EPA7 Annual Report 2015
Environmental Impact Monitoring Program

Ichthys On-Shore Liquefied Natural Gas Facilities

Bladin Point

Prepared for:
JKC Australia LNG Pty Ltd

Date: 28th July 2015

Prepared by:

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AEC Environmental

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EPA7 Annual Report 2015 – Environmental Impact Monitoring Program

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ABBREVIATIONS

Abbreviation	Description
ADWG	Australian Drinking Water Guidelines
AEMR	Annual Environmental Monitoring Report
AHD	Australian Height Datum
ALARP	As low as reasonably practicable
ALS	Australian Laboratory Services Global Pty Ltd
AMS	Adaptive Management Strategy
ANZECC	Australian and New Zealand Environment Conservation Council
ANZECC Guidelines	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS	Australian Standard
AS/NZS	Australian and New Zealand Standard
ASS	Acid Sulfate Soil
BOM	Bureau of Meteorology
BPMC	Bladin Point Mangrove Community
BTEX	Benzene, toluene, ethylbenzene, xylene
Ca	Calcium
$CaCO_3$	Calcium carbonate
CCPP	Combined cycle power plant
CEMP	Construction Environmental Management Plan
cm	Centimetre
COC	Chain of Custody
CSMC	Control Site Mangrove Community
Cth	Commonwealth
dB(A)	A-weighted Decibel
DGPS	Differential Global Positioning System
DLPE	Department of Lands, Planning and the Environment
DO	Dissolved Oxygen
DSM	Deep soil mixing
EC	Electrical Conductivity
E. coli	*Escherichia coli*
EIMP (Rev 0)	Environmental Impact Monitoring Program (Review 0)
EIMP (Rev 6)	Environmental Impact Monitoring Program (Review 6)
EIS	Environmental Impact Statement
EMA	Extractive Materials Area
EPA7	Environment Protection Approval 7-2

Abbreviation	Description
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPC	Engineering Procurement and Construction
ESCP	Erosion and Sediment Control Plan
FRP	Filterable Reactive Phosphorus
FSANZ	Food Standards Australia New Zealand
g	Gram
GEL	Generally Expected Level
GEP	Gas Export Pipeline
GIIP	Good International Industry Practice
GPS	Global Positioning System
ha	Hectare
HCO_3	Bicarbonate
hr	Hour
HSRG	Heat steam recovery generator
IEC	International Electrotechnical Commission
IECA	International Erosion Control Association
ISO	International Standards Organisation
ISQG	Interim Sediment Quality Guideline
Jetty	Product Loading Jetty
kg	Kilogram
km	Kilometre
L	Litre
L_{A01}	The noise level which is exceeded for 1% of the sample period
L_{A10}	The noise level which is exceeded for 10% of the sample period
L_{A90}	The noise level which is exceeded for 90% of the sample period
L_{Aeq}	Equivalent continuous A-weighted sound pressure level
L_{Amax}	The maximum noise level.
L_{Amin}	The minimum noise level.
LNG	Liquefied Natural Gas
LOR	Limit of Reporting
LPG	Liquefied Petroleum Gas
m	Metre
mg	Milligram
mL	Millilitre
mm	Millimetre
MOF	Module Offloading Facility
MGT	Eurofins|MGT Pty Ltd
MS	Matrix spikes

Abbreviation	Description
mV	Millivolt
NAFI	North Australian Fire Information
NATA	National Association of Testing Authorities
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NOAA	National Oceanic and Atmospheric Administration
NRETAS	Department of Natural Resources, Environment, the Arts and Sport
NSW	New South Wales
NSWDEC	New South Wales Department of Environment and Conservation
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTU	Nephelometric Turbidity Units
ORP	Oxidation reduction potential
PAH	Polycyclic Aromatic Hydrocarbon
Palmerston	City of Palmerston
PASS	Potential acid sulfate soils
pH	Acid/alkaline value
PM_{10}	Particulate matter of 10 micrometres or less in size
$PM_{2.5}$	Particulate matter of 2.5 micrometres or less in size
ppt	Parts per thousand
PVC	Polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QASSIT	Queensland Acid Sulfate Soils Investigation Team
RPD	Relative Percent Difference
RTK	Real Time Kinematic
s	Seconds
SE	Standard error
SO_4	Sulfate
SWL	Standing water level
TAA	Titratable Actual Acidity
TARP	Trigger Action Response Plan
TECs	Threatened Ecological Communities
TEOM	Tapered Element Oscillating Microbalance
TEQ	Toxic equivalence quotient
TOF	Temporary Office Facilities
TDS	Total Dissolved Solids
TPH	Total Petroleum Hydrocarbons
TPWC Act	*Territory Parks and Wildlife Conservation Act* (NT)

Abbreviation	Description
TRH	Total Recoverable Hydrocarbons
TSS	Total Suspended Solids
µg	Microgram
µm	Micrometres
µs	Microsiemens
U.S. EPA	United States Environmental Protection Agency
UXO	Unexploded ordinance
WM Act	*Weed Management Act* (NT)
WONS	Weeds of National Significance
WQOs	Water Quality Objectives

1. INTRODUCTION

1.1 Background

INPEX Operations Australia Pty Ltd, on behalf of Ichthys LNG Pty Ltd and the upstream Ichthys joint venture participants, is developing the Ichthys gas and condensate field (the Ichthys Field) in the Browse Basin, around 450 kilometres (km) north north-east of Broome in Western Australia (**Figure 1-1**). JKC Australia LNG Pty Ltd (JKC; Contractor), the joint venture between JGC Corporation, Kellogg Brown and Root Pty Ltd (KBR) and Chiyoda Corporation, has been appointed by INPEX Operations Australia Pty Ltd (Company) as the engineering, procurement and construction (EPC) Contractor for development of the following:

- Ichthys Onshore Liquefied Natural Gas (LNG) Facilities and its supporting infrastructure at Bladin Point;
- The Extractive Materials Area (EMA) adjacent to the LNG facilities; and
- Manigurr-ma Village at Howard Springs.

For the purposes of this document, the Project is defined to include the onshore facilities located at Bladin Point ('the Site'), including the product loading jetty (Jetty), module offloading facility (MOF) and the Gas Export Pipeline (GEP) terminating at the beach valve enclosure. The Project does not include the Manigurr-ma Village or offshore infrastructure. **Figure 1-2** identifies the Project area, being the area within the Site boundary which includes the construction footprint.

This document is the *EPA7 Annual Report 2015 – Environmental Impact Monitoring Program* (EPA7 Report [2015]), that reflects the environmental monitoring carried out from May 2014 to April 2015 (the annual monitoring period).

1.2 Purpose

This EPA7 Report has been prepared to comply with Condition 29 of the Environment Protection Approval (EPA7) for the Project and provides a synopsis of the monitoring undertaken during the annual monitoring period. The detailed assessment of all environmental monitoring results and trends throughout the annual monitoring period is presented in the *Annual Environmental Monitoring Report 2015 - Environmental Impact Monitoring Program* (AEC Environmental Pty Ltd, 2015) (AEMR [2015]).

Legend

- Site Boundary
- Subsea Pipeline
- Construction Footprint
- ConocoPhillips LNG Plant
- Bladin Central Enterprise Park
- Ichthys Field

Project Location		
Figure 1-1	**INPEX Bladin Point**	greencap AEC Environmental
Date: *9/07/2015*	**Author:** malcolm.nunn	
	Map Scale: 1:130,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	
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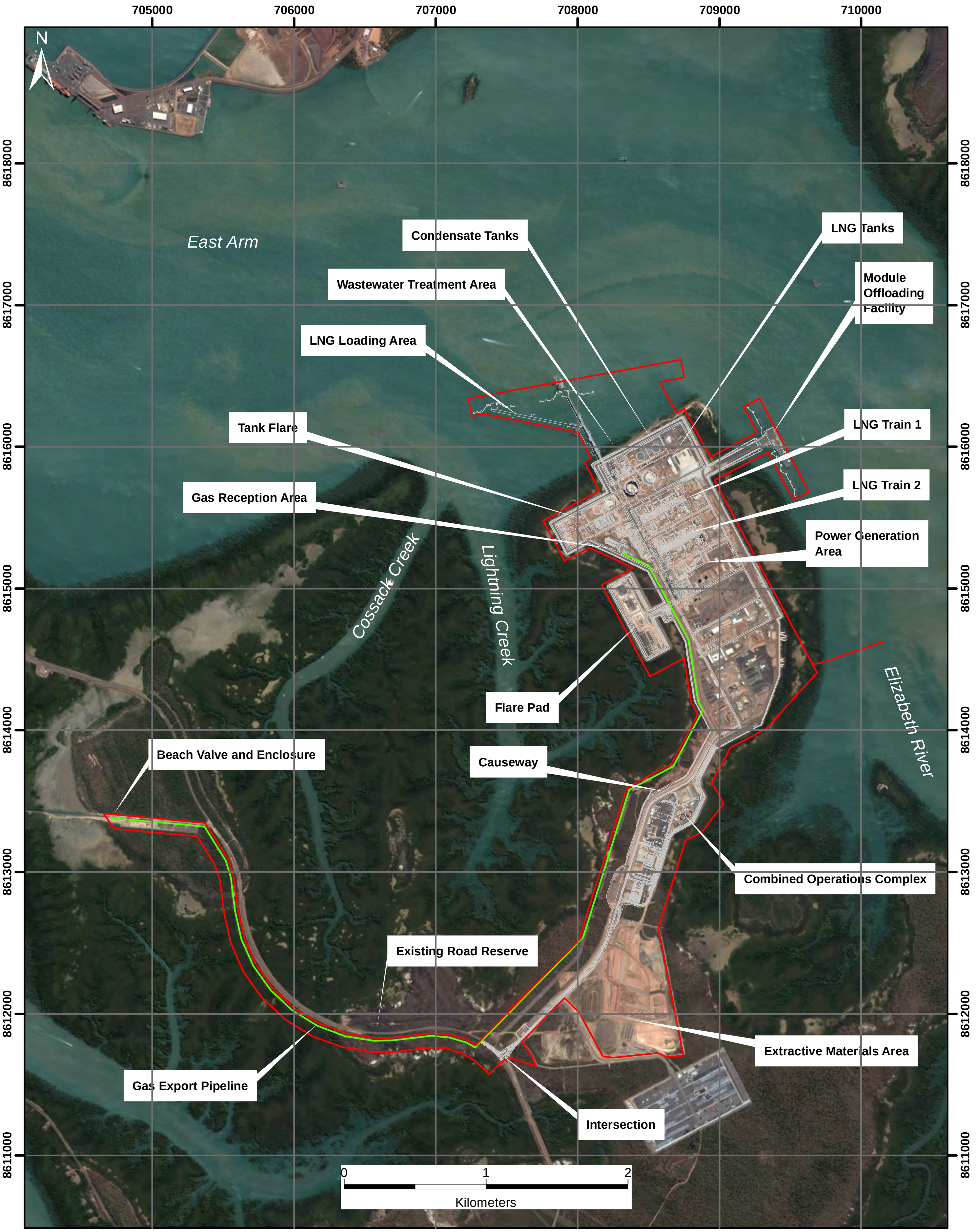

Legend

Site Boundary

Construction Footprint

Gas Export Pipeline

Project Site		
Figure 1-2	**INPEX Bladin Point**	greencap AEC Environmental
Date: *13/07/2015*	**Author:** malcolm.nunn **Map Scale:** 1:35,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	
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2. ENVIRONMENTAL STRATEGY

2.1 Construction Environmental Management Plan

A *Construction Environmental Management Plan* (L290-AH-PLN-0059) (JKC Australia LNG Pty Ltd, 2014) (CEMP) was developed for the onshore LNG facilities at Bladin Point, in accordance with the requirements of the EPA7 and the Development Permit (DP12/0065) for the Project. The CEMP details the environmental protection management measures and controls necessary to avoid, reduce or mitigate the environmental impacts during the construction of the onshore LNG facilities.

As a consequence of the risks identified in the CEMP, a series of management plans were produced detailing the strategies to minimise potential impacts on the environment and achieve the established objectives and targets. Fifteen specific environmental management strategies were identified to control the risks during the construction and commissioning phases of the Project and included:

- Flora and fauna management;
- Weed and pest management;
- Surface water management;
- Erosion and sediment control;
- Acid sulfate soil (ASS) management;
- Groundwater management;
- Rehabilitation management;
- Air quality (dust) management; and
- Airborne noise and vibration management.

2.2 Environmental Impact Monitoring Program

An *Environmental Impact Monitoring Program* (URS Australia Pty Ltd, 2012) (hereafter referred to as EIMP [Rev 0]) was developed to detail the establishment, implementation, monitoring performance criteria and reporting requirements of the monitoring requirements of the CEMP.

Monitoring programs for the following aspects of the Project were developed and documented in EIMP (Rev 0):

- Surface water monitoring;
- Groundwater quality monitoring;
- Mangrove community health, sediments and bio-indicator monitoring;
- Air quality (dust) monitoring;
- Airborne noise monitoring;
- Flora and fauna monitoring; and
- Weed monitoring.

In addition to the results of the monitoring programs listed above, ASS monitoring results have also been included in this EPA7 Report.

It should be noted that EIMP (Rev 0) was revised following recommendations of the *Annual Environmental Monitoring Report 2014 - Environmental Impact Monitoring Program* (AEC Environmental Pty Ltd, 2014) (AEMR [2014]). This revised EIMP (EIMP [Rev 6]) was approved by the Northern Territory Environment Protection Authority (NT EPA) on 2 April 2015.

While implementation of EIMP (Rev 6) will apply to the 2015/16 annual monitoring period (1 May 2015 to 30 April 2016), monitoring at some of the new locations specified in EIMP (Rev 6) commenced during this annual monitoring period (1 May 2014 to 30 April 2015), and data from these locations have been reported in this EPA7 Report.

Table 2-1 summarises the specific objectives of each environmental strategy in EIMP (Rev 0).

Table 2-1 EIMP (Rev 0) Objectives and Targets

Management Strategy	Objectives	Performance Criteria
Surface Water Management	To minimise transport of sediment across the Site into immediate surroundings including adjacent land, intertidal areas and receiving surface water bodies.	Stormwater and construction water discharged from the Site does not result in sediment deposition altering sediment elevation in the receiving environment by more than 50 mm, averaged over 1 m^2 and a 12 month period.
	To minimise changes in surface water quality resulting from the disturbance or dewatering of ASS. To minimise the discharge of water contaminated with nutrients, hydrocarbons or other contaminants off site.	Detectable changes in surface water quality should not exceed 10% of concurrently measured concentrations at buoys at BPSW30, BPSW31, BPSW32 and BPSW33. Monitoring data from these locations is to be relayed telemetrically for real time analysis. Installation of buoys is to be conducted by Company or its environmental monitoring specialist.
Groundwater Management	To minimise changes in groundwater levels and/or quality resulting from Site activities.	No statistically significant deterioration of groundwater levels and/or quality.
	To minimise disturbance to and alteration of mangrove communities as a result of changes to groundwater levels or quality arising from Site activities.	Zero decline in health of fringing mangrove communities as a result of changes to groundwater flows in on Site.
	To minimise disturbance to and alteration of mangrove communities as a result of changes to groundwater quality arising from Site activities.	Zero decline in health of fringing mangrove communities as a result of changes to groundwater quality on Site.
	To minimise disturbance to and alteration of mangrove communities as a result of oxidation of ASS soils from Site activities.	Zero decline in health of fringing mangrove communities as a result of metal accumulation in intertidal sediments.
Erosion and Sedimentation Management	To minimise transport of sediment across the Site into immediate surroundings including adjacent land, intertidal areas and receiving surface waters.	Stormwater and construction water discharged from the Site to receiving waters comply with water quality criteria. No decline in mangrove community health as a result of Site-related sediment accumulation[1] in intertidal areas.
Dust and Air Quality Management	To minimise adverse impacts from dust-generation on the environment and the health of the workforce during construction.	Zero impacts on vegetation health attributable to dust. No significant visible dust attributable to the Project outside the Site. Comply with Project air quality criteria.
Noise and Vibration Management	To minimise the impacts of construction noise and vibration on local communities (nearest sensitive receptors).	No exceedance of the Project noise limits.

