than $30k. CASH FLOW: no significant impact.	Public concern restricted to local complaints.	Local investigation, minor breach of regulation, on the spot fine or technical non-compliance. Prosecution unlikely.	LOW	LOW	LOW	MEDIUM	MEDIUM	MEDIUM

Appendix F

Memo: Potential Impact of Yolla Platform PFW Discharge on Marine Life

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Memorandum

To	Harry Grynberg	Page	1
CC	Ian Baxter, Peter Young		
Subject	Potential Impact of Yolla Platform PFW Discharge on Marine Life		
From	Abigail Ross		
File/Ref No.	60612990	Date	19-Dec-2019

This memo presents a high-level overview of the potential impacts of the Yolla PFW discharge on the marine environment to satisfy the following comment from Beach Energy (in response to their discussion with NOPSEMA):

- We need to ensure we have risk assessed and considered the potential effect on surrounding marine life. Please refer to our Existing Environment (Section 5) in particular Section 5.5 of the EP to get an understanding of what marine life we have that may frequent around the platform and what this means in connection to our WET results.

PFW toxicants effects in the Marine Environment

A brief overview of the potential effects on the marine environment associated with each of the toxicants which exceed detection limits in the Yolla Platform PFW discharge (see Table 4.0 in Yolla Platform ALARP Assessment) for which the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) provide default guideline values (DGVs, which are included in Table 4 of the ALARP assessment) is as follows:

- Naphthalene – The acute toxicity of naphthalene to marine organisms is considered by Bates, Young & Sutton (1997, in Nazir et al 2008) to be 'high to moderate'. Other toxicity effects include bioaccumulation, reproduction defects, and limited growth (Nazir et al 2008). It has been shown to biodegrade in water, with half-lives ranging from about 0.8 to 43 days (Toxnet 2017a).
- Benzene – The potential for benzene to bioconcentrate[1] in aquatic organisms is considered to be low (Toxnet 2017b). It also has a low tendency to bioaccumulate; hence it is not considered likely to biomagnify though food chains (ATSDR 2007). It has high volatility and relatively low water solubility and is rapidly lost to the atmosphere from water bodies (ANZG 2018). Biodegradation has been found to vary with season (e.g. Wakeham et al 1983), but is considered by ANZG (2018) to also be rapid.
- PAHs (phenanthrene, anthracene, fluoranthene and benzo(a)pyrene) - Concentrations of PAHs in marine ecosystems are generally highest in sediments, intermediate in biota and lowest in the water column (Neff 1979). Marine biota can take up PAHs via a number of routes, including dermal absorption, inhalation and consumption of contaminated prey or sediment (Meador et al. 1995). However, the persistence of these compounds in tissues and body fluids of exposed marine organisms varies depending upon the rates of uptake, metabolism and elimination (Krahn and Stein 1998, Rust et al 2004). Vertebrates, such as fish and marine mammals, quickly metabolise PAHs into more polar forms that are then excreted into urine or secreted into bile for rapid elimination via faeces (Roubal, Collier & Malins 1977, Krahn et al. 1984, Varanasi Stein & Nishimoto 1989). However, some of the PAH intermediates formed during metabolism can be more toxic, and may pose a greater health risk than the parent PAHs (Varanasi Stein & Nishimoto

[1] Bioconcentration is the intake and retention of a substance in an organism entirely by respiration from water in aquatic ecosystems. Bioaccumulation is the intake of a chemical and its concentration in an organism by all possible means, including contact, respiration and ingestion (Alexander 1999).

1989). Fish exposed to PAHs may exhibit an array of toxic effects including genetic damage, morphological deformities, altered growth and development, decreased body size, inhibited swimming abilities and mortality (e.g. White, Robitaille & Rasmussen 1999, Incardona et al 2005). Benzo(a)pyrene has a higher molecular weight than the other three PAHs, has a greater potential to bioaccumulate and has been found to cause tumours in fish (Hawkins et al. 1990).

- Toluene – Algae seem to be more resistant to the acute effects of toluene than fish and crustaceans (Jones and Zabel 1986). Bioaccumulation in marine organisms has been found to be low, and depuration rates high (Jones and Zabel 1986). Bioconcentration in aquatic organisms is considered to be low to moderate (Toxnet 2017c). Toluene has high volatility and relatively low water solubility and is rapidly lost to the atmosphere from water bodies (ANZG 2018). Complete degradation has been observed over periods of four days (summer) and 22 days (spring) in a marine mesocosm (Wakeham et al 1983).
- Ethylbenzene – The acute toxicity of ethylbenzene to marine algae, invertebrates and fish is rated by Toxnet (2017d) as ‘moderate’; there are no data reported for chronic toxicity. The potential for bioconcentration in aquatic organisms is considered low and ethylbenzene is considered to be volatile and inherently biodegradable in water under aerobic conditions (OECD 2002).
- Xylenes - Meta-, para- and ortho-xylenes are chemical isomers, with similar physicochemical properties and moderate to low toxicity (OECD 2003, Toxnet 2017e). They are inherently biodegradable under aerobic conditions and their bioaccumulation and bioconcentration potentials are considered to be relatively low (OECD 2003, Ogata et al 1984).
- Copper – adsorbed strongly by suspended material (Florence & Batley 1980 in ANZG 2018). Copper is readily accumulated by plants and animals and bioconcentration has been recorded for various species of phytoplankton, zooplankton, macrophytes, macro-invertebrates and fish (Spear & Pierce 1979 in ANZG 2018). Toxic effects occur when the rate of uptake exceeds the rates of physiological or biochemical detoxification and excretion (Rainbow 1996). Some marine invertebrates, particularly crustaceans, corals, sea anemones and bivalve molluscs, are sensitive to copper (ANZG 2018), while gastropod molluscs are more tolerant and can accumulate quite high concentrations without toxic effects (Taylor & Anstiss 1999). Marine fish appear to be relatively tolerant of copper (e.g. Denton & Burdon-Jones 1986 in ANZG 2018). Copper toxicity in algae, invertebrates and fish generally increases as salinity decreases (e.g. Stauber 1995). Precipitation of copper hydroxide reaches a maximum around pH8 (Ayres, Davis & Gietka 1994) but there is no clear relationship between pH and toxicity (ANZG 2018).
- Silver - one of the most toxic metals to aquatic life in laboratory experiments, in particular silver nitrate and silver iodide (CCREM 1987). However, in the natural environment silver is often found in less bioavailable complexes with chloride, dissolved organic carbon and sulfur-containing ligands and hence laboratory data may overestimate the toxicity of silver (Gorsuch & Purcell 1999 in ANZG 2018). The acute toxicity of silver to marine fish is considerably lower than for freshwater fish, though toxicity to most marine species increases with decreasing salinity and with elevated ammonia concentrations (Hogstrand & Wood 1998).
- Zinc – commonly forms complexes with organic matter in marine waters (Florence & Batley 1977 in ANZG 2018, Bruland 1989). Zinc is adsorbed by certain metal hydroxides (Dzombak & Morel 1990) and by suspended material; bioavailability after adsorption is variable (e.g. Vercauteren & Blust 1996). Zinc toxicity generally decreases with decreasing pH, at least up to pH 8, above which trends are variable (e.g. Everall, Macfarlane & Sedgwick 1989, Roy & Campbell 1995). Zinc uptake and toxicity generally decreases as salinity increases (e.g. Hamilton & Buhl 1990).
- Ammonia – lost from water by volatilisation (Johnson et al 2007) and rapidly oxidised by bacteria (under aerobic conditions) into nitrite (Ward 1996). Ammonia is directly toxic to biota and can cause convulsions, coma and/or death in marine vertebrates such as fish (Randall & Tsui 2002). The toxicity of ammonia in water increases with increasing temperature and pH, but decreases with increasing salinity (ATSDR 2004). Exposure to sub-lethal ammonia stress can lead to adverse reproductive effects in fish (e.g. Armstrong et al 2015) and invertebrates (e.g. Lee et al 2013), changes in invertebrate behaviour (e.g. Montresor et al 2013, Alonso & Camargo 2014) and reduced growth in a wide range of aquatic organisms (Cheng et al 2015). Some fish species

have been found to adapt to long-term sublethal ammonia concentrations by increased excretion from the body and detoxification in the brain (e.g. Kolarevic et al 2012).

- Phenol - Readily soluble in, and not expected to volatilise from, water (ANZG 2018). Phenol is expected to adsorb to suspended solids (Toxnet 2017e) but there has been no indication that it accumulates in sediment (IHCP 2006). Depuration is rapid (half-life ≤12 hours, ANZG 2018) and it is considered unlikely to bioaccumulate (e.g. Crookes & Howe 1996 in ANZG 2018, Toxnet 2017e). Toxicity to fish is considered high (Toxnet 2017e) and has been shown to increase with decreasing pH (e.g. Dalela et al. 1980 and Verma et al. 1980 in ANZG 2018).

Potential impacts of PFW discharge on marine life

Indirect impacts of the PFW discharge on marine life may include potential bioaccumulation, bioconcentration and/or biomagnification (i.e. increasing concentrations with increasing trophic levels) of toxicants through trophic levels. These may potentially arise from the ingestion/foraging of prey species that have established on, or are associated with, the legs and subsea infrastructure of the Yolla platform, particularly those established habitats/species that have been present within the PFW mixing zone for an extended period of time (i.e. they are less likely to arise in those species whose presence is of a transitory nature and not related to foraging). The level of any indirect impact would likely be localised to:

- the predator-prey relationships of those species that have interacted with, or been directly associated with, the habitat present within the PFW mixing zone; or
- the species that have inhabited the area within the zone of influence, that are more likely to have long-term exposure to those toxicants (see Table 4.0 of the Yolla Platform ALARP assessment).

Arnould et al (2015) investigated the use of habitat created by offshore infrastructure in Bass Strait by marine mammals and the potential benefits this infrastructure may have to certain marine ecosystems. The Australian fur seal (*Arctocephalus puillus doriferus*), is a benthic forager that feeds exclusively on demersal fish and cephalopod species over the continental shelf, with all but one of the known breeding colonies occurring within Bass Strait (Arnould et al 2015). This region is considered to be of low primary productivity (Gibbs 1992), therefore the presence of subsea infrastructure can potentially provide valuable foraging habitat. The study conducted by Arnould et al (2015) concluded that offshore infrastructure in the Bass Strait was potentially important foraging habitat for Australian fur seals, due to creation of fish habitat etc, however the study indicated that pipelines and cable routes appeared to be the most influential structures (over wells and shipwrecks), potentially providing habitat connectivity for prey species. Fur seals are often observed below the Yolla platform, which indicates that the associated subsea infrastructure may support suitable foraging habitat.

There is a potential for pinnipeds (seals and sea lions), specifically the Australian fur seal, to forage on species that have had a direct association with habitat within the PFW mixing zone, e.g. seals eat fish that may have eaten algae/crustaceans/molluscs that inhabit the zone of influence of the PFW mixing zone. Therefore, there is a potential that bioaccumulation or bioconcentration of toxicants within fur seals may occur.

The principal diet of most seals and sea lions consist of cephalopod molluscs and fish; unlike bivalves and suspension feeders these prey are not likely to accumulate petroleum hydrocarbons. All seals and sea lion species are assumed to have the necessary enzymes available within their systems to metabolise some petroleum fractions, while others may be deposited into fat stores. To date, no evidence of deleterious effects related to bioaccumulation of petroleum hydrocarbons has been documented (NOAA 1992).

Conclusion

Due to the small zone of impact associated with the PFW mixing zone, it is concluded that there is a negligible risk of the PFW having a significant impact upon the marine ecosystem within the receiving environment. It is reasonable to conclude that any impacts that may occur would be localised to those biological communities present in those habitats with long-term exposure to the PFW plume, which represent only a very small proportion of the total available similar habitat (i.e. other platform legs or subsea infrastructure). Any indirect impacts would be localised to those species that forage on the biota within the habitats that experience long-term exposure to the PFW plume.

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Appendix G

Proposed monitoring program

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10 February 2020

Commercial-in-Confidence

Adrian Cukovski
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Dear Adrian

PFW field sampling for model verification

I am pleased to provide this proposed methodology and cost proposal for AECOM Australia (AECOM) to assist Beach Energy Limited (Beach) with the field investigation at the Yolla Platform to supplement the recent ALARP assessment for Produced Formation Water (PFW) discharges.

This proposal is based on our telephone conversation on 14 January 2020 in which it was discussed that the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) have requested Beach to provide some verification of the plume dynamics modelled and those dilutions discussed in the ALARP assessment report (AECOM 2019[1]).

1.0 Proposed method

1.1 Review of model and discharge characteristics

An initial review of PFW discharge data will be undertaken to ascertain the most appropriate parameters to use for monitoring, and to provide an understanding of the likely plume character. These data should include data from the previous month for:

- PFW flow rates
- temperature, salinity and any other physico-chemical parameters routinely measured
- hydrocarbon concentrations.

A review of these data will provide insight to the possible plume character and the best parameters to measure.

1.2 Sampling methodology

A range of methods are available to undertake PFW plume sampling and model verification, varying in cost and technical complexity. It is our feeling that a staged approach would best serve Beach in this case, to provide a cost effective result that should meet NOPSEMA's expectations.

Generally, these options include:

- sampling from the Yolla platform
- sampling from a vessel adjacent the platform
- adding dye to the PFW stream to identify a plume, or to help estimate dilution with distance from the platform.

Given the expected small scale of the PFW plume and rapid dilution to below levels predicted to impact the receiving environment (7 – 10 m [AECOM 2019]), an initial sampling event from the platform is suggested. This will allow the collection of data without the added safety risk and expense of vessel operations. Pending the outcomes from the initial platform-based sampling, a methodology and costing for further investigations utilising a vessel and/or dye can be developed, should either of these be deemed necessary.

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[1] AECOM 2019 Yolla Platform ALARP Assessment. Report prepared for Beach Energy Ltd. 20 December 2019. Report Ref.: 60612990

We propose the following sampling methods from the Yolla platform as an initial investigation:

- Water column profiles using a multiparameter probe to measure physico-chemical indicators of the PFW plume through the water column, such as electrical conductivity (EC), temperature and pH.
- Collection of water samples for laboratory analysis and detection of PFW constituents such as TPH and BTEX (which were identified as contaminants of concern in the ALARP assessment) and barium which has been shown to be present and potentially detectable after release to the receiving environment.

Proposed sampling locations for these methods include:

- Water column physico-chemical profiles:
  - A location up-current from the discharge point to be used as a reference reading (once at the beginning and once on conclusion of each sampling event).
  - Within samples taken from the PFW stream prior to discharge into the caisson (once at the beginning and once on conclusion of each sampling event. Technically not a profile but a measurement taken using the same profiling instrument).
  - Within the discharge caisson (surface and sub-surface intervals). It is assumed that the caisson is of a size, and that turbulence within the caisson is sufficiently low, that will allow the deployment of a multi-parameter probe into the water safely and without the risk of damage to the instrument.
  - In the receiving environment as close to the discharge location as possible.
  - Incremental distances (approximately 5 m distances or wherever possible) moving away from the point of discharge in the direction of the prevailing current for as far as possible.
- Water samples for laboratory analysis collected (using a Niskin bottle sampler where sampling overboard) from:
  - A point up-current from the discharge point to be used as a reference reading (nominally surface, 2 m and 5 m depth), once at the beginning and once on conclusion of each sampling event.
  - The PFW stream prior to discharge into the caisson (once at the beginning and once on conclusion of each sampling event).
  - Within the discharge caisson (surface and sub-surface intervals).
  - As close to the discharge location as possible (top of plume, mid plume and below plume as determined from profile data).
  - Incremental distances (approximately 5 m distances) moving away from the point of discharge in the direction of the prevailing current for as far as possible from the platform (surface, mid and lower plume as detected by profile data).

Two sampling events are suggested, the timing of which should cover both a slack tide and a period of higher tidal flow.

Across the two sampling events, we expect that the approximately 50 water samples will be collected for laboratory analysis, thought this will be dependent on the conditions encountered in the field and the number of access points for sampling.

Sampling a slack or low current speed will increase the chance of detecting the plume in the immediate vicinity of the platform as discharged PFW will pool around the platform, rather than being carried away and diluting rapidly. This will also provide a conservatively low measurement of dilution.

Additional measurements should also be taken at a point in time where a higher current speed is present to provide an indication of the plume behaviour during that period. This plume will be more difficult to measure as the plume will generally be smaller in diameter and will be carried further away from the platform.

Observations and measurements of the plume, including any plume surface expression, should also be made over a longer period as tide changes occur. These should include:

- Photographs of any visible plume from the platform.
- Records of the direction in which the plume is dispersing from the platform.
- Records of wind speed and direction.
- Current speed and direction measurements, where possible through the water column.
- Physico-chemical water column profiles to detect any stratification that may be present, and plume location within the water column.

1.3 Use of a tracer dye

Tracer dyes such as Rhodamine WT can provide a means by which a discharge stream can be more readily identified to help with describing its character and dispersion pattern. It also allows, through the use of fluorometer instrumentation, another means by which the plume dilution can be estimated.

We have included an indicative cost for dye if this is of interest to Beach, although the use of such dye would require additional equipment on the platform, an injection point into the PFW stream, instrumentation to measure its concentration in the water and laboratory analysis to confirm the concertation of dye in samples collected.

It may be suitable to add the pre mixed dye from a large barrel or IBC tank into the discharge caisson. The dyed plume could then be identified as it emerges from the platform.

If a multiparameter probe can be deployed within the caisson, the measurement of dye within the caisson, compared to that in the open ocean may be used to estimate the PFW dilution. This is dependent on access to sampling the plume from the platform.

2.0 Data analysis and reporting

2.1 Data analysis

Data collected in the field will be processed where necessary and reviewed to characterise the PFW plume as it was able to be measured. This will include:

- Processing water physico-chemical profile data to plot parameters measured against depth.
- Tabulating laboratory analysis results for water samples collected in the field.
- Mapping locations of water column profiles and water samples.
- Metocean and meteorological data will be reviewed and summarised, and measurements at the time of sampling identified and matched to sampling records.
- Field observations of plume surface expression will be collated and summarised.

A consolidated database (MS Excel format) containing all data will be compiled.

2.2 Reporting

A factual report will be provided which outlines the sampling undertaken and the conditions encountered in the field. A summary of the data collected will be provided.

A description of the plume characterisation during the two sampling events undertaken will be provided and will comment on the PFW plume characteristics compared to those described in the ALARP assessment report.

An assessment of the water sample analytical results will be provided, with comment made in relation to the concentration of hydrocarbons in the PFW stream pre discharge, within the discharge caisson and in the receiving environment. Discussion of the measured concentrations will be provided with reference to the expected concentrations as discussed in the ALARP assessment report and modelling report.

3.0 Sampling logistics

Sampling on the Yolla platform can be undertaken by an AECOM scientist with support from production technicians. Alternatively, sampling could be undertaken by production staff with training on the operation of equipment from AECOM scientists prior to sampling, and telephone support during sampling if required.

Should AECOM personnel be required to undertake sampling, we have staff with TBOSIET (including HUET) and MSIC accreditation. If deemed necessary, the former could be supplemented with survival suit training (as per BOSIET requirements)

4.0 Cost Estimate

Details removed for Appendix G

5.0 Assumptions

It is assumed that:

- One AECOM marine scientist would be deployed to the Yolla Platform for a duration of two days to undertake sampling.
- Beach will provide all required inductions and approvals to mobilise to site. We have allowed three hours in our budget to undertake inductions. Additional time for inductions shall be charged to Beach at the relevant hourly rate.

