| | |
|---|---|
| Subcontractor's name | **Greencap-NAA Pty Ltd** |
| Subcontract No. | **0 - 6037- P- 3365-SC119** |
| | |
| Subcontract Package Name: | **ENVIRONMENTAL IMPACT MONITORING PROGRAM** |

| | |
|---|---|
| DOCUMENT TITLE: | EPA7 ANNUAL REPORT 2016 - ENVIRONMENTAL IMPACT MONITORING PROGRAM |
| Subcontractor's Doc. No.: | **AEC47** |

**ICHTHYS ONSHORE LNG FACILITIES**

JKC
JKC AUSTRALIA LNG PTY LTD

INPEX

Darwin, Australia

| | |
|---|---|
| Subcontractor ISSUE PURPOSE | ☐ FA ☐FR ☐FI X FC ☐AB ☐CA |
| CTR RESULT CODE | ☐A ☐B ☐N ☐F |
| NEXT STATUS : | ☐FA ☐FR ☐FI ☐FC ☐AB ☐NA |
| Subcontractor RESUB / NEXTSUB DATE : | |
| Approval or review hereunder shall not be construed to relieve Vendor / Subcontractor of his responsibilities and liability under the Contract. | |

| CTR ORGANIZATION | DEPT. NAME | SIGNATURE |
|---|---|---|
| PJ DEPT. | | |
| RESPONSIBLE DEPT. | | |
| RELATED DEPT. | | |

DOC-EIMP
Code A Approved.
A.Black
28/07/16

| | | | |
|---|---|---|---|
| CTR REVIEW DATE : | | | |
| JOB. NO. | 0-6037-2 | REVIEW CLASS | 1 |

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| CPY DOC.no. | L 290 - AH - REP - 10263 | 0 |
| | Subcontract No. - SERIAL no.. | |
| CTR DOC.no. | V - 3365 - SC119 - 8047 | |

# EPA7 Annual Report 2016
# Environmental Impact Monitoring Program

## Ichthys On-Shore LNG Facilities

## Bladin Point

Prepared for:
**JKC Australia LNG Pty Ltd**

Date: 27th July 2016

Prepared by:

GREENCAP

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## EPA7 Annual Report 2016 – Environmental Impact Monitoring Program

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## GREENCAP DOCUMENT CONTROL

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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 |
| 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 (refers to Ichthys Onshore LNG Facilities CEMP, Rev 12 and Rev 17) |
| 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 | Environmental Impact Monitoring Program (Rev 6) |
| EIS | Environmental Impact Statement |
| EMA | Extractive Materials Area |
| EPA7 | Environment Protection Approval 7-3 |

| 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 |

| Abbreviation | Description |
|---|---|
| MS | Matrix spikes |
| 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 |
| 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 |
| Site | The boundary of Contractor's scope of work as defined in Figure 1.3.1 of CEMP (Rev 17). |
| $SO_4$ | Sulfate |
| SWL | Standing water level |
| TARP | Trigger Action Response Plan |
| TOF | Temporary Office Facilities |
| TDS | Total Dissolved Solids |
| TPH | Total Petroleum Hydrocarbons |
| TPWC Act | *Territory Parks and Wildlife Conservation Act* (NT) |
| TRH | Total Recoverable Hydrocarbons |
| TSS | Total Suspended Solids |

| Abbreviation | Description |
|---|---|
| µg | Microgram |
| µm | Micrometres |
| µs | Microsiemens |
| U.S. EPA | United States Environmental Protection Agency |
| 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 (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:

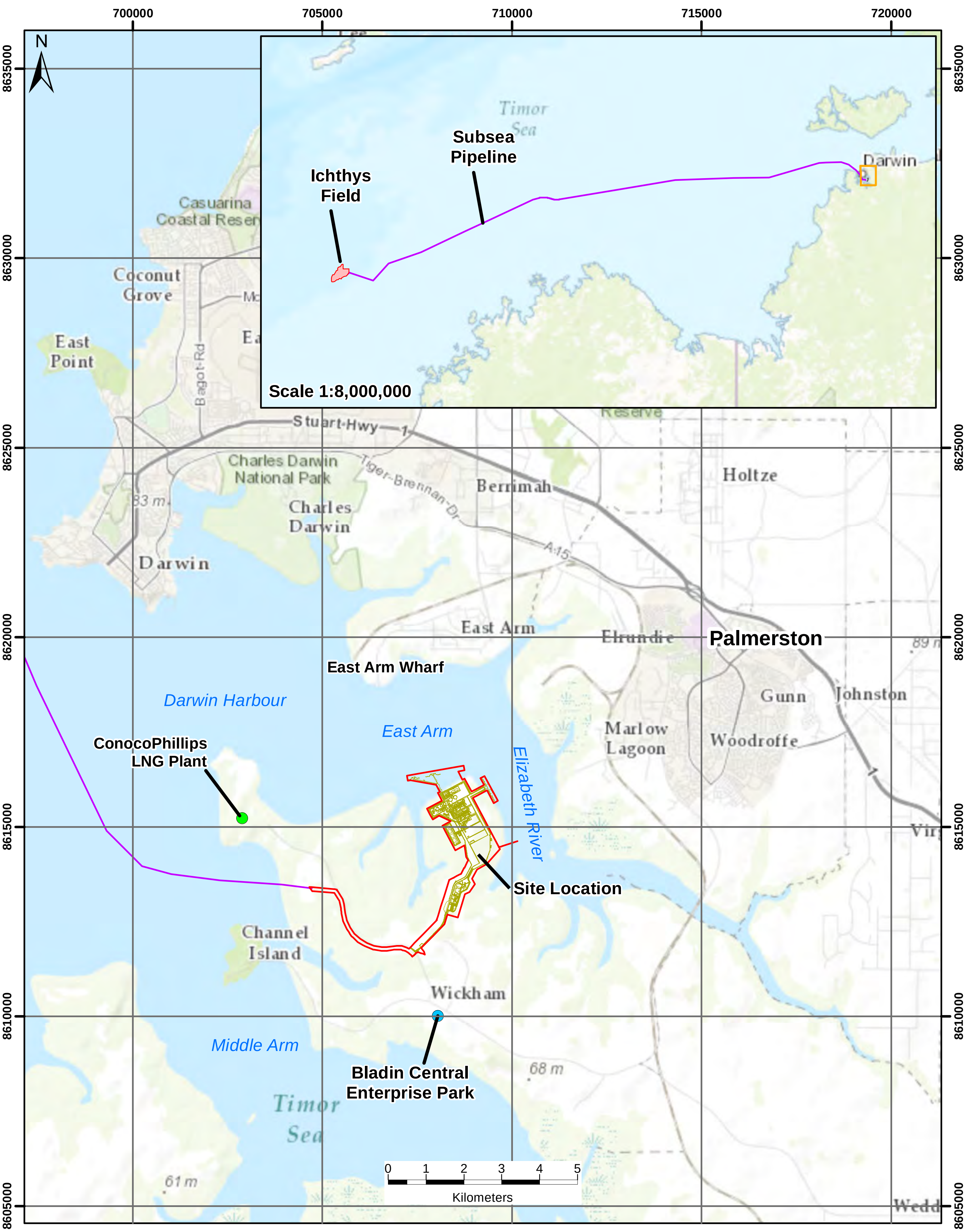
- Ichthys Onshore Liquefied Natural Gas (LNG) Facilities and its supporting infrastructure at Bladin Point; and
- Manigurr-ma Village at Howard Springs.

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), extractive materials area (EMA), module offloading facility (MOF) and the Gas Export Pipeline (GEP) terminating at the beach valve enclosure but excludes the Manigurr-ma Village or offshore infrastructure (see **Figure 1-2**).

This document is the *EPA7 Annual Report 2016 – Environmental Impact Monitoring Program* (EPA7 Report [2016]), that reflects the environmental monitoring carried out from 1 May 2015 to 30 April 2016 (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.




## 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 |
| *Date: 26/05/2016* | Author: malcolm.nunn | |
| | Map Scale: 1:130,000 | |
| Revision: A | Coordinate System: GDA 1994 MGA Zone 52 | |
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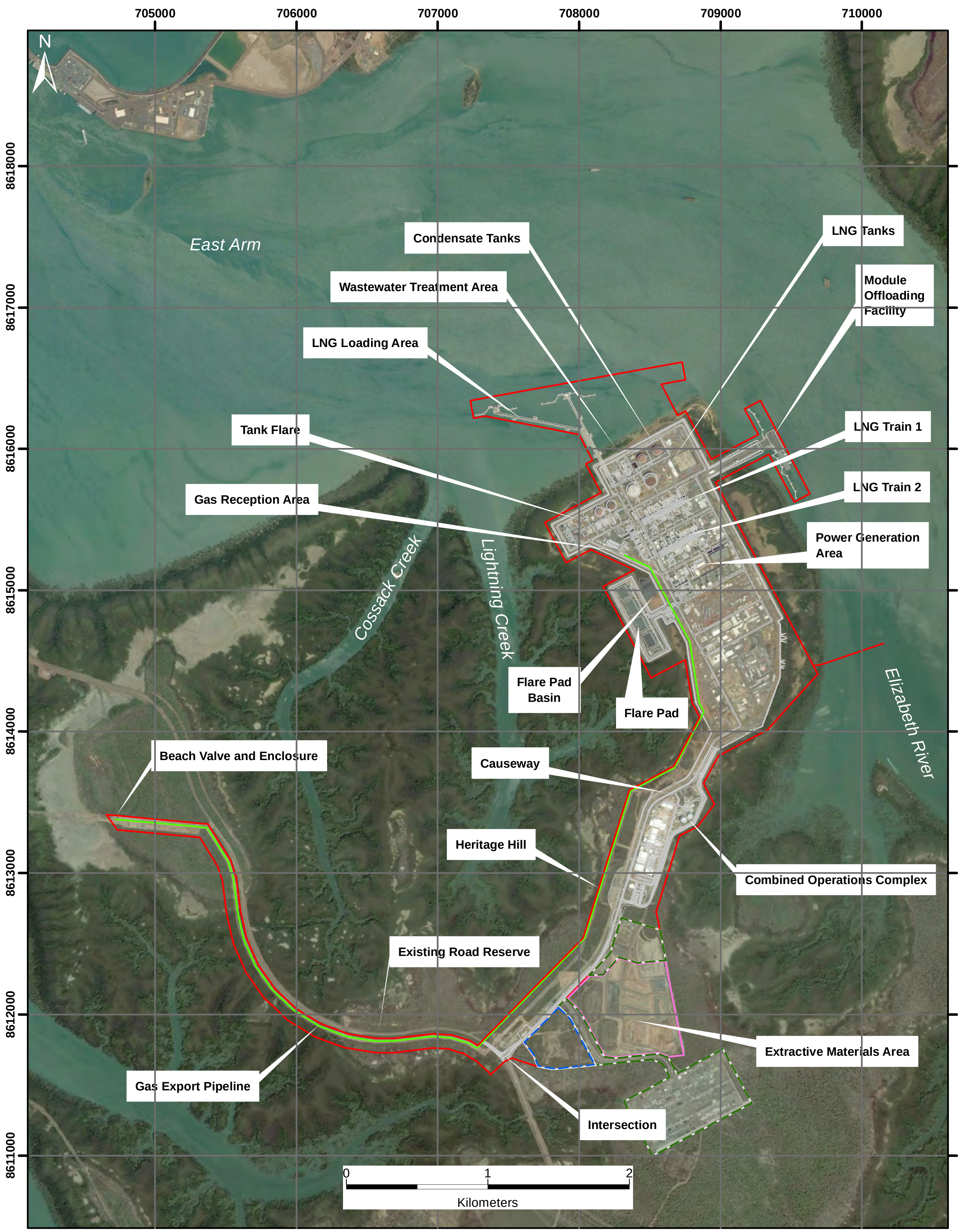



Site Boundary
EMA Boundary
Section 1888 Boundary
Section 1897 Boundary
Construction Footprint
Gas Export Pipeline



| **Bladin Point Site** | | |
|---|---|---|
| **Figure 1-2** | **INPEX Bladin Point** | GREENCAP |
| ***Date:*** *27/07/2016* | **Author:** malcolm.nunn<br>**Map Scale:** 1:35,000 | |
| **Revision:** A | **Coordinate System:** GDA 1994 MGA Zone 52 | |
| R:_Projects\C110043_Inpex\GIS\Maps\BP_EPA7_Report\2016\FIG_1_02_SiteFootprint_160727b.mxd | | |

# 2. ENVIRONMENTAL STRATEGY

## 2.1 Construction Environmental Management Plan

The *Ichthys Onshore LNG Facilities Construction Environmental Management Plan* (L290-AH-PLN-0059, Rev 12 and Rev 17) (JKC Australia LNG Pty Ltd, 2015) (hereafter referred to as the CEMP) was developed for the onshore LNG facilities at Bladin Point, in accordance with the requirements of the Environment Protection Approval (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.

## 2.2 Environmental Impact Monitoring Program

An *Environmental Impact Monitoring Program* (L290-AH-PLN-10013) (AEC Environmental Pty Ltd, 2014) (hereafter referred to as the EIMP) was prepared for the Project. The EIMP was prepared to meet the requirements of Condition 22 of EPA7 and was approved by the Northern Territory Environment Protection Authority (NT EPA) on 2 April 2015 and implemented from 1 May 2015. The document establishes the monitoring framework for the detection of potential impacts associated with the construction of the Project.

The monitoring programs for the following aspects were undertaken as part of the EIMP:

- Surface water monitoring;
- Groundwater quality monitoring;
- Mangrove community health, sediments and bio-indicator monitoring;
- Dust monitoring;
- Airborne noise monitoring; and
- Weed monitoring.

In addition to the results of the monitoring programs listed above, acid sulphate soils (ASS) monitoring results and flora and fauna reporting were also included in the AEMR.

In December 2015, the CEMP was approved and implemented, and was inclusive of the trigger values modified in the EIMP.

**Table 2-1** summarises the aims and objectives of each monitoring strategy.

### Table 2-1 CEMP Objectives and Targets Relevant to the EIMP

| Management Strategy | Objectives | Performance Criteria |
|---|---|---|
| Surface Water Management | To protect surface water quality from Project-related activities | No detectable changes in surface water quality in the receiving environment above relevant water quality parameters listed in Table 6.4.4 and Table 6.4.5 of CEMP (Rev 17) and in excess of 10% of concurrently measured background concentrations (defined as the 80$^{th}$ percentile of the reference site database).<br>Stormwater runoff actively discharged (within the design rainfall specification) from a controlled sediment basin does not exceed the water quality criteria listed in Table 6.4.4 of CEMP (Rev 17).<br>Construction water discharged from Site does not exceed the water quality criteria listed in Table 6.4.4 and Table 6.4.5 of CEMP (Rev 17) and other relevant parameters. |
| Groundwater Management | To minimise changes in groundwater levels and/or quality resulting from construction activities | No statistically significant trend showing a deterioration of groundwater levels outside of historical background seasonal fluctuations and that is attributable to construction activities.<br>No statistically significant trend showing a deterioration of groundwater quality listed in Table 6.7.3 of CEMP (Rev 17) and in excess of 10% of seasonal background concentrations and no plume trend that is attributable to construction activities. |
| ASS Management | To minimise the impacts of ASS resulting from construction activities on sediments and bio-indicators | Zero incidents of exceedances in the intertidal sediment quality criteria listed in Table 6.6.1 of CEMP (Rev 17) attributed to Project activities.<br>Zero incidents of exceedances in the bio-availability of heavy metals in bio-indicators criteria in Table 6.6.2 attributed to Project activities. |
| Erosion and Sedimentation Management | To minimise transport of sediment from the Site into immediate surroundings including adjacent land, intertidal areas and receiving surface waters | Stormwater actively discharged from a controlled sediment basin to receiving waters complies with the water quality criteria listed in Table 6.4.4 of CEMP (Rev 17). |
| Dust and Air Quality Management | To minimise impacts of dust generation on the nearby receptors (mangroves and adjacent communities) during construction | No significant visible dust attributable to the Project outside the Site.<br>Compliance with the air quality criteria listed in Table 6.10.3 of CEMP (Rev 17).<br>No deterioration of greater than 30% in mangrove community health.<br>No increase beyond 5 cm in ground level, averaged over 1 $m^2$ and a 12 month period attributed to sediment (veneer deposition in comparison to reference sites). |
| Noise and Vibration Management | To minimise the impacts of construction noise and vibration on local communities (nearest sensitive receptors). | No environmental nuisance infringements as a result of construction activities.<br>No exceedance of the noise limits defined in Table 6.11.1 of CEMP (Rev 17) which correlate with noise complaints. |

| Management Strategy | Objectives | Performance Criteria |
|---|---|---|
| Flora and Fauna Management | To minimise disturbance to flora and alteration of mangrove communities outside the Site boundary due to Site activities. | Vegetation clearing within the approved clearing boundary. |
| | | No detected impact to mangroves outside the Site boundary attributable to the works (acceptable change in mangrove canopy cover is <30% reduction in canopy cover and in tree condition, including pneumatophores). |
| | To avoid injury or death to native terrestrial fauna attributable to Project activities. | Zero incidents of death or injury to native fauna attributable to Project activities. |
| Weed and Pest Management | To prevent the introduction of new weed species to the Site and the spread of ‘declared’ weed species and Weeds of National Significance (WONS) within the Site | Zero introduction and spread of new weeds to Site. |
| | | Effective and strategic control of weeds. |

# 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 1-1**). 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 west 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 discharges 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). 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, namely 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 at the onsite weather station since October 2012 and collects data on rainfall, temperature, humidity, wind speed and wind direction.