[1] For the purposes of this EPA7 Report, this also includes erosion.

3. SITE INFORMATION

3.1 Site Identification

The Site is located at Bladin Point on Middle Arm Peninsula in Darwin Harbour, approximately 16 kilometres (km) south-east of the City of Darwin and occupies an area of 406 hectares (ha) (**Figure 1-2**). The Site is located at NT Portion 07002, 144 Wickham Point Road, Wickham NT 0822; Section 1901 and Section 1896, Hundred of Ayers, Wickham NT 0822; and 1000 Channel Island Road, Wickham NT 0822.

The Site is surrounded by the following land uses:

- North – Darwin Harbour and East Arm Peninsula (approximately 2.5 km to the north-west);
- East – Elizabeth River;
- West – Lightning Creek and Wickham Point beyond; and
- South – Bladin Central Enterprise Park (approximately 2 km to the south).

The City of Palmerston (Palmerston) is located approximately 4 km to the north-east and the existing Darwin Liquefied Natural Gas plant is located approximately 2 km to the west of the Site.

3.2 Surrounding Environment

Bladin Point is a low-lying peninsula which is separated from the mainland by a mudflat dominated by deeply weathered lateritic regolith formed on labile Cretaceous marine sediments. The dominant soils covering over half the area on the undulating terrain are shallow to moderately deep, very gravely massive earth (surface lateritic gravel). The residual soils are typically lateritic clay, silts and sand with ferricrete layers often close to the surface or outcropping.

Bladin Point is surrounded on three sides by water: to the east is the Elizabeth River, to the north the East Arm of Darwin Harbour and to the west is Lightning Creek. Rainfall during the wet season forms ephemeral overland streams that discharge into the surrounding water bodies. Surface water historically flowed from the high point along the centre of the Peninsula to the east, north and west. Construction works have modified the topography of the Site but have maintained the general discharge to the north, east and south through specifically constructed discharge points. The main access road for the Site has been constructed through a salt flat located at the isthmus between Bladin Point and the mainland.

The water quality of Darwin Harbour is regarded as '*slightly modified*' in accordance with the *Water Quality Objectives for the Darwin Harbour Region – Background Document* (Darwin Harbour Water Quality Objectives [WQOs]) (NRETAS, 2010a), which states the following:

> *Hydrodynamic modelling, supported by water quality studies, indicate that significant tidal movement in the Harbour does not, on a time scale of weeks or even months, transport diffuse and point source nutrients out of the Harbour, but rather assists in their dispersal within the Harbour precinct.*

From the above it is considered that the impacts of urban and point source discharge are likely to be localised and remain within the confines of Darwin Harbour.

Aquifers within the Site occur within the Cretaceous and Proterozoic sediments and rocks (Appendix 18, *Ichthys Project Environmental Impact Statement* [INPEX Browse, Ltd, 2010] [EIS]). The uppermost aquifer at Bladin Point occurs in the clayey sand/gravel horizons of the Cretaceous Darwin Formation. The Darwin Formation is underlain by weathered Proterozoic rocks represented by a cemented gravel horizon. Cretaceous sediments covering the gravel horizon comprise sand, clay and silt.

Bladin Point is considered to be part of the Darwin Coastal Bioregion. The flora of Bladin Point, prior to clearing, was dominated by woodland and monsoon vine forest with fringing patches of mixed low woodland species and *Melaleuca* forest. The woodland community mostly consisted of *Eucalyptus miniata* (Darwin woollybutt) and *E. tetrodonta* (Darwin stringybark) with mixed mid-storey species including *Cycas armstrongii* (NRETAS, 2011) which is listed as vulnerable under the *Territory Parks and Wildlife Conservation Act* (NT) (TPWC Act). Clearing was undertaken as part of the approved development permit.

Bladin Point is fringed by an extensive mangrove community, typical of the majority of the shoreline of Darwin Harbour. The intertidal areas of Darwin Harbour contain over 27,000 ha of mangroves, which constitutes 44% of the mangrove community in the Darwin Coastal Bioregion (NRETAS, 2011). Darwin Harbour contains 36 mangrove species, six of which are common: *Rhizophora stylosa*, *Ceriops tagal*, *Sonneratia alba*, *Bruguiera exaristata*, *Avicennia marina* and *Camptostemon schultzii* (Brocklehurst *et al.*, 1996).

3.3 Climate

The Site is located within tropical northern Australia and is subject to two distinct weather seasons, the wet and dry season. The wet season generally occurs from October to April, in accordance with the way the Bureau of Meteorology (BOM) calculates its statistics, and also how the NT EPA applies wet season controls, and is characterised by warm and humid weather. The monsoonal rainfall period generally occurs between December and March and is characterised by higher than average rainfall and an increased potential for cyclone development. The dry season occurs between May and September and is typically characterised by dry days and cooler day-time temperatures.

Climatic data has been recorded by the Project's onsite weather station since October 2012. The weather station collected data on rainfall, temperature, humidity, wind speed and wind direction during the annual monitoring period.

During the annual monitoring period, the Site received rainfall of 1,820 millimetres (mm), with rain falling on 99 days, mainly in the wet season. October was the hottest month with a temperature range of 23.2°C minimum to 37.9°C maximum. A summary of the climatic data collected during the annual monitoring period is presented in **Figure 3-1**.

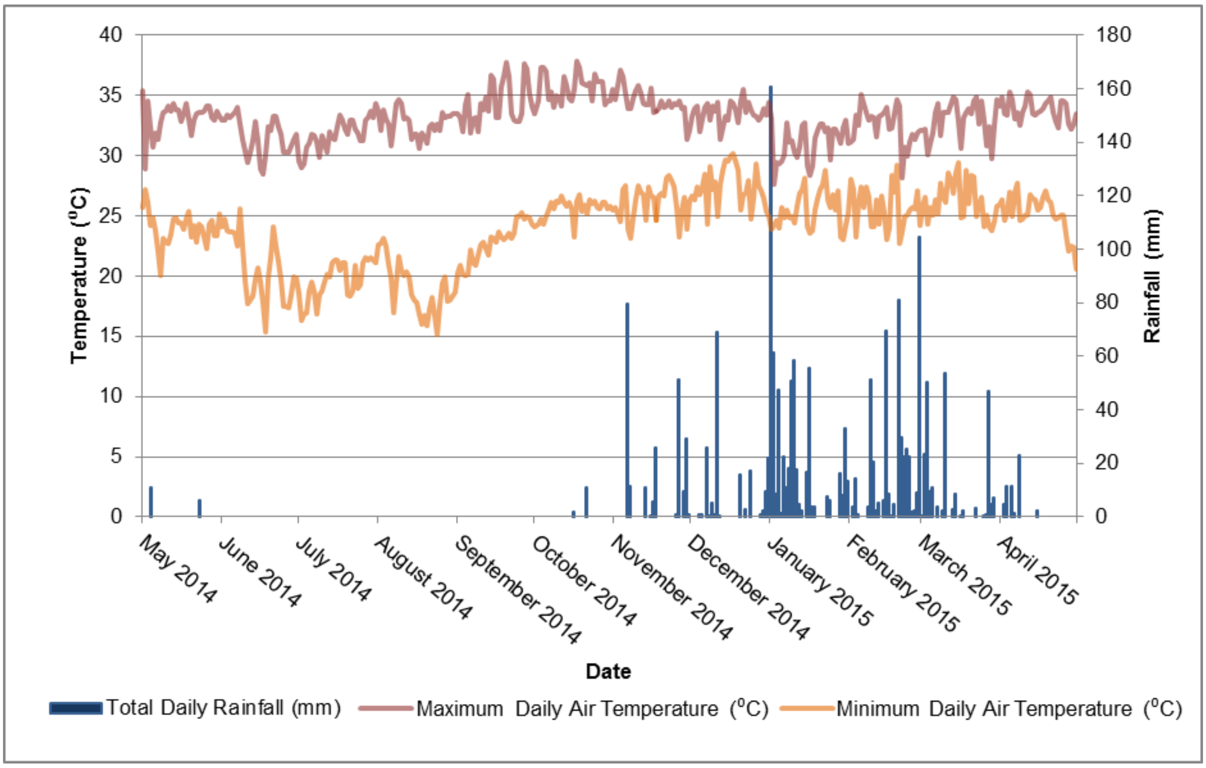


Figure 3-1 Summary of Climatic Data, May 2014 – April 2015

3.4 Site Construction Activities – May 2014 – April 2015

Civil and infrastructure works continued through the annual monitoring period on Site, comprising:

- Earthworks;
- Roadworks and facilities installation;
- Civil works; and
- Piling.

4. RESULTS

4.1 Surface Water

4.1.1 Monitoring Methodology

The monthly surface water monitoring was intended to detect potential upstream and downstream impacts from discharges associated with onsite basins, spills and leaks from Site activities and |ASS impacts. Since completion of EIMP (Rev 0), an erosion and sediment control plan (ESCP) has been completed for the Site and a number of onsite basins have been installed based on the erosion hazard risk assessment and permanent design.

In accordance with EIMP (Rev 0), samples were collected from the receiving environment and suitable basins (where sufficient water was present) on a monthly basis. Surface water monitoring during the annual monitoring period was undertaken at:

- Fifteen offsite marine monitoring sites located in Darwin Harbour around the Site. Two of these monitoring sites, BPSW34 and BPSW35, were monitored from August 2014 onwards as set out in EIMP (Rev 6);
- Four reference sites located in Darwin Harbour near East Arm. Two of these reference sites, CSSW03 and CSSW04, were monitored from August 2014 as set out in EIMP (Rev 6);
- Six telemetered marine buoy monitoring sites located in Darwin Harbour around the Site, as set out in EIMP (Rev 6); and
- Twelve onsite basins within the Site.

Figure 4-1 and **Figure 4-2** present the surface water monitoring locations.

The following analytes were recorded in-situ:

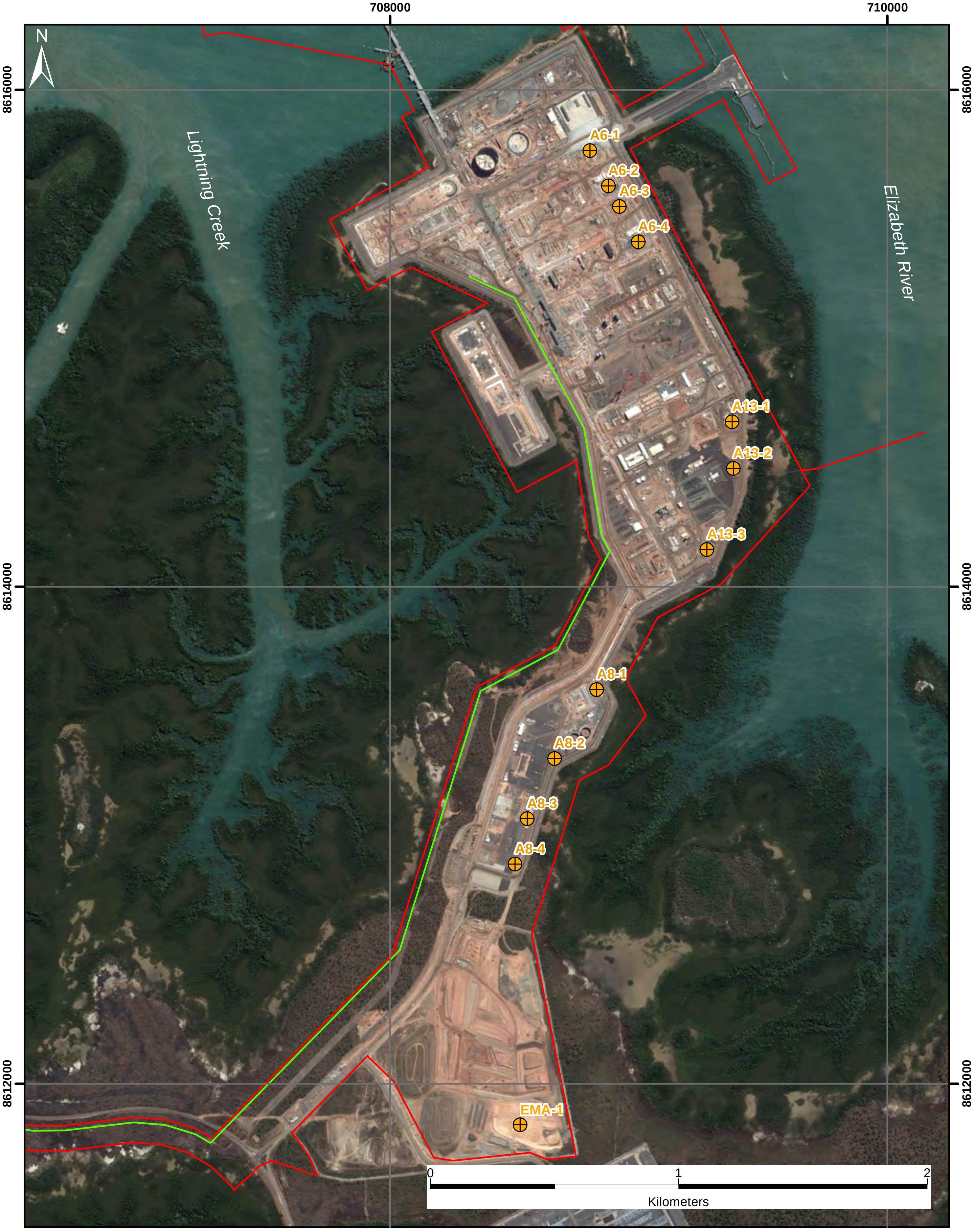
- Temperature;
- Electrical conductivity;
- pH;
- Turbidity;
- Total dissolved solids (TDS);
- Dissolved oxygen (DO);
- Oxidation reduction potential (ORP);
- Total chlorine; and
- Salinity.

Each of the collected surface water samples were analysed for:

- Total and dissolved metals;
- Total suspended solids (TSS);
- Alkalinity;
- Nutrients (ammonia, oxides of nitrogen, total kjeldahl nitrogen, total nitrogen, filterable reactive phosphorus [FRP] and total phosphorus);
- Major ions; and
- Hardness.

Specifically identified surface water locations were also analysed for the following additional parameters:

- Total recoverable hydrocarbons (TRH);
- Benzene, toluene, ethylbenzene, xylenes (BTEX) and naphthalene; and
- Biological indicators (*E. coli,* enterococci, and chlorophyll-a).



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Site Boundary

Gas Export Pipeline

Surface Water Monitoring Locations

Basin Sampling Locations

Onsite Surface Water Monitoring Locations		
Figure 4-1	**INPEX Bladin Point**	greencap AEC Environmental
Date: *9/07/2015*	**Author:** malcolm.nunn	
	Map Scale: 1:20,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	
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Legend

Site Boundary
Gas Export Pipeline

Surface Water Monitoring Locations

Reference Sites
EIMP (Rev 6) New Reference Sites
Off-site Marine Sampling Locations
EIMP (Rev 6) New Off-site Marine Sampling Locations
EIMP (Rev 6) Marine Buoy Locations

Offsite Surface Water Monitoring Locations

Figure 4-2	**INPEX Bladin Point**	greencap AEC Environmental
Date: *9/07/2015*	**Author:** malcolm.nunn	
	Map Scale: 1:50,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	
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4.1.2 Results

Marine field and analytical results obtained from sites in Darwin Harbour during the annual monitoring period were considered representative of an estuarine environment due to the observed variability in salinity concentrations. Generally, results from the reference sites were similar to impact sites, which indicated that Site activities were unlikely to have impacted the receiving marine environment during the annual monitoring period. Assessment of trends in results from marine buoy monitoring data indicated, as expected, a strong diurnal tidal influence.