- Mobilisation from Perth to the Yolla platform would occur in a single day and the return trip would also occur over a single day (no accommodation has been included in the cost estimate for mobilisation or demobilisation).
- Beach will provide helicopter transfers to and from Melbourne Airport.
- Beach is able to provide access to the required sampling locations on the platform.
- Cost estimates assume collection and analysis of 50 water samples across two sampling events.
- It is assumed that the discharge caisson is of sufficient size to safely lower a water quality profiling instrument into the water in a manner that it will not be damaged.
- Allowance has been made for the hire and freight of two water profiling instruments to be hired for a duration of seven days to allow for freight to and from the Yolla platform. This cost is subject to availability.
- No allowance has been included for weather down time or other occurrences beyond AECOM's control. Should AECOM staff be delayed during a field survey, costs for staff time would be charged to Beach at the relevant hourly rate.
- Beach will obtain any required work permits for the undertaking of sampling on the platform, including for access to sampling sites and operation of equipment (camera, multiparameter probe and laptop computer) which may not be intrinsically safe certified. AECOM will provide specifications of equipment on request.
- Costs have been provided for sampling on the Yolla Platform only. Should additional sampling be required to meet NOPSEMA expectations, this can be costed at a later date.
- Laboratory fees have been estimated based on the number of samples identified in this proposal. It is expected that this will be confirmed with Beach on delivery of the final sampling plan.
- Allowance has been made for the incorporation of a single set of consolidated comments on the draft report to produce the final deliverable.

6.0 Contract

We propose to undertake this work as a variation to the work recently undertaken for Beach and in accordance with the same T&Cs agreed for the ALARP Assessment report (AECOM 2019).

I trust this proposal provides you with the information that you require at this stage. If you have any queries or would like to discuss any component of this proposal, please don't hesitate to contact the undersigned.

Kind regards

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Appendix 10

Yolla Platform – Bass Strait Produced Water Dispersion Near-Field Modelling (RPS, 2017)

YOLLA PLATFORM – BASS STRAIT

Produced Water Dispersion Near-Field Modelling

Prepared for ***Lattice Energy***

28 NOVEMBER 2017

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Executive Summary

Background

Lattice Energy Pty Ltd (Lattice) operates the Yolla Platform which is located within the production license T/L1 and is approximately 100 km offshore from mainland Victoria in the Bass Strait.

As part of Lattice's due diligence, they have commissioned RPS to assess the fate of produced water (PW) being operationally discharged from the Yolla Platform. Recent debottlenecking upgrades to the produced water system has increase the maximum discharge rate, therefore Lattice requested RPS to assess a range of operational states; i) Design, ii) Typical and iii) Worst Case.

The rates of discharge for these three cases were 100 m^3/day, 200 m^3/day and 300 m^3/day, which represented the original PW design flow rate, expected operation post-debottlenecking, and worst-case (end of field life, large amounts of PW production) operation scenarios, respectively. All scenarios were modelled as single port discharge through the bottom of the discharge caisson.

Methodology

The modelling study was carried out by firstly generating a high resolution vertical current profile for the study area, which included the combined influence of ocean and tidal currents. Secondly, the vertical profiles for typical seasonal salinity and temperature profiles were obtained from the World Ocean Atlas. Finally, a near-field discharge model (CORMIX) was used to assess the rate of dilution (defined as the ratio of the initial concentration (at the discharge port) to the concentration at a given location based on the centreline of the plume) of the plume under static low and high current speeds for each of the three model scenarios under summer and winter conditions.

Key Findings

Near-field Modelling

- The furthest distance for any plume to reach 1000:1 dilution was 70 m, for Case 3 – Worst Case Operation scenario (300 m^3/day) under summer conditions with high current speeds.
- Plumes released during summer conditions required a greater distance before reaching 1,000:1 dilution, in comparison to plumes released during winter.
- Plumes released during low current speed conditions rose higher in the water column and travelled less horizontally than plumes released in high current speed conditions for all three flow rates modelled under summer and winter conditions.

1.0 Introduction

Lattice Energy Pty Ltd (Lattice) operates the Yolla Platform which is located within the production license T/L1 and is approximately 100 km offshore from mainland Victoria in the Bass Strait.

As part of Lattice's due diligence, they have commissioned RPS to assess the fate of produced water (PW) being operationally discharged from the Yolla Platform. Recent debottlenecking upgrades to the produced water system has increase the maximum discharge rate, therefore Lattice requested RPS to assess a range of operational states; i) Design, ii) Typical and iii) Worst Case.

The rates of discharge for these three cases were 100 m^3/day, 200 m^3/day and 300 m^3/day, which represented the original PW design flow rate, expected operation post-debottlenecking, and worst-case (end of field life, large amounts of PW production) operation scenarios, respectively. All scenarios were modelled as single port discharge through the bottom of the discharge caisson.

Table 1 Location of the release site used for the dispersion modelling assessment.

Release Site	Latitude	Longitude	Water Depth (m)
Yolla Platform	39° 50' 39.5" S	145° 49' 5.9" E	80

1.1 Scope of work

The physical mixing of the PW stream can be separated into two distinct zones: (a) near-field; and (b) far-field. The limits of the near-field zone are defined by the area where the levels of mixing and dilution are controlled by the plume's initial jet momentum and the buoyancy flux, resulting from the density difference. When the plume encounters a boundary such as the water surface, or loses its buoyancy, the near-field mixing is complete, and the far-field mixing begins.

Therefore, to accurately determine the dilution of the discharge and the mixing zones, the effect of near-field dynamics need to be considered first.

The scope of work included the following components:

1. Generate a 5-year 3-dimensional current data set (2012-2016) that included the combined influence of ocean and tidal currents;
2. Generate seasonal vertical profiles of salinity and water temperature at the release site; and
3. Simulate the near field-mixing and dilution zone using the three-dimensional near-field model (CORMIX) under static low and high current speeds for each of the three model scenarios under summer and winter conditions.

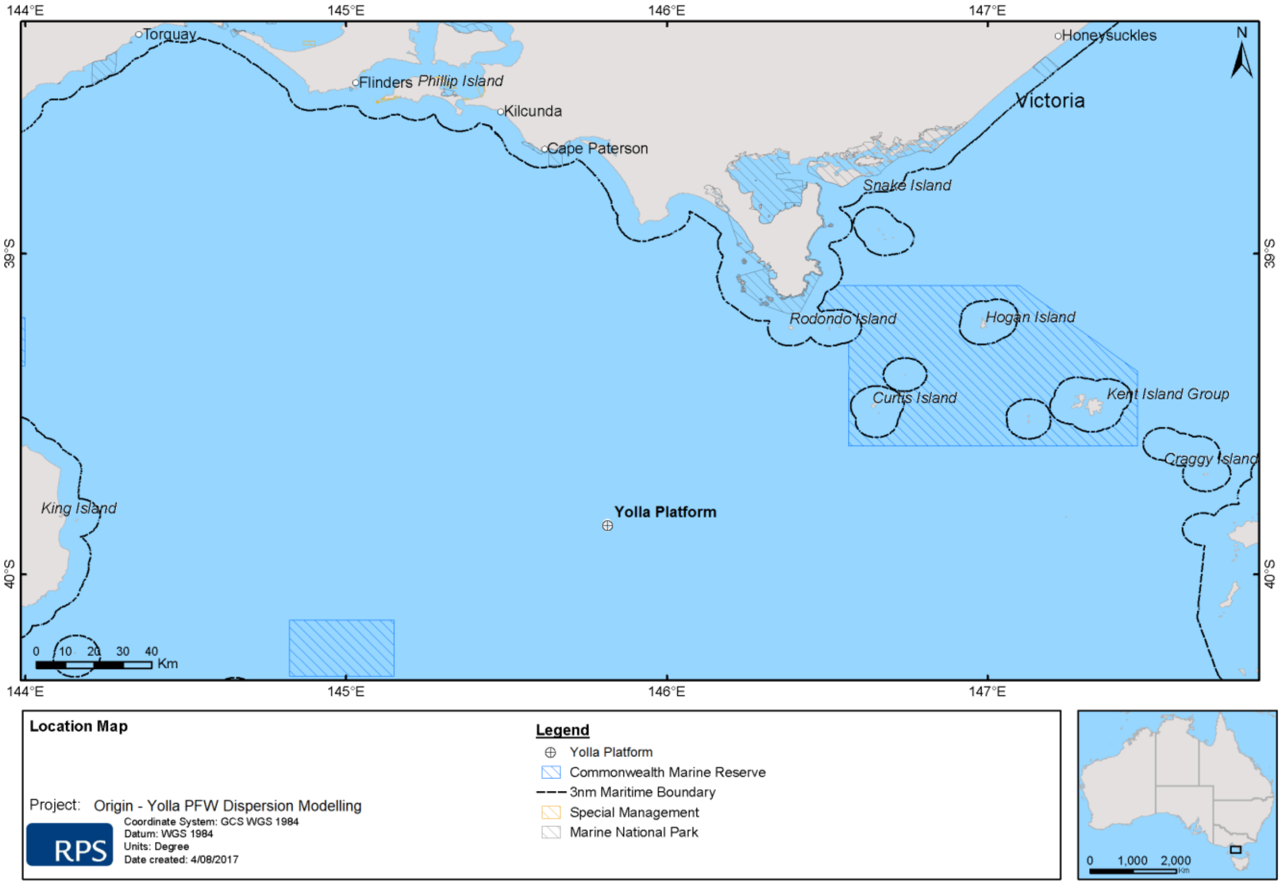

Figure 1 Location of the Yolla Platform used in the dispersion modelling study.

2.0 Discharge Characteristics

The PW stream, consists of both PW and water of condensation, is discharged vertically downwards through a discharge caisson at a depth of 45 meters below mean sea level (MSL). The depth of the surrounding water is approximately 80 m.

The PW discharge properties, are summarised in Table 2. The PW plume is slightly hotter (1°C above ambient at 45 m below MSL) and less saline than the receiving waters, resulting in a positively buoyant plume.

Table 2 Summary of the modelled discharge parameters used to simulate the discharges at Yolla.

Component	Design Operation	Typical Operation	Worst Case Operation
Flow rate (m^3/d)	100	200	300
Temperature (°C)	13.784 – 16.760	13.784 – 16.760	13.784 – 16.760
Salinity (PSU)	0.14	11.9	14.7
Diameter of discharge pipe (m)	0.73		
Depth of discharge (m)	45		
Pipe orientation	Downward		

2.1 Produced Water Contaminants Assessed

Lattice has provided a list of measured contaminant levels and trigger values for 99% species protection (Table 3), which were adopted as part of this study.

As shown, the majority of the contaminants require a dilution factor of less than 75.

Contaminants of concern include mercury, phenol, glycol and oil and petroleum hydrocarbons, all of which require dilutions greater than 100 to reach the 99% species protection.

For conservatism the discharge was assessed to a maximum dilution of 1000:1.

Table 3 Summary of produced water contaminants and trigger values

Component	Max recorded produced water concentration (µg/L)	99% Species protection trigger value (µg/L)	Required dilution factor to achieve 99% trigger value
Aluminium	3,200	27*	119
Arsenic	BD	1	-
Boron	3,400	90*	38
Barium	13,000	NL	-
Chromium	1	0.14	7.1
Iron	4,300	ID	-
Lead	BD	1	-
Mercury	29	0.1	290
Manganese	30	1200*	NR (<1)
Molydenum	1	ID	-
Nickel	10	7	1.4
Selenium	1	5*	NR (<1)
Strontium	810	NL	-
Zinc	90	7	12.9
Benzene	12,000	500	24
Toluene	14,000	110*	127
Ethylbenzene	450	50*	90
o-Xylene	1,600	200*	8
m&p-Xylene	5,200	50*	104
Napthalene	1,000	50	20
Phenol	64,000	270	237
Cresols	75,000	NL	-
2,4-Dimethyl Phenol	8,700	NL	-
Oil & Petroleum Hydrocarbons	<30,000 (current discharge limit)	70	428
Glycol	2 vol% (20,000,000 µg/L)	50,000^	400

^ = Guideline for working limits only, insufficient data to determine level of species protection
* = Taken from data for 99% species protection in fresh water systems ANZECC
BD = Historical testing shows these contaminants are below the limit of detection of 0.001 mg/L
ID = Insufficient data to determine a trigger value for marine or freshwater environment
NL = Component not listed in ANZECC guidelines
NR = Dilution not required, below ANZECC guideline concentration at point of discharge

3.0 Currents

Bass Strait is a body of water separating Tasmania from the southern Australian mainland, specifically the state of Victoria. The strait is a relatively shallow area off the continental shelf, connecting the southeast Indian Ocean with the Tasman Sea. Currents within the straight are driven by tides, winds, incident continental shelf waves and density driven flows. High winds and strong tidal currents are frequent within the area (Jones, 1980).

The varied geography and bathymetry of the region, in addition to the forcing of the south-eastern Indian Ocean and local meteorology lead to complex shelf and slope circulation patterns (Middleton & Bye, 2007). Figure 2 displays seasonal current trends within the Bass Strait. During winter there is a strong eastward water flow due to the strengthening of the South Australian Current (fed by the Leeuwin Current in the Northwest Shelf), which bifurcates with one extension moving though the Bass Strait, and another forming the Zeehan Current off western Tasmania (Sandery & Kampf 2007). During summer, water flow reverses off Tasmania, King Island and the Otway Basin travelling eastward, as the coastal current develops due to south-easterly winds.

To accurately describe the variability in currents between the inshore and offshore region, a hybrid regional dataset was developed by combining deep ocean predictions obtained from HYCOM (Hybrid Coordinate Ocean Model) with surface tidal currents developed by RPS. The following sections provide a summary of the hybrid regional data set.

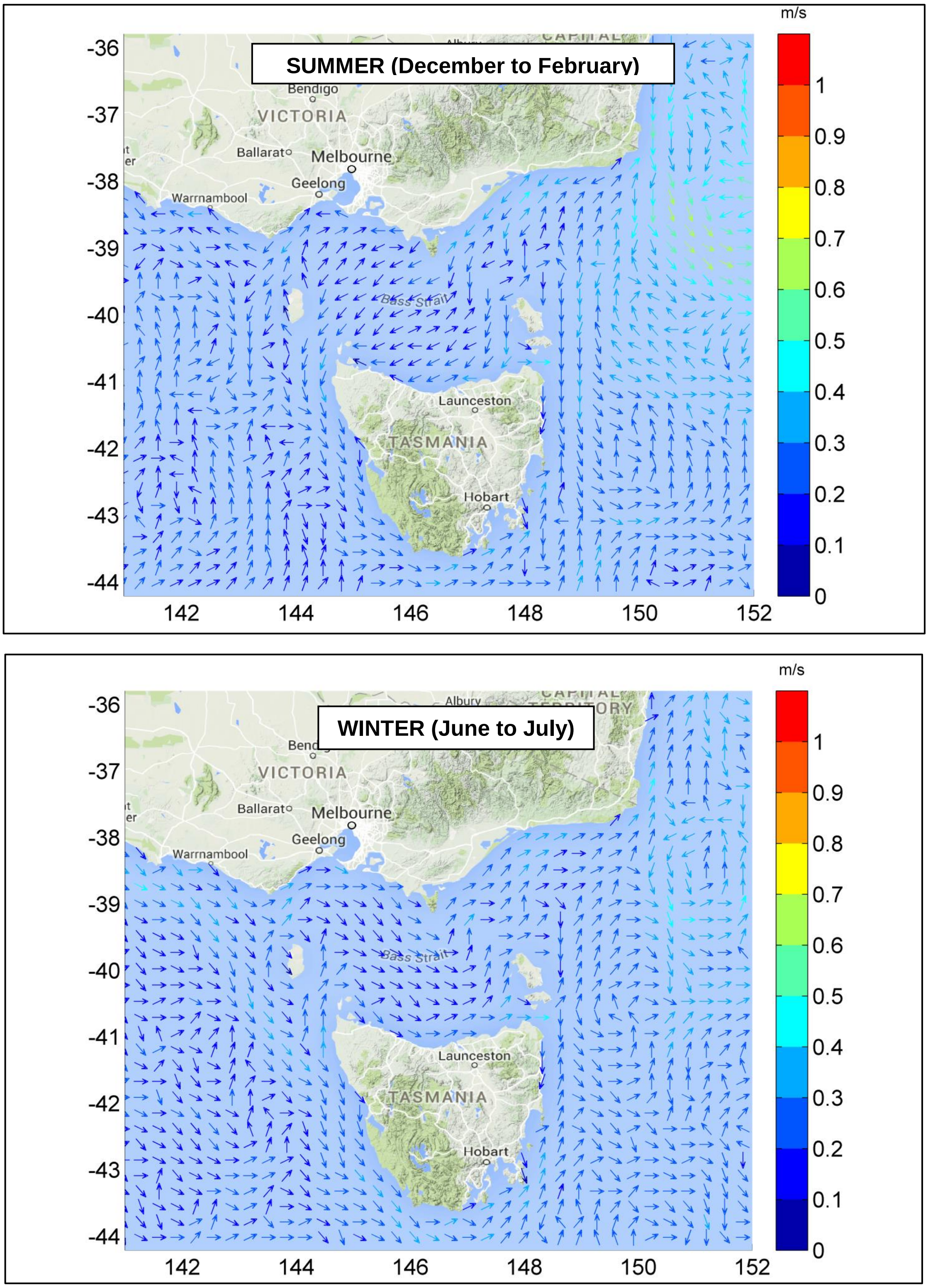

Figure 2 HYCOM averaged seasonal surface drift currents during summer and winter.

3.1 Tidal Currents

Tidal current data was generated using RPS's advanced ocean/coastal model, HYDROMAP. The HYDROMAP model has been thoroughly tested and verified by comparison to field measurements throughout the world over the past 32 years (Isaji & Spaulding, 1984; Isaji, et al., 2001; Zigic, et al., 2003). HYDROMAP tidal current data has been used as input to forecast (in the future) and hindcast (in the past) pollutant spills in Australian waters and forms part of the Australian National Oil Spill Emergency Response System operated by AMSA (Australian Maritime Safety Authority).

HYDROMAP employs a sophisticated sub-gridding strategy, which supports up to six levels of spatial resolution, halving the grid cell size as each level of resolution is employed. The sub-gridding allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, and/or of particular interest to a study.

The numerical solution methodology follows that of Davies (1977a and 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji and Spaulding (1984) and Isaji et al. (2001).

3.1.1 Grid Setup

RPS has a global tidal model with global coverage. The model is sub-gridded to a resolution of 500 m for shallow and coastal regions, starting from an offshore (or deep water) resolution of 8 km. The finer grids are progressively allocated in a step-wise fashion to more accurately resolve flows along the coastline, around islands and over regions with more complex bathymetry. Figure 3 shows the tidal model grid covering the study domain.

A combination of datasets were used and merged to describe the shape of the seabed within the grid domain (Figure 4). These included spot depths and contours which were digitised from nautical charts released by the hydrographic offices as well as Geoscience Australia database and depths extracted from the Shuttle Radar Topography Mission (SRTM30_PLUS) Plus dataset (see Becker et al., 2009).

