Wheatstone Project

Offshore Facilities and Produced Formation Water Discharge Management Plan: Stage 1

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ACRONYMS, ABBREVIATIONS AND TERMINOLOGY

°C	Degrees Celsius
µg/L	Micrograms per Litre
ACR	Acute to Chronic Ratio
ADBAC	Alky Dimethyl Benzyl Ammonium Chloride
ADCP	Acoustic Doppler Current Profiler
ANSIA	Ashburton North Strategic Industrial Area
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BCF	Bioconcentration Factor
CAR	Compliance Assessment Report
CEFAS	Centre for Environment, Fisheries & Aquaculture Science
CFC	Chlorofluorocarbons
CHARM	Chemical Hazard and Risk Management
Cth	Commonwealth
DBNGP	Dampier-to-Bunbury Natural Gas Pipeline
DDG	DBP Development Group Pty Ltd
DG	Dangerous Goods
Domgas	Domestic gas
DOTE	Department of the Environment - formerly Department of Sustainability, Environment, Water, Population and Communities (Cth)
Draft EIS/ERMP	The Environmental Impact Statement/Environmental Review and Management Program
EC	Effect Concentration
EMBA	Environment that may be Affected
EP Act (WA)	*Environmental Protection Act 1986*
EPBC Act (Cth)	*Environment Protection and Biodiversity Conservation Act 1999*
EPBC 2008/4469	The Commonwealth Primary Environmental Approval and conditional requirements for the Wheatstone Project. Commonwealth Government of Australia, Minister for Sustainability, Environment, Water, Populations and Communities, Hon. Tony Burke, 22 September 2011, with variations to EPBC 2008/4469 conditions 44, 45, 55, 56 and 66 made pursuant to section 143 of the EPBC Act, as amended from time to time.
FCG	Flooding, Cleaning And Gauging
FCGT	Flooding, Cleaning, Gauging and Testing
HBFC	Hydrobromofluorocarbons
HCFC	Hydrochlorofluorocarbons
HES	Health, Environment and Safety
HFC	Hydrofluorocarbons

HMAAF	Hazardous Material Approval Application Form
HMAP	Hazardous Materials Approval Procedure
hr(s)	Hour(s)
kg	Kilogram(s)
km	Kilometre(s)
LNG	Liquefied Natural Gas
LOEC	Lowest Observed Effect Concentration
m	Metre(s)
m/s	Metres per second
MDMP	Marine Discharge Management Program
mg/L	Milligrams per litre
MS 873	Ministerial Statement No. 873: The State (WA) Primary Environmental Approval, and conditional requirements for the Wheatstone Project. Government of Western Australia, Minister for the Environment; Water, Hon. Bill Marmion MLA, 30 August 2011 as amended by MS 903, MS 922, MS 931 and Attachments 1 to 4 and amended from time to time.
MSDS	Material Safety Data Sheet
MTPA	Million Tonnes Per Annum
Nearshore	Marine habitat from the 20 m contour to the shoreline
NOEC	No Observed Effect Concentration
ODS	Ozone-Depleting Substances
OFPFWDMP	Offshore Facilities and Produced Formation Water Discharge Management Plan
OPGGS(E)R	Offshore Petroleum Greenhouse Gas Storage (Environment) Regulations 2009
PCB	Polychlorinated biphenyls
(The) Plan	Offshore Facilities and Produced Formation Water Discharge Management Plan: Stage 1
ppm	Parts per million
Project	Nearshore and offshore marine facilities, trunkline, and onshore facility
Practicable	Means reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge (*taken from the EP Act)*
Proponent	Chevron Australia Pty Ltd
SSD	Species Sensitivity Distribution
THPS	Tetrakishydroxymethyl phosphonium sulphate
UV	Ultra Violet
WA	Western Australia
WET	Whole of Effluent Toxicity
WP	Wheatstone Platform

1.0 BACKGROUND

1.1 Project Overview

Chevron Australia Pty Ltd (Chevron Australia) will construct and operate a multi-train Liquefied Natural Gas (LNG) and domestic gas (Domgas) plant near Onslow on the Pilbara Coast, Western Australia. The Wheatstone Project (the Project) will process gas from various offshore fields in the West Carnarvon Basin. Ashburton North Strategic Industrial Area (ANSIA) is the approved site for the LNG and Domgas plants.

The Project requires installation of gas gathering, export and processing facilities in Commonwealth and State waters and on land. The initial Project will produce gas from Production Licences WA-46-L, WA-47-L and WA-48-L, at the Wheatstone Platform (WP) 145 km offshore from the mainland, approximately 100 km north of Barrow Island and 225 km north of Onslow, and will also process gas from Production Licence WA-49-L operated by Woodside Petroleum Limited. Figure 1.1 shows the location of the Project.

The ANSIA site is located approximately 12 km south-west of Onslow along the Pilbara coast within the Shire of Ashburton. The initial Project will consist of two LNG processing trains, each with a capacity of approximately 5 million tonnes per annum (MTPA). Environmental approval was granted for a 25 MTPA plant to allow for the expected further expansions. The Domgas plant will be a separate but co-located facility and will form part of the Project. The Domgas plant will tie-in to the existing Dampier-to-Bunbury Natural Gas Pipeline infrastructure via third party DBP Development Group Pty Ltd Domgas pipeline.

1.2 Proponent

Chevron Australia is the proponent and the company taking the action for the Project on behalf of its joint venture participants Woodside Petroleum Limited, PE Wheatstone Pty Ltd a company part-owned by Tokyo Electric Power Company, Kuwait Foreign Petroleum Exploration Company and Kyushu Electric Power Company.

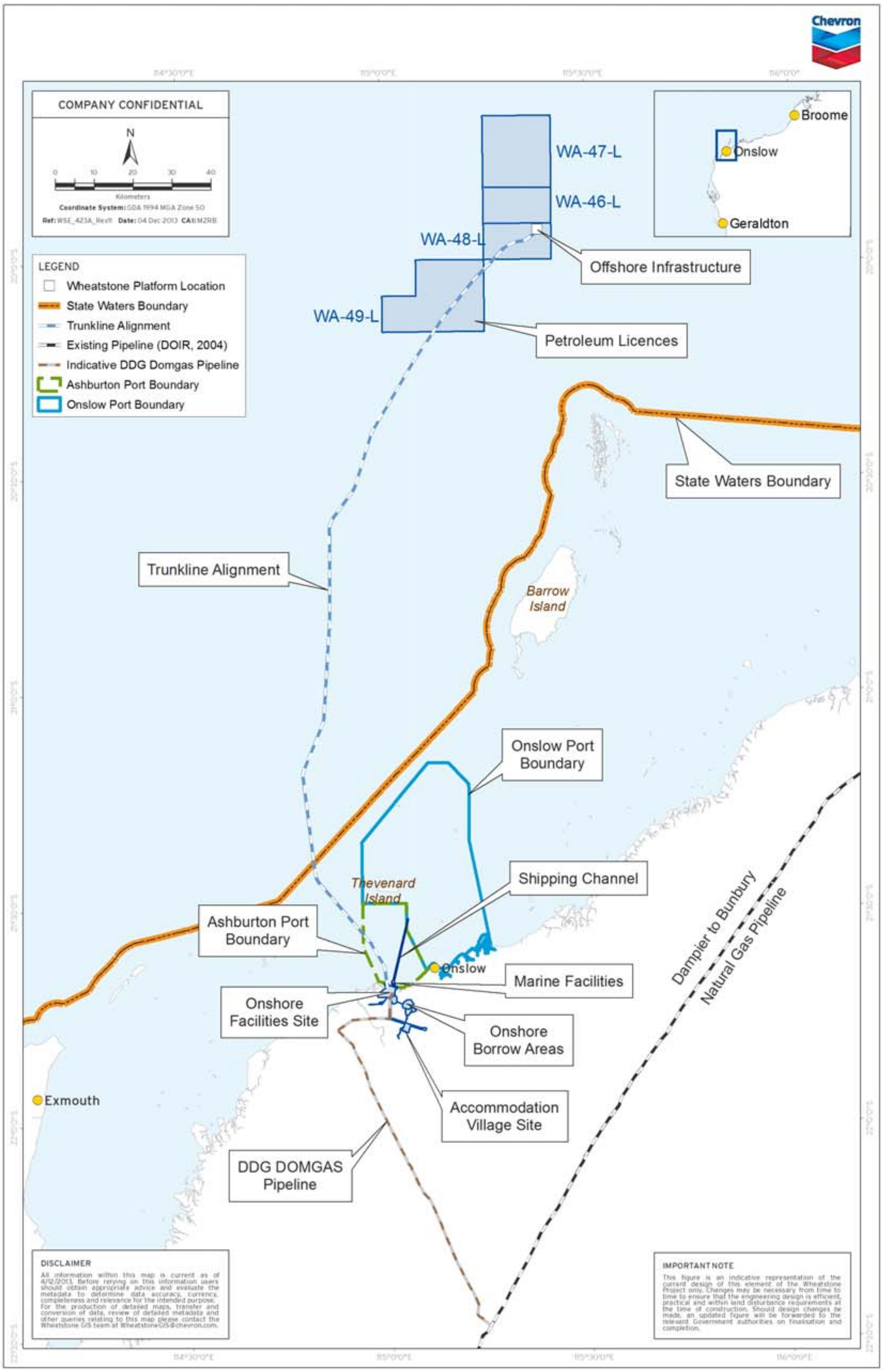

Figure 1.1: Planned Location of Project Infrastructure

1.3 Environmental Approvals

The Project was assessed through an Environmental Review and Management Program pursuant to the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The Commonwealth Minister for Sustainability, Environment, Water, Population and Communities approved the Project on 22 September 2011 by way of EPBC 2008/4469, with subsequent variations made pursuant to Section 143 of the EPBC Act.

The Plan shall be read and interpreted as only requiring implementation of EPBC 2008/4469 for managing the impacts of discharges from Offshore Facilities on EPBC Act listed matters. Amendments to the approvals in place for the Project may be made from time to time and if so will be reflected in the next revision of this Plan. Table 1.1 lists the requirements of the Commonwealth conditions relevant to this Plan.

The activities described in this Plan are also regulated via the Offshore Petroleum Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS(E)R). The OPGGS(E)R requires that an accepted Environment Plan (EP) be in place prior to the commencement of a Petroleum activity. There are a number of accepted EPs in place (or under assessment) which contemplate the Project. In addition to the controls described in this Plan, a specific EP for Trunkline Flooding, Cleaning, Gauging and Testing (FCGT), Dewatering and Drying was approved by NOPSEMA (the regulatory authority for this activity) on 7 August 2014 and for Flowlines Installation, FCGT, Dewatering and Drying approved by NOPSEMA on 5 December 2013.

Table 1.1: Requirements of Commonwealth Ministerial Conditions: EPBC 2008/4469 relevant to this Plan

No.	Condition	Section
45	The person taking the action must develop and submit the following plans (and associated reports) to the Minister for approval, as component parts of the Marine Discharge Management Program (MDMP).	The Plan
45 b.	Offshore Facilities and Produced Formation Water Discharge Management Plan (OFPFWDMP) which must address discharges from offshore facilities. The OFPFWDMP must include:	The Plan
	♦ Water quality targets based on the ANZECC Water Quality Guidelines (2000)	Section 4.2
	♦ Trigger levels	Section 5.2
	♦ Management (actions)	Section 5.1
	♦ Corrective actions	Section 5.2
	♦ Monitoring programs.	Section 5.3

1.4 Objectives

The objective of this Plan is to meet the relevant requirements of Commonwealth EPBC 2008/4469 approval Condition 45(b) in that the Plan specifically addresses hydrostatic test water discharges from offshore facilities and includes water quality targets based on the ANZECC Water Quality Guidelines (2000); monitoring programs; trigger levels; management and corrective actions. The Plan also satisfies the requirements of Condition 46 (EPBC 2008/4469) in that it forms a stage of the MDMP.

1.5 Scope

This Plan considers the Trunkline and Flowline discharges associated with pre-commissioning activities in Commonwealth waters including:

- Flooding, Cleaning and Gauging (FCG)
- Hydrotesting
- Dewatering.

The discharges considered in this stage of the Plan will occur following the installation of the carbon steel trunkline and flowlines (here in referred to as pipeline) for the transport of treated gas from the WP. If required, subsequent plans will consider discharges from other activities associated with the Project such as routine operational activities at the WP i.e. Produced Formation Water and explain the management of these discharges.

1.6 Public Availability

The approved Plan will be made publicly available on Chevron's website within one month of approval (EPBC2008/4469 Condition 8) unless otherwise agreed to in writing by the Minister for Environment.

2.0 PROJECT DESCRIPTION

The Project description which follows has been included for the purpose of contextualising the management and monitoring measures which are required under this Plan. Elements of the Project may be amended from time to time. The Project elements which are detailed in this Plan should therefore be read as subject to any project amendments which are made from time to time.

2.1 Overview

Following installation of the pipeline, pre-commissioning activities including FCGT are carried out to prove the ability of the pipeline to contain product without leaking. Following FCGT the pipeline is dewatered and dried. Dewatering activities are proposed to commence approximately 12 to 36 months following FCGT of the Trunkline and approximately 12 to 24 months following FCGT of the Flowlines.

The timing is indicative, and subject to potential delays caused by weather events, vessel availability and other unforeseen factors such as the readiness of both the offshore and onshore operations scopes.

The planned FCGT activities and discharges occurring in Commonwealth waters that are the subject of this Plan include the following:

- Flooding, cleaning and gauging (FCG);
- Hydrotesting; and
- Dewatering.

The following sections describe the chemical selection process undertaken to select the flooding fluid treatment as well as the FCG, hydrotesting and dewatering activities for the Trunkline. The Wheatstone flowlines will also be subject to FCG but these activities will require considerably smaller volumes of flooding fluids, which are dosed at or below the chemical concentrations required for the trunkline FCG activities. Flowline discharges will be in the range of the trunkline discharge plume (refer Section 4.2.2) and as such any impacts associated with Flowline FCG, Hydrotesting and Dewatering will be encompassed by the descriptions presented for the Trunkline in this Plan.

2.2 Chemical Selection Process

The chemicals considered for the treatment of the flooding-fluid were subject to a detailed review and selection process as described in Appendix A. This involved four key analysis steps:

1. Treatment Options Analysis.
2. Chemical Options Analysis.
3. Chemical Screening - using the Chevron Hazardous Materials Approval Process (Appendix B).
4. Chemical Approval.

Treatment of flooding water with biocides and oxygen scavengers is a technical requirement to prevent corrosion of the pipeline structures. In the case of the current project, the trunkline will remain flooded for the longest duration, meaning that the selected treatment needs to remain effective for at least 36 months.

Following the application of the review and selection process (described in detail in Appendix A) the following factors were also taken into account:

- The volumes of flooding water required
- The need for high effectiveness for an extended duration of flooding
- Safety issues relating to handling and dosing of chemicals
- Relative toxicity of available products.

On the basis of this analysis, Hydrosure 0-3670R was identified as the preferred option for treatment of the flooding water and was subsequently approved for use by Chevron.

2.3 Trunkline Flooding, Cleaning and Gauging

The trunkline will be subject to FCG, commencing with the injection of a flooding fluid (inhibited seawater) at the WP location from a vessel via a 6” down-hose (see Section 2.3.2 for a description of the flooding fluids) to verify trunkline integrity prior to introduction of hydrocarbons. A schematic of the process is provided at Figure 2.1.

2.3.1 Flooding

Up to 1000 m^3 of flooding fluid (which is inhibited seawater and called forewater) will be injected in front of a four pig train. The pig train consists of four pigs (devices that are inserted into a pipeline for cleaning and inspection purposes) that travel through the trunkline and clean and gauge the trunkline. The forewater is required to facilitate the launch of the train at the WP location and control its progress through the trunkline. To maintain separation of the pigs within the train, up to 500 m^3 of flooding fluid will be injected between each pig (separation slugs, requiring a total volume of 1500 m^3 of flooding fluids). The forewater and separation slug water is expected to have a residence time of less than two weeks within the trunkline.

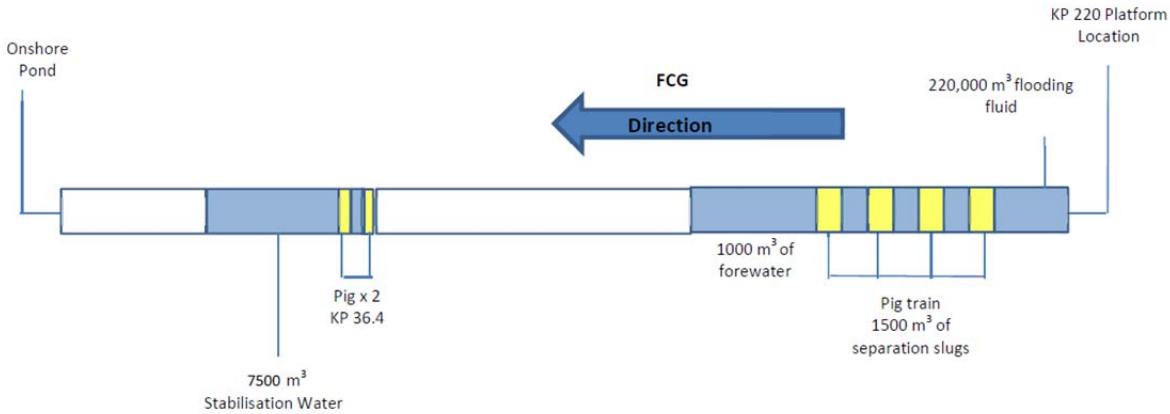

Figure 2.1: Schematic of a Trunkline FCG PIG Train showing forewater and separate slugs of flooding fluid

To propel the pig train towards the shore the main flood will be injected behind the pig train. As the main flood is injected into the trunkline it pushes the forewater and the pig train along the trunkline. The stabilisation water (up to 7500 m^3), forewater (up to 1000 m^3) and separation slugs (1000–1500 m^3) will be discharged into an existing lined onshore storage pond. If the main flood is insufficient to push the last of the pigs through then additional flooding fluid (called overpump) will be injected at the WP site to move the last pig to the onshore location. The volume of overpump required will range from zero up to 10 000 m^3 and is dependent on the receipt of the last pig of the four pig train.

The fluids associated with FCG are temporarily held in an onshore pond prior to hydrotesting activities described in Section 2.4. A summary of the volumes of all fluids that are associated with this activity are shown in Table 2.1.

2.3.2 Flooding Fluids

The flooding fluids injected into the trunkline for FCG and hydrotest activities will be seawater, sourced from open water in the vicinity of the injection point at the WP location. The seawater is chemically treated to prevent corrosion from oxidation and microbial action for the duration the flooding fluid is expected to remain in the trunkline. The chemical selection process for the treatment of the seawater to be flooded is detailed in Appendix A. The same flooding fluid will be used throughout the trunkline with varying concentration depending on the required residence time of flooding fluid.

To maintain the appropriate level of protection and provide flexibility in the project schedule while reducing environmental impact when the flooding fluid is released, Hydrosure 0-3670R, a proprietary chemical mixture designed for the treatment of water (neutralising bacteria and dissolved oxygen) was selected for use in hydrotest water. Hydrosure 0-3670R contains 10-30% quaternary ammonium chloride as a biocide along with an oxygen scavenger and corrosion inhibitor.

Hydrosure 0-3670R will be mixed with filtered seawater to achieve appropriate concentrations to maintain trunkline integrity during FCGT activities prior to commissioning (see Table 2.1). The dosage is dependent on the residence time of the flooding fluid in the trunkline. A fluorescein dye is added to the main flooding fluid and overpump and hydrotest fluid to visually identify leaks during hydrotesting. A calibrated chemical injection pump will be used during trunkline flooding and the following parameters will be logged:

- Time
- Pressure
- Flow rate and volume of water pumped
- Volume of chemicals injected (concentrations).