The three occasions where metals patterns were present in the data were assessed and it was concluded they were not a result of Site activities or discharges. Following a review of the activities undertaken on Site during the annual monitoring period, no direct correlation with the trends noted above could be established. This was supported by the similarities in monitoring results from the impact sites and reference sites, which demonstrated that conditions were generally consistent across the East Arm area with no apparent impact from Site activities. The increased number of exceedances during the dry season were not likely to be attributable to Site activities.

Surface water retained within onsite basins is subject to treatment to achieve surface water discharge criteria prior to any controlled release offsite and into the receiving environment. The basins are designed to allow the infiltration of surface and/or groundwater. In general, the results obtained over the last year were typical of surface water runoff as opposed to groundwater expression.

4.1.2.1 Marine Surface Water Quality

Salinity

The salinity in the marine locations ranged from 13 to 35.8 g/L with a median of 29 g/L during the annual monitoring period (**Figure SW5-7**, **Appendix SW5**). During the dry season salinity remained relatively stable with values between 27 and 34 g/L before increasing in September 2014 with a median of 30.9 g/L.

A noticeable decrease in salinity was observed during December 2014 and January 2015 as a result of dilution associated with rainfall events where salinity also remained lower for longer periods during neap tides due to the reduced water exchange with the outer harbour. Salinity then progressively increased to values ranging from 23.9 to 28.7 g/L in April 2015. **Figure 4-3** presents the salinity data trends from May 2014 to April 2015.

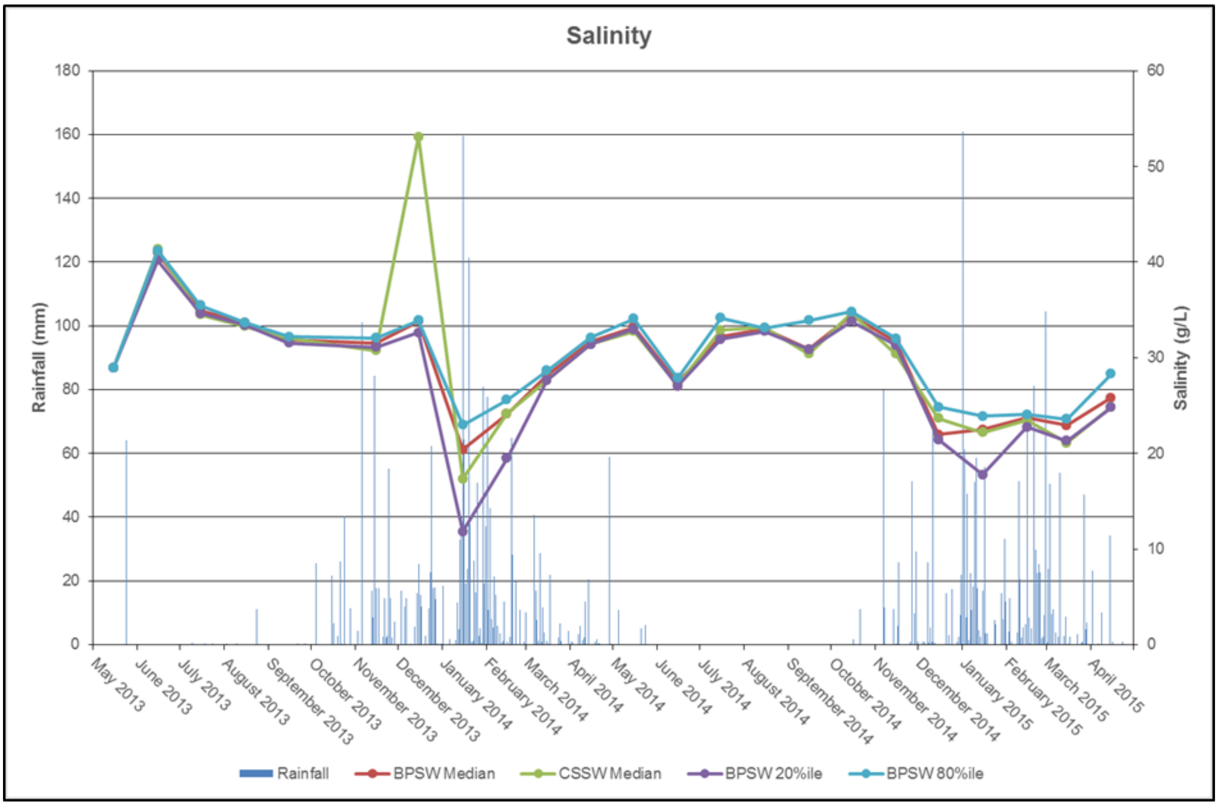


Figure 4-3 Marine Surface Water Salinity vs Daily Rainfall, May 2014 to April 2015

<u>Turbidity and TSS</u>

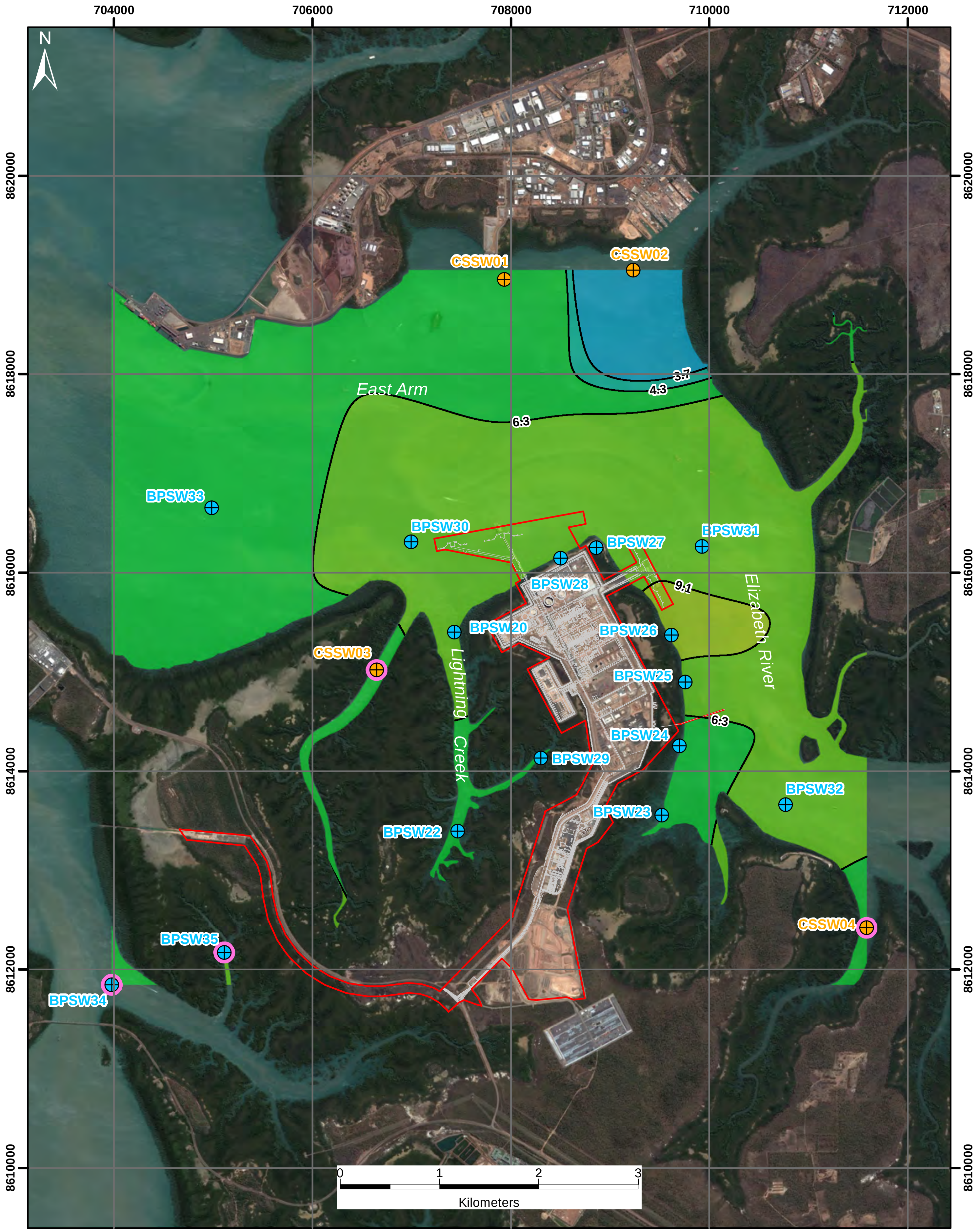
During the dry season turbidity remained relatively stable and ranged from 0.3 to 13.7 NTU, with a few isolated readings slightly above the 20 NTU trigger value. Unlike the 2013/14 wet season, turbidity decreased with the onset of the wet season in December 2014 and did not exceed 9 NTU. The measured turbidity exceedances primarily differed between the 2011/2012 period (Cardno, 2014) and the exceedances reported in the AEMR (2013) and AEMR (2014). During the current annual monitoring period, the peak elevations in turbidity were measured during increased wave height and heavy rainfall periods associated with monsoonal events and to a lesser extent, contribution from capital dredging works which continued to mid-2014 for sites located in East Arm. Only two exceedances in June 2014 were recorded during this annual monitoring period, which represented a significant reduction from previous years (AEMR [2013]; AEMR [2014]). Turbidity results were consistent across impact sites and reference sites, which demonstrated that results were indicative of conditions within the East Arm area of Darwin Harbour.

Turbidity trends recorded by the marine buoys showed daily tidal influence, generally with two peaks and two troughs per 24 hour period. These peaks generally coincided with both the high and low tides within a 24 hour period. The turbidity range due to tidal influence was between 5 – 20 NTU, depending on the buoy location, with the greatest range noted at the most upstream location BPSB08. In addition, turbidity was influenced by tidal range across each month, with generally elevated turbidity recorded at all sites on a bi-monthly basis, associated with the period of spring tides. The turbidity range due to the influence of spring tides was in the order of 5 – 15 NTU.

The TSS in the marine surface water locations ranged from 1.6 to 69.0 mg/L with a median of 16 mg/L during the annual monitoring period. During the dry season TSS increased steadily until August 2014 where it peaked at 61.0 mg/L before falling in October 2014 to 4.0 mg/L. Values increased again in November 2014 to 69.0 mg/L before decreasing from December 2014 to April 2015. The number of trigger value exceedances decreased significantly from December 2014 to April 2015, in contrast to the exceedances reported in the AEMR (2013) and AEMR (2014). It should be noted that the adopted exceedance trigger value (10 mg/L) for TSS is quite low in relation to the true values of suspended solids that naturally occur in this environment.

Another factor is that the exceedance graphs show values over the trigger but not what the values are. For example, median TSS in the harbour peaked at 22.4 mg/L in June 2013 and 21 mg/L in April 2014 in comparison to peaks in the wet season of 77 mg/L in January 2014. In contrast the peaks in median TSS observed in the dry season in this annual monitoring reporting period (August 2014) were around 40 mg/L. Note also that the 80^{th} percentile value in December 2013/January 2014 was 300 mg/L.

The isopleth maps illustrating the distribution of turbidity averages over the dry season and the wet season are provided as **Figure 4-4** and **Figure 4-5** respectively.



Legend

- Site Boundary
- Construction Footprint
- Turbidity Level Contours (NTU)

Surface Water Monitoring Locations

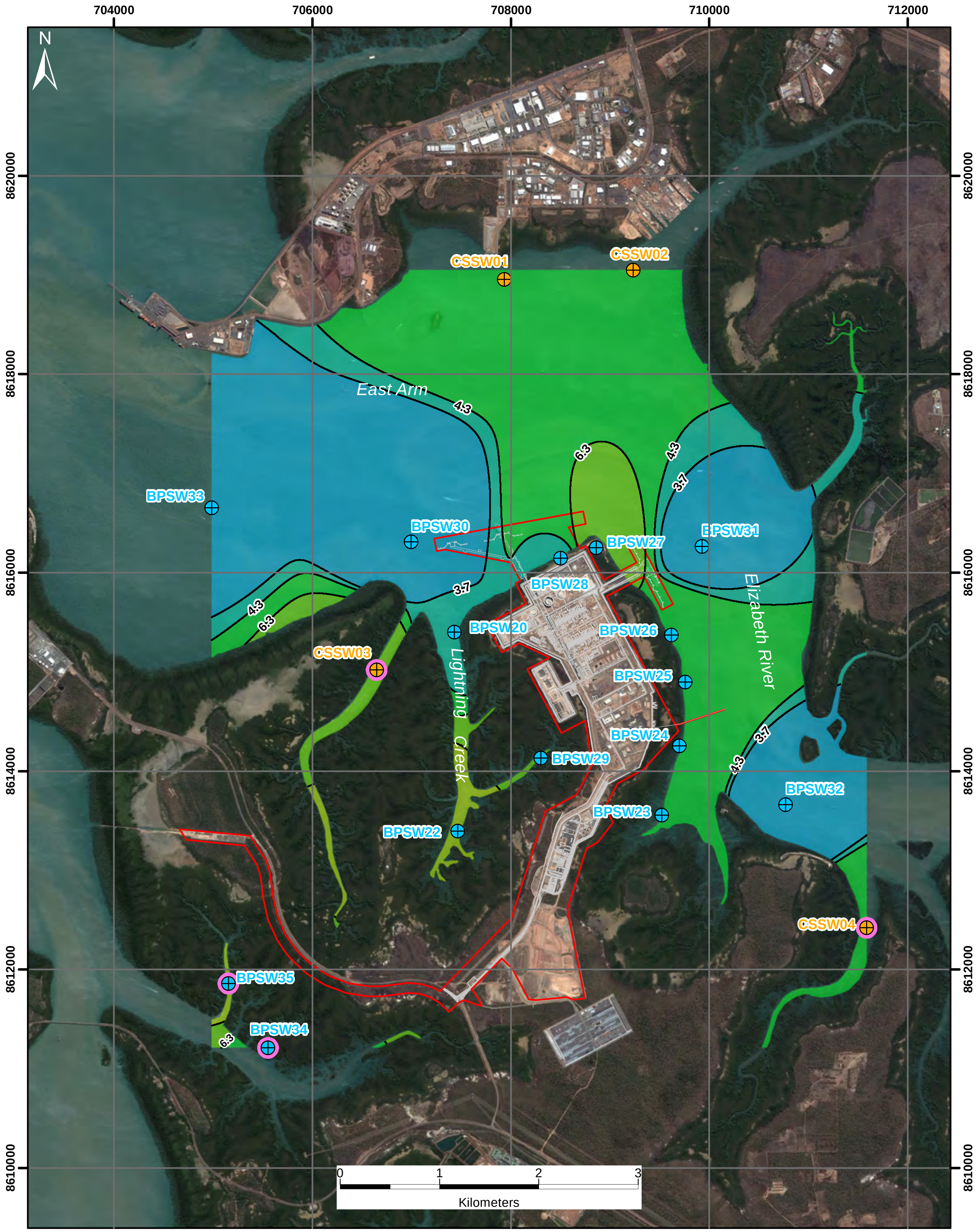
- Off-site Marine Sampling Locations
- EIMP (Rev 6) New Off-site Marine Sampling Locations
- Reference Sites
- EIMP (Rev 6) New Reference Sites