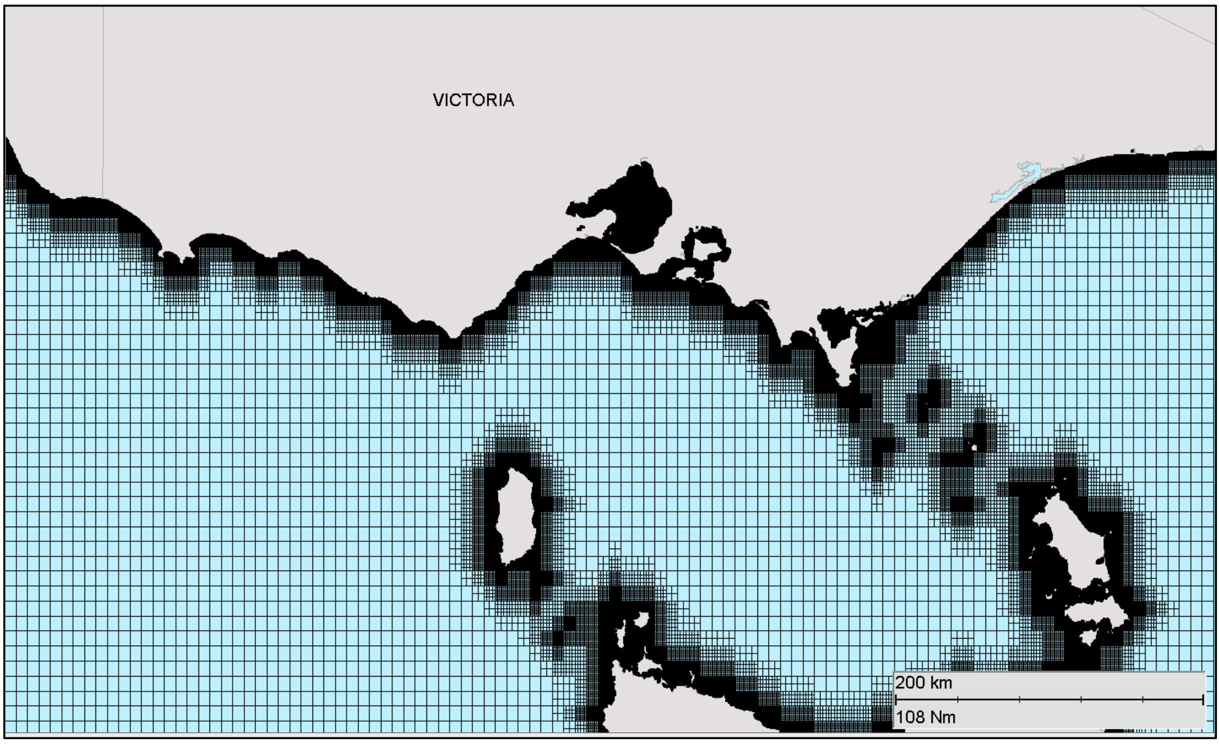

Figure 3 Sample of the model grid used to generate the tidal currents for the study region. Higher resolution areas are shown by the denser mesh.

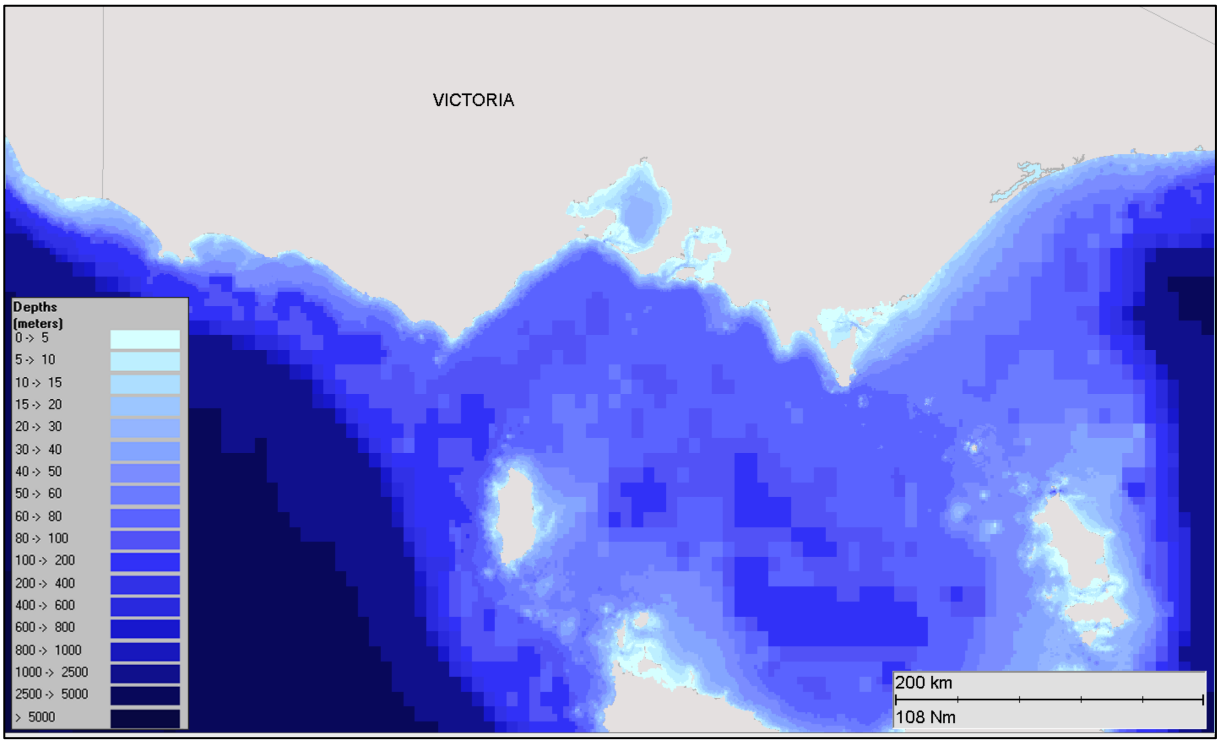

Figure 4 Bathymetry defined throughout the tidal model domain.

3.1.2 Tidal Conditions

The ocean boundary data for the regional model was obtained from satellite measured altimetry data (TOPEX/Poseidon 8.0) which provided estimates of the eight dominant tidal constituents at a horizontal scale of approximately 0.25 degrees. The eight major tidal constituents used were K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1. Using the tidal data, time series surface heights were calculated along the open boundaries for the simulation period.

The Topex-Poseidon satellite data has a resolution of 0.25 degrees globally, with higher resolution in coastal regions, and is produced and quality controlled by NASA (National Aeronautics and Space Administration). The data capturing satellites, equipped with two altimeters capable of taking sea level measurements accurate to less than ± 5 cm, measured oceanic surface elevations (and the resultant tides) for the period 1992–2005. In total these satellites carried out 62,000 orbits of the planet. The Topex-Poseidon tidal data has been widely reported amongst the oceanographic community, being included in more than 2,100 research publications (e.g. Andersen, 1995; Ludicone et al., 1998; Matsumoto et al., 2000; Kostianoy et al., 2003; Yaremchuk & Tangdong, 2004; Qiu & Chen 2010). The Topex/Poseidon tidal data is considered suitably accurate for this study.

3.1.3 Surface Elevation Validation

To ensure that tidal predictions were accurate, predicted surface elevations were compared to data from five locations situated within the study area (Figure 5).

Figure 6 and Figure 7 illustrate comparisons of the predicted and observed surface elevations for each location for January 2014. As shown on the graph, the model accurately reproduced the phase and amplitudes throughout the spring and neap tidal cycles.

To provide a statistical measure of the model's performance, the Index of Agreement (IOA – Willmott, 1981) and the Mean Absolute Error (MAE – Willmott, 1982; Willmott & Matsuura, 2005) were used.

The MAE is the average of the absolute values of the difference between the model-predicted (P) and observed (O) variables. It is a more natural measure of the average error and more readily understood (Willmott & Matsuura, 2005).

$$MAE = N^{-1} \sum_{i=1}^{N} |P_i - O_i|$$

The Index of Agreement (IOA) is determined by:

$$IOA = 1 - \frac{\sum |X_{model} - X_{obs}|^2}{\sum (|X_{model} - \overline{X_{obs}}| + |X_{obs} - \overline{X_{obs}}|)^2}$$

Where: X represents the variable being compared and the time mean of that variable. A perfect agreement exists between the model and field observations if the index gives an agreement value of 1 and complete disagreement will produce an index measure of 0 (Wilmott, 1981). Willmott et al. (1985) also suggests that values meaningfully larger than 0.5 represent good model performance. Clearly, a greater IOA and lower MAE represent a better model performance.

Table 4 Statistical comparison between the observed and HYDROMAP predicted surface elevations. shows the IOA and MAE values for the selected locations.

Figure 8 shows a screenshot of the predicted tidal current vectors within the Otway Basin.

Table 4 Statistical comparison between the observed and HYDROMAP predicted surface elevations.

Tide Station	IOA	MAE (m)
Gabo Island	0.98	0.08
Port MacDonnell	0.98	0.05
Port Welshpool	0.92	0.30
Portland	0.97	0.07
Stack Island	0.96	0.22

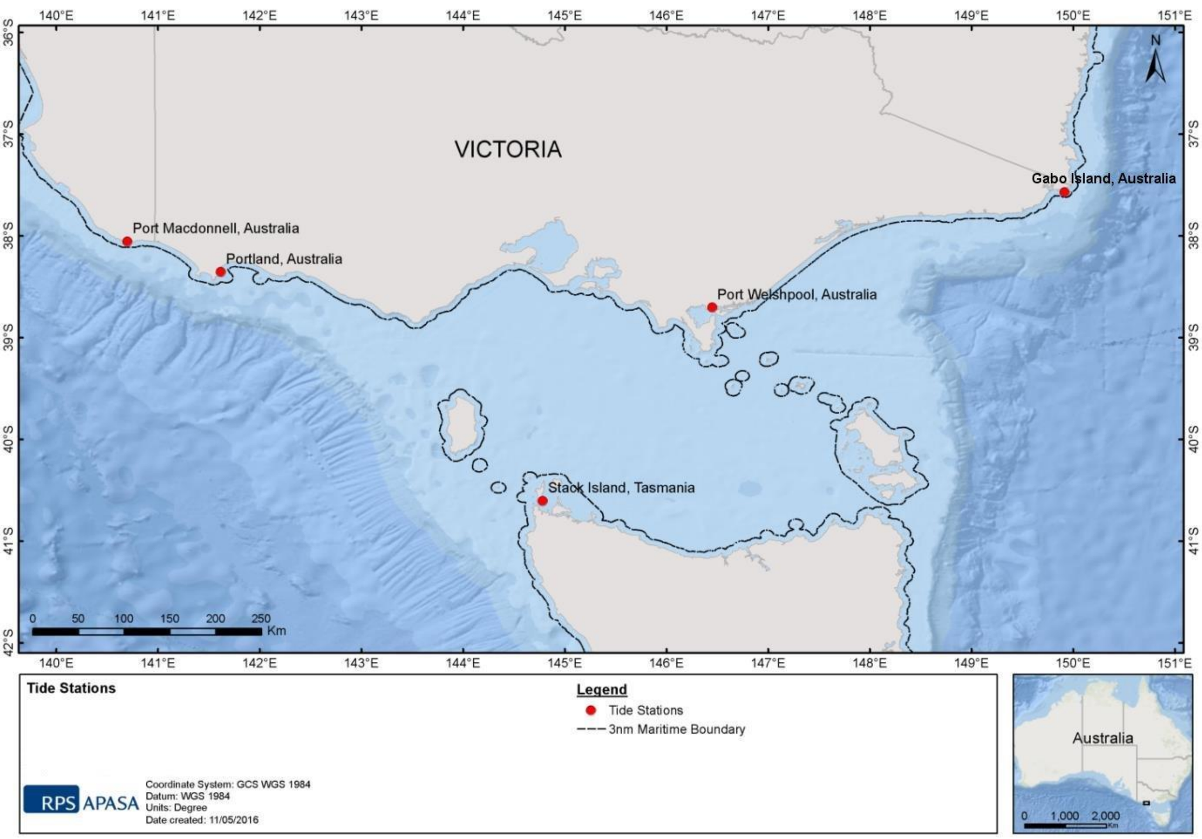

Figure 5 Location of the tide stations used in the surface elevation validation.

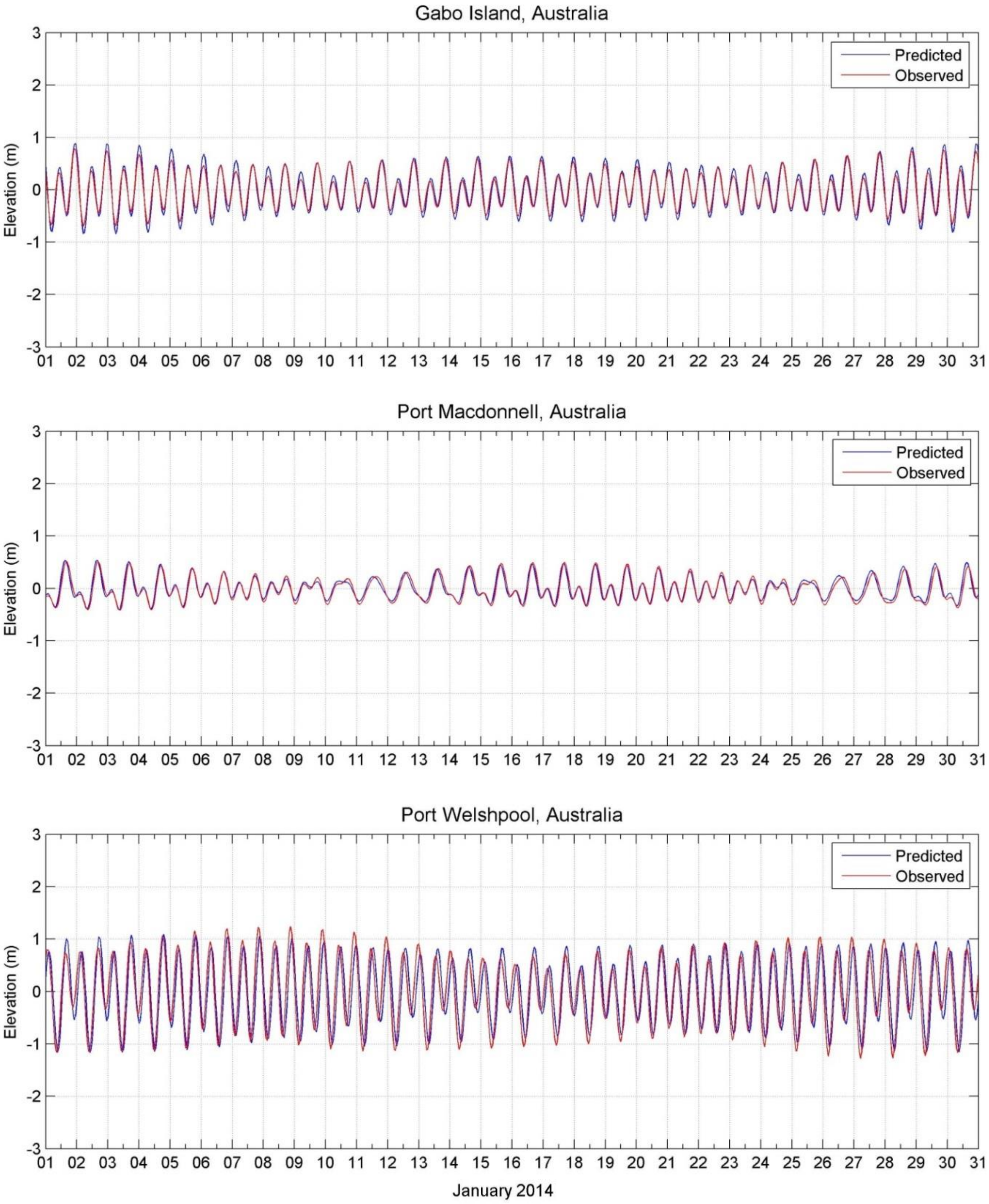

Figure 6 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation at tidal stations Gabo Island (upper image), Port MacDonnell (middle image) and Port Welshpool (lower image).

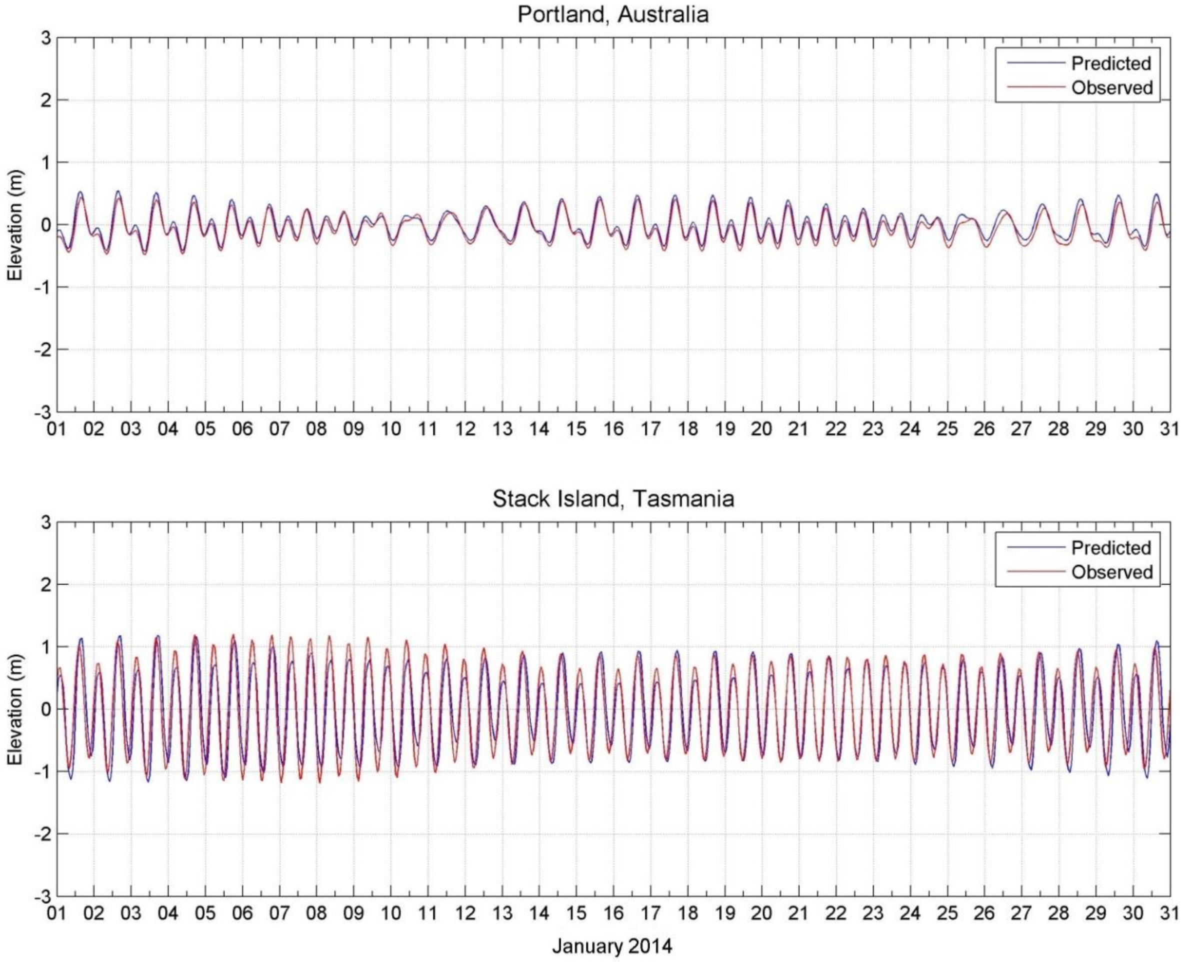

Figure 7 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation at tidal stations Portland (upper image) and Stack Island (lower image).