Table 2.1: Summary of Flooding Fluid Concentrations Pumped into the Trunkline

Dosing Sequence and flooding fluid		Maximum Volume (m^3)	Hydrosure Concentration (ppm*)	Dye Concentration (ppm)	Comment
1	Stabilisation fluid	7500	385	0	Temporarily held in the onshore pond
2	FCG forewater	1000	385	0	Temporarily held in the onshore pond
3	Water between pigs (separation slugs) (total volume)	1500	385	0	Temporarily held in the onshore pond
4	Overpump (if required)	0 - 10 000	550	50	Temporarily held in the onshore pond

Dosing Sequence and flooding fluid		Maximum Volume (m^3)	Hydrosure Concentration (ppm*)	Dye Concentration (ppm)	Comment
5a	Hydrotest fluid	3500	550	50	Approximately 3500 m^3 is taken from the flooding fluid in the onshore pond and used to bring the pipeline up to pressure. This volume will either be discharged at the WP during depressurisation or will be sent back to the onshore pond until ultimately discharged as part of the full 20 000 m^3 retained onshore.
5b	Flooding fluid in storage pond, re-dosed before reinjection into the trunkline	Up to 20 000	Additional dosing (assume maximum possible concentration up to ~1000 ppm)	0	The flooding fluid held in the pond (sequences 1,2,3 and 4) is to be re-dosed with Hydrosure 0-3670R prior to reinjection into the trunkline, and for eventual discharge as a 'slug' at the end of the 220 000 m^3 flooding fluid discharge
6	Main flood (entire trunkline volume)	220 000	550	50	Discharged in Commonwealth waters (WP site) ~45 m below the surface, ~30 m above sea bed

* *ppm (parts per million)*

2.4 Trunkline Hydrotest

The trunkline Hydrotest will be undertaken to establish the integrity of the trunkline following FCG activities and will require the reinjection of approximately 3 500 m^3 of the flooding fluid contained within the temporary onshore storage ponds to bring the pressure within the trunkline up to a minimum 175.6 bar. Following the hydrotest, up to 3 500 m^3 flooding fluid will be discharged back into the temporary onshore storage pond, or alternatively at the WP, to return the trunkline to hydrostatic equilibrium. After the hydrotest all flooding fluids remaining in the temporary onshore storage ponds (between ~16 500 m^3 and 20 000 m^3) will be reinjected into the trunkline resulting in a simultaneous discharge of an equivalent volume at the WP. The total volume discharged at the WP at the end of the hydrotest will be approximately 20 000 m^3.

The discharge(s) immediately following hydrotest will take place at the WP via a 6" outlet positioned approximately two metres above the seafloor and aligned within 30 degrees to the vertical. A summary of discharges during the hydrotest of the trunkline is provided below (Table 2.2). These are the planned discharges into Commonwealth waters during the FCGT activities.

Table 2.2: Summary of Flooding Fluids Discharged from Trunkline into Commonwealth Waters following Hydrotesting Activities

Flooding Fluid Description	Release of flooding fluids held in the trunkline following reinjection of flooding fluids held in the onshore lined pond (including maximum overpump)
Discharge Location	WP location ~2 m above seabed, 50 m from the outside edge of the rock blanket and water depth of approximately 70 m
Discharge Port	6" outlet oriented upwards
Total Approximate Flooding Fluid Discharge Volume following Hydrotesting (m^3)	20 000

2.5 Trunkline Dewatering

Following the completion of the hydrotest and subsequent discharges at the WP (refer Section 2.4), the trunkline will remain flooded for a period between 18 and 36 months until dewatering and drying. Dewatering will involve the discharge of approximately 220 000 m^3 of flooding fluid at the WP site. A summary of all discharges into Commonwealth waters has been presented in Table 2.2. The volume in the trunkline shown in Table 2.3 includes a contingency for an additional 10% on top of the trunkline flood volume.

Table 2.3: Summary of Flooding Fluid Discharge from Trunkline into Commonwealth Waters during Dewatering

Trunkline	Onshore to WP
Discharge Location	WP location ~30 m above seabed
Discharge Port	13" outlet oriented downwards
Trunkline Length (m)	221 000
Volume per meter of trunkline (m^3)	0.896
Approximate Trunkline Flood Volume* (m^3)	200 000
Contingency Discharge Volume (m^3)**	20 000
Total Approximate Flooding Fluid Discharge Volume during Dewatering (m^3)* **	220 000

* Volumes have been rounded to the nearest 10 000 m^3
** 10% of the total Trunkline Flood Volume
*** Includes 20 000 m^3 'slug' of flooding fluid re-dosed prior to injection

During dewatering, the flooding fluid will be discharged from a caisson attached to the WP. The fluid will discharge through a 13" pipe oriented vertically downward at a depth of 45 m below sea level (approximately 30 m above the sea floor). Based on design flow rates, discharges associated with dewatering will occur over approximately six to eight days. The mixing and dispersion of the planned discharge was modelled and the results are described in Appendix C. The chemical selection process, characteristics and toxicity evaluations of Hydrosure 0-3670R are presented in Appendix A and Appendix D and discussed in Section 2.2, with potential impacts from the discharge discussed in Section 4.3.2.

The trunkline will be dewatered utilising a specifically designed pig train similar in make up to a typical pig train shown in Figure 2.2. The pig train is designed to bulk dewater and remove residual water to a level sufficient to commence drying operations. The internal surface of the trunkline will be desalinated by pushing fresh air through the trunkline from onshore to the WP.

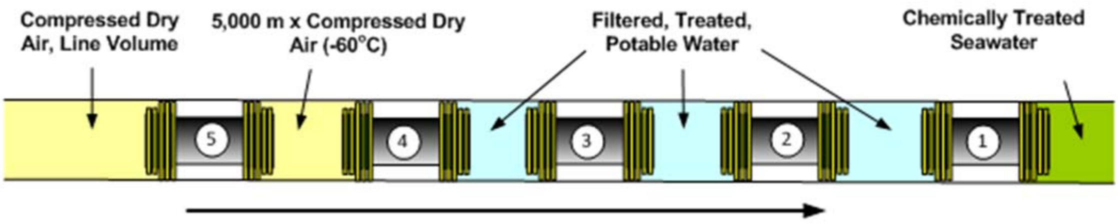

Figure 2.2: Typical Dewatering Pig Train

It is important to note, that to account for potential degradation to the fluids held in the temporary onshore storage pond for the trunkline hydrotest, as described in Section 2.4, and to ensure that flooding fluids reinjected during the hydrotest maintain the appropriate level of trunkline protection during the wet storage period, the flooding fluids retained in the temporary onshore storage pond will be re-dosed with an additional 550 ppm of Hydrosure 0-3670R (refer to Table 2.1) prior to reinjection. As a result, the onshore end of the trunkline is conservatively expected to contain a slug of flooding fluid with an approximate volume of 20 000 m^3 and a maximum expected concentration of approximately 935 ppm of Hydrosure 0-3670R (this concentration is considered a highly conservative estimate as it assumes zero degradation during temporary onshore storage). The modelling of trunkline dewatering, as described in Appendix C includes consideration of this slug of re-dosed flooding fluid.

3.0 EXISTING ENVIRONMENT

This section describes the existing 'environment that may be affected' (EMBA) by the planned FCG and dewatering trunkline discharges. The EMBA (Figure 3.1) is considered the maximum radius from the WP within which there is the potential for an environmental affect to occur as a result of the discharge. An "environmental affect" is considered possible where the median concentration of Hydrosure 0-3670R in the marine environment exceeds the threshold criteria of 0.06 mg/L over a 48 hr exposure duration, with the rationale for this consideration provided in Section 4.0. The environmental receptors described in this section are considered to potentially occur within the EMBA and are relevant as EPBC Act listed matters.

3.1 Oceanography and Water Quality

The EMBA occurs in a transitional climatic region between the dry tropics to the south and the humid tropics to the north. The surface waters of the EMBA are tropical year-round with summer sea surface temperatures around 26 °C, and winter temperatures around 22 °C (DEWHA 2008).

The oceanography of the EMBA is highly seasonal and is dominated by the movement of surface currents derived from waters of the Indonesian Throughflow. The influence on the water column reaches a peak during the austral winter when the southern throughflow is at its greatest. During summer when the throughflow is weaker, strong winds from the southwest cause intermittent reversals of the currents, which may be associated with occasional upwelling's of colder, deeper water onto the shelf (Condie *et al*. 2006). The Ningaloo Current, flowing northwards, is also thought to intrude into the EMBA during summer. Tidal activity is also a significant factor as tides contribute to vertical mixing of surface water layers and sediments.

Turbidity in the NWS is generally greater nearshore during summer—approximately one Nephelometric Turbidity Units (NTUs)—than during winter due to stronger offshore winds and increased sediment discharges (~6 NTU) (SKM 2012). Elevated turbidity levels (>80 NTU) are also recorded during cyclonic activity. The waters at the WP location are characterised as having relatively low turbidity but displaying high temporal and spatial variability. Fine sediments are often resuspended by ground swell and deeper areas can become highly turbid near the seabed (Chevron 2010a). Offshore turbidity can also be influenced by nearshore conditions as the result of tidal, wave action or current induced re-suspension and episodic runoff from adjoining rivers.

Salinity in the EMBA typically varies between 34.4 g/L and 36.3 g/L (Chevron 2010b). Surface salinity may be elevated in summer due to evaporation. Higher salinity is typically recorded at inshore sites (SKM 2012). Cyclone events may also increase or decrease salinity to varying water depths depending on the rate of vertical mixing and level of rainfall, respectively. The EMBA is characterised as having low background concentrations of trace metals and organic chemicals. The offshore waters are considered oligotrophic (low nutrient levels) with upwelling of deep nutrient-rich waters being suppressed by the Indonesian Throughflow and Leeuwin Current.

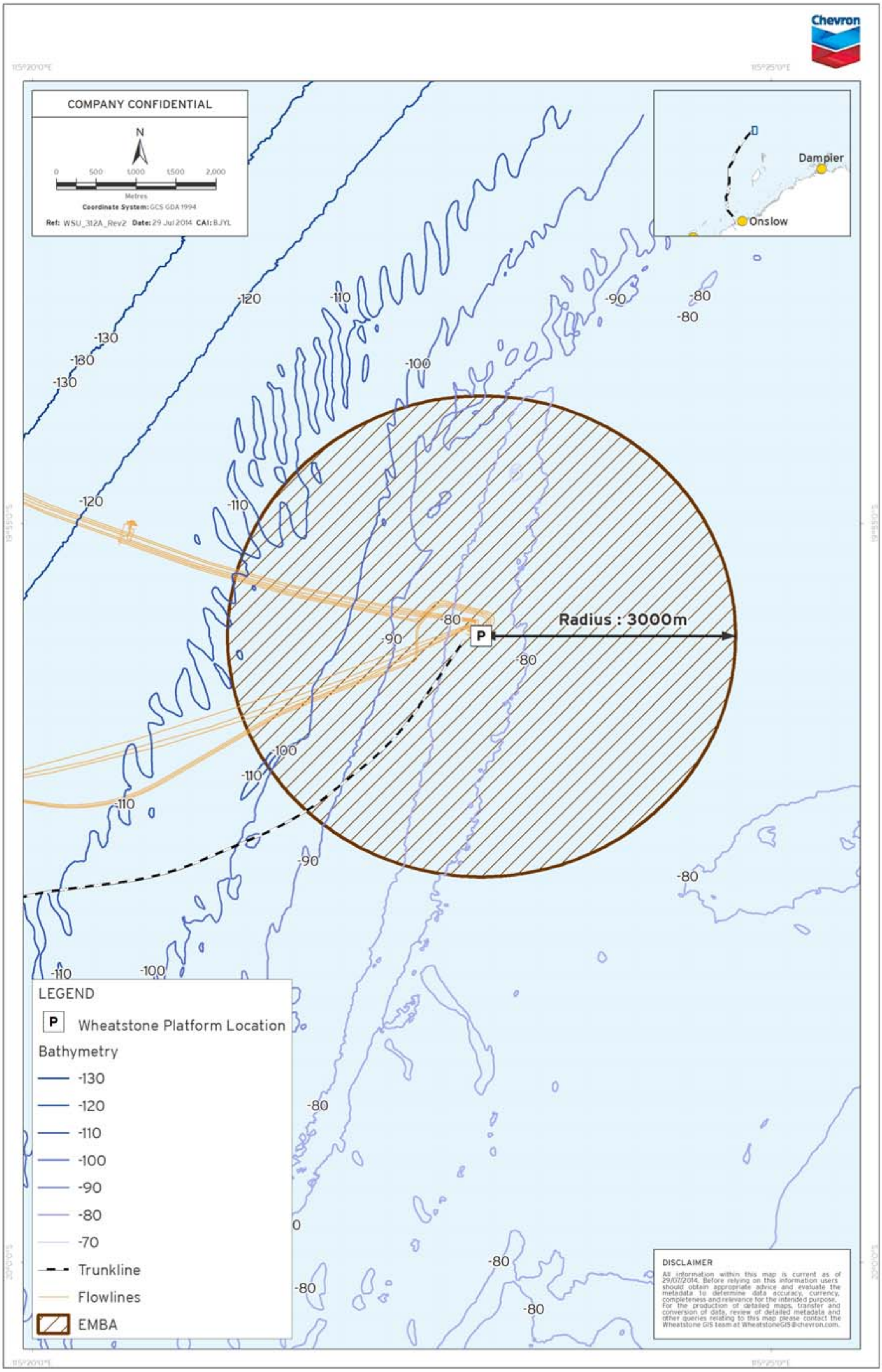

Figure 3.1: Environment that may be affected (EMBA) from potential impacts associated with FCG and hydrotest discharges

3.2 Geomorphology & Benthic Habitats

The EMBA is located on the outer continental shelf in water depths of approximately 120 m, which gradually slopes from the coast to the shelf break. Figure 3.2 illustrates the spatial distribution of the various substrates and benthic habitats within the operational area, and is based on data from both ROV and hydro-acoustic surveys. These habitats were classified into the following substrate types:

- Flat to micro rippled (< 0.5 m)
- Silt/sand substrate
- Sparse (1–10 m^2) to abundant (50–100 m^2) bioturbation (evidence of infauna such as burrows and mounds)
- Trace to very sparse (< 1%) benthic sessile and motile invertebrates including soft corals, sea pens, sponges, sea whips, ascidians, urchins and hydroids.

Seabed sediments of the EMBA were deposited at a relatively slow and uniform rate comprising of bio-clastic, calcareous and organogenic sediments (Carrigy and Fairbridge 1954). Coarse and medium-grained calcareous sandy sediments dominate to the 100 m depth contour, with a transition to continental slope silts around 100–150 m water depths (Black *et al*. 1994). The WP will be constructed on the apex of a large ridgeline (approximately 11 km long and 3 km wide), which represents a morphologically distinct seafloor feature within the EMBA (Chevron 2010a). Substrates surrounding the WP are largely characterised as soft, unconsolidated and relatively homogenous coarse and medium grained calcareous sandy sediments (Black *et al*. 1994, DEWHA, 2008; Chevron, 2010a).

As the EMBA is largely characterised by soft, unconsolidated sediments (DEWHA, 2008; Chevron, 2010a) benthic biotic communities are likely to comprise sparse assemblages of benthic epifauna, such as bryozoans, echinoids, crustaceans, molluscs and sponges, typical of the North-West Province (DEWHA, 2008; Chevron, 2010a).

Hard substrates are also present in the EMBA at the WP location, where a large ridgeline (approximately 11 km long) supports occasional (2–10%) coverage of a diverse array of benthic sessile invertebrates, dominated by gorgonians (sea fans and sea whips), sponges and soft coral (Chevron, 2010a).

3.3 Fish and Marine Fauna

Fish communities of the EMBA are likely to be strongly depth related, indicative of a close association with benthic habitats (DEWHA 2008). The fish diversity is likely to compose demersal species such as goatfish, lizardfish, ponyfish and threadfin bream, as well as pelagic species such as trevally, billfish and tuna.

Marine fauna (including marine mammals, reptiles, birds and sharks) are likely to be present at the WP location, however there are no known breeding, feeding or aggregation areas within the EMBA. A search for EPBC Act Protected Matters was conducted for the EMBA and found a total of nine threatened species; 17 migratory species, 40 marine species and 22 cetaceans were listed as potentially occurring, however only four of these species were recorded as known from the EMBA, these were the Humpback Whale (*Megaptera novaeangliae*); Flatback Turtle (*Natator depressus*); Giant Manta Ray (*Manta birostris*) and Whale Shark (*Rhincodon typus*). The full list of species identified by this search is provided in Appendix E.

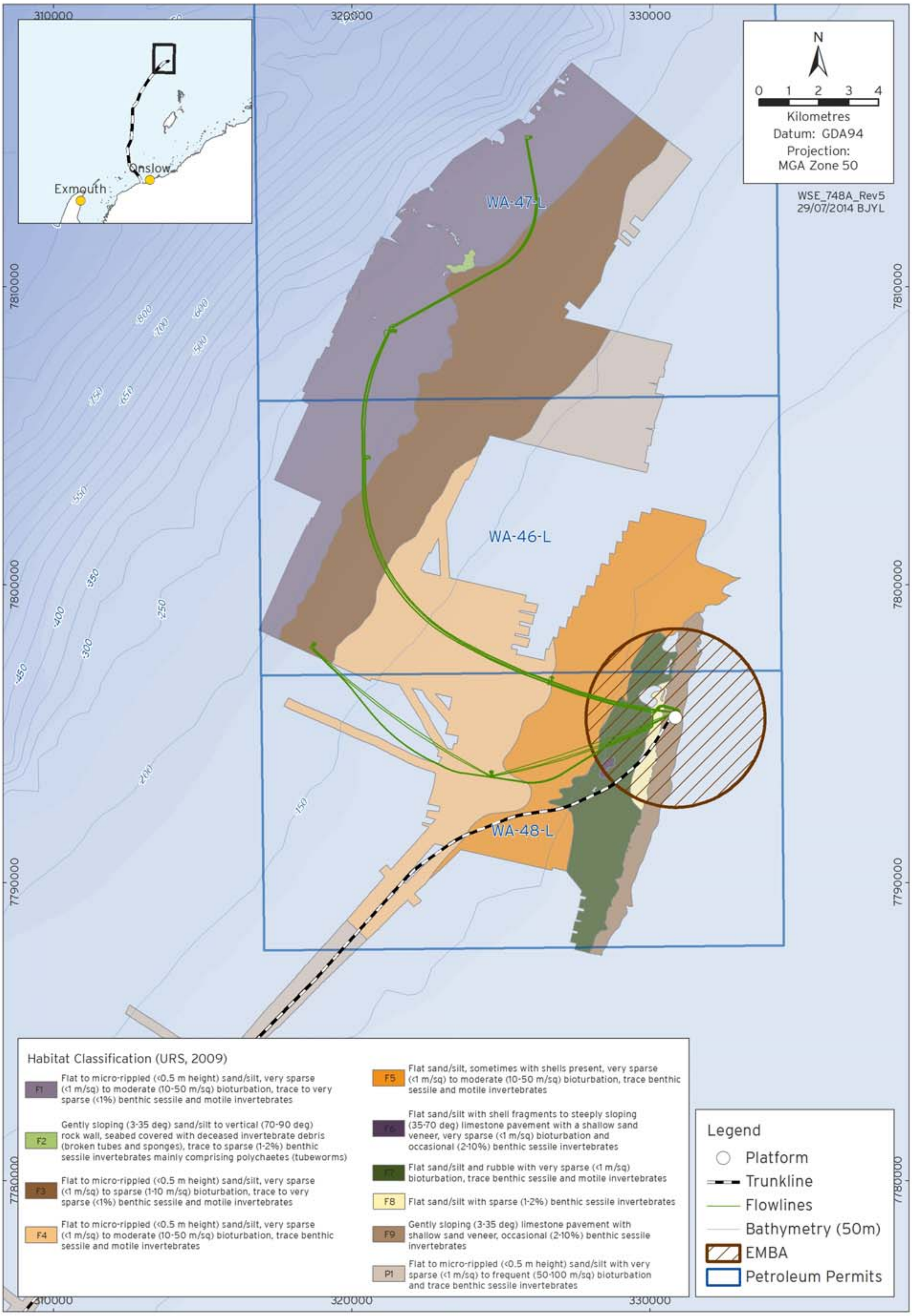

Figure 3.2: Classification of the Benthic Habitat within the Operational Area

4.0 ENVIRONMENTAL RISK ASSESSMENT

An environmental risk assessment has been undertaken to evaluate significant impacts and risks arising the FCGT and dewatering activities. This section summarises the methods used to assess the environmental risks associated with these activities.

4.1 Risk Assessment Approach

The risk assessment of discharges described under this Plan was undertaken in accordance with the Chevron Corporate Health, Environment and Safety (HES) Risk Management Process (Chevron 2012) using the Chevron Integrated Risk Prioritization Matrix. The approach generally aligns with the processes outlined in Australian Standard/New Zealand Standard (AS/NZS) ISO 31000:2009 Risk Management and Handbook 203:2012 Managing Environment-related Risk (Standards Australia/Standards New Zealand 2009, 2012).

The risk assessment process and evaluation involved consultation with environmental consultants, emergency response and transport professionals as well as installation and chemical engineers. Risks were identified and informed by:

- Experience gained during Wheatstone Construction Environmental Plans
- Experience of Chevron Australia personnel involved in other Chevon major projects
- Stakeholder engagement.