Turbidity Level (NTU)

- 0 - 3.7
- 3.7 - 4.3
- 4.3 - 6.3
- 6.3 - 9.1
- 9.1 - 20.4

Distribution of Turbidity Averages, June - September 2014

Figure 4-4	INPEX Bladin Point	greencap AEC Environmental
Date: 9/07/2015	**Author:** malcolm.nunn	
	Map Scale: 1:50,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\BP_EPA7_Report\2015\FIG_4_4_SW_BP_2014_Dry_TUR_150612.mxd		



Legend

- Site Boundary
- Construction Footprint
- Turbidity Level Contours (NTU)

Surface Water Monitoring Locations

- Off-site Marine Sampling Locations
- EIMP (Rev 6) New Off-site Marine Sampling Locations
- Reference Sites
- EIMP (Rev 6) New Reference Sites

Turbidity Level (NTU)

- 0 - 3.7
- 3.7 - 4.3
- 4.3 - 6.3
- 6.3 - 9.1
- 9.1 - 20.4

Distribution of Turbidity Averages, December 2014 - March 2015

Figure 4-5	INPEX Bladin Point	greencap AEC Environmental
Date: *9/07/2015*	**Author:** malcolm.nunn	
	Map Scale: 1:50,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\BP_EPA7_Report\2015\FIG_4_5_SW_BP_2014_Wet_TUR_150612.mxd		

Nutrients

All nutrients remained relatively stable across the annual monitoring period with the following exceptions:

- Ammonia – ranged from <5 to 620 µg/L. It was noted that the maximum result was an isolated value for BPSW35 in February 2015 and the next highest result was 210 µg/L at BPSW20 in July 2014. The majority of ammonia results were lower with a median of 16 µg/L. These elevated results did not correlate with any rainfall events. Results increased and decreased between August and December 2014, before increasing in January 2015 with a median value of 27 µg/L, correlating with the significant amount of rainfall recorded during that month. Results decreased from February 2015, with a median value of 17 µg/L recorded in April 2015. Insufficient knowledge of seasonal ammonia cycling in Darwin Harbour exists to relate the current monitoring results, although previous studies consider that ammonia concentrations in the Harbour do not vary remarkably from 10 µg/L (Butler *et al.*, 2013), 6 µg/L lower than the median reported here. These authors do concede that ammonia concentrations may be higher in creek arms due to remineralisation, presumably through the lower oxygen environments that exist in the dry season. Alternatively, increased water input through the wet season may reduce ammonia by flushing and/or advection through the same environments;
- Oxides of nitrogen – ranged from <5 to 85 µg/L, with a median value of 18 µg/L. Results decreased between May and July 2014 (median of 21 µg/L), increased from August 2014 and reached a maximum in January 2015 (median of 27 µg/L), which correlated with the significant amount of rainfall recorded during that month. Results decreased from February 2015, with a median value of 17 µg/L recorded in April 2015. Insufficient knowledge of seasonal oxides of nitrogen cycling in Darwin Harbour exists to relate the current monitoring results. It was possible, however, that increased water input through the wet season reduced oxides of nitrogen by flushing and/or advection;
- Total nitrogen – ranged from <50 to 1,100 µg/L, with a median value of 120 µg/L. Total nitrogen results increased in June 2014 (median of 25 µg/L), decreased between July and December 2014, and increased again in January 2015 (median of 73 µg/L), which correlated with the significant amount of rainfall recorded during that month. Results decreased from February 2015, with a median value of 40 µg/L recorded in April 2015. Total nitrogen is mostly comprised of organic nitrogen, either attached to sediment or (more commonly) as part of the natural degradation processes of organic material. Its generation, therefore, is independent of wet and dry season cycles (Butler *et al.*, 2013) and thus, unlike dissolved forms such as ammonia or oxides of nitrogen, it may not have a stronger signal due to runoff associated with the wet season;
- Total phosphorus – ranged from <5 to 220 µg/L, with a median value of 32 µg/L. Elevated total phosphorus results were recorded in May (a median value of 51 µg/L) and September 2014 (a median value of 42 µg/L). These elevated results did not correlate with any rainfall events. Total phosphorus results were elevated again in January (a median value of 73 µg/L) and March 2015 (a median value of 48 µg/L), which correlated with the significant amount of rainfall recorded during those months. As phosphorus is a conservative nutrient, i.e. it is not generated by the same additive process that applies to nitrogen such as nitrogen fixation, its input into Darwin Harbour would be as predominantly organic material washed from the catchment. On this basis, higher concentrations would be expected in the wet season; and

- FRP - ranged from <1 to 89 µg/L, with a median value of 4 µg/L. Elevated FRP results were recorded in August (a median value of 6 µg/L) and October 2014 (a median value of 6 µg/L). These elevated results did not correlate with any rainfall events. Results decreased from November 2014 to February 2015, where the median value was 3 µg/L, which correlated with the significant amount of rainfall recorded during those months. FRP is the reactive form of this nutrient and readily available for uptake by plants. Its generation would occur from natural degradation processes acting on the organic phosphorus (a major component of total phosphorus) in Darwin Harbour which would have been delivered from the catchment.

Metals and Metalloids

With the exception of three occasions, marine field and analytical metal and metalloid results obtained during the annual monitoring period were generally reflective of seasonal trends and historical values based on the extended dataset now collected for the Project.

There were three occasions where patterns presented in the monitoring dataset, however following further assessment none of these were attributed to Site activities. The three occasions were:

- Elevated concentrations of aluminium, cadmium, cobalt, lead, manganese, nickel and zinc reported at BPSW23 in September 2014. These metal signatures were consistent with groundwater at some locations on Site and are known to be associated with the regional Cretaceous aquifer. Following further assessment, it was found that Site activities had a low risk of resulting in the signature evident at BPSW23 because:
  - Groundwater levels typically peak in April and are substantially receding in September so there would not be any groundwater expression;
  - There was no ongoing trend. The signatures disappeared in the next monitoring month and were not repeated;
  - No other examples of this pattern were seen for any marine location in the dataset;
  - Only the EMA-1 basin contained water during September 2014 and analysis of this water showed that it did not contain any metals above the trigger values; and
  - No rainfall occurred and no dewatering permit discharges occurred for the month of September 2014. The exceedances of multiple filtered metals at BPSW23 in September 2014 were anomalous and considered to potentially be the result of an offsite groundwater or surface water contribution to the Harbour waters.
- Elevated concentrations of copper reported at nine locations (BPSW20, 30, 32, 33, 34 and 35, and CSSW01, 02 and 03) in January 2015. Following further investigation, it was found that Site activities had a low risk of resulting in the January 2015 multiple surface water copper exceedances because:
  - There was no spatial pattern in the copper occurrences. Exceedances were recorded at the Site perimeter, both of the reference sites across the other side of the estuary as well as upstream and downstream sites; and
  - Copper was detected at basin A13-2 at 3 µg/L, which was less than the majority of the detections in the Harbour. After accounting for dilution in the receiving environment, significantly higher concentrations and large volumes of discharge would be needed to elicit a signature in the marine environment. No Site activities could be attributed to the distribution of the elevated copper concentrations and it was attributed to offsite regional influences.

- Elevated concentrations of nickel reported for nine locations (BPSW24, 25, 26, 27, 28, 31 and 32 and CSSW03 and 04) in January 2015. Following further investigation, it was found that Site activities had a low risk of resulting in the January 2015 multiple surface water nickel exceedances because:
    - While there were six locations adjacent to the Site with exceedances, these were also detected at an upstream site and one of the reference sites;
    - No basins contained nickel exceedances. Significantly higher concentrations and large volumes of discharge would be needed to elicit a signature in the marine environment;
    - There was no ongoing trend. The signature disappeared in the next monitoring month and was not repeated. No Site activities could be attributed to the distribution of the elevated nickel concentrations and it was attributed to offsite regional influences.

In summary, for all of the above instances, no confirmed pathways could be established between Site activities and spatial patterns, trends, rainfall, discharges or water storage in the basins. It was concluded that there was a low risk of Site activities impacting the receiving environment during the annual monitoring period.

Other Parameters

No exceedances of adopted trigger values were recorded for *E. coli* or enterococci during the annual monitoring period, in contrast to the AEMR (2014), where two enterococci exceedances were recorded.

One exceedance of the trigger value for chlorophyll-a was recorded at BPSW29 in March 2015 (0.005 mg/L). As only one isolated exceedance was recorded, no correlation with Site activities was identified.

Chloride/Sulfate Ratio

Chloride/sulfate ratios can be used to determine whether there has been discharge from ASS-impacted streams into marine environments. Chloride/sulfate ratios are often <3 in ASS-impacted streams, whereas ratios between ~5 and 7 are expected in estuarine streams (Sammut *et al.,* 1996). **Figure 4-6** demonstrates that the salinity results from the surface water monitoring program are generally consistent with seawater and therefore, there has not been discharge from ASS-impacted streams into the adjacent marine environment. In addition, the data collected during this annual monitoring period was similar to the AEMR (2013) and AEMR (2014), demonstrating that surface water has not been measurably impacted by ASS to date.

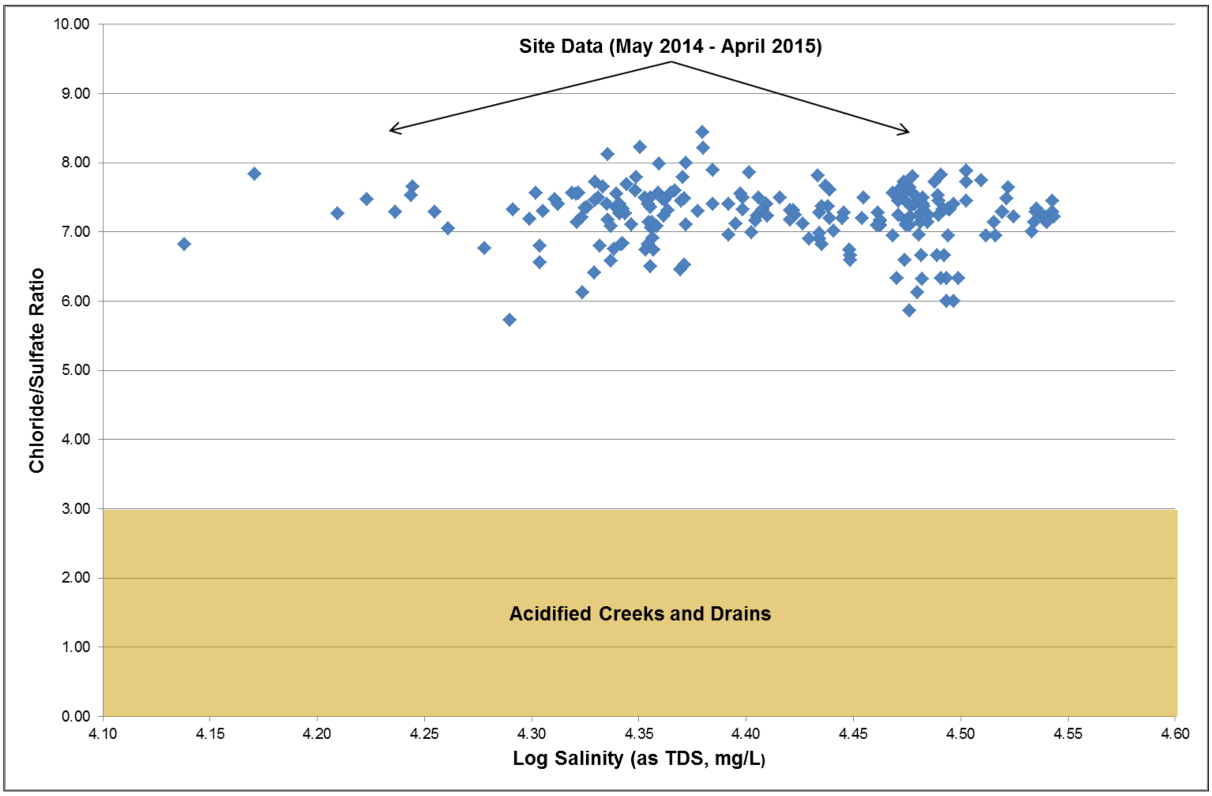


Figure 4-6 Surface Water Chloride/Sulfate Ratio

4.1.2.2 Terrestrial Surface Water Quality

Surface water retained within onsite basins is subject to treatment to achieve surface water discharge criteria prior to any controlled release offsite and into the receiving environment. The basins are designed to allow the infiltration of surface and/or groundwater. In general, the results obtained over the last year were typical of surface water runoff as opposed to groundwater expression.

Turbidity and pH exceedances were reported but they were considered to be reflective of the basins' functional role in erosion and sediment control. This water often required treatment prior to discharge which necessitated sampling and permitting in accordance with the dewatering procedure.

There were no trends observed in the quality of surface water in the basins. Water discharged from the basins was treated prior to discharge thus potential impacts on the receiving environment from discharged water could not be attributed to Site activities. The water quality within basins was also dependent on recent rainfall events and the volume of surface water flows containing suspended material at the time of sampling. The basins generally contained water of neutral pH, low salinity, positive ORP, and turbidity and pH levels exceeding discharge criteria at the time of sampling. The turbidity and pH measurements were indicative of water retention prior to treatment and flocculation to achieve discharge criteria prior to any controlled release into Darwin Harbour.

4.2 Groundwater

4.2.1 Monitoring Methodology

The groundwater management objectives for the Site seek to minimise changes in groundwater levels and quality which may be arising from Site activities including impacts associated with the possible oxidation of ASS, which may lead to disturbance of the fringing mangrove communities where groundwater may discharge. Monitoring also aims to assess potential impacts resulting from onsite spills and leaks at the nominated higher risk locations.

The current bore network comprises 44 monitoring locations, identified on **Figure 4-7**. During the annual monitoring period, three wells were decommissioned (removed and filled over) and eight additional bores were installed. As set out in EIMP (Rev 6), monitoring commenced at MW04d, MW05d, MW08d, MW10a, MW11a, MW14, MW16, MW18b and MW20b along the GEP corridor to monitor for any potential impacts from the expanded construction footprint. Data loggers were used to continuously monitor standing water level (SWL), pH, ORP, DO, TDS, turbidity and temperature at selected bores during the annual monitoring period.

In accordance with EIMP (Rev 0), samples were collected from the monitoring bores on a monthly basis.