During the annual monitoring period, the Site received 1,649.6 mm of rainfall, with rain falling on 99 days, mainly in the wet season. April was the hottest month with a temperature range of 23.8°C minimum to 37.0°C maximum. A summary of the climatic data collected during the annual monitoring period is presented in **Figure 3-1**.

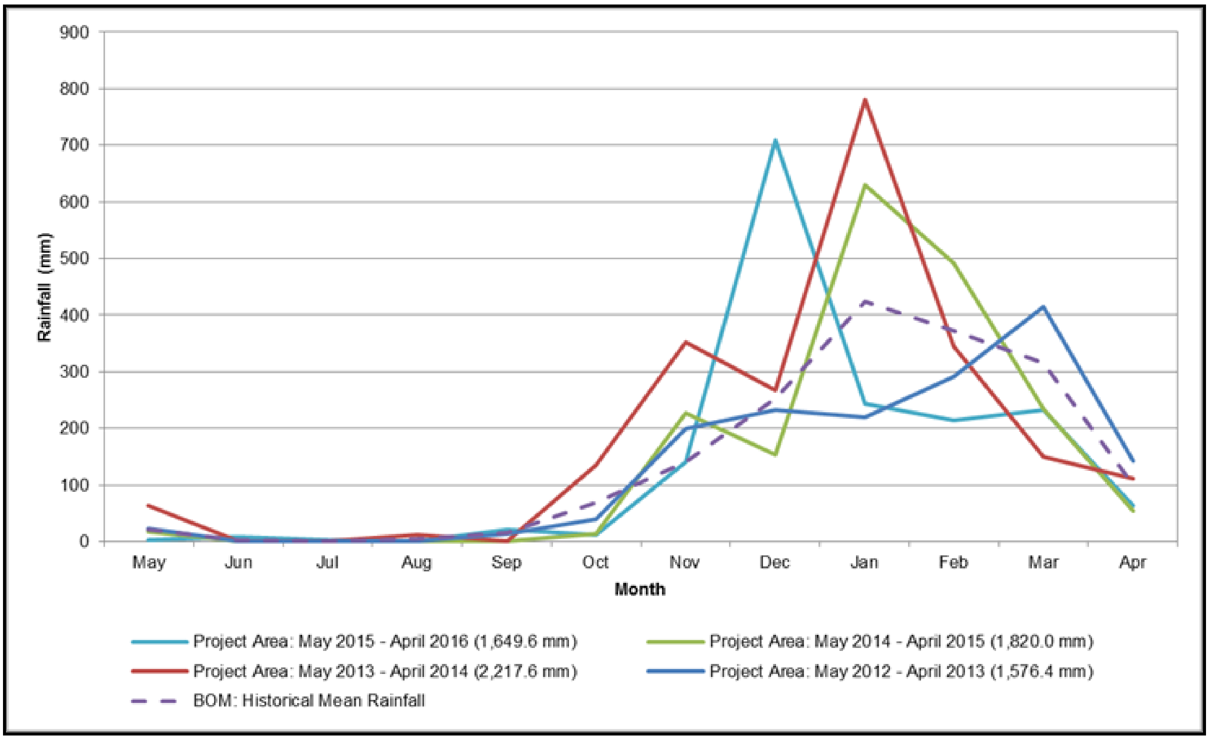



**Figure 3-1 Summary of Climatic Data, May 2012 – April 2016**

## 3.4 Site Construction Activities – May 2015 to April 2016

Civil and infrastructure site works continued through the annual monitoring period on Site, comprising activities such as:

- Earthworks;
- Facilities installation;
- Civil works;
- Construction of LNG tanks;
- Construction of Utility Area Tanks; and
- Construction of Propane and Butane Tanks.

# 4. RESULTS AND DISCUSSION

## 4.1 Surface Water

### 4.1.1 Monitoring Methodology

The surface water management objectives for the Site seek to minimise changes in receiving water quality resulting from the disturbance or dewatering of ASS and discharges offsite of water containing nutrients, dissolved metals, hydrocarbons or other contaminants. Surface water monitoring during the annual monitoring period was undertaken at:

- Fifteen offsite marine impact sites located in Darwin Harbour around the Site;
- 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 the EIMP;
- Seven telemetered marine buoy monitoring sites located in Darwin Harbour around the Site, as set out in the EIMP;
- Four auto-samplers situated within drainage outfalls at strategic locations in the drainage structures to monitor stormwater basin overtopping events. All four auto-samplers were installed in late November 2015 and collected samples from December 2015 to April 2016; and
- Up to six 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 (EC);
- pH;
- Turbidity;
- Total dissolved solids (TDS);
- Dissolved oxygen (DO);
- Oxidation reduction potential (ORP);
- Total chlorine; and
- Salinity.

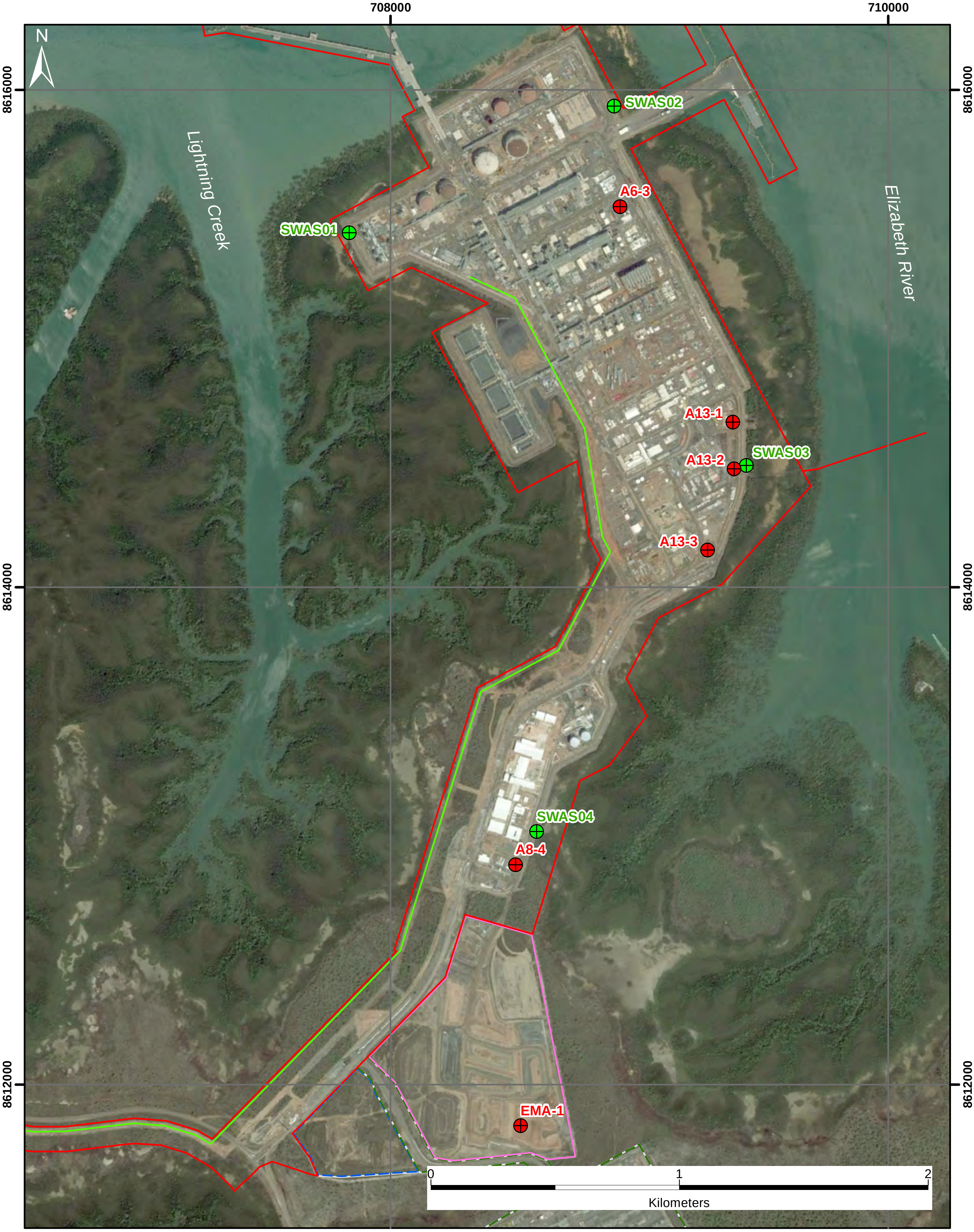
Turbidity and EC concentrations were also recorded by auto-samplers.

Each of the surface water samples collected at onsite and offsite locations 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); and
- Major ions and hardness.

Surface water locations were also analysed for the following additional parameters, as required:

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




Site Boundary

EMA Boundary

Section 1888 Boundary

Section 1897 Boundary

Gas Export Pipeline

**Surface Water Monitoring Locations**

Auto-Sampler Monitoring Location

Basin Sampling Locations

# Onsite Surface Water Monitoring Locations

| Figure 4-1 | INPEX Bladin Point | GREENCAP |
|---|---|---|
| ***Date:*** *26/05/2016* | **Author:** malcolm.nunn | |
| | **Map Scale:** 1:20,000 | |
| **Revision:** A | **Coordinate System:** GDA 1994 MGA Zone 52 | |
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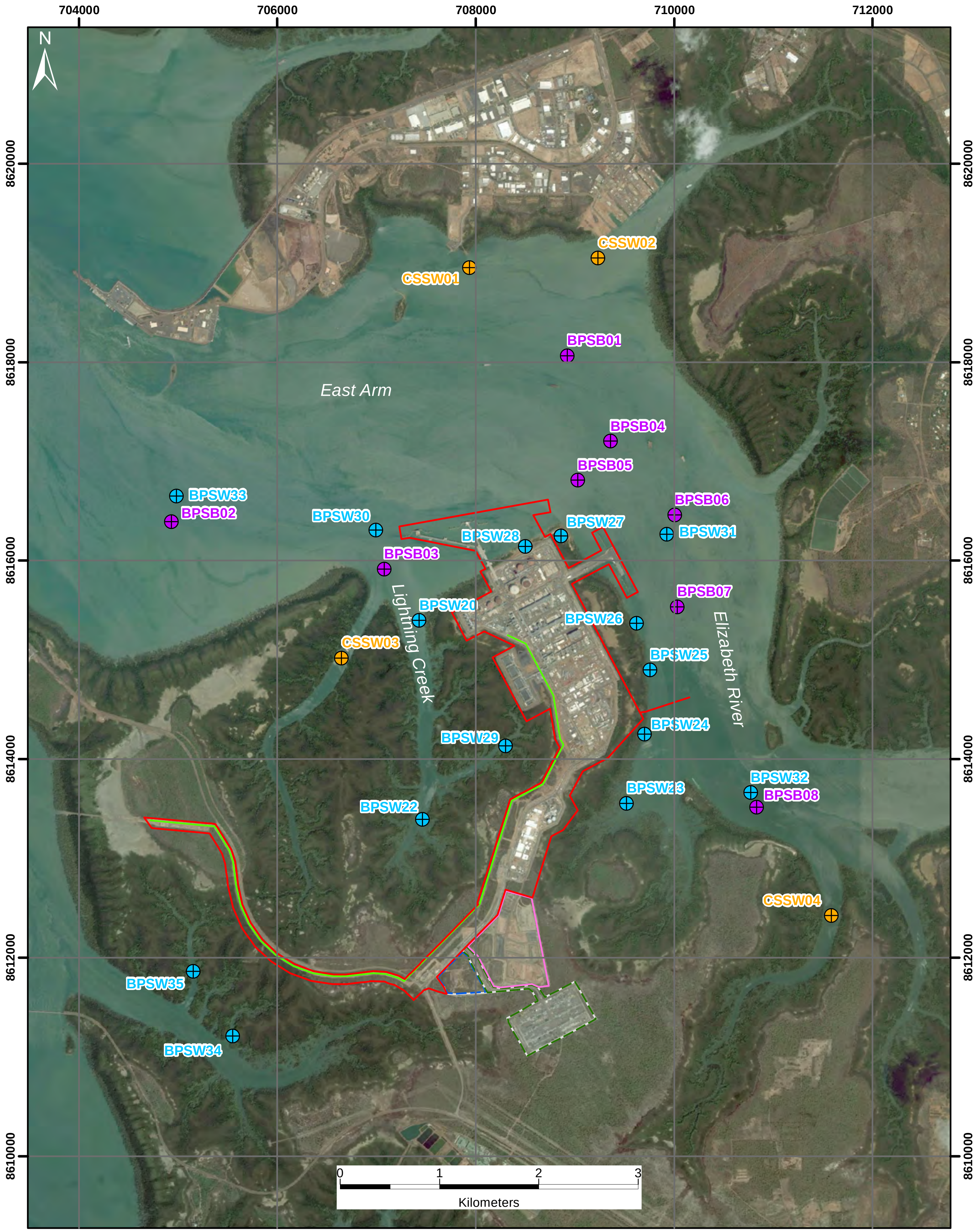



Site Boundary
EMA Boundary
Section 1888 Boundary
Section 1897 Boundary
Gas Export Pipeline

**Surface Water Monitoring Locations**

Reference Sites
Off-site Marine Sampling Locations
Marine Buoy Locations

| **Offsite Surface Water Monitoring Locations** | | |
|---|---|---|
| **Figure 4-2** | **INPEX Bladin Point** | GREENCAP |
| ***Date:*** *26/05/2016* | **Author:** malcolm.nunn<br>**Map Scale:** 1:50,000 | |
| **Revision:** A | **Coordinate System:** GDA 1994 MGA Zone 52 | |
| R:_Projects\C110043_Inpex\GIS\Maps\BP_Annual_Report\2015_2016\FIG_4_02_OffsiteSurfaceWater_160525.mxd | | |

## 4.1.2 Field and Analytical Results

### 4.1.2.1 Marine Surface Water Quality

**Salinity**

Salinity recorded at the marine surface water locations ranged from 17.2 to 39.4 g/L with a median of 35.4 g/L during the annual monitoring period.

Further analysis of the salinity data revealed the following:

- During the dry season, salinity remained relatively stable with values ranging between 34.2 and 39.3 g/L with a median of 37.6 g/L;
- Salinity decreased in October 2015 with a median of 32.8 g/L before increasing again in November and December 2015 with median values of 35.3 and 35.7 g/L, respectively;
- From January 2016, salinity decreased (median of 32.4 g/L) as a result of dilution associated with a number of heavy rainfall events; and
- Overall, the wet season salinity in this annual monitoring period (with a median of 34.0 g/L) was higher than the 2014/15 wet season (median of 24.3 g/L) and this was attributed to lower rainfall (1,820 mm in 2014/15 versus 1,649 mm in 2015/16).