Physical and ecological, consequences were also informed by:

- Experienced in-house environmental and social practitioners
- Experienced external specialist environmental consultants
- Knowledge of the existing environment, its values, sensitivities, and regional importance
- Predictive modelling
- Available scientific and research literature.

The environmental impact identification and risk assessment process comprised the following components:

- Identification of activities and associated aspects with the potential to impact identified physical, biological, and socioeconomic receptors
- Identification of physical, biological, and socioeconomic receptors within the EMBA by the activities and aspects, and identification of particular environmental values and sensitivities
- Evaluation of the potential consequences to the identified receptors without safeguards
- Identification of safeguards to reduce the potential likelihood of the consequence occurring
- Evaluation of the likelihood of the consequence occurring with planned and confirmed safeguards in place
- Quantification of the risk ranking with safeguards in place
- Determination of whether the potential environmental impacts and risks are ALARP after considering the effectiveness of the identified safeguards
- Determination of whether the potential environmental impacts and risks are acceptable
- Development of environmental performance objectives, performance standards, and measurement criteria.

The outcomes of the environmental impact identification and risk assessment process relevant to this management plan are summarised in Section 4.3.

4.2 Discharge Characterisation

4.2.1 Toxicity

The process of chemical toxicity determination has been developed to establish a threshold of toxicity for the chemical (Hydrosure 0-3670R) used during the FCGT activities. The process used the following steps:

- Whole of Effluent Toxicity (WET) testing – assessing the toxicity of the effluent on a suite of relevant local species under a range of exposure concentrations using the recommended protocols from ANZECC and ARMCANZ (2000)
- Establishing environmental protection threshold criteria –based on ANZECC and ARMCANZ (2000) guidelines, results from WET testing and software to develop species protection limits.

WET testing involves exposing organisms to various concentrations of a potentially toxic medium and then measuring a pre-determined experimental endpoint (e.g. mortality, growth, or reproductive characteristics) after a selected period of time (ANZECC & ARMCANZ 2000). WET testing of the proposed flooding fluid was conducted for a mixture of Hydrosure 0-3670R diluted with seawater which was sourced in the vicinity of the trunkline route (Latitude -21.28850°, Longitude 114.51600°); and was undertaken using five locally relevant species from four different taxonomic groups.

Single species WET test laboratory results can be extrapolated to determine the effects in the wider aquatic ecosystem by investigating the statistical distribution of all of the single species toxicities. This extrapolation uses the statistical endpoints from the single species ecotoxicity testing to estimate a species sensitivity distribution (SSD), from which guideline values for estimating the maximum concentrations at which a given level of species protection can be achieved (refer Table 4.1).

Table 4.1: Species protection concentrations for Hydrosure 0-3670R based on the NOEC* SSD from WET testing

	PC99% (ppm or mg/L)	PC95% (ppm or mg/L)	PC90% (ppm or mg/L)	PC80% (ppm or mg/L)
Hydrosure (based on NOEC)	0.06	0.10	0.15	0.23

** NOEC (No Observed Effect Concentration)*

The 99% species protection concentration is suggested by ANZECC and ARMCANZ (2000) for development of environmental criterion for *high conservation ecosystems* or chemicals that have a tendency to bioaccumulate. While Hydrosure 0-3670R has a negligible risk for bioaccumulation and the EMBA does not occur in a *high conservation ecosystem,* the 99% species protection level was selected to ensure the environmental risk assessment outcomes represented a conservative appraisal of the potential toxicity impacts of the discharge. This resulted in threshold criteria for modelling expressed as:

- Over a 48 hour period, the median concentration of Hydrosure 0-3670R is not to exceed 0.06 mg/L.

The methodology and results of WET testing, including development of environmental protection thresholds that were subsequently applied to flooding fluid modelling results, are described in detail in Appendix D, and the application of these results to modelling of flooding fluid discharges is presented in Appendix B and described in Section 4.3.

4.2.2 Dispersion

Modelling of the discharge of flooding fluid was conducted to predict the spread of the outfall plume based on the concentration and duration of the discharge under a range of climate/oceanographic conditions. The aim of modelling was to predict the environmental fate (concentration and duration) of flooding fluid discharged at the WP for two discharge scenarios:

- Discharge 1: 20 000 m^3 flooding fluid discharged at two metres above sea floor over 20 hours modelled with an assumed Hydrosure 0-3670R discharge concentration of 550 ppm
- Discharge 2: 220 000 m^3 flooding fluid discharged at -45 m (approximately 30 m above sea floor) over six to eight days. The first 200 000 m^3 modelled with an assumed Hydrosure 0-3670R discharge concentration of 500 ppm. The last 20 000 m^3 modelled with a conservative Hydrosure 0-3670R discharge concentration of 1000 ppm.

A hybrid application of a near-field expert system (CORMIX) and a quasi-3D Lagrangian dynamic far-field model (MIKE21 NPA) were applied to assess the dilution characteristics of the plume. A range of conservative assumptions were applied, and supporting sensitivity testing was performed, in order to improve confidence that the potential dilution limits have been captured. Stationary plume characteristics were evaluated using CORMIX to estimate plume centreline dilutions and plume widths. A customised tool was generated to project CORMIX plume predictions onto a high-resolution grid. Utilising this tool in combination with available Acoustic Doppler Current Profiler (ADCP) data near the platform location to define ambient flow conditions, a full year of quasi-stationary 2D fields was generated within the region ±2 km from the platform for the range of expected flow rates. A more detailed description of the modelling undertaken for these discharges is provided in Appendix C.

The selected threshold concentration of a 48-hour median concentration of 0.06 mg/L was used to determine the maximum envelope within which the discharge plume may occur subject to the likely prevailing metocean conditions at the time of the discharge. Discussion of the application of this concentration is further described in Section 4.3.2 in the assessment of potential impacts from the discharge.

As with the development of the threshold criteria, the modelling approach and assumptions represent a highly conservative appraisal of the dispersion concentrations of the discharge, some of the conservatisms associated with the modelling include:

- Running the model as a continuous effluent release under a range of expected flow rates over 12 months rather than as a single release of limited duration (6–8 days)
- Basing discharge concentrations on the initial dosing concentration of Hydrosure 0-3670R, without accounting for expected degradation of active ingredients during residence time in the pipeline.
- Representation of all model outputs over the 12 month simulation to identify the total envelope of possible impacts, which exaggerates the spatial extent of potential impacts.

As a result of the above approach/assumptions, the impact envelopes presented in Figure 4.1 capture the most adverse combination of environmental factors over a full year.

Whereas, actual discharges under typical ambient conditions for the site can be expected to generate a significantly smaller impact footprint. In summary the modelling found that:

- Under certain conditions median concentrations of the 220 000 m^3 flooding fluid discharge over the 12 month simulation period may exceed the threshold criteria of 0.06 mg/L over a 48 hour period, but as illustrated in Figure 4.1, the results were highly influenced by seasonal metocean conditions.
- In general, for the targeted pigging speed (0.5 m/s) the area in which the discharge concentration exceeded the threshold criteria over the 12 month simulation period was very limited, and did not extend beyond 400 m from the discharge point (≥ 1% probability).
- Where seasonal conditions resulted in low residual currents (May, July and August) and during high dispersion scenarios, the area in which the discharge concentration exceeded the threshold criteria over the 12 month simulation period extended up to 800 m from the platform (≥1% probability).
- At a pigging speed of 0.75 m/s (representing the worst case discharge scenario) the area in which the discharge concentration exceeded the threshold criteria over the 12 month simulation period extended up to 1.5 km from the platform (≥1% probability).
- For both low and high dispersion settings, during periods of ambient current activity (in May and August), an atypical plume behaviour is observed which resulted in ‘fingers’ of the discharge extend up to 3 km from the platform at concentrations exceeding the threshold criteria over the 12 month simulation period.

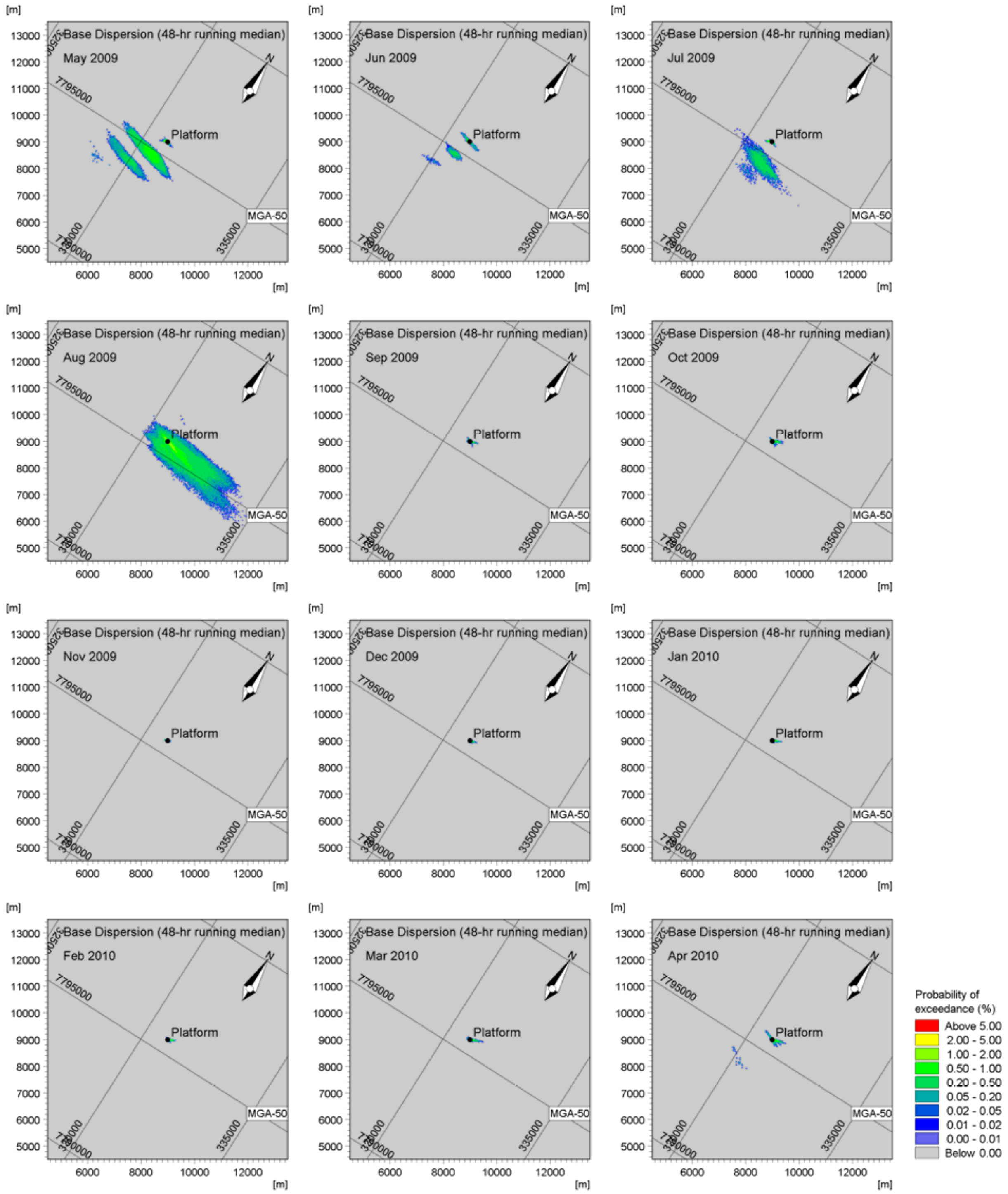

Figure 4.1: Potential discharge impact envelopes based on a 48 hour median of 0.06 mg/L and typical discharge rate (0.5m/s pigging speed)

4.3 Potential Impacts

Potential impacts associated with the discharge include:

- Physical impacts resulting from the temporary suspension and subsequent settlement of sediments on benthic biota, and
- Toxic impacts to benthic and pelagic species resulting from water quality changes.

4.3.1 Physical impacts

The release of 20 000 m^3 flooding fluid at approximately two metres above the seabed will initially be at a high velocity but will decrease quickly over a short period of time (first 10 to 15 mins). Minor and localised seabed disturbance is anticipated as a result of possible sediment suspension surrounding the point of discharge. However, as this discharge will be directed vertically upwards, not towards the seabed; it will rapidly decrease in velocity (within 10 to 15 sec); and will take place on a ridge line comprising mostly hard substrates, the potential for sediment suspension and associated physical impacts to benthic habitats is likely to be negligible.

The discharge of 220 000 m^3 of flooding fluid 45 m below the sea surface from the dewatering activities has the potential to result in physical seabed disturbance due to both the duration (six to eight days) and velocity (between 2.69 m/s and 8.06 m/s), typically, 5.37 m/s is the rate at which it is expected to occur. However, the height of the discharge above the seabed (30 m) and the presence of the rock blanket below the SGS and predominantly hard substrates more broadly surrounding the WP are expected to minimise any risk of scouring and / or a sediment plume.

4.3.2 Toxicity Impacts

WET testing described in Section 4.2.1 demonstrated that the discharge of the flooding fluid containing Hydrosure 0-3670R has the potential to cause acute toxicity to marine organisms if present in the immediate surrounds of the discharge at concentrations above 0.06 mg/L. However, modelling showed that under most circumstances the discharge plume above this concentration value did not extend beyond 1.5 km.

Based on these findings, there is a reasonable likelihood that marine species that are present out to a distance of 1.5 km from the discharge point, could experience acute toxic impacts (both lethal and non-lethal) as a result of exposure to the discharge at concentrations above the 0.06 mg/L threshold (noting that the 0.06 mg/L threshold concentration is less than the half the NOEC value for any invertebrate species tested).

WET testing included consideration of impacts to fish and pelagic invertebrate species however the likelihood of these species being exposed to the discharge at concentrations higher than the threshold for periods greater than 48 hours is negligible. Furthermore, highly motile fish and other marine fauna have the capacity to adapt their behaviour in response to changes in environmental conditions and can be expected to move away from the discharge if exposed.

Given the limited abundance of benthic habitats and/or biota within the EMBA , the large area of similar habitat from which re-colonisation may occur, the high reproductive rates of most benthic invertebrate species; the low likelihood of pelagic species being exposed to the discharge; and the ability of fish and marine fauna to move away from the discharge plume, the potential for toxic impacts to occur from the flooding fluid discharge are considered to be localised, short-term and negligible at the population or bioregional scale.

4.4 Risk Assessment Summary

Based on the combination of consultation, WET testing and dispersion modelling as described in Sections 4.1, 4.2.1 and 4.2.2, the risk assessment for trunkline (and hence Flowline) dewatering following FCG and hydrotesting indicate that the risk to benthic habitat and pelagic species is considered low. A summary of the risk assessment findings for these discharges is shown in Table 4.2.

Table 4.2: Summary Risk Assessment outcomes for the dewatering of Trunkline following FCG and Hydrotesting

Activity	Potential Environmental Impact	Consequence	Likelihood	Residual Risk
Discharge of flooding fluid from storage pond following hydrotest (20 000 m^3)	Minor and localised disturbance to habitat through sediment suspension and settlement.	Incidental (6)	Remote (5)	Low (10)
	Temporary and localised reduction in water quality resulting in acute toxicity effects on marine fauna.	Incidental (6)	Unlikely (4)	Low (9)
Discharge of flooding fluid due to dewatering of trunkline from onshore to WP (220 000 m^3) during dewatering activities.	Minor and localised disturbance to habitat through sediment suspension and settlement.	Incidental (6)	Remote (5)	Low (10)
	Temporary and localised reduction in water quality resulting in acute toxicity effects on marine fauna.	Minor (5)	Unlikely (4)	Low (8)

5.0 ENVIRONMENTAL MANAGEMENT, MONITORING AND REPORTING

5.1 Management Measures

This section describes the management actions to be implemented or standards to be adopted by Chevron to manage environmental risk under this Plan (Table 5.1). They reflect both the mitigation measures put in place during the design of these activities as well as potential control measures that can be implemented at the time of trunkline discharge, in accordance with the scenarios modelled.

Table 5.1: FCGT and Trunkline Dewatering Management Actions or Standards

Management Item	Management Action or Standard
♦ Chemical Selection Process	♦ A formal chemical selection process (Appendix A) assessed alternative options for the treatment of the flooding fluid to ensure that the chemical selected presented: ▪ the lowest practicable environmental risk while meeting requisite technical performance criteria and HES requirements ▪ a low risk of persistence or bioaccumulation once released into the marine environment.
♦ Chemical Dosing Strategy	♦ To optimise concentrations for both technical pipeline integrity and environmental outcomes dosing will undergo QA/QC to determine final required chemical concentrations (refer to Section 2.3.2).
♦ Volumes	♦ The volume of flooding fluid released from the storage pond will not exceed 20 000 m^3 ♦ The volume of the flooding fluid discharged from the dewatering of the trunkline will not exceed 220 000 m^3
♦ Concentrations	♦ The Hydrosure 0-3670R concentration of flooding fluid (excluding the last 20 000 m^3) will not exceed a mean concentration of 550 ppm
♦ Discharge Rate[1]	♦ Trunkline dewatering discharge rate of 220 000 m^3 of flooding fluid is expected to remain between 0.22 m^3/s and 0.68 m^3/s during dewatering (between pigging speeds of 0.25 and 0.75 m/s) ♦ Discharge rate for the 20 000 m^3 of flooding fluid released from the storage pond will remain below 0.28 m^3/s during discharge
♦ Marine Fauna Hazing	♦ Should the discharge occur during the whale migration season (May-October) hazing techniques will be employed during day light hours, where practicable and safe to do so, in an effort to divert whales away from the EMBA during the discharge. Where practicable and appropriate, hazing techniques will be consistent with those employed for oil spill response

[1] – Note that the anticipated Discharge Rates are estimates only and the actual values will depend on a number of operational aspects. However it is anticipated that any deviations from these values or ranges will be accounted for by the inherent conservatism built into the forecast model as described in Section 4.2.2 of this Plan and the Addendum (Appendix F). This assumption will be validated by hind-cast modelling as required.

5.2 Triggers and Corrective Actions

The corrective actions and associated triggers included in this plan are focussed on flooding operations.

Triggers and Corrective Actions for flooding operations include:

- The trigger value for flooding fluid which has a shorter residence time in the trunkline (stabilisation fluid, FCG forewater and water between the pigs) will be a mean concentration no greater than 385 ppm.
- The trigger value for flooding fluid with a longer residence time (overpump and main flood) in the trunkline will be a mean concentration no greater than 550 ppm
- The trigger value for the re-dosage of flooding fluid stored in the temporary onshore ponds prior to reinjection will be a mean concentration of 550 ppm (assumes a concentration of zero ppm in water received from the trunkline at the time of redosing).
- Stroke counters and/or flow meters will be used for the chemical injection in combination with the main line flow meters to ensure the correct dosing of chemicals. Flow rate, volume of water pumped (position of pig) and volume of chemicals injected (concentrations) will be logged every 15 minutes while the tank level will be checked every 30 minutes to confirm the correct amount of chemicals has been injected.
- Should the monitoring described above determine that the mean dosage concentration has exceeded the relevant trigger value, immediate actions will be taken to reduce the dosage rate to bring the mean concentration below the trigger level.

The primary reasons for adaptive management not being considered for the dewatering operations are:

- During dewatering of the trunkline the discharge flow rate is determined by the pigging speed which must be controlled to minimise the risk of trunkline obstruction, as such flow rates cannot be adjusted in response to environmental considerations without significant risk to the overall operation.
- The manufacturer of Hydrosure has developed an in-house test that will be used for monitoring end-of-pipe concentrations but the Limit of Reporting (sensitivity) of this test is currently 200 ppm and therefore is not suitable for monitoring in the marine environment.
- Monitoring of discharge concentrations within the marine environment post-discharge would require laboratory analysis of water samples collected from within the EMBA to provide meaningful information. As there is no prescribed and commercially available laboratory test to detect Hydrosure 0-3670R concentrations and no suitable surrogate parameter exists other than Nitrogen that can be monitored, which is expected to exhibit a large range of natural variability, laboratory analysis of the discharge in the marine environment is impracticable.
- Even if a suitable water quality test were commercially available, the discharge duration is expected to be completed in 6 to 8 days, meaning that water sampling and laboratory analysis would not be completed in time to enable adaptive management measures to be implemented during discharge operations.

5.3 Monitoring

The monitoring program is designed to support the triggers and corrective actions associated with flooding operations, however, as no corrective actions are proposed for the dewatering discharge, infield monitoring of the marine environment at the WP for these pre-commissioning activities is not proposed.
However a range of operational data will be collected to verify the model outcomes. This includes collection of operational records (fluid composition, discharge volumes and timing, and metocean data) as evidence that discharges are consistent with model predictions.

