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Subcontract Package Name:	**ENVIRONMENTAL IMPACT MONITORING PROGRAM**
DOCUMENT TITLE:	EPA7 ANNUAL REPORT 2014 - ENVIRONMENTAL IMPACT MONITORING PROGRAM
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ICHTHYS ONSHORE LNG FACILITIES

JKC AUSTRALIA LNG PTY LTD

INPEX

Darwin, Australia

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

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PJ DEPT.		
RESPONSIBLE DEPT.	DOC-EIMP	A PHU
RELATED DEPT.		
CTR REVIEW DATE :	15-JUL-2014	

JOB. NO.	0-6037-2	REVIEW CLASS	~~2~~ 1

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CPY DOC.no.	**L 290 - AH - REP - 10215**	**0**
CTR DOC.no.	Subcontract No. - SERIAL no.. **V - 3365 - SC119 - 8011**	

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Annual Environmental Monitoring Report required by EPA7 Condition 29

Ichthys On-Shore Liquefied Natural Gas Facilities

Bladin Point

Prepared for:
JKC Australia LNG Pty Ltd

Date: 14 July 2014

Prepared by:

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Annual Environmental Monitoring Report required by EPA7 Condition 29, July 2014

Contractor Doc. No: V-3365-SC119-8011

Company Doc. No: L290-AH-REP-10215

AEC Doc No.: AEC11

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Written:	**Checked:**	**Approved:**
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ABBREVIATIONS

Abbreviation	Description
ADWG	Australian Drinking Water Guidelines
ALARP	As low as reasonably practicable
AMS	Adaptive Management Strategy
ANZECC	Australian and New Zealand Environment Conservation Council
ANZECC Guidelines	*Australian and New Zealand Guidelines for Fresh and Marine Water Quality*
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASS	Acid Sulfate Soil
BOM	Australian Bureau of Meteorology
CEMP	Construction Environmental Management Plan
DLNG	Darwin Liquefied Natural Gas
DO	Dissolved Oxygen
EC	Electrical Conductivity
E. *coli*	*Escherichia coli*
EIMP	Environmental Impact Monitoring Program
EIS	Environmental Impact Statement
EMA	Extractive Materials Area
EPA7	Environment Protection Approval 7-2
EPC	Engineering Procurement and Construction
ESCP	Erosion and Sediment Control Plan
FRP	Filterable Reactive Phosphorus
FSANZ	Food Standards Australia New Zealand
g	Gram
GEP	Gas Export Pipeline
GIIP	Good International Industry Practice
GPS	Global Positioning System
ha	Hectare
HCO_3	Bicarbonate
IECA	International Erosion Control Association
ISQG	Interim Sediment Quality Guideline
Jetty	Product Loading Jetty
L	Litre
L_{Aeq}	Equivalent continuous A-weighted sound pressure level
LNG	Liquefied Natural Gas
LOR	Limit of Reporting
LPG	Liquefied Petroleum Gas

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Abbreviation	Description
m	Metre
mg	Milligram
mm	Millimetre
MOF	Module Offloading Facility
mV	Millivolt
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
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTU	Nephelometric Turbidity Units
Palmerston	City of Palmerston
PASS	Potential acid sulfate soil
pH	Acid/alkaline value
PM_{10}	Particulate matter of 10 microns or less in size
$PM_{2.5}$	Particulate matter of 2.5 microns or less in size
ppt	Parts per thousand
PVC	Polyvinyl chloride
QASSIT	Queensland Acid Sulfate Soils Investigation Team
Redox	Reduction-oxidation
s	Second
SO_4	Sulfate
SWL	Standing water level
TECs	Threatened Ecological Communities
TEOM	Tapered Element Oscillating Microbalance
TDS	Total Dissolved Solids
TPWC Act	*Territory Parks and Wildlife Conservation Act* (NT)
TRH	Total Recoverable Hydrocarbons
TSS	Total Suspended Solids
µg	Microgram
uPVC	Unplasticised polyvinyl chloride
WM Act	*Weed Management Act* (NT)
WONS	Weeds of National Significance
WQOs	Water Quality Objectives

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1. INTRODUCTION

1.1 Project Background

INPEX Holdings Australia Pty Ltd (INPEX) is working with its joint venture partners Total, Tokyo Gas, Osaka Gas, Chubu Electric and Toho Gas to develop the Ichthys gas and condensate field (the Ichthys Field) in the Browse Basin, around 450 km north-northeast 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 Project.

The 'Project' is defined to include the Ichthys Onshore Liquefied Natural Gas (LNG) Facilities and its supporting infrastructure at Bladin Point, including the product loading jetty (Jetty) and module offloading facility (MOF). The Project does not include the Manigurr-ma Village or offshore infrastructure. **Figure 1-2** identifies the Project area, being the area within the site boundary, and includes the construction footprint.

This document is the *Annual Environmental Monitoring Report required by EPA7 Condition 29* (EPA7 Report [2014]*)*, that reflects the environmental monitoring carried out from 1 May 2013 to 30 April 2014 (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. This report provides a synopsis of the monitoring undertaken during the annual monitoring period. The detailed assessment of all environmental monitoring results and trends throughout the annual monitoring period is presented in the *2013-2014 Annual Report Environmental Impact Monitoring Program Ichthys On-Shore Liquefied Natural Gas (LNG) Facilities* (AEC Environmental Pty Ltd, 2014).

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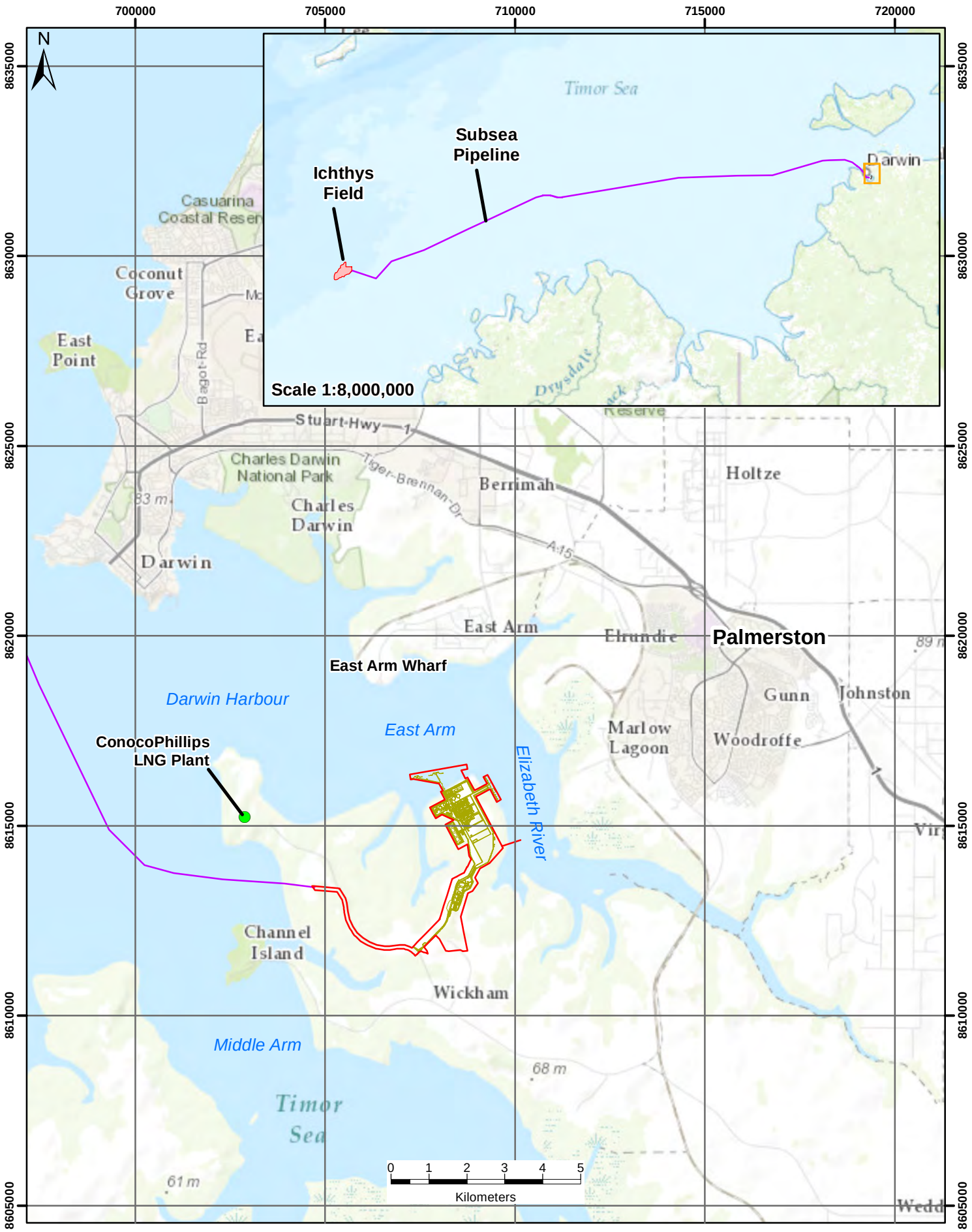

Legend

- Site Boundary
- Subsea Pipeline
- Construction Footprint
- ConocoPhillips LNG Plant
- Ichthys Field

Project Location		
Figure 1-1	INPEX Bladin Point	greencap AEC Environmental
Date: 20/06/2014	Author: Christopher.Maddox	
	Map Scale: 1:130,000	
Revision: R1	Coordinate System: GDA 1994 MGA Zone 52	
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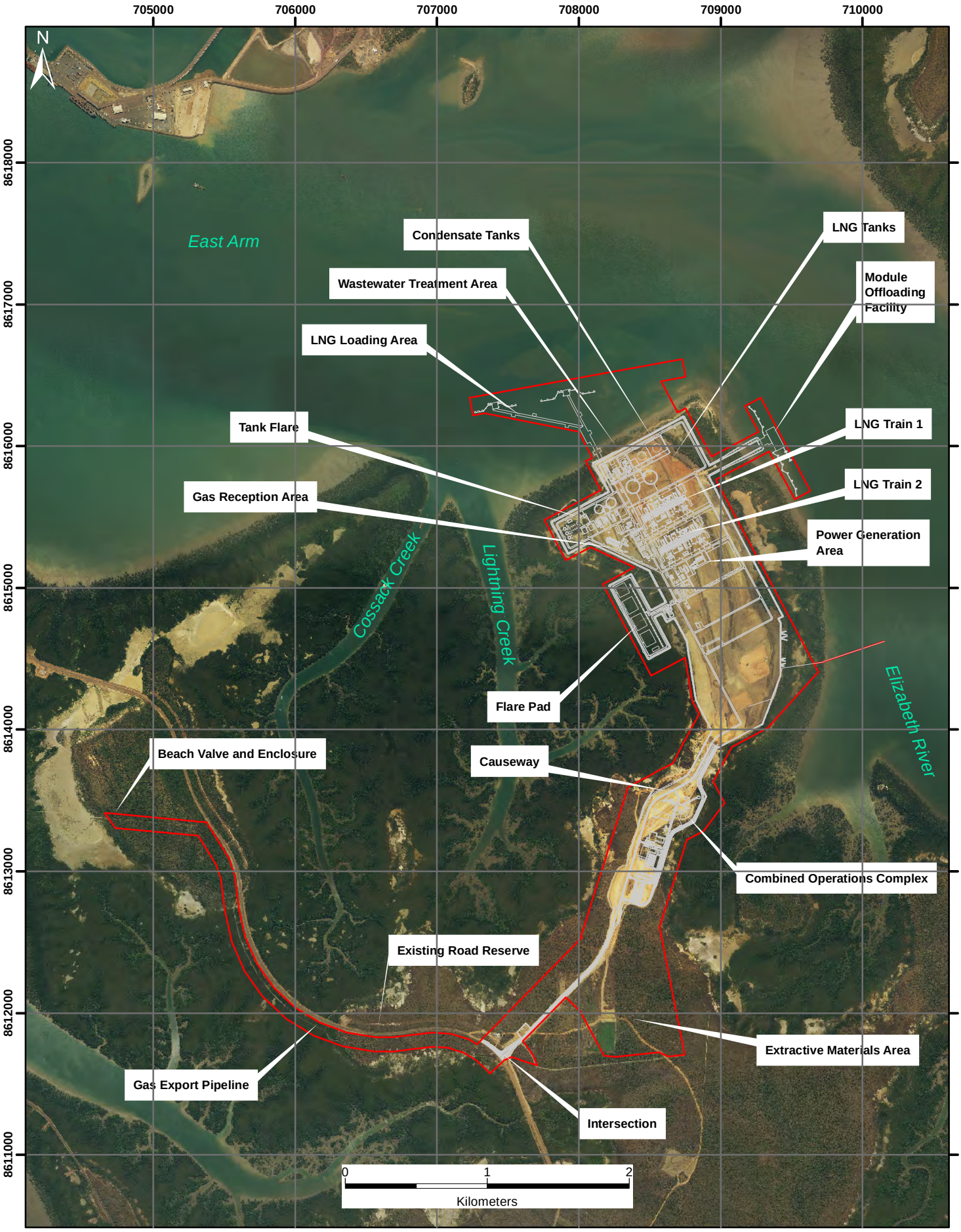

Legend

- Site Boundary
- Construction Footprint

Project Area of the Bladin Point Site

Figure 1-2	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:35,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
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2. ENVIRONMENTAL STRATEGY

2.1 Construction Environmental Management Plan

The *Construction Environmental Management Plan* (JKC Australia LNG Pty Ltd, 2014) (L290-AH-PLN-0059) (CEMP) details the environmental protection management measures and controls necessary to avoid, reduce or mitigate the environmental impacts during the construction phase of the Project. The CEMP provides objectives and targets for monitoring of:

- Surface water;
- Groundwater;
- Mangrove community health, sediment and bio-indicators;
- Air quality;
- Airborne noise;
- Flora and fauna; and
- Weeds.

2.2 Environmental Impact Monitoring Program (EIMP)

An *Environmental Impact Monitoring Program* (JKC Australia LNG Pty Ltd, 2013) (L290-AH-PLN-10013) (EIMP) was developed to detail the establishment, implementation, monitoring performance criteria and reporting requirements of the monitoring requirements of the CEMP.

Monitoring programs for the following aspects of the Project have been developed and documented in the EIMP:

- Surface water monitoring;
- Groundwater quality monitoring;
- Mangrove community health, sediments and bio-indicator monitoring;
- Air quality (dust) monitoring; and
- Airborne noise monitoring (this does not include the results of underwater noise monitoring, as this is outside the scope of the EIMP and this EPA7 Report).

In addition to the results of the monitoring programs listed above, other monitoring results for the following have also been included in this EPA7 Report:

- Acid sulfate soil (ASS) management;
- Flora and fauna management; and
- Weed management.

While not part of the ongoing EIMP, these are a component of the ongoing maintenance and inspection/site tracking process.

Table 2-1 summarises the specific objectives of each environmental strategy in the EIMP.

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Table 2-1 EIMP Objectives and Targets

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

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

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3. SITE INFORMATION

3.1 Site Identification and History

The Project area is located approximately 16 kilometres (km) south-east of Darwin in the Northern Territory, adjoining the southern portion of Darwin Harbour, and occupies an area of approximately 406 hectares (ha) (**Figure 1-1**).

The Project area is located on Bladin Point on Middle Arm Peninsula. The Project area is located at 1000 and 1232 Channel Island Road, adjacent Crown Land and sections of Darwin Harbour (Sections 1980 and 1814).

The Project area is situated approximately 2 km to the south-west of the City of Palmerston (Palmerston) and approximately 2.5 km south-east of East Arm Peninsula which is developed with light industry, warehouses and a cement manufacturing plant (**Figure 1-1**). The existing Darwin Liquefied Natural Gas (DLNG) plant is located approximately 2 km to the west of the Project area.

3.2 Surrounding Environment

Bladin Point is a low-lying peninsula which is separated from the mainland by a mudflat. The dominant soils covering over half the area on the undulating terrain are shallow to moderately deep, very gravely massive earth. The residual soils are typically 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 overland streams that discharge into the surrounding water bodies. Surface water historically flowed from the high point along the centre of the Peninsula to the east, north and west. Construction works have modified the topography of the site but have maintained the general discharge to the north, east and south through specifically constructed discharge points. The main access road for the site has been constructed through a salt flat located at the isthmus between Bladin Point and the mainland.

The water quality of Darwin Harbour is regarded as '*slightly modified*' in accordance with the *Water Quality Objectives for the Darwin Harbour Region – Background Document* (Darwin Harbour WQOs) (NRETAS, 2010). Bladin Point is part of the Darwin Coastal Bioregion and prior to clearing was dominated by woodland and monsoon vine forest with fringing patches of mixed low woodland species and *Melaleuca* forest. The woodland community mostly consisted of *Eucalyptus miniata* (Darwin woollybutt) and *E. tetrodonta* (Darwin stringybark) with mixed mid-storey species including *Cycas armstrongii* (NRETAS, 2011) which is listed as vulnerable under the *Territory Parks and Wildlife Conservation Act* (NT) (TPWC Act). Clearing was undertaken as part of the approved development permit.