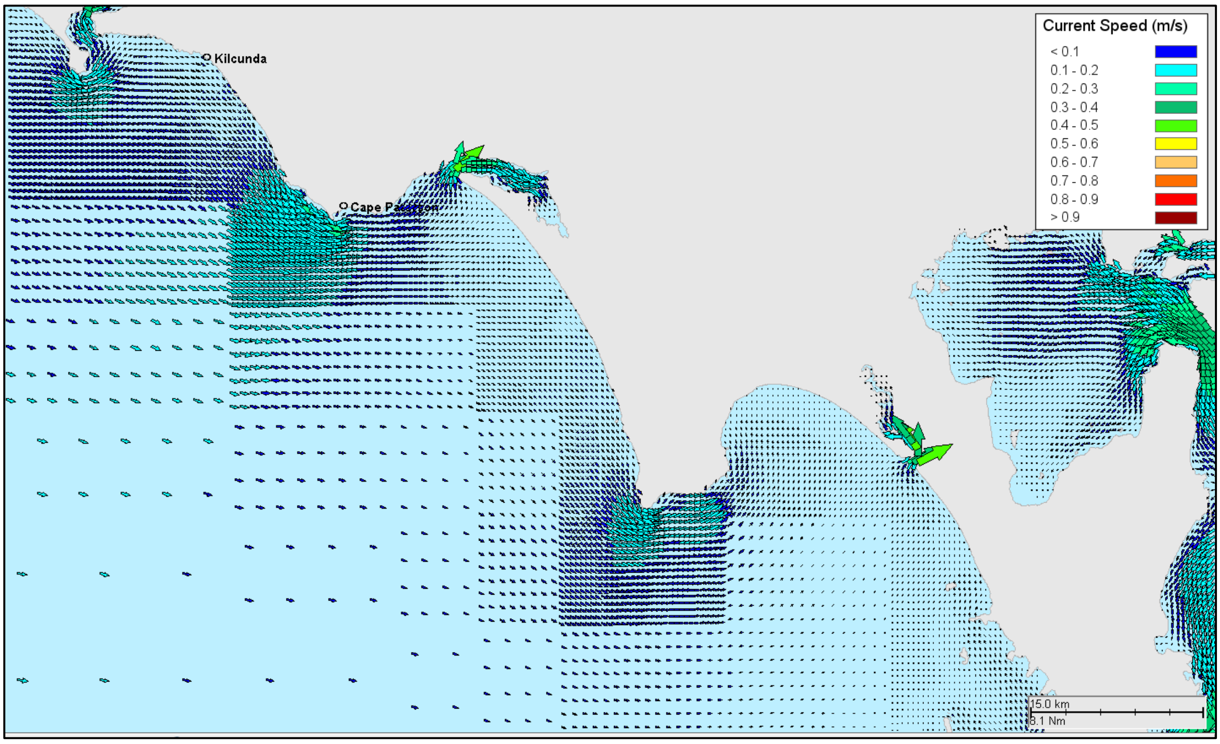

Figure 8 Snapshot of the predicted tidal current vectors. Note the density of the tidal vectors vary with the grid resolution, particularly along the coastline and around the islands and sholas. Colourations of individual vectors indicate current speed.

3.2 Ocean Currents

Data describing the flow of ocean currents was obtained from HYCOM (Hybrid Coordinate Ocean Model, (Chassignet et al., 2007), which is operated by the HYCOM Consortium, sponsored by the Global Ocean Data Assimilation Experiment (GODAE). HYCOM is a data-assimilative, three-dimensional ocean model that is run as a hindcast (for a past period), assimilating time-varying observations of sea surface height, sea surface temperature and in-situ temperature and salinity measurements (Chassignet et al., 2009). The HYCOM predictions for drift currents are produced at a horizontal spatial resolution of approximately 8.25 km (1/12th of a degree) over the region, at a frequency of once per day. HYCOM uses isopycnal layers in the open, stratified ocean, but uses the layered continuity equation to make a dynamically smooth transition to a terrain-following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or unstratified seas.

For this study, the HYCOM hindcast currents were obtained used. Figure 9 shows an example modelled surface ocean currents (HYCOM) during the study period.

Figure 10 and Figure 11 show the monthly and total current rose distributions resulting from the combination of HYCOM ocean current data and HYDROMAP tidal data nearby the Yolla release site.

Note the convention for defining current direction is the direction the current flows towards, which is used to reference current direction throughout this report. Each branch of the rose represents the currents flowing to that direction, with north to the top of the diagram. Sixteen directions are used. The branches are divided into segments of different colour, which represent the current speed ranges for each direction. Speed intervals of

0.1 m/s are predominantly used in these current roses. The length of each coloured segment is relative to the proportion of currents flowing within the corresponding speed and direction.

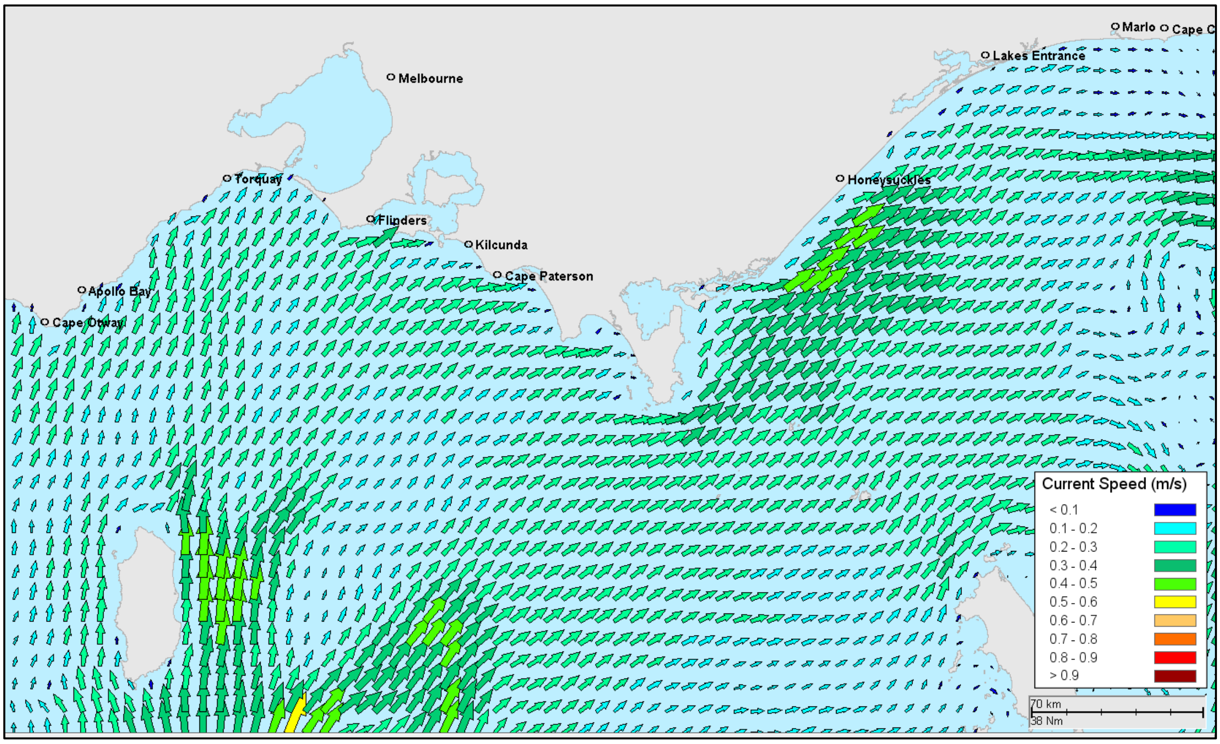

Figure 9 Modelled surface ocean currents presented for the 1st May 2012. Derived from the HYCOM ocean hindcast model. The colours of the vectors indicate current speed in m/s.

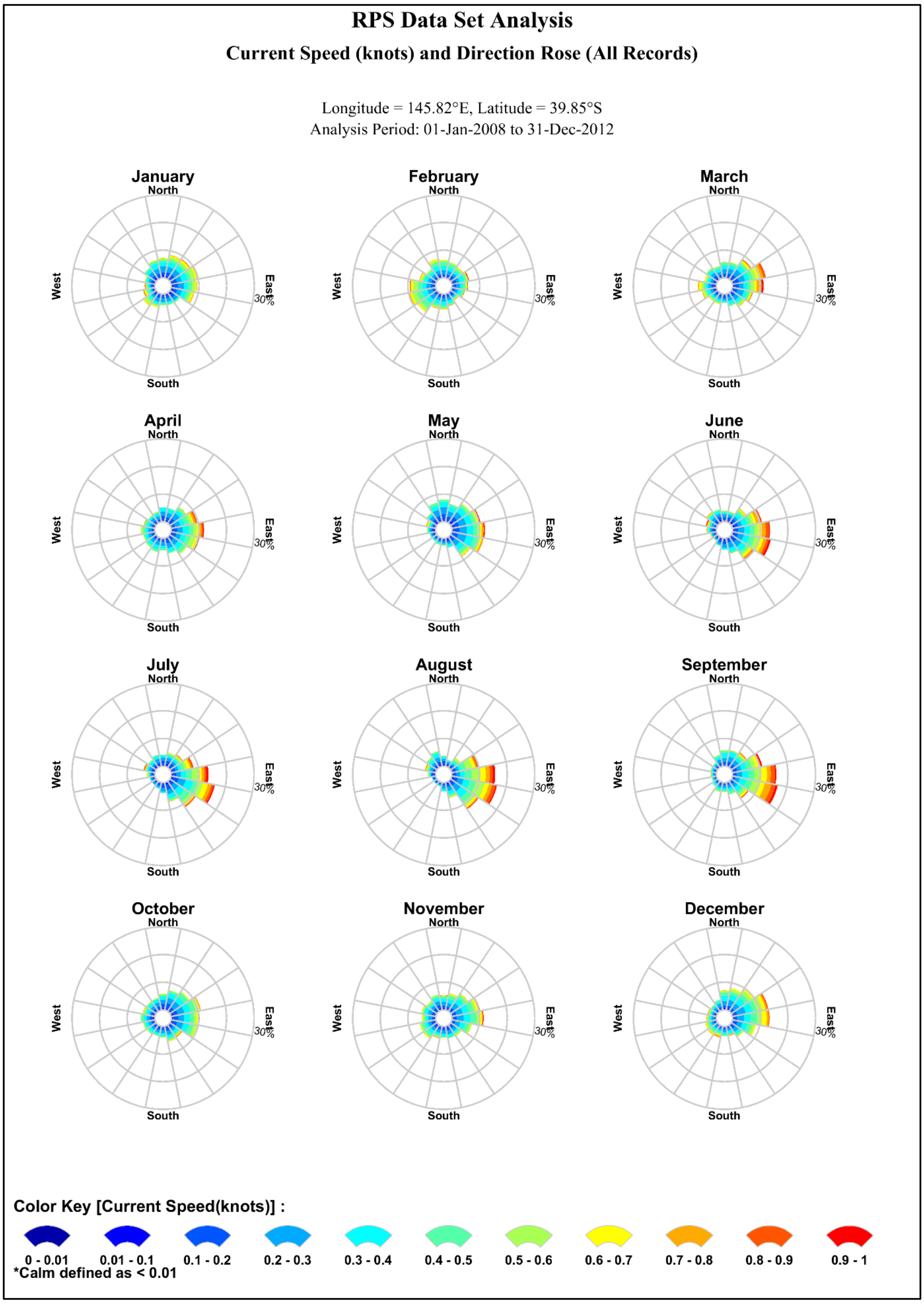

Figure 10 Monthly surface current rose plots nearby the Yolla release site (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2008–2012 (inclusive). The colour key shows the current magnitude (m/s), the compass direction provides the current direction flowing TOWARDS and the length of the wedge gives the percentage of the record for a particular speed and direction combination.

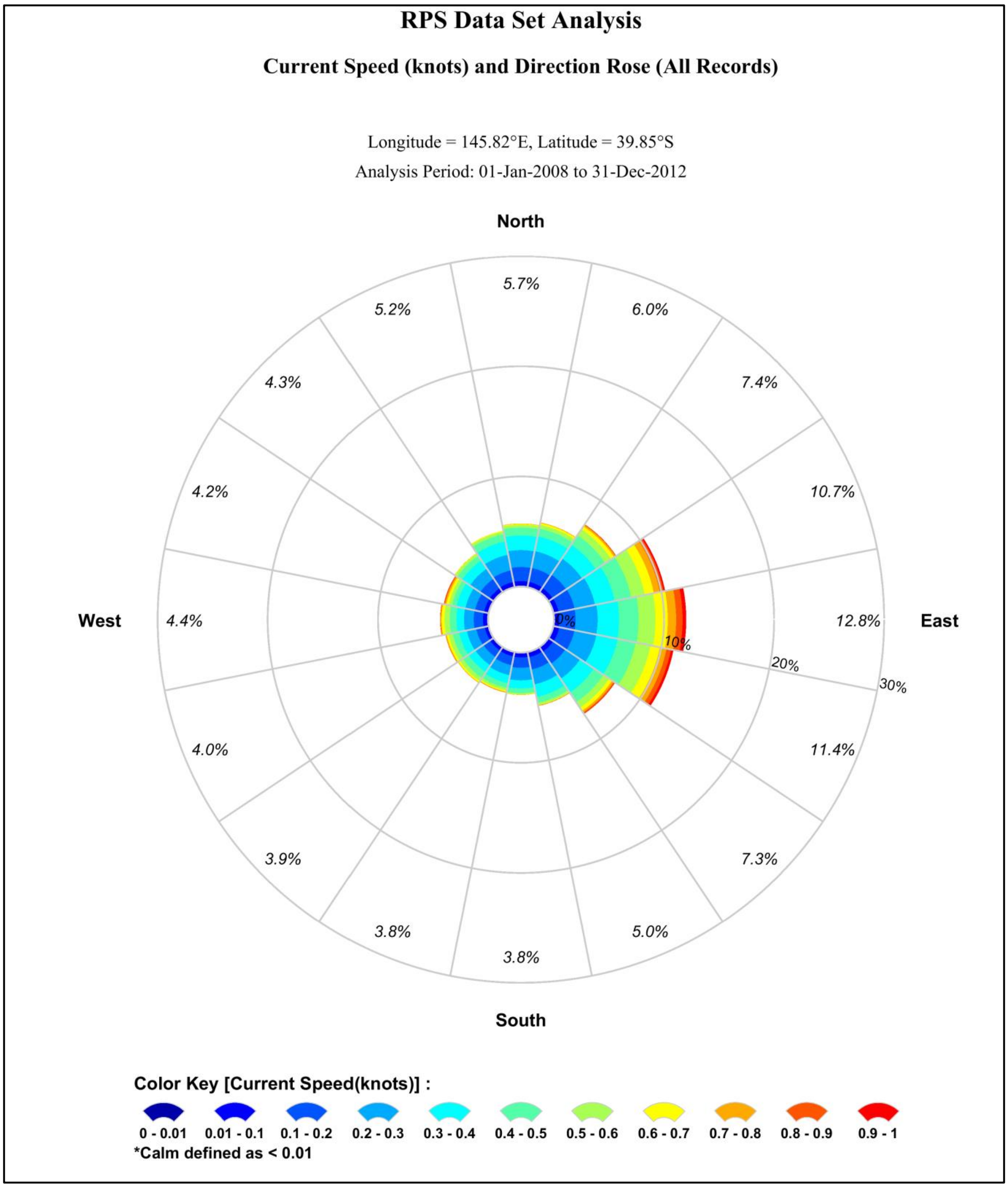

Figure 11 Modelled total surface current rose plot nearby the Yolla release site (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2008–2012 (inclusive). The colour key shows the current magnitude (m/s), the compass direction provides the current direction flowing TOWARDS and the length of the wedge gives the percentage of the record for a particular speed and direction combination.

4.0 Modelling Methods

4.1 Description of Models

4.1.1 Near-Field Model

The near-field mixing and dispersion of the operational discharge was simulated using the fully three-dimensional flow model in CORMIX.

CORMIX is a mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones.

CORMIX contains a series of elements for the analysis and design of conventional or toxic, single or multi-port, submerged or surface, buoyant or nonbuoyant, pollutant discharges into stratified or unstratified watercourses, with emphasis on the geometry and dilution characteristics on the initial mixing zone. (Doneker, 1990; Jirka & Doneker, 1991)

CORMIX has been validated in many independent studies over the years. A list of some of these studies is provided on the CORMIX website (http://www.cormix.info/validations.php).

4.2 Near-Field Model Setup

4.2.1 Ambient Environmental Conditions

Inputs for the ambient environmental conditions included a vertical profile of salinity and water temperature, along with static current speeds and general direction. The salinity and water temperature and profiles are important to accurately account for buoyancy of the diluting plume, whilst the current speeds influence the intensity of initial mixing and the deflection of the PW plume. These inputs are described below.

4.2.1.1 Ambient Temperature and Salinity

Table 5 shows the seasonal water temperature and salinity levels at varying depths from 0 to 50 m at the release site. The data was sourced from the World Ocean Atlas 2013 database produced by the National Oceanographic Data Centre (National Oceanic and Atmospheric Administration) and its co-located World Data Center for Oceanography (see Levitus et al., 2013).

Seasonal water temperature profiles show a 2–4 °C difference between the summer and winter conditions. The temperature ranged from 14.74 to 17.79°C during the summer season and 12.78 to 13.11°C during the winter season. Alternatively, salinity values demonstrate greater consistency across the seasons and depth range. Salinity values during the summer season ranged from 35.36 to 35.52 PSU and 35.49 to 35.61 PSU during the winter season.

Table 5 Seasonal temperature and salinity profile adjacent at the release site.

Season	Depth (m)	Temperature (°C)	Salinity (PSU)
Summer	0	18.05	35.36
	10	17.79	35.41
	20	17.55	35.44
	30	17.36	35.44
	40	16.78	35.44
	50	14.74	35.52
Winter	0	13.11	35.49
	10	13.07	35.57
	20	13.02	35.58
	30	12.81	35.60
	40	12.79	35.61
	50	12.78	35.61

4.2.1.2 Ambient Currents

The 5-year current dataset was analysed to determine the 5^{th} and 95^{th} percentile current speeds as input into the near-field model, representative of low and high current speeds, respectively.

Table 6 presents the 5^{th} and 95^{th} percentiles of current speeds through the water column, which produce contrasting dilution and advection cases:

- 5^{th} percentile current speed: low current speed, low dilution and slow advection;
- 95^{th} percentile current speed: high current speed, high dilution and rapid advection to nearby areas.

The 5^{th} and 95^{th} percentile values are referenced as low and high current speeds throughout the remainder of the report, respectively.

Table 6 Adopted ambient current conditions.

Depth (m)	5^{th} Percentile or low current speed (m/s)	95^{th} Percentile or high current speed (m/s)
0	0.042	0.390
10	0.030	0.254
20	0.028	0.227
30	0.027	0.224
40	0.026	0.218
50	0.026	0.212

5.0 Results

5.1 Near-Field Modelling Results

Table 7 presents a summary of the near-field plume results for each of the three cases for summer and winter conditions under low and high current speed conditions.

Figure 12 to Figure 14 show the trajectory of the plume through the water column as the current transport it away from the discharge point.

The furthest distance for any plume to reach 1000:1 dilution was 70 m, for the Case 3 – Worst Case Operation scenario (300 m^3/day) under summer conditions with high current speed.

Plumes released during summer conditions required a greater distance before reaching 1,000:1 dilution, in comparison to plumes released during winter.

Plumes released during low current speed conditions rose higher in the water column and travelled less horizontally than plumes released in high current speed conditions for all three flow rates modelled under summer and winter conditions.

Table 7 Maximum horizontal distance from the discharge point that centreline dilution (X:1) was predicted to travel.