Table 5.2 provides the parameters that will be measured and associated criteria that will be used to confirm that the discharges are consistent with model prediction. These monitoring criteria have been developed to determine whether the objectives of the management actions or standards have been met. Where no practical quantitative target exists, a qualitative target is set and used.

Table 5.2: Monitoring Parameters and Criteria

Activity	Parameter	Measurement criteria
Flooding of the Trunkline during FCGT activities	Concentration	♦ Dosing records for the flooding fluid injected during flooding demonstrate a mean Hydrosure 0-3670R concentration that is 550 ppm or less ♦ Re-dosing records for the flooding fluid stored in the temporary onshore pond demonstrate a mean dosage Hydrosure 0-3670R concentration that is 550 ppm or less (assumes a concentration of zero ppm in water received from the trunkline at the time of redosing)
Discharge of 20 000 m^3 associated with dewatering the onshore pond	Volume	♦ Dewatering records demonstrate no more than 20 000 m^3 released
	Discharge Pipe Direction	♦ Inspection of trunkline outlet orientation shows vertical alignment with a deviation of ≤30°
	Discharge Rate	♦ Dewatering records demonstrating a mean average discharge rate is at or below 0.28 m^3/s
Discharge of 220 000 m^3 Flooding Fluid	Concentration	♦ Analysis of end-of-pipe samples collected at the WP demonstrates that Hydrosure 0-3670R concentrations in the flooding fluid at the time of dewatering are consistent with modelled input parameters.(to be used for Hind-cast Modelling refer Section 5.4)
	Volume	♦ Dewatering records demonstrate no more than 220 000 m^3 released
	Discharge Rate	♦ Dewatering records demonstrating discharge rate between 0.22 m^3/s and 0.68 m^3/s during dewatering
	Marine Fauna Observers	♦ For the duration of trunkline dewatering activities Marine Fauna Observers (MFOs) will be used from the WP or a vessel during day light hours to record the presence of marine fauna within 1500 m of the discharge location ♦ For the duration of trunkline dewatering activities, MFOs will also record any observations of fish or mass fish mortality that are observed during day light hours within 1500 m of the discharge location

Activity	Parameter	Measurement criteria
	Metocean data	♦ Metocean conditions will be monitored in the vicinity of the WP to collect data on wind, wave, tidal, surface and residual current conditions as well as water temperature and salinity. Metocean data will be collected prior to, during, and following the discharge to confirm that metocean conditions at the time of the discharge are consistent with the input parameters used for the model

5.4 Hind-Cast Modelling

Hind-cast modelling will be conducted to amalgamate metocean, engineering and flooding fluid water quality data into an integrated hind-cast dispersion model. The dispersion model will be re-run after the completion of trunkline dewatering using end-of-pipe Hydrosure 0-3670R concentration measurements, recorded or estimated flow rates, confirmed as-built outfall configuration and actual metocean conditions at the time of discharge. Some model assumptions used in the forecast model may be adjusted based on field validation work. The modelling will estimate the direction, dispersion and potential persistence of median Hydrosure 0-3670R concentrations above the threshold criteria of 0.06 mg/L to verify the observed dispersion was consistent with the predictions of the forecast model described in Appendix C and to demonstrate the point after the completion of dewatering when conditions within the EMBA are returned to below the threshold criteria.

5.5 Reporting

A Commonwealth annual Compliance Assessment Report (CAR) is required as per Condition 3 of EPBC 2008/4469. The report will assess compliance against Ministerial conditions within the compliance reporting period being 31 August to 30 August of each compliance year, with the CAR due by 30 November of each year.

6.0 REFERENCES

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Appendix A Chemical Selection Process

APPENDIX A CHEMICAL SELECTION PROCESS

Chemical treatment of the flooding-fluid is recommended to protect the integrity of the trunkline by preventing microbial growth leading to corrosion within the pipeline through the effective use of biocide. Since biocides are by their very nature designed to be toxic to marine biota, they are classified as High Hazard Category chemicals according to the Chevron Hazardous Materials Approval Process (Appendix C). As a result the chemicals considered for the treatment of the trunkline flooding fluid were subject to a detailed review and selection process. The chemical selection process examined all relevant information to demonstrate that planned discharges meet ALARP and Acceptability criteria. The process involved four key analysis steps:

1. Treatment Options Analysis
2. Chemical Options Analysis (including Chemical Screening)
3. Chemical Approval
4. Endorsement of Selected Option.

The Chevron Hazardous Materials Approval Procedure is designed to assess the hazardous properties of a broad spectrum of chemicals, not just biocides. The criteria used for assessment under this procedure confirm that chemicals used as marine growth inhibitors (biocides) will be assessed as being highly hazardous chemicals causing potential environmental harm due to their intended toxicity. The Chevron Hazardous Materials Approval Procedure was therefore used as the third step in the chemical selection process as a pre-screening tool to eliminate any chemical treatments that contained constituents which were either banned by legislation and/or the Chevron Environmental Stewardship Process or which presented the potential risk of persistence or bioaccumulation once released into the marine environment.

A1.0 Treatment Options Analysis

The trunkline will be flooded for hydrotesting as part of the FCGT activities. To identify leaks during hydrotesting, Fluorescein Dye was selected for use as a leak detection dye. Fluorescein Dye was selected due to its low toxicity, availability, low cost, water solubility and stability, and ease of detection. In addition, rapid breakdown of Fluorescein Dye following exposure to sunlight suggests that concentrations likely to be encountered by these organisms in the field would be low (Walthall and Stark 1999). Fluorescein Dye is routinely used in offshore petroleum projects.

The trunkline is constructed by welding together mild steel pipe sections internally coated with Pipegrad P100 to prevent corrosion. The welded-joints are not coated and are exposed to the flooding fluid. This flooding fluid can contain corrosive oxygen, and bacterial species that support microbiologically influenced corrosion, which are both detrimental to carbon steel and the internal integrity of the pipeline. Therefore treatments that limit the effect of corrosive oxygen and bacteria were considered for the flooding-fluid. The following treatment options were identified:

1. Seawater treated with oxygen scavenger and exposed to Ultra Violet (UV) light
2. Deoxygenated freshwater
3. Seawater treated with oxygen scavenger and the biocide Tetrakishydroxymethyl phosphonium sulphate (THPS)

4. Seawater treated with oxygen scavenger and the biocide Glutaraldehyde
5. Seawater treated with Hydrosure 0-3670R, a proprietary hydrotest chemical containing oxygen scavenger and biocide (Quaternary Ammonium Chloride Salts (Quats).

Each option contained its own technical, commercial, health and safety, and operational challenges that were considered in conjunction with the potential environmental impacts associated with discharging the flooding fluid into the marine environment.

Option 1

The option of seawater treated with oxygen scavenger and exposed to UV light for bacterial sterilisation was not considered acceptable to prevent internal corrosion and ensure trunkline integrity. The effectiveness of UV sterilization to kill bacteria species is affected by particulate shadowing, therefore it cannot provide an absolute sterilisation solution. This option is not suitable for long-term wet storage of pipelines as there is no 'residual' treatment action and there is a potential lag-time required to validate the effectiveness of this method of treatment.

Option 2

The use of deoxygenated freshwater in place of seawater was eliminated as an option due to the large volume of freshwater required, specifically that it would need to be supplied continuously to the WP during the FCGT activities.

Options 3, 4 and 5

The remaining three options involved treatment of seawater with biocide. The flooding fluid would be seawater that is filtered and treated with a biocide and oxygen scavenger. Seawater was selected as it is readily available in the operational area and will be released back into the marine environment adjacent to the trunkline prior to commissioning.

A2.0 Chemical Options Analysis

The following three chemicals were considered as biocide treatments for the filtered seawater:

- THPS (tetra*kis*hydroxymethyl phosphonium sulphate)
- Glutaraldehyde
- Hydrosure™ 0-3670R (Quaternary Ammonium Chloride + Oxygen Scavenger).

Information on the three biocide options was gathered to compare their performance against a list of assessment criteria, including effectiveness of integrity preservation and performance; health and safety impacts and application as well as the environmental hazardous properties of the chemicals i.e. their eco- toxicity, biodegradation and bioaccumulation potential. A detailed assessment was conducted using manufacturer-provided information and published literature. The three biocide options were taken from chemical vendor treatment recommendation submitted by Baker Petrolite and Champion Technologies. A comparison of key chemical characteristics including half-lives, ecotoxicity (including residual toxicity), biodegradability and bioaccumulation for Hydrosure 0-3760R, THPS and Glutaraldehyd, respectively, is shown in Table A 1.

Table A 1: Comparison of published test data on persistence, acute and chronic eco-toxicity, biodegradability, bioaccumulation and concentration characteristics of chemical treatment options

Published Data	THPS	Glutaraldehyde	Hydrosure
Concentration	300 ppm	300 ppm	350 ppm
Acute Toxicity **Rainbow Trout, 96 hrs LC50 (ppm)**	94 – 119	12	1.0
Chronic Toxicity **Daphnia, 21 days NOEC (ppm)**	0.413	0.032	0.004
Persistence **(Abiotic half-life)**	72 days @ pH 7	63.8 days @ pH 9 25°C	379 days @ pH 9
Biodegradability	Inherently biodegradable Highly water soluble with a low volatility Degradation occurs by a combination of hydrolysis, oxidation, photo-degradation and biodegradation	Readily biodegradable. Breaks down to simple molecules (carbon dioxide and water) through the natural action of oxygen, sunlight, bacteria and heat. Degradation rate or half-life varies depending on the pH and temperature	Biodegradation is inversely proportional to alkyl chain length. Degradation rate or half-life in seawater is 5–8 days for typical solutions, but can be more than 15 days when the alkane chains are predominately C16. No major persistent metabolites are known for the active substances.
Bioaccumulation	Does not bioaccumulate	Does not bioaccumulate	Moderate potential to bioaccumulate in freshwater fish

Data sourced from:

1. Dow AQUCAR (Water Treatment Microbiocides) - Oil & Gas Biocide Selection Guide (Comparing Glutaraldehyde, THPS & Quaternary Amine Microbiocides Chemistries)
2. DOW Product Safety Assessment: gluteraldehyde. Revised:April11,2013
3. Baker Hughes :- Safety Data Sheet - XC24380
4. Baker Hughes :- Safety Data Sheet - XC24105
5. Champion Technologies :- Safety Data Sheet - Hydrosure O-3670R
6. Champion Technologies: CTLP-PLP-059 Monitoring Method O-3670R (Draft)\
7. Reregistration Eligibility Decision for Alky Dimethyl Benzyl Ammonium Chloride (ADBAC)

The assessment of Hydrosure 0-3670R required the use of surrogate information due to incomplete data for this proprietary product at the time of assessment. The surrogate information was for similar active components in Hydrosure 0-3670R, namely Quaternary Ammonium Chloride (ADBAC) The Material Safety Data Sheet (MSDS) for Hydrosure identifies the quaternary ammonium chloride as CAS No. 68424-85-1, which is Benzalkonium Chloride or synonym ADBAC and Ammonium Bisulphate, considered appropriate analogues for the hazardous action of the whole product. The performance and hazard ranking of each biocide option was assessed with regard to meeting the necessary performance criteria. Summaries of the assessment findings are presented in Table A 2, Table A 3 and Table A 4.

Table A 2: Option 3 - THPS Performance and Implementation Summary

Biocide	Advantages	Disadvantages	Summary of findings
Use of an oxygen scavenger and THPS	THPS is a highly reactive biocide and is unlikely to persist in the environment when discharged. Non bio-accumulative and inherently biodegradable (or biodegradable). THPS 75% is ranked GOLD on the OCNS (CEFAS, 2013).	Oxygen scavenger requires between 15 seconds to 48 hours reaction time in advance of biocide injection. At higher concentrations (>500 ppm) THPS can lower the pH of fluids to below 4, which can lead to corrosion of mild steel. At 30 °C THPS has a half-life close to 40 days. The trunkline will experience temperatures up to 32 °C, therefore a very high dose of THPS is required to maintain pipeline integrity for 12 to 36 months. Residual toxicity effect on the environment initially when released, as it is a biocide. The OCNS ranking carries a substitution warning (CEFAS, 2013).	Oxygen scavenger reacts directly with proposed biocide and must be injected well before the biocide. The oxygen scavenger needs to have totally reacted before the biocide can be injected. A time range of between 15 sec to 48 hrs is noted in literature as being required for the oxygen scavenger to react before the biocide is added. For a 12 to 36 months plus “protection” duration, injection of more than 500 ppm of THPS is required. Long term THPS contact with Carbon Steel causes pitting corrosion, which could lead to loss of pipeline integrity.

The trunkline could remain flooded for a period of 12 to 36 months at an immersion water temperature of 32 °C, so a dose of more >500 ppm of THPS would be needed to achieve the optimum microbial influence corrosion protection. This concentration of THPS would lower the fluid pH to a level considered unacceptable, therefore eliminating THPS as a biocide treatment option.

Table A 3: Option 4 - Glutaraldehyde Performance and Implementation Summary

Biocide	Advantages	Disadvantages	Summary of findings
Use of an oxygen scavenger and a glutaraldehyde	Glutaraldehyde is Non bio-accumulative and bio-degradable. Glutaraldehyde 50% is ranked GOLD on the OCNS and carries no substitution warnings (CEFAS, 2013).	Oxygen scavenger requires between 15 seconds to 48 hours reaction time in advance of biocide injection. Complex chemical injection methodology, which requires additional equipment and operating personnel. Requires large volumes of chemicals to be stored and handled offshore as over 1200 ppm of the product would need to be applied to maintain pipeline integrity for 12 to 36 months. Requires the reduction in PIG velocity during discharge events. Residual toxicity effect on the environment initially when released, as it is a biocide.	Comprehensive chemical inhibition and treatment of filtered seawater is only achieved, if the oxygen scavengers have “fully reacted”. Should a full reaction not be achieved the biocide component will be neutralised and deactivated. The added system complexity required to minimise the risk of biocide neutralisation increases the risk of incorrectly treating the seawater, which may result in “overdosing” thus increasing the environmental impact and offshore duration to complete the works. A 200% additional volume of chemical is required to treat the same volume of filtered seawater, compared to Hydrosure 0-3670R thus increasing HSE risks associated with transportation and containment during mobilisation and offshore execution. Availability of large volumes of these chemicals is limited resulting in additional schedule risk. Increased equipment spread and additional operational needs require larger offshore support vessels. To minimise the risk of inadequate chemical inhibition and air inclusion, which will affect pre-hydro test stabilisation, a reduction in the average PIG velocity to 0.35 m/s during discharges will be required, extending the offshore execution duration, costs and additional environmental impact (emissions and discharges) due to extended vessel presence in the field.

The health and safety issues associated with handling and use of glutaraldehyde, the increased equipment spread, and the reaction caused by incompatibility with oxygen scavenger, eliminated glutaraldehyde as a biocide chemical treatment option.

Table A 4: Option 5 - Hydrosure 0-3670R (Quaternary Ammonium Chloride Salt) Performance and Implementation Summary

Biocide	Advantages	Disadvantages	Summary of findings
Use of a chemical blend which contains an oxygen scavenger, biocide (Quaternary Ammonium Chloride Salt) and a small amount of surfactant	Hydrosure 0-3670R can be applied as one product and does not require a time lag as with a separate oxygen scavenger and biocide. Temperatures up to 150 °C do not affect the product which enables a lower concentration (ppm) to be used than other assessed biocides. Exhibits surfactant properties which act as a corrosion inhibitor to protect the carbon steel surface from corrosion. Simplified offshore equipment spread. Biodegradable and non-bioaccumulative Hydrosure 0-3670R is ranked GOLD on the OCNS (CEFAS, 2013).	Residual toxicity effect on the environment when initially released, as it is a biocide. OCNS ranking carries a substitution warning (CEFAS, 2013).	Simplified offshore injection methodology, equipment spread – not complex and commonly executed within the industry. Reduced volume of chemical required to treat the same volume of filtered seawater, compared to other assessed biocides, thus significantly reducing HSE risks associated with transportation and containment during mobilisation and offshore execution.

Hydrosure 0-3670R active biocide component (Table A 5) has a longer half-life when compared to the other biocides. The half-life allows Hydrosure 0-3670R dosage at a lower concentration and makes it desirable for long-term pipeline integrity preservation. Hydrosure 0-3670R is a one-part product, which does not involve the mixing of two incompatible products with an injection time-lag to limit incompatibility reaction as for THPS and Glutaraldehyde.

Table A 5: Chemical composition of Hydrosure 0-3670R

Chemical	Formula	Composition
Coco benzyldimethylammonium chloride (Quaternary Ammonium)	$C_{22}H_{40}ClN$	10–30 %
Ammonium Bisulphite	NH_4HSO_3	10–30 %
Dipropylene Glycol Methylether	$C_7H_{16}O_3$	1–10 %
Ethanediol	$C_2H_6O_2$	<1 %
Water	H_2O	30–50 %

The application advantages of using a product containing both biocide and oxygen scavenger, together with the additional corrosion inhibition properties to protect the carbon steel weld sections, makes Hydrosure 0-3670R the preferred option for treatment of the filtered seawater.

A3.0 Chemical Approval

Hydrosure 0-3670R was screened using the Chevron Hazardous Materials Approval Procedure (HMAP). An overview of the procedure can be found in Appendix C. The HMAP is designed to:

- Assess Hazardous Materials requested for procurement for their HES risks and provide an opportunity for selection and procurement of less hazardous chemicals (substitution), where reasonably practicable
- Ensure that appropriate controls are identified for the use of procured Hazardous Materials and communicated to the requestors of the materials and end users.

Step 1 – Treatment Options Analysis (Section A1.0) and Step 2 – Chemical Options Analysis (and screening) (Section A2.0) were completed prior to the HMAP being conducted so all of the relevant information could be provided to demonstrate the process which had been undertaken to arrive at the selected chemical and to provide information that is not usually included as part of an MSDS. The HMAP was used to get an independent assessment of the selected chemical to ensure the selected chemical meets all the requirements outlined in Steps 1 (Section A1.0) and 2 (Section A2.0).

A4.0 Endorsement of Selected Option

A workshop was completed involving Chevron Environment, Construction, Subsea Flowlines and Pipeline Engineering, and Management to review the selected chemical. The workshop discussed how the decision to select the chemical was arrived at, and why it was the most feasible in meeting project requirements. The criteria considered as part of the final chemical selection decision were that the chemical option selected must:

- Be technically robust and safe to implement offshore, with minimal risk to personnel or pipeline integrity
- Be industry proven and readily available to support commencement of pipe-lay by Q1 2014 (schedule subject to change)
- Have a confirmed preservation period of 12 to 36 months to avoid the potential for contingency dewatering and re-flooding
- Be screened through the internal Chevron HMAP which includes the Environmental Chemical Assessment Tool
- Reduce health, environment and safety risks to ALARP at the proposed discharge locations
- Meet the Projects FCG specification requirement which includes maintaining pipeline integrity.

Hydrosure is considered biodegradable and non-bioaccumulative. Testing of analogous products (ADBAC) which contain the same active substances as Hydrosure are reported to have a half-life of between 8 and 15 days in seawater and are considered to be highly biodegradable. This indicates that the potential persistence of Hydrosure in marine water and sediments is unlikely. Further, Bioconcentration factor (BCF) testing of ADBAC reported BCF values for fish of 79 L/Kg (Centre for Environment, Fisheries & Aquaculture Science [CEFAS] Chemical Hazard and Risk Management [CHARM] OCNS Grouping: GOLD). Bioconcentration is the process by which a chemical substance is absorbed by an organism from the ambient environment through its respiratory and dermal surfaces (Arnot and Gobas 2006). Substances with a BCF reported below 1000 L/Kg are considered to not bioconcentrate (Champion Technologies. 2013)). Bioaccumulation is analogous to BCF, but applies to field measurements or to laboratory measurements with multiple exposure routes (USGS 2013).

Given that ADBAC is considered an appropriate surrogate, the data suggests that the active substances in Hydrosure 0-3670R do not bioconcentrate. Bio-accumulation of Hydrosure 0-3670R was investigated under the CEFAS CHARM system. The evaluation of Hydrosure 0-3670R ranked the product as non-bioaccumulative on the basis that it has a Log Pow <3 (GOLD ranking) for Coco benzyldimethylamonium chloride (Quaternanry ammonium compound).

Impacts to water quality from the metabolites of Hydrosure are also considered to be short term, localised and negligible as the chemical composition of Hydrosure (refer Section A2.0) is mostly comprised of carbon, nitrogen and oxygen.