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

3.3 Climate

The Project area lies within the monsoonal tropics of northern Australia and experiences two distinct seasons: a hot wet season from November to March and a warm dry season from May to September. April and October are transitional months between the wet and dry seasons. Climatic data has been recorded by the Project's on-site weather station since October 2012.and includes collected rainfall, temperature, humidity and wind speed/direction data.

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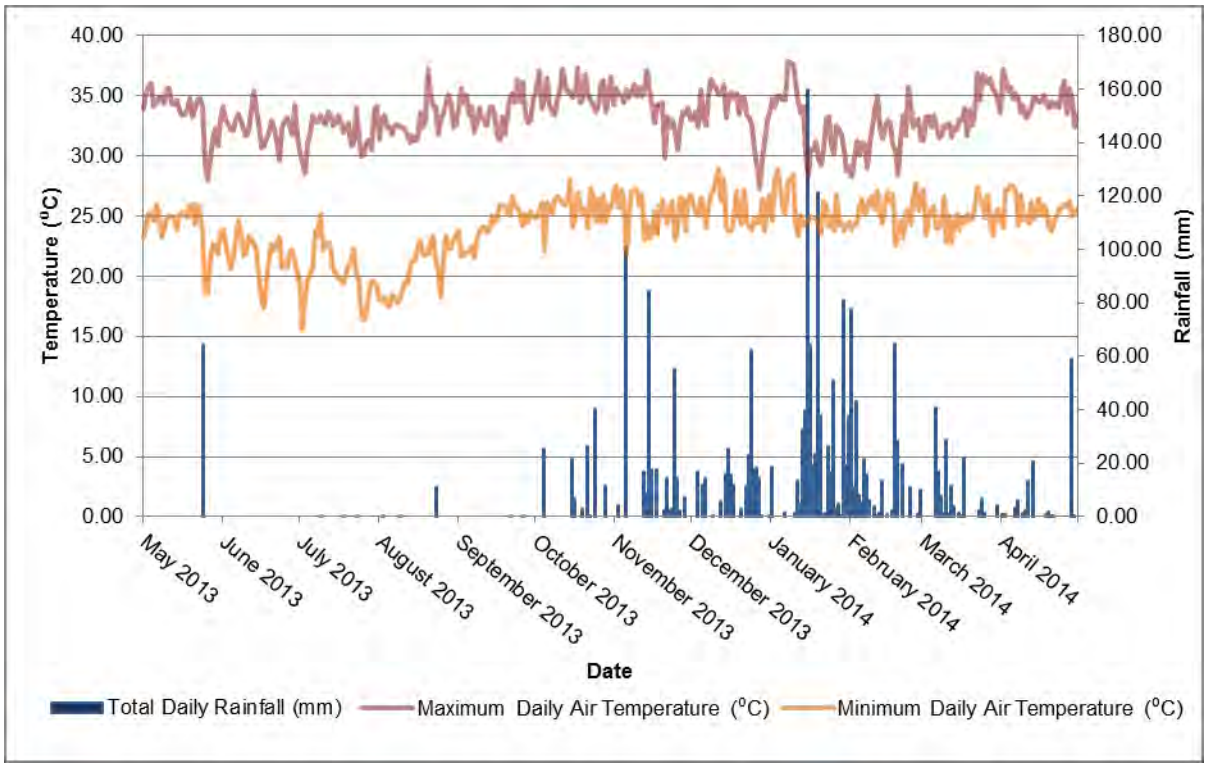
Rainfall in the 2014 wet season was significantly higher than both the previous wet season and the historical average, whilst temperature and wind speeds were consistent for the area. The Australian Bureau of Meteorology (BOM) reported the following summary (BOM, 2014):

> *A typical buildup period was followed by one of the earliest monsoon onsets on record at Darwin. The last week of November saw an active monsoon trough over the Top End and included the impact of tropical cyclone* Alessia*. Early January saw high temperatures and a few January temperature records set across the Top End. Around 13 January another active monsoon period began which lasted nearly five weeks and included ex-tropical cyclone* Fletcher *and two other tropical lows which moved across the Territory. March was quite dry across the Top End. The wet season ended with a series of small rainfall events that continued until the end of April.*

During the annual monitoring period the Project area received a total rainfall of 2217.6 millimetres (mm), with rain falling on 123 days, mainly in the wet season. October was the hottest month with a temperature range of 22.2 °C minimum to 37.3 °C maximum.

A summary of the climatic data collected during the annual monitoring period is presented in **Chart 3-1**.

Chart 3-1 Summary of Climatic Data, May 2013 – April 2014



3.4 Site Construction Activities – May 2013 - April 2014

Civil and infrastructure site works continued through the annual monitoring period in the Project area, comprising:

- Bulk earthworks;
- Ground improvement;
- ASS treatment and hardstand construction;
- Roadworks and facilities installation; and
- Piling.

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4. RESULTS

4.1 Surface Water

4.1.1 Monitoring Methodology

The monthly surface water monitoring program is designed to detect potential upstream and downstream impacts from discharges associated with basins, spills and leaks from construction activities and ASS impacts.

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

- Thirteen off-site marine monitoring sites located in Darwin Harbour around the Project area;
- Two reference sites located in Darwin Harbour near East Arm; and
- On-site basins within the Project area.

Figure 4-1 presents the surface water monitoring locations.

The following analytes were recorded in-situ:

- Temperature;
- Electrical conductivity;
- pH;
- Turbidity;
- Dissolved oxygen (DO);
- Oxidation reduction potential (ORP); and
- Salinity.

Each of the collected surface water samples were analysed for:

- Total and dissolved metals;
- Total dissolved and suspended solids (TDS and TSS);
- Alkalinity;
- Nutrients (ammonia, nitrate, nitrite, total kjeldahl nitrogen, total nitrogen, reactive phosphorus and total phosphorus);
- Major ions; and
- Hardness.

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

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

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Legend

- Site Boundary
- Construction Footprint

Surface Water Monitoring Locations

- Control Sites
- Off-site Marine Sampling Locations
- Basin Sampling Locations

Surface Water Monitoring Locations

Figure 4-1	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:50,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
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4.1.2 Results

Marine field and analytical results obtained during the monthly surface water monitoring undertaken during the annual monitoring period are considered representative of standard values for an estuarine environment, and have not indicated a net effect from site-based activities. Results of the onsite surface water monitoring program are not indicative of water being discharged from site but rather are a snapshot of the surface water management process that may include chemical treatment, settling and reuse onsite.

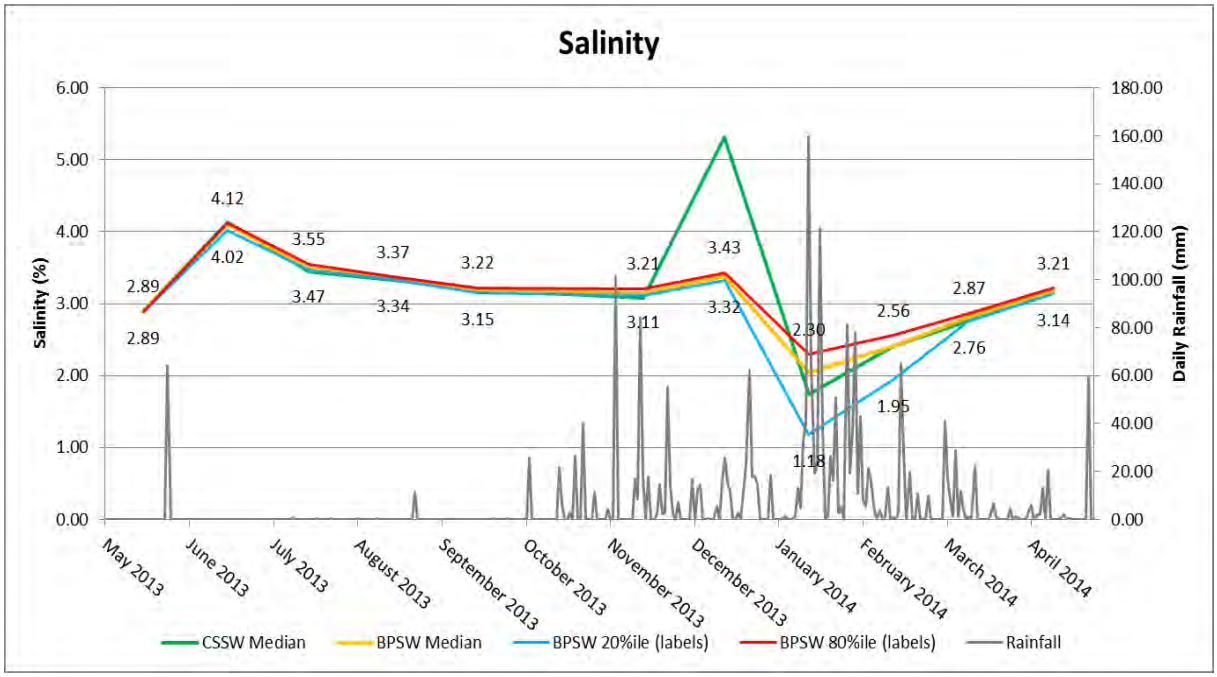
Throughout the annual monitoring period there were other activities undertaken in Darwin Harbour including construction site work, marine developments, shipping activities and dredging. This EPA7 Report is unable to draw any inferences or correlations between these activities and results as they are tasks undertaken by others and the monitoring program was not designed to evaluate the broader industrial works in the harbour. Based on the water quality monitoring program undertaken it is considered unlikely that the construction works in the Project area are impacting marine water quality.

4.1.2.1 Marine Surface Water Quality

Salinity

Salinity ranged from 10.1 to 37.3 gram (g)/litre (L) for the annual monitoring period. During the dry season, salinity remained relatively stable with values ranging from approximately 34 to 37 g/L, depending upon tidal cycles. A noticeable decrease in salinity was observed during December 2013 and January 2014 as influenced by dilution associated with seasonal rainfall events. Salinity then progressively increased to values ranging from 31 to 32 g/L in April 2014. **Chart 4-1** presents the salinity data trends from May 2013 to April 2014.

Chart 4-1 Marine Surface Water Salinity vs Daily Rainfall, May 2013 to April 2014



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Turbidity and TSS

During the dry season turbidity remained relatively stable and ranged from 1.3 to 10 nephelometric turbidity units (NTU), with a few isolated readings up to 17.2 NTU. During the wet season NTU typically ranged between 3 and 90 NTU, with isolated results observed at both monitoring and reference sites to a maximum value of 1810 NTU. This indicates that the observed increase in turbidity is related to an East Arm wide event such as seasonal variation and is not attributed to onshore discharge related to construction activities.

This is further supported by comments made in the Northern Territory Government's report *Understanding water quality and pollution sources* (Department of Land Resource Management, 2013), which states:

> *Turbidity is at its highest in the wet season. Rainfall events result in the first flush of more turbid freshwater into the estuary influencing water clarity, light attenuation, productivity and oxygen demand. During these periods it is not unusual for dissolved oxygen to decrease dramatically.*

TSS values were generally reflective of the observed turbidity trends.

The isopleth maps illustrating the distribution of turbidity averages over the dry season and the wet season are provided as **Figure 4-2** and **Figure 4-3** respectively.

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Legend

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

Turbidity Level (NTU)

- 0 - 75 NTU

Surface Water Monitoring Locations

- Control Sites
- Off-site Marine Sampling Locations
- Basin Sampling Locations

Distribution of Turbidity Averages, June 2013 – September 2013

Figure 4-2	**INPEX Bladin Point**	greencap AEC Environmental
Date: *3/07/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:50,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_2_Turbidity_Jun_2013_to_Sep_2013_SurfaceWater_140703.mxd		

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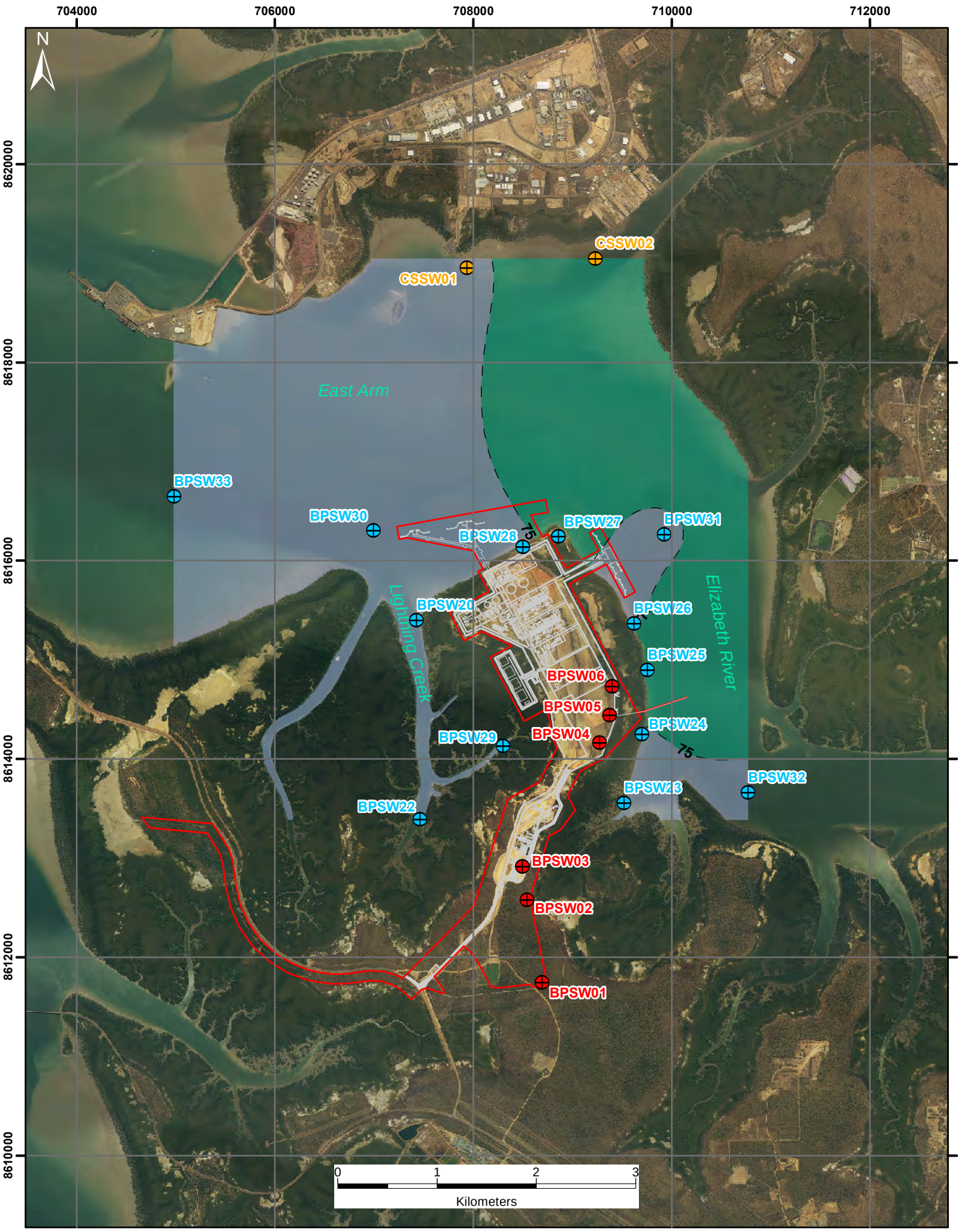

Legend

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

Turbidity Level (NTU)

- 0 - 15 NTU
- 75 - 500 NTU

Surface Water Monitoring Locations

- Control Sites
- Off-site Marine Sampling Locations
- Basin Sampling Locations

Distribution of Turbidity Averages, December 2013 – March 2014

Figure 4-3	**INPEX Bladin Point**	greencap AEC Environmental
Date: *3/07/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:50,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_3_Turbidity_Dec_2013_to_Mar_2014_SurfaceWater_140703.mxd		

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Nutrients

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

- Ammonia – ranged from 5 to 73 µg/L with an average of 28 µg/L. September to October 2013 and December 2013 to April 2014 contain the majority of exceedances. Of note, three results were reported over 60 µg/L; CSSW01 and CSSW02 in December 2013 and CSSW02 in January 2014. **Figure 4-4** shows the isopleth for ammonia distribution in marine water during January 2014. This indicates that ammonia concentrations are greater at the opposite side of the harbour and therefore are not attributable to Project activities;
- Oxides of nitrogen – ranged from 7 - 390 µg/L with an average of 44 µg/L. May 2013, July 2013, August 2013 and December 2013 to April 2014 contain the majority of exceedances. Of note, six results were reported over 100 µg/L; these were BPSW22, BPSW23, BPSW27, BPSW29, BPSW30 and CSSW01 in December 2013 and CSSW01 in April 2014;
- Total nitrogen – ranged from 9 - 4000 µg/L with an average of 238 µg/L. October 2013, January 2013, and to a lesser extent March 2014 contained the majority of exceedances. Of note, nine results were reported over 700 µg/L; these were BPSW29 in October 2013, BPSW20, BPSW22, BPSW24, BPSW25, BPSW26 and BPSW32 in January 2014, BPSW28 in March 2014 and BPSW26 in April 2014; and
- Total phosphorus – ranged from 5 - 350 µg/L with an average of 33 µg/L. November 2013 to January 2014 contain the majority of exceedances. Of note, six results reported over 100 µg/L; these were BPSW33 in November 2013, BPSW31 in December 2013, BPSW27 and BPSW29 in February 2014 and BPSW25 and BPSW26 April 2014.