The following analytes were recorded in-situ:

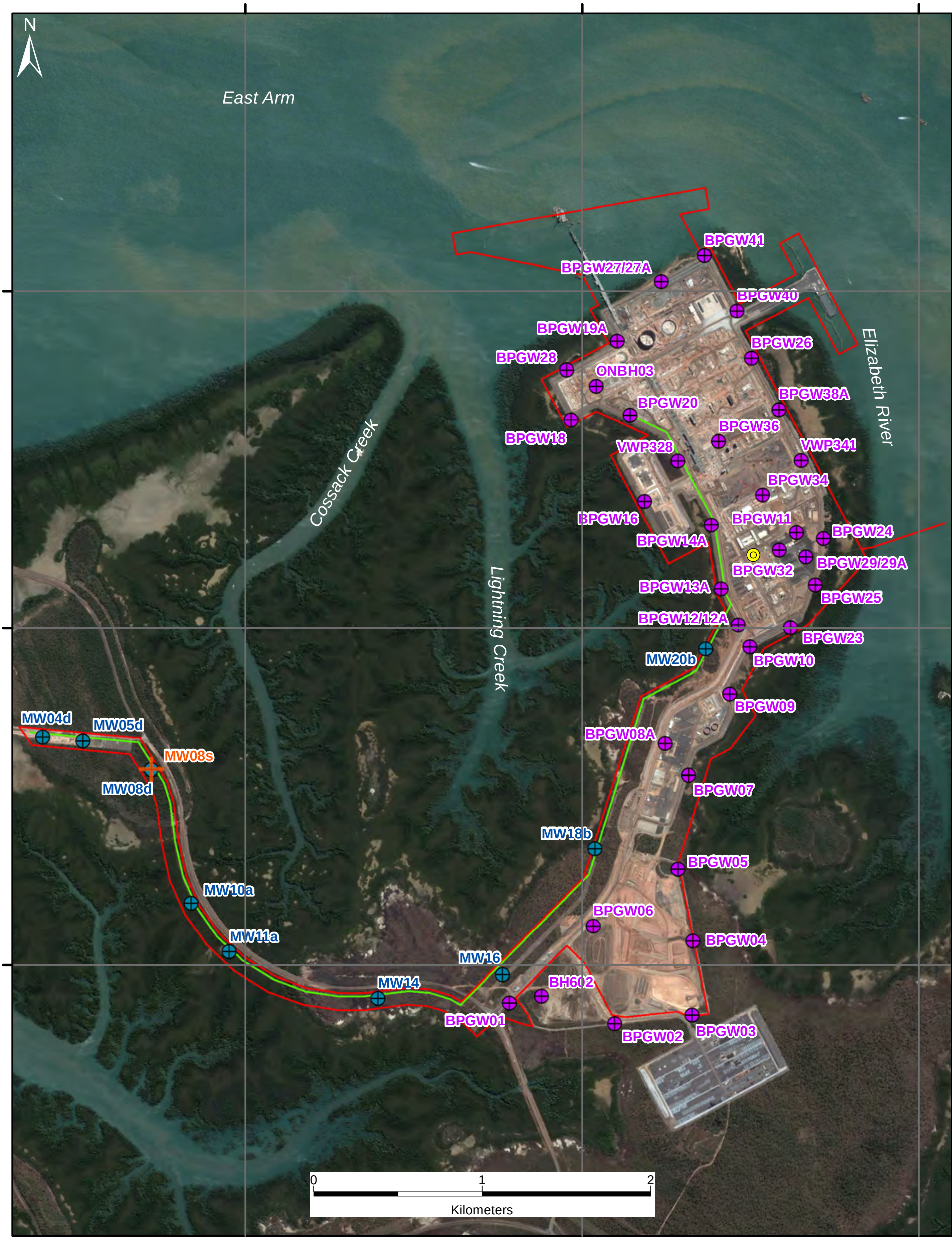
- Temperature;
- Electrical conductivity;
- pH;
- Turbidity;
- TDS;
- DO;
- ORP; and
- Salinity.

Each of the collected groundwater samples were analysed for:

- Total and dissolved metals;
- TSS;
- Alkalinity;
- Nutrients (ammonia, oxides of nitrogen, total kjeldahl nitrogen, total nitrogen, FRP and total phosphorus);
- Major ions; and
- Hardness.

Specifically identified groundwater monitoring bores were also analysed for the following additional parameters:

- TRH, BTEX and naphthalene.



Legend

- Site Boundary
- Gas Export Pipeline
- EIMP (Rev 6) GEP Groundwater Sampling Locations
- GEP Groundwater Sampling Location (monitored January and February 2015 only)
- Groundwater Sampling Locations
- Approximate Location of Diesel Spill

Groundwater Sampling Locations		
Figure 4-7	INPEX Bladin Point	greencap AEC Environmental
Date: 21/07/2015	**Author:** malcolm.nunn **Map Scale:** 1:30,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\BP_Annual_Report\2014_2015\FIG_5_1_GroundWater_150721.mxd		

4.2.2 Results

4.2.2.1 Field Parameters

pH

All pH values for the annual monitoring period were generally below the lower limit of the adopted trigger value range (pH 7), indicating groundwater acidity, which was consistent with historical ranges (INPEX Browse, Ltd, 2010). There were three nodes of low pH within the Site and these occurred in the southern portion of the EMA (centred on bore BH602), in the central part of the Site (centred on bores BPGW11, BPGW32, BPGW34 and BPGW36) and a narrow strip along the north-west portion of the Site (centred on bore ONBH03). None of these areas correlated with the major ground improvement works that have occurred on Site.

Isopleth maps illustrating the distribution of pH at the end of the dry season (October 2014) and the end of the wet season (March 2015) are provided as **Figure 4-8** and **Figure 4-9**. The lowest pH values in October 2014 were recorded at monitoring bores BH602 (3.62) and BPGW36 (4.10). In March 2015, the lowest pH values were in BH602 (3.52) and BPGW02 (3.80).

Groundwater Elevation

Groundwater elevation was highest in the south of the isthmus and bores BH602 and BPGW06 were typically higher in comparison with other bores during any given month. During the dry season, groundwater levels in the majority of the bores across the Site were highest in May 2014 and decreased until October 2014 due to the absence of rainfall-driven aquifer recharge. Typical reductions ranged from 1.5 m (north of the isthmus) to 3.5 m (south). From November 2014 to January 2015, groundwater levels rose as a result of increased rainfall events and remained steady until March 2015, before declining slightly in April 2015. In contrast, seasonal trends were not observed in the perimeter bores adjacent to intertidal zones (e.g. BPGW07, BPGW09, BPGW10, BPGW18 and BPGW28) and these groundwater levels were more influenced by tides than rainfall.

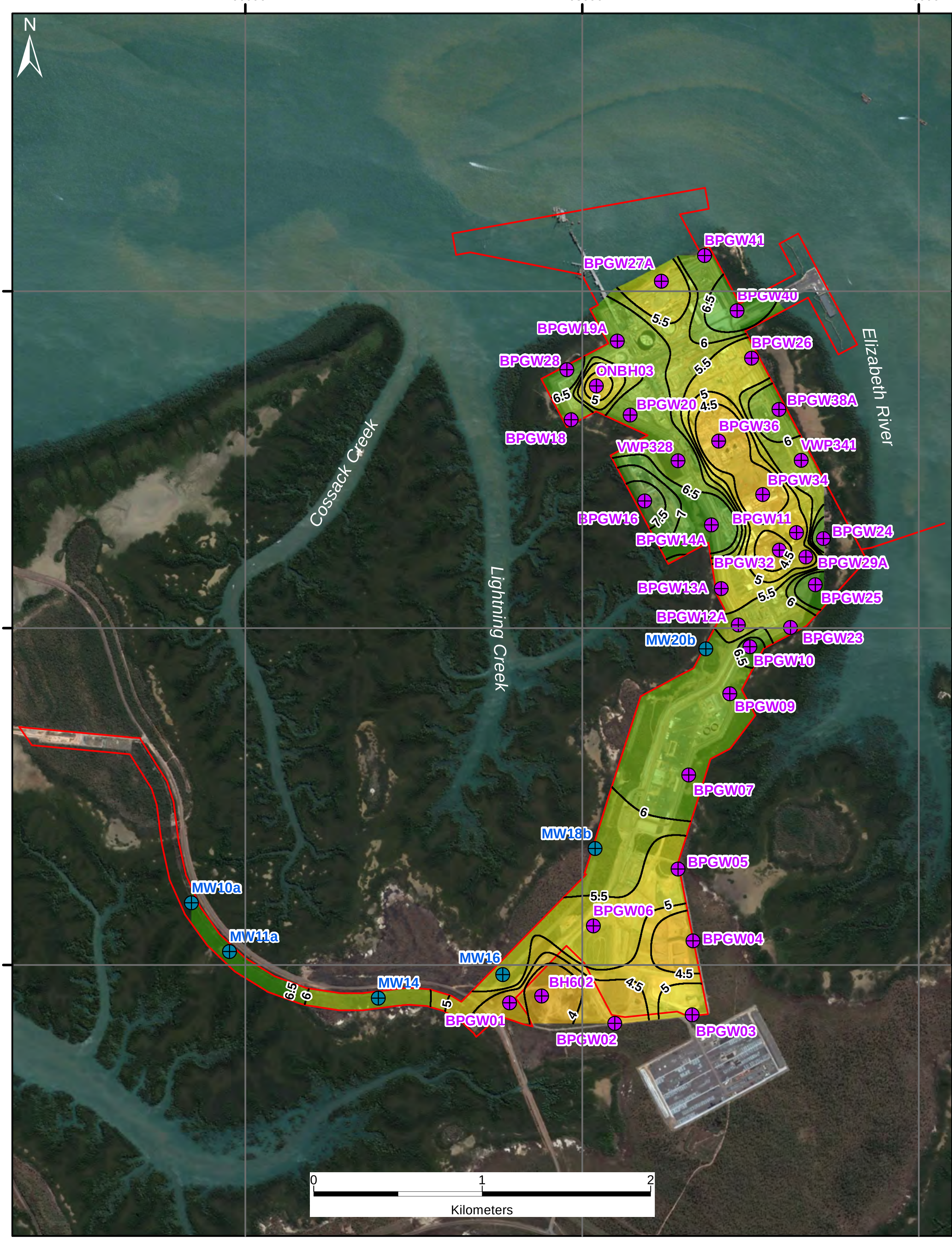
Analysis of the groundwater level patterns for the duration of the Project (2012-2015) indicated the following:

- Generally, groundwater levels appeared to be higher within the central parts of the Site, where groundwater levels changed more significantly in response to rainfall. Groundwater levels appeared to be lower around the coastal (intertidal) areas where the influence from rain water recharge was not significant;
- The groundwater level seasonal fluctuation pattern indicated that the highest water levels were observed during the wet seasons (typically between October and April) and the lowest water levels were observed during the dry season (typically between May and September) during all annual monitoring periods;
- The groundwater level rises were proportional to the amount of rain recorded each year, i.e. the 2013/14 wet season had the highest rainfall in comparison with the 2012/13 and 2014/15 wet seasons, and recorded the highest groundwater levels; and
- Site activities did not appear to notably influence the overall seasonal groundwater level fluctuation amplitude within the Site boundary because no long-term rising trends (increased aquifer recharge due to an increase in rainwater infiltration) or falling trends (due to sealing the areas where groundwater recharge typically occurs) were observed between 2012 and 2015.

Salinity

Field measured salinity ranged between 0.0 g/L to 96 g/L. It was noted that salinity values varied between seasons, decreasing during the wet season and increasing during the dry season.

At each monitoring location, groundwater salinity appeared to be consistent with expected seasonal variations over the course of the annual monitoring period, which confirmed previous observations that groundwater salinity on Site varies depending on proximity to the coastal margins. Areas of hyper-salinity were centred on three nodes and freshwater at two.



pH Level Contours, October 2014

Figure 4-8	INPEX Bladin Point	greencap AEC Environmental
Date: *9/07/2015*	**Author:** malcolm.nunn	
	Map Scale: 1:30,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	

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Legend

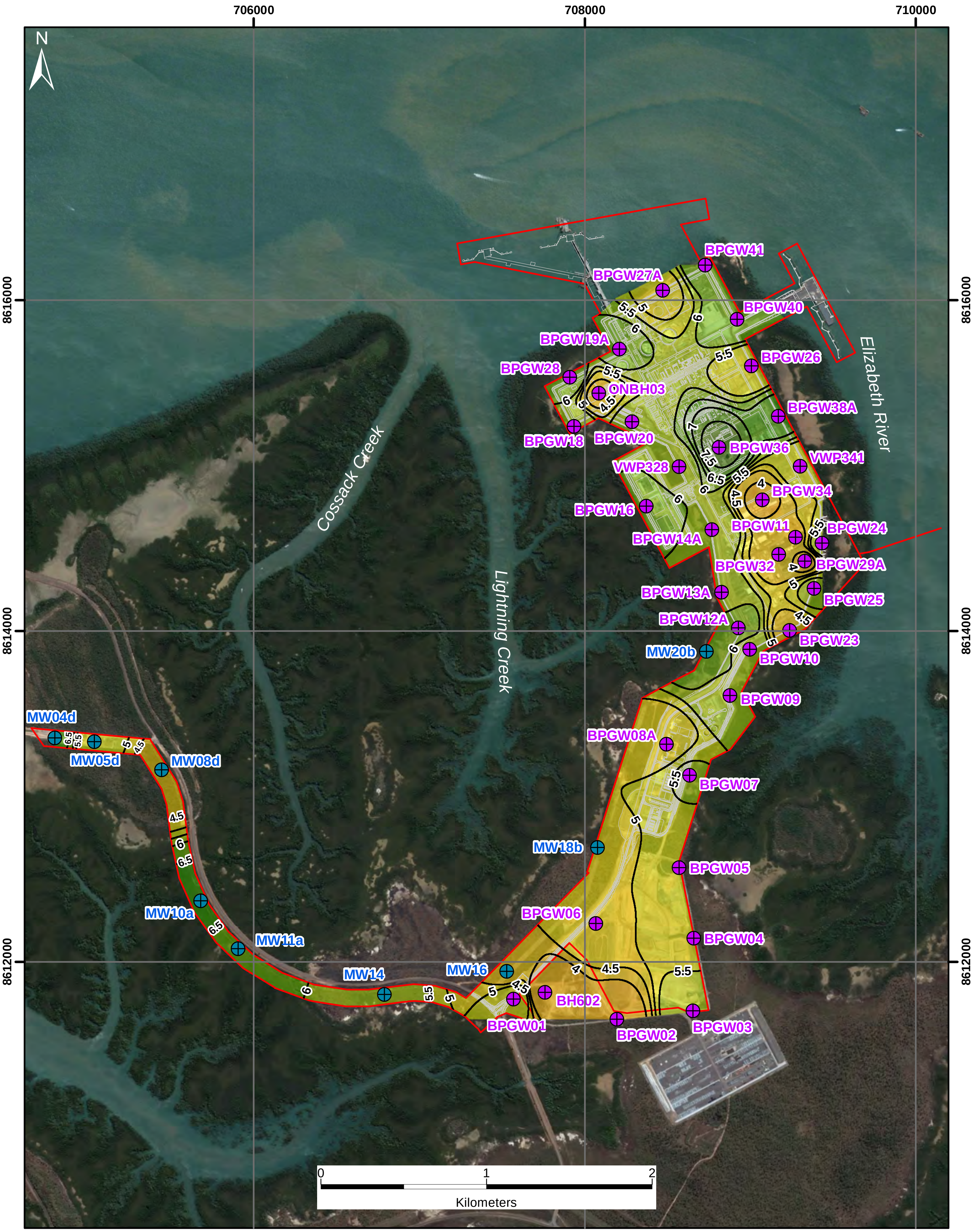
- Site Boundary
- pH Level Contours

Monitoring Locations

- Groundwater Sampling Locations
- EIMP (Rev 6) GEP Groundwater Sampling Locations

pH Level

- <4.0
- 4.0 - 4.5
- 4.5 - 5.0
- 5.0 - 5.5
- 5.5 - 6.0
- 6.0 - 6.5
- 6.5 - 7.0
- 7.0 - 7.5
- >7.5



Legend

- Site Boundary
- Construction Footprint
- pH Level Contours

Monitoring Locations

- Groundwater Sampling Locations
- BIMP (Rev 6) GEP Groundwater Sampling Locations

pH Level

<4.0	5.5 - 6.0
4.0 - 4.5	6.0 - 6.5
4.5 - 5.0	6.5 - 7.0
5.0 - 5.5	7.0 - 7.5
	>7.5

pH Level Contours, March 2015

Figure 4-9	INPEX Bladin Point	greencap AEC Environmental

Date: 9/07/2015

Author: malcolm.nunn

Map Scale: 1:30,000

Revision: C

Coordinate System: GDA 1994 MGA Zone 52

G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\BP_EPA7_Report2015\FIG_4_9_BP_GW_2015_03_March_pH_150612.mxd

4.2.2.2 Analytical Results

Nutrients

All nutrients consistently exceeded the trigger values during the annual monitoring period, which was also reported in the AEMR (2013) and AEMR (2014). This could be an indication that the elevated nutrient levels were due to the naturally elevated background levels in this environment. The reported concentrations of nutrients did not show any significant increasing trends, with the number of exceedances for each nutrient fairly consistent across each month of the annual monitoring period. Some correlation was noted between areas of hyper-salinity and levels of ammonia and total phosphorus.