**Figure 4-3** presents the salinity data trends from May 2014 to April 2016.

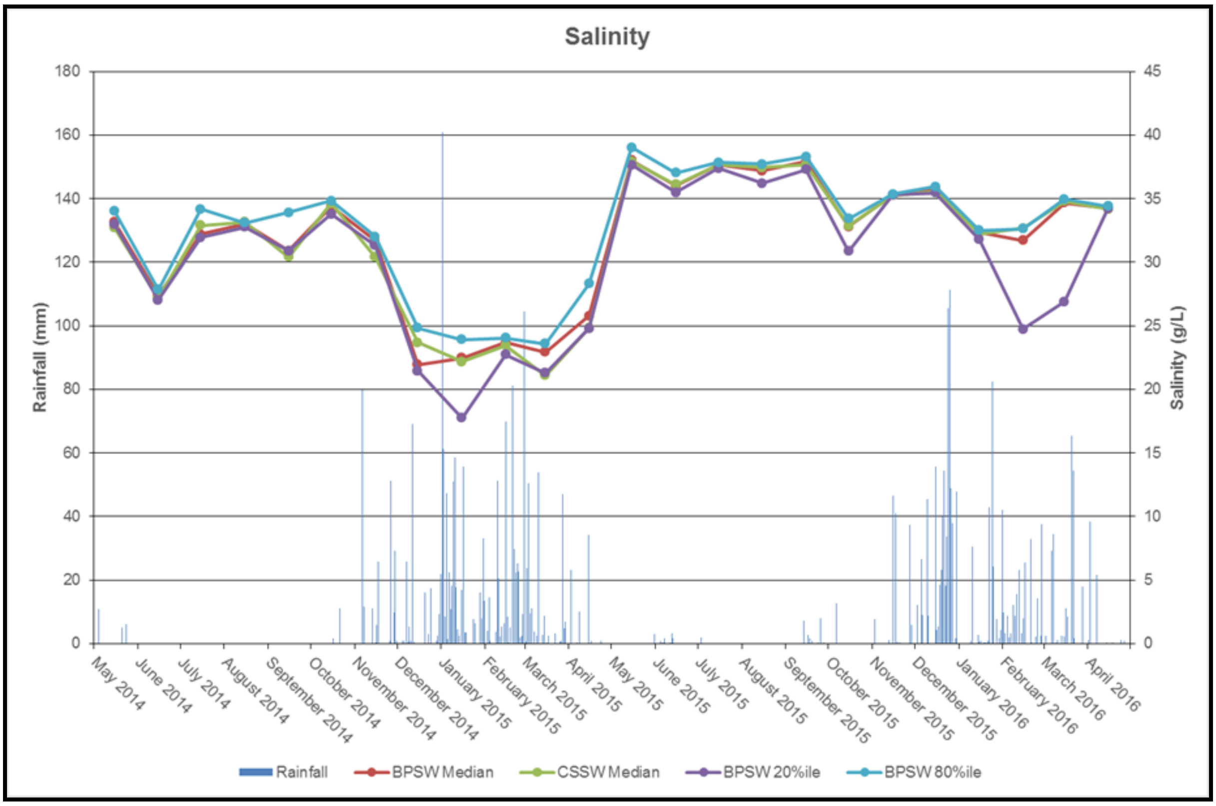



**Figure 4-3 Marine Surface Water Salinity vs Daily Rainfall, May 2014 to April 2016**

**Dissolved Oxygen**

The DO at marine surface water locations ranged from 15 to 101.0% saturation with a median of 85.4% saturation during the annual monitoring period. Results for DO were lowest in February 2016 with a median of 36.6% saturation and the highest values were recorded in July 2015 with a median of 98.0% saturation. There was no observed DO correlation with results for ORP, pH, nutrients and chlorophyll in the monitoring period.

Two potential contributing factors to the low DO saturation levels in the marine environment in the 2015/16 wet season could have been the lower rainfall and the higher than average water temperatures. Water temperatures were higher than average, particularly in the period between January and March 2016, and this may have contributed to the lower DO saturation levels observed across the whole of Darwin Harbour in this period. Furthermore, the monitoring results for DO saturation were consistent across impact sites and reference sites, which suggested these results were indicative of conditions within the East Arm area of Darwin Harbour.

**pH**

pH in the marine surface water locations ranged from 6.46 to 8.17 pH units with a median of 7.79 pH units during the annual monitoring period.

Further analysis of the pH data revealed the following:

- The highest pH readings were observed in May and August 2015 with median values of 8.05 and 8.01 pH units, respectively;
- During the dry season, pH remained relatively stable with the lowest readings observed during July and September 2015 with median values of 7.67 and 7.58 pH units, respectively;
- Similarly, during the wet season, pH also remained relatively stable with median values between 7.74 in February 2016 and 7.91 in March 2016; and
- pH results did not correlate with DO and ORP during the annual monitoring period.

pH was influenced by rainfall events, with an increase of up to 0.8 pH units following rainfall. The monitoring results for pH were consistent across impact sites and reference sites, which suggested the results were indicative of conditions within the East Arm area of Darwin Harbour.

**Turbidity**

During the dry season, turbidity remained relatively stable and ranged from 0.4 to 6.2 NTU, with no trigger value exceedances recorded. Similar to previous wet seasons, turbidity increased with the onset of the rains with the highest reading recorded in February 2016 at an impact site (28.9 NTU). This was the only turbidity exceedance (>20 NTU) recorded during the annual monitoring period and was lower than previous years (AEMR [2013], AEMR [2014] and AEMR [2015]). Turbidity results were consistent across impact sites and reference sites and this was indicative of Darwin Harbour-wide conditions.

During the annual monitoring period, turbidity peaks were measured during increased wave height and heavy rainfall periods associated with monsoonal events.

Isopleths were prepared that identify turbidity distribution during the dry season and wet season **Figure 4-4** and **Figure 4-5** respectively.

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 1 and 7 NTU. Turbidity did not appear to be influenced by tidal range associated with the period of spring tides each month which was observed in the previous monitoring period. However, the influence of rainfall events on turbidity was evident at the onset of the wet season in late December 2015 as high rainfall events correlated with elevated turbidity.

**Total Suspended Solids**

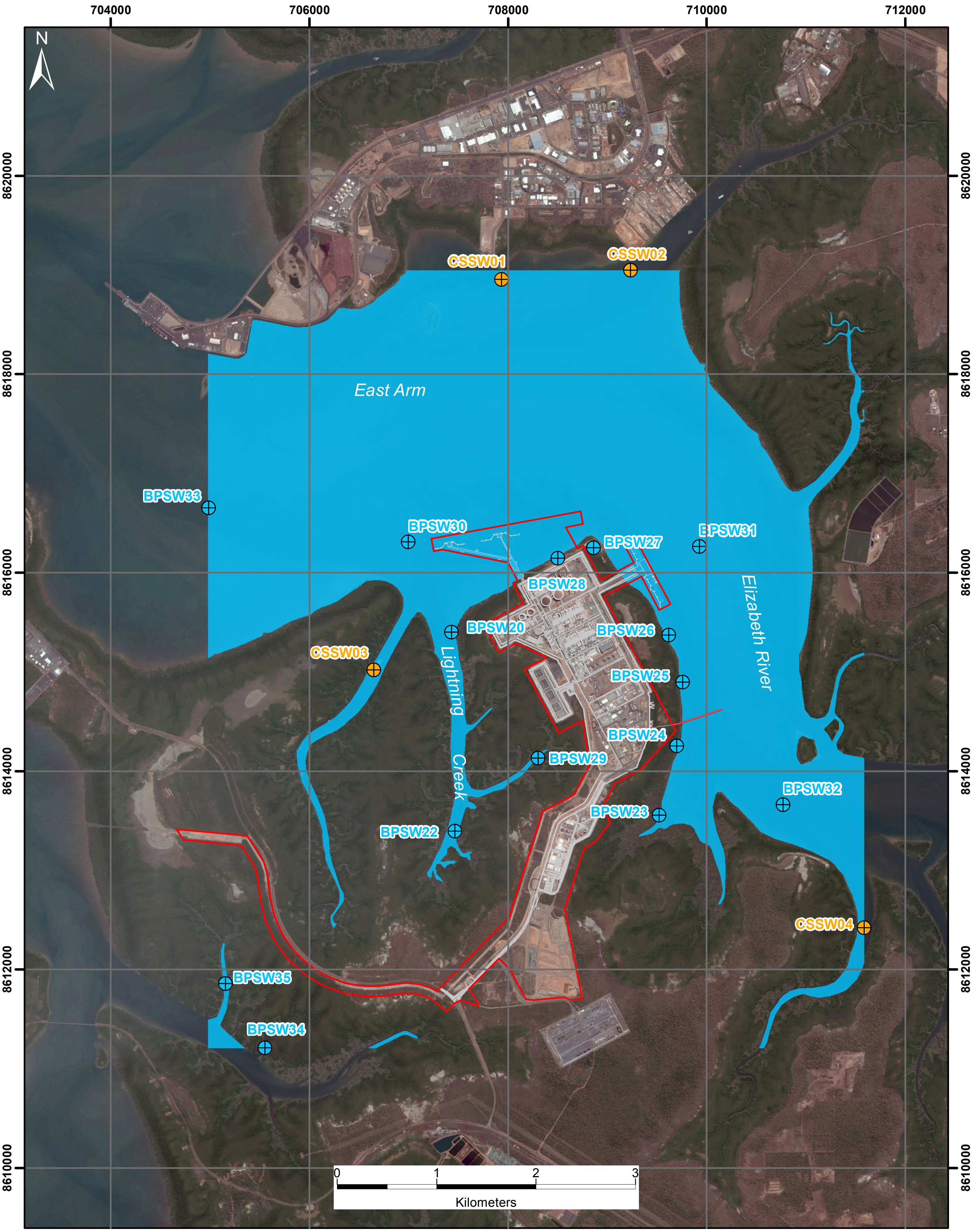
The TSS in the marine surface water locations ranged from <1 to 73.0 mg/L with a median of 7.8 mg/L during the annual monitoring period.

Further analysis of the TSS data revealed the following:

- During the dry season, TSS was highest in May and June 2015 with median values of 30.0 and 50.0 mg/L, respectively;
- Between July and September 2015 the TSS levels decreased;
- In October 2015, TSS concentrations started to increase until the onset of the wet season in late December 2015; and
- From January 2016, TSS concentrations decreased (median of 5.4 mg/L) before increasing again in February and March 2016 (median values of 7.6 and 11.0 mg/L, respectively). A decrease in TSS concentrations was observed in April 2016 (median of 6.0 mg/L).

This annual monitoring period presented a different trend to that reported in AEMR (2015) with fewer exceedances recorded during the dry season (between June and November 2015). However, these results were more consistent with those recorded in AEMR (2013) and AEMR (2014).

The monitoring results for TSS were consistent across impact sites and reference sites throughout the annual monitoring period, which suggested these results were indicative of conditions within the East Arm area of Darwin Harbour.




**Legend**

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

**Surface Water Monitoring Locations**

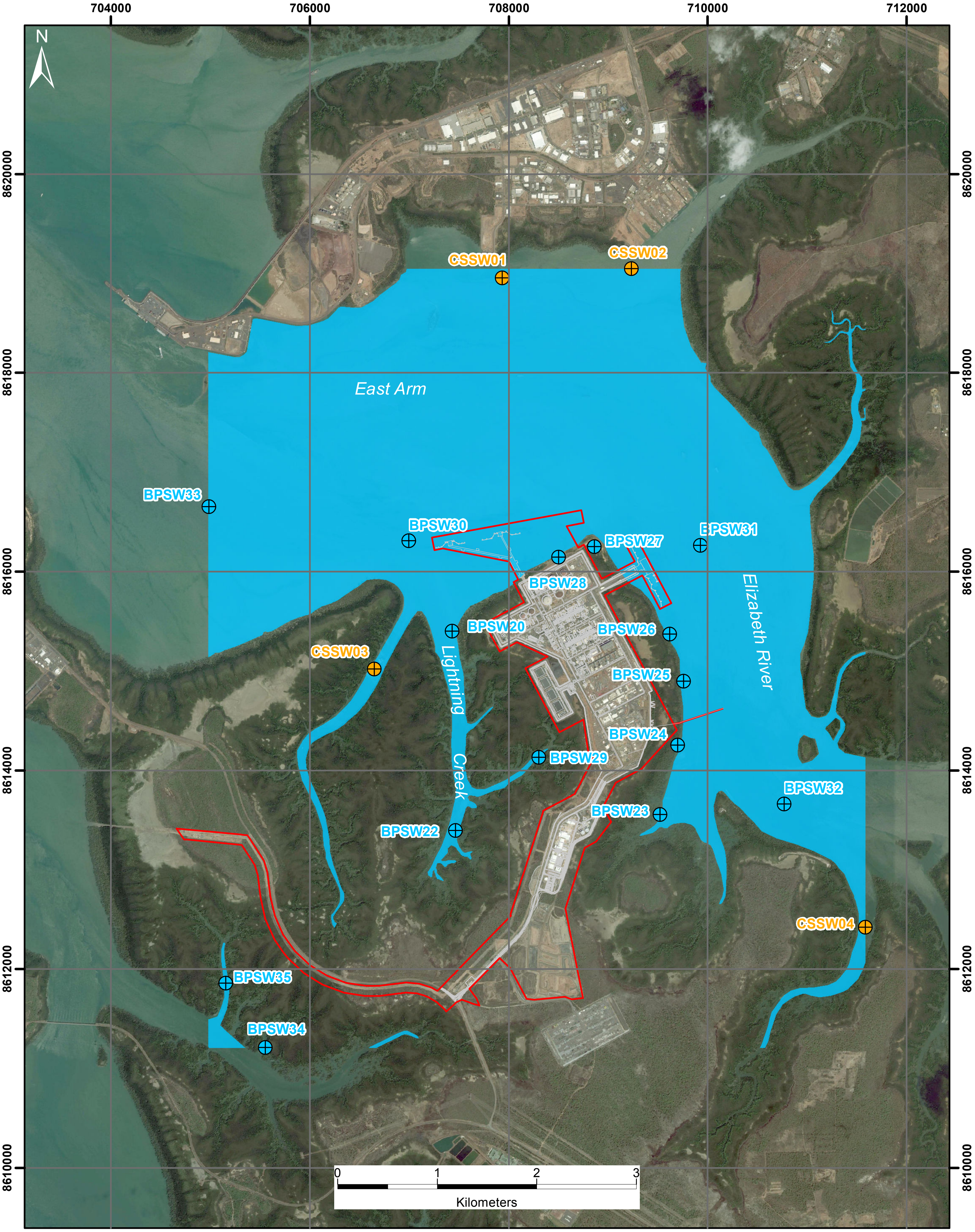
- Off-site Marine Sampling Locations
- Reference Sites

**Turbidity Level (NTU)**

- 0.0 - 20.0
- 20.0 - 30.0
- 30.0 - 40.0
- 40.0 - 60.0
- 60.0 - 100.0
- >100.0

## Marine Surface Water Turbidity Distribution, October 2015

| | | |
|---|---|---|
| Figure 4-4 | INPEX Bladin Point | GREENCAP |
| Date: 6/05/2016 | Author: malcolm.nunn<br>Map Scale: 1:50,000 | |
| Revision: A | Coordinate System: GDA 1994 MGA Zone 52 | |
| R:_Projects\C110043_Inpex\GIS\Maps\BP_EPA7_Report2016\FIG_4-4_BP_2015_10_October_TUR_160506.mxd | | |




**Legend**

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

**Surface Water Monitoring Locations**

- Off-site Marine Sampling Locations
- Reference Sites

**Turbidity Level (NTU)**

- 0.0 - 20.0
- 20.0 - 30.0
- 30.0 - 40.0
- 40.0 - 60.0
- 60.0 - 100.0
- >100.0



## Marine Surface Water Turbidity Distribution, March 2016

**Figure 4-5**

**INPEX Bladin Point**

GREENCAP

***Date:*** *6/05/2016*

**Author:** malcolm.nunn

**Map Scale:** 1:50,000

**Revision:** A

**Coordinate System:** GDA 1994 MGA Zone 52

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**Nutrients**

Ammonia

Ammonia results ranged from <5 to 170 µg/L with a median of 9 µg/L in the annual monitoring period.

Further analysis of the ammonia data revealed the following:

- The highest ammonia concentrations were recorded in August 2015 with a median of 19.0 µg/L;
- The lowest concentrations were recorded in December 2015, with a median of 2.5 µg/L;
- Relatively low ammonia concentrations were evident in the first few months of the wet season from October 2015 to January 2016; and
- There was no apparent correlation between rainfall and ammonia concentrations in the annual monitoring period.

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), which was equal to the median reported here. These authors do concede that ammonia concentrations may be higher in creek arms due to mineralisation, 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.

Elevated ammonia concentrations (22 to 77 µg/L) were detected in February 2016 but these were recorded at both impact and reference sites and were assessed to be related to tidal movements prior to the sampling events.

Discharges and monitoring information related to JKC-held Waste Discharge Licence-192 (WDL-192) and WDL-211 has been included in this assessment because it represents a pathway for potential environmental impacts on the receiving environment.

An ammonia exceedance that did not comply with Condition 27.2 of WDL-211 was detected on 30 March 2016. The WDL-211 investigation concluded that the ammonia trigger value exceedance was an isolated detection, was not indicative of an ammonia plume and the risk of potential environmental harm was assessed to be low.