The nutrient exceedances typically occurred at the build-up and onset of the wet season, and associated rainfall events. As such they are considered to be reflective of seasonal variations and not a result of construction activities.

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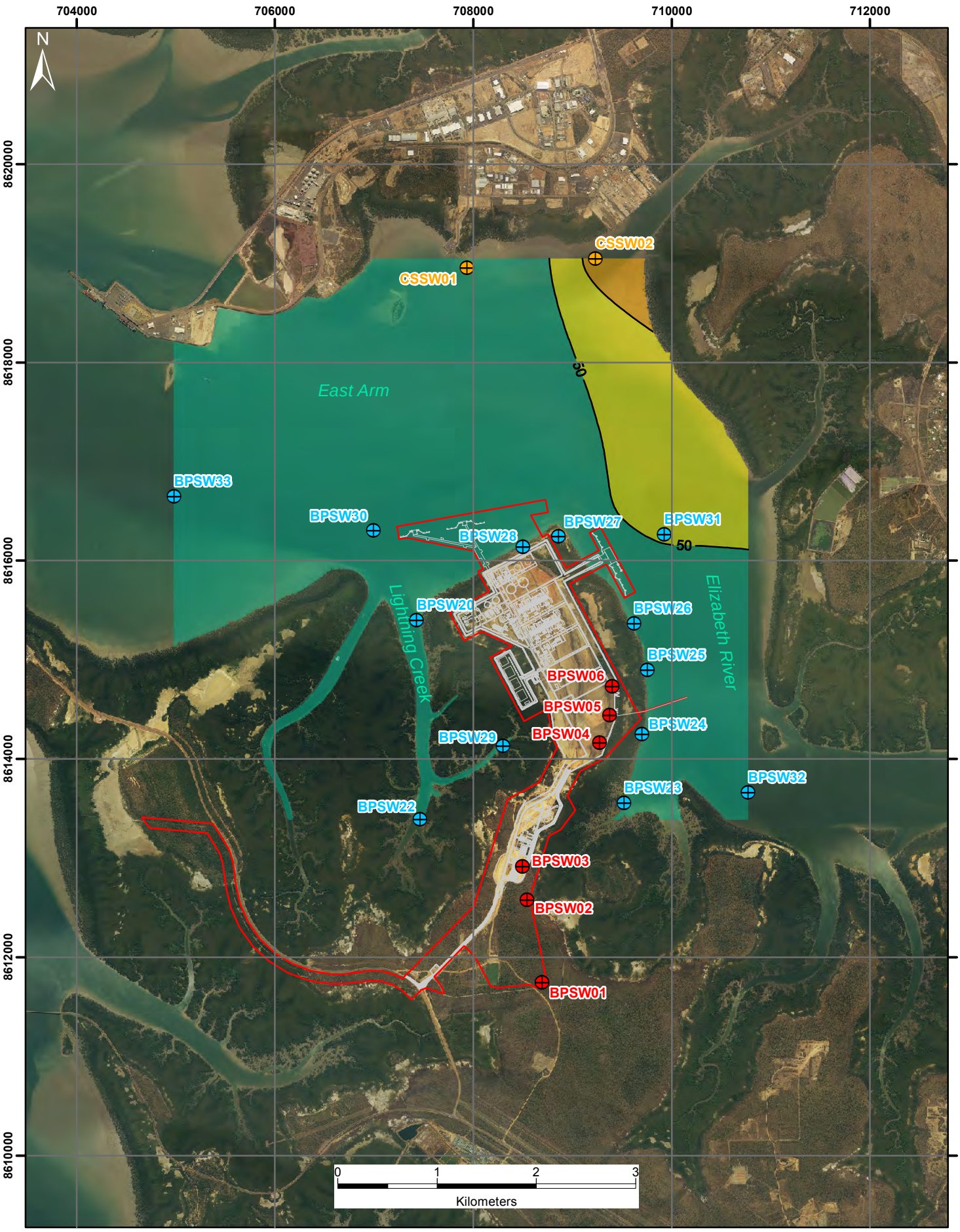

Legend

- Site Boundary
- Construction Footprint
- Ammonia Level Contours (µg/L)

Ammonia Level (µg/L)

- 20.0 - 50.0
- 50.0 - 60.0
- >60.0

Surface Water Monitoring Locations

- Control Sites
- Off-site Marine Sampling Locations
- Basin Sampling Locations

Distribution of Ammonia, January 2014

Figure 4-4	**INPEX Bladin Point**	greencap AEC Environmental
Date: *3/07/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:50,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_4_Ammonia_Jan14_140703.mxd		

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Metals and Metalloids

The majority of monitoring locations did not exceed the adopted trigger values for metals and metalloids during the annual monitoring period with the following exceptions:

- Filtered copper – reported above trigger value in September and October 2013 and March 2014 at one sampling site. Filtered copper exceedances ranged from 2.0 – 3.0 µg/L, these values are close to the LOR and are not considered indicative of a contaminant point source; and
- Filtered zinc – reported above trigger value at CSSW01 reference site in May 2013 and at five harbour sites and both reference sites in December 2013. Filtered zinc exceedances ranged from 16.0 to 42.0 µg/L. The exceedances observed in December 2013 are noted in all directions of East Arm and are likely to be attributed to a harbour wide event. Detections returned to below trigger values at the next monitoring event. **Figure 4-5** shows the isopleth for zinc distribution in marine water during December 2013. This chart shows higher zinc concentrations at locations not in the immediate vicinity of the site and hence that these higher concentrations are not attributable to Project activities.

There are no patterns evident for exceedances of metals between the 2012/2013 and 2013/2014 monitoring periods.

Biological Indicators

Two *Enterococci* trigger value exceedances were recorded during the monitoring period, both of these exceedances were recorded during the January monitoring round at reference locations CSSW01 and CSSW02. Both of these locations are on the northern side of East Arm and are not affected by construction activities at Bladin Point.

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 of seawater in a dilution series with rainwater range from ~5 to 7 (Sammut *et al,* 1996*).* **Chart 4-2** demonstrates that the salinity results from the surface water monitoring program are generally consistent with seawater and therefore, there has not been discharge from ASS-impacted streams into marine receptors.

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Legend

- Site Boundary
- Construction Footprint
- Zinc Level Contours (µg/L)

Zinc Level (µg/L)

- 0.0 - 15.0
- 15.0 - 40.0
- 40.0 - 50.0

Surface Water Monitoring Locations

- Control Sites
- Off-site Marine Sampling Locations
- Basin Sampling Locations

Distribution of Zinc, December 2013

Figure 4-5	**INPEX Bladin Point**	greencap AEC Environmental
Date: *3/07/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:50,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_5_Zinc_Dec13_140703.mxd		

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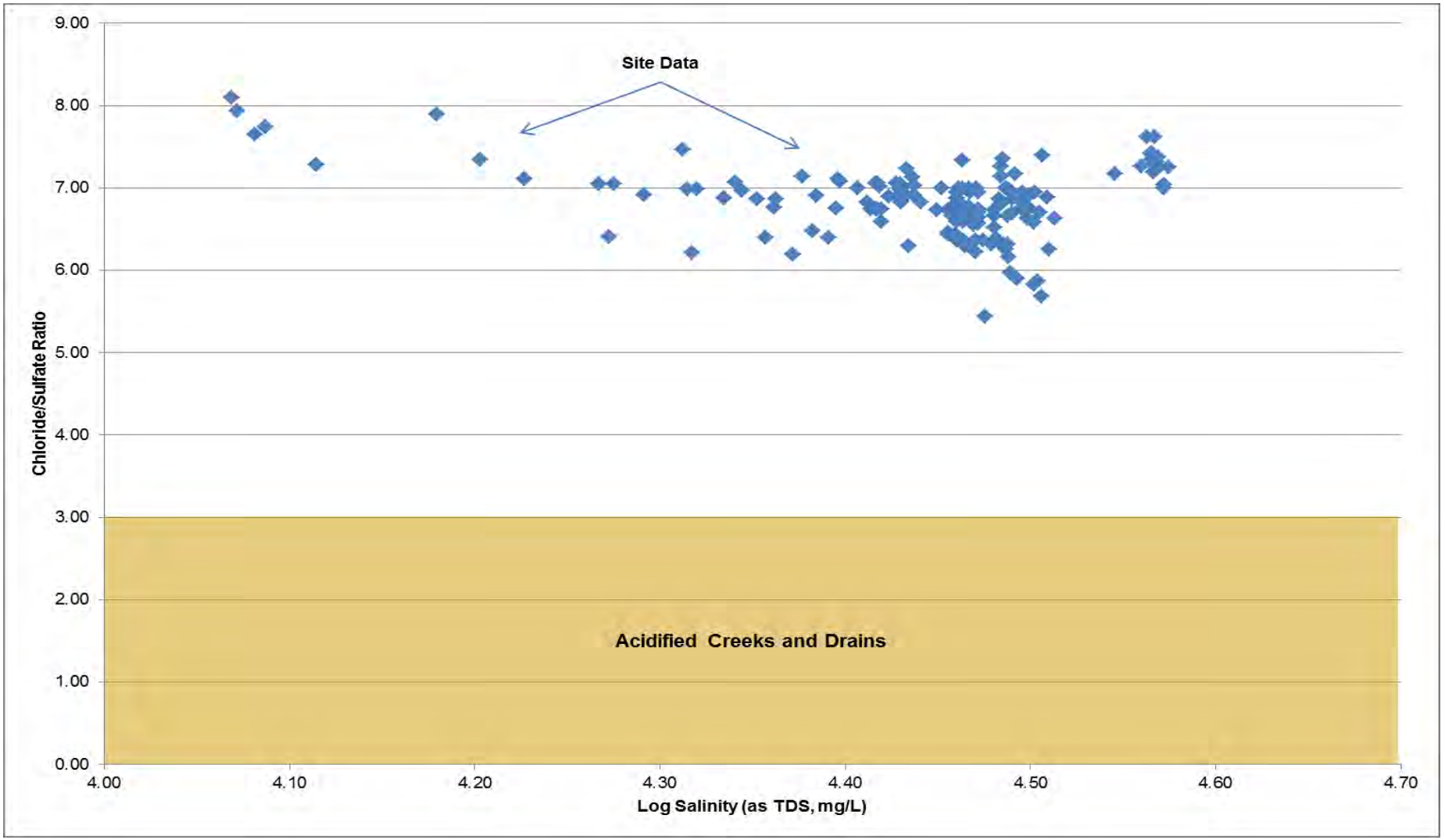
Chart 4-2 Surface Water Chloride/Sulfate Ratio



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4.1.2.2 Terrestrial Surface Water Quality

No seasonal trends can be observed from either the physico-chemical parameters or nutrient concentrations in the basins. The basins are designed to allow the infiltration or exfiltration of surface or groundwater respectively, however it appears that the results are typically indicative of surface water runoff as opposed to groundwater. Turbidity exceedances were reported but are a function of the basins' role in erosion and sediment control. This water often required treatment prior to discharge in order to meet environmental approval requirements in accordance with onsite procedures. This requires sampling and a permit in accordance with Contractor's water discharge procedure to determine that surface water discharge criteria were met. Sampling of the basins occurred prior to discharge, and permit to discharge was only issued where sampling results confirmed compliance with the surface water discharge criteria, in accordance with the requirements of the EIMP.

There were no trends observed in the quality of surface water in the basins which could be attributed to Project-related activities undertaken at the time of sampling. The water quality within basins is also dependent on recent rainfall events and the volume of surface water flows containing suspended material at the time of sampling. The basins generally contained water of neutral pH, low salinity, positive ORP and turbidity levels exceeding discharge criteria at the time of sampling. The elevated turbidity measurements are indicative of water retention prior to treatment and flocculation to achieve discharge criteria prior to any controlled release into Darwin Harbour.

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4.2 Groundwater

4.2.1 Monitoring Methodology

The aim of the groundwater monitoring program is to assess changes in groundwater chemistry and levels and assess if impact from ASS has been identified.

The current bore network comprises 30 monitoring locations, identified on **Figure 4-6**. During the annual monitoring period, two wells were decommissioned and two additional bores were installed in January 2014.

Data loggers were used to continuously monitor standing water level (SWL), pH, ORP, DO, TDS, turbidity and temperature at selected bores during the annual monitoring period.

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

The following analytes were recorded in-situ:

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

Each of the collected groundwater samples were analysed for:

- Total and dissolved metals;
- TDS and TSS;
- Alkalinity;
- Nutrients (ammonia, nitrate, nitrite, total kjeldahl nitrogen, total nitrogen, reactive phosphorus and total phosphorus);
- Major ions; and
- Hardness.

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

- Total recoverable hydrocarbons; and
- Benzene, toluene, ethylbenzene, xylenes and naphthalene.

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Legend

- Site Boundary
- Construction Footprint
- Groundwater Sampling Locations
- Decommissioned Groundwater Sampling Locations

Groundwater Monitoring Locations		
Figure 4-6	INPEX Bladin Point	greencap AEC Environmental
Date: 25/06/2014	Author: Christopher.Maddox	
	Map Scale: 1:30,000	
Revision: R1	Coordinate System: GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\AnnualReport_BladinPoint\FIG_5_1_Groundwater_140625.mxd		

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4.2.2 Results

4.2.2.1 Field Parameters

pH

All pH values for the annual monitoring period were generally below the lower limit of the trigger value range indicating groundwater acidity; this is consistent with previous data previous data presented in the *2012-2013 Annual Report Environmental Impact Monitoring Program Ichthys On-Shore Liquefied Natural Gas (LNG) Facilities* (URS Australia Pty Ltd, 2013) (Annual Report [2013]) and the *Ichthys Project Environmental Impact Statement* (INPEX Browse, Ltd, 2010) (EIS).

The pH levels of groundwater were typically below the 7 pH lower trigger value prior to commencement of construction activities. This indicates that the low pH levels are likely to be a result of natural processes that historically occurred at the site and not associated with the construction activities.

Interaction of rainfall recharge with the naturally acidic soils may have contributed to the genesis of the resident low pH groundwater. The natural soils generally have a low pH and when in contact with water can further lower the pH value. Furthermore, based on the information reported in the EIS, natural onsite material contains metals which can be mobilised into solution under acidic conditions.

Isopleth maps illustrating the distribution of pH at the end of the dry season (October 2013) and the end of the wet season (March 2014) are provided as **Figure 4-7** and **Figure 4-8**. The isopleth maps show that there are three nodes of low pH within the Project area. These occur during both wet and dry season at the southern portion of the EMA, the southern central edge of the main site and a narrow strip along the northwest portion of the site. It is noted that all of these areas do not correlate with the major ground improvement works that have occurred onsite.

Groundwater Elevation

Groundwater elevation has historically been highest in the south of the isthmus. Generally, groundwater levels in the majority of the bores across the Project area reached year-end lows in late October, after which time they have been rising and reaching their peaks in late March/early April. Typical ranges of seasonal groundwater level rise have been between 1.5 m (north of the isthmus) to 6 m (south of the isthmus). The seasonal groundwater level rises are proportional to the amount and intensity of rainfalls as well as the influence of construction excavation, or exposed and uncompacted ground in the recharge area. No long term rising trends which may be associated with the changes in the onsite activities have been noted for the Project area. This will further be verified via a numerical model which is being constructed.