Metals and Metalloids

The metals/metalloids exceeding the trigger values during this annual monitoring period included aluminium, arsenic, cobalt, copper, lead, manages and zinc. The reported exceedances indicated seasonal fluctuation and no significant trends in metal/metalloid concentrations were observed during this annual monitoring period and in the AEMR (2013) and AEMR (2014). The metal species exceeding the trigger values in 2009 (pre-construction) were generally consistent with exceedances identified in this AEMR. Also, the observed lateral distribution of metals did not identify any point sources for the metals on Site. Any variation in metal concentrations appeared to correspond with the pH nodes described earlier. The seasonal trend in metals and metalloids noted in the AEMR (2014) was not as evident during this annual monitoring period, which was attributed to the reduction in rainfall. In summary, no significant trends in metal concentrations were observed during the annual monitoring period and it was concluded that Site activities did not influence concentrations of metals in groundwater.

Sulfate/Chloride Ratio

The *Acid Sulfate Soils Assessment Guidelines* (Acid Sulfate Soil Management Committee NSW, 1998) (ASS Guidelines) states the following:

> *The potential influence from ASS on groundwater quality was assessed using sulfate/chloride ratios. A typical sulfate-chloride ratio for seawater is 0.14 (19,400 mg/L chloride and 2,700 mg/L of sulfate). As the ratios of the dominant ions in saline water remains approximately the same when diluted with rainwater, estuaries, coastal saline creeks and associated groundwater can be expected to have similar ratios to the dominant ions in seawater (Mulvey, 1993). Where the analysis indicates that there is an elevated level of sulfate ions relative to the chloride ions, these results provide a good indication of the presence of acid sulfate soils in the landscape. A Cl-:SO4 2- ratio of less than four and certainly a ratio less than two, is a strong indication of an extra source of sulfate from previous sulfide oxidation (Mulvey, 1993).*

In other words, a greater ratio would indicate a potential influence from a sulfate-containing source e.g. ASS oxidation. A lower ratio would indicate a sulfate salt precipitation or dilution with water, with minor sulfate content, e.g. rainwater. **Figure 4-10** shows that the sulfate-chloride ratio for onsite groundwater was generally consistent with the typical seawater ratio, indicating a negligible influence from sulfate generation sources and some influence from dilution. Accordingly, the overall influence on groundwater quality from potential oxidation of ASS was likely to be insignificant.

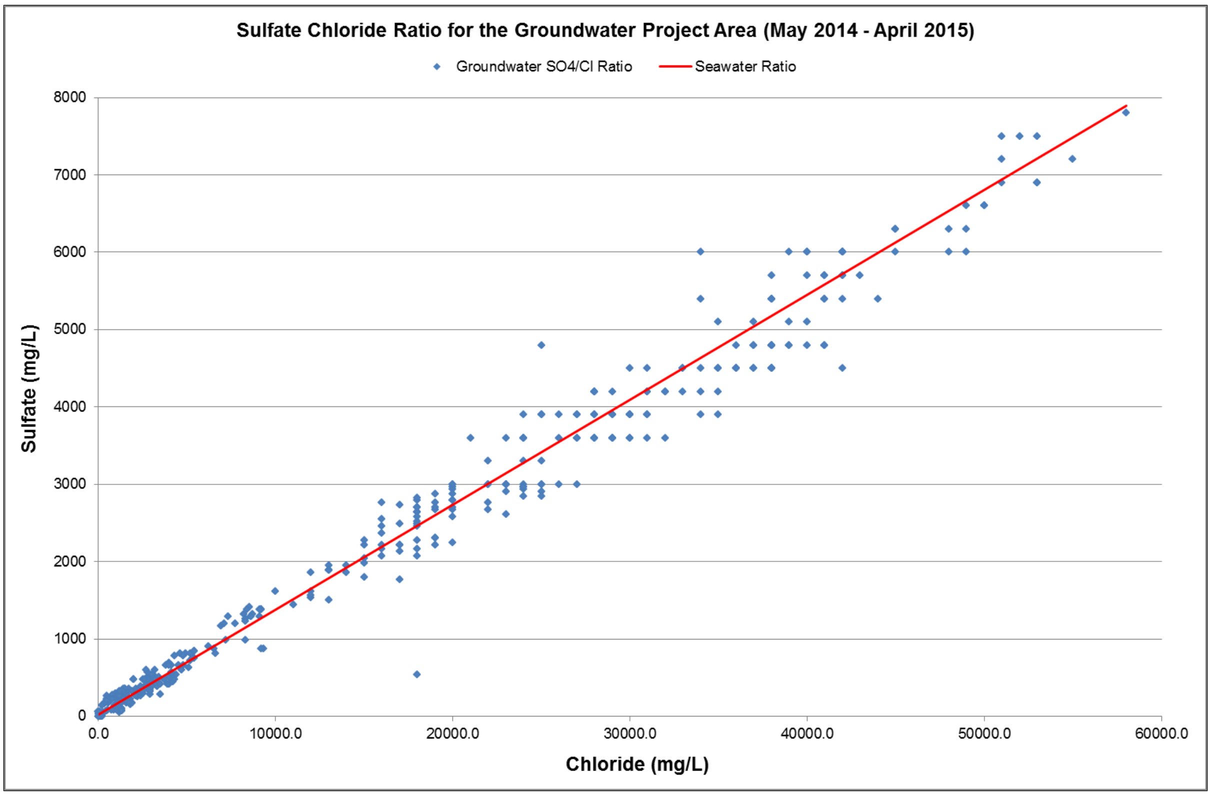


Figure 4-10 Sulfate/Chloride Ratio

Improved Understanding of Onsite Groundwater Aquifers

Investigations and modelling undertaken during this annual monitoring period improved the understanding of the inferred seasonal groundwater system on Site. The model simulated seasonal variations in dissolved chemicals and groundwater salinity, and comparison between the predicted and sampled data generally confirmed the hypothesis regarding saline and fresh water separation in the shallow aquifer.

Metal and salinity concentrations decrease in groundwater samples during wet seasons and increase during dry seasons. These changes, most often recorded for the groundwater bores with the screens which may intersect the inferred interface between the saline and fresh aquifers, may be due to the following:

- Seasonal groundwater level fluctuations that result from wet season recharge. During wet seasons a dominant inflow of groundwater from the fresh (perched) aquifer occurs during groundwater sampling, which would result in a decrease in concentrations found in samples (i.e. some dilution occurs with the fresh waters);
- During dry seasons a dominant inflow of groundwater from the regional saline aquifer would occur during groundwater sampling and a concomitant increase in sample concentrations is observed; and
- The seasonal variations both in groundwater salinity and other chemical concentrations may be a result of a mixture between two aquifers along the bore screens installed across the saline/fresh water interface.

While it is not currently possible to define the full extent of the seasonal (freshwater lens) and fresher groundwater system/s, their source is likely to be rainwater infiltration and these will 'float' on the top of saline water due to the density contrast. It is anticipated that there is a confining layer present on the top of the saline groundwater aquifer which essentially minimises mixing between them and this varies in depth and completeness across the Site.

Conceptually there are three different groundwater bodies as follows:

- A freshwater lens groundwater body which is formed seasonally as a result of wet season groundwater recharge associated with the rainwater infiltration;
- A regional (permanent) saline groundwater body which underlies the Site and is separated from the freshwater lens groundwater by a confining layer or is a result of the density contrast; and
- Hyper-saline groundwater lenses which have no or very limited hydraulic connection with the other two groundwater bodies as well as the marine waters of Darwin Harbour.

Hyper-saline Groundwater Lenses

The source of the hyper-saline groundwater is the saline soils present within the salt flats where the high soil salt content is maintained at very high levels due to evaporation. These are then transported into the shallow aquifer by either rainfall, tidal seawater or infiltrating stormwater.

The locations of hyper-saline groundwater bores commonly have a layer of a low permeable material represented by clays and extremely weathered phyllite/siltstones. These potentially confining layers are located at shallow depths and generally restrict downward leakage of hyper-saline waters into deeper aquifer/s if present.

Tidal seawater was considered to be the major groundwater recharge in the areas where hyper-saline groundwater lenses are present. The tidal waters are infiltrated through the saline soils and bring significant salt load into the shallow groundwater. Rainfall recharge to the hyper-saline groundwater does not generally occur and the interaction of this groundwater with other aquifers (if present) may be a result of the leakage through the bore screens installed across the inferred confining beds underlying the hyper-saline groundwater. This leakage, however, is unlikely to be significant and no evidence of the direct connection between fresh groundwater lenses and hyper-saline groundwater lenses has been identified.

4.3 Mangrove Community Health, Sediments and Bio-Indicators

4.3.1 Monitoring Methodology

Monitoring of mangrove community health, sediments and bio-indicators was undertaken to assess potential impacts from the Site activities on mangrove communities surrounding the Site.

During the annual monitoring period, mangrove monitoring occurred at the locations identified on **Figure 4-11**.

As set out in EIMP (Rev 6), additional reference transects (CSMC03 and CSMC04) and GEP transects (BPMC27, BPMC28 and BPMC29) were established and monitored from March 2015 onwards. These locations were established on 30 and 31 March 2015 and initial baseline data were collected. Quarterly monitoring of these locations will commence from June 2015 onwards.

The two parameters used to monitor mangrove community health were canopy cover and tree condition. These were monitored on a quarterly basis. To complement the collection of this data, photographs were taken of mangroves within the monitoring plots from standard reference points.

To monitor for potential sedimentation and erosion effects, surveying of ground levels profiles (annually) through tidal flat and mangroves areas and the monitoring of relative sediment heights (quarterly) from within the monitoring plots using fixed marker stakes were used.

Within each mangrove monitoring plot, a sample of sediment from the surface was collected for metal and hydrocarbon analysis within an area of 1 x 1 m. Using a sterile wooden spatula, the sediment surface (top 1 to 5 cm) was scraped and the material directly transferred into a Whirlpak™ bag.

As per EIMP (Rev 0), bio-indicators are sampled on an annual basis. However, in response to elevated metal concentrations (in particular aluminium) detected in June 2014 – in comparison to previous years (AEMR [2013]; AEMR [2014]) – bio-indicators were sampled on a quarterly basis from September 2014 onwards.

High concentrations of metals and hydrocarbons are potentially toxic to benthic macro-fauna that live within the sediment or at the sediment-water interface (Clark, 2001). Additionally, many organisms that live in or on the sediment are known to accumulate metals and hydrocarbons in their tissue (bioaccumulation) which may cause a threat to human health if consumed. The measurement of metals and hydrocarbons in the tissue of organisms can therefore be used as an indicator for bioavailability of contaminants in the environment (Gay *et al*., 2003). For this particular assessment, a large snail, the mudwhelk (*Telescopium telescopium*), was selected as an indicator of bioaccumulation.

4.3.2 Results

The mangrove monitoring program was carried out in accordance with the requirements of EIMP (Rev 0). While exceedances of the trigger values in EIMP (Rev 0) were noted for some parameters, the monitoring results indicate that the majority of mangrove systems at Bladin Point are in a healthy condition and relatively undisturbed by Site activities. The data collected is broadly consistent with AEMR (2013) and AEMR (2014).

4.3.2.1 Mangrove Community Health

There were no exceedances of the 20% trigger value (i.e. a 20% decrease in canopy cover compared to June 2012 baseline data) at any transects during the annual monitoring period. In general, total canopy cover increased in comparison to the June 2012 results by around 10% in the assemblages present at each transect and decreased by around 5% during the annual monitoring period. Canopy cover data has been summarised in **Figure 4-12** by comparing mean canopy cover for the three mangrove assemblages monitored, namely:

- *Rhizophora* forest zone;
- *Ceriops* dominated tidal flat zone; and
- Hinterland margin zone.

Differences in canopy cover between the three assemblages reflected the range of mangrove community structures that occur. Typically the closed forests and woodlands that are found in the tidal creek *Rhizophora* and hinterland margin assemblage produce slightly higher canopy cover percentage cover values (80-90%) compared to the lower and more open (or lower canopy) tidal flat *Ceriops* which occupies much of the mid-upper tidal flat zone.

Tree health at BPMC06 [impacted by mud wave and water ponding issues as per the AEMR (2013) and AEMR (2014)] has improved, while BPMC07 has shown no change over the annual monitoring period. These results indicate that these sites may be stabilising and/or recovering and that the extent of mud wave development has not changed from that observed since the start of the annual monitoring period.

BPMC07 is located on the eastern side of the Flare Pad where some mangrove mortality (approximately 1.8 ha) occurred due to permanent ponding (AEMR, 2014). In October 2014, mangrove clearing and rock infill works commenced in the area marked as high risk due to prevailing ponding. Mangroves at BPMC03 and BPMC07 and fringing this core area are considered to be potentially at risk because they are highly stressed during the wet season as the area of ponding substantially expands after rains. Observations at BPMC03 and BPMC07 over December 2014 and March 2015 did not record any significant deterioration in mangrove tree health in these areas.

The results in this annual monitoring period are generally consistent with the June 2012 survey (AEMR [2013]) with the exception of BPMC06 and BPMC07. However, these sites are showing signs of stabilisation and are in a state of recovery. No distinctive reductions in mangrove community health were detected at the 23 BPMC transects in the annual monitoring period, indicating that Site activities have not compromised mangrove health adjacent to the Site. There were no distinct mangrove community health impacts attributable to Site activities.