Hydrosure 0-3670R was considered the most viable chemical treatment option due to the following factors:

- Provides significantly greater pipeline integrity performance than the alternatives (options 3 and 4)
- Has a longer half-life reducing the risk of potential contingency dewatering and re-flooding should the pipe-lay schedule be extended
- Provides better HES performance than the alternatives (less likelihood of reflooding requirements and therefore fewer and reduced duration of vessels in the operational area)
- Provides greater operational performance and reduced logistic requirements (smaller chemical volumes and vessel requirements compared to the alternatives)
- The product is biodegradable and has a negligible risk for bioaccumulation.

Hydrosure 0-3670R offers the optimum solution in terms of preservation of pipeline integrity, operational implementation and practicality, Health and Safety and commercial differentiators.

Appendix B Overview of the ABU Hazardous Materials Approval Procedure

APPENDIX B OVERVIEW OF THE ABU HAZARDOUS MATERIALS APPROVAL PROCEDURE

The ABU Hazardous Materials Approval Procedure (HMAP) falls under the Chevron Australia Hazardous Materials Communication Process and applies only to procured Hazardous Materials, a collective term for those chemical materials/products that are classified as Hazardous Substances or Dangerous Goods (DG).

The HMAP is designed to:

- Assess Hazardous Materials requested for procurement for their HES risks, and provide an opportunity for selection and procurement of less hazardous chemicals (substitution), where reasonably practicable

  and
- Ensure that appropriate controls are identified for the use of procured Hazardous Materials and communicated to the requestors of the materials and end users at locations within Chevron's Area of Operations.

The main steps and tools used with the HMAP include:

- Use of a Hazardous Material Approval Application Form (HMAAF) to request chemical HES assessment and approval for acceptability of HES risk prior to purchasing a material. The HMAAF identifies the proposed uses of the material and exposure pathways for personnel, and is accompanied by a compliant MSDS as per legal and company requirements.
- A team of nominated HES and DG chemical reviewers reviews each application for HES risks and compliance with DG licensing requirements.
- The first step in the HES review in the HMAP is to verify that the requested material does not contain ingredients which are listed on the company's Prohibited list of chemicals. The ABU also maintains a Restricted list of chemical ingredients, which are typically higher consequence ingredients, which may be used subject to more rigorous controls being in place. The Restricted and Prohibited lists are derived from company requirements which are based on national HES regulations and international conventions (e.g. ozone depleting substances, etc.). Chemicals which contain ingredients on the company's Restricted and Prohibited lists are either (a) in the case of prohibited chemicals, rejected or (b) for restricted chemicals approved for use with conditions in accordance with legal requirements.
- Certain requests involving materials with a reasonable potential to be discharged to the environment, undergo a detailed hazard assessment using an internally developed assessment tool. The tool ranks the inherent chemical environmental hazardous properties against six hazard rankings aligned with the Chevron Risk Management Process RiskMan[2] Risk Prioritisation Matrix. Inherent chemical environmental hazards assessed in this step include acute and chronic eco-toxicity, biodegradability, bioaccumulation, as well as additional considerations such as composition, waste disposal options and requirements, safety and risk phrases. The assessment is carried out by suitably qualified environmental professionals.

Chemicals that are assessed to be in the High Hazard Category (and in some cases in the Moderate Hazard Category) are challenged and chemical requestors have to either demonstrate a solid business case for the selected chemical (e.g. technically the best chemical for the proposed application and no suitable less hazardous alternative) or else propose alternative chemicals that are technically suitable for the job, but have lower inherent environmental and health and safety hazards.

The HMAP is supported by the ChemAlert system, which:

- Is used to process the chemical requests
- Serves as a register of MSDSs
  and
- Records the approval conditions and any restrictions that may apply.

The HMAP described above is a high level protocol that nonetheless represents the top of the hierarchy of risk controls pyramid as applied to chemicals management in the company, i.e. substituting the hazard (with a less hazardous product). It also identifies additional controls (that sit lower on the risk control hierarchy) that are applied to chemicals throughout their life cycle including transportation, storage, use and disposal, as reflected in other HES management documents (e.g. management plans, operating procedures, job hazard analyses, permits to operate etc.).

A1.0 Hazardous Material Environmental Assessment and Associated Tools

The environmental assessment aspect of the Hazardous Materials Approval Procedure, along with description of the supporting tools, is summarised in the following paragraphs and Figure B 1.

The key supporting tools of the environmental assessment are the CVX Prohibited List of Materials (Table B 1), the Environmental Hazardous Properties Assessment Table (Table B 2) and the Rule-sets for Adjustment for Environmental Performance Table (Table B 3). The Environmental Hazardous Properties Assessment Table provides criteria against which the chemical can be ranked according to 6 ranking bands (6 being the lowest hazard and 1 being the highest hazard band). The criteria cover three key inherent chemical properties: Persistence, Bioaccumulation potential and Toxicity (PBT). A tabulation of Additional Considerations such as Risk Phrases/ Hazard Statements, Waste Management and Disposal and the Offshore Chemical Notification Scheme (OCNS) ranking against the 6 ranking categories is provided as a guide only; these are not used to rank the chemical but may provide useful benchmarking information to the assessor.

Using the Environmental Hazardous Properties Assessment Table (Table B 2), chemicals are initially ranked based on their Toxicity using the scale provided. A final rating is derived by adjusting the initial ranking according to the adjustment criteria provided for Persistence and Bioaccumulation Potential (Table B 3).

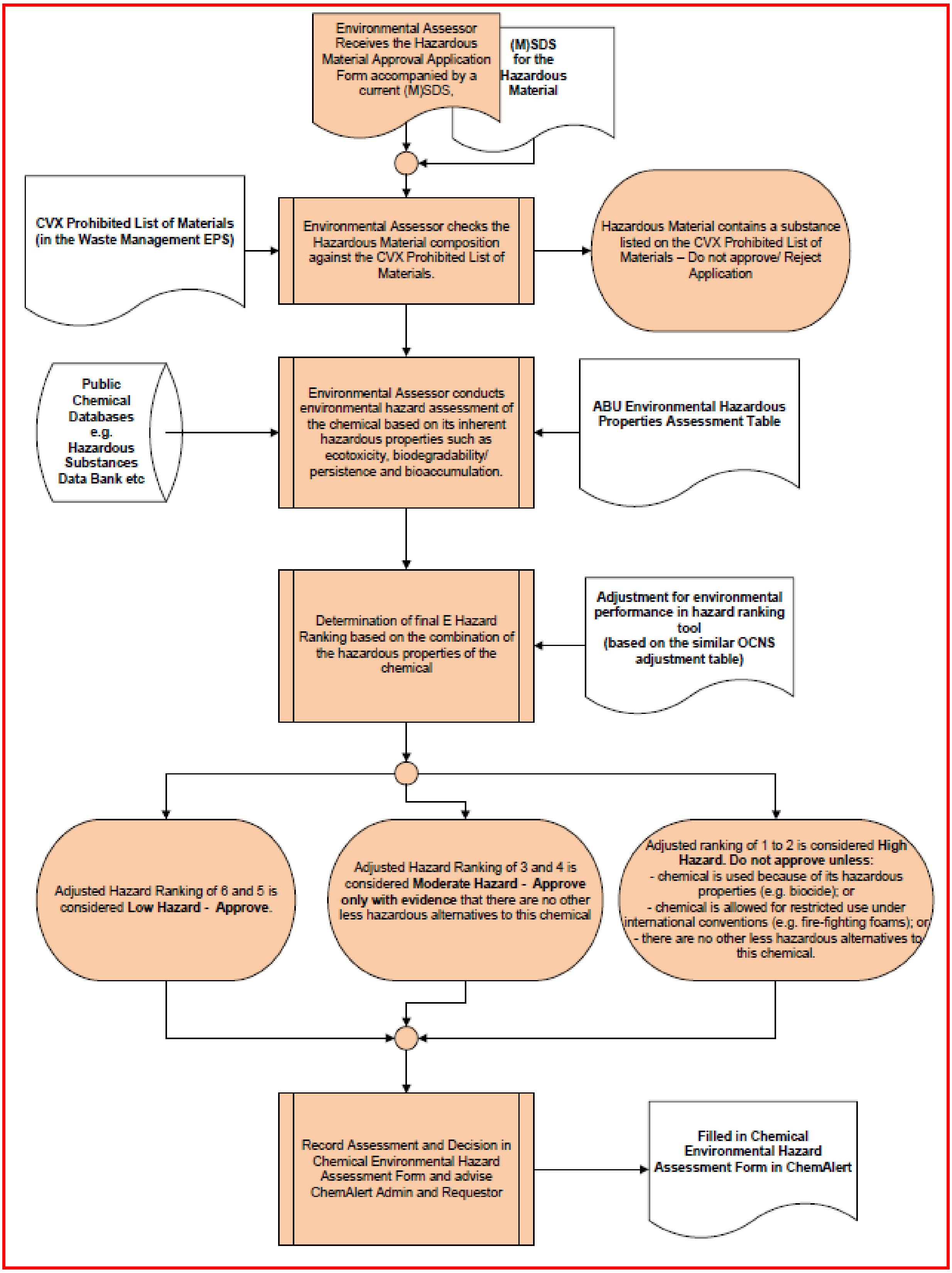

Figure B 1: Environmental Assessment of Chemicals within the Hazardous Materials Approval Procedure

Table B 1: Chevron List of Prohibited Materials

Prohibited Material	Prohibited Material Definition
Effective January 1, 2009 the procurement of new materials or any equipment (new or used) containing materials listed below is prohibited (Ref. CVX Waste Management Environmental Performance Standard):	
Ozone-Depleting Substances (ODSs), as defined by the Montreal Protocol	Specific chemicals that have been defined by the Montreal Protocol as having adverse effects on the stratospheric ozone layer. They include Chlorofluorocarbons (CFCs) (CFC 11, 12, 13, 111, 112, 113, 114, 115, 211, 212, 214, 215, 216, and 217); Halon 1211, 1301, and 2402; hydrobromofluorocarbons (HBFCs); carbon tetrachloride, 1, 1, 1-trichloroethane and methyl bromide. Includes bromomethane. The CVX List of Prohibited Materials exceptions for ODSs include: ♦ ODSs that have been designated as "essential use chemicals" by local government and are exempt from the requirements of the Montreal Protocol shall be excluded from the Prohibited Materials restrictions for the operating facility where the government exemption applies. ♦ Hydrochlorofluorocarbons (HCFCs) are not included in the list of Prohibited Materials under ODSs. Although defined under some regulatory regimes as ODSs, they have less impact on stratospheric ozone than CFCs. They have been introduced as temporary replacements for CFCs. ♦ Hydrofluorocarbons (HFCs) are not included in the list of Prohibited Materials under ODSs. They were introduced as alternatives to ozone depleting substances in serving many industrial, commercial, and personal needs. HFCs are emitted as by-products of industrial processes and are also used in manufacturing. They do not significantly deplete the stratospheric ozone layer.
All forms of asbestos-containing products	Any material containing more than 1% asbestos. While not an exhaustive list, the following products may fall into this category: pipe-covering, insulating cement, insulating block, asbestos cloth, gaskets, packing materials, thermal seals, refractory and boiler insulation materials, transite board, asbestos cement pipe, fireproofing spray, joint compound, vinyl floor tile, ceiling tile, mastics, adhesives, coatings, acoustical textures, duct insulation for heating, ventilation and air conditioning (HVAC) systems, roofing products, insulated electrical wire and panels, and brake and clutch assemblies.
Lead-based paint	Any paint containing lead
Polychlorinated biphenyls (PCBs) and PCB-contaminated materials	PCBs are employed in industry as heat exchange fluids, in electric transformers and capacitors, and as additives in paint, carbonless copy paper, sealants and plastics. PCB-contaminated materials are defined as materials exceeding 50 mg/kg of PCB oil.
Leaded thread compound (pipe dope)	Pipe dope containing lead

Table B 2: ABU Environmental Hazardous Properties Assessment Table

Env Hazard Category	Env Hazard Final Adjusted Ranking	Ecotoxicity				Bioaccumulation Potential		Persistence / Biodegradability		Additional Considerations			
		Acute Ecotoxicity		Chronic Ecotoxicity									
		Acute Aquatic Hazard	Acute Chemical Toxicity LD50 (oral)	Chronic Aquatic Hazard for Persistent Chemicals (28 day biodegradation <60%)	Chronic Aquatic Hazard for Readily / Rapidly Degradable Chemicals (28 day biodegradation >60%)	Text Description and Octonol-Water Partition Coefficient, log K_{ow}	Text description and Bioaccumulation / Bioconcentration Factor (BAF / BCF)	Text Description and Halflife in Aquatic Environment, $T_{1/2}$ [days]	Text Description and Biodegradability in Aquatic Environment, (over 28 days)	OCNS Ranking	Safety and Risk Phrases [5]	GHS Hazard Statements	Waste Management and Disposal
LOW	6	Almost Non-Toxic LC50 >10,000 ppm Fish LC50 (96hr) of >10,000 mg/L Crustacea EC50 (48hr) of >10,000 mg/L Algae or other aquatic plants ErC50 (72 or 96hr) of >10,000 mg/L [2]	>200,000 mg/kg body weight [4]	Unlikely to find chronic toxicity data in this range	Unlikely to find chronic toxicity data in this range	Will not bioaccumulate log Kow: <1	Will not bioaccumulate BCF<100 and MW > 700	Readily / Rapidly biodegradable ≤14	Readily / Rapidly biodegradable >99%	OCNS Initial Group E	None	None	- No waste planned to be generated (e.g. diesel fuel), or - Waste can be reused on site
	5	Slightly toxic LC50 >1,000 - 10,000 ppm Fish LC50 (96hr) of >1,000 to 10,000 mg/L Crustacea EC50 (48hr) of >1,000 to 10,000 mg/L Algae or other aquatic plants ErC50 (72 or 96hr) of >1,000 to 10,000 mg/L [2]	>20,000 to 200,000 mg/kg body weight [4]	Unlikely to find chronic toxicity data in this range	Unlikely to find chronic toxicity data in this range	Non Bioaccumulative log Kow: 1 to 3	Non Bioaccumulative BCF<100 and MW > 700	Readily / Rapidly biodegradable >14 to 50	Readily / Rapidly biodegradable >60% to 99%	OCNS Initial Group E	None	None	- Waste is non-hazardous and can be reused / recycled / recovered off-site within state with permits, or - Waste is non-hazardous and can be disposed of on-site with permits (e.g. downhole injection, offshore discharge)
MODERATE	4	Moderately toxic LC50 >100 - 1,000 ppm Fish LC50 (96hr) of >100 to 1,000 mg/L Crustacea EC50 (48hr) of >100 to 1,000 mg/L Algae or other aquatic plants ErC50 (72 or 96hr) of >100 to 1,000 mg/L [2]	>2,000 to 20,000 mg/kg body weight [4]	Unlikely to find chronic toxicity data in this range	Unlikely to find chronic toxicity data in this range	Not expected to bioaccumulate log Kow: 3 to 4	Not expected to bioaccumulate BCF (100 to 500) [6] and MW > 700	Inherently biodegradable (or biodegradable) >50 to 150	Inherently biodegradable (or biodegradable) >40% to 60%	OCNS Initial Group D	**S61** - Avoid release to the environment. **R54** - Toxic to flora **R55** - Toxic to fauna **R56** - Toxic to soil organisms **R57** - Toxic to bees **R53** - May cause long-term adverse effects in the aquatic environment	**H413** - May cause long lasting harmful effects to aquatic life	- Waste is non-hazardous and can be treated / disposed of off-site within state with permits - Waste is hazardous and can be reused / recycled / recovered off-site within state with permits
	3	Toxic (or Harmful) LC50 >10 - 100 ppm Harmful to aquatic life Fish LC50 (96hr) of >10 to 100 mg/L Crustacea EC50 (48hr) of >10 to 100 mg/L Algae or other aquatic plants ErC50 (72 or 96hr) of >10 to 100 mg/L [1]	>200 to 2,000 mg/kg body weight [3]	Unlikely to find chronic toxicity data in this range	Harmful to aquatic life with long lasting effects Fish NOEL or ECx >0.1 to 1 mg/L Crustacea NOEL or ECx >0.1 to 1 mg/L Algae or other aquatic plants NOEL or ECx >0.1 to 1 mg/L [3]	Expected to bioaccumulate log Kow: 4 to 5	Expected to bioaccumulate BCF (500 to 1000) and MW < 700	Inherently biodegradable (or biodegradable) >150 to 182	Inherently biodegradable (or biodegradable) >20% to 40%	OCNS Initial Group C	**R52** - Harmful to aquatic organisms **R53** - May cause long-term adverse effects in the aquatic environment	**H402** - Harmful to aquatic life **H412** - Harmful to aquatic life with long lasting effects	Waste is hazardous and must be treated / disposed of off-site within Australia with permits
HIGH	2	Toxic / Toxic to aquatic life LC50 >1 - 10 ppm Fish LC50 (96hr) of >1 to 10 mg/L Crustacea EC50 (48hr) of >1 to 10 mg/L Algae or other aquatic plants ErC50 (72 or 96hr) of >1 to 10 mg/L [1]	>25 to 200 mg/kg body weight [3]	Toxic to aquatic life with long lasting effects Fish NOEL or ECx >0.1 to 1 mg/L Crustacea NOEL or ECx >0.1 to 1 mg/L Algae or other aquatic plants NOEL or ECx >0.1 to 1 mg/L [3]	Toxic to aquatic life with long lasting effects Fish NOEL or ECx >0.01 to 0.1 mg/L Crustacea NOEL or ECx >0.01 to 0.1 mg/L Algae or other aquatic plants NOEL or ECx >0.01 to 0.1 mg/L [3]	Bioaccumulative log Kow: 5 to 6	Bioaccumulative BCF (1000 to 5000) and MW < 700	Not biodegradable >182 to 365	Not biodegradable >0% to 20%	OCNS Initial Group B	**R51** - Toxic to aquatic organisms **R53** - May cause long-term adverse effects in the aquatic environment	**H401** - Toxic to aquatic life **H411** - Toxic to aquatic life with long lasting effects	Waste is highly hazardous (e.g. DG Class 1 explosives or Class 7 radioactive) requiring high cost treatment / disposal
	1	Very Toxic / Very toxic to aquatic life LC50 <1 ppm Fish LC50 (96hr) of ≤ 1 mg/L Crustacea EC50 (48hr) of ≤ 1 mg/L Algae or other aquatic plants ErC50 (72 or 96hr) of ≤ 1 mg/L [1]	<25 mg/kg body weight [3]	Very toxic to aquatic life with long lasting effects Fish NOEL or ECx ≤ 0.1 mg/L Crustacea NOEL or ECx ≤ 0.1 mg/L Algae or other aquatic plants NOEL or ECx ≤ 0.1 mg/L [3]	Very toxic to aquatic life with long lasting effects Fish NOEL or ECx ≤ 0.01 mg/L Crustacea NOEL or ECx ≤ 0.01 mg/L Algae or other aquatic plants NOEL or ECx ≤ 0.01 mg/L [3]	Highly bioaccumulate log Kow: >6	Highly bioaccumulate BCF >5000 and MW < 700	Not biodegradable >365	Not biodegradable 0%	OCNS Initial Group A	**R50** - Very toxic to aquatic organisms **R53** - May cause long-term adverse effects in the aquatic environment **R58** - May cause long-term adverse effects in the environment **R59** - Dangerous for the ozone layer	**H400** - Very toxic to aquatic life **H410** - Very toxic to aquatic life with long lasting effects **H420** - Harms public health and the environment by destroying ozone in the upper atmosphere	No known disposal pathway for waste within Australia.

Table B 3: Rule-sets for Adjustment for Final Ranking

Increase ranking by 2 levels (e.g. from 4 to 6)	Increase ranking by 1 level (e.g. from 4 to 5)	Do not adjust initial ranking	Decrease ranking by 1 level (e.g. from 3 to 2)	Decrease ranking by 2 levels (e.g. from 3 to 1)
Substance is readily biodegradable (rankings 6, 5) and is non-bio-accumulative (rankings 6, 5, 4)	Substance is inherently biodegradable (rankings 3, 4) and is non-bio-accumulative (rankings 6, 5, 4)	Substance is not biodegradable (rankings 1, 2) and is non-bio-accumulative (rankings 6, 5, 4), or Substance is readily biodegradable (rankings 6, 5) and bio-accumulates (rankings 3, 2, 1)	Substance is inherently biodegradable (rankings 3, 4)and bio-accumulates (rankings 3, 2, 1)	Substance does not biodegrade (rankings 1, 2) and bio-accumulates (rankings 3, 2, 1)

Depending on the final adjusted ranking, chemicals are grouped into the following hazard categories:

- Low Environmental Hazard Chemicals – those with a Final Adjusted Ranking of 6 or 5.
- Moderate Environmental Hazard Chemicals - those with a Final Adjusted Ranking of 4 or 3.
- High Environmental Hazard Chemicals - those with a Final Adjusted Ranking of 2 or 1.