Case	Season	Current Speed (%ile)	Maximum Distance from Discharge Point to Centreline Dilution X:1 (m)																		
			10	20	30	40	50	60	70	80	90	100	200	300	400	500	600	700	800	900	1000
Case 1 Design Operation	Summer	5th	0.2	0.4	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.5	2.7	3.7	4.6	5.4	6.2	7.0	7.8	8.5	9.2
		95th	1.2	2.2	3.0	3.6	4.2	4.8	5.3	5.8	6.3	6.7	11.0	14.9	18.4	21.8	25.1	28.4	31.6	34.8	38.0
	Winter	5th	0.2	0.4	0.6	0.7	0.9	1.0	1.1	1.2	1.4	1.5	2.6	3.6	4.5	5.3	6.1	6.8	7.6	8.3	9.0
		95th	1.2	2.2	3.0	3.6	4.2	4.7	5.2	5.7	6.2	6.7	10.9	14.6	18.0	21.2	24.3	27.3	30.1	32.9	35.6
Case 2 Typical Operation	Summer	5th	0.3	0.5	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	3.8	5.3	6.6	7.9	9.1	10.2	11.2	12.3	13.3
		95th	1.4	2.6	3.6	4.5	5.4	6.2	6.9	7.7	8.4	9.1	15.4	21.1	26.5	31.8	37.1	42.5	48.1	53.9	59.9
	Winter	5th	0.3	0.5	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.1	3.7	5.2	6.5	7.7	8.9	10.0	11.1	12.2	13.2
		95th	1.4	2.6	3.6	4.5	5.3	6.1	6.8	7.6	8.3	9.0	15.1	20.5	25.5	30.2	34.7	39.0	43.2	47.2	51.2
Case 3 Worst Case Operation	Summer	5th	0.3	0.6	0.9	1.1	1.4	1.6	1.8	2.1	2.3	2.5	4.4	6.1	7.6	9.0	10.4	11.6	12.9	14.0	15.1
		95th	1.5	2.9	4.0	5.0	6.0	6.9	7.7	8.6	9.4	10.2	17.5	24.1	30.5	36.8	43.3	49.9	56.7	63.5	70.3
	Winter	5th	0.3	0.6	0.9	1.1	1.4	1.6	1.8	2.0	2.2	2.4	4.3	5.9	7.4	8.9	10.2	11.5	12.8	14.1	15.4
		95th	1.5	2.8	3.9	4.9	5.9	6.8	7.6	8.5	9.3	10.1	17.1	23.2	28.9	34.4	39.5	44.5	49.3	54.0	58.6

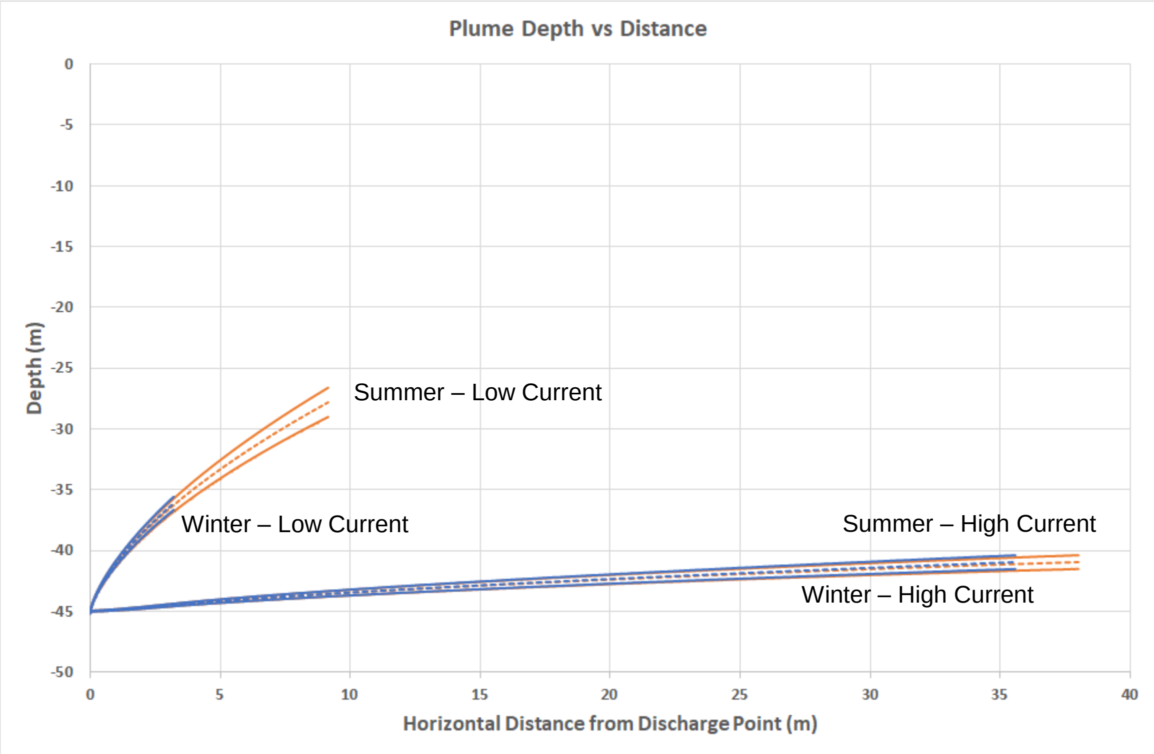

Figure 12 Plume depth versus distance for Case 1 Design Operation (100 m^3/day flow) for summer and winter under low and high current flow conditions.

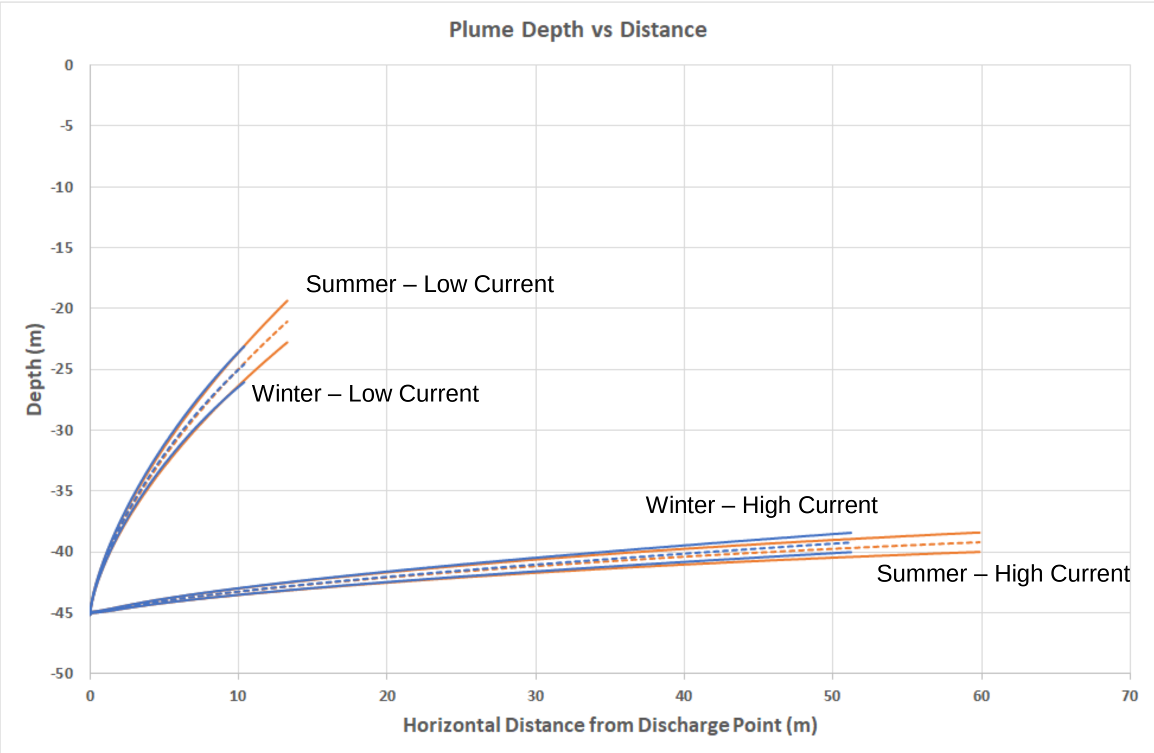

Figure 13 Plume depth versus distance for Case 2 Typical Operation (200 m^3/day flow) for summer and winter under low and high current flow conditions.

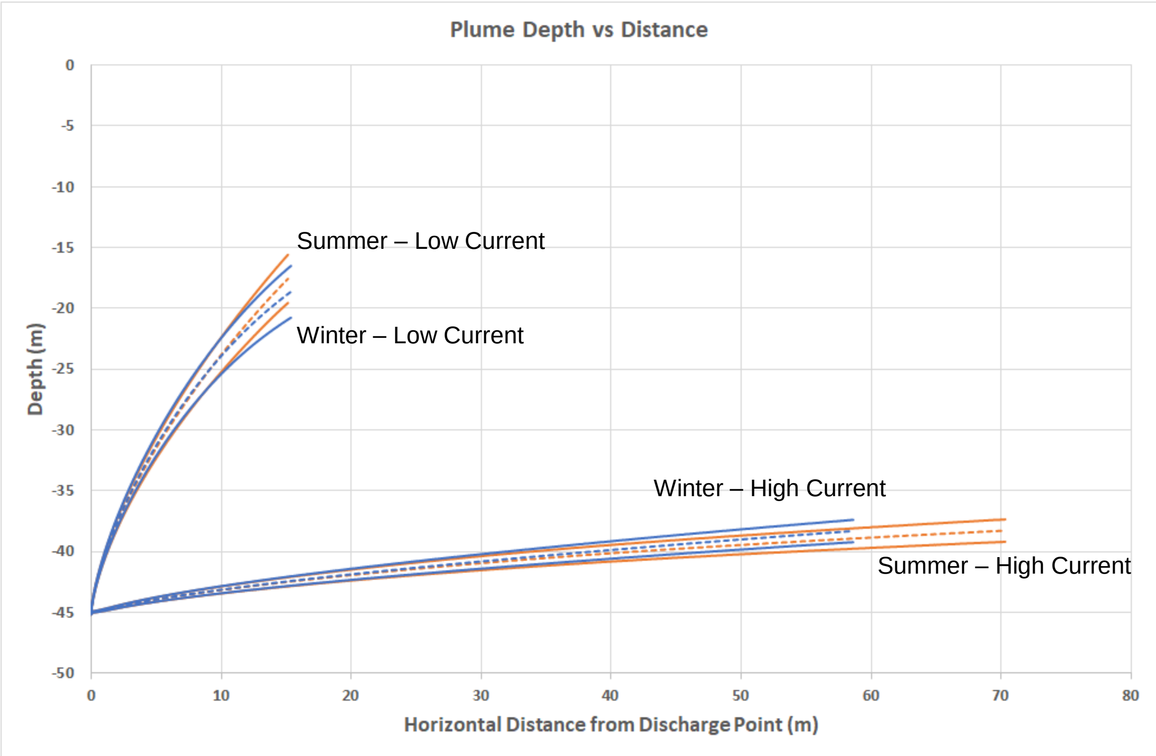

Figure 14 Plume depth versus distance for Case 3 Worst-Case Operation (300 m^3/day flow) for summer and winter under low and high current flow conditions.

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Appendix 11

Beach Yolla Platform Produced Water Dispersion Far-Field Modelling Study (RPS, 2020)

MAKING COMPLEX EASY

BEACH YOLLA PLATFORM

Produced Water Dispersion Far-Field Modelling Study

MAQ0975J
Beach Yolla Platform PW
Rev0
23 September 2020

rpsgroup.com

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
RevA	Draft issued for internal review	Dr Ryan Dunn	Dr Sasha Zigic	Dr Sasha Zigic	23 September 2020
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Approval for issue

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1.0 PROJECT BACKGROUND

Beach Energy Limited (Beach) is the operator the Yolla Platform which is located within the production license T/L1 approximately 100 km offshore from mainland Victoria in the Bass Strait (Table 1.1 and Figure 1.1). The water depth in the vicinity of the platform is approximately 80 m.

In 2017, RPS was commissioned to undertake a near-field produced water (PW) dispersion modelling study (MAQ0573) for the Yolla Platform based on the following three cases: Case 1- Design (100 m^3/day); Case 2 - Typical (200 m^3/day; and Case 3- Worst Case (300 m^3/day). The cases and in turn discharge rates are based on the original PW design flow rate, expected operation post-debottlenecking and end of field life, respectively. The study findings revealed that the furthest distance travelled by the plume was 70 m and achieved a 1:1,000 dilution for Case 3 under high current speeds. (RPS, 2017).

Subsequently, Beach has requested modelling to assess the zones of dilution for the average (1:3,482) and maximum (1:5,400) total recoverable hydrocarbons (TRH) based on ANZECC guidelines. As well as reporting the distance to achieve the 1:62.5 dilution for the three cases.

Table 1.1 Yolla Platform used as the release location for the produced formation water dispersion modelling study.

Release location	Latitude	Longitude	Water Depth (m)
Yolla Platform	39° 50' 39.5" S	145° 49' 5.9" E	80

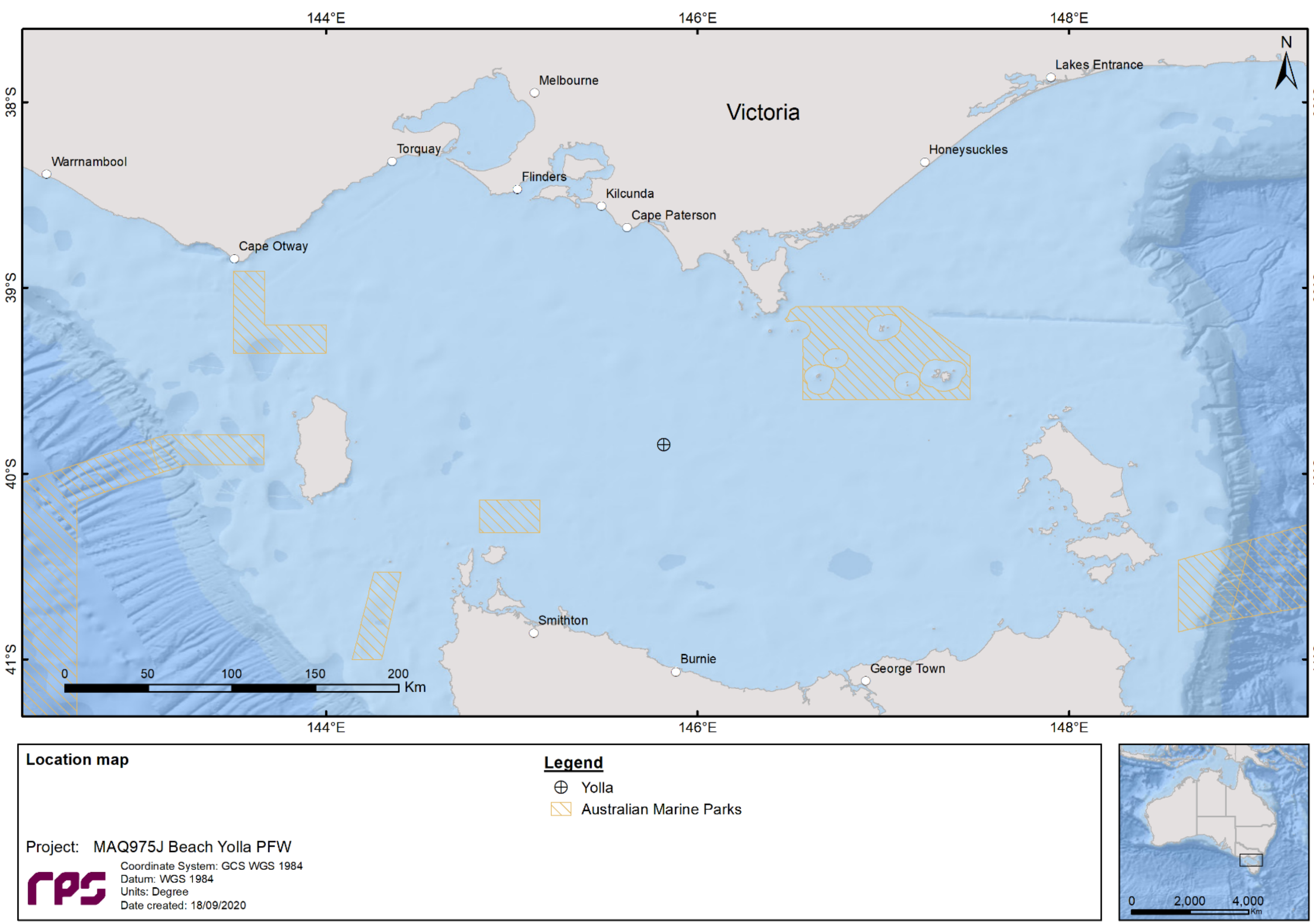


Figure 1.1 Map showing the location of the Yolla Platform used as the release location for the produced formation water dispersion modelling study.

2.0 SCOPE OF WORK

The physical mixing of the PW stream can be separated into two distinct zones: (a) near-field; and (b) far-field. The limits of the near-field zone are defined by the area where the levels of mixing and dilution are controlled by the plume's initial jet momentum and the buoyancy flux, resulting from the density difference. When the plume encounters a boundary such as the water surface, or loses its buoyancy, the near-field mixing is complete, and the far-field mixing begins.

This study utilises the findings from the previously completed near-field modelling to accurately assess the predicted far-field plume dynamics. Therefore, the scope of work included the following components:

1. Generate a 5-year 3-dimensional current data set (2008-2012) that included the combined influence of ocean and tidal currents;
2. Determine the least energetic month and lower current speeds for input into the far-field three-dimensional dispersion model. This approach provides a conservative approach in estimating the level of mixing and dispersion.
3. Generate vertical profiles of salinity and water temperature for the identified period;
4. Model the far-field mixing of the PW discharge based on each of the three operational discharge rates (i.e., 100 m^3/day, 200 m^3/day and 300 m^3/day) over a 31-day period using time-varying current data;
5. Generate plots illustrating the predicted zones of dilution for the whole PW stream for each discharge rate based on dilutions of 1:62.5, 1:3,482.4 dilutions (TRH average) and 1:5,400 dilutions (TRH maximum); and
6. Generate a summary table presenting the maximum horizontal distance from the discharge point to predicted PW plume dilutions.

3.0 REGIONAL CURRENTS

Bass Strait is a body of water separating Tasmania from the southern Australian mainland, specifically the state of Victoria. The strait is a relatively shallow area off the continental shelf, connecting the southeast Indian Ocean with the Tasman Sea. Currents within the straight are driven by tides, winds, incident continental shelf waves and density driven flows. High winds and strong tidal currents are frequent within the area (Jones, 1980).

The varied geography and bathymetry of the region, in addition to the forcing of the south-eastern Indian Ocean and local meteorology lead to complex shelf and slope circulation patterns (Middleton & Bye, 2007). Figure 3.1 displays seasonal current trends within the Bass Strait. During winter there is a strong eastward water flow due to the strengthening of the South Australian Current (fed by the Leeuwin Current in the Northwest Shelf), which bifurcates with one extension moving though the Bass Strait, and another forming the Zeehan Current off western Tasmania (Sandery & Kampf 2007). During summer, water flow reverses off Tasmania, King Island and the Otway Basin travelling eastward, as the coastal current develops due to south-easterly winds.

To accurately describe the variability in currents between the inshore and offshore region, a hybrid regional dataset was developed by combining deep ocean predictions obtained from HYCOM (Hybrid Coordinate Ocean Model) with surface tidal currents developed by RPS. The following sections provide a summary of the hybrid regional data set.