Legend

- Site Boundary
- Gas Export Pipeline
- Mangrove Transects
- EIMP (Rev 6) New Mangrove Transects
- Mangrove Transects (Reference Sites)
- EIMP (Rev 6) New Mangrove Transects (Reference Sites)

Mangrove Monitoring Locations

Figure 4-11	INPEX Bladin Point	greencap AEC Environmental
Date: *9/07/2015*	**Author:** malcolm.nunn	
	Map Scale: 1:35,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\BP_EPA7_Report\2015\FIG_4_11_Mangroves_150612.mxd		

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Client Issue

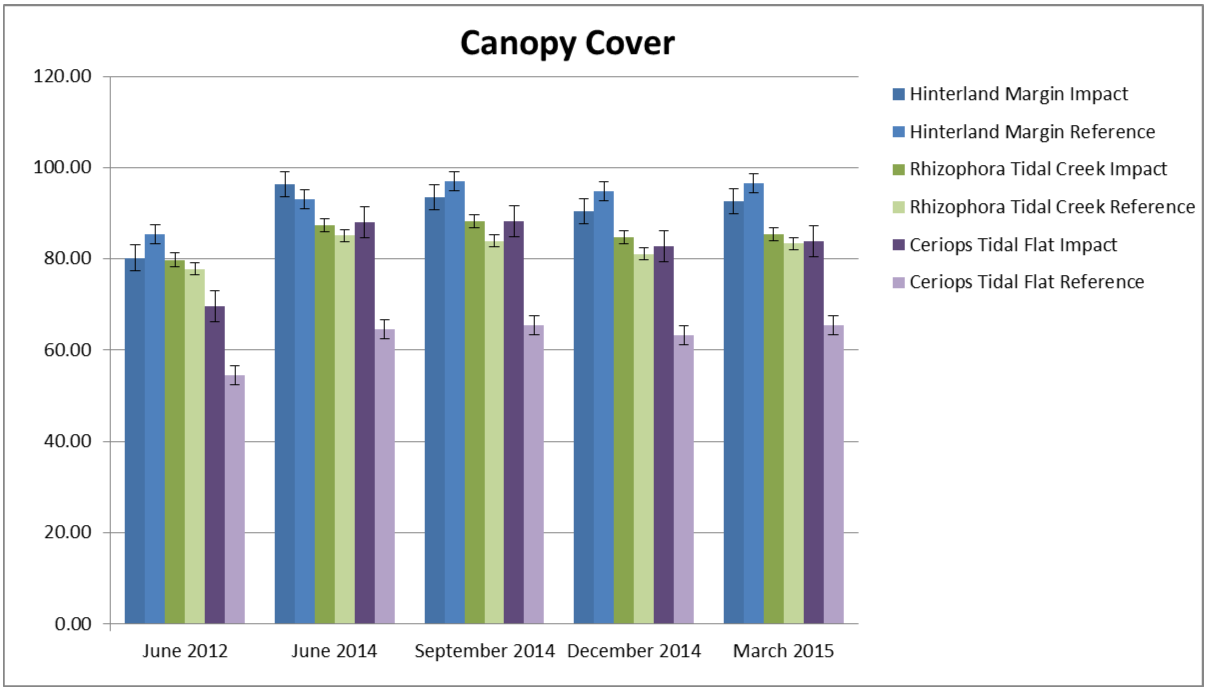

Figure 4-12 Canopy Cover (mean values) Summarised for each Mangrove Assemblage

4.3.2.2 Sediment Quality

Exceedances of total metals in sediments, recorded during this annual monitoring period, were below the ISQG high trigger values with the exception of total arsenic at two monitoring locations. After consideration of bio-availability, all of the exceedances dropped below the ISQG low trigger values. In accordance with the ANZECC Guidelines, these results were characterised as low risk and therefore no further action was required.

Total arsenic concentrations remained consistent with those reported in the AEMR (2013) and AEMR (2014) and background data collected in June 2012 at impact and reference sites, however an overall increase in elevated concentrations of total arsenic exceeding the trigger values was recorded, for reasons which remain unclear.

4.3.2.3 Sedimentation and Erosion

Sediment height data from the annual monitoring period indicated minor changes which were generally similar at impact sites and reference sites. No distinct trends were observed from the 23 monitoring locations surrounding the Site, indicating civil works within the area have not significantly contributed to elevated rates of sedimentation or erosion in mangrove forests. Consistent with the AEMR (2014), all notable changes in sediment height were caused by bioturbation by crabs and mud-lobsters and where significant ground level variation was recorded it was generally associated with known site conditions (e.g. a small mud wave and ponding). Although ground level variations of greater than 5 cm were recorded at ten survey points during the annual monitoring period this mud wave appears to have had no significant deleterious effect on the health of the mangroves, apart from BPMC06. However, tree condition findings indicate that this location is stabilising and/or recovering.

4.3.2.4 Bio-indicators

The bio-indicator data collected at 15 monitoring sites over the annual monitoring period were broadly consistent with background data collected in June 2012 (as reported in the AEMR [2013[). The exception was elevated arsenic concentrations detected at impact and reference sites, which may indicate a natural temporal/seasonal variation and/or a regional source. Potential sources of the increased total arsenic concentrations in impact and reference sites may be the mobilisation and distribution of fine sediments (e.g. dredging and surface water run-off) containing naturally-occurring high concentrations of total arsenic.

4.4 Air Quality (Dust)

4.4.1 Monitoring Methodology

The objective of the air quality (dust) monitoring program is to assess whether dust on Site is giving rise to exceedances of the approved trigger values at identified sensitive receptors.

The Project's dust monitoring program comprises the collection of particulate matter of 10 micrometres or less in size (PM_{10}) and particulate matter of 2.5 micrometres or less in size ($PM_{2.5}$) as well as dust deposition rates at the Site and the nearby City of Palmerston. The data are intended to inform Site activities so that impacts from dust on the environment and nearby sensitive receptors are minimised.

During the annual monitoring period, air quality monitoring occurred at the locations set out in **Figure 4-13**.

EIMP (Rev 0) allows for up to 16 dust deposition monitoring locations to be established and to date, 15 dust deposition locations (BPDD01 to BPDD14 and PADD01) have been installed. Sample bottles were retrieved from the dust deposition gauges on a monthly basis and submitted to the laboratory for analysis.

Five E-Samplers (BPPM01 to BPPM04 and PAPM01) have been installed. BPPM01, BPPM04 and PAPM01 monitor both $PM_{2.5}$ and PM_{10} whilst BPPM02 and BPPM03 solely monitor PM_{10}. As set out in the EIMP (Rev 6), monitoring at BPPM04 commenced from June 2014 onwards whilst all other monitoring locations were established prior to the commencement of this annual monitoring period.

4.4.2 Results

4.4.2.1 PM_{10} and $PM_{2.5}$

Analysis of dust roses for exceedances of the trigger values for 24-hour averaged dust levels indicated that there was no clear correlation between the dust levels recorded at the Site and the levels recorded at Palmerston (PAPM01). The dates of exceedances recorded at PAPM01 did not align with exceedance dates at the Site and the wind only rarely blew from the Site towards Palmerston.

Some correlation was identified between dust levels recorded at BPPM04 and BPPM03, indicating both dust monitors were impacted by the same dust source. However, as the wind rarely blew from the Site towards the Bladin Central Enterprise Park, it was unlikely that Site activities impacted on this sensitive receptor location.

4.4.2.2 Dust Deposition

The dust monitoring program implemented during the annual monitoring period was carried out to monitor the potential impacts from Site activities on the sensitive receptors at Palmerston and the Bladin Central Enterprise Park.

Two exceedances of the dust deposition trigger value were recorded at the Palmerston monitoring location during the annual monitoring period.

Dust deposition gauges in the Site provided data on potential impacts on the mangrove communities fringing the Site. The trigger value was exceeded at 13 out of 14 dust deposition gauges, however during mangrove monitoring surveys, no correlation between the presence of dust deposition on mangrove leaves and decline in mangrove community health was established.

Legend

- Site Boundary
- Gas Export Pipeline
- Dust Monitoring Location (Dust Deposition Sample)
- EIMP (Rev 6) New Dust Monitoring Location (Dust Deposition Sample)
- Dust Monitoring Location (Particulate Matter Sample)
- EIMP (Rev 6) New Dust Monitoring Location (Particulate Matter Sample)

Air Quality Monitoring Locations

Figure 4-13	INPEX Bladin Point	greencap AEC Environmental
Date: *9/07/2015*	**Author:** malcolm.nunn **Map Scale:** 1:40,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	

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4.5 Airborne Noise

4.5.1 Monitoring Methodology

The objective of the airborne noise monitoring program is to assess whether noise on Site is giving rise to exceedances of the adopted noise trigger values at identified sensitive receptors.

EIMP (Rev 0) requires that noise monitoring occurs at four locations, however, monitoring occurred at three locations during the annual monitoring period (BPAN01, BPAN02 and PAAN01) (**Figure 4-14**). It is considered that compliance at PAAN01 would demonstrate compliance at other nearby industrial receptors at East Arm (i.e. the proposed location for EAAN01) and therefore only three locations were required to determine potential noise impacts associated with Site activities. The existing noise monitoring network meets the intent of EIMP (Rev 0).

4.5.2 Results

The noise monitoring data collected during the annual monitoring period was consistent with the requirements of EIMP (Rev 0).

No noise complaints were received during the annual monitoring period.

It was concluded that the day-time and night-time exceedances recorded at PAAN01 were unrelated to Site activities. The exceedances were assessed with reference to available audio files and were confirmed to be related to aircraft noise, train noise, wildlife sounds and turf farm activities.

Assessment of available audio files collected from BPAN02 indicated that the majority of exceedances were caused by Site activities that took place within the Area 1888 Laydown Area. Noise attenuation monitoring was undertaken for piling which is a percussive blast and represents a worst case scenario for noise propagation from Site. The distance from BPAN02 to the Bladin Central Enterprise Park is 1.3 km. The noise attenuation curve developed as part of the noise attenuation investigation using hard ground shows that at a distance of 1.3 km from the noise source there is a reduction of 54 dB(A). Therefore, in order for there to be an exceedance of the trigger value at Bladin Central Enterprise Park there would need to be a noise level of 109 dB(A) in the day time and 99 dB(A) in the night time at the noise monitoring location (BPAN02). The data collected during the annual monitoring period indicated that there were no noise levels of this magnitude at BPAN02.

Noise levels at BPAN01 remained relatively consistent over the annual monitoring period and ranged from 43.6 to 68.7 dB(A) during the day and 46.4 to 67.2 dB(A) during the night.

4.6 Flora and Fauna

The flora and fauna monitoring data collected during the annual monitoring period was consistent with the requirements of EIMP (Rev 0).

All vegetation clearance has now been completed up to the approved clearing limit, including clearing associated with the GEP. If further clearing is required on Site, the clearance will be assessed against the clearance permit and the results reported in the next AEMR.

A series of bird deaths (approximately 64 birds) between May and July 2014 in the Area 8 and 13 basin areas triggered a bird mortality investigation, which included sediments, water, autopsies, liver toxin and pesticide screening. The findings of this investigation indicated no common cause of mortality. The most common cause of death was physical trauma, indicative of predation. It was concluded that the bird deaths were not related to Site activities. In the Northern Territory, most water birds undertaken significant population shifts in response to dramatic seasonal changes. This means that it was highly likely the affected birds were attracted to the water habitats in the basins and the cause of death originated from an offsite area. Water management practices were adapted to minimise standing water within the Site.

Otherwise, faunal injury or deaths on Site were rare and were not attributed to Site activities thus achieving the objective of the flora and fauna monitoring program. Where required, fauna species such as snakes and birds were relocated away from Site activities to avoid injuries.

Legend

- Site Boundary
- Gas Export Pipeline
- Noise Monitoring Location
- EIMP (Rev 6) New Noise Monitoring Location

Noise Monitoring Locations		
Figure 4-14	INPEX Bladin Point	greencap AEC Environmental
Date: 9/07/2015	**Author:** malcolm.nunn	
	Map Scale: 1:40,000	
Revision: C	**Coordinate System:** GDA 1994 MGA Zone 52	
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4.7 Weeds

The weed monitoring data collected during the annual monitoring period were consistent with the requirements of EIMP (Rev 0).

Weed survey reports identified that weed occurrence was centred around the Extractive Materials Area. Five new weed species were recorded during the annual monitoring period compared to results recorded during the pre-construction stage of the Project, but these weed species commonly occur in the Darwin region. Although these new species were recorded on Site, there has been an overall reduction in the number of observed weed species since the commencement of weed monitoring at the Site.

The significant weed species with the highest recorded abundance in this annual monitoring period were Gamba Grass (a Weed of National Significance), Annual Mission Grass, Perennial Mission Grass and Horehound. These species were identified as the most abundant species in the AEMR (2014) indicating the relative abundance of weed species remained unchanged.

Project control measures have been effective in restricting the weed re-growth to within the Site boundaries and overall, results have shown that since commencement of monitoring in 2012, there has been in a significant reduction in the number of weeds species recorded. As the remainder of the Site has either been cleared or cleared and sealed, it is considered that the potential for further weed reoccurrences is low.

5. RISK ASSESSMENT

The risk assessment used in this AEMR is aligned with the environmental risk identification and assessment process in CEMP and draws from the Environmental Risk Register (dated 15 April 2015; L290-AH-REP-10539). The Risk Register is a collation of the Projects risks generated from the various Environmental Risk Assessments (ENVIDs) that have been undertaken.

As part of the interpretation and analysis of the monitoring results, a qualitative assessment against the key identified construction risk pathways for the monitoring program was carried out. This included comparison of the results and discussion to identify if any of the contaminant pathways were complete and potential impacts visible in the monitoring data collected during the annual monitoring period.

Furthermore, the risk assessment provides recommended solutions and/or changes to the monitoring program to align with the monitoring program objectives. Where improvements were deemed necessary, justification was provided for the amended monitoring elements. This included an assessment of the locations, number of sampling points and methodologies to improve data quality and consistency to achieve the objectives of the monitoring program.

The data collected was also used to inform other management plans and tools including the CEMP and the Environmental Risk Register to mitigate the major risks posed by construction activities. The risk assessment in this AEMR has been updated to reflect Project staging and emerging risks as identified from updates to the Risk Register and monitoring data collected.

It is noted that in the AEMR (2014), a beneficial use assessment was undertaken which confirmed that the only applicable beneficial use for groundwater at the Site was for environmental purposes. Other uses not applicable to the Site include agriculture, public water supply, rural stock and domestic supply.

This section addresses the protection of the environmental aspects identified in EIMP (Rev 0) and risk framework defined in the EIS.

5.1 National Environmental Protection Measure Requirement

In accordance with the NEPM (2013), environment risk assessment is based on identifying plausible source-pathway-receptor linkages and then assessing the magnitude of the risk of an adverse effect. If there is no linkage between a source and a receptor (i.e. no pathway), then there is no inherent risk.

The estimate of risk used in this AEMR is qualitative (e.g. low, moderate, high and critical) and is based on the potential for exposure (likelihood) and the potential magnitude of environmental impacts (consequences) which results in changes in the risk profile.

This risk assessment makes a qualitative assessment of risk via comparison with environmental criteria for potential source-pathway-receptor linkages and then evaluates the completeness of the pathways based on the finding of the monitoring undertaken during this period. The criteria are derived from various Project-related regulatory documents including the CEMP and EIMP (Rev 0). The best application of these criteria for beneficial use is specific to surface water and groundwater, as opposed to other environmental parameters considered in accordance with the Darwin Harbour WQOs. However the groundwater and surface water beneficial use criteria apply to the broader environment including ecotoxicology, flora and fauna protection, commercial use relating to primary and secondary use of waters and agricultural purposes for marine and surface activities (DLRM, 2010a; DLRM, 2010b).

5.2 Surface Water Monitoring Program

5.2.1 Qualitative Risk Assessment

5.2.1.1 Sediment Transport

The sediment objective for the EIMP (Rev 0) surface water monitoring program was to minimise transport of sediment into the immediate surroundings including adjacent land, intertidal areas and receiving surface water bodies.

A number of environmental events relating to sedimentation transport and associated controls were recorded. These events involved the release of sediment to the receiving environment via some occurrences of incomplete sedimentation controls, poor haul road condition and damaged bunds. The Project received a direction notice from the NT EPA (Letter EN2011/0234-01-055 dated 10 October 2014) that raised concerns about deficiencies in the erosion and sedimentation control measures on Site. Following this direction, the Project produced fortnightly reports (compiled by a Certified Professional in Erosion and Sediment Control) until 30 April 2015, which outlined and monitored the improvement measures that were put in place to address the erosion and sedimentation issues.

Results of mangrove community and sediment monitoring indicated that stormwater and construction water discharged from the Site did not result in any sedimentation accumulation, or erosion and did not have any appreciable impact on mangroves fringing the Site. Therefore, the risk ranking remained low and the monitoring program objectives were achieved.