Approval or challenging of the chemical approval application will depend on the Hazard Category of the chemical (Low, Moderate or High) and the other considerations listed in Figure B 1. The assessment results and the decision (approve or challenge) are recorded on the Chemical Environmental Hazard Assessment Form and submitted to ChemAlert.

Note that approval of chemicals proposed for use in discharges to the environment, is only part of the risk management process for the discharge. Demonstration of risk acceptance for the planned discharge will be required in consideration of other factors such as discharge location and its environmental sensitivities, rate of discharge, etc. and an overall assessment of potential impacts on the environment.

A2.0 Additional Uses of the Environmental Hazardous Properties Assessment for Chemicals

The Hazardous Materials Environmental Assessment Form (HMEAF) in the HMAP is also being used as an environmental hazard acceptability screening tool in chemical selection and planning for both Operations and Major Capital Projects (see Figure B 2). The screening exercise helps Operations and Project personnel screen out High Hazard chemicals, if possible to do so, and carry forward into detailed planning only Low and Moderate Hazard chemicals. Specifically, the Chemical Environmental Hazard Assessment Tool can be used in the following contexts (see also Figure B 2):

- Review and approval of the Hazardous Material prior to purchase through the ChemAlert System as described in the Overview of the ABU HMAP

  and

- Screening assessment and selection of the least hazardous chemical for a specific application as part of operational planning (as per the requirements of the ABU Chemical Selection and Use Environmental Performance Standard).

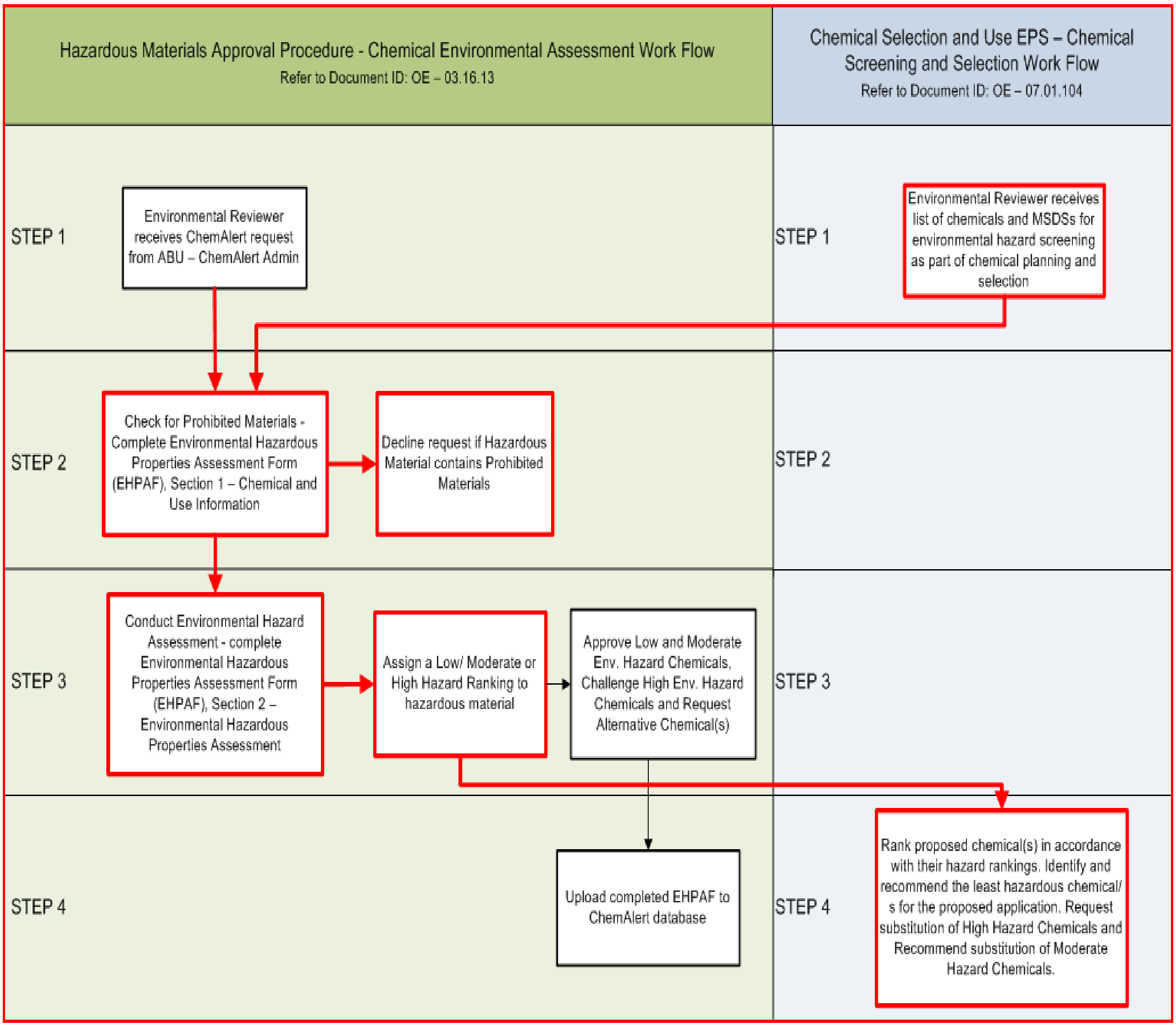

Figure B 2: Intended Use and Application of the Chemical Environmental Hazard Assessment Tool for ABU Operations and Major Capital Projects

Appendix C Modelling Report

APPENDIX C MODELLING FOR THE DEWATERING OF FLOODING FLUID

A1.0 Introduction

Modelling of the discharges of flooding fluid was conducted to predict the spread of the outfall plume based on the concentration and duration of the discharge under a range of climate/oceanographic conditions. The aim of modelling was to predict the environmental fate (concentration and duration) of flooding fluid discharged at the WP (refer to Section 2.3 of the Plan). The following sections describe the modelling discharge scenarios, input, methodology and results. These are described in full in the modelling report provided (DHI 2014).

A2.0 Discharge Scenarios

The summary of key discharge characteristics is provided in Table C 1 and Table C 2.

Table C 1: Key characteristics of modelled discharge scenario (20 000 m^3)

Property	Value
Wheatstone Platform coordinates	GEO: (115.38395°, -19.92938°)
	MGA-50: (330 860 m, 7 795 520 m)
Ambient water depth	72 m
Discharge elevation	+2 m above seabed
Discharge geometry	124.5 mm ID pipe, vertical upward
Total volume	20 000 m^3
Discharge duration	20 hours
Discharge rate	0.278 m^3/s
Port area	0.0122 m^2
Port velocity	22.8 m/s
Chemical released	Hydrosure, 550 mg/L
Effluent buoyancy	Neutral

Table C 2: Key characteristics of modelled discharge scenario (220 000 m^3)

Property	Value
Wheatstone Platform coordinates	GEO: (115.38395°, -19.92938°)
	MGA-50: (330 860 m, 7 795 520 m)
Ambient water depth	71.5 m
Discharge elevation	-45 m LAT
Discharge geometry	326 mm ID pipe, vertical downward
Total volume	220 000 m^3
Discharge duration	6–8 days

Pigging Speed	0.25 m/s to 0.75 m/s, typical 0.5 m/s
Discharge rate	0.224 m^3/s to 0.672 m^3/s, typical 0.448 m^3/s
Port area	0.0834 m^2
Port velocity	2.69 m/s to 8.06 m/s, typical 5.37 m/s
Waste constituent	Hydrosure, 500 mg/L for 200,000 m^3 followed by 916 mg/L for 20,000 m^3
Effluent buoyancy	neutral

The neutral buoyancy of the discharges is based upon the fact that the discharge will be predominantly composed of seawater from the WP area 12 to 36 months earlier. While small temporal variations in salinity or temperature are possible due to seasonal changes or outer shelf variability, fundamentally the seawater discharged will be consistent with ambient seawater at the discharge site.

A3.0 Model Inputs

Data sources used as inputs to the model, and used in some cases for extensive model validation, are shown in Table C 3.

Table C 3: Model Input data

Data	Source
Bathymetry	Local surveys, digital nautical charts accessed via DHI's software MIKE-C-MAP and satellite imagery. Additional detail from the 250 m resolution gridded bathymetric/topographic database established by Geosciences Australia.
Winds	Modelled wind fields from the Australian Bureau of Meteorology's numerical weather predictions system, MesoLAPS/Access-A and measured winds at Onslow meteorological station.
Sea levels	A tide (high resolution pressure) gauge attached to a rigid mooring at roughly 0.15 m ASB, recorded data once per minute from May 2009 – Nov 2010.
Currents	A bottom mounted Teledyne RDI 300 kHz workhorse ADCP was deployed from May 2009 – Nov 2010 at a height of 4.6 m above seabed.
Salinity and temperature	2 Conductivity Temperature Depth (CTD) casts at two separate locations close to the platform location recorded at 74 m depth on 10 Nov 2009 and 03 Nov 2010 combined with near bottom temperature data from tide gauge and ADCP instruments near the bottom and long term Sea Surface Temperature (SST) from National Oceanic and Atmospheric Administration (NOAA).

A4.0 Methodology

A hybrid application of a near-field expert system (CORMIX) and a quasi-3D Lagrangian dynamic far-field model (MIKE21 NPA) was applied to assess the dilution characteristics of the flooding fluid plume. The near-field assessment, performed using CORMIX is designed to provide baseline information about mixing processes due to the simple outfall geometry, and to assess coupling options between the near-field and far-field models. The far-field model has been implemented through a combination of the depth-integrated MIKE21 NHD hydrodynamic model and the quasi-3D Lagrangian (particle tracking) model MIKE21 NPA.. The Lagrangian particle tracking model (MIKE21 NHD) is a method for calculating the trajectories of discrete particles in a flow field. The displacement of each particle is assumed to consist of two components: an advective deterministic component and an independent, random Markovian component, which statistically approximates the random or chaotic nature of turbulence in natural flows.

The modelling methods were designed to use a quasi-3D Lagrangian far-field model to provide a reasonable set of results for a base discharge scenario, from which the results could be scaled to provide a bounding envelopes for the impact areas with due consideration of the range of potential discharge rates which may in practice occur. The base discharge scenario is determined for the middle estimate of 0.5 m/s pigging speed. As such, impact areas for 0.75 m/s pigging speed are inferred by upscaling the 0.5 m/s pigging speed results, and impact areas for 0.25 m/s pigging speed are inferred by downscaling the 0.5 m/s results.

A range of conservative assumptions, including seawater stratification, flow conditions and buoyancy of the discharge, were applied and supporting sensitivity testing performed in order to improve confidence that the potential dilution limits were captured (refer to DHI 2014a and 2014b). The plume characteristics were first assessed using the near-field expert system CORMIX for a range of ambient flow conditions, assuming a neutrally buoyant effluent. A customised tool was generated to project CORMIX-predicted plume geometries onto a high-resolution grid surrounding the WP. The dynamic plume response, including pooling during flow reversals and the medium-term build-up of concentrations in the vicinity of the WP, was then assessed using the MIKE21 NPA model.

Achievement of the environmental criterion (Appendix D) is driven by the influences of plume dispersion and plume mobility. As the plume travels away from the WP it will dilute, increasing the size of footprint in the process. In the vicinity of the WP, the plume closely weathervanes with the instantaneous current direction.

Due to the lack of certainly around timing of the discharge, an *a priori* determination of representative or worst-case evaluation periods is difficult. Further, the residual current climate is such that particles very rarely remain within the model for longer than 8 days. The model therefore assesses a continuous discharge over a full calendar year, rather than the actual limited duration of 20 hours for the 20 000 m^3 discharge and 6 to 8 days for the 200 000 m^3 discharge. To account for potential variations in pigging speed during the 220 000 m^3 discharge, resulting in minor changes to the discharge rate, results from a typical discharge rate were scaled up. The model results were interrogated hourly to assess whether the 48-hr running median of Hydrosure concentration exceeded 0.06 mg/L. By example, if at time X the 48 hr running median concentration is larger than 0.06 mg/L, this would be recorded as one hour of exceedance. The final results are presented as impact envelopes, which capture the most adverse combination of environmental forcing over a full year. Discharges under typical ambient conditions for the site can be expected to generate a smaller impact footprint.

A5.0 Modelling results

A.5.1 Near-field (CORMIX) Modelling

An initial screening assessment was performed based upon the extracted 10th, 50th and 90th percentiles from the annual distribution of current speed, assuming neutrally buoyant effluent and a uniform ambient density. The CORMIX setup excludes wind, considers an unbounded domain, and applied a roughness index of 0.025 (Manning's n). The simulations were run for a total distance of 5000 m downstream of the release point. In order to assess the impacts due to the variability in pigging speed/flowrate, the model results were scaled from the typical conditions (0.5 m/s pigging speed) to the maximum (0.75 m/s) and minimum (0.25 m/s) conditions. The three ambient current conditions induce quite different responses in the plume. Under most conditions, the effluent reaches the seabed and dissipates its remaining momentum as lateral spreading within 1 km of the outfall location.

At low discharge rates (0.25 m/s pigging speed) and 90% ambient current speeds, the plume does not reach the bottom within 1 km of the outfall location. For both the 10% and 50% current speeds, the plume does reach the bottom within 50 m and 500 m, respectively. For the typical discharge rate corresponding to a 0.5 m/s pigging speed, all conditions result in the plume interacting with the bottom. For the high discharge rate corresponding to a 0.75 m/s pigging speed, all conditions result in the effluent reaching the seabed. From these results, it is seen that at 1000 m, downstream of the outfall location, the dilution and size (half-width) of the plume under the typical and maximum pigging speed conditions are similar.

As expected, the maximum discharge rates corresponding to the 0.75 m/s pigging speeds show the largest impact area and the minimum discharge rates show the smallest impact area. Of note is that the typical discharge impact area is almost as large as that shown for the maximum discharge rate. The individual "shafts" of exceedances tend to be determined by specific periods of residual currents, typically neap tide, which set in one direction for long enough to hold the plume within one directional band. Results are shown in Table C 4, Table C 5 and Table C 6 for 0.25 m/s, 0.5 m/s and 0.75 m/s pigging speeds respectfully.

Table C 4: Near-field dilution and plume dimensions from CORMIX with a pigging speed of 0.25 m/s

Current Speed Percentile	Speed (m/s)	Distance from Discharge (m)	Dilution Factor	Plume Half-width (m)*
10%	0.10	50	90	11
		100	140	15
		200	261	21
		500	816	46
		1000	2400	99
50%	0.25	50	51	3.1
		100	77	3.9
		200	120	4.8
		500	350	14
		1000	1400	28
90%	0.45	50	39	2.1
		100	59	2.5
		200	87	3.1
		500	150	4.0
		1000	220	4.9

* All CORMIX width definitions converted here to B = distance from centreline to 37% of the centreline concentration

Table C 5: Near-field dilution and plume dimensions from CORMIX with a pigging speed of 0.50 m/s.

Current Speed Percentile	Speed (m/s)	Distance from Discharge (m)	Dilution Factor	Plume Half-width (m)*
10%	0.10	50	30	2.4
		100	56	4.4
		200	120	9.3
		500	370	30
		1000	970	77
50%	0.25	50	64	4.9
		100	140	12
		200	2200	15
		500	510	23
		1000	1200	39
90%	0.45	50	53	3.3
		100	81	4.2
		200	120	5.1
		500	460	15
		1000	1100	23

* All CORMIX width definitions converted here to B = distance from centreline to 37% of the centreline concentration

Table C 6: Near-field dilution and plume dimensions from CORMIX with a pigging speed of 0.75 m/s.

Current Speed Percentile	Speed (m/s)	Distance from Discharge (m)	Dilution Factor	Plume Half-width (m)*
10%	0.10	50	24	2.8
		100	43	5
		200	85	10
		500	260	31
		1000	660	78
50%	0.25	50	73	11
		100	99	12
		200	150	15
		500	340	23
		1000	790	39
90%	0.45	50	61	4.9
		100	120	9.4
		200	230	13
		500	450	18
		1000	920	26

* All CORMIX width definitions converted here to B = distance from centreline to 37% of the centreline concentration

As an initial diagnostic exercise, and as a reality check of the dynamic far-field assessment to follow, the CORMIX-predicted plume geometries have been processed into a long-term quasi-stationary series of concentration fields within a 2 km square area around the platform. This provides a simple and transparent means of assessing the balance between the expansion of the plume footprint due to dilution with the spatial variability induced by rapidly changing ambient current conditions. The outputs of these projections are shown in Figure C 1, Figure C 2 and Figure C 3.

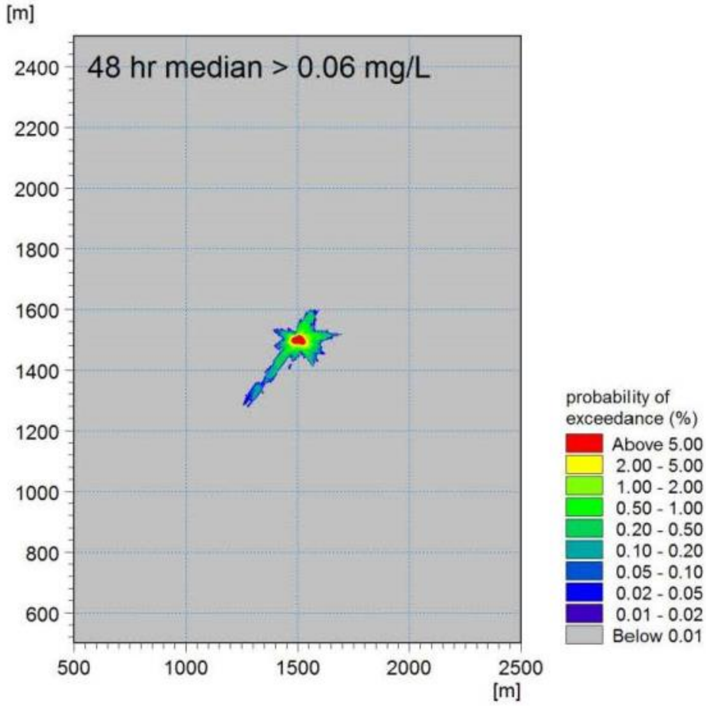

Figure C 1: Number of hourly instances for which the median Hydrosure concentration exceeds 0.06 mg/L over 48 hr duration for a pigging speed of 0.25 m/s, based upon quasi-stationary CORMIX results projected onto a 2D grid

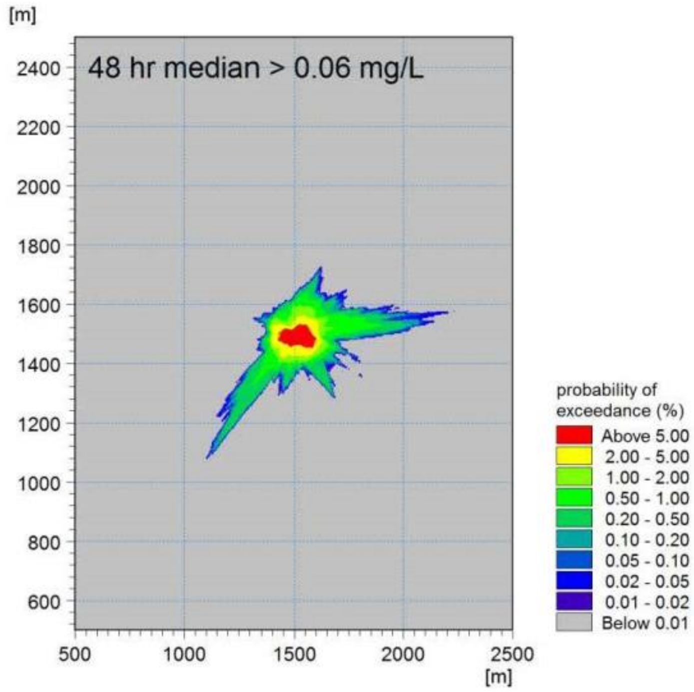

Figure C 2: Number of hourly instances for which the median Hydrosure concentration exceeds 0.06 mg/L over 48 hr duration for a pigging speed of 0.50 m/s, based upon quasi-stationary CORMIX results projected onto a 2D grid