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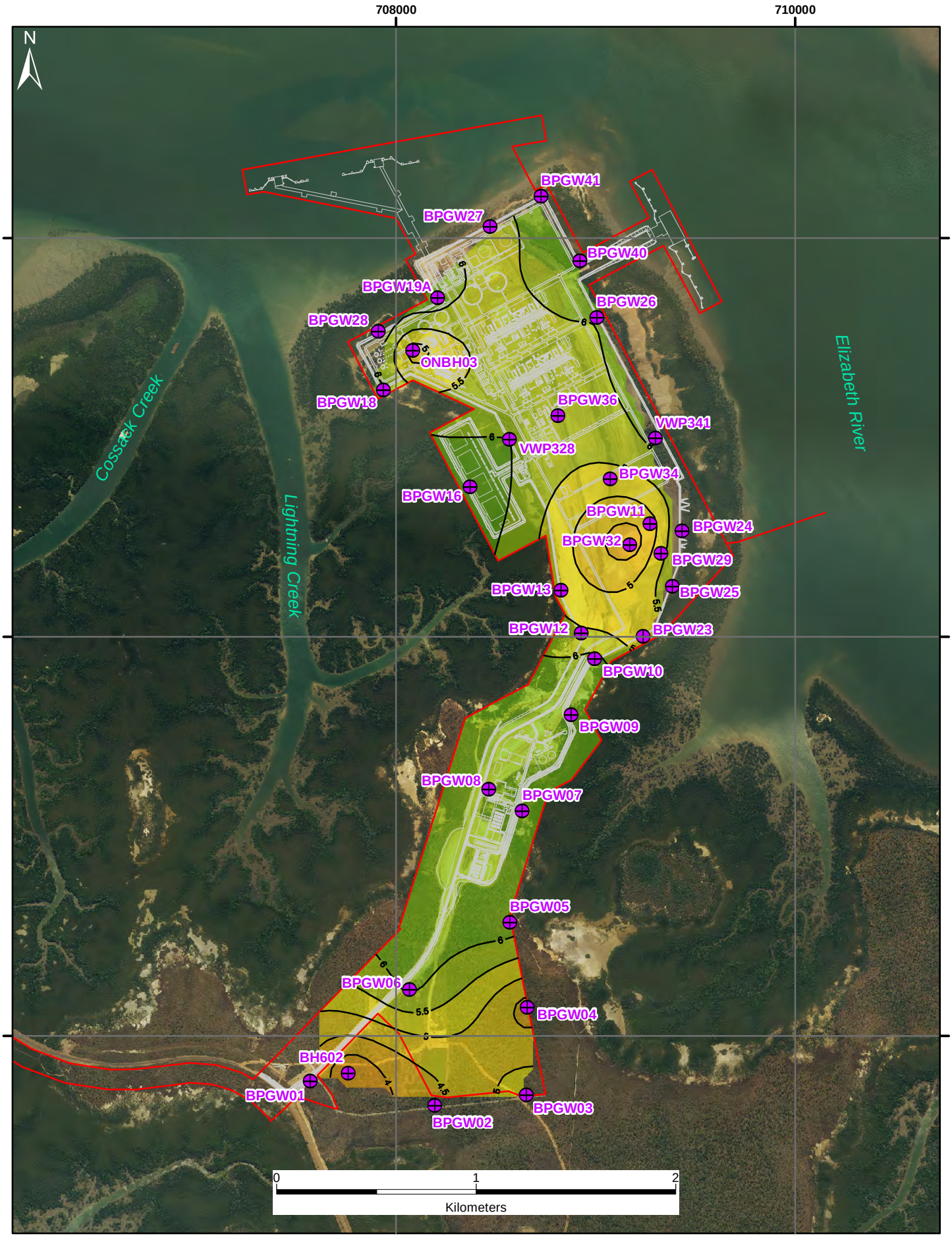

Legend

- Site Boundary
- Construction Footprint
- pH Level Contours
- Groundwater Sampling Locations

pH Level

- <4.0
- 4.0 - 4.5
- 4.5 - 5.0
- 5.0 - 5.5
- 5.5 - 6.0
- >6.0

pH Level Contours, October 2013

Figure 4-7	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_7_pH_Oct2013_Contours_140620.mxd		

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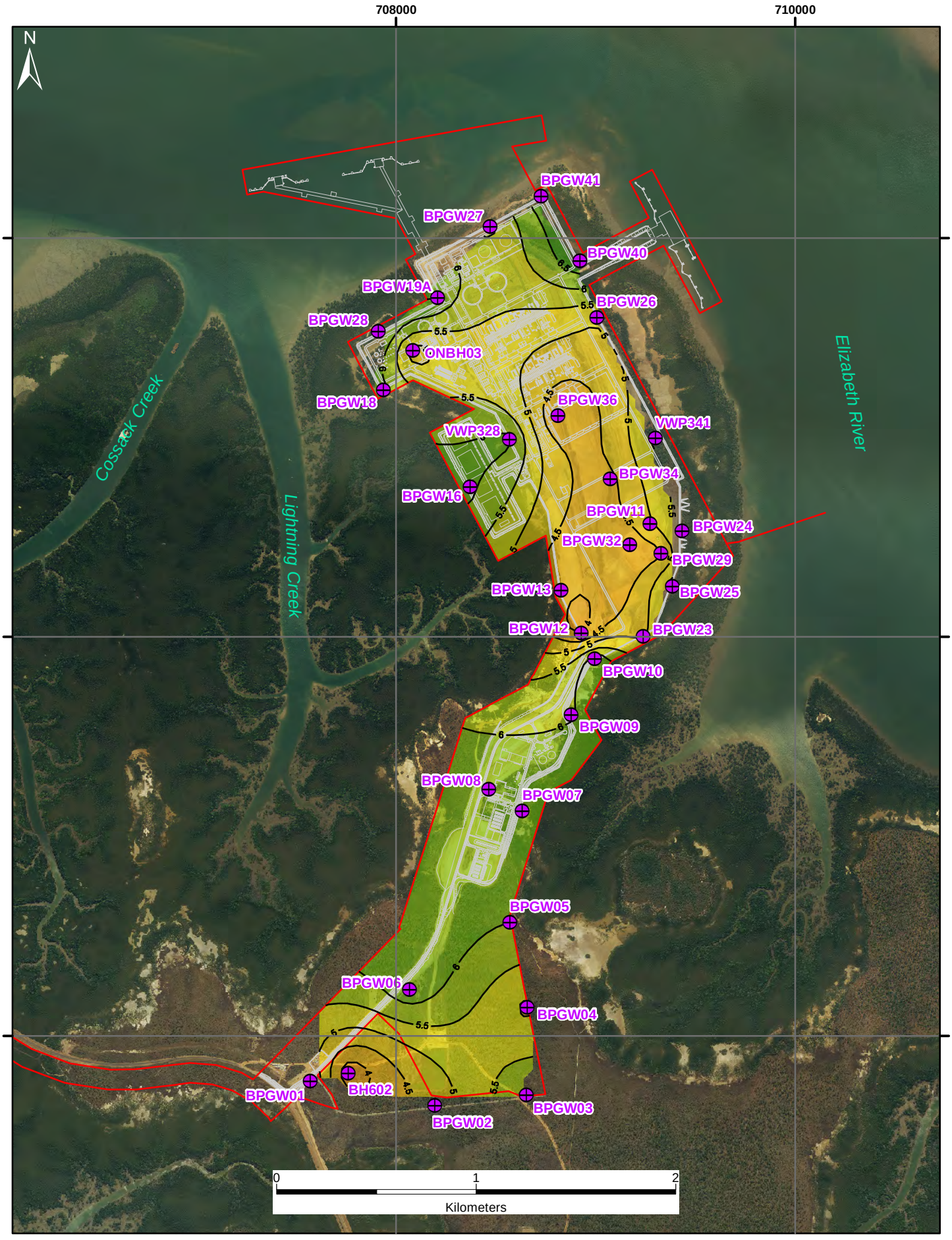

Legend

- Site Boundary
- Construction Footprint
- pH Level Contours
- Groundwater Sampling Locations

pH Level

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

pH Level Contours, March 2014

Figure 4-8	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_8_pH_Mar2014_Contours_140620.mxd		

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Salinity

Salinity readings for the annual monitoring period identified two mechanisms which affect groundwater level and quality. Typically costal and intertidal zone bores are influenced by tidal fluctuations and to a lesser extent by rainwater recharge and display higher salinity values. Bores located further inland from the intertidal zone are predominantly influenced by rainwater recharge, which is indicated by fresher water quality.

4.2.2.2 Analytical Results

Nutrients

Nutrients reported to exceed the adopted trigger values are ammonia, oxides of nitrogen, total nitrogen, total phosphorus and reactive phosphorus. **Figure 4-9** to **Figure 4-12** present the isopleth summaries for both wet and dry seasons for nutrient distribution.

Phosphorus and nitrogen are essential nutrients for plants and animals that make up the food web. There are many natural sources of nitrogen and phosphorus related to organic muds and inorganic minerals in rocks and soils. The exceedances reported are consistent with previous findings.

The following points are noted in relation to nutrients in groundwater:

- Naturally existing phosphate salts may be absorbed within acidic soils underlying the Project area;
- Phosphates can be released into solution when groundwater with pH levels between 5 and 7 pH units interacts with natural soils;
- When groundwater pH decreases, phosphates interact with dissolved aluminium and iron and are partially removed from solution. This process may be reversed when groundwater pH rises;
- The processes maintaining the presence of dissolved phosphorus compounds in groundwater are extremely complex and require more detailed assessment;
- Increases and decreases in total phosphate and FRP in groundwater beneath the Project area are unlikely to be associated with on-site construction activities;
- The source of ammonia in groundwater is naturally occurring anoxic organic material present at the Project area;
- Variation in ammonia concentrations is a result of localised groundwater recharge from the infiltration of rainwaters containing oxygen. Oxygenated infiltrated rainwaters alter ORP conditions and causes oxidation of ammonia into oxidised nitrogen;
- The presence of oxidised nitrogen in groundwater was reported in 2008-09, indicating that the source of oxidised nitrogen in groundwater existed prior to on-site construction;
- The sources of oxidised nitrogen in groundwater are likely to be associated with natural organic rich soils with organic nitrogen content. Organic nitrogen is converted into oxidised nitrogen as a result of nitrification; and
- It is unlikely that on-site construction activities contribute to the presence of oxidised nitrogen in groundwater.

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Legend

- Site Boundary
- Construction Footprint
- pH Level Contours
- Groundwater Sampling Locations

pH Level

- <4.0
- 4.0 - 4.5
- 4.5 - 5.0
- 5.0 - 5.5
- 5.5 - 6.0
- >6.0

October 2013 Groundwater pH and Distribution of Nutrient Exceedances

Figure 4-9	**INPEX Bladin Point**	greencap AEC Environmental
Date: *14/07/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_9_pH_Nutrient_Exceedences_Oct13_140714.mxd		

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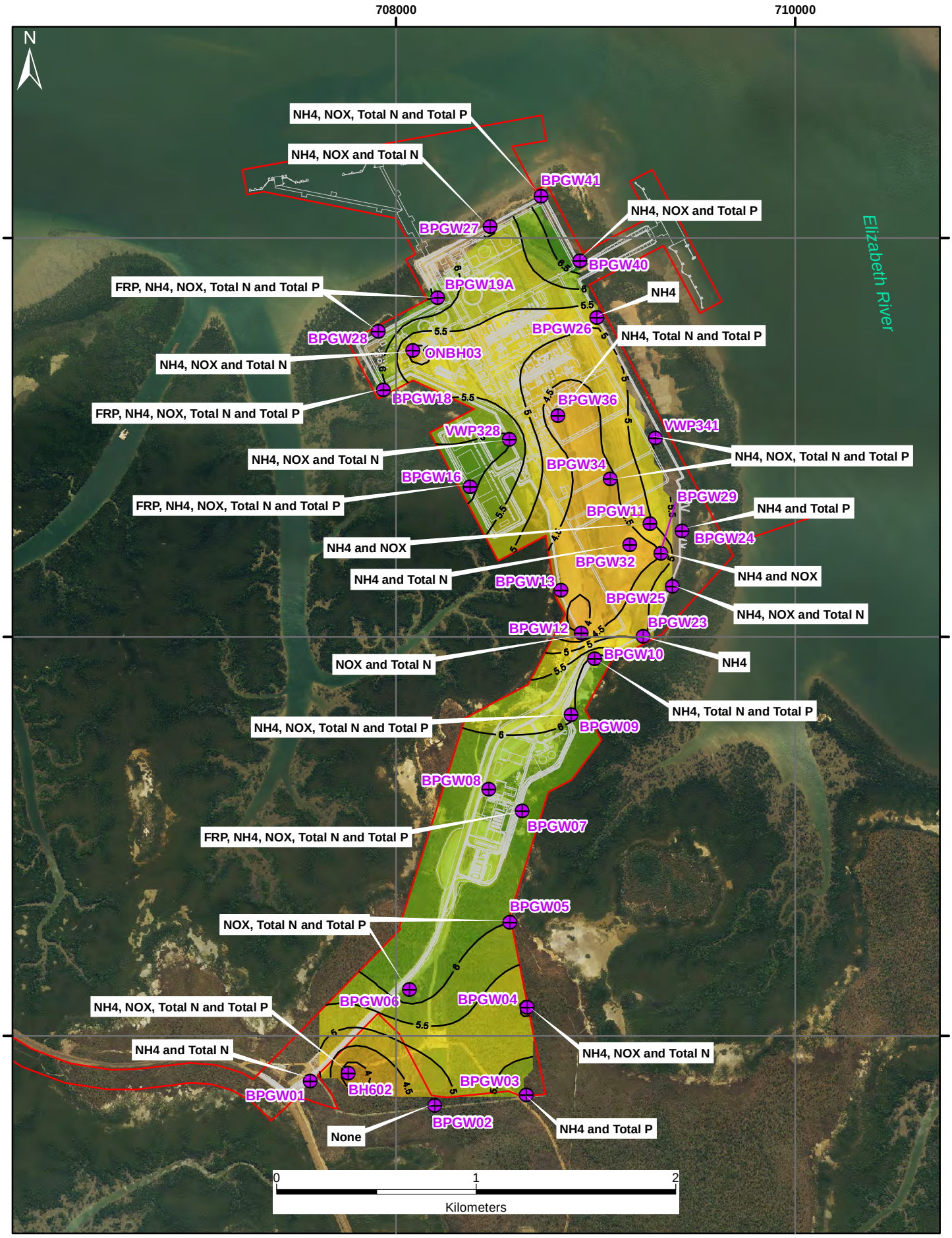

Legend

- Site Boundary
- Construction Footprint
- pH Level Contours
- Groundwater Sampling Locations

pH Level

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

March 2014 Groundwater pH and Distribution of Nutrient Exceedances

Figure 4-10	**INPEX Bladin Point**	greencap AEC Environmental
Date: *14/07/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_10_pH_Nutrient_Exceedences_Mar14_140714.mxd		

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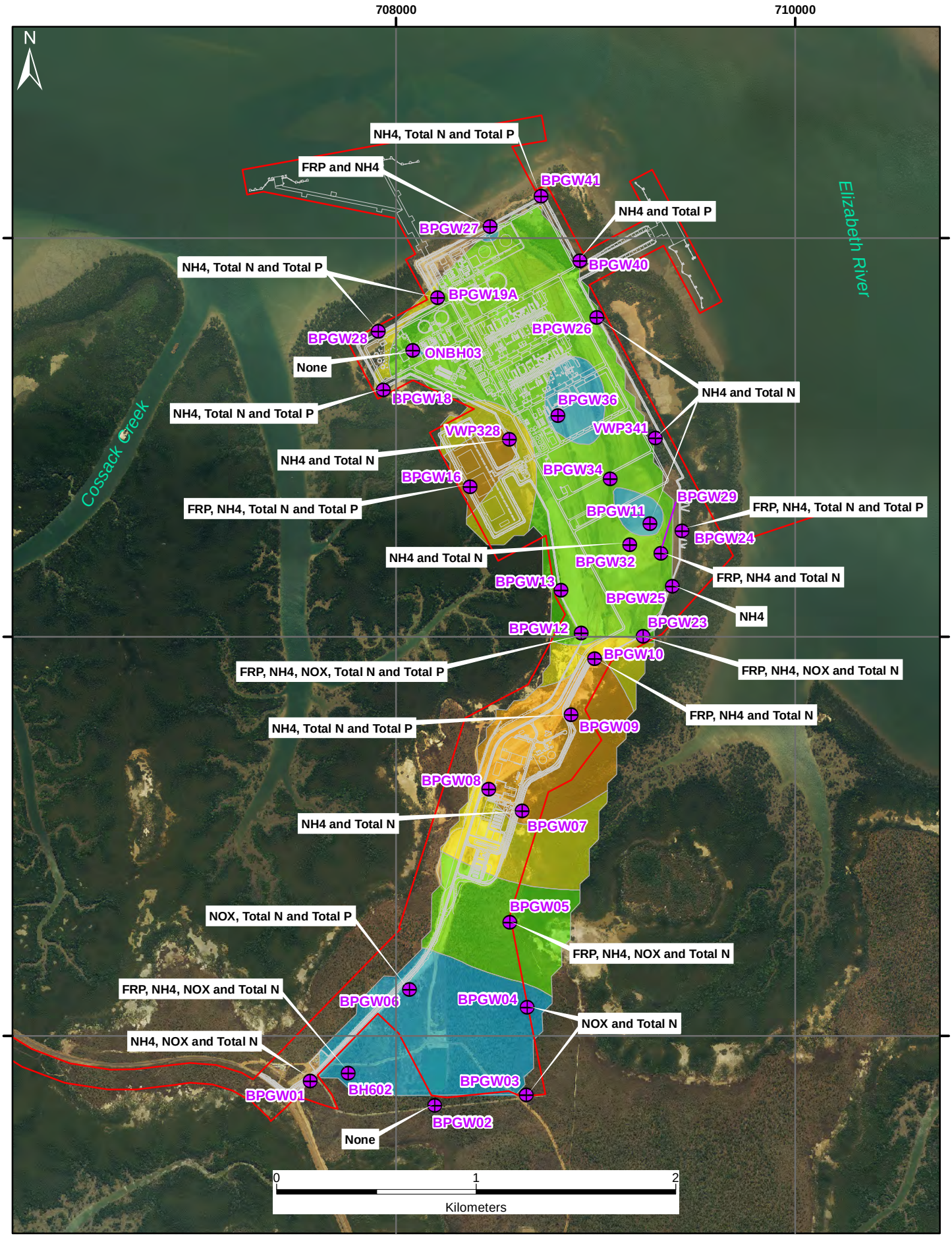

Legend

- Site Boundary
- Construction Footprint
- Groundwater Sampling Locations

Groundwater TDS (October 2013)

- 50,000 to 70,000 mg/L
- 35,000 to 50,000 mg/L
- 11,000 to 35,000 mg/L
- 0 to 11,000 mg/L

October 2013 Groundwater TDS and Distribution of Nutrient Exceedances

Figure 4-11	**INPEX Bladin Point**	greencap AEC Environmental
Date: *14/07/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_11_GroundwaterTDS_Nutrient_Exceedences_Oct13_140714.mxd		