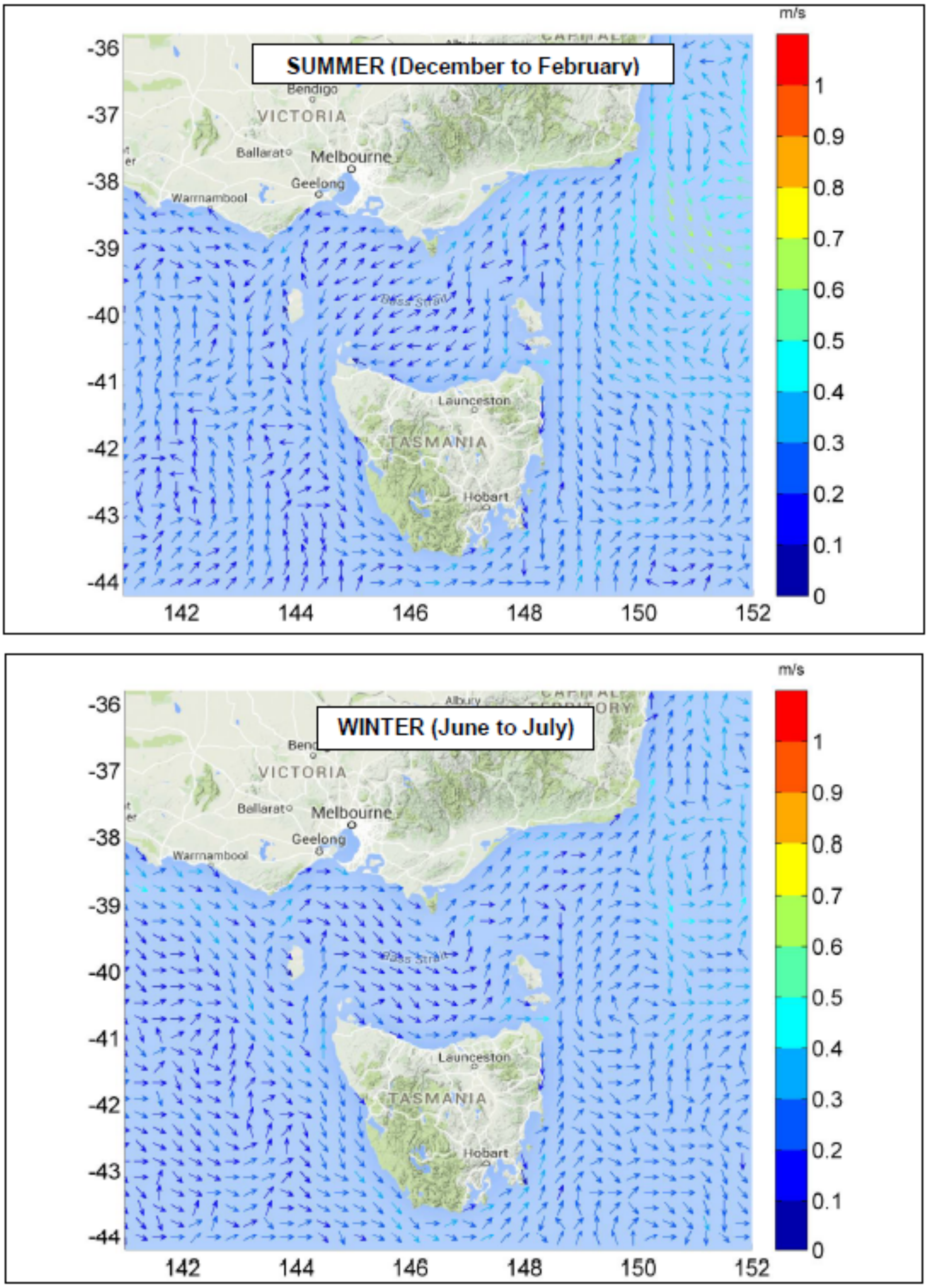


Figure 3.1 Example HYCOM averaged seasonal surface drift currents during summer and winter.

3.1 Tidal currents – HYDROMAP

Tidal current data was generated using RPS's advanced ocean/coastal model, HYDROMAP. The HYDROMAP model has been thoroughly tested and verified through field measurements throughout the world for over 30 years (Isaji and Spaulding, 1984; Isaji et al., 2001; Zigic et al., 2003). In fact, HYDROMAP tidal current data has been used as input to forecast (in the future) and hindcast (in the past) oil spills in Australian waters and forms part of the Australian National Oil Spill Emergency Response System operated by AMSA (Australian Maritime Safety Authority).

HYDROMAP employs a sophisticated sub-gridding strategy, which supports up to six levels of spatial resolution, halving the grid cell size as each level of resolution is employed. The sub-gridding allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, and/or of particular interest to a study.

The numerical solution methodology follows that of Davies (1977a, 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji and Spaulding (1984) and Isaji et al. (2001).

3.1.1 Grid Setup

The model is sub-gridded to a resolution of 500 m for shallow and coastal regions, starting from an offshore (or deep water) resolution of 8 km. The finer grids are progressively allocated in a step-wise fashion to more accurately resolve flows along the coastline, around islands and over regions with more complex bathymetry. Figure 3.2 shows the tidal model grid covering the study domain.

A combination of datasets was used and merged to describe the shape of the seabed within the grid domain (Figure 3.3). These included spot depths and contours which were digitised from nautical charts released by the hydrographic offices as well as Geoscience Australia database and depths extracted from the Shuttle Radar Topography Mission (SRTM30_PLUS) Plus dataset (see Becker et al., 2009).

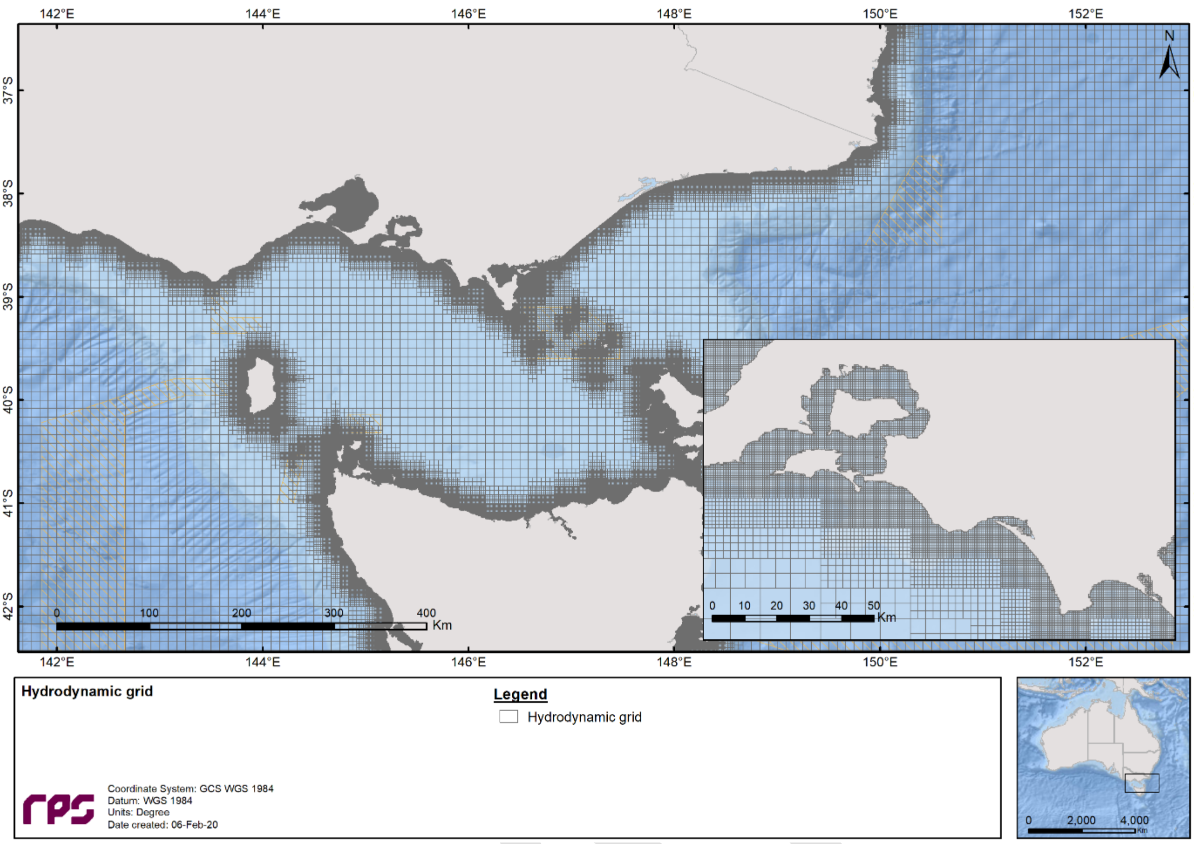


Figure 3.2 Sample of the model grid used to generate the tidal currents for the study region. Higher resolution areas are shown by the denser mesh.

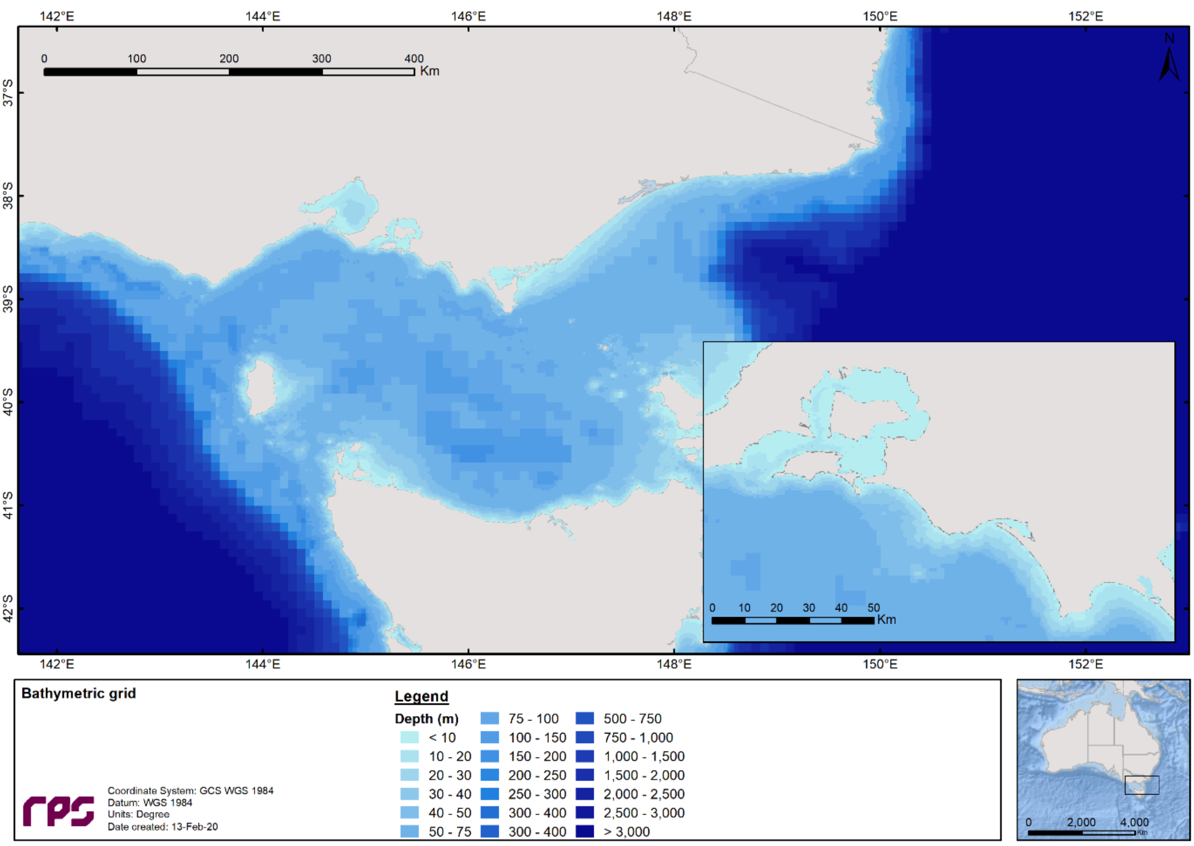


Figure 3.3 Bathymetry defined throughout the tidal model domain.

3.1.2 Tidal Conditions

The ocean boundary data for the regional model was obtained from satellite measured altimetry data (TOPEX/Poseidon 8.0) which provided estimates of the eight dominant tidal constituents at a horizontal scale of approximately 0.25 degrees. The eight major tidal constituents used were K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1. Using the tidal data, time series surface heights were calculated along the open boundaries for the simulation period.

The Topex/Poseidon satellite data has a resolution of 0.25 degrees globally, with higher resolution in coastal regions, and is produced and quality controlled by NASA (National Aeronautics and Space Administration). The data capturing satellites, equipped with two altimeters capable of taking sea level measurements accurate to less than ± 5 cm, measured oceanic surface elevations (and the resultant tides) for the period 1992–2005. In total these satellites carried out 62,000 orbits of the planet. The Topex-Poseidon tidal data has been widely used amongst the oceanographic community, being included in more than 2,100 research publications (e.g. Andersen, 1995; Ludicone et al., 1998; Matsumoto et al., 2000; Kostianoy et al., 2003; Yaremchuk & Tangdong, 2004; Qiu & Chen 2010). The Topex/Poseidon tidal data is considered suitably accurate for this study.

3.1.3 Surface Elevation Validation

To ensure that tidal predictions were accurate, predicted surface elevations were compared to data observed at a location situated within the study area (Figure 3.4).

To provide a statistical measure of the model performance, the Index of Agreement (IOA – Willmott, 1981) and the Mean Absolute Error (MAE – Willmott, 1982; Willmott & Matsuura, 2005) were used.

The MAE (Eq.1) is simply the average of the absolute values of the difference between the model-predicted (P) and observed (O) variables. It is a more natural measure of the average error (Willmott and Matsuura, 2005) and more readily understood. The MAE is determined by:

$$MAE = N^{-1} \sum_{i=1}^{N} |P_i - O_i| \qquad \text{Eq.1}$$

Where: N = Number of observations

P_i = Model predicted surface elevation

O_i = Observed surface elevation

The Index of Agreement (IOA; Eq. 2) in contrast, gives a non-dimensional measure of model accuracy or performance. A perfect agreement between the model predicted and observed surface elevations exists if the index gives an agreement value of 1, and complete disagreement between model and observed surface elevations will produce an index measure of 0 (Wilmott, 1981). Willmott et al (1985) also suggests that values larger than 0.5 may represent good model performance. The IOA is determined by:

$$IOA = 1 - \frac{\sum |X_{model} - X_{obs}|^2}{\sum (|X_{model} - \overline{X_{obs}}| + |X_{obs} - \overline{X_{obs}}|)^2} \qquad \text{Eq.2}$$

Where: X_{model} = Model predicted surface elevation

X_{obs} = Observed surface elevation

Clearly, a greater IOA and lower MAE represent a better model performance.

Figure 3.5 and Figure 3.6 illustrate a comparison of the predicted and observed surface elevations in February 2017. As shown on the graph, the model accurately reproduced the phase and amplitudes throughout the spring and neap tidal cycles.

Table 3.1 shows the IOA and MAE values for the selected tide station locations indicating that the model is performing well.

Table 3.1 Statistical comparison between the observed and HYDROMAP predicted surface elevations.

Tide Station	IOA	MAE (m)
Gabo Island	0.98	0.08
Port MacDonnell	0.98	0.05
Port Welshpool	0.92	0.30
Portland	0.97	0.07
Stack Island	0.96	0.22

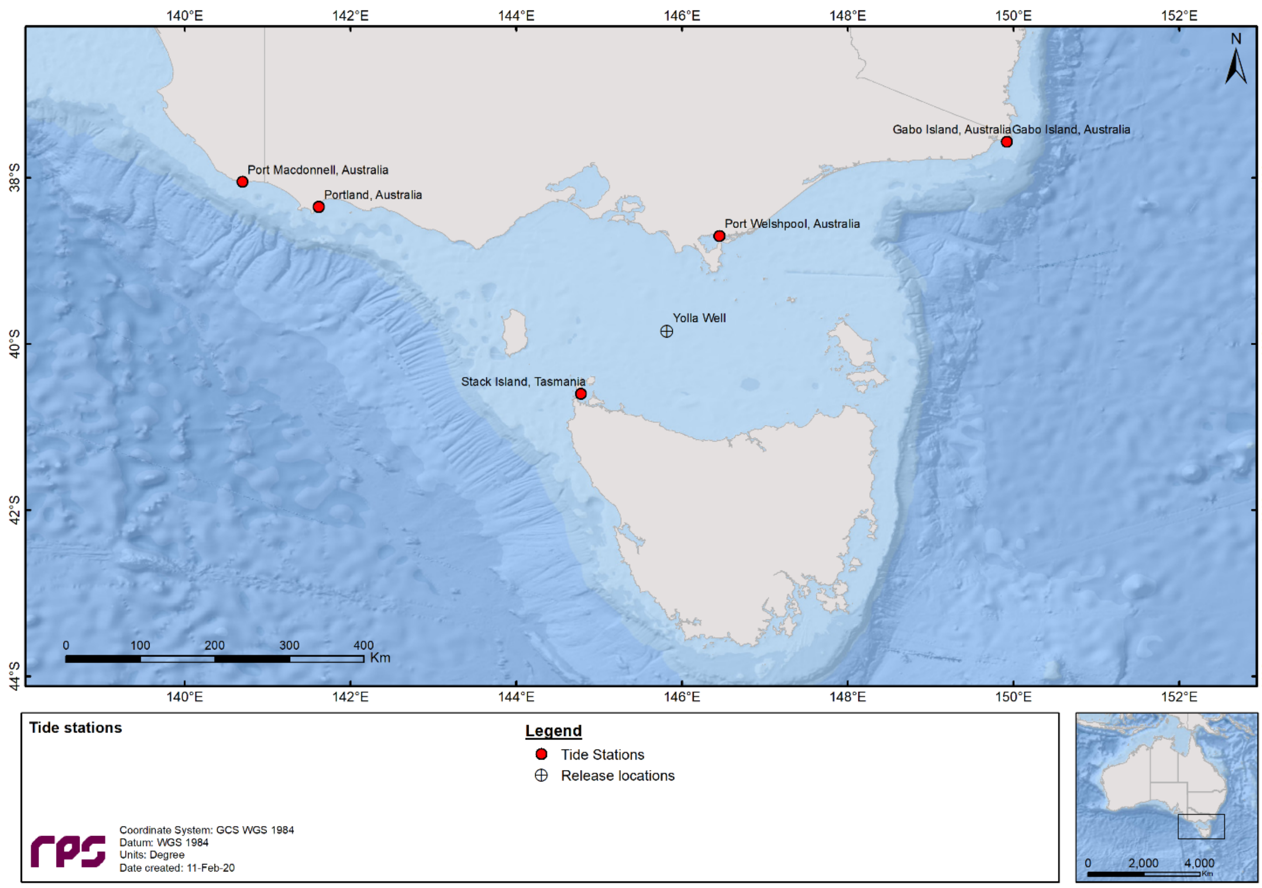
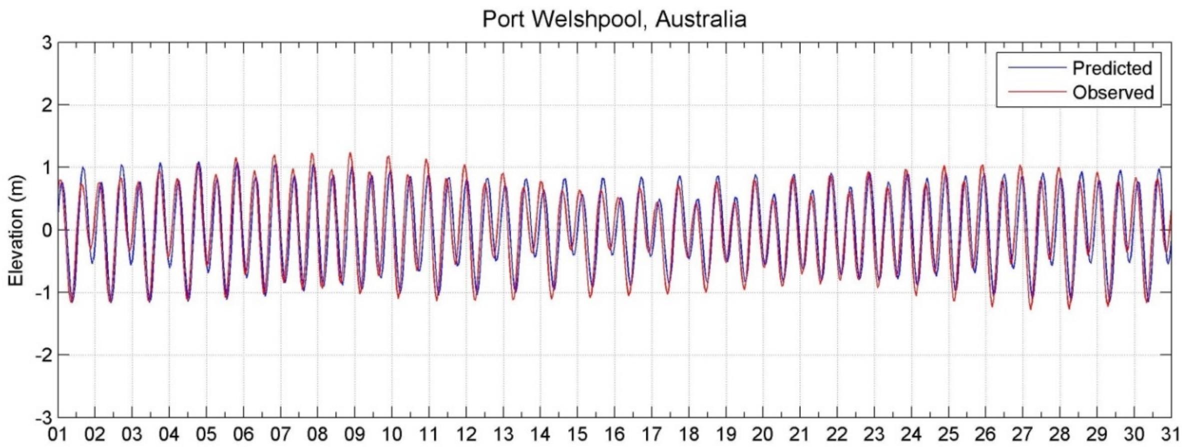
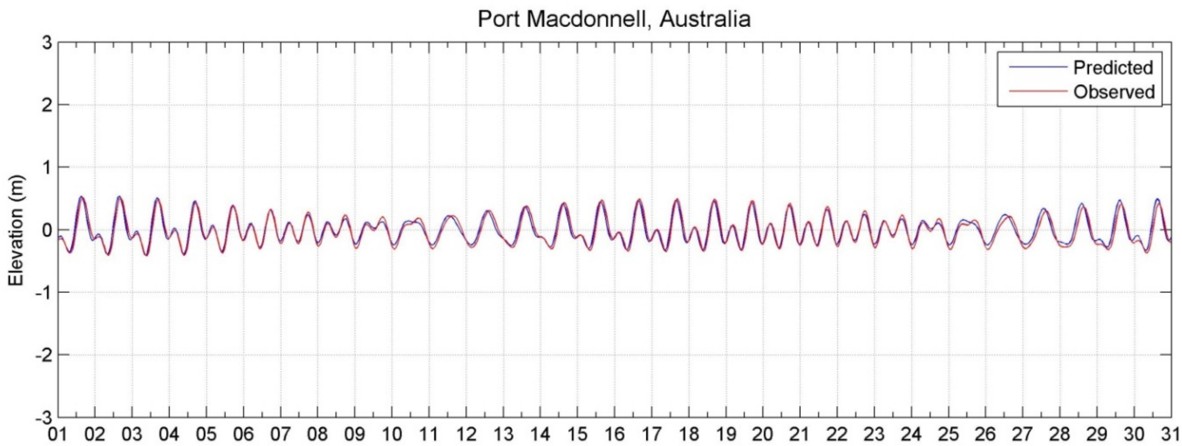


Figure 3.4 Location of the tide stations used in the surface elevation validation.