5.2.1.2 Acid Sulfate Soils and Surface Water Contamination

The ASS objectives for the EIMP (Rev 0) surface water monitoring program were to:

- To minimise changes in surface water quality resulting from the disturbance or dewatering of ASS; and
- To minimise the discharge of water contaminated with nutrients, hydrocarbons or other contaminants off site.

In accordance with the ANZECC Guidelines, the collection and analysis of 24 consecutive months of monitoring data is required before seasonality can be assessed. This required a suitably robust dataset, which was completed in June 2014.

With the exception of one event, all spill events on Site were limited in scale, rapidly cleaned up and impacts were not detected in either the surface or groundwater monitoring programs. It was therefore concluded that the potential for on-and-offsite contamination remained low.

Any groundwater encountered in excavations was treated and tested to ensure it complied with permit conditions prior to discharge. All excavated ASS were treated within treatment pads. The treatment pads were constructed and operated in accordance with QASSIT (1998) guidelines and possessed impermeable leachate collection sumps. Therefore, no ASS-impacted waters were released into the drainage system on Site or discharged into Darwin Harbour.

Surface water monitoring assessment of pH, ORP and alkalinity correlations indicated that no changes to the geochemistry associated with ASS impacts was evident. Further, the majority of surface water monitoring locations did not exceed the adopted trigger values for metals and metalloids during the 2014/2015 monitoring period. For those events where metals exceedances occurred, a qualitative assessment was performed. All assessments demonstrated that Site activities were unlikely to be the source of these elevated metals concentrations. Following review of the data and isopleths, there did not appear to be any spatial patterns or trends indicating impacts on surface water metals from Site activities.

Nutrient exceedances at impact sites typically coincided with exceedances at the reference sites and were not correlated with distance from the Site discharge points. Exceedances at both monitoring and reference sites were generally in accordance with the commencement with seasonal fluctuations associated with the onset of the wet season. As reference and offsite marine monitoring locations were correlated, this suggested that increases in nutrient concentrations were not attributable to Site activities.

The risk ranking as detailed in the CEMP and Environmental Risk Register remains moderate for ASS treatment and contamination associated with spills and leaks, and any effects on the surrounding environment were localised and minor. It was considered that the intent of the monitoring program objectives pertaining to ASS, contamination and nutrients in surface water was achieved and no net effect from Site activities was evident.

5.2.2 Recommended Improvements

It is recommended that chlorine is reconsidered as an analyte to be monitored or a further investigation is conducted into the detections currently occurring around the Site. These recommendations are made because there is no current methodology that can detect chlorine accurately to the trigger value of 3 µg/L and there are no sources of chlorine on Site, despite the detections reported in this AEMR.

There are no other recommended improvements to the surface water monitoring program in addition to those already documented in EIMP (Rev 6), which has been approved by the NT EPA, or as detailed in **Section 6**.

5.3 Groundwater Monitoring Program

5.3.1 Qualitative Risk Assessment

5.3.1.1 Groundwater Levels and Quality

The groundwater height objective for the EIMP (Rev 0) groundwater monitoring program was to assess changes in groundwater levels and/or quality resulting from construction activities.

Groundwater level fluctuations in bores located in the centre of the Site were attributed to seasonal rainfall trends and recharge of bores located adjacent the perimeter of the Site were influenced by tidal variations.

To assess groundwater quality, the ANZECC Guidelines stipulate that the collection and analysis of at least 24 consecutive months of monitoring data is required before seasonality can be assessed. This required the establishment of a suitably robust dataset which was completed in June 2014. The influence of seasonality has been included in EIMP (Rev 6) which has been approved by the NT EPA.

The results of groundwater monitoring conducted confirmed historical seasonal trends and indicated that the groundwater beneath the Site contains elevated metal concentrations resulting from natural processes involving groundwater interaction with acidic soils known to contain acid-extractable metals. The trend analysis confirmed the presence of metals in groundwater which showed seasonal variation dependent on rainfall events and subsequent aquifer recharge. No point source/s were identified on Site that could be attributed to elevated metal concentrations associated with the effects of ASS or Site activities.

With the exception of one event, the majority of the onsite spills were limited in scale, routinely and rapidly cleaned up and were not detected in the groundwater monitoring program. They were therefore concluded to have a low risk to onsite and offsite ecosystems. The one larger hydrocarbon spill event was detected in surrounding bores, but was below trigger values and it was concluded that, due to limited groundwater movement and natural attenuation, there was a low risk to all ecosystems on and off site.

The risk ranking has remained moderate for concentrations of metals in soils and groundwater and any effects observed on the surrounding environment during the annual monitoring period were localised and minor.

5.3.1.2 Mangrove Community Impacts

The mangrove objective for the EIMP (Rev 0) groundwater monitoring program was to minimise disturbance to and alteration of mangrove communities as a result of changes to groundwater levels or quality arising from construction activities.

No impacts on groundwater from ASS or spills were observed. The mangrove systems adjacent to the Site were in a healthy condition and relatively undisturbed by Site activities. The data collected were broadly consistent with data collected in June 2012, the AEMR (2013) and the AEMR (2014).

The risk ranking remained moderate for ASS impacts to groundwater and any effects on the surrounding mangrove environment were localised and minor. It was considered that the intent of the monitoring program objectives pertaining to levels, quality and mangrove health from groundwater was achieved.

5.3.2 Recommended Improvements

There were no recommended improvements to the groundwater monitoring program in addition to those already documented in EIMP (Rev 6), which has been approved by the NT EPA or as detailed in **Section 6**.

5.4 Mangrove, Sediments and Bio-indicator Monitoring Program

5.4.1 Qualitative Risk Assessment

5.4.1.1 Sediment Accumulation and Quality

Survey results of sediment accumulation indicated minimal annual mean increases or decreases (more than 50 mm) with no net deleterious effect. Veneers were observed at some transects, consisted of fine material washed downslope from the edge of the Site and generally appeared as orange-brown sediment over the underlying grey/brown mangrove muds between 1 and 5 mm thick.

The data collected were consistent with that collected in June 2012, in the AEMR (2013) and AEMR (2014). It was also noted that the majority of mangrove systems adjacent to the Site remained in a healthy condition and relatively undisturbed by Site activities. The risk ranking for sedimentation of mangrove areas fringing the Site remained low and the intent of the monitoring program objectives was achieved.

Any surface water releases showed no signs of erosion or sedimentation and observations at points of discharge and indicated no impacts to mangrove ecosystems surrounding the Site. It was therefore concluded that the risk remained low.

The results of sediment quality analysis indicated that, after consideration of bio-availability, all metal exceedances were below the ISQG low trigger values. In accordance with the ANZECC Guidelines, these results were characterised as low risk and therefore no further action was required. Similarly bio-indicator tissue metal concentrations in mudwhelks did not exceed adopted trigger values other than minor exceedances for arsenic, copper and mercury and were within the range of background concentrations. The risk ranking for ASS metal mobilisation from sediments remained moderate and the intent of the monitoring program objectives was achieved.

5.4.1.2 Mangrove Impact

The results of the mangrove monitoring program showed that the majority of mangrove trees were healthy at all transects and the trigger value for tree condition was not exceeded at 22 out of 23 onsite transects. Trends in canopy cover at impact monitoring locations were generally consistent with the dry and wet season trends observed at the reference sites.

The risk ranking for loss of mangrove habitat and loss of biodiversity around the Site remained moderate and the intent of the monitoring program objectives was achieved.

5.4.2 Recommended Improvements

There were no recommended improvements to the mangrove community health, sediments and bio-indicators monitoring program in addition to those already documented in EIMP (Rev 6), which has been approved by the NT EPA or as detailed in **Section 6**.

5.5 Air Quality (Dust) Monitoring Program

5.5.1 Qualitative Risk Assessment

5.5.1.1 Dust Impacts on the Environment and Workforce

The prevailing wind directions were easterly to south-easterly during the dry season and westerly to south-westerly during the wet. Palmerston is located to the north-east of the Site, therefore dust migration from the Site towards Palmerston would primarily occur during periods of south-westerly winds (the impact pathway). Similarly, Bladin Central Enterprise Park is located to the south of the Site and dust could migrate towards this location during periods of northerly winds (the impact pathway).

South-westerly and northerly winds were relatively uncommon in the dry season and rainfall reduced airborne dust levels in the wet season (when the impact pathway winds were more common), hence the monitoring program recorded limited dust migration towards Palmerston and Bladin Central Enterprise Park.

Suspension and transport of dust particles are affected by wind velocity, with greater wind speeds often resulting in greater transport distances. The relatively low speeds observed along each impact pathway specified above minimised the potential for dust particles to be transported from the Site to Palmerston and Bladin Point Enterprise Park. The monitoring location at Palmerston recorded two exceedances of the dust deposition trigger value during the annual monitoring period.

The dust deposition gauges on Site provided data on potential impacts on the mangrove community fringing the Site. While the trigger value was exceeded at most gauges, during mangrove monitoring surveys, no correlation between the presence of dust deposition on mangrove leaves and decline in mangrove community health could be established. Data demonstrated that the decline in tree condition at BPMC05 and BPMC07 was attributable to other environmental factors (e.g. a mud wave).

The risk ranking remained low for nuisance and health impacts (of dust on nearby sensitive receptors) and deposition on surrounding vegetation resulting in smothering and reduced growth. The intent of the dust monitoring program objectives was therefore achieved.

5.5.2 Recommended Improvements

There were no recommended improvements to the air quality monitoring program in addition to those already documented in EIMP (Rev 6), which has been approved by the NT EPA or as detailed in **Section 6**.

5.6 Airborne Noise Monitoring Program

5.6.1 Qualitative Risk Assessment

5.6.1.1 Noise Impacts to Local Community

The comparison of Site activities with work timings, noise monitoring results and analysis of audio files confirmed that local noise sources (e.g. animal sounds, vehicles, aircraft) were the most common sources of noise exceedances at Palmerston and Bladin Central Enterprise Park. It was noted that during the Christmas to New Year period, when limited Site activities occurred, noise levels decreased at the onsite monitors. However, noise exceedances continued at Palmerston over this time suggesting that noise levels at Palmerston were more influenced by local noise sources than Site activities. No complaints were received during the annual monitoring period.

The risk ranking for nuisance and health impacts associated with noise remained low and the intent of the monitoring program objectives was therefore achieved.

5.6.2 Recommended Improvements

There were no recommended improvements to the airborne noise monitoring program in addition to those already documented in EIMP (Rev 6), which has been approved by the NT EPA or as detailed in **Section 6**.

5.7 Flora and Fauna Monitoring Program

5.7.1 Qualitative Risk Assessment

5.7.1.1 Flora and Fauna Clearance

All vegetation clearance was completed within the approved clearing limit.

A series of bird mortalities were recorded across the wider Site. However, the outcomes of the investigation found no common cause of mortalities. It was concluded that the avian mortality events were caused by a variety of factors including; vehicle strikes, disease and natural attrition. The risk ranking related to fauna and flora impacts remains moderate and any effects on the surrounding environment have been localised and minor.

5.7.2 Recommended Improvements

There were no recommended improvements to the flora and fauna monitoring program in addition to those already documented in EIMP (Rev 6), which has been approved by the NT EPA or as detailed in **Section 6**.

5.8 Weed Monitoring Program

5.8.1 Qualitative Risk Assessment

5.8.1.1 Weed Management

Weed surveys confirmed that the occurrence of weeds was centred around the EMA while the remainder of the Site had either been cleared or was scheduled to be cleared and sealed, indicating that the potential for future weed reoccurrences are low. The results indicated that the spread of weeds across the Site had not increased, with the exception of a single plant of Barnyard Grass found at surface water basin A13-3. Survey results demonstrated that since weed monitoring commenced on Site, there has been a significant reduction in the number of weeds species recorded over time.

Project control measures appear to have been effective in restricting the weed regrowth to within the Site boundaries. Therefore, the risk ranking remains moderate, as any effects on the surrounding environment were localised and minor.

5.8.2 Recommended Improvements

There were no recommended improvements to the weed monitoring program in addition to those already documented in EIMP (Rev 6), which has been approved by the NT EPA or as detailed in **Section 6**.

6. SUGGESTED IMPROVEMENTS TO THE MONITORING PROGRAM

Based on the projected completion of construction activities within each discrete area, there is the potential for optimisation of the monitoring network. For example, once ground disturbing activities are completed within a discrete area, the risk of ASS mobilisation will be low and consideration may be made for amending the requirement for groundwater data loggers to be in place. Monthly sampling data would be sufficient for assessment of potential impacts going forward. The changes will be made within the next revision of the EIMP which is scheduled for September 2015.

The recommended improvements adopted within EIMP (Rev 6) are summarised below.

Surface Water

- Establish two additional reference sites (CSSW03 and CSSW04) and two GEP surface water monitoring sites (BPSW34 and 35), located in tidal creeks to the east and west of the Site;
- Change the surface water monitoring methodology from static monitoring at four sites to continuous monitoring at eight marine buoy sites;
- Reduce the number of terrestrial monitoring locations;
- Introduce auto samplers in the discharge drop structures and receiving environment to allow for assessment of water quality overflowing the surface water basins during above design rainfall events;
- Review and refine selected trigger values (e.g. DO) in the surface water monitoring program;
- Incorporate seasonality effects in surface water using a statistical analysis approach; and
- Adopt appropriate Australian Standards for surface water sampling e.g. marine water monitoring to replace freshwater sampling methodology.

Groundwater

- Change the monitoring of groundwater quality from weekly in-situ monitoring of selected bores to continuous monitoring of all bores;
- Remove turbidity from the analyses suite for continuous/weekly monitoring and only monitor on a monthly basis;
- Review and refine selected trigger values (e.g. benzene) in the groundwater monitoring program;
- Incorporate seasonality effects in groundwater using a statistical analysis approach;
- Adopt appropriate Australian Standards for groundwater sampling; and
- Review and refine the groundwater monitoring network.

Mangroves

- Remove six transects from the monitoring program taking the total number of monitoring transects from 23 to 17;
- Add two reference transects, CSMC03 and CSMC04, to the monitoring program taking the total number of reference transects from two to four;
- Restructure transects for sedimentation and bio-indicator monitoring;
- Increase the frequency of bio-indicator monitoring from annual to bi-annual sampling; and
- Refine data collection methods to ensure protection of potential high impact mangrove assemblages.

Air Quality (Dust)

- Review and refinement of dust monitoring network (e.g. add BPPM04).

Noise

- Review and refinement of noise monitoring network (e.g. add BPAN02).

EIMP (Rev 6) has been approved by the NT EPA and will be implemented during the 2015/16 annual monitoring period.

As a result of analysing the monitoring data collected during the annual monitoring period and undertaking the risk assessment in **Chapter 5**, the following improvements could be considered for future revisions of EIMP (Rev 6):

- Further refinement of selected trigger values e.g. aluminium and manganese to align with recent Australian research; and
- Chlorine be either reconsidered as an analyte to be monitored or an investigation be made into the detections currently made around the Site. This suggestion is made for two primary reasons. Firstly there is no current methodology that can detect chlorine accurately to the trigger value of 3 µg/L and secondly, it is believed that there are no sources of chlorine on Site, despite the detections reported in this AEMR.

7. CONCLUSION

In conclusion, the intent of EIMP (Rev 0) was satisfactorily implemented during the annual monitoring period, providing a clear understanding of the Site risks and the Project's potential impacts on the adjacent receiving environment and broader Darwin Harbour. While there were exceedances across some parameters, none of them represented any net deleterious effects on the receiving environment.

There are a number of adaptive management strategies (detailed in AEMR [2015]), that could be implemented to provide further information for the management of emerging construction risks and to mitigate against potentially significant non-compliant metalliferous and pH-related groundwater and surface water events that may have an acute or long-term effect on the receiving environment.

8. REFERENCES

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