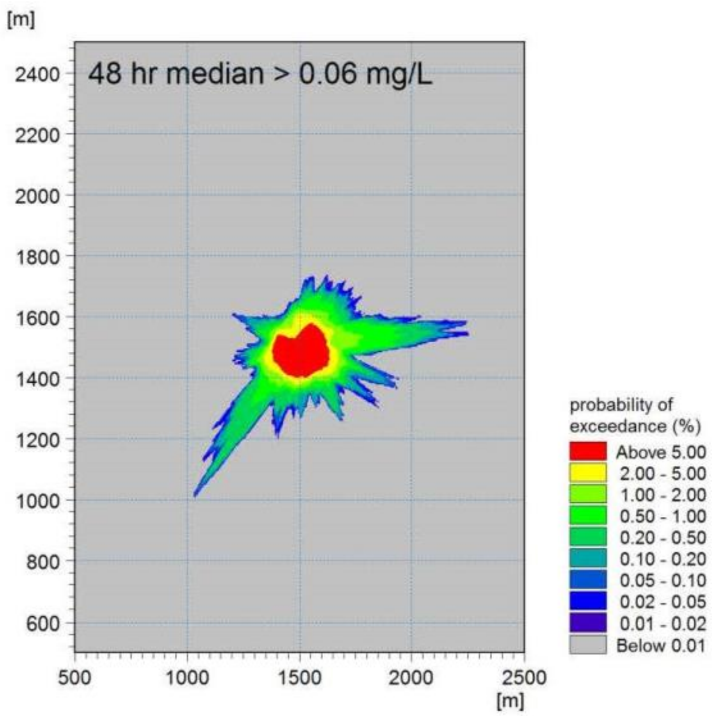

Figure C 3: Number of hourly instances for which the median Hydrosure concentration exceeds 0.06 mg/L over 48 hr duration for a pigging speed of 0.75 m/s, based upon quasi-stationary CORMIX results projected onto a 2D grid

Several useful conclusions regarding plume behaviour in the vicinity of the platform can be drawn from the CORMIX analyses:

- Plumes are narrow and tend to be well above the trigger level of 0.06 mg/L of Hydrosure. However, the combination of narrow plume widths and high directional variability means that the 48 hr median criteria are only triggered very close to (<~200 m) the platform.
- an increase in the estimated rate of plume dilution will tend to increase the size of the resulting impact areas.
- The shape of the impact area tends to be controlled by residual rather than tidal currents.
- Extents of impact areas for typical (0.5 m/s pigging speed) and maximum (0.75 m/s pigging) speeds are similar (as predicted with near-field tools)

A.5.2 Far-field (MIKE21 NPA) Modelling

The primary output of the NPA model is the time-varying instantaneous concentration field of particles. In this application the NPA model output has been saved in multiple resolutions, due to the differing plume geometries near and at distance from the platform. Close to the platform the horizontal and vertical plume dimensions are small, and small integration volumes are required to avoid excessive over-dilution due to insufficient resolution. At distance from the platform, the plume dimensions increase but the particle cloud also disperses and can become sparsely populated, which necessitates larger integration volumes. Figure C 4 illustrates the evolutionary behaviour of the plume by showing daily instantaneous concentrations at midday during each day of a 12 day period in August 2009,

The model is then run for a full year (May 2009 – Apr 2010), in one month increments. Each simulation starts on the first day of the given month, and concludes at the end of the fourth day of the following month. This provides for an overlap to account for the 'warm-up' period at the start of each simulation, and to avoid transitional gaps in the coverage of the running median calculations. Far field modelling results are processed from the 45 m x 20 m resolution NPA output area, and are provided for the base simulations as well as low and high dispersion sensitivity tests. The outputs of the model therefore show cumulative monthly plots of the daily median concentrations over a 12 month period.

From the model outputs, it is clear that higher dispersion results in elevated exceedance frequencies close to the Platform, and much smaller frequencies at distance from the platform, while concentrations above the threshold occurred at the greatest distance from the WP when seasonal weather presented calm metocean conditions and under higher dispersion settings.

Taking into account all months, model results for the 220 000 m^3 discharge indicated that violations of the 48 hr median threshold where primarily confined to areas within 400 m of the platform (1% exceedance) for the base case discharge rate and dispersion settings. Areas outside of this 400 m area (<1% exceedance) were shown to have potential for “fingers” to extend out to as far as 3 km. Sensitivity testing of higher and lower dispersion settings within the NPA model showed the potential for a larger impact radius of up to 3 km. The 1% exceedance for this case extended up to approximately 800 m from the platform.

The model was scaled and interrogated under base case, minimum and maximum expected discharge rates (pigging speed) and varying far-field dispersion settings. Footprints for the maximum discharge rate corresponding to a 0.75 m/s pigging speed indicated total footprints could extend up to 3.5 km from the platform. The 1% exceedance footprint extended up to 1.5 km from the platform . The results from the modelling of the 20 000 m^3 discharge showed that, while instantaneous values exceeded 0.06mg/L, the 48-hour median criterion was not exceeded at any time or under any dispersion scenario modelled.

The results of this analyses showed specifically that discharges which took place during the months of May, July and August, where there was the least current movement, exhibited a significantly greater impact footprint than the other months. Figure C 5, Figure C 6 and Figure C 7 illustrate the range of potential dispersion scenarios that are predicted by the model for the 220 000 m^3 discharge under the simulated pigging speeds and dispersion settings.

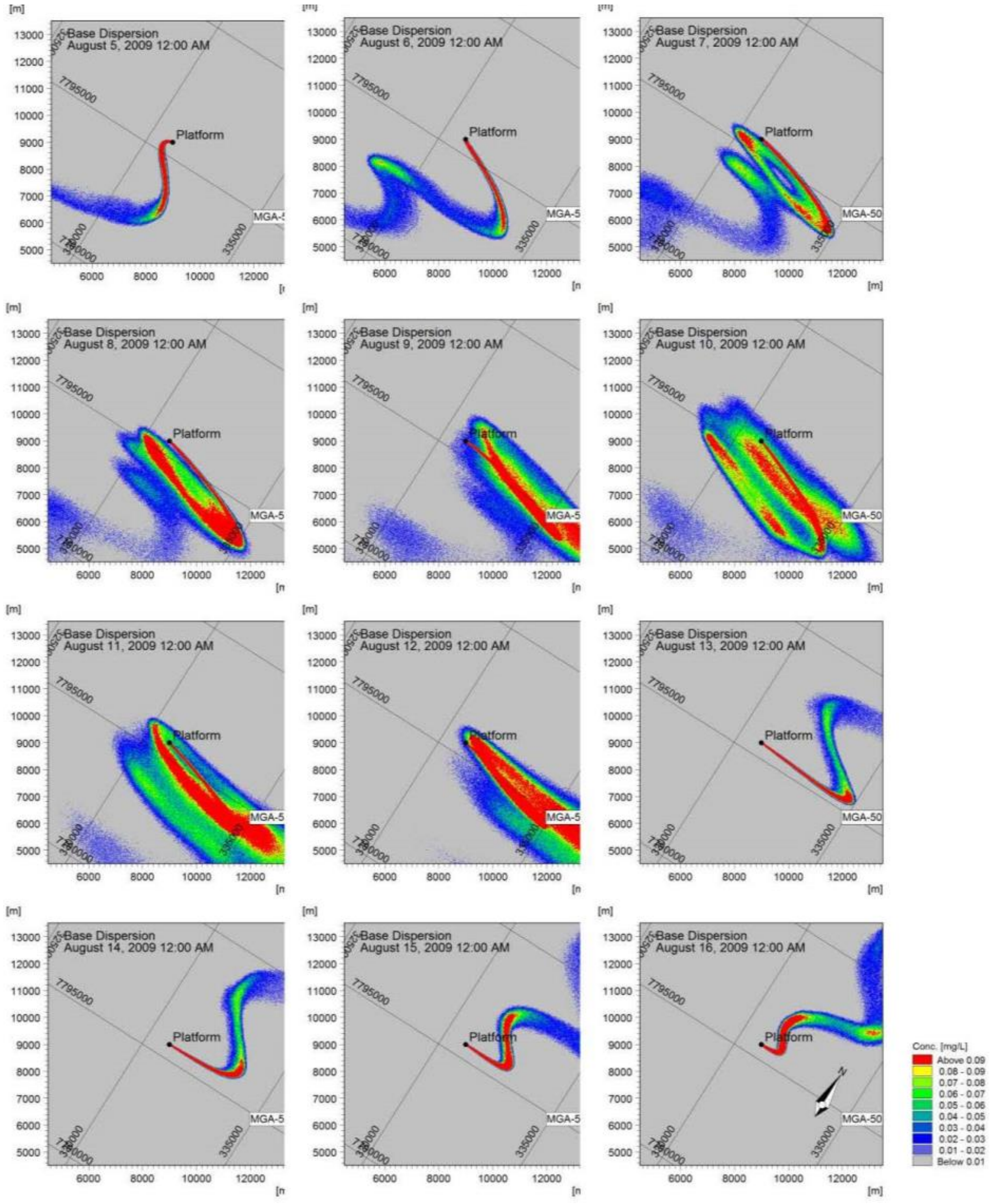

Figure C 4: Illustration of plume behaviour over 12 consecutive days between Aug 3 and Aug 16, 2009, inclusive

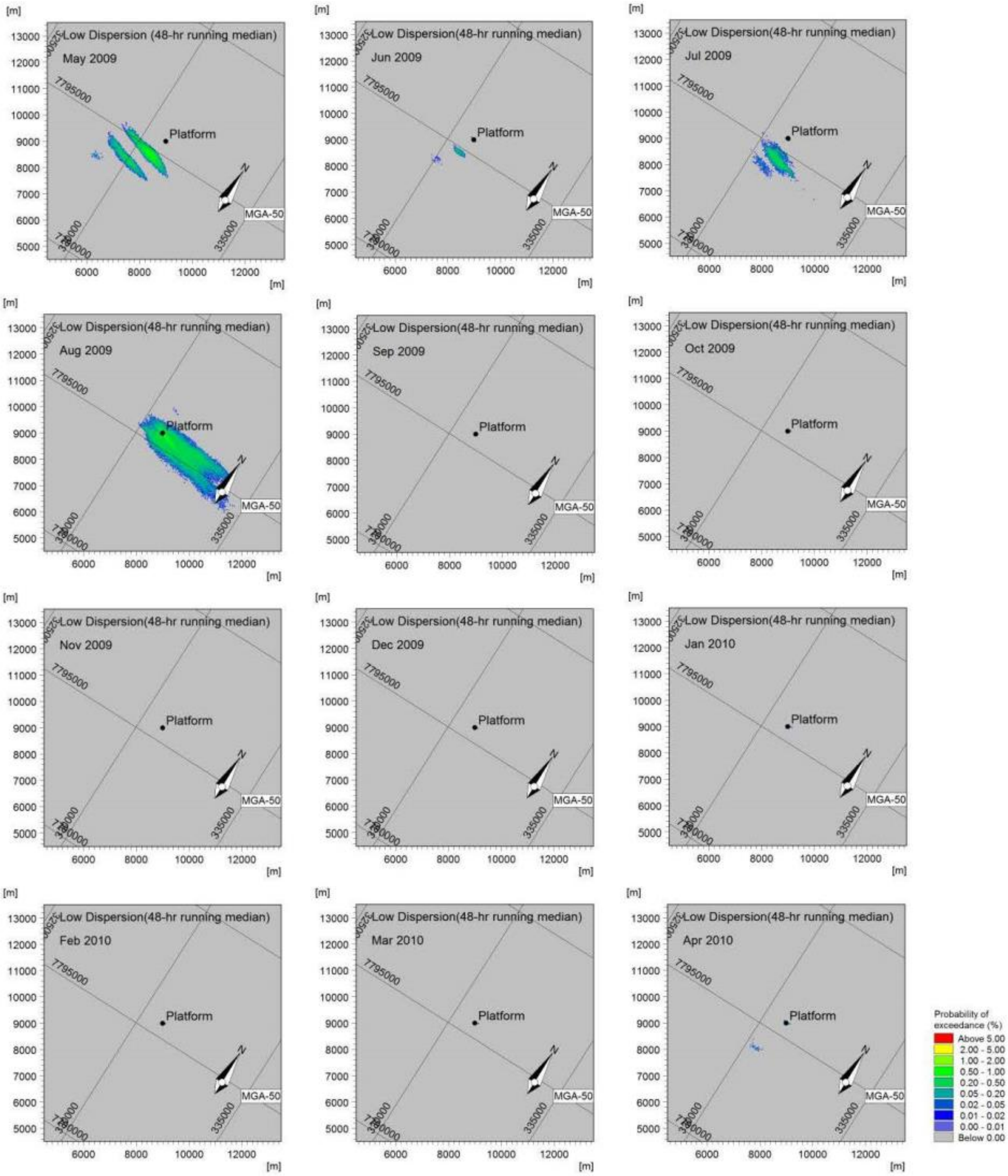

Figure C 5: Monthly exceedance of the 0.06 mg/L 48-hour median criterion at the WP location at low pigging speed and under low dispersion settings

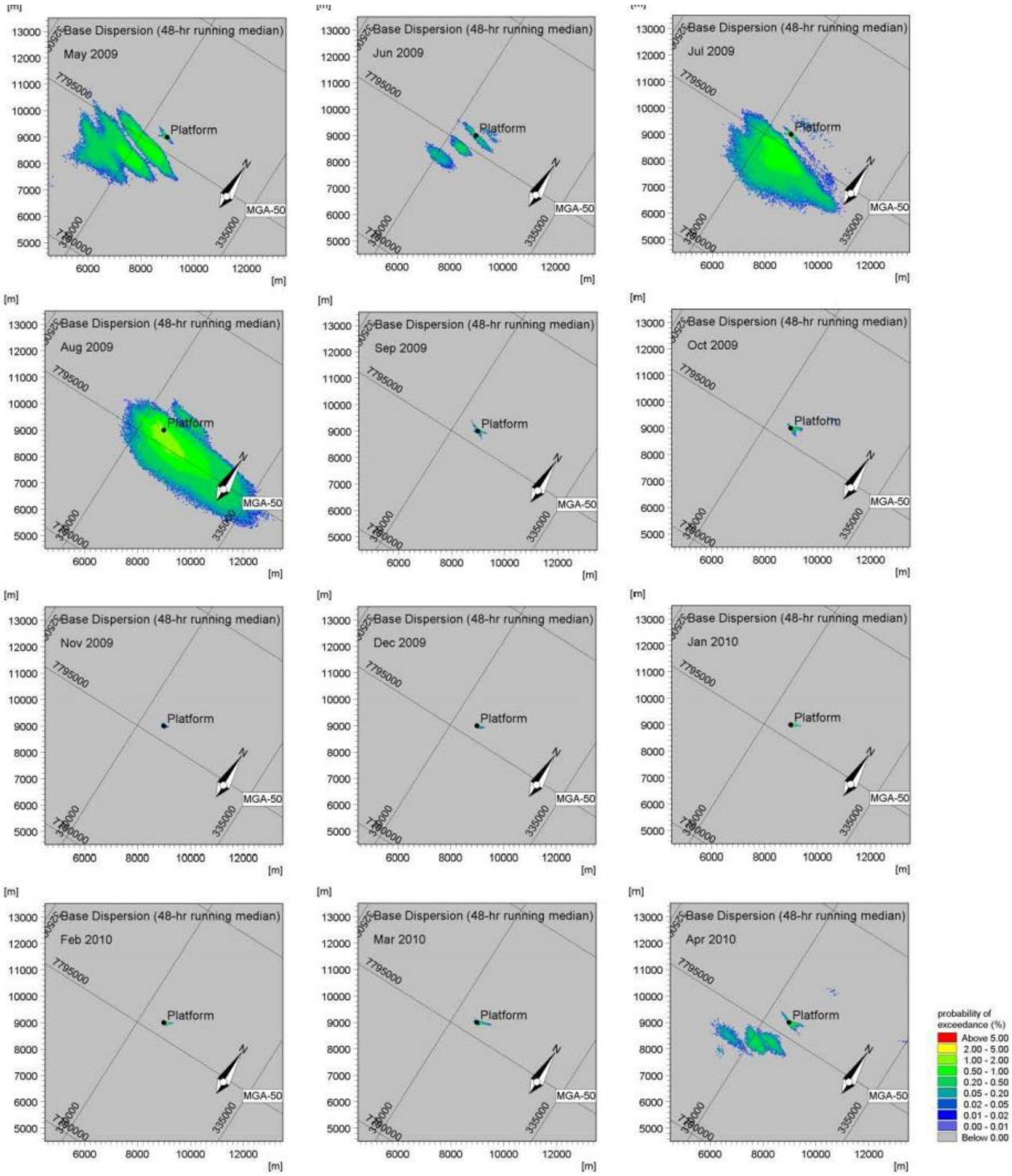

Figure C 6: Monthly exceedance of the 0.06 mg/L 48-hour median criterion at the WP location at base pigging speed and under base dispersion settings

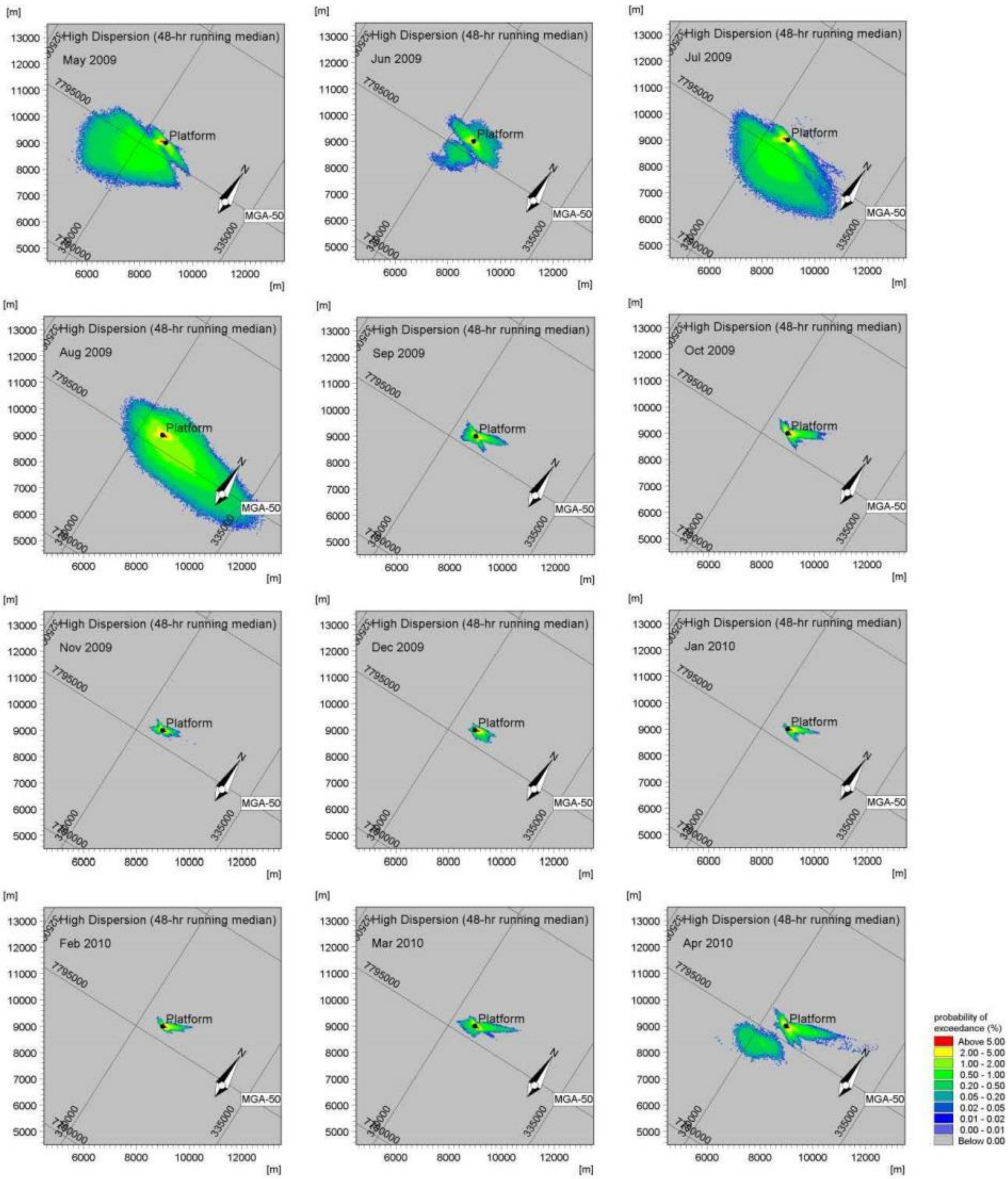

Figure C 7: Monthly exceedance of the 0.06 mg/L 48-hour median criterion at the WP location at high pigging speed and under high dispersion settings

Conclusions

A hybrid application of a near-field expert system (CORMIX) and a quasi-3D Lagrangian dynamic far-field model (MIKE21 NPA) is applied to assess the dilution/plume characteristics of the trunkline water discharged from the WP the plume. The resulting plume dilution fields are compared to the calculated environmental compliance criterion. Modelling of the base dispersion for the 220 000 m^3 discharge indicated that ≥1% exceedance of the 48-hour median threshold is confined to areas within 800 m of the WP under typical conditions. Sensitivity testing of higher and lower dispersion settings and higher pigging speeds shows the potential for a larger impact radius of up to 3.5 km for any exceedence, and 1.5 km where there was ≥1% exceedance. Modelling of the 20 000 m^3 discharge indicated no exceedances of the 48-hour median threshold.