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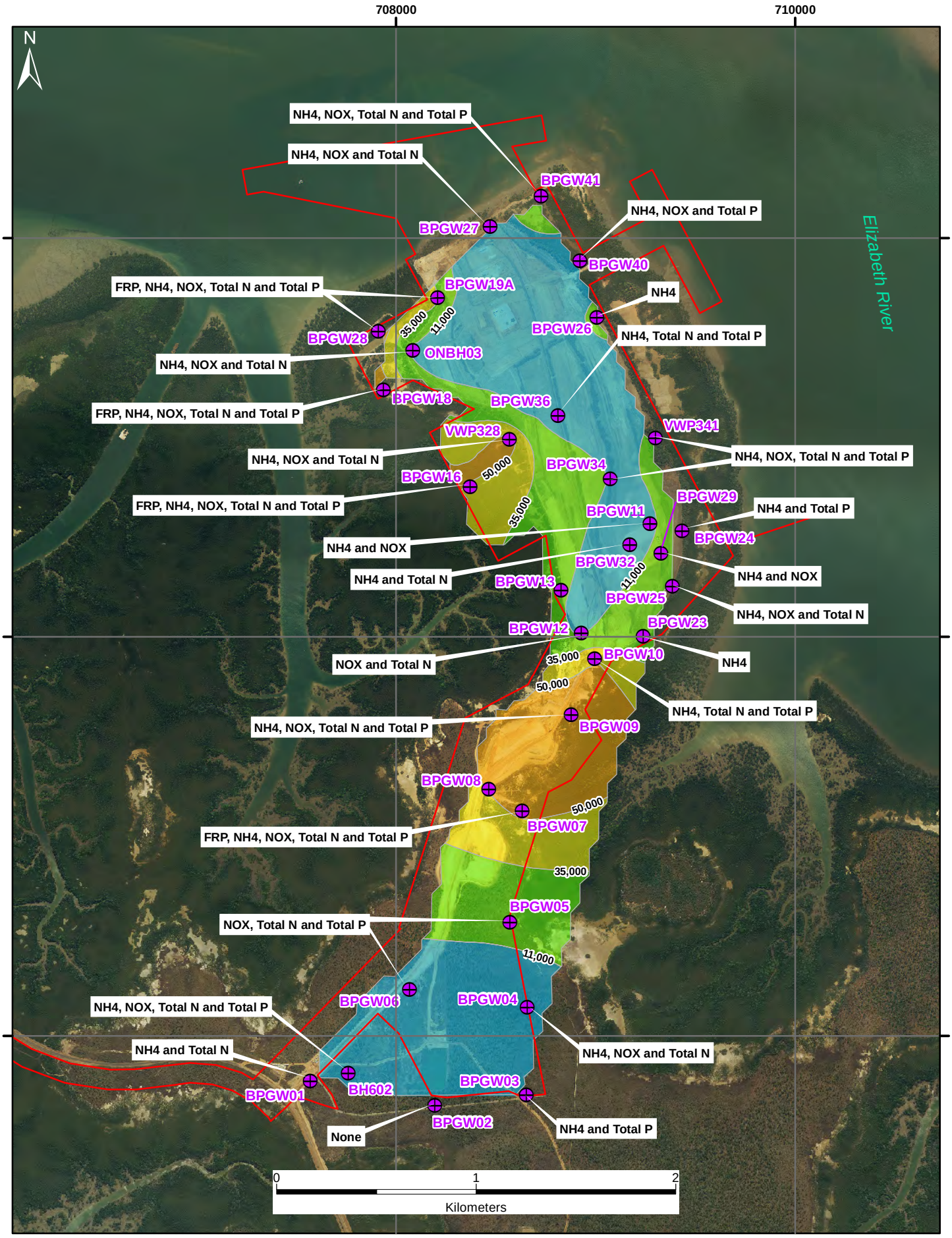

Legend

- Site Boundary
- Construction Footprint
- Groundwater Sampling Locations

Groundwater TDS (March 2014)

- 50,000 to 70,000 mg/L
- 35,000 to 50,000 mg/L
- 11,000 to 35,000 mg/L
- 0 to 11,000 mg/L

March 2014 Groundwater TDS and Distribution of Nutrient Exceedances

Figure 4-12	**INPEX Bladin Point**	greencap AEC Environmental
Date: *14/07/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_12_GroundwaterTDS_Nutrient_Exceedences_Mar14_140714.mxd		

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Metals and Metalloids

The metals/metalloids exceeding the trigger values during this annual monitoring period include aluminium, arsenic, cobalt, copper, lead, manganese and zinc. **Figure** 4-13 presents the salinity and metals reported above the trigger values for each groundwater monitoring bore. **Figure 4-14** to **Figure 4-17** present the isopleth summaries for both wet and dry seasons for metal distribution.

The reported exceedances indicated seasonal fluctuation and no significant trends in metal / metalloid concentrations have been observed during the current (2013/2014) and previous (2012/2013) monitoring periods above that provided by the EIS. The metal species exceeding the trigger values reported in 2009 are generally consistent with metals shown on **Figure 4-13**. Also, the observed lateral distribution of metals does not identify any point-sources for the metals observed in groundwater at the Project area. It is concluded that the onsite construction activities have not influenced concentrations of metals in groundwater to date.

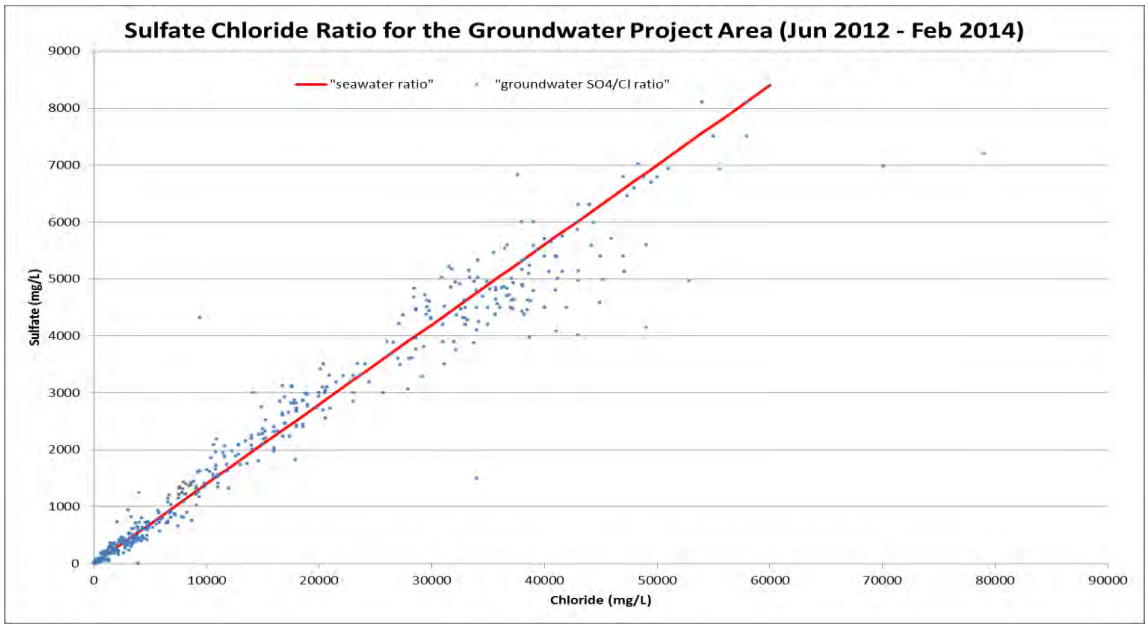
Sulfate/Chloride Ratio

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

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

In accordance with the above; a greater ratio would indicate a potential influence from a sulfate-containing source e.g. ASS oxidation. A lower ratio would indicate a sulfate salt precipitation or dilution with water, with minor sulfate content, e.g. rainwater. **Chart 4-3** shows that the sulfate-chloride ratio for onsite groundwater is generally consistent with the typical seawater ratio, indicating that the overall influence on groundwater quality from potential oxidation of ASS is likely to be insignificant.

Chart 4-3 Sulfate/Chloride Ratio



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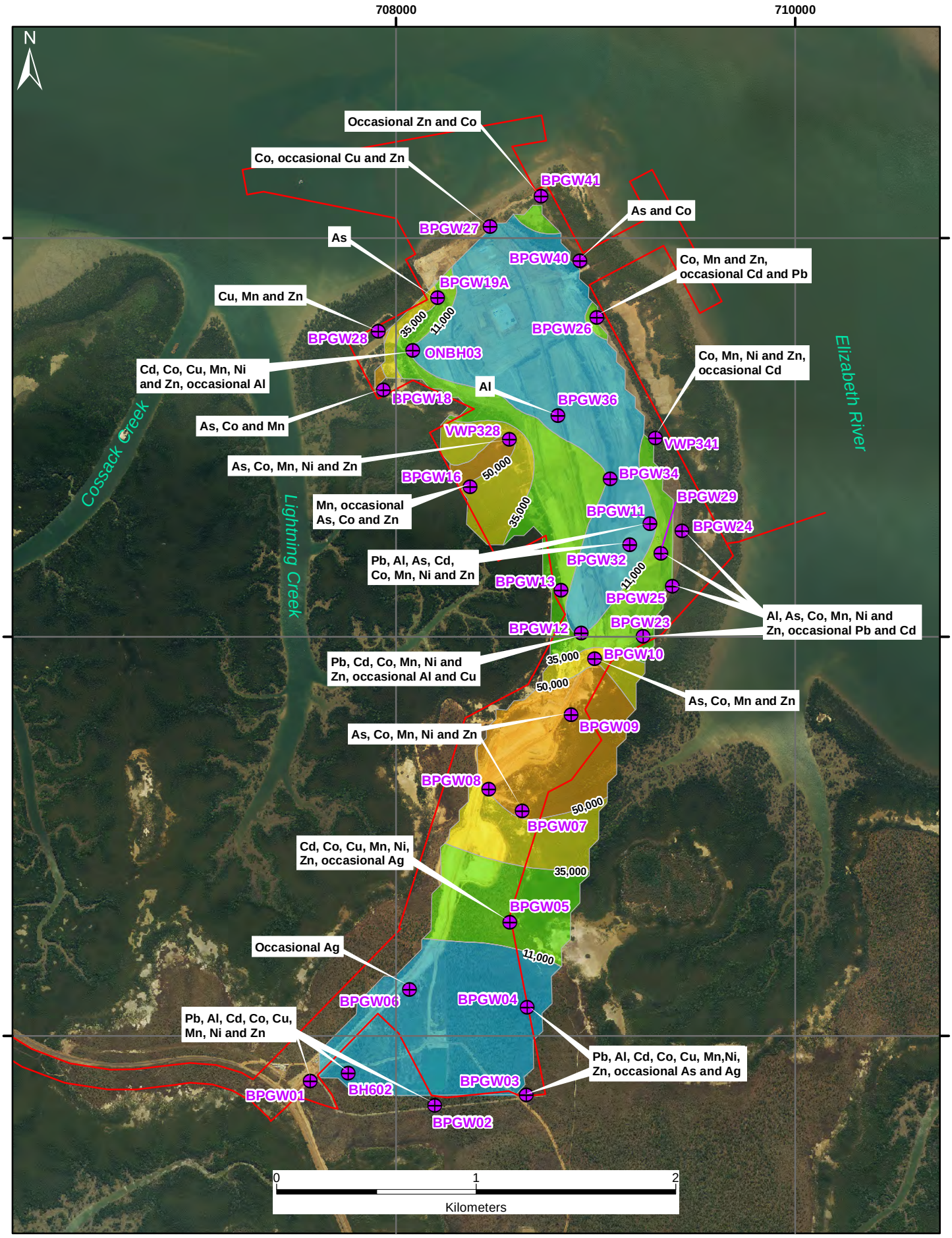

Legend

- Site Boundary
- Construction Footprint
- Groundwater Sampling Locations

Groundwater TDS (March 2014)

- 50,000 to 70,000 mg/L
- 35,000 to 50,000 mg/L
- 11,000 to 35,000 mg/L
- 0 to 11,000 mg/L

Metal Distribution and Groundwater Salinity, March 2014

Figure 4-13	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_13_Metals_Salinity_Mar14_140620.mxd		

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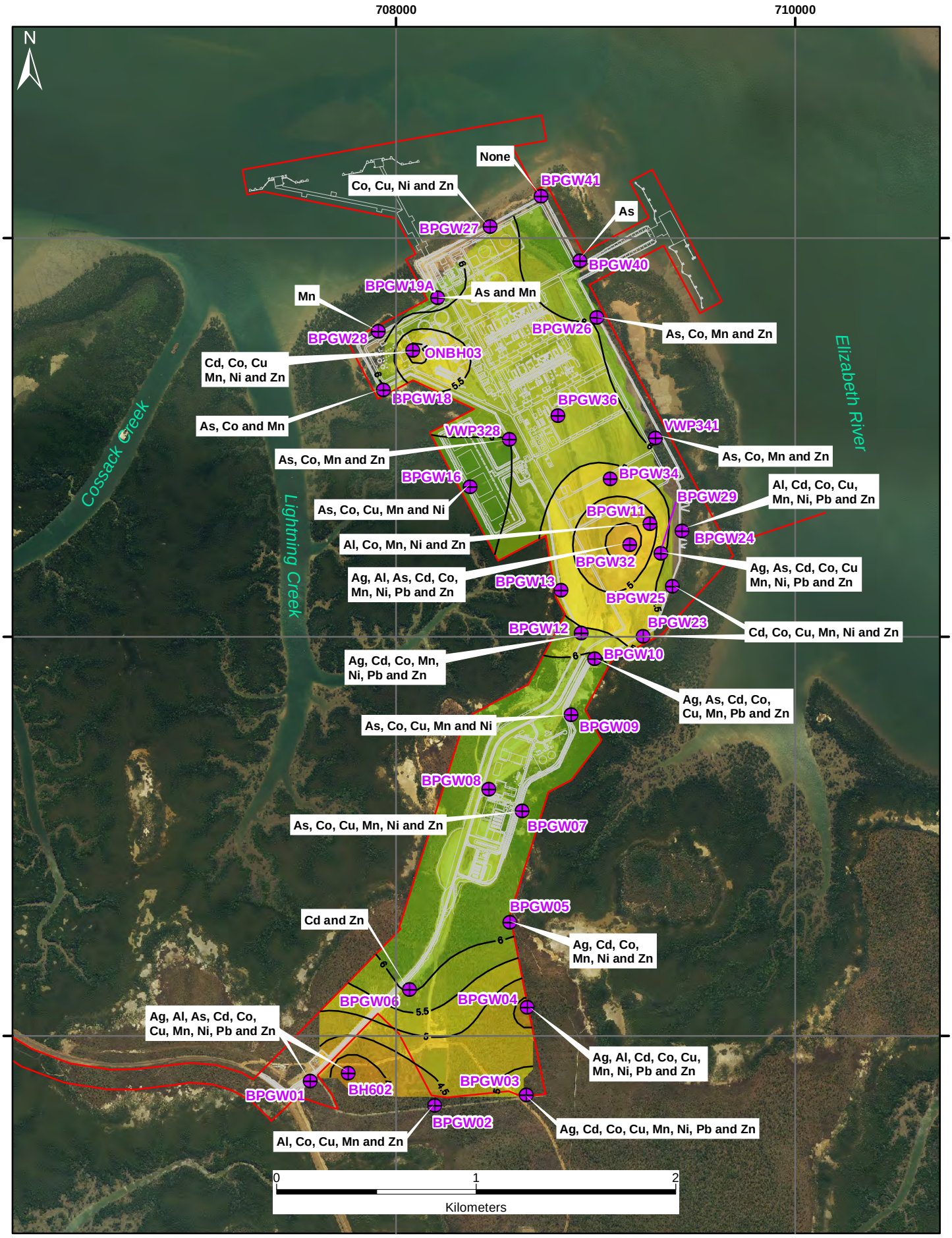

Legend

- Site Boundary
- Construction Footprint
- pH Level Contours
- Groundwater Sampling Locations

pH Level

- <4.0
- 4.0 - 4.5
- 4.5 - 5.0
- 5.0 - 5.5
- 5.5 - 6.0
- >6.0

Groundwater pH and Distribution of Metal Exceedances, October 2013

Figure 4-14	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_14_pH_Metals_Exceedences_Oct13_140620.mxd		