Surface water monitoring undertaken as part of WDL-192 detected ammonia exceedances in March 2016 and April 2016. The March investigation found that the ammonia exceedances were not caused by the onsite Wastewater Treatment Plant (WwTP) discharges because during the concurrent surface monitoring conducted as part of the EIMP, exceedances were also recorded at the WDL-192 and EIMP reference sites. The April investigation found that the single ammonia exceedance was an isolated event and was not indicative of an ammonia plume, therefore, the risk of potential environmental harm via algal blooms was considered low, as evidenced by low chlorophyll-a results.

Surface water monitoring undertaken as part of WDL-211 detected an ammonia exceedance with a value of 40 µg/L at one sampling location at the edge of the mixing zone on 30 March 2016. This exceedance constituted a non-compliance as defined by Condition 27.2 of the licence and triggered an investigation. The investigation concluded that the ammonia exceedance was only detected in one of the three samples collected at the edge of the mixing zone. The downstream monitoring site (based on an outgoing tidal phase at the time of sampling), did not exceed the trigger value and was substantially lower than the concentration at the monitoring site where the exceedance was detected.

The investigations of the above-mentioned ammonia exceedances concluded that the exceedances were isolated detections, were not indicative of ammonia plumes and the risk of potential environmental harm was assessed to be low.

Oxides of Nitrogen

Results for oxides of nitrogen ranged from <5 to 130 µg/L, with a median of 10 µg/L during the annual monitoring period.

Further analysis of the oxides of nitrogen data revealed the following:

- The median oxides of nitrogen concentrations decreased from 18 µg/L in May 2015 to 8 µg/L in June 2015 and increased between July and September 2015 with a median range between 10 and 16 µg/L;
- Concentrations decreased again and were lowest in October 2015 with all results below the LOR of <5 µg/L;
- Concentrations increased in December 2015 (median of 16 µg/L) before decreasing again in January 2016 (median of 5 µg/L) and February 2016 (median of 7 µg/L);
- Oxides of nitrogen concentrations increased in March 2016 with a median of 42.5 µg/L and were higher than any other month in the annual monitoring period. Oxides of nitrogen concentrations decreased again in April 2016 (median of 10); and
- Oxides of nitrogen results did not correlate with the rainfall recorded during each month.

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 to Darwin Harbour after the first substantial rains in late December 2015 and early January 2016, reduced oxides of nitrogen levels by flushing and/or advection through the system. Lower than average rainfall would also likely have played a role and contributed to the lower oxides of nitrogen concentrations over the wet season.

Elevated oxides of nitrogen concentrations were detected in close proximity to the MOF in December 2015 but these were not related to WDL-211 hydrotesting because no hydrotest discharge events took place in this month. Oxides of nitrogen exceedances at WDL-192 impact sites and reference sites were detected in December 2015 and were assessed as being unrelated to the WwTP discharges because they occurred at the WDL reference sites as well.

Oxides of nitrogen exceedances were recorded at WDL-192 monitoring locations in March 2016 that were non-compliant with WDL-192 conditions and the NT EPA requested an investigation report. The investigation concluded that the exceedances were not caused by the WwTP discharges because concurrent monthly surface water monitoring conducted as part of the EIMP also recorded exceedances at EIMP reference sites and across the majority of Darwin Harbour.

Total Nitrogen

Results for total nitrogen ranged from <50 to 560 µg/L, with a median of 120 µg/L during the annual monitoring period.

Further analysis of the total nitrogen data revealed the following:

- Total nitrogen concentrations decreased from May to June 2015 (medians of 130 µg/L and 100 µg/L), before increasing from July to August 2015 (both with a median of 170 µg/L);
- Concentrations decreased sharply to their lowest levels in September 2015 (median of 27 µg/L); and
- An increasing trend was observed from October 2015 onwards to the highest level in January 2016 (median of 180 µg/L) before decreasing again in February, March and April 2016.

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

Results for total phosphorus ranged from <5 to 300 µg/L, with a median of 22 µg/L during the annual monitoring period.

Further analysis of the total phosphorus data revealed the following:

- Elevated total phosphorus results were recorded in October 2015 (a median of 110 µg/L);
- Concentrations were low in May 2015 (median of 16 µg/L) and increased to a median of 23 µg/L in July 2015;
- The lowest concentrations were recorded in August 2015 (median of 14 µg/L) but rose sharply to a median of 110 µg/L in October 2015;
- Concentrations decreased in the lead up to the wet season and remained relatively stable during the wet season with medians between 18 and 29 µg/L between November 2015 and April 2016; and
- Results across the annual monitoring period could generally not be correlated with rainfall.

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, which did not occur in the 2015/16 wet season, and may be attributable to the lower rainfall.

Elevated total phosphorus concentrations were detected at WDL-192 impact sites in January 2016 and at some of the EIMP impact sites located to the north-west of the Site in the more open waters of Darwin Harbour. There were no other nutrients that exceeded their trigger values in the WDL-192 monitoring in this month and no chlorophyll-a exceedances.

There was an isolated total phosphorus exceedance detected at one WDL-192 impact site in April 2016 (42 µg/L). The subsequent investigation concluded the exceedance may have been caused by the WwTP discharge. However, low chlorophyll-a results at the time led to the conclusion that the exceedance of total phosphorus did not generate algal blooms and therefore the risk of environmental harm was low.

Filterable Reactive Phosphorus

The results for FRP ranged from <1 to 16 µg/L, with a median of 2 µg/L during the annual monitoring period.

Further analysis of the total phosphorus data revealed the following:

- Elevated FRP concentrations were recorded in May 2015 (median of 5.0 µg/L) and March 2016 (median of 5.5 µg/L). These elevated results did not correlate with any rainfall events; and
- Results were consistent throughout the remainder of the annual monitoring period with medians between July 2015 and February 2016 ranging from 0.5 to 3.0 µg/L.

Filterable reactive phosphorus is the reactive form of this nutrient and is readily available for uptake by plants. Its generation would occur from degradation processes acting on the organic phosphorus (a major component of total phosphorus) in Darwin Harbour which would have been delivered from the catchment. Phosphorus cycling within Darwin Harbour is not a well understood process.

**Metals and Metalloids**

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 two isolated metal exceedances (Co, Cu) detected in the WDL-211 monitoring program but these were recorded at reference sites. There were no metal exceedances at WDL-211 impact sites.

Filtered Copper

The results for filtered copper ranged from <1 to 2 µg/L. Trigger value exceedances were recorded at one impact site in each of September 2015 and March 2016. An elevated copper concentration was detected in close proximity to the MOF and MOF outfall in September 2015 but this was not related to WDL-211 hydrotesting because no hydrotest discharge events took place in this month.

The filtered copper exceedances recorded in this annual monitoring period were isolated and there did not appear to be any spatial patterns or trends indicating any influences from Site activities or discharges on copper concentrations in the receiving environment.

Filtered Zinc

The results for filtered zinc ranged from <5 to 49 µg/L with the majority of results below the LOR. Trigger value exceedances for filtered zinc were recorded at three impact sites in July 2015 and at one reference site in May 2015. The filtered zinc exceedances in July 2015 were recorded in Lightning Creek and the creek to the south-west of the Site.

The filtered zinc exceedances recorded in this annual monitoring period were isolated and there did not appear to be any spatial patterns or trends indicating any influences from Site activities or discharges on zinc concentrations in the receiving environment.

**Other Parameters**

Hydrocarbons

One isolated TRH detection (185 µg/L) was recorded at an impact site (BPSW27) in January 2016. Following initial analysis there was an insufficient remaining quantity of sample to conduct silica gel clean up in order to determine if the TRH was of a natural or anthropogenic source. No sheen was observed during sample collection indicating that no hydrocarbon plume was present.

Biological Parameters

No *E. coli* exceedances were recorded during the annual monitoring period.

Two enterococci exceedances were recorded in March 2016, one at an impact site (BPSW32) and the other at a reference site (CSSW04). No enterococci exceedances were recorded at WDL-192 impact sites in March 2016, and in addition the exceedances that were detected, occurred at an impact site and reference site, hence indicating a source other than Site.

Two chlorophyll-a exceedances were recorded at BPSW23 in December 2015 (0.0059 mg/L) and BPSW34 in February 2016 (0.0053 mg/L).

No correlation with Site activities or discharges was identified in any of these exceedances.

Chloride/Sulfate Ratio

Chloride/sulfate ratios can be used to determine whether there has been discharge from ASS-impacted streams into marine receptors. 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). Salinity results from the surface water monitoring program, while slightly higher than previous annual monitoring periods, remained generally consistent with seawater (**Figure 4-6**) and it can be concluded that there have not been discharges from ASS-impacted streams into marine receptors. In addition, the data collected during this annual monitoring period was similar to AEMR (2013), AEMR (2014) and AEMR (2015), with ratios values between 5 and 9 demonstrating that surface water has not been measurably impacted by ASS to date.

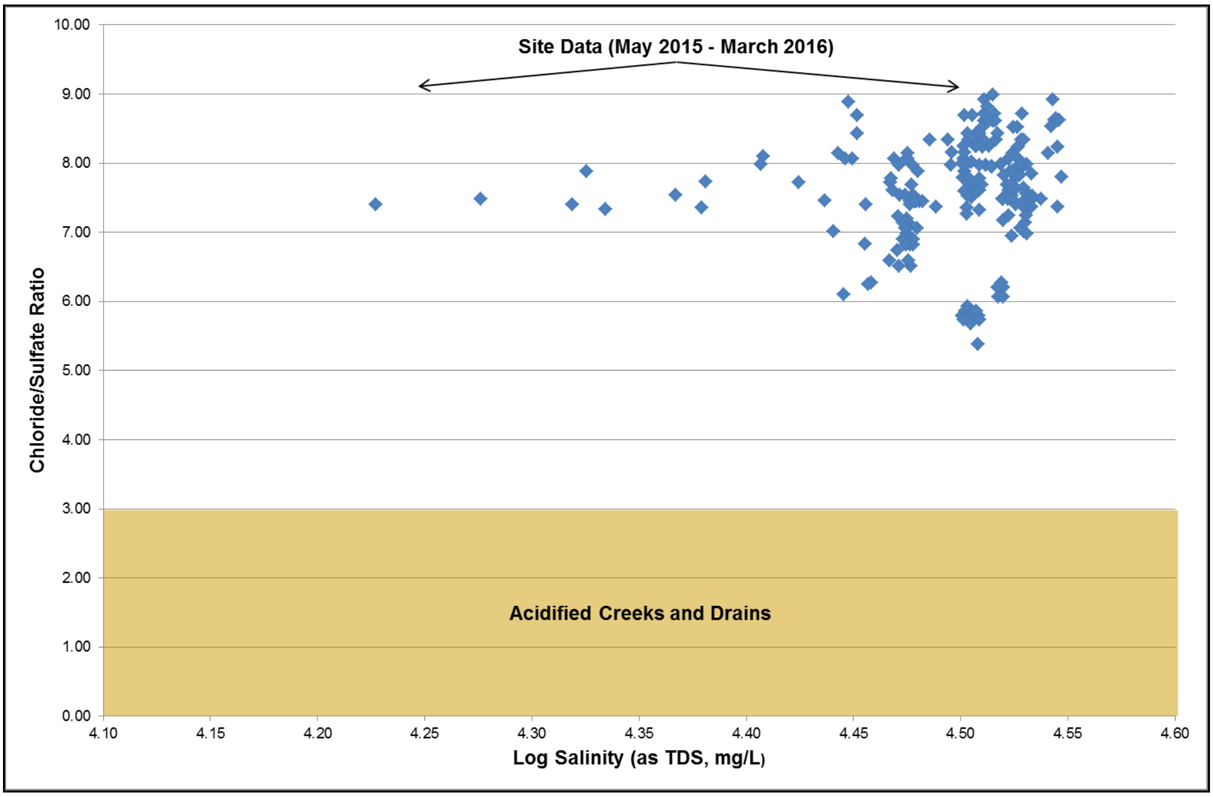



**Figure 4-6 Surface Water Chloride/Sulfate Ratio**

### 4.1.2.2 Terrestrial Surface Water Quality

Onsite basin results were indicative of water quality in the basins while the auto-sampler results were representative of the water quality discharged from Site during overtopping and storm events. The onsite basins are utilised for water retention prior to discharge and no seasonal trends were expected in the results, rather the data are considered representative of the functionality of the basins during the annual monitoring period.

For passive discharges, auto-samplers were installed to collect samples of water discharging through the erosion and sediment controls. They are not compliance points for stormwater discharge and provide further information on water quality during overtopping events.

Auto-sampler results were cross-referenced with results from nearby marine surface water monitoring locations (monitored once a month) and/or marine buoy locations. However, there were limitations in this type of analysis, for example the marine surface water monitoring locations were typically not sampled in the same time period in which the auto-samplers recorded exceedances.

There were no trends observed in the quality of surface water in the onsite basins, which was largely dependent on recent rainfall events and the volume of surface water flows containing suspended materials at the time of sampling. Elevated ammonia, oxides of nitrogen, total nitrogen, total phosphorus and aluminium concentrations were recorded in the onsite basins. The turbidity, DO and pH measurements were indicative of water quality in the onsite basins prior to any controlled release into Darwin Harbour.

Auto-sampler results were representative of the water quality discharged from Site during overtopping and storm events. There were instances where aluminium, arsenic (III and V), cobalt, copper, manganese and zinc concentrations in the auto-sampler samples were above the receiving environment trigger values but there is no direct evidence that these concentrations were correspondingly found in the marine receiving environment.

Auto-samplers are positioned at the outfalls of the regulating reservoir and collect surface water samples associated with overtopping of the drainage network following rain events. As such the collected samples are not associated with active discharges from Site. As the collected samples are correlated with rain events, the water is representative of precipitation and surface water flow that contains sediments from unsealed surfaces. The local geology and soils are known to contain naturally elevated metal concentrations. The sediment load in the collected samples is therefore considered to be the source of the metal exceedances observed at the auto-samplers. Furthermore, as the auto-samplers often collect samples during the night or on a weekend the samples are not decanted and submitted to the laboratory until the following day. This delay in laboratory submission has the potential to produce elevated concentrations of metals and should only be considered as indicative of the surface water quality following overtopping events.

The auto-sampler results were cross-referenced with results from nearby marine surface water monitoring locations and/or marine buoy locations. The assessment did not indicate a direct link between auto-sampler exceedances and the results from the offsite marine surface water monitoring program.

## 4.2 Groundwater

### 4.2.1 Monitoring Methodology

The groundwater management objectives for the Site seek to minimise changes in groundwater levels and groundwater quality which may be arising from construction 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 as identified via environmental incident reporting.