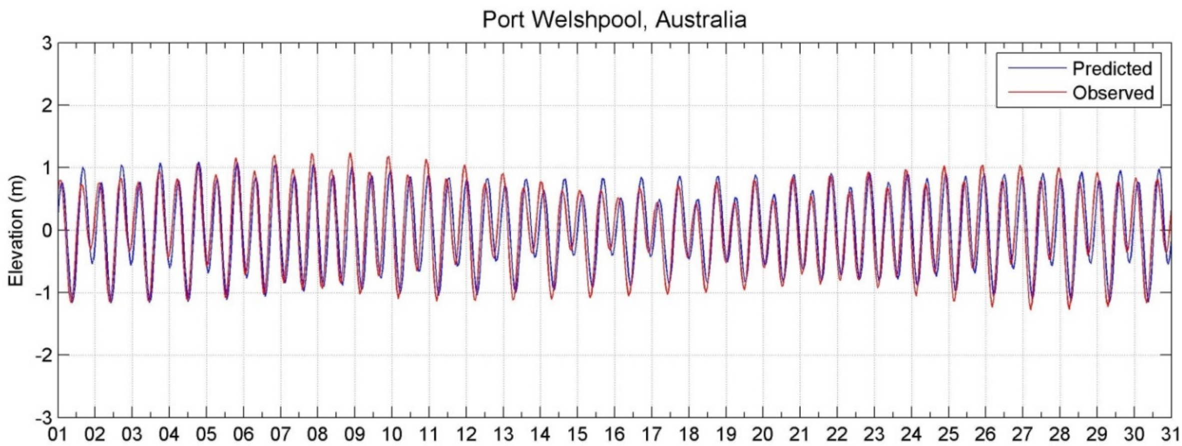


Figure 3.5 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation at tidal stations Gabo Island (upper image), Port MacDonnell (middle image) and Port Welshpool (lower image).

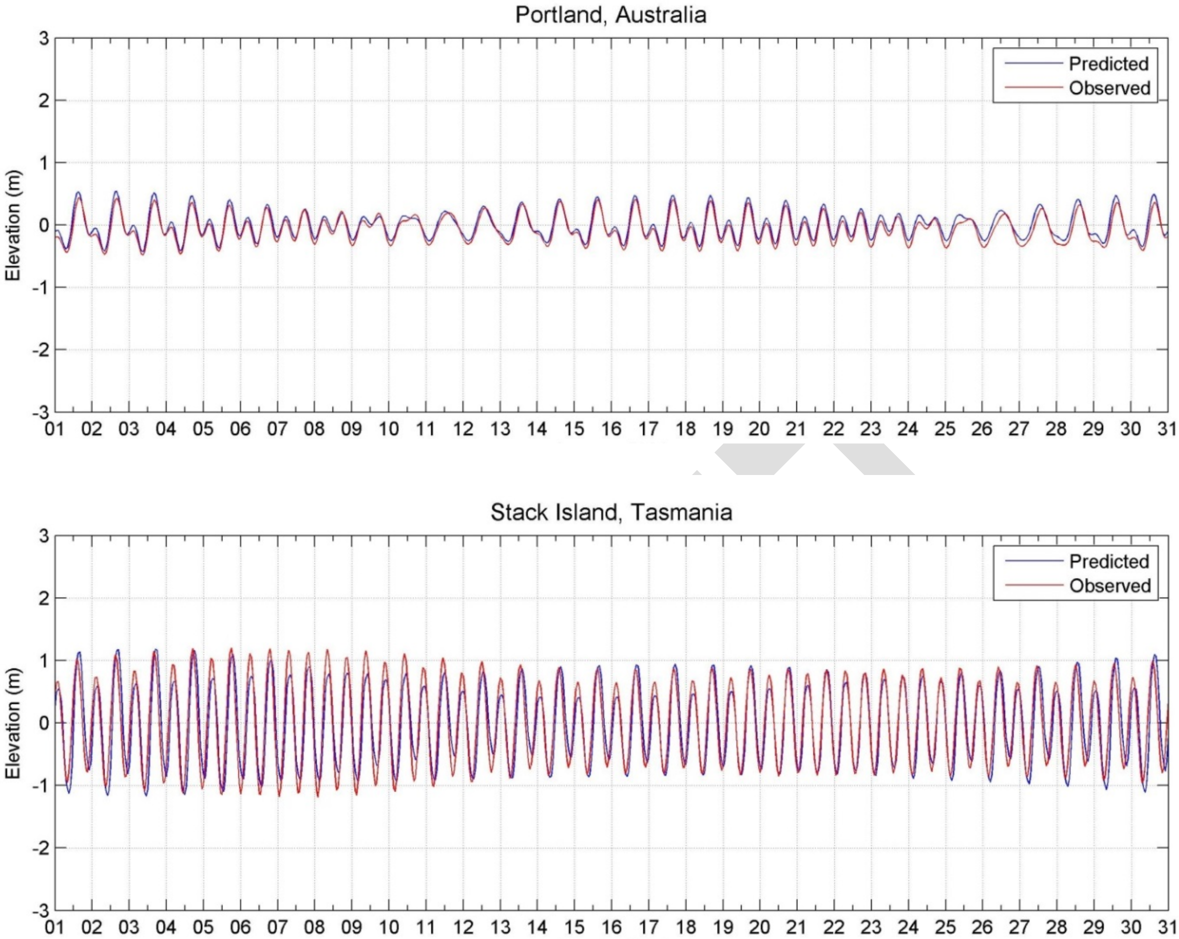


Figure 3.6 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation at tidal stations Portland (upper image) and Stack Island (lower image).

3.2 Ocean currents – HYCOM

The ocean currents (non-tidal) were represented by the output from a third-party three-dimensional ocean model, HYCOM (HYbrid Coordinate Ocean Model) (Wallcraft et al. 2003; Chassignet et al. 2007, 2009). HYCOM is operated by the HYCOM Consortium and sponsored by the Global Ocean Data Assimilation Experiment (GODAE). It uses an array of measured data as input to understand the current state of the water body, including time-varying observations of sea-surface height, sea-surface temperature and *in situ* temperature and salinity measurements (Chassignet et al. 2009). Numerical modelling is then employed to determine how the sea-state evolves between the measurement points. The HYCOM predictions are three-dimensional with a horizontal resolution of approximately 8.25 km and are recorded once per day. Hence, the data provides estimates of meso-scale ocean circulation, with horizontal resolution suitable to resolve eddies of approximately 20 kilometres in diameter, as well as connecting stream currents of similar spatial scale. HYCOM provides a comprehensive dataset spanning decades, with increasing data quality over more recent years through the increased availability of ocean observations from satellite and sensor data.

For this study, the HYCOM hindcast currents were obtained for the years 2008 to 2012 (inclusive). The ocean current data was retrieved at 10 m depth layers (0 – 80 m).

3.3 Current Speeds at the Release Site

Figure 3.7 presents the monthly current rose distributions resulting from the combination of HYCOM ocean current data and HYDROMAP tidal data nearby the Yolla release site.

Note the convention for defining current direction is the direction the current flows towards, which is used to reference current direction throughout this report. Each branch of the rose represents the currents flowing to that direction, with north to the top of the diagram. Sixteen directions are used. The branches are divided into segments of different colour, which represent the current speed ranges for each direction. Speed intervals of 0.1 m/s are predominantly used in these current roses. The length of each coloured segment is relative to the proportion of currents flowing within the corresponding speed and direction.

Table 3.2 presents the average and maximum net current speeds from combined HYCOM and tidal currents nearby the Yolla release site. Monthly current spends varied throughout the years ranging between 0.16 m/s (January) and 0.22 m/s (August). The dominant direction of surface currents was predominantly eastward.

The least energetic month of the current data was May 2011, which had an average monthly surface current speed of 0.13 m/s.

Table 3.2 Predicted monthly average and maximum surface current speeds nearby the Yolla release site. The data was derived by combining the HYCOM ocean data and HYDROMAP tidal data from 2008–2012 (inclusive).

Month	Average current speed (m/s)	Maximum current speed (m/s)	General direction
January	0.16	0.48	Variable
February	0.18	0.66	Variable
March	0.18	0.68	East-northeast
April	0.17	0.98	East
May	0.16	0.73	East
June	0.19	0.85	East-southeast
July	0.20	1.02	East-southeast
August	0.22	0.99	East-southeast
September	0.21	0.73	East-southeast
October	0.16	0.54	East-northeast
November	0.17	0.61	East
December	0.18	0.48	East
Minimum	**0.16**	**0.48**	
Maximum	**0.22**	**1.02**	

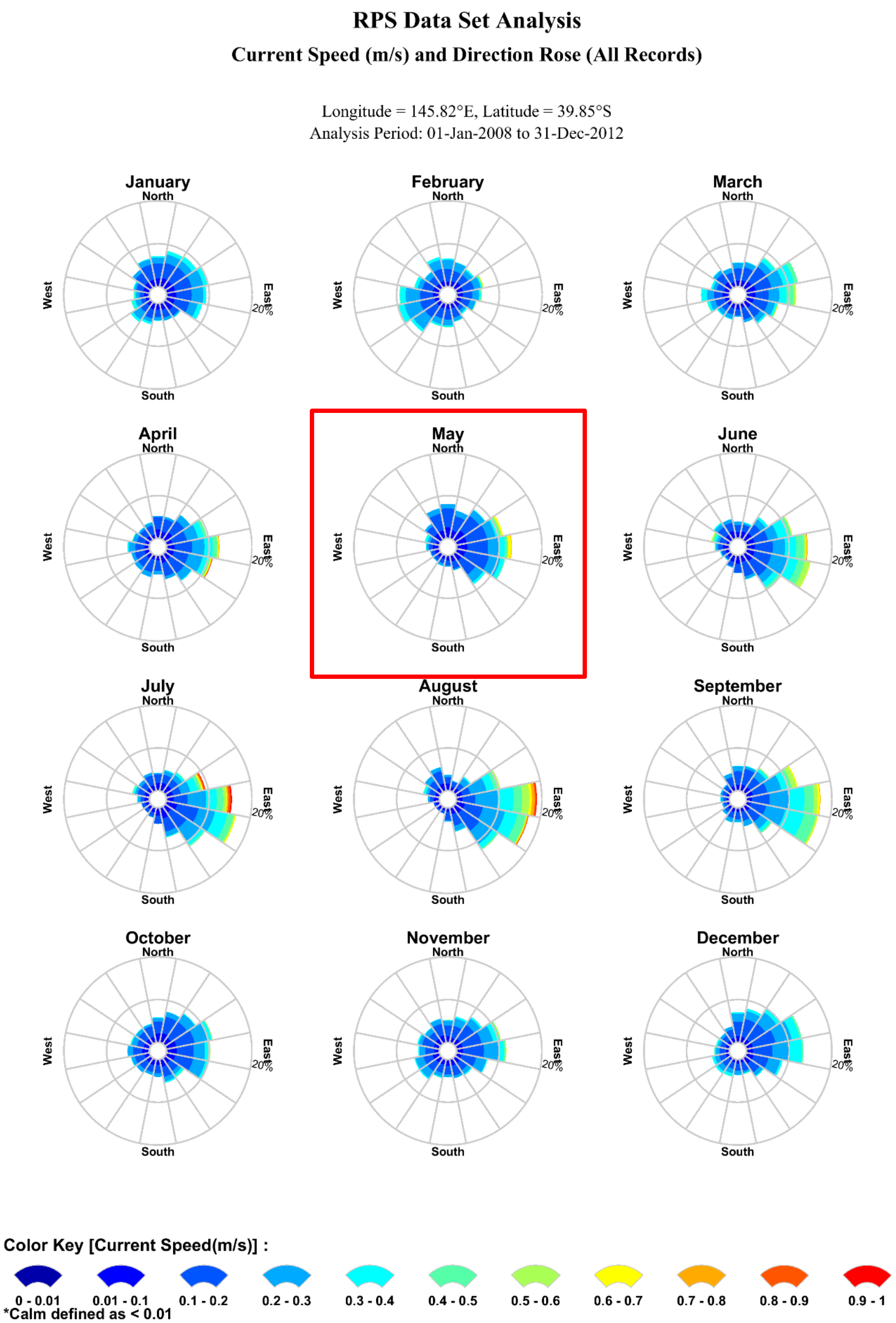


Figure 3.7 Monthly surface current rose plots nearby the Yolla release site (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2008–2012 (inclusive). The month of May used as model input for the far-field dispersion modelling is indicated for ease of reference

4.0 WATER TEMPERATURE AND SALINITY

To account for depth-varying sea temperature and salinity, data was obtained from the World Ocean Atlas 2013 database produced by the National Oceanographic Data Centre (National Oceanic and Atmospheric Administration) and its co-located World Data Center for Oceanography (see Levitus et al., 2013).

Table 4.1 presents the sea temperature and salinity of the surface layer nearby the release sites.

The monthly average sea surface temperatures ranged between 12.7°C and 18.1°C, while the salinity values remain relatively consistent ranging between 24.9 and 35.5 psu. Water temperature and salinity during May conditions was 17°C and 35.4 PSU, respectively.

Figure 4.1 illustrates the vertical profile of sea temperature and salinity.

Table 4.1 Monthly average sea surface temperature and salinity nearby the release location.

	Jan	Feb	Mar	Apr	May*	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)	17.1	18.0	18.1	17.0	17.3	13.0	12.7	13.2	13.1	14.3	15.7	15.1
Salinity (PSU)	35.3	35.3	35.5	35.5	35.4	34.9	35.2	35.1	35.3	35.5	35.5	35.3

* Far-field dispersion modelling month

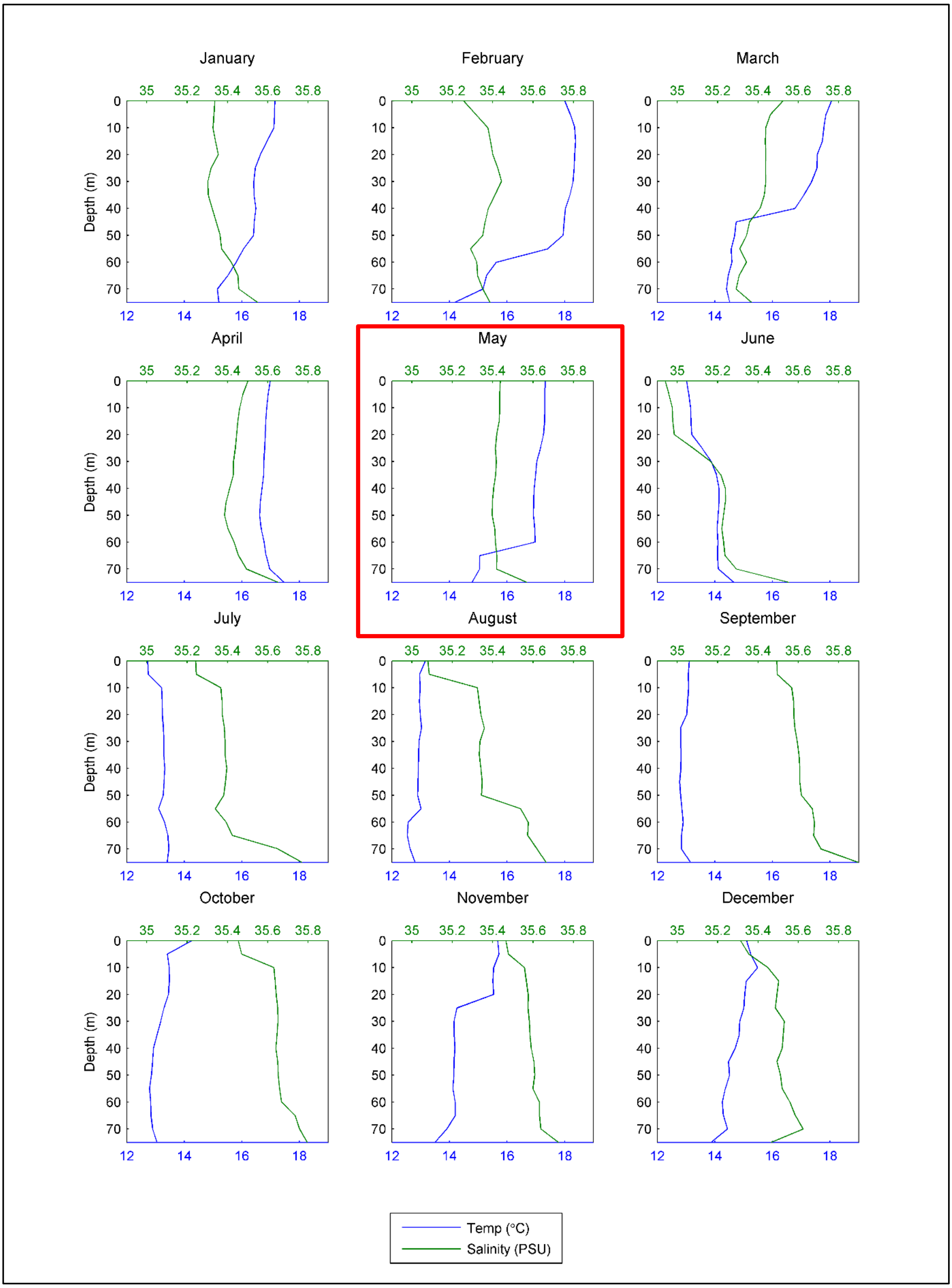


Figure 4.1 Temperature and salinity profiles nearby the release location. May conditions were used as the model input.

5.0 REPORTING CRITERIA

The area of exposure was determined based on dilutions of the whole PW discharge stream. Reported dilutions are based on the predicted instantaneous maximum concentrations and thus represent the predicted minimum dilution within any given grid cell over the duration of the 31-day model simulation.

A list of measured contaminant levels and trigger values for 99% species protection is shown in (Table 5.1), which were adopted as part of the near-field modelling study (RPS, 2017). As shown, the majority of the contaminants require a dilution factor of less than 1:75. Furthermore, as part of the near-field modelling study maximum dilutions of 1:1,000 were reported.