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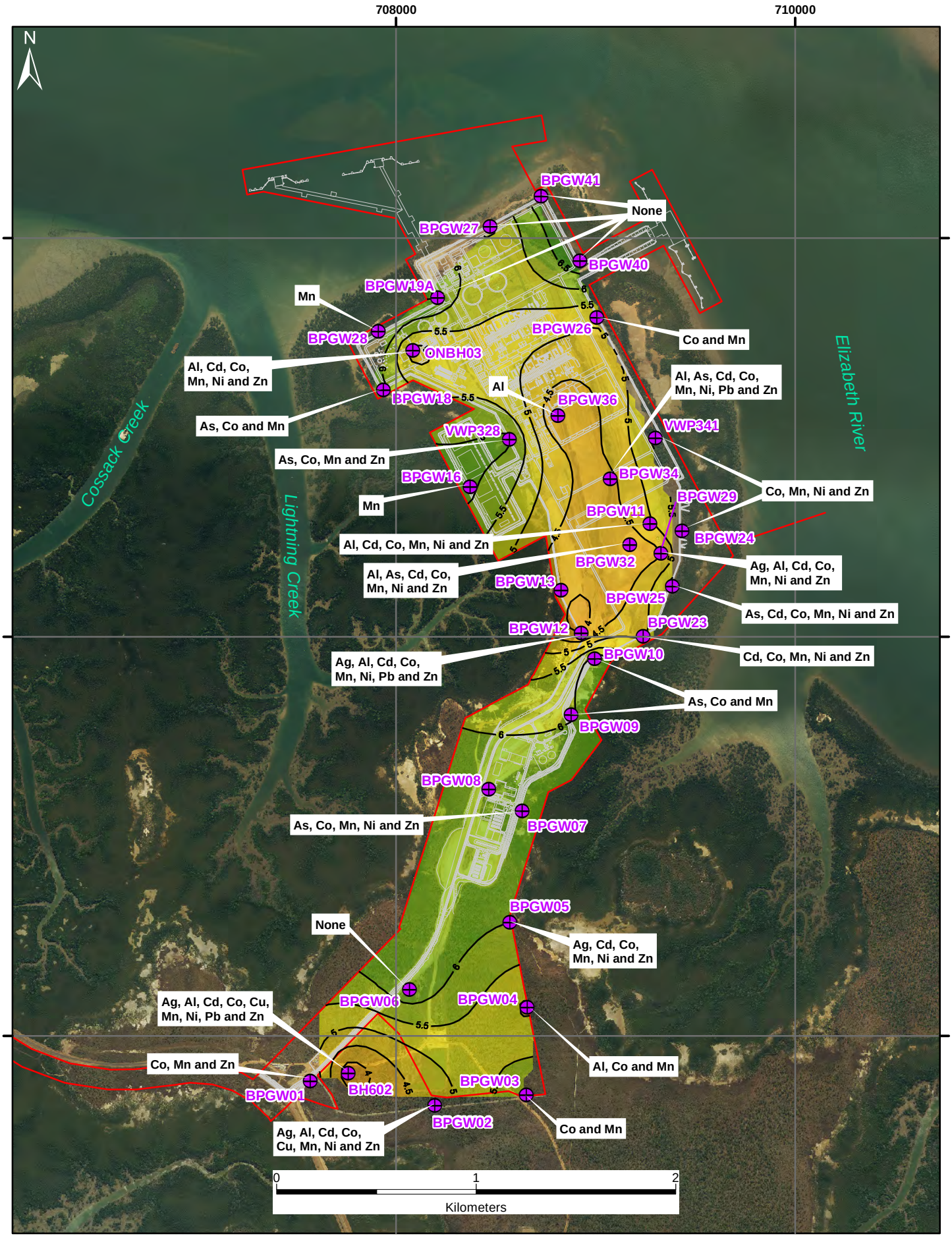

Legend

- Site Boundary
- Construction Footprint
- pH Level Contours
- Groundwater Sampling Locations

pH Level

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

Groundwater pH and Distribution of Metal Exceedances, March 2014

Figure 4-15	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_15_pH_Metals_Exceedences_Mar14_140620.mxd		

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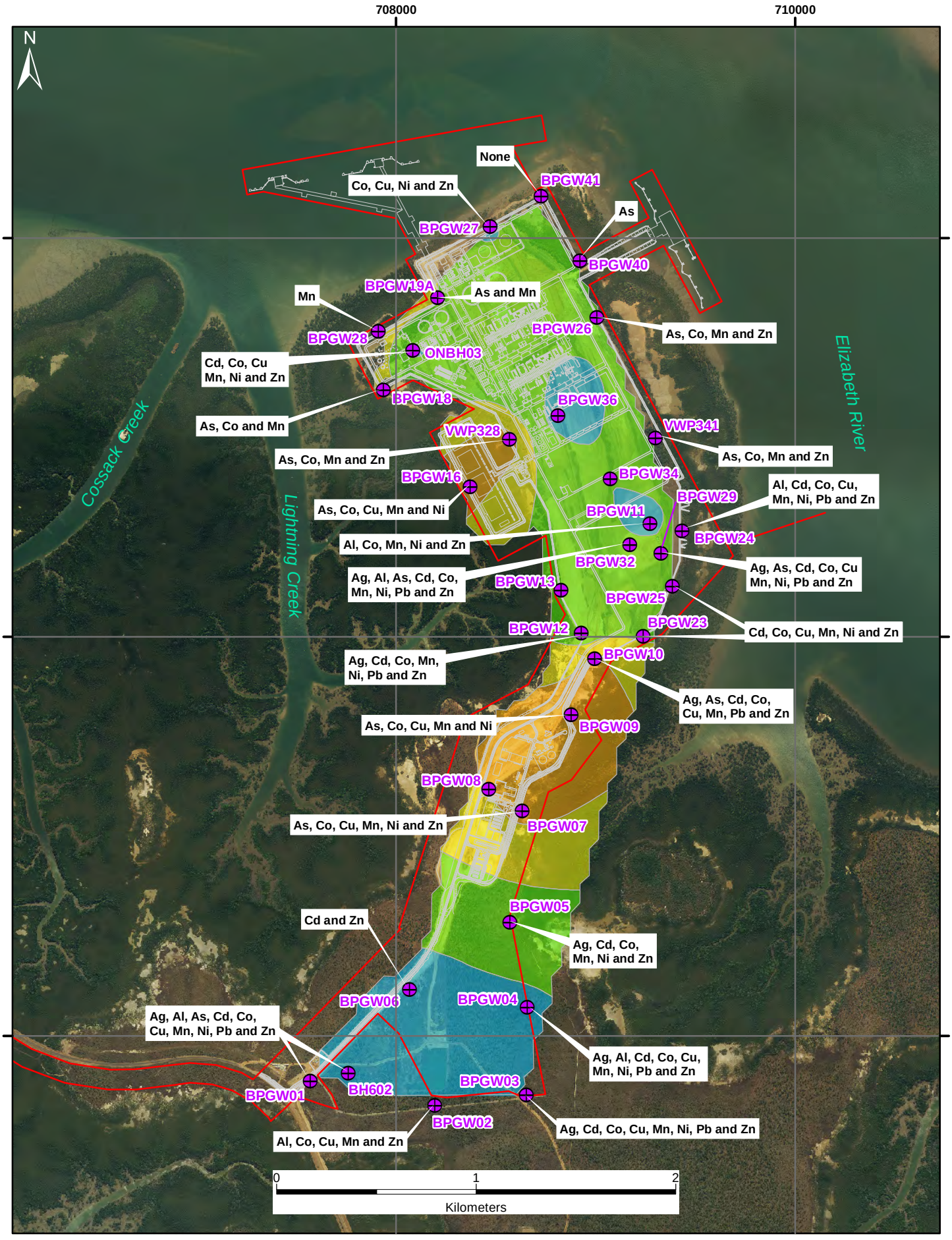

Legend

- Site Boundary
- Construction Footprint
- Groundwater Sampling Locations

Groundwater TDS (October 2013)

- 50,000 to 70,000 mg/L
- 35,000 to 50,000 mg/L
- 11,000 to 35,000 mg/L
- 0 to 11,000 mg/L

Groundwater TDS and Distribution of Metal Exceedances, October 2013

Figure 4-16	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_16_GroundwaterTDS_Metals_Exceedences_Oct13_140620.mxd		

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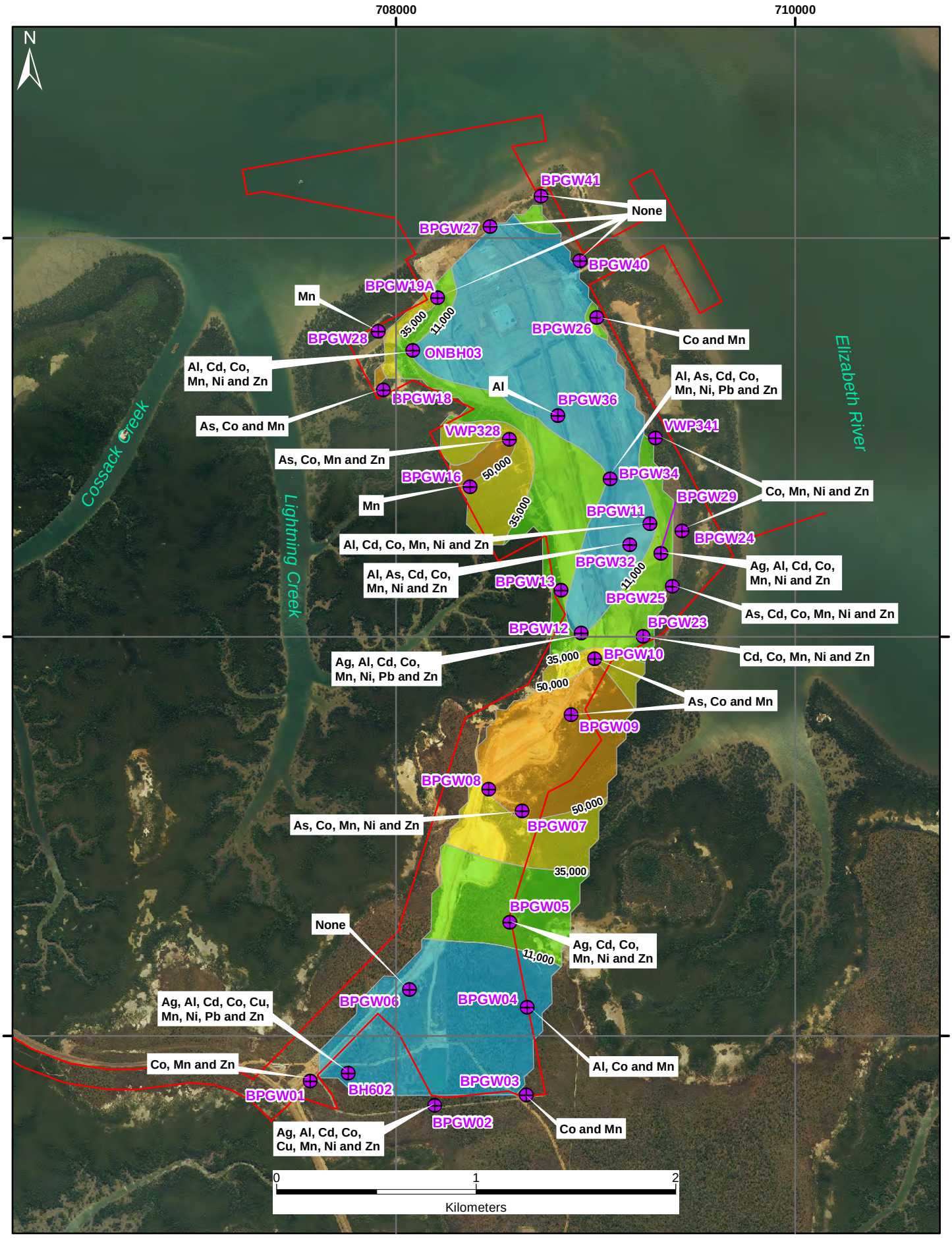

Legend

- Site Boundary
- Construction Footprint
- Groundwater Sampling Locations

Groundwater TDS (March 2014)

- 50,000 to 70,000 mg/L
- 35,000 to 50,000 mg/L
- 11,000 to 35,000 mg/L
- 0 to 11,000 mg/L

Groundwater TDS and Distribution of Metal Exceedances, March 2014

Figure 4-17	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_17_GroundwaterTDS_Metals_Exceedences_Mar14_140620.mxd		

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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 Project on mangrove communities surrounding the Project area.

Twenty-five transects were established in June 2012 to provide the locations for the mangrove monitoring program. These locations are identified on **Figure 4-18**. The identifier 'BPMC' is used to identify transects located within or adjacent to the Project area. The identifier 'CSMC' is used to identify reference transects. At each monitoring location a transect was established from the landward mangrove margin into the mangroves, in a seaward-direction. Along each transect, survey points and monitoring plots were established.

The two parameters used to measure mangrove community health were canopy density and mangrove tree 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 site, sediment samples from the mudflat surface were collected quarterly for laboratory analysis to determine particle size distribution and metals concentrations. Opportunistic sampling for hydrocarbons in response to minor (<20 L) hydrocarbon spills did not occur during the annual monitoring period, as the soils were removed and it was determined that the potential for migration was low following the clean-up activities.

A large snail, the mudwhelk (*Telescopium Telescopium*) was selected as an indicator of bio-accumulation. Mudwhelks were collected on an annual basis for analysis of metal concentrations in accordance with the EIMP.

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Legend

- Site Boundary
- Construction Footprint
- Mangrove Transects
- Mangrove Transects (Control Sites)

Mangrove Monitoring Locations

Figure 4-18	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:25,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA 7\FIG_4_18_Mangrove_Monitoring_Locations_140620.mxd		

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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 in the EIMP 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 Project activities. The data collected is broadly consistent with previous findings.

4.3.2.1 Mangrove Community Health

Results indicate that canopy cover generally increased in all sites since June 2012, with the greatest overall increase recorded within the tidal flat (17.1 % ± 1.8) at monitoring sites. Canopy density data has been summarised in **Chart 4-4** by comparing mean canopy density for the three mangrove assemblages monitored, namely:

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

This suggests that mangrove communities located close to the construction activities remain in healthy condition and tree canopies have not diminished in response to environmental stress. The data indicates that there has not been any broad-scale sediment accumulation or erosion during the annual monitoring period that has or may impact mangroves fringing the Project area that can be attributed to Project activities. This conclusion is also confirmed by the measurement of relative ground levels at mangrove monitoring sites where only one exceedance of the trigger value was recorded.

Small mudwaves were observed at monitoring locations BPMC04, BPMC05 and BPMC06 associated with the construction of the perimeter rock bund for the Flare Pad; this is consistent with the findings presented in the Annual Report (2013) and no increases have been observed.

There are three locations where mangroves have been affected by construction works and include areas directly north of the inlet facilities, as well as areas north and south of the Flare Pad entry. The mangrove deaths are attributed to ponding water and are believed to have reached the maximum extent of impact. These areas have contained ponded water due to a change in topography and subsequent drainage. Strategies are in place to rectify ponding of water in these areas and encourage regeneration and recruitment. Mangrove assessments have indicated that there are no broader net effects in the wider mangrove community.

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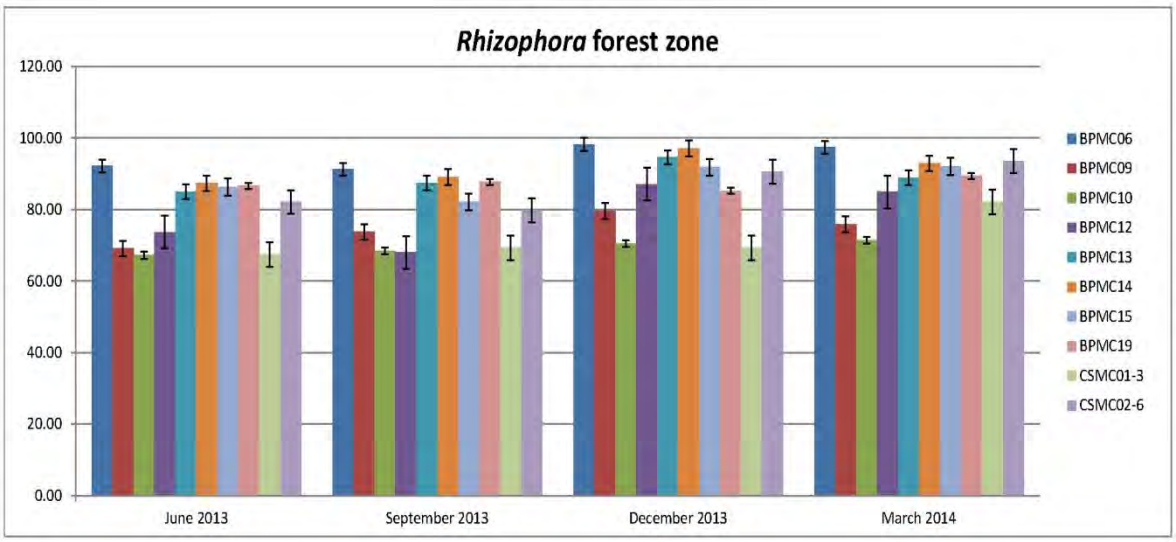