The current bore network comprises 44 monitoring locations, identified on **Figure 4-7**. 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. There are currently 27 data loggers installed at various locations across the monitoring bore network. Samples were collected from the monitoring bores on a monthly basis. The following analytes were recorded in situ:

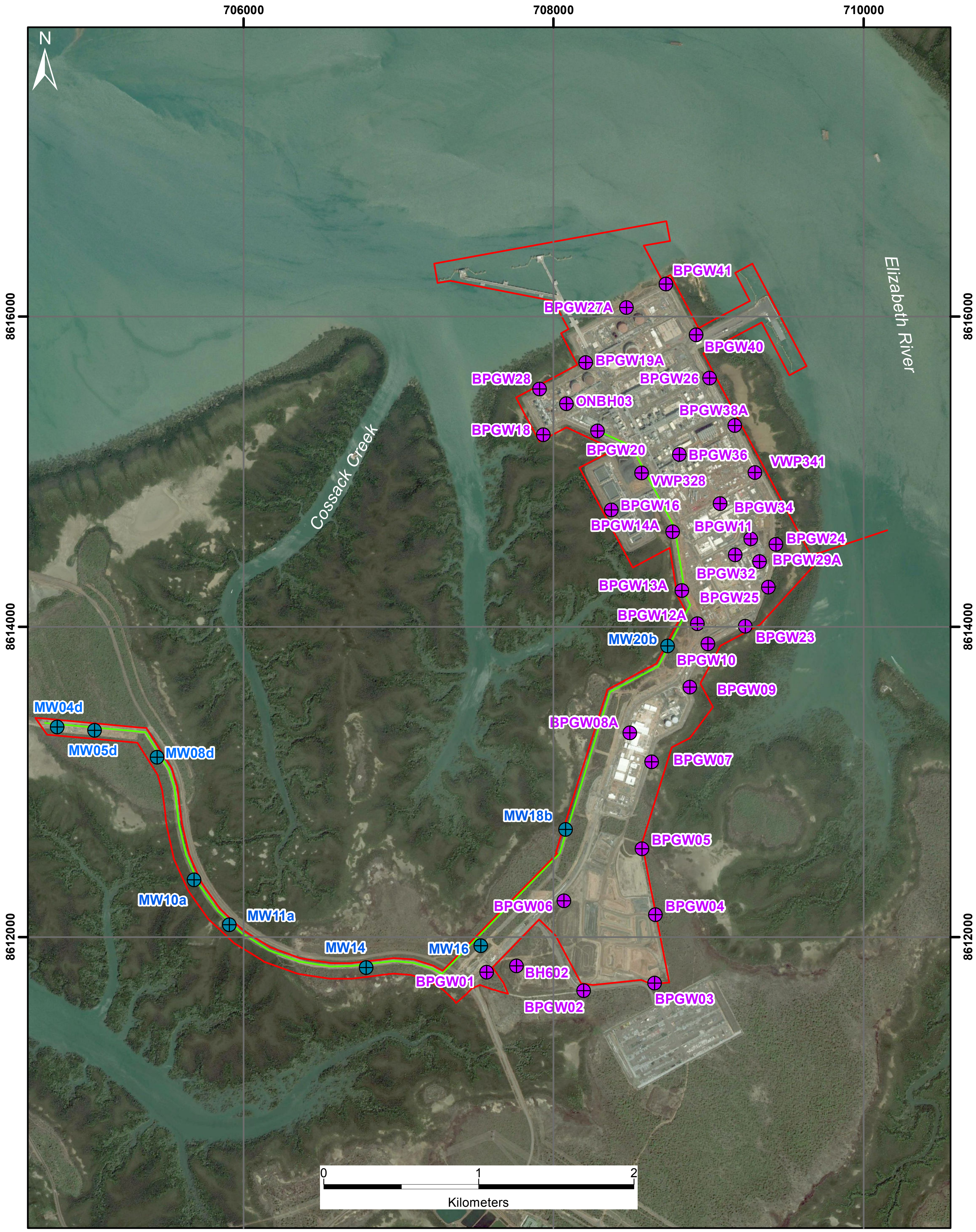
- Temperature;
- Electrical conductivity;
- pH;
- Turbidity;
- TDS;
- DO;
- ORP; and
- Salinity.

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); and
- 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

**Monitoring Locations**

Groundwater Sampling Locations

EIMP (Rev 6) GEP Groundwater Sampling Locations

| **Groundwater Sampling Locations** | | |
|---|---|---|
| **Figure 4-7** | **INPEX Bladin Point** | GREENCAP |
| ***Date:*** *6/05/2016* | **Author:** malcolm.nunn<br>**Map Scale:** 1:32,000 | |
| **Revision:** A | **Coordinate System:** GDA 1994 MGA Zone 52 | |
| R:_Projects\C110043_Inpex\GIS\Maps\BP_EPA7_Report\2016\FIG_4-7_Groundwater_160506.mxd | | |

#### 4.2.2 Results

##### 4.2.2.1 Field Parameters

**Dissolved Oxygen**

In December 2015, a DO trigger value (80% saturation) was adopted for groundwater. All DO results reported between December 2015 and April 2016 were below this trigger value (i.e. were exceedances). Review of the spatial data indicated no consistent, distinctive nodes of low DO concentrations.

**Groundwater Elevation**

Groundwater levels were highest south of the isthmus where typically the underlying soils are less compacted and covered in a more permeable layer allowing increased recharge compared to the north of the isthmus were the soils are typically more compacted and covered in more impermeable surface materials. Groundwater bores have been grouped within two main zones, namely: areas above the high water mark i.e. above the highest astronomical tide (HAT) and those below the HAT which are periodically inundated by tidal waters. Bores above the HAT exhibit seasonal variation in water levels and are more influenced by rainfall recharge while bores below the HAT are influenced by tidal movements. Groundwater levels may also be influenced by the amount of hardstanding on Site.

Analysis of groundwater level patterns for the period between 2012 and 2016 indicated the following:

- Direct comparison of groundwater level contours plotted for all years of monitoring was not possible due to the changes in the number and positions of the groundwater monitoring bores during each year of monitoring;
- 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 rainwater 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 compared to the 2012/13, 2014/15 and 2015/16 wet seasons, and recorded the highest groundwater levels; and
- Site activities did not appear to 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 2016.

**Salinity**

Field measured salinity ranged from 0.04 g/L to 101.0 g/L. Seasonal variation was evident over the annual monitoring period. Groundwater salinity on Site varied depending on proximity to the coastal margins and showed a gradual increase and stabilisation at a higher level in line with seasonal influences, such as a lack of freshwater recharge. Along the GEP corridor, naturally occurring hypersaline conditions were noted for MW10a, MW11a, MW18b and MW20b and no freshwater nodes were observed.

**pH**

All pH values were below the lower limit of the pH trigger value range (pH 7.0) between May and November 2015, indicating groundwater acidity, and this was consistent with results from the previous annual monitoring periods. From December 2015 onwards when the lower limit of the pH trigger level was changed to pH 6.0, the number of the trigger value exceedances decreased.

There were two primary nodes (i.e. points) of low pH observed on Site, as follows (**Figure 4-8** and **Figure 4-9**):

- The southern portion of the EMA centred on bore BH602; and
- The central portion of the Site centred on bores BPGW11, BPGW29A, BPGW32 and BPGW34.

There were several seasonal nodes of low pH which typically developed towards the end of the dry season, as follows:

- Areas within the northern portion of the Site in the vicinity of ONBH03 and BPGW27A;
- Areas within the south-eastern portion of the Site in the vicinity of BPGW23;
- The area to the west of the Operations Complex at BPGW08A;
- The central portion of the EMA in the vicinity of BPGW06; and
- The south-eastern portion of the EMA in the vicinity of BPGW02 and BPGW04.

It was noted, however, that the size of the low pH nodes decreased significantly during the 2015/16 wet season and this was likely attributable to the late onset of the wet season and the lower rainfall and recharge. There were also two seasonal points of low pH centred at BPGW27A and ONBH03 which were only observed during the dry season. Similar trends were observed during previous annual periods.

There were five primary zones of near neutral pH that were observed on Site, as follows:

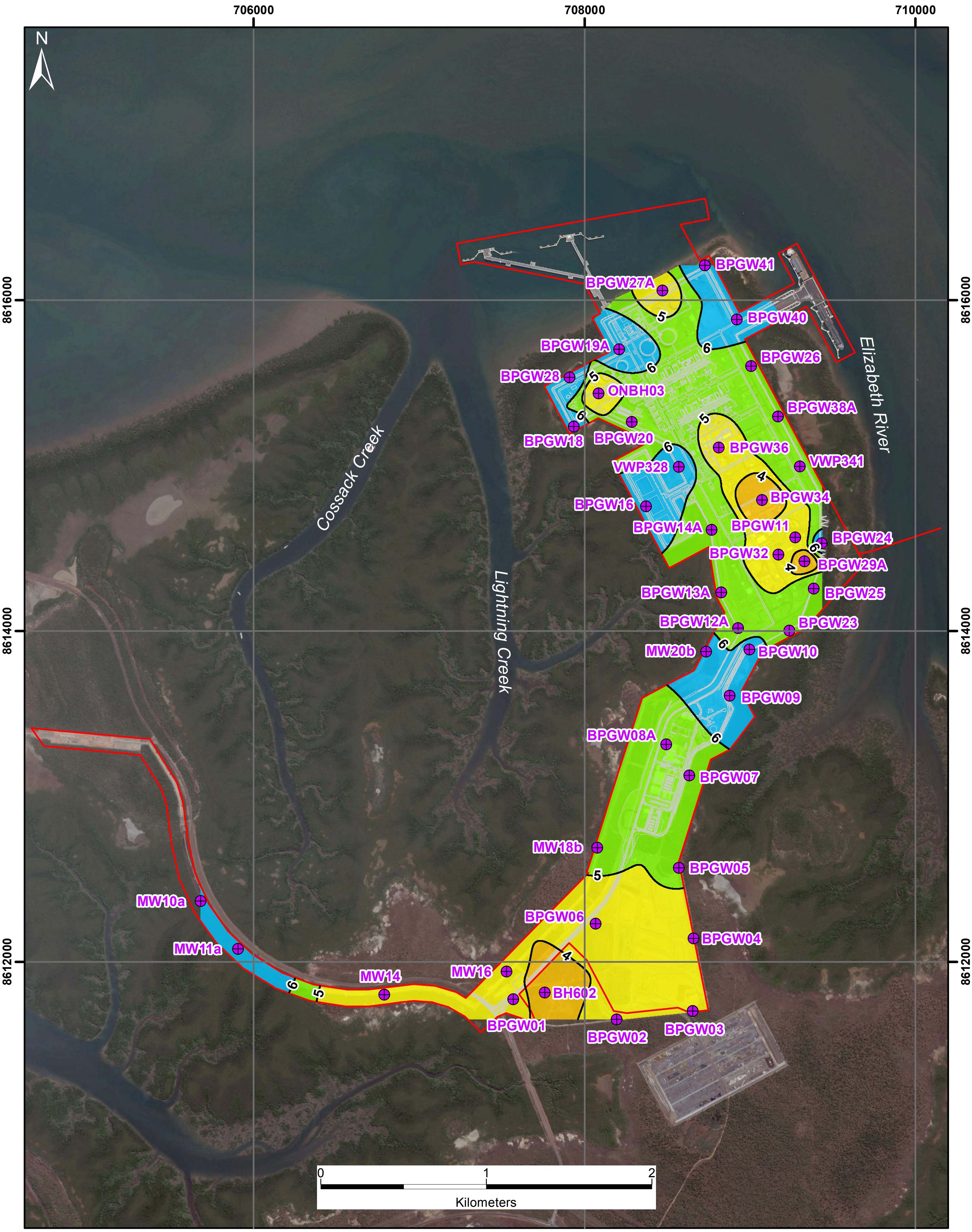
- The central isthmus area at bores BPGW07, BPGW09 and BPGW10;
- The central western  area around BPGW16;
- The north-western areas around bores BPGW18, BPGW19A and BPGW28;
- The north-eastern area around BPGW40 and BPGW41; and
- Along the GEP corridor.

The near neutral pH areas were generally associated with the high salinity groundwater zones along the coastal fringes of the Site.

Groundwater acidity was assessed to be unrelated to Site activities or discharges because background data indicates it was present prior to the commencement of construction, it is a known characteristic of the saline aquifer and it is the result of natural processes historically occurring in the area. Acid sulfate soils management has been completed and validated, all major earthworks packages have finished, no groundwater extraction has taken place and all analytical testing undertaken to date has not identified any ASS-related geochemical changes in the groundwater. The 2015/16 wet season recharge of the groundwater occurred and the pH and groundwater levels were within seasonal ranges.

Giving that the baseline and current pH values along the GEP are within similar ranges, the low pH groundwater along the GEP was assessed to be attributable to natural, background conditions resulting from groundwater interaction with acidic soils that also causes metal mobilisation from the soil matrix.

Based on the historical background data and results from the annual monitoring period, it has been inferred that the most likely cause of the low pH levels in the groundwater on Site and along the GEP is the natural processes historically occurring in these areas. There were no observed increasing or decreasing trends in groundwater pH along the GEP and on Site and therefore Site activities or discharges do not appear to have impacted groundwater pH in these areas.




## Legend

Site Boundary
Construction Footprint
Groundwater Sampling Locations
pH Level Contours (pH Level)

| pH | | | |
|---|---|---|---|
| | <4.0 | | 6.0 - 7.0 |
| | 4.0 - 5.0 | | 7.0 - 8.0 |
| | 5.0 - 6.0 | | 8.0 - 8.5 |
| | | | >8.5 |

## pH Level Contours, October 2015

Figure 4-8

INPEX
Bladin Point

GREENCAP

**Date:** 6/05/2016

**Author:** malcolm.nunn
**Map Scale:** 1:30,000
**Revision:** A
**Coordinate System:** GDA 1994 MGA Zone 52

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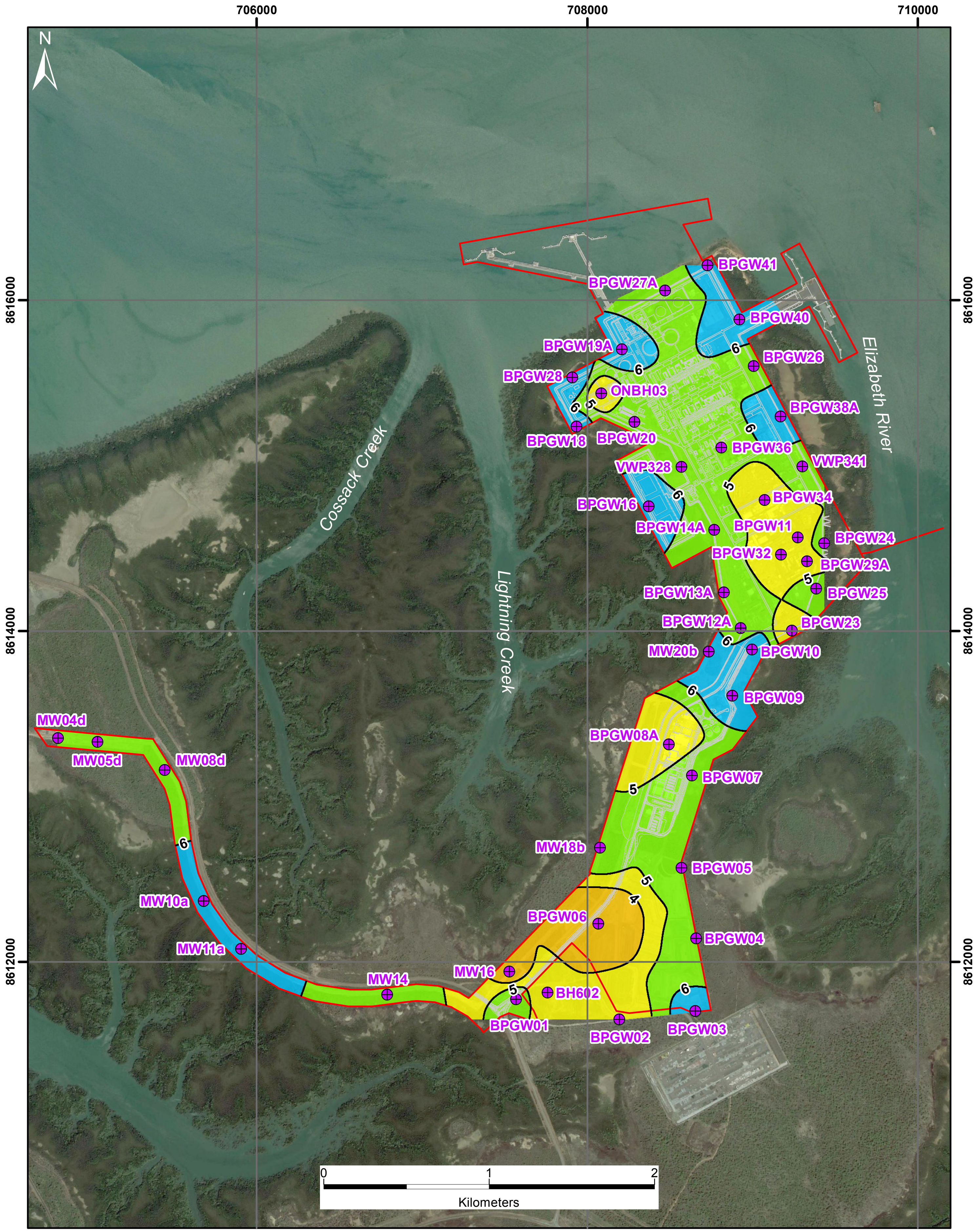



## Legend

| | | | |
|---|---|---|---|
| Site Boundary | pH | | 6.0 - 7.0 |
| Construction Footprint | | <4.0 | 7.0 - 8.0 |
| Groundwater Sampling Locations | | 4.0 - 5.0 | 8.0 - 8.5 |
| pH Level Contours | | 5.0 - 6.0 | >8.5 |

# pH Level Contours, March 2016

| | | |
|---|---|---|
| Figure 4-9 | INPEX Bladin Point | GREENCAP |
| *Date: 6/05/2016* | Author: malcolm.nunn<br>Map Scale: 1:30,000 | |
| Revision: A | Coordinate System: GDA 1994 MGA Zone 52 | |

R:_Projects\C110043_Inpex\GIS\Maps\BP_EPA7_Report\2016\FIG_4-9_BP_2016_03_March_pH_160506.mxd

#### 4.2.2.2 Analytical Results

**Metals**

Metals reported to exceed the adopted trigger levels in the bores on Site and along the GEP corridor during the annual monitoring period were (all filtered) aluminium, arsenic, cadmium, cobalt, copper, lead, manganese, mercury, nickel, silver, zinc and total arsenic. The following observations from the nutrient results were made:

- The majority of the elevated metals concentrations were found in brackish to saline groundwater. Elevated concentrations of arsenic and manganese were more common in the hypersaline groundwater locations;
- Metal concentrations tended to decrease during the wet season when freshwater infiltration reduced the groundwater salinity and diluted the concentrations of these metals;
- The reduction in metals concentrations during the wet season also indicated that no additional metals infiltrated groundwater from the surface, which means that the source of the metals in the groundwater was more likely to be the in situ soils on Site, rather than ASS-release plumes or spills and leaks; and
- Review of the data collected during the annual monitoring period did not indicate continuous increasing or decreasing trends in metals concentrations in the majority of the bores on Site and along the GEP; and
- There were some exceptions where specific metal concentrations appeared to be increasing, including; aluminium in BPGW08A and BPGW11; total arsenic in BPGW34 and MW20b; arsenic (III) in BPGW13a; arsenic (V) in MW20b; cadmium in BPGW05 and BPGW11; cobalt in BPGW11; manganese in VWP341; nickel in BPGW11; silver in BPGW05; and zinc in BPGW05, BPGW11 and MW11a. These increases may be attributable to natural variation and future monitoring will provide data to further assess any on-going trends.