In line with ANZECC requirements, this modelling assessment reports the predicted zones of dilutions for 1:3,482.4 (TRH average) and 1:5,400 (TRH maximum).

The following dilutions (1:x) were also presented for completeness; 60, 62.5, 70, 80, 90, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 3482.4 and 5400.

Table 5.1 Summary of produced water contaminants and trigger values (source: RPS, 2017).

Component	Max recorded produced water concentration (µg/L)	99% Species protection trigger value (µg/L)	Required dilution factor to achieve 99% trigger value
Aluminium	3,200	27*	119
Arsenic	BD	1	-
Boron	3,400	90*	38
Barium	13,000	NL	-
Chromium	1	0.14	7.1
Iron	4,300	ID	-
Lead	BD	1	-
Mercury	29	0.1	290
Manganese	30	1200*	NR (<1)
Molydenum	1	ID	-
Nickel	10	7	1.4
Selenium	1	5*	NR (<1)
Strontium	810	NL	-
Zinc	90	7	12.9
Benzene	12,000	500	24
Toluene	14,000	110*	127
Ethylbenzene	450	50*	90
o-Xylene	1,600	200*	8
m&p-Xylene	5,200	50*	104
Napthalene	1,000	50	20
Phenol	64,000	270	237
Cresols	75,000	NL	-
2,4-Dimethyl Phenol	8,700	NL	-
Oil & Petroleum Hydrocarbons	<30,000 (current discharge limit)	70	428
Glycol	2 vol% (20,000,000 µg/L)	50,000^	400

^ = Guideline for working limits only, insufficient data to determine level of species protection
* = Taken from data for 99% species protection in fresh water systems ANZECC
BD = Historical testing shows these contaminants are below the limit of detection of 0.001 mg/L
ID = Insufficient data to determine a trigger value for marine or freshwater environment
NL = Component not listed in ANZECC guidelines
NR = Dilution not required, below ANZECC guideline concentration at point of discharge

6.0 DISPERSION MODELLING

6.1 Model Description

The MUDMAP model is an industry standard computerised modelling system, which has been applied throughout the world to predict the dispersion of sediment (cuttings and muds) and liquid (produced water) discharges since 1994 (Spaulding, 1994). The model is a development of the Offshore Operators Committee (OOC) model and like the OOC model calculates the fates of discharges through three known distinct integrated stages (Koh and Chang, 1973; Khondaker, 2000; Brandsma and Sauer, 1983a, 1983b).

The produced formation water release is represented by placing a fixed number of “particles” at the release location on each time-step. These particles are moved on each subsequent time-step according to the horizontal and vertical components from the hydrodynamic model. The plume spread is dependent on the horizontal and vertical mixing coefficients.

The MUDMAP system is based on a conservative tracer (no reaction or decay), constituting a “worst case” scenario, to examine the mixing and dilution of effluent plumes. The concentration distribution of the constituent in water is estimated using a counting grid. The number of particles in a grid square over a depth interval from the water surface down to a specified depth is counted, giving the mass of the constituent in a known volume, and therefore concentration.

The system has been extensively validated and applied for discharge operations in Australian waters (e.g. Burns et. al., 1999; King and McAllister, 1998, 1997).

6.2 Discharge Input Data

The detailed input data used in the far-field discharge model setup included:

- The relative temperatures and salinities of the PFW plume and receiving waters;
- The PFW rate of discharge;
- The height of the discharge point relative to mean sea level; and
- Current data to represent local physical forcing.

The PW stream, consists of both PW and water of condensation, is discharged vertically downwards through a discharge caisson at a depth of 45 meters below mean sea level (MSL) from a 0.73 m diameter outlet. The depth of the surrounding water is approximately 80 m.

The PW discharge properties are summarised in Table 6.1. The PW plume is slightly hotter (1°C above ambient at 45 m below MSL) and less saline than the receiving waters, resulting in a positively buoyant plume.

Table 6.1 Summary of the far-field model inputs used to simulate the PW discharges at the Yolla platform.

Parameter	Design Operation	Typical Operation	Worst Case Operation
Month and year simulated		May conditions 2011	
PW discharge flow rate (m^3/day)	100	200	300
Discharge type	Continuous	Continuous	Continuous
Period of discharge (days)	31	31	31
Discharge water temperature (°C)	13.8 – 16.8	13.8 – 16.8	13.8 – 16.8
Discharge water salinity (PSU)	0.14	11.9	14.7
Depth of discharge (m)	45	45	45

6.3 MUDMAP Mixing Parameters

The horizontal and vertical dispersion coefficients represent the mixing and diffusion caused by turbulence, both of which are sub-grid processes. Both of these coefficients are expressed in units of rate of area change (i.e. m^2/s). Increasing the horizontal dispersion coefficient will increase the horizontal spread of the discharge plume and decrease the centreline concentrations. Increasing the vertical dispersion coefficient spreads the discharge across the vertical layers.

Spatially constant, conservative horizontal and vertical dispersion coefficients of 0.2 m^2/s and 0.0001 m^2/s were used to control the exchange of the PW in the horizontal and vertical directions respectively. Each of the mixing parameters was selected following an extensive sensitivity testing to recreate plume characteristics with respect to the near-field plume behaviour (see RPS, 2017).

6.4 MUDMAP Grid Configuration

MUDMAP uses a three-dimensional grid to represent the water depth and bathymetric profiles of the study area. Due to the rapid mixing and small-scale influences of the discharge, it was necessary to use a very fine grid with a resolution of 5 m x 5 m x 2 m (x, y and z) to track the movement and fate of the plume. The extent of the grid region measured 5 km (longitude or x-axis) x 5 km (latitude or y-axis).

7.0 MODELLING RESULTS

7.1 Predicted Zones of Dilution

Figure 7.1 to Figure 7.3 present the predicted zones of dilution for the whole PFW stream up to a 1:5,400 for each of the three cases over the 31 day simulation period:

- Case 1: Design operation: 100 m^3/day
- Case 2: Typical operation: 200 m^3/day
- Case 3: Worst case operation: 300 m^3/day

Table 7.1 presents the maximum horizontal distance from the discharge point to varying dilutions (1:x) for each for design (i.e. Cases 1, 2 and 3). Dilutions achieved at horizontal distance sub-grid cell size (i.e. 5 m) are denoted < 5m.

The 1:62.5 dilution was achieved within <5 m from the release location for all three cases. Dilutions of 1:3,482.4 (TRH average) and 1:5,400 (TRH maximum), were achieved at maximum horizontal distances from the release location of 133 m to 485 m and 292 m to 693 m, respectively (Figure 7.1 to Figure 7.3 and **Error! Reference source not found.**).

The 1:500 dilution was achieved within 70 m of the release location for all three cases. While the 1:1,000 dilution was reached 69 m, 73 m and 121 m from the release location under Case 1 (100 m^3/day), Case 2 (200 m^3/day) and Case 3 (300 m^3/day) operational rates, respectively.

Table 7.1 Maximum horizontal distance from the discharge point to varying dilutions (1:x) for each case.

Dilution (1:x)	Maximum horizontal distance (m)		
	Case 1 Design Operation	Case 2 Typical Operation	Case 3 Worst Case Operation
60	<5 m	<5 m	<5 m
62.5	<5 m	<5 m	<5 m
70	<5 m	<5 m	26
80	<5 m	<5 m	26
90	<5 m	<5 m	26
100	<5 m	26	26
200	39	64	64
300	39	64	64
400	64	64	64
500	69	64	64
600	69	64	64
700	69	64	114
800	69	64	114
900	69	64	118
1,000	69	73	121
3,482.4	133	295	485
5,400	292	490	693

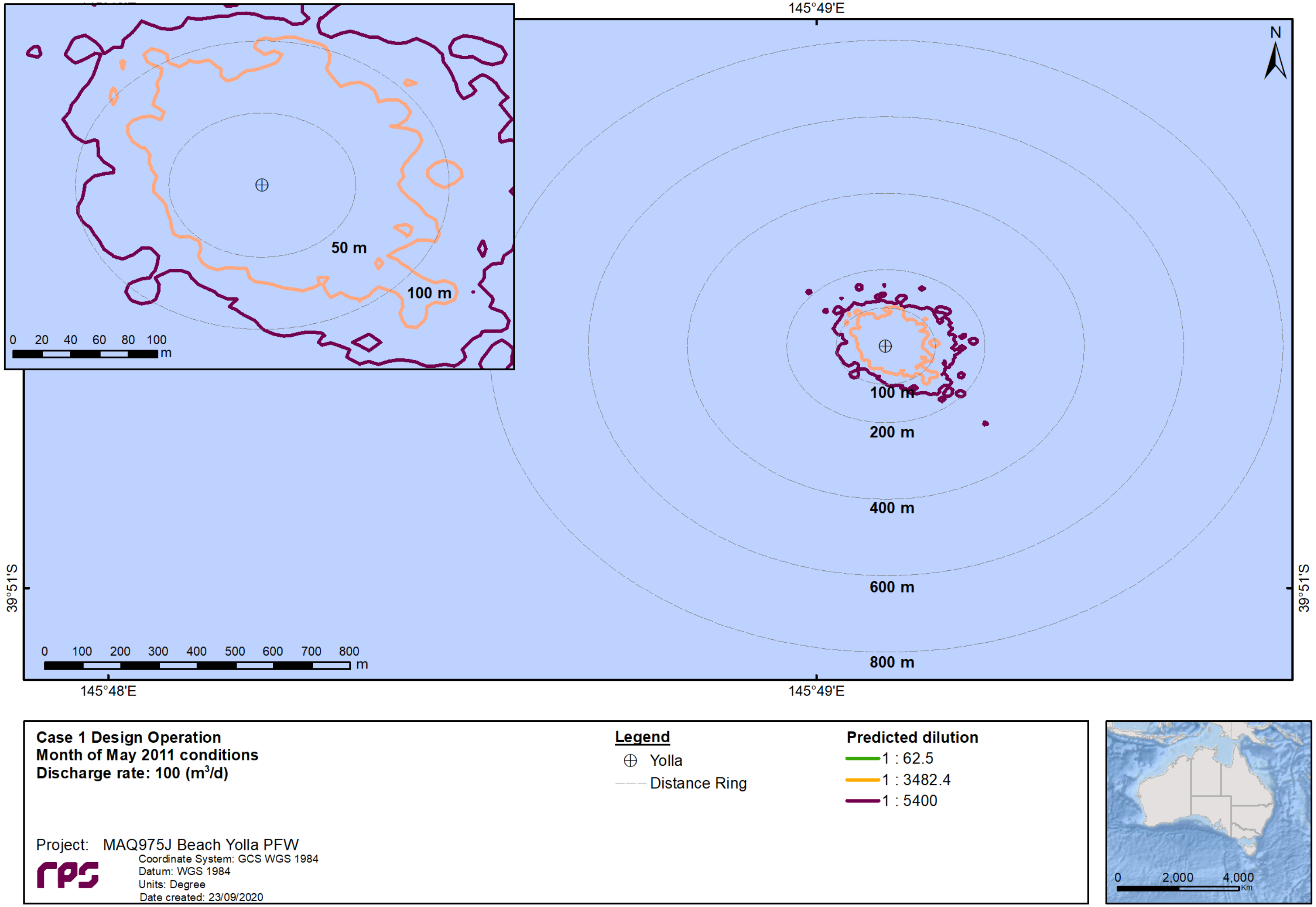


Figure 7.1 **Predicted zones of dilution for the whole PW stream up to a 1:5,400 dilution. Modelling based on a flow rate of 100 m³/day over 31-days during May conditions representing design operation (Case 1).**

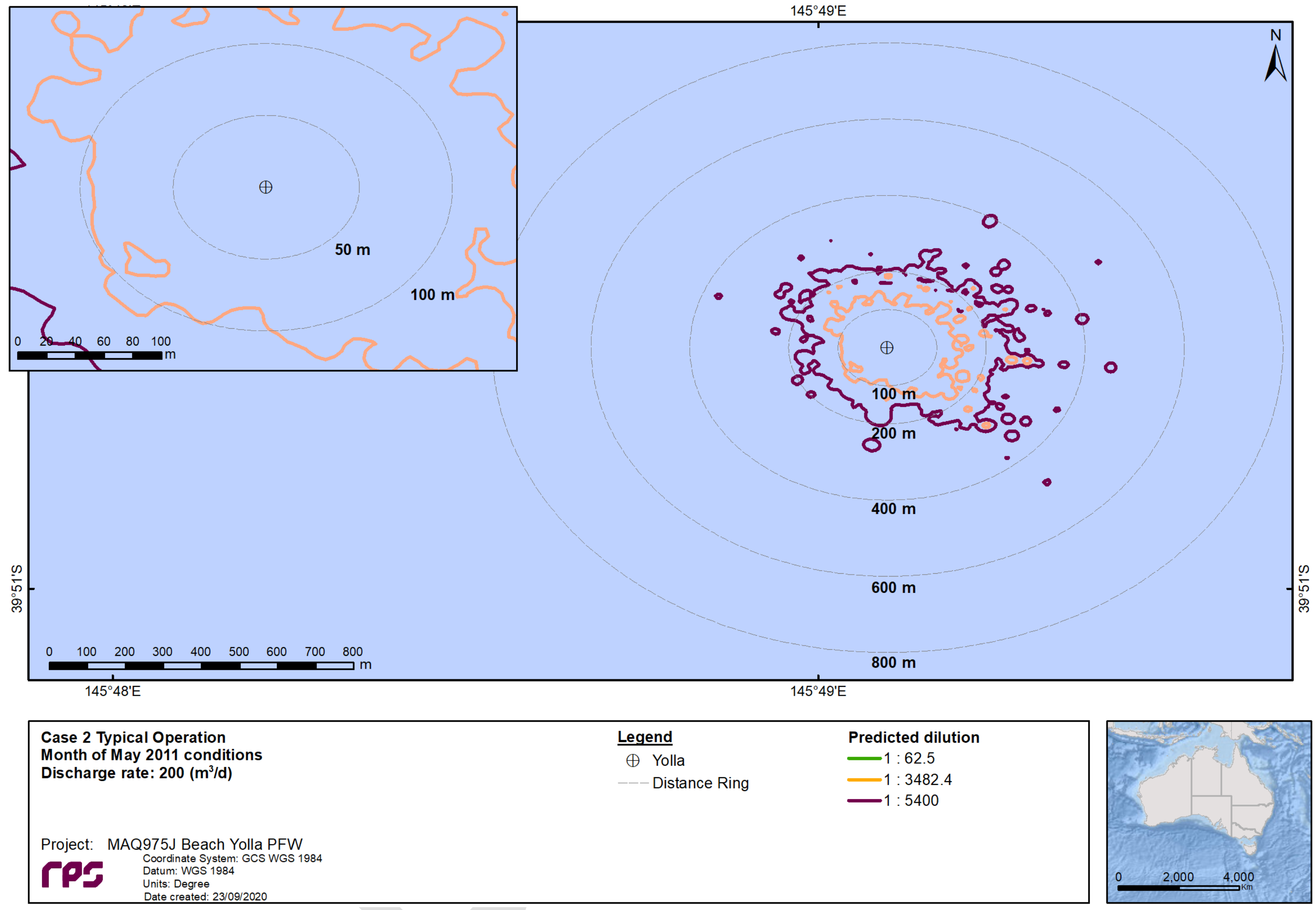
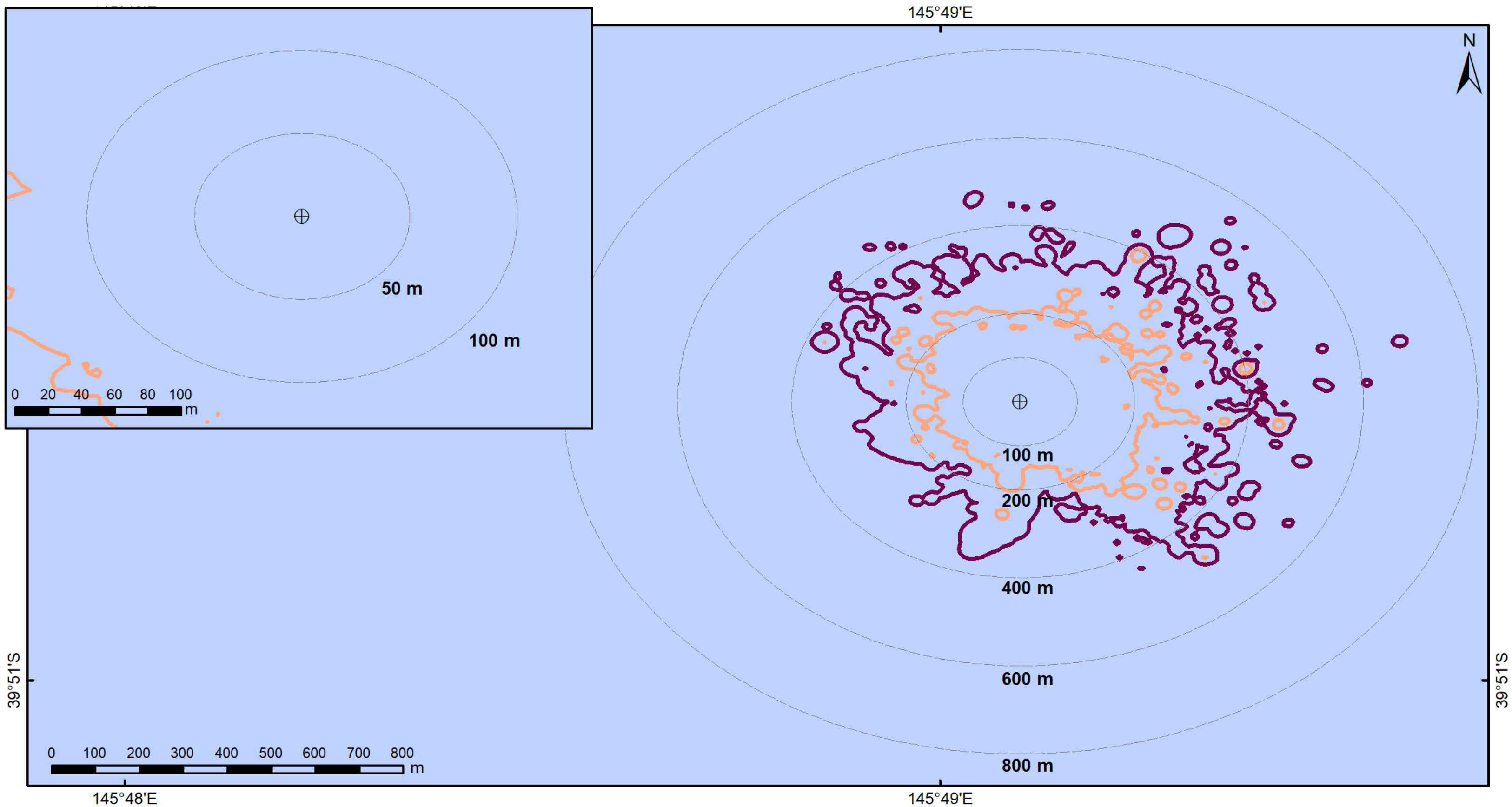


Figure 7.2 **Predicted zones of dilution for the whole PFW stream up to a 1:5,400 dilution. Modelling based on a flow rate of 200 m^3/day over 31-days during May conditions representing typical operation (Case2).**



Case 3 Worst Case Operation
Month of May 2011 conditions
Discharge rate: 300 (m^3/d)

Legend
Yolla
Distance Ring

Predicted dilution
1 : 62.5
1 : 3482.4
1 : 5400

Project: MAQ975J Beach Yolla PFW
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
Date created: 23/09/2020

Figure 7.3 Predicted zones of dilution for the whole PFW stream up to a 1:5,400 dilution. Modelling based on a flow rate of 300 m^3/day over 31-days during May conditions representing worst case operation (Case 3).

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