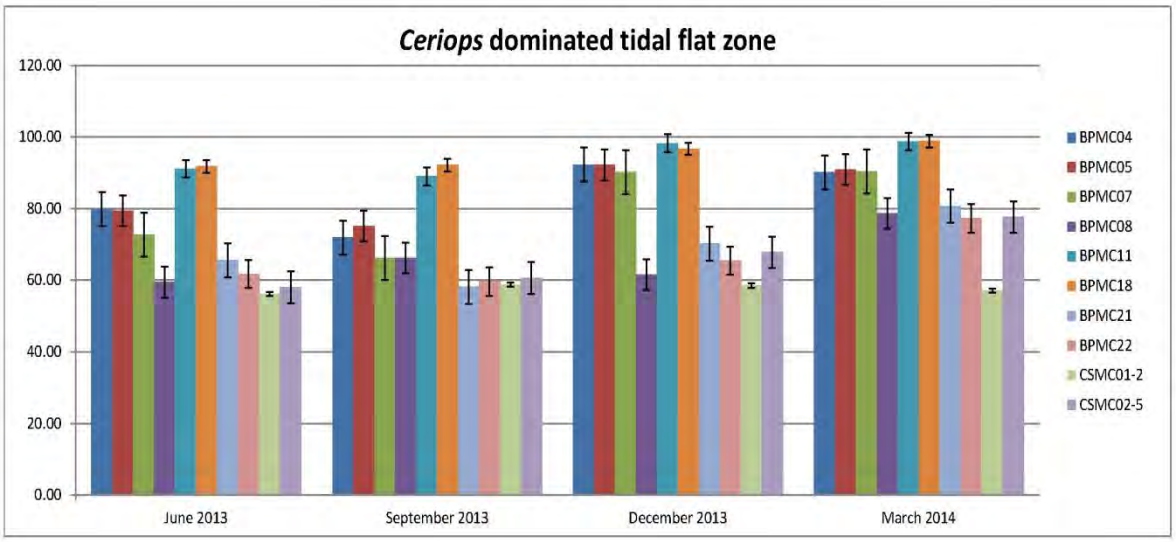

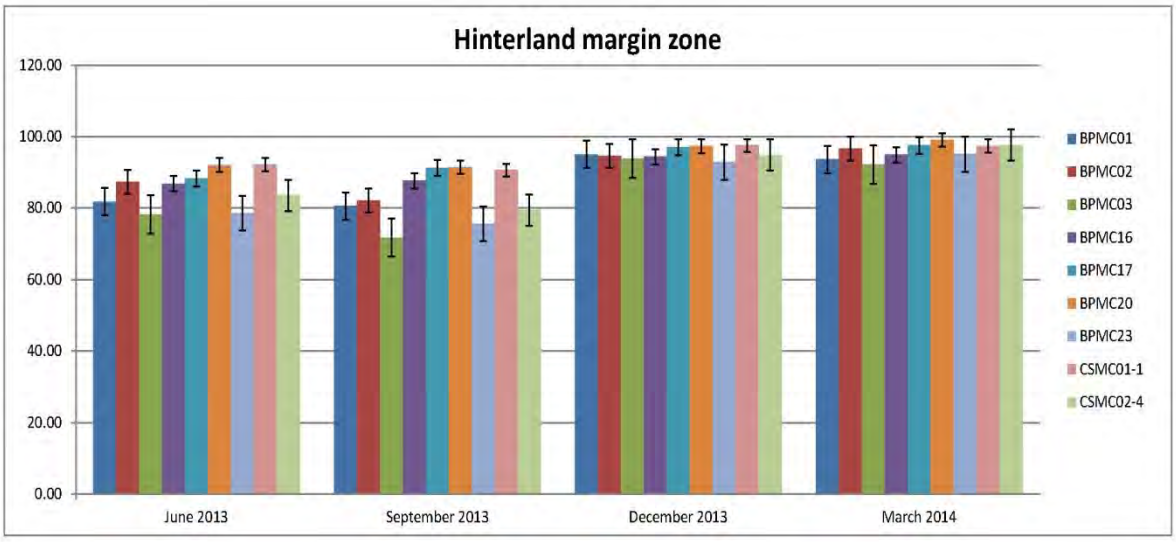

Chart 4-4 Canopy Density Summarised for each Mangrove Assemblage

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4.3.2.2 Sediment Quality

The sediment quality within the mangrove community has, after consideration of bio-availability, no metals/metalloids that exceeded the Interim Sediment Quality Guideline (ISQG) low trigger values. In accordance with the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Environment Conservation Council [ANZECC] and the Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ], 2000) (ANZECC Guidelines), there is no indication that any adverse effect from metals has occurred.

4.3.2.3 Sedimentation and Erosion

The data is consistent with the findings from the previous monitoring period, with no significant increase or decrease in sediment heights. There is no evidence of a >20 % change in mangrove community health as a result of sediment accumulation. It is noted that where increases in sediment height have been observed these increases are associated with known site conditions, namely a small mudwave and bioturbation, and are not as a result of sediment accumulation.

4.3.2.4 Bio-indicators

One mercury exceedance was recorded at BPMC05. This result was 0.1 mg/kg wet weight above the Food Standards Australia New Zealand (FSANZ) trigger value. Two mercury exceedances were noted in the Annual Report (2013), so this finding is consistent with previous results.

One copper exceedance was recorded at CSMC05. This result of 38 mg/kg wet weight falls within the range of background concentrations for Darwin Harbour recorded by Peerzada *et al* (1990).

These results indicate that construction activities are not having any appreciable bioaccumulation impacts to the mudwhelks to date.

4.4 Air Quality (Dust)

4.4.1 Monitoring Methodology

The Project's air quality (dust) monitoring objective is to record particulate matter of 10 microns or less in size (PM_{10}) and particulate matter of 2.5 microns or less in size ($PM_{2.5}$) concentrations as well as dust deposition rates at the site and at Palmerston. The data is collected at nominated sites and is intended to inform site construction 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 4-19**.

Fourteen dust deposition monitoring locations (BPDD01 to BPDD13, 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.

Four particulate matter E-Samplers (BPPM01 to BPPM03, and PAPM01) have been installed to undertake continuous sampling and light scatter analysis of PM_{10} and $PM_{2.5}$. BPPM01 and PAPM01 monitor both PM_{10} and $PM_{2.5}$ whilst BPPM02 and BPPM03 solely monitor PM_{10}.

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Legend

- Site Boundary
- Construction Footprint
- Dust Monitoring Location (DD Sample)
- Dust Monitoring Location (PM Sample)

Air Quality Monitoring Locations

Figure 4-19	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:40,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_19_AirQuality_140620.mxd		

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4.4.2 Results

4.4.2.1 Particulate Matter

Analysis of dust roses for exceedances of the trigger values for 24-hour averaged dust levels indicates that there is no clear correlation between the respirable dust levels recorded at the Project area and the levels recorded at the Palmerston monitoring location. The dates of exceedances recorded at the Palmerston monitoring location do not align with exceedance dates at the Project area, and the wind direction very rarely occurs from the Project area towards Palmerston.

There have not been any reports of dust-related complaints in relation to impacts in Palmerston as a result of Project activities during the annual monitoring period.

4.4.2.2 Dust Deposition

The monitoring location at Palmerston recorded an exceedance of the dust deposition trigger value on two occasions, in March and April 2014. Dust deposition gauges in the Project area provide data on potential impacts to the mangrove community fringing the Project area. The trigger value was exceeded at most dust deposition gauges, however during mangrove monitoring surveys, there was no indication that the physiological function of the mangroves had been impaired, or the health of the mangroves had deteriorated, arising from dust deposition.

4.5 Airborne Noise

4.5.1 Monitoring Methodology

The purpose of airborne noise monitoring is to collect data to determine whether activities within the Project area are resulting in exceedances of noise trigger values at Palmerston. Other potential sensitive receptors are either further away or are less likely to experience exceedances of noise trigger values, such as industrial or commercial premises.

During the annual monitoring period, continuous noise monitoring occurred at two locations identified on **Figure 4-20**.

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Legend

- Site Boundary
- Construction Footprint
- Noise Monitoring Locations

Airborne Noise Monitoring Locations		
Figure 4-20	**INPEX Bladin Point**	greencap AEC Environmental
Date: *20/06/2014*	**Author:** Christopher.Maddox	
	Map Scale: 1:40,000	
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 52	
G:\CLIENTS\E-TO-M\INPEX\GIS\Maps\EPA7\FIG_4_20_Noise_140620.mxd		

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4.5.2 Results

Site logs confirm that, throughout the annual monitoring period, a wide range of construction activities with the potential to generate noise took place within the Project area. The most significant of these works were conducted during:

- May – September 2013: Dynamic replacement ground improvement works inclusive of dynamic compaction of graded material;
- May 2013 – ongoing: Bulk earthwork excavations and movements; and
- July 2013 – January 2014: On-shore and off-shore piling works.

Comparison of construction work timings with noise monitoring results shows that 5 % or less of exceedances recorded at the Palmerston monitoring location may be related to Project activities. It is noted that during the Christmas to New Year period, when no Project activities occurred, noise exceedances ceased. However, noise exceedances continued at the Palmerston monitoring location. This suggests that the noise level exceedances at Palmerston are unlikely to be caused by Project activities and that there are other localised noise sources that are not related to the Project. A review of wave files obtained from the noise loggers confirms that the majority of other noise sources include vehicle movements (car and aircraft), animal noises (frogs, bird song, insects etc.) and weather events.

No noise complaints were received during the annual monitoring period. It is concluded that Project activities are causing minimal impact at the nearest residential receptors at Palmerston.

4.6 Flora and Fauna

Approximately 391.10 ha of land was cleared within the site boundary by the end of the annual monitoring period. All clearing occurred within the Project development approval boundary and therefore compiled with clearance limits.

4.7 Weeds

Weed survey reports identified that the occurrence of weeds were centred around the extractive materials area (EMA) and the remainder of the site had either been cleared or was scheduled to be cleared and sealed, indicating the potential for future weed reoccurrences were low.

No new weed species were recorded during the April 2014 survey in the EMA compared to the April 2013 survey. Of the four weed species previously recorded, three species are listed under the *Weed Management Act* (WM Act). With one of these species (Gamba Grass [*Andropogon gayanus*]) also listed as a Weed of National Significance. Project control measures appear to have been effective in restricting the weed re-growth to the Project boundaries.

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5. RISK ASSESSMENT AND RECOMMENDED UPGRADES TO THE EIMP

As part of the interpretation and analysis of the monitoring results in this EPA Report, a qualitative risk assessment against the key identified risks for the monitoring program and proposed solutions to the identified risks has been carried out. This includes recommended changes to the EIMP and/or management practices to improve the monitoring program objectives. Where improvements are deemed necessary, justification is provided for the amended monitoring elements. This includes an assessment of the locations, number of sampling points and methodologies; to improve data quality and dataset consistency to achieve the objectives of the monitoring program. The findings are also used to inform other management plans such as the CEMP to mitigate major risks to the receiving environment. This will be updated on an annual basis to reflect construction staging, and emerging risks from changing activities such as commissioning of plant and new construction elements.

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

5.1 National Environmental Protection Measure Requirements

In accordance with the *National Environmental Protection (Assessment of Site Contamination) Measure 1999*, as amended May 2013, (NEPM [2013]), human health and environment risk assessment is based on identifying plausible source-pathway-receptor linkages, and then making an assessment of the magnitude of the risk of an adverse effect. If there is no linkage between a source and a receptor, then there is no inherent risk. The estimate of risk used in this EPA7 Report is qualitative (e.g. an acceptable/unacceptable risk or a low/medium/high risk) and the potential for exposure (likelihood) which results in changes in the risk profile posed by the impacts.

This particular risk assessment makes a qualitative assessment of risk via comparison with common environmental criteria for potential source-pathway-receptor linkages. These criteria are derived from documentation associated or referenced in the various project related regulatory documents including the EIS, CEMP, and the EIMP. The best application of these criteria for beneficial use is specific to surface water and groundwater as opposed to other environmental parameters that could be 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 effects, commercial use relating to primary and secondary use of waters and agricultural purposes for marine and surface activities.

The identifications of complete source-pathway-receptor linkages and the level of risks to identified potential beneficial uses for groundwater are discussed in following sections.

5.1.1 Beneficial Use Assessment

An assessment has been undertaken for potential beneficial uses as provided in the Darwin Harbour WQOs, as follows:

- Agriculture – to provide irrigation water for primary production including related research;
- Aquaculture – to provide water for commercial production of aquatic animals;
- Public water supply – to provide water for drinking purposes;
- Environment – to provide water to maintain the health of aquatic ecosystems;
- Cultural – to provide water to meet aesthetic, recreational and cultural needs;
- Industry – to provide water for industry; and
- Rural stock and domestic – to provide water for specific use.

From the above list agriculture, cultural, industry and rural stock and domestic are not applicable beneficial uses for the site due to the industrial nature of the area.

The remaining beneficial uses are assessed below.

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5.1.1.1 Public Water Supply

The salinity of the on-site groundwater is highly variable and ranges between less than 1,200 mg/L, the limit of drinking water salinity as per the *Australian Drinking Water Guidelines* (National Health and Medical Research Council, 2004) to greater than 70,000 mg/L. This indicates that onsite groundwater has very limited suitability for drinking purposes.

Currently groundwater is not extracted onsite for any purposes. Any groundwater that is encountered through excavations may be applied onsite for construction purposes as part of the groundwater disposal strategy.

Offsite groundwater use was assessed via a regional bore search conducted through *Natural Resources Maps NT* (NT Government, 2014).

The search indicated that the majority of the registered bores within and in the vicinity of the Project area were constructed for the Project with the exception of nine bores located to the south-east and south-west of the Project area.

These bores were drilled to depths greater than 40m indicating that they targeted deeper aquifer(s) than those used for EIMP monitoring purposes.

Based on the data, only three out of nine non-Project bores have been completed for groundwater extraction purposes. These are RN021856, RN032249 and RN33148. Other bores have been backfilled indicating that they did not intersect any suitable groundwater supply strata.

Borehole records indicated that the target strata for groundwater supply have been the hard rocks, likely to be of the Burrell Creek Formation. The groundwater bearing zones within this formation may contain saline to fresh groundwaters. The bore yields do not generally exceed 2 L/sec.

It is concluded that the productive zones in the regional aquifers have very limited distribution and are not suitable for significant water supply.

None of the registered bores targeted the uppermost aquifer; as such, no off-site beneficial uses have been identified for the groundwater monitored within the Project area.

5.1.1.2 Aquaculture and Environment

The site area is a peninsula surrounded by marine aquatic ecosystems of Darwin Harbour and its estuaries, Elizabeth River and Lightning Creek. The monitoring data indicates that at the end of the dry season groundwater flows towards the coastal margins with an estimated hydraulic gradient of 0.001 across the site. The data for the end of wet season shows a significant groundwater level rise in the areas away from the coastal margins, with the inferred groundwater flow towards the coastal margins. The hydraulic gradient estimated for the bores away from coastal margins, north of the isthmus, was 0.003 and south of the isthmus was 0.004. This indicates a significantly steeper hydraulic gradient during the wet season when compared to the dry season. It is further noted that groundwater during the wet season also flows towards the isthmus area from both the northern and southern areas of the site. This indicates that the aquatic ecosystems of the above marine water bodies are likely to be the discharge areas for the uppermost groundwaters. This also indicates that Aquaculture and Environment are the likely potential beneficial uses for the uppermost aquifer.

5.1.1.3 Beneficial Use Summary

Based on the beneficial use assessment the only identified potential beneficial use is marine aquatic ecosystems of Darwin Harbour, Elizabeth River and Lightning Creek.

5.1.2 Determination of Background Concentrations

The assessment of the background groundwater quality is required by NEPM (2013).

The chemicals presented in the background groundwater are not attributable to the potential contaminating activities associated with the onsite works.

The background concentrations are defined as:

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- **Natural**: the amount of naturally occurring chemical substances derived / originating from natural processes in the environment as close as possible to natural conditions, exclusive of specific anthropogenic activities or sources; and
- **Ambient**: the concentration of chemical substances in the environment that are representative of the area surrounding the site not attributable to a single identifiable source. These are typically from historic activities, widespread diffuse impacts.

As identified in this EPA7 Report, the monitored exceedances are limited to metals, low pH values and nutrients.

The initial assessment of the onsite groundwater quality was conducted for the EIS during 2008/09, which was reported to be undeveloped at that time, i.e. prior to any on-site construction activities which started in 2012. It is noted that the groundwater assessment was limited in nature and restricted to the northern portion of the site.

As such, for the purpose of this risk assessment the results of the EIS studies can be used as an estimate of background groundwater quality and the reported concentrations in the EIS for the chemicals of concern are likely to be reflective of the natural groundwater quality.

As discussed in this EPA7 Report, the majority of the analytes, including low groundwater pH values, were identified on the site before the Project commenced. This indicates that metals, nutrients and low groundwater pH can be considered attributable to natural groundwater quality and not Project activities. The reported seasonal variations in the concentrations of chemicals of concern are also considered to be a result of natural processes occurring at the Project area.

5.2 Surface Water Monitoring Program

5.2.1 Qualitative Risk Assessment

Objectives for the EIMP surface water monitoring program are as follows:

- To minimise transport of sediment across the site into immediate surroundings including adjacent land, intertidal areas and receiving surface water;
- To minimise changes in surface water quality resulting from the disturbance or dewatering of acid sulfate soils; and
- To minimise the discharge of water contaminated with nutrients, hydrocarbons or other contaminants offsite.

5.2.1.1 Sediment Transport

In order to minimise the transport of sediment across the site into the immediate surroundings including adjacent land, intertidal areas and receiving surface water environments, a number of controls have been implemented.