The late onset of the 2015/16 wet season resulted in some metal concentrations outside of their historical maxima. The concentration peaks were also consistent with the lowest pH levels. After a number of significant rainfall events from mid-December onwards, the peak metals concentrations decreased quite rapidly and fell back to within their historical ranges.

Based on statistical analysis of the dataset, baseline data and the results from the annual monitoring period, it has been inferred that elevated metals concentrations in groundwater on Site and along the GEP corridor were attributable to the naturally high background concentrations in the in situ soils. There were no continuous increasing or decreasing trends in metals concentrations observed in the majority of the bores on Site and along the GEP apart from those exceptions noted above, and future monitoring will provide data to further assess any on-going trends in those bores.

**Nutrients**

The nutrients that exceeded the adopted trigger values in the Site bores and along the GEP corridor during the annual monitoring period were ammonia, oxides of nitrogen, FRP, total nitrogen and total phosphorus. The following observations from the nutrient results were made:

- Review of the data collected during the annual monitoring period did not indicate continuous increasing or decreasing trends in nutrient concentrations in the majority of the bores on Site and along the GEP corridor. The exceptions were BPGW32, BPGW24, VWP341 and MW10a where ammonia concentrations appeared to be increasing compared to previous monitoring periods. These increases may be attributable to natural variation and future monitoring will provide data to further assess any on-going trends;
- Elevated ammonia concentrations were generally noted in saline and hypersaline groundwater. Concentrations varied seasonally and three types of trends were noted:
  - Slight seasonal variations in the bores below the HAT where groundwater levels were not significantly influenced by rainwater infiltration;

- Decreases in concentrations in the bores above the HAT during the wet season as a result of freshwater recharge and subsequent dilution;
- Increases in concentrations in the bores above and below the HAT where ammonia associated with rainwater infiltrated through organic rich natural soils.

- FRP concentrations occasionally exceeded the trigger levels during the wet season in the areas where rainwater infiltrated through natural soils;
- A seasonal increase in oxides of nitrogen concentrations was noted mainly during the wet in areas where groundwater had high ORP levels, which supported conversion of natural ammonia into nitrite and nitrate;
- Seasonal increases and decreases in total nitrogen concentrations generally attributable to the proportion of the oxides of nitrogen and ammonia, which are the main constituents of total nitrogen values in the onsite groundwater; and
- Seasonal increases in total phosphorus concentrations were noted mainly during the wet season as a result of pH level increases.

The late onset of the 2015/16 wet season resulted in ammonia concentrations in a limited number of bores (e.g. BPGW24) outside of their historical maxima. After a number of significant rainfall events from mid-December onwards, the peak ammonia concentrations decreased quite rapidly and fell back to within their historical ranges.

Based on statistical analysis of the dataset, baseline data and the results from the annual monitoring period, it has been inferred that elevated nutrient concentrations in groundwater on Site and along the GEP corridor were attributable to the naturally high background concentrations in the in situ soils and muds in these areas. There were no continuous increasing or decreasing trends in nutrient concentrations observed in the majority of the bores on Site and along the GEP apart from those exceptions noted above, and future monitoring will provide data to further assess any on-going trends in those bores.

**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).*

A higher sulfate/chloride 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.

Groundwater was generally consistent with the typical seawater ratio (**Figure 4-10**), 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. Ionic concentrations in BPGW36 showed some increase in the proportions of $SO_4$ and Ca ions during 2015/2016 wet season (**Figure 4-11**). This was considered to be attributable to the concreting works which occurred in the vicinity of this bore during the annual monitoring period.

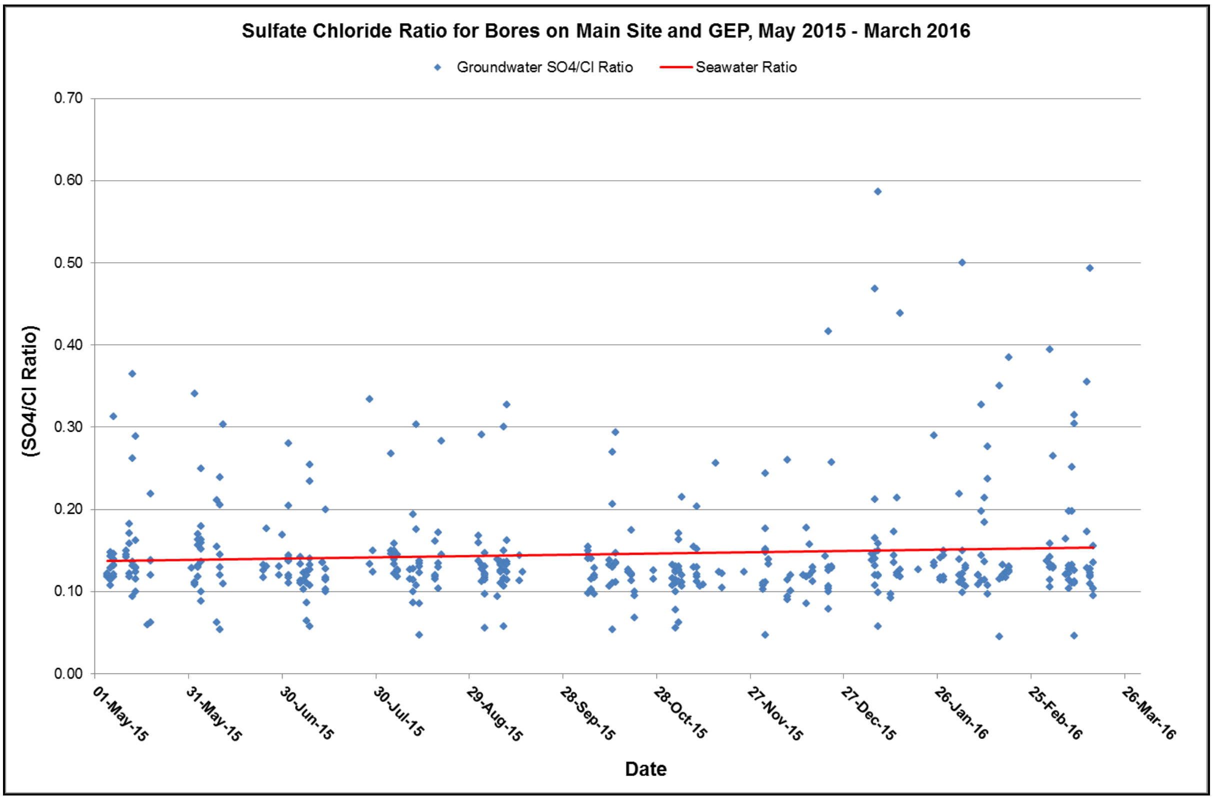



**Figure 4-10 Sulfate/Chloride Ratio for Bores on Site and GEP**

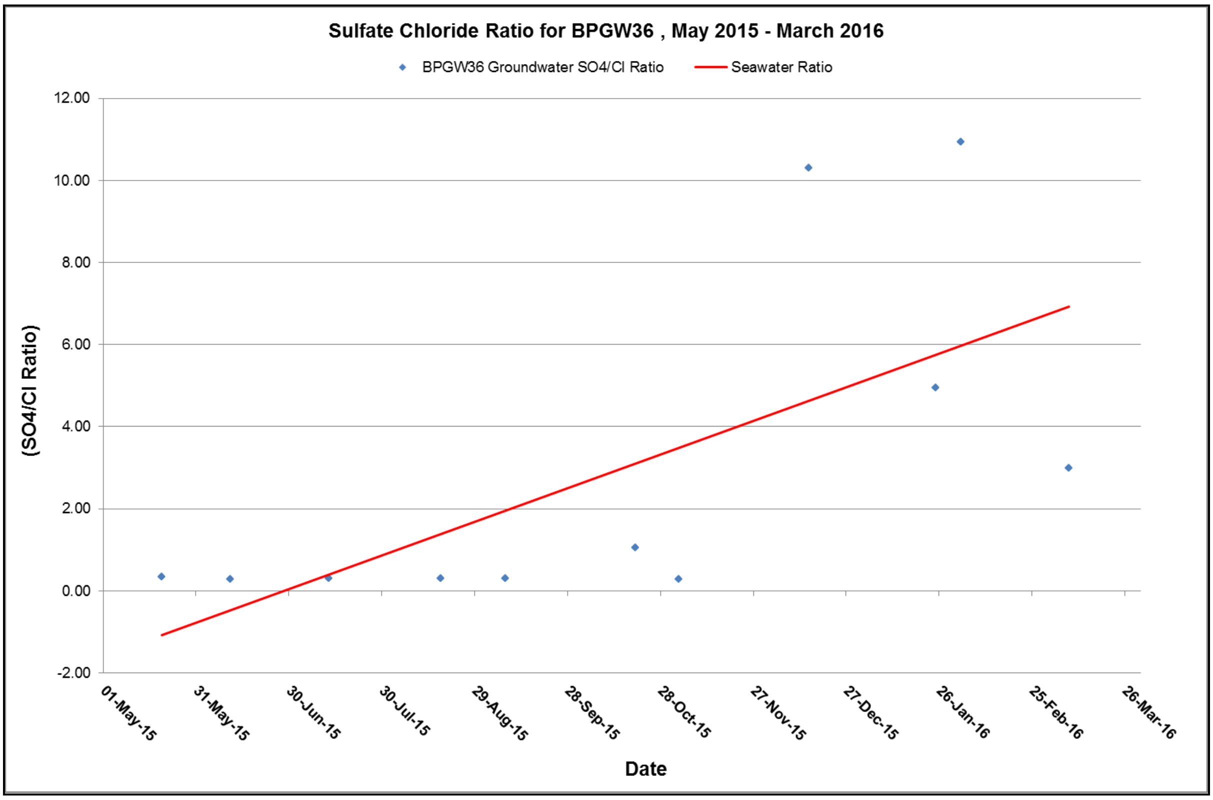



**Figure 4-11 Sulfate/Chloride Ratio for Bore BPGW36**

### 4.2.3 Understanding of Onsite Groundwater Aquifers

A numerical groundwater model was constructed for the Site during the previous annual monitoring period. The model was constructed for the uppermost aquifer which was considered to be the most susceptible to potential contamination from construction activities, spills and leaks. The uppermost aquifer was assessed to have very limited connection with the underling deep aquifers. The modelling concept was that the aquifer recharge occurred via rainwater infiltration and aquifer discharge occurred via groundwater flow to the estuary, creeks and Darwin Harbour.

The other key aspects of the Site hydrogeology were as follows:

- The presence of fresh and saline groundwater zones;
- Seasonal groundwater level and chemical concentration fluctuations; and
- The presence of hypersaline groundwater zones.

Conceptually there are three different groundwater bodies on Site, as follows:

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

With the existing groundwater monitoring bore network, it is not currently possible to define the extent of the seasonal freshwater lens, however, their source is likely to be rainwater infiltration. The depth of this lens also varies across the Site. It is likely that there is a confining layer that is present on the top of the saline groundwater aquifer which essentially minimises mixing between these two groundwater bodies. If a confining layer is absent, the freshwater lens may “float” on top of the saline water due to the density differential.

Groundwater sampling results show that the concentrations of chemicals of concern and groundwater salinity decrease during the wet seasons and increase during the dry seasons. These changes, which are mostly recorded for the groundwater bores with screens that may intersect the inferred interface between the saline and freshwater lenses may be due to the following:

- During groundwater sampling in the dry season there is a dominant inflow of groundwater into bore screens from the regional saline aquifer, which is naturally acidic and contains high concentrations of dissolved metals and nutrients, typically the metals and nutrients exceed the adopted trigger levels;
- During the wet season groundwater levels rise because of rainwater recharge and there is a dominant inflow into bore screens from the freshwater lens during groundwater sampling. As a result of this, groundwater samples contain a fresh and saline water mixture in variable proportion and the results show decreases in groundwater salinity and dissolved metals and nutrients due to dilution; and
- As the freshwater lens dissipates during the dry season, saline groundwater gradually becomes dominant in the groundwater samples which results in an increase in salinity and metals and nutrients concentrations.

## 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 4-12**.

During the annual monitoring period, a number of new sites were established and retained, as follows:

- Impact site BPMC24 was established (and background data were collected) in June 2015;
- Impact sites BPMC05, 06 and 07 were retained to monitor mangrove recovery in an area where a known mud wave and water ponding had occurred previously (AEMR [2014] and AEMR [2015]). The following mangrove community health parameters were monitored in December 2015 and March 2016; canopy cover, tree condition, photo monitoring, seedlings, crab burrows and pneumatophores; and
- Impact sites BPMC25 and BPMC26 were established (and background data were collected when the impact site was established) in December 2015 and September 2015, respectively.

The parameters used to monitor mangrove community health were seedling density and species composition, canopy cover, tree condition and benthic community health. 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.

Bio-indicators were sampled on a quarterly basis to account for seasonal variation.

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 mud whelk (*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 the EIMP. While exceedances of the trigger values 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 and discharges. The data collected is broadly consistent with the previous annual monitoring periods and both impact and reference locations.

#### 4.3.2.1 Mangrove Community Health

There were no exceedances of the 30% trigger value at any sites during the annual monitoring period. Canopy cover increased in the majority of survey plots in March 2016 with the largest overall increase recorded at impact sites (+5.72% ± 1.67 SE) when compared to reference sites (+2.05% ± 1.60 SE). Mean canopy cover was similar at reference sites (83.08 ± 1.23 SE) and impact sites (83.89 ± 2.04 SE). Across both impact and reference sites, the total canopy cover remained consistent with background data.

Canopy cover data has been summarised in **Figure 4-13** by comparing mean canopy cover for the three mangrove assemblages monitored, namely:

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

The results recorded during the annual monitoring period indicated that canopy cover has generally increased at all sites in comparison to background data, with the greatest overall increase recorded at impact sites within the Tidal Flat *Ceriops* assemblage. Tree condition has generally decreased slightly at all sites in comparison to background data however results were consistent with previous annual monitoring periods. Seedlings, pneumatophore and crab burrow data all recorded minor changes across impact sites and reference sites which indicated that this was likely attributable to natural temporal and/or seasonal variation.