These conclusions are generated under the conservative assumption of a continuous effluent release rather than one of limited duration and are based on the initial dosing concentration of Hydrosure, without accounting for expected degradation of active ingredients during residence time in the pipeline. While this is useful for identifying the envelope of possible impacts, it may in many cases exaggerate those impacts.

Appendix D Whole of Effluent Toxicity (WET) Testing

APPENDIX D WET TESTING

Subsequent to the conclusion of the chemical selection process described in Appendix A Whole Effluent Toxicity (WET) testing was conducted on Hydrosure 0-3670R (Champion Chemicals Pty Ltd) to identify the potential toxicity of the effluent following discharge to the marine environment. Toxicity of Hydrosure 0-3670R was evaluated using product obtained from the manufacturer, diluted in seawater obtained from the Wheatstone operational area. A series of dilutions of the Hydrosure 0-3670R in seawater were prepared to test a range of product concentrations in order to determine the relative toxicity to individual species.

Measures of toxicity from all of the test species were combined to develop environmental performance objectives, standards and measurement criteria for comparison with the anticipated concentrations of the flooding fluid at the time of flooding (500 ppm of Hydrosure 0-3670R). These assumptions do not take into account any degradation of the active constituents within the hydrotest flooding fluid while held within the pipe.

A1.0 WET Testing Methods

WET testing involves exposing organisms to various concentrations of an effluent or flooding fluid and then measuring a pre-determined experimental endpoint (e.g. mortality, growth, or reproductive characteristics) after a selected period of time (ANZECC & ARMCANZ 2000). WET testing was conducted on Hydrosure 0-3670R diluted with seawater and the dilution water was sourced from waters in the vicinity of the trunkline route (Latitude -21.28850^{o}, Longitude 114.51600^{o}). The water was collected directly from an onsite vessel in accordance with ANZECC & ARMCANZ (2000) procedures for water sampling. Water samples were packed in ice and sent via air freight directly to the NATA accredited ecotoxicity testing laboratory (Ecotox Service Australasia). Full details of the ecotoxicity methodology are presented in Chevron Australia (2013a).

WET testing was undertaken on five locally relevant species from four different taxonomic groups using the recommended protocols from ANZECC and ARMCANZ (2000). The Wheatstone marine project development area lies at the southern extent of NWS marine region which is considered to represent tropical waters as classified by IMCRA 4.0 (Commonwealth of Australia 2006). The waters in this region contain both tropical and temperate organisms so the selection of species from both regions for WET testing was considered relevant. WET testing included mostly tropical species from a range of trophic levels (primary producer, herbivore and carnivore), where chronic (where available) and acute tests for toxicity were applied.

WET tests were conducted using two experimental components. The first being a range finding test in which the effective concentration range for each experimental end-point and species was determined. Once the effective concentration range was determined, the definitive ecotoxicological assays were conducted over this concentration range to capture the complete dose response relationship. Since Hydrosure 0-3670R is a mixture containing both the oxygen scavenger and the biocide for chemical treatment, only one assay in each test species was necessary to evaluate the toxicity of the product.

Concentration range varied depending on the test species and experimental end-point. The concentrations used for each test can be found in (Table D 1). In all experiments, the ratio of concentrations selected was relative to the following proportions: 100, 50, 25, 12.5 and 6.25 %. Four replicates (N=4) were used in all experiments for each test concentration.

Table D 1: Whole Effluent Toxicity Testing of Hydrotest Medium Discharges in Commonwealth Waters

Species	Test	Type	End-Point	Temp ˚C	Conc.
Nitzschia closterium (Algae)	72 hr Growth Inhibition	Chronic	Cell yield	21 ± 1	0.2–10.0 mg/L
Saccostrea echinata (Mollusc)	48 hr Larval Abnormality	Chronic	Normal development rate	29 ± 1	31.3–2000.0 µg/L
Heliocidaris tuberculata (Echinoderm)	72 hr Larval Development	Chronic	Normal development rate	20 ± 1	78.1–5000.0 µg/L
Melita plumulosa (Crustacean)	96 hr Acute Toxicity	Acute*	Survival	20 ± 1	0.03–1.00 mg/L
Lates calcifer (Fish)	96 hr Acute Toxicity	Acute*	Imbalance	25 ± 2	6.3–100.0 mg/L

*ACR=10, where ACR is the Acute to Chronic Ratio used as a divisor for transformation of acute values into chronic test values.

Two main procedures are currently used for developing single species toxicity measures based on these ecotoxicity tests, hypothesis testing and point estimation techniques. Hypothesis testing using Dunnett's test (Dunnett 1955) compares each test concentration in order to determine the lowest test concentration that is significantly different from the dilution water control (the Lowest Observed Effect Concentration - LOEC); the No Observed Effect Concentration (NOEC) is then inferred to be the highest test concentration below the LOEC. Point estimation techniques use regression analysis of the dose response curve to derive a figure such as EC_p (Effect Concentration), the concentration that causes a stated effect in ‘p’ percent of the test organisms.

There is debate over the appropriateness of each estimate of single species toxicity when extrapolating results to the wider aquatic ecosystem; however the prevailing guidance in ANZECC and ARMCANZ (2000) appears to advocate the use of NOEC (hypothesis tested). Both endpoints have been reported in the presentation of results. Test results for locally relevant species used for the WET testing program are described in Table D 2. Chronic tests were selected where available for that taxonomic group.

Table D 2: WET testing results for flooding fluid / medium treated containing Hydrosure

Species	Duration (hrs)	EC10 (mg/L)	EC50 (mg/L)	LOEC (mg/L)	NOEC (mg/L)
Nitzschia closterium (Algae)	72	1.5 *	3.3 (3.0–3.58)	2.50	1.30
Saccostrea echinata (Mollusc)	48	0.29 (0.24–0.33)	0.54 (0.52–0.56)	0.50	0.250
Heliocidaris tuberculata (Echinoderm)	72	1.30 (1.27–1.32)	1.71 (1.70–1.74)	2.50	1.25
Melita plumulosa (Crustacean)#	96	0.08 (0.04–0.11)	0.14 (0.10–0.16)	0.25	0.13
Lates calcifer (Fish)#	96	13.5 (12.3–18.0)	17.5 (17.1–18.0)	25.0	12.5

*95% confidence limits are not reliable; Numbers in brackets represent the 95% fiducial limits.
Toxicity test is defined as an acute test.

Single species toxicity assessments for flooding fluid, Hydrosure 0-3670R, showed toxicity in all species tested. This result was expected given that the active substances of the chemical treatment (oxygen scavenger and biocide) are designed to interfere with natural (bio)-chemical processes. For Hydrosure the species rank toxicity (NOEC) from most observed toxicity to least was: crustacean > oyster (mollusc) > sea urchin (echinoderm) = microalgae > fish.

A2.0 Environmental Criteria

Environmental criteria have been developed to be applied to a discharge of a large volume of flooding fluid (approximately 220 000 m^3) over a duration of approximately 6 - 8 days. Discharges associated with other activities are significantly smaller and for a shorter duration. Application of the same environmental criteria to these smaller discharges can be viewed as a more conservative approach.

Single species WET test laboratory results can be extrapolated to effects in the wider aquatic ecosystem using a risk based approach. By investigating the statistical distribution of all of the single species toxicities, guideline values can be developed to estimate the maximum concentrations unlikely to cause adverse environmental effects. Environmental criteria to be applied to the discharge were developed from the results of WET testing (Table D 2) using the recommended methods in ANZECC and ARMCANZ (2000), with the three following modifications:

1. The ANZECC and ARMCANZ (2000) trigger development methods are intended for application to long-term outfalls that result in chronic effects, with long-term continuous exposure. Any NOECs derived from an acute toxicity test (*Melita plumulosa* and *Lates calcarifer* in the current tests) can be converted to a chronic value by dividing by the ACR. The discharge of flooding fluid is not a chronic

discharge (approximately 192 hrs at approximately -40 m LAT) so an acute toxicity trigger is more appropriate. Therefore the ACR was not applied to the acute toxicity test results; test results defined as chronic were retained for use without transformation.

2. Effluent toxicity is based on a concentration by time interaction. There are some difficulties in extrapolating results from a laboratory (where concentrations can be maintained throughout the duration) to application in the field (where concentrations at a single point will vary over time depending on the metocean conditions). For this reason, the best available approach for a concentration that varies over time was to compare the fixed laboratory value with the median field concentration of the chemical over a defined duration.
3. As a methodology for chronic discharge, the triggers developed using the ANZECC and ARMCANZ (2000) guidelines do not specify a prescribed duration of exposure. Again this is not appropriate for a short term exposure of a potentially acutely toxic discharge, as is the case here. It is appropriate that if an acute intensity trigger is to be used, this must be associated with specific exposure duration. The durations of exposures in the laboratory tests ranged from 48–96 hrs. The discharge will be subject to hydrodynamic conditions that result in higher median concentrations over short durations than at longer durations. Therefore the most conservative approach (i.e. the highest median value in the field) is to establish an exposure duration for trigger comparison based on the minimum test duration, in this case 48 hrs

The latest available version of the BurrliOZ software (TclPro Application V8.3.2, last modified: 25 July 2001; Copyright 2000 Ajuba Solutions) supplied with the National Water Quality Management Strategy Paper No. 4 package (ANZECC & ARMCANZ 2000) was used to analyse the ecotoxicity of Hydrosure 0-3670R. The NOEC values were used as the statistical endpoints from the single species ecotoxicity testing for estimation of the species sensitivity distribution (SSD), fitted using BurrliOZ. Full details of the methodology are included in MScience (2013). Calculation of environmental criteria for the flooding medium using the SSD and raw NOEC values are presented in Table D 3.

Table D 3: Species protection concentrations for Hydrosure 0-3670R based on the NOEC SSD from WET testing

	PC99% (ppm or mg/l)	PC95% (ppm or mg/l)	PC90% (ppm or mg/l)	PC80% (ppm or mg/l)
Hydrosure (based on NOEC)	0.06	0.10	0.15	0.23

The 99% species protection concentration is suggested by ANZECC and ARMCANZ (2000) for development of environmental criterion for *high conservation ecosystems* or chemicals that have a tendency to bioaccumulate. This would result in an environmental criterion trigger of 0.06 mg/L (or ppm). Since Hydrosure 0-3670R has a negligible risk for bioaccumulation the 95 % level of species protection may also be applied. In this instance the environmental criterion trigger would be 0.10 mg/L (or ppm). These criteria have been developed for chronic discharges and do not recognise the duration of the exposure to the flooding fluid.

In order to establish a conservative environmental criterion for application in Commonwealth waters, the data from Table D 3 and the three modifications listed above were applied. The environmental criterion applied to modelling and assessment was therefore defined as follows:

- Over a 48 hour period, the median concentration of Hydrosure 0-3670R is not to exceed 0.06 mg/L.

As the Commonwealth Conditions for approval (EPBC/2008/4469) do not define spatial zones of environmental protection, this criterion applies to all spatial points around the discharge. Since the concentration of Hydrosure 0-3670R in the flooding fluid is 500 ppm, significantly greater than 0.06 ppm, there is no scenario in which the discharge will be able to comply with this environmental criterion at all locations and times around the discharge. As such, this criterion will be used to interrogate the results of the modelling to define a mixing zone, outside of which the environmental criterion will be considered to have been met.

As Hydrosure 0-3670R has a negligible risk for bioaccumulation (Appendix A) and the discharge is to occur over a short period (less than 192 hrs), no additional environmental criteria have been set.

Unpublished data for the degradation profile for Hydrosure 0-3670R during a 12 month field simulation test shows approximately 20% reduction in activity over 12 months at 10 °C (Figure D 1). Based on this data, the application of the results of the WET testing program to develop environmental criteria is considered to represent a conservative approach. That is, while the Hydrosure toxicity to local species remains constant (e.g. the environmental criterion), the concentration of the toxic components in the flooding fluid discharge (e.g. those used in the modelling) will likely be reduced from the concentrations known at the time of flooding (i.e. 500 ppm). Therefore the extent of the mixing zone defined by modelling is predicted to be larger than the actual mixing zone during discharge.

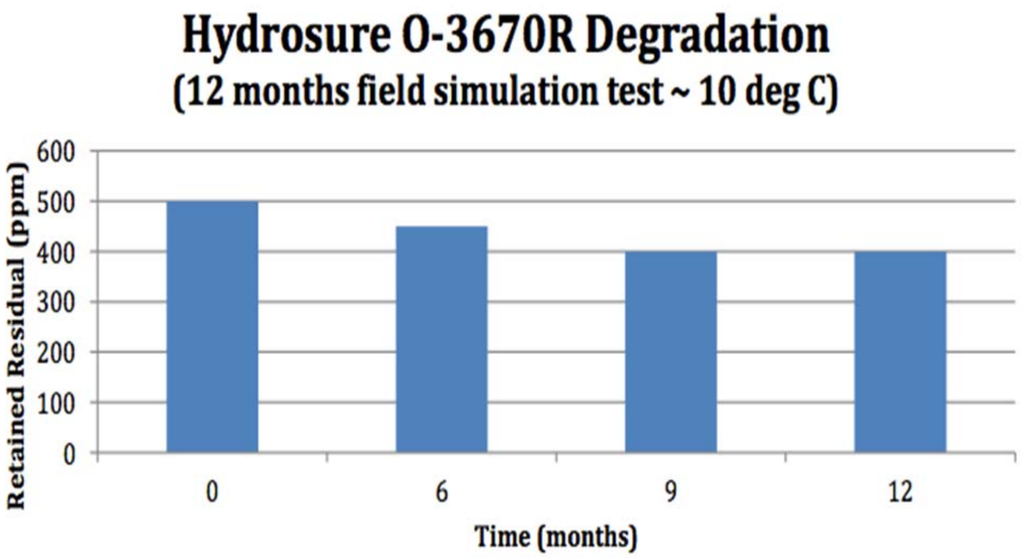

Figure D 1: Hydrosure 0-3670R degradation profile (source: Champion Technologies 2011)

In addition to Hydrosure 0-3670R, the flooding medium is also planned to contain Fluorescein dye (50 ppm). The ecological information in the Fluorescein MSDS report the product is not expected to be hazardous to the environment (Champion Technologies 2011) and estimates of the lethal concentration of sodium fluorescein solution (Walthall and Stark 1999) were higher than the concentrations proposed for use in FCGT activities of the trunkline (50 ppm). Based on the routine use of Fluorescein in offshore projects, WET testing and environmental criteria were not considered relevant for this compound.

Appendix E EPBC Matters of National Environmental Significance

EPBC Status: E = Endangered, V = Vulnerable, Mi= Migratory, Ma = Marine, C = Cetacean

Common Name	Scientific Name	EPBC Status	Occurrence
Cetaceans			
Blue Whale	*Balaenoptera musculus*	E Mi	May occur
Humpback Whale	*Megaptera novaeangliae*	V Mi C	Known to occur
Antarctic Minke Whale	*Balaenoptera bonaerensis*	Mi C	May occur
Bryde's Whale	*Balaenoptera edeni*	Mi C	May occur
Killer Whale	*Orcinus orca*	Mi C	May occur
Sperm Whale	*Physeter macrocephalus*	Mi C	May occur
Spotted Bottlenose Dolphin	*Tursiops aduncus*	Mi C	May occur
Common Dolphin	*Delphinus delphis*	C	May occur
Pygmy Killer Whale	*Feresa attenuata*	C	May occur
Short-finned Pilot Whale	*Globicephala macrorhynchus*	C	May occur
Risso's Dolphin	*Grampus griseus*	C	May occur
Pygmy Sperm Whale	*Kogia breviceps*	C	May occur
Dwarf Sperm Whale	*Kogia simus*	C	May occur
Melon-headed Whale	*Peponocephala electra*	C	May occur
False Killer Whale	*Pseudorca crassidens*	C	May occur
Spotted Dolphin	*Stenella attenuata*	C	May occur
Striped Dolphin	*Stenella coeruleoalba*	C	May occur
Long-snouted Spinner Dolphin	*Stenella longirostris*	C	May occur
Rough-toothed Dolphin	*Steno bredanensis*	C	May occur
Bottlenose Dolphin	*Tursiops truncatus*	C	May occur
Cuvier's Beaked Whale	*Ziphius cavirostris*	C	May occur
Sharks			
Great White Shark	*Carcharodon carcharias*	V Mi	May occur
Whale Shark	*Rhincodon typus*	V Mi	Known to occur
Shortfin Mako	*Isurus oxyrinchus*	Mi	Likely to occur
Longfin Mako	*Isurus paucus*		Likely to occur
Giant Manta Ray	*Manta birostris*	Mi	Known to occur
Seabirds and Migratory Shorebirds			
Osprey	*Pandion haliaetus*	Ma	May occur
Bonyfish			
Three-keel Pipefish	*Campichthys tricarinatus*	Ma	May occur
Pacific Short-bodied Pipefish	*Choeroichthys brachysoma*	Ma	May occur
Pig-snouted Pipefish	*Choeroichthys suillus*	Ma	May occur
Reticulate Pipefish	*Corythoichthys flavofasciatus*	Ma	May occur
Roughridge Pipefish	*Cosmocampus banneri*	Ma	May occur
Banded Pipefish	*Doryrhamphus dactyliophorus*	Ma	May occur

Common Name	Scientific Name	EPBC Status	Occurrence
Bluestripe Pipefish	*Doryrhamphus excisus*	Ma	May occur
Cleaner Pipefish	*Doryrhamphus janssi*	Ma	May occur
Tiger Pipefish	*Filicampus tigris*	Ma	May occur
Brock's Pipefish	*Halicampus brocki*	Ma	May occur
Mud Pipefish	*Halicampus grayi*	Ma	May occur
Spiny-snout Pipefish	*Halicampus spinirostris*	Ma	May occur
Ribboned Pipehorse	*Haliichthys taeniophorus*	Ma	May occur
Beady Pipefish	*Hippichthys penicillus*	Ma	May occur
Western Spiny Seahorse	*Hippocampus angustus*	Ma	May occur
Spiny Seahorse	*Hippocampus histrix*	Ma	May occur
Spotted Seahorse	*Hippocampus kuda*	Ma	May occur
Flat-face Seahorse	*Hippocampus planifrons*	Ma	May occur
Hedgehog Seahorse	*Hippocampus spinosissimus*	Ma	May occur
Tidepool Pipefish	*Micrognathus micronotopterus*	Ma	May occur
Pallid Pipehorse	*Solegnathus hardwickii*	Ma	May occur
Gunther's Pipehorse	*Solegnathus lettiensis*	Ma	May occur
Robust Ghost Pipefish	*Solenostomus cyanopterus*	Ma	May occur
Rough-snout Ghost Pipefish	*Solenostomus paegnius*	Ma	May occur
Double-end Pipehorse	*Syngnathoides biaculeatus*	Ma	May occur
Bentstick Pipefish	*Trachyrhamphus bicoarctatus*	Ma	May occur
Straightstick Pipefish	*Trachyrhamphus longirostris*	Ma	May occur
Reptile			
Loggerhead Turtle	*Caretta caretta*	E Mi Ma	Likely to occur
Green Turtle	*Chelonia mydas*	V Mi Ma	Likely to occur
Leatherback Turtle	*Dermochelys coriacea*	E Mi Ma	Likely to occur
Hawksbill Turtle	*Eretmochelys imbricata*	V Mi Ma	Likely to occur
Flatback Turtle	*Natator depressus*	V Mi Ma	Known to occur
Olive Seasnake	*Aipysurus laevis*	Ma	May occur
Spectacled Seasnake	*Disteira kingii*	Ma	May occur
Olive-headed Seasnake	*Disteira major*	Ma	May occur
Fine-spined Seasnake	*Hydrophis czeblukovi*	Ma	May occur
Elegant Seasnake	*Hydrophis elegans*	Ma	May occur
Spotted Seasnake	*Hydrophis ornatus*	Ma	May occur
Yellow-bellied Seasnake	*Pelamis platurus*	Ma	May occur

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