The project controls implemented during the monitoring period include:

- No large scale vegetation clearing has been undertaken during the 2013/2014 monitoring period, which minimises additional risks associated with monsoon rains in the wet season.
- Any exposed surfaces and stockpiles are managed via the implementation of a certified Erosion and Sedimentation Control Plan (ESCP) in accordance with guidance from the International Erosion Control Association (IECA) (2008).
- Erosion protection infrastructure has been installed to ensure sediment is contained within the site boundaries within the design parameters specified by IECA.
- The surface water drainage network at the site has been designed in accordance with IECA best practice guidance and is governed by an overarching ESCP. Clean water drains from the site through designated drainage swales into the Harbour. Water with relatively high sediment content is drained through drainage swales into various sediment detention basins located at the site. This water, if required, is subject to flocculation and pH adjustment to achieve surface water discharge criteria prior to release into Darwin Harbour. Key features of the site drainage includes the regulating reservoir and multiple discharge outlets which ensures the

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even distribution of surface water loads around the site perimeter and limits concentrated channel flow, scouring and sediment mobilisation.

Results of mangrove community and sediment monitoring carried out during the monitoring period indicate that stormwater and construction water discharged from the site has not resulted in sediment deposition altering sediment elevation in the receiving environment by more than 50 mm as averaged over 1 m^2 and a 12 month period. Therefore, the risk ranking as detailed in the EIS remains low and the monitoring program objectives have been achieved.

5.2.1.2 Acid Sulfate Soils and Surface Water Contamination

The target relating to ASS, nutrients and contamination impacts to surface water requires that surface water quality should not exceed 10 % of concurrently measured background concentrations at reference sites and/or water quality parameters listed in the CEMP.

In accordance with ANZECC Guidelines, the collection and analysis of twenty-four consecutive months of monitoring data is required before seasonality can be assessed. This requires the establishment of a suitably robust dataset which will be completed in June 2014. Consequently, at the present time it is not possible to conduct statistical analysis on the surface water data, therefore analysis for trends has therefore been limited to graphical presentation and correlation.

During the monitoring period no groundwater was deliberately extracted, treated or discharged from the site.

All excavated ASS were treated within ASS treatment pads and/or lined skips subject to the volume of soil being treated. The treatment pads are constructed and operated in accordance with QASSIT guidelines and possess impermeable leachate collection sumps. Therefore, no ASS impacted waters have been released into the site drainage or discharged into Darwin Harbour.

Surface water monitoring assessment of pH, ORP and alkalinity correlations indicated that no changes to the geochemistry associated with ASS impacts was evident. Further, the majority of surface water monitoring locations did not exceed the adopted trigger values for metals and metalloids during the 2013/2014 monitoring period.

Nutrient exceedances typically coincide with exceedances noted at the reference sites and are not correlated with distance from the site discharge points. Nutrient exceedances at the offsite marine monitoring and reference locations are generally in accordance with the commencement of the buildup, onset of the wet season and associated monsoonal rainfall events. As reference and offsite marine monitoring locations are correlated this suggests that increases in nutrient concentrations can be attributed to East Arm wide events and not to Project activities.

The risk ranking as detailed in the EIS remains medium for ASS treatment and contamination associated with spills and leaks and any effects on the surrounding environment have been localised and minor. It is considered that the intent of the monitoring program objectives pertaining to ASS, contamination and nutrients in surface water has been achieved and no net effect from Project activities is evident.

5.2.2 Recommended EIMP Improvements

Recommended improvements to the EIMP surface water monitoring program are as follows:

- Two additional reference sites, CSSW03 and CSSW04 are being recommended to increase the spatial resolution of the monitoring program. This will assist in the refinement of the datasets for risk assessment and revision of the trigger values. The new reference sites will be situated in tidal creeks located to the east and west of the Project. A further benefit provided by the additional reference sites is the evaluation of any plumes generated by the Project.
- Upgrade the surface water monitoring sites from four to eight marine buoys with telemetered continuous monitoring. The eight sites provide an increased spatial coverage needed to detect any plume associated with the project. Installation of the marine buoys is anticipated to occur in 2014 once dredging in the area is finalised.

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- Change the basin monitoring methodology from in-basin monitoring events to opportunistic auto sampling of surface water flows at drop structures in the drainage network. The rationale for this change in approach is as follows:
    - Site access, lightning and other safety constraints have prevented sampling during storms, which is the critical time for collection of data on discharges from the surface water basins; and
    - The introduction of auto samplers in the drop structures will allow for assessment of water quality overflowing the surface water basins during above design rainfall events.

5.3 Groundwater Monitoring Program

5.3.1 Qualitative Risk Assessment

Objectives for the EIMP groundwater monitoring program are as follows:

- To minimise changes in groundwater levels and/or quality resulting from construction activities;
- To minimise disturbance to and alteration of mangrove communities as a result of changes to groundwater levels arising from construction activities;
- To minimise disturbance to and alteration of mangrove communities as a result of changes to groundwater quality arising from construction activities; and
- To minimise disturbance to and alteration of mangrove communities as a result of oxidation of acid sulfate soils from construction activities.

5.3.1.1 Groundwater Levels and Quality

As discussed in **Section 4.2**, groundwater level fluctuations to bores located in the centre of the site are attributed to seasonal rainfall trends, and recharge of bores located adjacent the site perimeter are influenced by tidal variations.

To assess groundwater quality, the ANZECC Guidelines stipulate that the collection and analysis of twenty-four consecutive months of monitoring data is required before seasonality can be assessed. This requires the establishment of a suitably robust dataset which will be completed in June 2014. Consequently, at the present time it is not possible to conduct statistical analysis of the groundwater data, therefore analysis for trends has therefore been limited to graphical presentation and correlation.

As discussed in **Section 4.2** the results of the groundwater monitoring conducted over the annual monitoring period confirm the results of the EIS. The EIS indicated that the groundwater beneath the Project area contains metals resulting from natural processes involving groundwater interaction with acidic soils which are known to contain acid extractable metals. The trend analysis for this monitoring period confirms the presence of metals in groundwater which show seasonal variation dependent on rainfall events and subsequent aquifer recharge. No point source/s has been identified in the Project area that can be attributed to elevated metal concentrations associated with the effects of ASS and construction activities.

The risk ranking as detailed in the EIS remains medium for concentrations of metals in soils and groundwater and any effects on the surrounding environment have been localised and minor.

5.3.1.2 Mangrove Community Impacts

As discussed in **Section 4.2** no impacts to groundwater from ASS has been observed during the monitoring period. Furthermore as discussed in **Section 4.3** for mangrove community health, the monitoring results indicate that the majority of mangrove systems at Bladin Point are in a healthy condition and relatively undisturbed by Project activities. The data collected is broadly consistent with data collected in June 2012. Therefore, no net effects to mangrove health and disturbance are attributable to changes in groundwater level or oxidisation of ASS associated with the Project.

The risk ranking as detailed in the EIS remains medium for ASS impacts to groundwater and any effects on the surrounding mangrove environment have been localised and minor. It is considered

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that the intent of the monitoring program objectives pertaining to levels, quality and mangrove health from groundwater has been achieved.

5.3.2 Recommended EIMP Improvements

Recommended improvements to the EIMP groundwater monitoring program are as follows:

- Increase the network of telemetered data loggers to provide increased resolution on fluctuating groundwater levels and conditions across the Project. This involves increasing the logger network of up to 43 telemetered groundwater loggers. This would improve the frequency of data collection and provide real time data pertaining to groundwater levels and quality. This will help to augment the existing monitoring at groundwater bores in high risk ASS areas.
- Remove the requirement for turbidity analysis for continuous/weekly monitoring from the monitoring program and only monitor on a monthly basis.

5.4 Mangrove, Sediments and Bio-indicator Monitoring Program

5.4.1 Qualitative Risk Assessment

Objectives for the EIMP mangrove community health, sediment and bio-indicator monitoring program are as follows:

- No decline in mangrove community health as a result of construction-related sediment accumulation in intertidal areas;
- To minimise disturbance to and alteration of mangrove communities as a result of changes to groundwater levels arising from construction activities;
- To minimise disturbance to and alteration of mangrove communities as a result of changes to groundwater quality arising from construction activities;
- To minimise disturbance to and alteration of mangrove communities as a result of oxidation of acid sulfate soils from construction activities; and
- To prevent impact to mangroves outside the site boundary.

5.4.1.1 Sediment Accumulation and Quality

Survey results of sediment accumulation indicate no annual mean increases or decreases of more than 50 mm during the monitoring period. Veneers were observed at some transects and consisted of fine material washed downslope from the edge of the Project area. Veneers generally appeared as orange-brown sediment over the underlying grey/brown mangrove muds. The thickness of the veneers ranged from 1 to 3 mm in depth. The data collected is consistent with data collected in June 2012, and the data presented in the Annual Report (2013). It is also noted that the majority of mangrove systems at Bladin Point are in a healthy condition and relatively undisturbed by Project activities. The risk ranking as detailed in the EIS for sedimentation of mangrove areas fringing the onshore development area remains low and the intent of the monitoring program objectives has been achieved.

A low mudwave averaging 20 to 30 cm high occurred intermittently along the western edge of the Flare Pad from BPMC04 to BPMC06. The most pronounced mud displacement was observed by a tidal creek close to BPMC04 where the soft sediments mounded up to 1 m higher than surrounding substrate. Because the mud wave was not pronounced near BPMC05 and BPMC06, it is unlikely to be having a substantial effect on the health of the mangroves. Relatively minor impacts which have been detected by the monitoring program at these sites include leaf yellowing and shedding, and some tree senescence. No correlation between the presence of the mudwave and these impacts has been established and mangrove community health data demonstrated that the condition of mangroves at these sites had not deteriorated between December 2013 and March 2014. The mud waves observed at the Flare Pad are minor in extent, rarely extending more than a couple of metres into the forest from the edge of the construction area. They do not appear to have caused major or significant changes in mangrove health and because no changes have been made to the drainage pattern there is a low risk of future impacts associated with the mudwaves and they will continue to stabilise and diminish over time.

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The results of sediment quality analysis show that after consideration of bio-availability, all metal exceedances were below the ISQG low trigger values. Similarly, bio-indicators tissue metal concentrations in mudwhelks, did not demonstrate exceedances of triggers values, other than one minor exceedance of mercury, and were within the range of background concentrations. In accordance with the ANZECC Guidelines, these results are characterised as low risk and therefore no further action is required. The EIS presents a risk ranking for ASS metal mobilisation from sediments which remains medium and the intent of the monitoring program objectives have been achieved.

5.4.1.2 Mangrove Impact

The results of the mangrove monitoring program show that greater than 80% (accounting for natural variation) of mangrove trees were healthy at all transects and the trigger value for tree condition was not exceeded at 21 out of 23 onsite transects. Trends in canopy cover at monitoring locations were generally consistent with the dry and wet season trends observed at the reference locations. The risk ranking as detailed in the EIS for loss of mangrove habitat and loss of biodiversity around the onshore development area remains medium and the intent of the monitoring program objectives has been achieved.

5.4.2 Recommended EIMP Improvements

Recommended amendments to the EIMP mangrove community health, sediments and bio-indicator monitoring program are as follows:

- Change in methodology to enable a more detailed assessment to be undertaken at the targeted transects, expanding the range of parameters monitored in accordance with the surveillance approach. This will involve removal of six redundant transects to provide a more meaningful dataset taking the total number of monitoring transects from 23 to 17. The current number of transects monitored are surplus to the requirements of the EIMP.
- Additional reference transects CSMC03 and CSMC04, should be added to the monitoring program taking the total number of reference transects from two to four. Two additional reference transects are recommended to improve the spatial resolution of the reference sites to be representative of the broader region. A further benefit provided by the additional reference sites is the evaluation of any plumes generated by the project.
- Collect data relating to benthic mangrove community health for example crab counts and number of fauna burrows.

5.5 Air Quality (Dust) Monitoring Program

5.5.1 Qualitative Risk Assessment

The objective for the EIMP air quality (dust) monitoring program is as follows:

- To minimise adverse impacts from dust generation on the environment and the health of the construction workforce and nearest residential receptors.

5.5.1.1 Dust Impacts on the Environment and Workforce

The prevailing wind direction was easterly to south-easterly for the dry season and, during the wet season, the wind direction was north to north-westerly. The Project area is located to the south-west of Palmerston and therefore dust migration from the site towards Palmerston would primarily occur during a period of south-westerly wind. However, the data collected confirms that a south-westerly wind direction was relatively uncommon during the monitoring period. This limits the migration of dust from the Project area towards Palmerston. In addition, suspension and transport of dust particles is affected by wind velocity, with greater wind speeds often resulting in greater transport distances. The relatively low speeds observed for the dominating south-westerly winds minimised the potential for dust particles to be transported from the Project area to Palmerston. No complaints have been received pertaining to dust generation from Project activities at Palmerston.

The monitoring location at Palmerston recorded two exceedances of the dust deposition trigger value. The dust deposition gauges in the Project area provide data on potential impacts to the mangrove

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community fringing the Project area. The trigger value was exceeded at most dust deposition gauges, however during mangrove monitoring surveys, no correlation between the presence of dust deposition on mangrove leaves and decline in mangrove community health was established. Data demonstrated that the condition of mangroves at BPMC02 and BPMC03 has not deteriorated significantly, while decline in tree condition at BPMC05 and BPMC07 was attributable to other factors.

The risk ranking as detailed in the EIS remains low for nuisance and health impacts (of PM_{10} on nearby community) and deposition on surrounding vegetation resulting in smothering and reduced growth. The intent of the air quality (dust) monitoring program objectives has been achieved.

5.5.2 Recommended EIMP Improvements

Recommended amendments to the EIMP air quality (dust) monitoring program are as follows:

- Amend the objectives from the EIMP which state:
  - *To minimise adverse impacts from dust generation on the environment and the health of the construction workforce; and*
  - *To minimise adverse impacts from dust generation on the environment and the health of the construction workforce and nearest residential receptors.*
- Remove sites BPPM05, BPPM07, BPPM08 and BPPM10 as they are surplus to monitoring needs.
- Add site BPPM04 for better coverage at the Wickham Point Business Park. Following the addition of the Wickham Point Business Park site the number of dust stations is sufficient to establish compliance with the CEMP.

5.6 Airborne Noise Monitoring Program

5.6.1 Qualitative Risk Assessment

The objective for the EIMP airborne noise monitoring program is as follows:

- To minimise the impacts of construction noise and vibration on local communities (nearest sensitive receptors).

5.6.1.1 Noise Impacts to Local Community

The comparison of construction work timings with noise monitoring results confirms that less than 5 % of the exceedances recorded at Palmerston (nearest receptor) could be attributed to Project activities, however, there are other local sources that more likely to be the source of these noise exceedances. As noted previously these other sources based on WAV files include animal sounds, vehicles and the like. It is noted that during the Christmas to New Year period, when no Project activities occurred, noise exceedances ceased at the onsite monitor. However, noise exceedances continued at Palmerston over this time. This suggests that the noise level exceedances at Palmerston are unlikely to be caused by Project activities and that there is other localised noise sources that are not related to the Project including turf farming activities, shooting ranges and local traffic. No complaints from the nearest receptor have been received.

The EIS recognises effects to the community from factors such as airborne noise. The risk ranking attributed to noise remains low for nuisance and health impacts. The intent of the monitoring program objectives has been achieved.

5.6.2 Recommended EIMP Improvements

Recommended amendments to the EIMP airborne noise monitoring program are as follows:

- Remove EAAN01 as surplus to monitoring needs.
- Relocate BPAN02 to cover the Wickham Point Business Park.

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5.7 Flora and Fauna Monitoring Program

5.7.1 Qualitative Risk Assessment

The objective for the EIMP Flora and Fauna monitoring program is as follows:

- To avoid disturbance to flora and fauna outside the approved clearing footprint following initial clearance of handover area.

5.7.1.1 Flora and Fauna Clearance

Clearance occurred within the clearance limits.

No improvements to the EIMP are recommended.

5.8 Weed Monitoring Program

5.8.1 Qualitative Risk Assessment

The objective for the EIMP Weed monitoring program is as follows:

- Zero introduction and spread of new weeds and to prevent the spread of weeds and the introduction of new weed species to the Site.

5.8.1.1 Weed Management

Weed survey reports identified that the occurrence of weeds were centred around the EMA and the remainder of the site had either been cleared or was scheduled to be cleared and sealed, indicating the potential for future weed reoccurrences were low.

No new weed species were recorded during the April 2014 survey in the EMA compared to the April 2013 survey. Of the four weed species previously recorded, three species are listed under the WM Act. With one of these species (Gamba Grass [*Andropogon gayanus*]) also listed as a WONS. Project control measures appear to have been effective and restricting the weed re-growth to the project boundaries. The risk ranking as detailed in the EIS remains medium and any effects on the surrounding environment have been localised and minor.

5.8.2 Recommended EIMP Improvements

Incorporate quarterly surveys for fugitive weeds into the mangrove monitoring program.

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6. CONCLUSION

In conclusion, the intent of the EIMP was satisfactorily implemented during the annual monitoring period, providing a clear understanding of the site risks and the projects potential impacts on the adjacent receiving environment and broader Darwin Harbour. Whilst there were a number of exceedances across a number of parameters, none of these exceedances represented any net deleterious effect to the receiving environment. The report makes recommendations for refinement of the EIMP, specifically in regards to the distribution of the number of monitoring locations across the site to increase the spatial resolution of the monitoring program.

The Project will reach a key milestone in June 2014, where in accordance with the ANZECC Guidelines, the collection and analysis of 24 consecutive months of monitoring data has been completed and seasonality can be assessed. This will allow the finalisation of a suitably robust dataset which will establish a set of Northern Territory and Project site-specific criteria with which to evaluate environmental performance and long term strategies for environmental management.

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