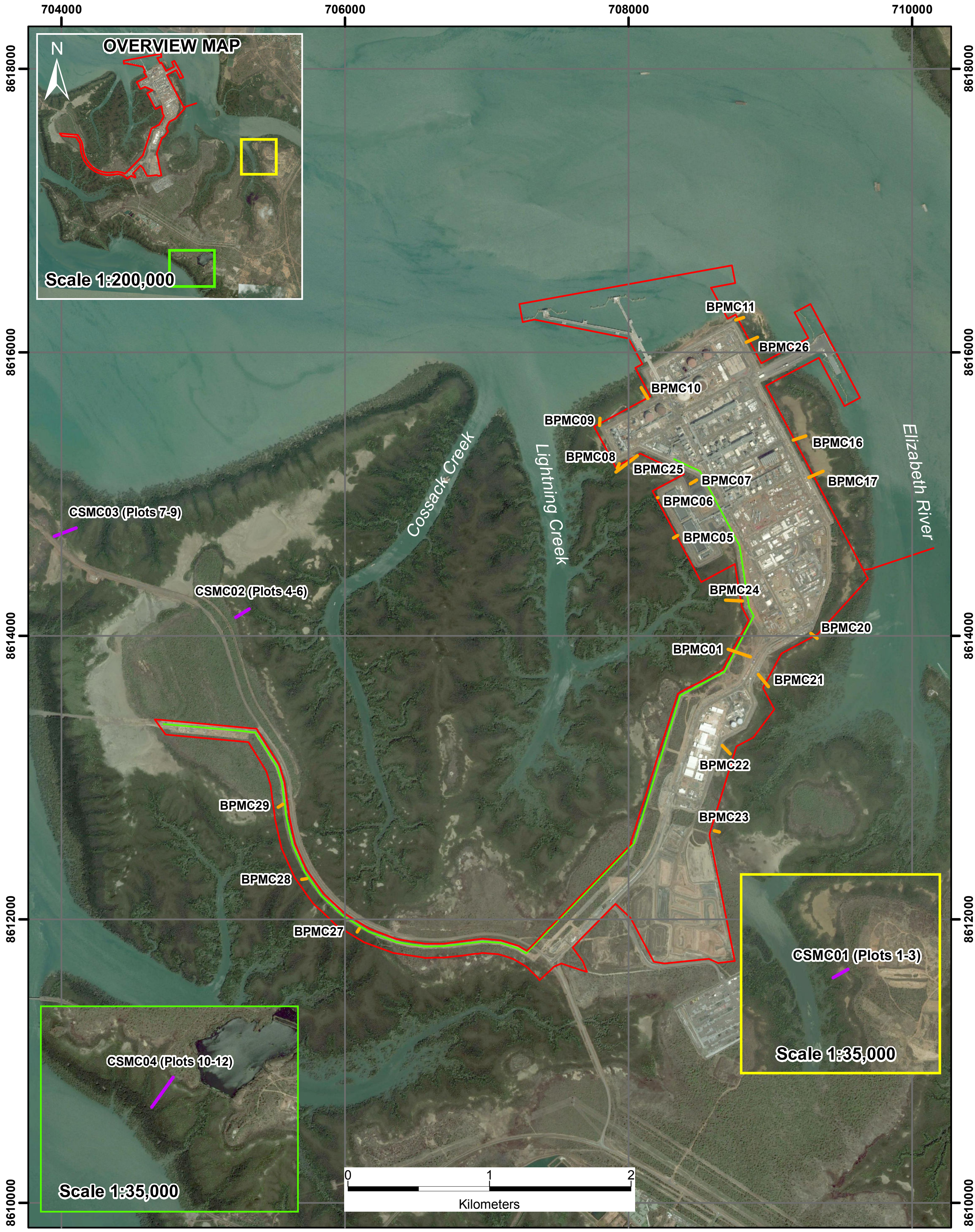
The following additional trends were also noted:

- Coinciding with the dry season, a slight increase in dust on mangrove canopies was noted for several locations during the June 2015 and September 2015 surveys; and
- Coinciding with the wet season, a decrease in dust on mangrove canopies was noted for the majority of locations during the December 2015 and March 2016 surveys.

The results in this annual monitoring period were also generally consistent with the June 2012 survey (AEMR [2013]) and background data collected in March 2015, June 2015, September 2015 and December 2015 with the exception of BPMC06 and BPMC07.

No discernible decline in mangrove community health was detected at the 20 impact sites surveyed during the annual monitoring period and this indicated that the mangrove communities located close to the Site have remained in a healthy condition.

There were no distinct mangrove community health impacts that could be attributed to Site activities and discharges, with the exception of BPMC06 and BPMC07. However, the decline in tree condition at these locations was associated with a known mud wave which occurred in June 2013 and ponding adjacent to the Flare Pad and was not considered representative of the overall health of fringing mangrove communities. These sites also appeared to be stabilising after the mud wave impacts in this area.




## Legend

- Site Boundary
- Gas Export Pipeline
- Mangrove Transects
- Mangrove Transects (Reference Sites)

| Mangrove Monitoring Locations | | |
|---|---|---|
| Figure 4-12 | INPEX Bladin Point | GREENCAP |
| ***Date:*** *6/05/2016* | **Author:** malcolm.nunn<br>**Map Scale:** 1:35,000 | |
| **Revision:** A | **Coordinate System:** GDA 1994 MGA Zone 52 | |
| R:_Projects\C110043_Inpex\GIS\Maps\BP_EPA7_Report\2016\FIG_4-12_Mangroves_160506.mxd | | |

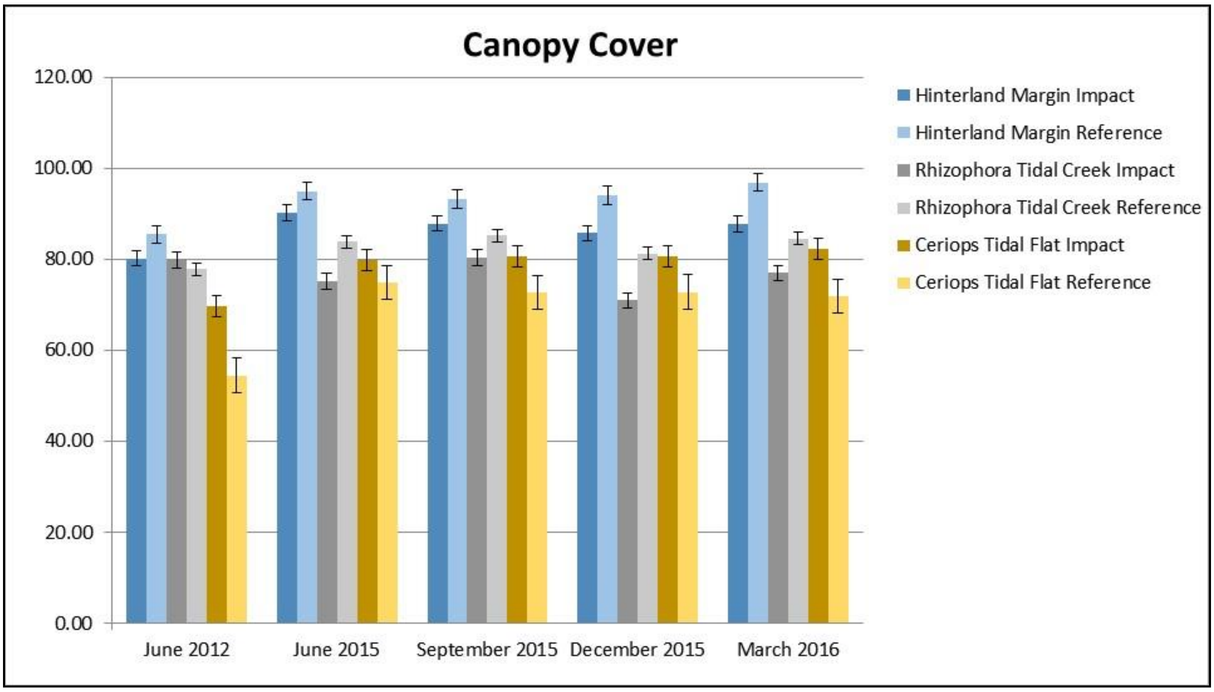



**Figure 4-13 Canopy Cover (mean values) Summarised for each Mangrove Assemblage**

#### 4.3.2.2 Sediment Quality

Total metals in sediments were within the adopted trigger values with the exception of arsenic, antimony and chromium. Bio-available metals in sediments were all below the adopted trigger values during the annual monitoring period.

Trigger value (high) exceedances of total arsenic were recorded at BPMC01 and BPMC24 during the majority of the quarterly monitoring events in the annual monitoring period. A possible reason for the consistently elevated arsenic concentrations at these locations may be their proximity to the isthmus, an area of known groundwater expression. Groundwater bore MW20b is located in relatively close proximity to these mangrove sites and contains elevated arsenic concentrations which suggests that arsenic-rich groundwater in the area could be expressing to these mangrove areas.

There was no trends observed indicating increasing metal concentrations in sediments at impact and reference sites during the annual monitoring period with the exception of total arsenic. While the number of arsenic exceedances has generally not increased since AEMR (2015) there has been an increasing trend in concentrations since June 2012 at impact and reference sites.

#### 4.3.2.3 Sedimentation and Erosion

The quarterly relative sediment height results indicated that there were no exceedances of the sedimentation and erosion trigger values and relative sediment heights remained stable in the annual monitoring period. The annual Differential Global Positioning System survey recorded two survey points where sediment level changes exceeded the trigger value. The largest change was along BPMC06 where the ground levels decreased by 20 cm in comparison to June 2014 and increased by a net 6.7 cm in comparison to the June 2012 background.

The data indicated that there had not been any broad-scale sedimentation or erosion during the annual monitoring period that had impacted mangroves fringing the Site. Within the mangrove environment, there is a dynamic relationship between erosion and sediment deposition resulting from tidal, cyclone and surface water runoff. Hence, small scale changes in sediment deposition or erosion are not necessarily deleterious to the mangrove environment and should be seen as part of the longer term processes driving mangrove habitat development.

Although there was a decrease in the number of ground level exceedances recorded between June 2014 and June 2015, two ground level exceedances were recorded. The largest decrease was along BPMC06 (20 cm) which indicated that the mud wave had moved through this area and sediment levels were decreasing. Results of mangrove community, and sediment and erosion monitoring indicated that it was unlikely that stormwater and construction water discharged from the Site resulted in any net deleterious effects on the mangrove communities fringing the Site.

#### 4.3.2.4 Bio-indicators

Metals in mud whelk tissue were within the adopted trigger values with the exception of arsenic, copper and mercury. The number of arsenic exceedances that were recorded during the annual monitoring period decreased in comparison to AEMR (2015). Conversely, the number of copper exceedances increased at both impact and reference sites while the number of mercury exceedances increased at impact sites in comparison to AEMR (2015).

There were no consistent increasing trends in metals concentrations at impact and reference sites in the period between June 2012 and March 2016, with the exception of arsenic. In the majority of cases, exceedances and elevated tissue metals concentrations have been recorded at both reference sites and impact sites, and no correlation was detected between the surface water monitoring program and sediment sampling program. This was assessed to be an indication that these patterns were attributable to natural seasonal variation and/or a regional source(s).

## 4.4 Dust

### 4.4.1 Monitoring Methodology

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

The 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 used 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 4-14**.

Fifteen 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 $PM_{10}$.

### 4.4.2 Results

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

During the annual monitoring period, there were 119 $PM_{10}$ and 71 $PM_{2.5}$ exceedances at PAPM01. However, there were no exceedances of the trigger values for 24-hour averaged dust levels recorded during vector-averaged south-westerly winds, which are the winds that blow along the impact pathway from Site towards the sensitive receptor location of Palmerston.

There were 162 $PM_{10}$ and 69 $PM_{2.5}$ exceedances at BPPM04 during the annual monitoring period and 20 exceedances of the trigger values for 24-hour averaged dust levels during vector-averaged northerly winds, which are winds that blow along the impact pathway from Site towards the sensitive receptor location of Bladin Central Enterprise Park.

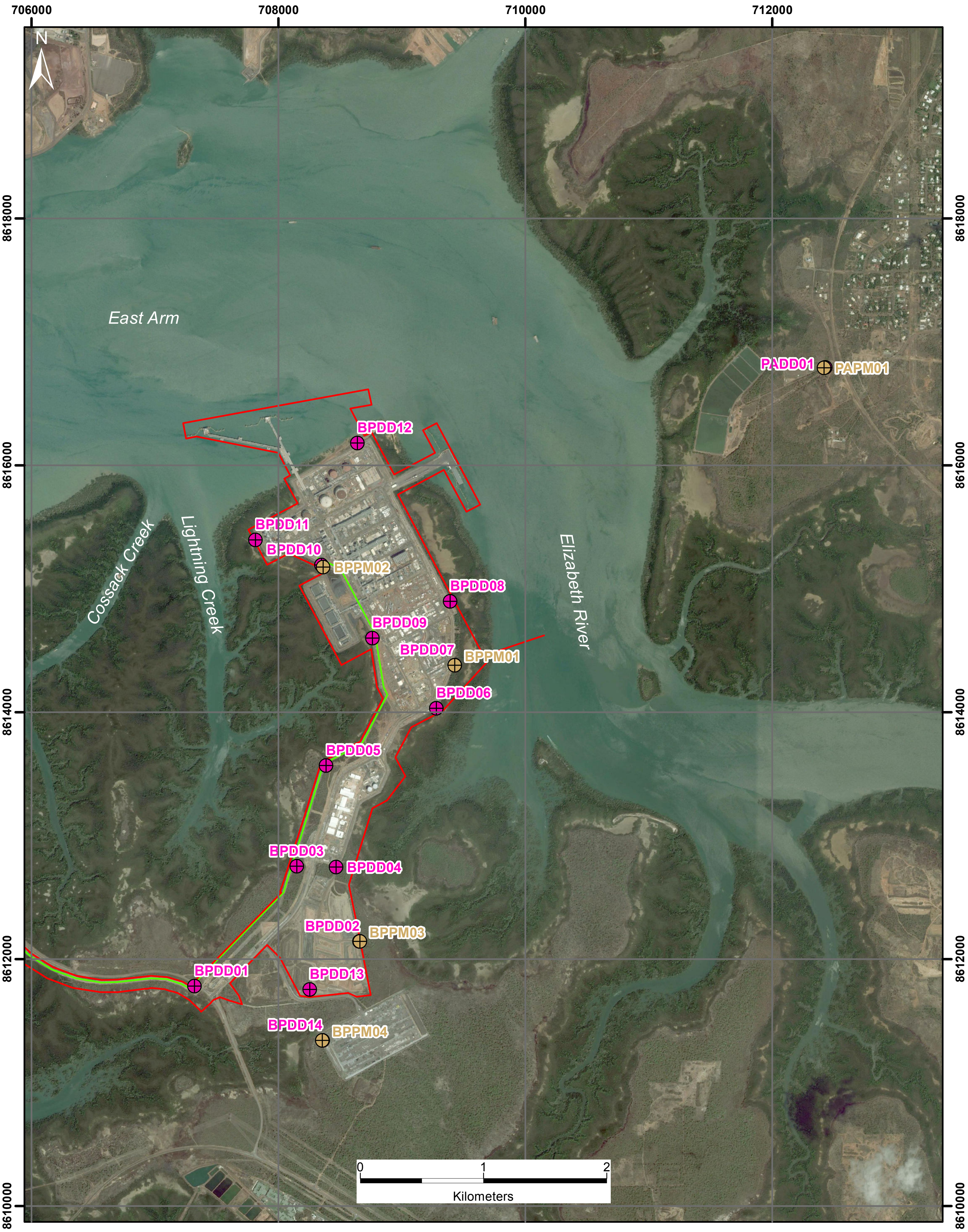
The exceedances recorded at BPPM04 were unlikely to impact receptors at Bladin Central Enterprise Park due to the distance between the dust monitor and the sensitive receptor location. The monitor is positioned at the Site boundary adjacent to the active lay-down area which is 1.28 km away. The winds speeds were relatively low (2-5 m/s) at the times that the exceedances were recorded at BPPM04 and therefore it is unlikely that dust exceedances at the monitor location would result in dust nuisance or health impacts at the sensitive receptor located this far away.

#### 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.

One exceedance of the dust deposition trigger value was recorded at the Palmerston monitoring location during the annual monitoring period.

Dust deposition gauges on Site provided data on potential impacts on the mangrove communities fringing the Site. The trigger value was exceeded at 12 out of 14 dust deposition gauges on Site, however, based on the fact that the mangroves remained in a healthy condition during the annual monitoring period, it was assessed that dust deposition did not adversely affect the mangrove community surrounding the Site.




## Legend

- Site Boundary
- Gas Export Pipeline
- Dust Monitoring Location (Dust Deposition Sample)
- Dust Monitoring Location (Particulate Matter Sample)

| Dust Monitoring Locations | | |
|---|---|---|
| Figure 4-14 | INPEX Bladin Point | GREENCAP |
| Date: 6/05/2016 | Author: malcolm.nunn<br>Map Scale: 1:40,000 | |
| Revision: A | Coordinate System: GDA 1994 MGA Zone 52 | |
| R:_Projects\C110043_Inpex\GIS\Maps\BP_EPA7_Report2016\FIG_4-14_Dust_160429.mxd | | |



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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 Site noise is giving rise to exceedances of the adopted noise trigger values at identified sensitive receptors

Monitoring occurred at three locations during the annual monitoring period (BPAN01, BPAN02 and PAAN01) (**Figure 4-15**).

### 4.5.2 Results

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

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 1.28 km. The noise attenuation curve developed as part of the noise attenuation investigation using hard ground shows that at a distance of 1.28 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 45.0 to 82.5 dB(A) during the day and 48.5 to 85.9 dB(A) at night. It was noted that noise levels at BPAN01 decreased over the Christmas period between 21 and 31 December 2015.

## 4.6 Flora and Fauna

The flora management objectives identified in the CEMP were to minimise disturbance to flora and alteration of mangrove communities outside the Site boundary due to Site activities. The fauna management objective was to avoid injury or death to native terrestrial fauna as a result of Site activities or discharges from Site.

Approximately 0.7 ha of vegetation was cleared along the GEP corridor during the annual monitoring period.

The majority of fauna interactions reported related to observations of fauna that was active on Site. Where required, fauna species such as snakes and birds were relocated away from Site activities or discharges. A small proportion of reported fauna interactions related to fauna injury or death and the most common cause was physical trauma due to entanglement in the perimeter fencing. Common species recorded in the fauna interactions register were migratory and non-migratory birds, flying foxes, wallabies, snakes, wild dogs and cats and crocodiles.

There were a number of incidents of flying foxes becoming entangled in the perimeter fence. The immediate response was the rescue of the animals by an approved fauna handler for transport to the veterinary hospital for treatment and visible tape was used as a temporary measure to avoid collisions. The solution to these incidents was the installation of humming tape around the Site perimeter fencing as an audible deterrent fauna control. Following the installation of the audible fauna deterrent tape, no further incidents were reported.


## Legend

- Site Boundary
- Gas Export Pipeline
- Noise Monitoring Locations

**Noise Monitoring Locations**

| | | |
|---|---|---|
| **Figure 4-15** | **INPEX Bladin Point** | GREENCAP |
| ***Date:*** *6/05/2016* | **Author:** malcolm.nunn | |
| | **Map Scale:** 1:40,000 | |
| **Revision:** A | **Coordinate System:** GDA 1994 MGA Zone 52 | |
| R:_Projects\C110043_Inpex\GIS\Maps\BP_EPA7_Report2016\FIG_4-15_Noise_160429.mxd | | |

## 4.7 Weeds

The objective of the weed monitoring program is to assess the impact of Site activities on the distribution of weed species.

The results of the weed surveys carried out in the annual monitoring period indicated that the spread of weeds across the Site had generally increased and in some cases had spread into adjacent woodland. Weed infestations were mainly restricted to the EMA, the EMA stabilised stockpiles, the EMA haul roads and the GEP corridor area.

The weed species which were most abundant on Site included Gamba Grass, both Mission Grass species and Horehound.

The control measures as specified in the CEMP are still considered to be appropriate and effective to prevent the introduction and increase of declared weed species and WONS. It is recommended that an extensive weed control program including the application of herbicides commences around December 2016 or at the onset of the wet season when re-growth occurs.

Four new weed species were recorded on Site during the annual monitoring period, namely one Class B species (Sicklepod) and three exotic, non-native species (Cobbler's Peg, Goat Weed and Carribean Stylo), which are all common in the Darwin Region.

# 5. RISK ASSESSMENT

The risk assessment used in the AEMR is aligned with the environmental risk identification and assessment process in the CEMP and the risk rankings are drawn from the Environmental Risk Register (dated 22 February 2016; S-0290-1242-C303). The Risk Register is a collation of the Projects risks generated from the various Environmental Risk Assessments 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 was carried out. This included comparison of the results to identify if any potential impacts had arisen during the annual monitoring period.

The data collected was also used to inform other management plans and tools that included the CEMP and the Environmental Risk Register to support the mitigation of the major environmental risks posed by Site activities or discharges. The risk assessment in the AEMR was updated to reflect Project staging and emerging risks as identified from updates to the Risk Register and monitoring data collected.

## 5.1 National Environmental Protection Measure Requirement

In accordance with the NEPM (2013), environmental 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 the AEMR was qualitative (e.g. low, moderate, high and critical) and was based on the potential for exposure (likelihood) and the potential magnitude of environmental impacts (consequences) which resulted in changes in the risk profile. These risk factors are described further in the CEMP.

This risk assessment makes a qualitative assessment of risk via comparison with environmental criteria for potential source-pathway-receptor linkages in the CEMP and the Environmental Risk Register. 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).

It should be noted that a beneficial use assessment was undertaken in AEMR (2014), that is still applicable, and assessed that the only applicable beneficial use at the present time for groundwater at the Site was for environmental purposes. Other potential future uses not applicable to the Site included agriculture, public water supply, rural stock and domestic supply.

## 5.2 Surface Water Monitoring Program

### 5.2.1 Qualitative Risk Assessment

According to the risk assessment approach the potential sources of impacts were noted as construction activities generating surface water and sediment discharges. The potential impact pathways include mobilisation of contamination to groundwater or surface waters and discharge into the receiving environment. Receptors include the mangrove habitats and the ecosystems in Darwin Harbour.

##### 5.2.1.1 Surface Water Contamination

All spill events on Site were limited in area, were routinely cleaned up and impacts were not detected in either the surface monitoring programs. It was therefore concluded that the potential for on-and-offsite surface water contamination remained low.

The majority of surface water monitoring locations did not exceed the adopted trigger values for metals and metalloids during the annual monitoring period. For those isolated events where metal exceedances occurred, they were assessed as being within natural, seasonal and/or annual variations.

Where elevated analyte concentrations were noted (e.g. nutrients and metals), these were mostly demonstrated to be isolated events or related to natural, seasonal and/or annual variations, organic inputs from catchment areas and tidal movements in Darwin Harbour. There were instances where non-compliant exceedances with the WDL-192 and WDL-211 Licence conditions were recorded. Investigations concluded that these exceedances were either isolated exceedances or were also detected at EIMP and WDL reference sites. It was assessed that the risk of environmental harm from these WwTP discharges was low.

Results of the onsite surface water monitoring program were representative of the surface water quality in the onsite basins and no direct link between auto-sampler water quality results and marine surface water monitoring results could be established. Metal concentrations in the auto-sampler samples were considered representative of differing rain event intensities and duration and the interaction with naturally metalliferous soils commonly found on Site.

The risk ranking as detailed in the CEMP and Environmental Risk Register remained moderate for any potential contamination associated with spills and leaks.

##### 5.2.1.2 Sediment Transport

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

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

## 5.3 Groundwater Monitoring Program

### 5.3.1 Qualitative Risk Assessment

According to the risk assessment approach the potential sources of impact were earthworks, ground improvement works, ASS and spills. The impact pathway is ingress/inflow of contaminated water into groundwater and migration offsite. Receptors include the mangrove habitats and the ecosystems in Darwin Harbour.

##### 5.3.1.1 Groundwater Levels and Quality

The objectives for the groundwater monitoring program were to minimise changes in groundwater levels and quality as a result of Site activities or discharges from Site.

Groundwater level fluctuations in bores located in the centre of the Site were attributed to seasonal rainfall and recharge while bores located along the perimeter of the Site were more influenced by tides. Following the late onset of the wet season and subsequent recharge, groundwater levels returned to the normal seasonal cycle.

The results of the groundwater quality monitoring conducted during the annual monitoring period confirmed the historical seasonal trends and indicated that the groundwater beneath the Site contains elevated metal and nutrient concentrations resulting from natural processes involving groundwater interaction with acidic soils and organic sources.

The trend analysis confirmed the presence of metals and nutrients in groundwater which showed seasonal variation dependent on rainfall events and subsequent aquifer recharge.

The majority of the onsite spills were limited in area, were routinely cleaned up and were not detected in the groundwater monitoring program, and the potential for on-and-offsite groundwater contamination remained low.

The risk ranking has remained moderate for concentrations of metals and nutrients 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 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 Site activities or discharges from Site.

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 or discharges from Site. The data collected were broadly consistent with data collected during previous annual monitoring periods.

The risk ranking remained moderate for ASS impacts to groundwater and any effects on the surrounding mangrove environment were localised and minor.

## 5.4 Mangrove, Sediments and Bio-indicator Monitoring Program

### 5.4.1 Qualitative Risk Assessment

Objectives for the mangrove community health, sediment and bio-indicator monitoring program included minimising the disturbance to and alteration of mangrove communities as a result of changes to groundwater levels or quality arising from Site activities or discharges.

#### 5.4.1.1 Sedimentation, Erosion, Sediment Quality and Bio-indicators

The data collected indicated that there had not been any broad-scale sedimentation or erosion impacts during the annual monitoring period that had impacted mangroves fringing the Site. Although there was a decrease in the number of ground level exceedances recorded between June 2014 and June 2015, two ground level exceedances were recorded. The largest decrease was along BPMC06 (20 cm) which indicated that the mud wave had moved through this area and sediment levels were decreasing.

There was no trend indicating increasing metal concentrations in sediments at impact and reference sites during the annual monitoring period with the exception of total arsenic. While the number of arsenic exceedances has generally not increased since AEMR (2015) there has been an increasing trend in concentrations since June 2012 at impact and reference sites. After consideration of bio-availability, all metals exceedances in sediments were below the ISQG-Low trigger value in the annual monitoring period.

Since June 2014, when the frequency of bio-indicator monitoring was revised to quarterly, there has been substantial variability in the data between monitoring periods and between impact sites and reference sites. Some of this variability may be attributed to sample size variation, location, tides, and climatic and seasonal changes. In the majority of cases, exceedances and elevated tissue metals concentrations have been recorded at both reference sites and impact sites, which indicated that these patterns were likely attributable to natural seasonal variation and/or a regional source(s).

Based on the results of the sedimentation, erosion, sediment quality and bio-indicator monitoring it was assessed that stormwater and construction water discharged from the Site had not resulted in deleterious effects on the mangrove communities fringing the Site.

The risk ranking for sedimentation, erosion, sediment quality and bio-indicator impacts remained low.

#### 5.4.1.2 Mangrove Community Health

The results of the mangrove community health monitoring program indicated that the majority of mangrove trees were healthy and the trigger value for tree condition was not exceeded in 19 out of 20 impact sites. BPMC06 was previously impacted by a known mud wave and water ponding, however, this area appears to have stabilised.

Dust deposition gauges on Site provided data on potential impacts on the mangrove communities fringing the Site. The trigger value was exceeded at 12 out of 14 dust deposition gauges on Site, however during mangrove monitoring surveys, no correlation between dust deposition on mangrove leaves and a decline in mangrove community health was established.

Trends in canopy cover at impact sites 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.

## 5.5 Dust Monitoring Program

### 5.5.1 Qualitative Risk Assessment

According to the risk assessment approach the potential sources of impact were earthworks and general construction activities, the impact pathway is winds blowing from Site and the receptors were mangroves fringing the Site and sensitive receptors located in Palmerston and Bladin Central Enterprise Park.

#### 5.5.1.1 Dust Impacts on the Environment and Workforce

No $PM_{10}$ or $PM_{2.5}$ exceedances were recorded at Palmerston (PAPM01) during south-westerly winds (i.e. along the impact pathway) and therefore, it was assessed that Site activities had not resulted in dust impacts at this sensitive receptor location.

Twenty $PM_{10}$ exceedances and no $PM_{2.5}$ exceedances were recorded at BPPM04 during northerly winds (i.e. along the impact pathway). No reports of dust complaints were received.

Only one exceedance of the dust deposition trigger value was recorded at PADD01. No records of dust complaints were received during the annual monitoring period. No dust deposition exceedances were recorded at BPDD14 during the annual monitoring period.

The risk ranking remained low for dust impacts (nuisance and health impacts) and dust deposition on surrounding vegetation resulting in smothering and reduced growth. The risk ranking of low for Bladin Central Enterprise Park is based on the fact that the BPPM04 dust monitor is not located at the sensitive receptor location itself but is positioned at the Site boundary adjacent to the active lay-down area which is 1.28 km away. In addition, the winds speeds were relatively low (2-5 m/s) at the times that the exceedances were recorded. As such, it is very unlikely that dust exceedances at the monitor location (which would probably be caused by Site activities when winds blow from the northern quadrant) would necessarily result in dust nuisance or health impacts at the sensitive receptor located this far away.

## 5.6 Airborne Noise Monitoring Program

### 5.6.1 Qualitative Risk Assessment

According to the risk assessment approach the potential source of impact was general construction activities, the impact pathway was sound propagation through air (as a longitudinal wave) and sensitive receptors are in Palmerston and Bladin Central Enterprise Park.

#### 5.6.1.1 Noise Impacts to Local Community

No noise complaints were received during the annual monitoring period.

The day-time and night-time exceedances recorded at PAAN01 were evaluated with reference to available audio files and were typically confirmed to be related to insects, frogs, birdsong and passing trains and aircraft.

Assessment of available audio files collected from BPAN02 indicated that the majority of exceedances at this noise monitoring location were caused by Site activities within the Area 1888 Laydown Area, however, noise attenuation analysis undertaken previously indicated that these events would not have caused an exceedance of the residential trigger values at the Bladin Central Enterprise Park.

The risk ranking for noise impacts (nuisance and health impacts) remained low.

## 5.7 Flora and Fauna Monitoring Program

### 5.7.1 Qualitative Risk Assessment

According to the risk assessment approach the potential sources of impact were vegetation clearing and ponding water. The receptors were mangrove fauna and flora at the Site.

#### 5.7.1.1 Flora and Fauna

Limited vegetation clearance, restricted to the GEP corridor, occurred during the annual monitoring period.

Fauna injury or deaths did not occur frequently on Site during the annual monitoring period and the only investigation involved the incidents relating to flying fox entanglements in the perimeter fence. The majority of fauna interactions reported related to observations of fauna occurring on Site. In these instances, no follow up action was required. The risk ranking related to fauna and mangrove flora impacts remained moderate and any effects on the surrounding environment have been localised and minor.

## 5.8 Weed Monitoring Program

### 5.8.1 Qualitative Risk Assessment

According to the risk assessment approach the potential sources of impact were general site activities, vehicles and clearing activities. The pathway is the transport of weed/pest species and the receptors were natural vegetation communities surrounding the Site.

#### 5.8.1.1 Weed Management

The results of the weed surveys carried out in the annual monitoring period indicated that the spread of weeds across the Site had generally increased and in some cases had spread into adjacent woodland. Weed infestations were mainly restricted to the EMA, the EMA stabilised stockpiles, the EMA haul roads and the GEP corridor area. The weed species that were most abundant on Site included Gamba Grass, both Mission Grass species and Horehound.

Four new weed species were recorded on Site during the annual monitoring period, namely one Class B species (Sicklepod) and three exotic, non-native species (Cobbler's Peg, Goat Weed and Carribean Stylo), and are common in the Darwin Region.

Remaining areas of weed colonisation which require further attention are along the EMA eastern boundary, EMA stabilised stockpiles, along the Site access road opposite build-1, at several locations in stormwater drains throughout Site, along the GEP corridor, along the eastern Site perimeter and of particular priority is a Gamba Grass incursion into undisturbed natural vegetation adjacent to the GEP corridor which has increased in size since first recorded in November 2015.

The control measures as specified in the CEMP are still considered to be appropriate and effective to prevent the introduction and increase of declared weed species and WONS. However, the control measures need to be applied more frequently, extensively and during the correct season to prevent the further distribution and abundance of weed infestations. In many cases the weed control measures have been applied when the plants are at the end of their active growth stage and will not take up herbicide. It is recommended that an extensive weed control program including the application of herbicides commences around December 2016 or at the onset of the wet season when re-growth occurs.

## 5.9 Adaptive Response Monitoring

### 5.9.1 Firefighting Product Spill

A spill of firefighting product that was stored at Bladin Point was identified on 16 October 2015. The Site was immediately remediated and an investigation was completed. Nearby soil, surface water, groundwater, sediment and bio-indicator testing was undertaken during and after the remediation works were completed. The investigation found that risks to the receiving environment from surface water and groundwater pathways to be low, that no deleterious effects to offsite mangrove habitats occurred and there were no exceedances of trigger values for bio-indicator species.

### 5.9.2 Diesel Spill

A diesel spill was reported at the northern end of Area E600 at the fire hydrant tanks on 3 September 2014. Clean up activities were immediately undertaken. Groundwater sampling at nearby groundwater monitoring bores was instigated and no hydrocarbons (diesel) were detected. Diesel was also not detected through monitoring of mangrove sediments and bio-indicators.

## 6. CONCLUSION

In conclusion, the AEMR provided a clear understanding of the Project's potential impacts on the adjacent receiving environment -. While there were exceedances across some parameters during the annual monitoring period, it was assessed that these did not result in environmental harm in the receiving environment.

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