Terrestrial Water

This chapter describes the local hydrology of the site and potential impacts associated with the proposed expansion on groundwater and surface water.

10.1 Existing Environment

10.1.1 Surface Water Hydrology

Site Hydrology

The topography of the development areas and the earth-worked areas (fills and hardstands) are designed to drain as overland flow to detention/sediment basins and to the harbour. Currently surface water runoff for most of the EAW hardstand areas is collected into stormwater collection pits that passively seep into the harbour. Stormwater collection pits that drain from the ship loader catchment and the hardstand east of the bulk loader have recently been diverted to discharge to a retention pond. There are further plans underway to improve existing stormwater management, including:

- Implementation of stormwater contaminant capture such as gross pollutant traps
- Developing a “cut off drain” along the wharf berth in front on the ship bulk loader.

Elsewhere across the EAW, engineered and natural water courses direct stormwater runoff and overland flow into the surrounding harbour. These water courses appear to be intermittent in nature, and likely only carry flow within the wet season.

In the wider context, Bleesers and Hudson Creeks collect runoff from urbanised areas in portions of Darwin, Berrimah, and Palmerston into the harbour.

Surface Water Sampling and Analysis

Limited water quality studies have been conducted on Bleesers and Hudson Creeks. According to Padovan (2003), dissolved oxygen levels in Bleesers Creeks have been reported at 60% at low tide, compared to 90% at high tide. Similar reductions in pH have also been observed. Relatively high concentrations of chlorophyll and seasonable variability in nitrate concentrations have also been reported in Bleesers Creek.

NRETAS conducts regular sampling and analysis of water samples for microbial contaminants, including *E. coli* and *Enterococci* bacteria from Bleesers Creek, which receives discharge from the nearby Berrimah waste stabilisation lagoons. Water quality has generally been interpreted to be good.

Surface water samples were collected by URS personnel from four locations at EAW on 21 February 2011. The surface water sampling locations are indicated on Figure 10-1. The samples were collected shortly after the passing of Cyclone Carlos, during which time more than 700 mm of rainfall had fallen in the greater Darwin area during the course of just four days.

At the time of sampling, water quality parameters (pH, temperature, dissolved oxygen [DO], electrical conductivity [EC], reduction-oxidation potential [redox], and total dissolved solids [TDS]) were measured and recorded in the field using calibrated, hand-held meters. Following measurement of field parameters, water samples were collected in general accordance with NT Department of Resources recommended methodology for the collection of surface water samples.

Each water sample was analysed at NATA (National Association of Testing Authorities) accredited laboratories for the following parameters:

- Total Petroleum Hydrocarbons (TPH)
- Benzene, toluene, ethylbenzene, xylenes (BTEX)
- Total and dissolved metals
- Major cations and anions, and
- pH, EC and TDS.

On the basis that the area is slightly to moderately disturbed, the following guidelines were adopted for comparison with laboratory analytical results and site field data, respectively:

- Ecological based Trigger Values for Marine Ecosystems (protective of 95% species) for Slightly to Moderately Disturbed Systems, as specified in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, (ANZECC/ARMCANZ, 2000); and
- Ecological based Trigger Values for Freshwater Ecosystems (protective of 95% species) for Slightly to Moderately Disturbed Systems, as specified in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, (ANZECC/ARMCANZ, 2000).

Field Parameter Results

Water quality parameters measured at the time of sampling for the four surface water sampling locations are provided in Table 10-1. Listed in the table are default trigger values for each parameter, with which water quality can be assessed relative to ANZECC (2000) water quality guidelines for lowland rivers in tropical Australia.

Table 10-1 Field Parameter Results for Surface Water Samples

Sampling Location	Date Sampled	pH	Temperature (ºC)	DO (% saturation)	EC (µS/cm)	TDS (mg/L)	Redox (mV)
ANZECC Trigger Value		6.0 - 8.0	--	85 - 120	20 - 250	--	--
SW1	21/02/11	6.87	32.1	69.2	1,197	778	92
SW2	21/02/11	7.72	29.8	45.5	263	171	264
SW3	21/02/11	6.20	30.6	64.3	2,017	1,311	125
SW4	21/02/11	6.92	31.6	59.4	1,525	991	32

The field measured pH values range between 6.2 and 7.7, which indicate approximate neutral acidity conditions and fall within the ANZECC trigger value range of 6.0 to 8.0. Temperatures were relatively consistent and averaged approximately 31ºC. Dissolved oxygen values vary between 45.5 and 69.2 %, which fall below the ANZECC trigger value range of 85 – 120%. EC values were elevated at each sampling location and exceed the ANZECC trigger value range of 20 – 250 µS/cm. There are no trigger values for TDS or Redox. TDS and EC are closely related and are indicative of high concentrations of dissolved constituents.

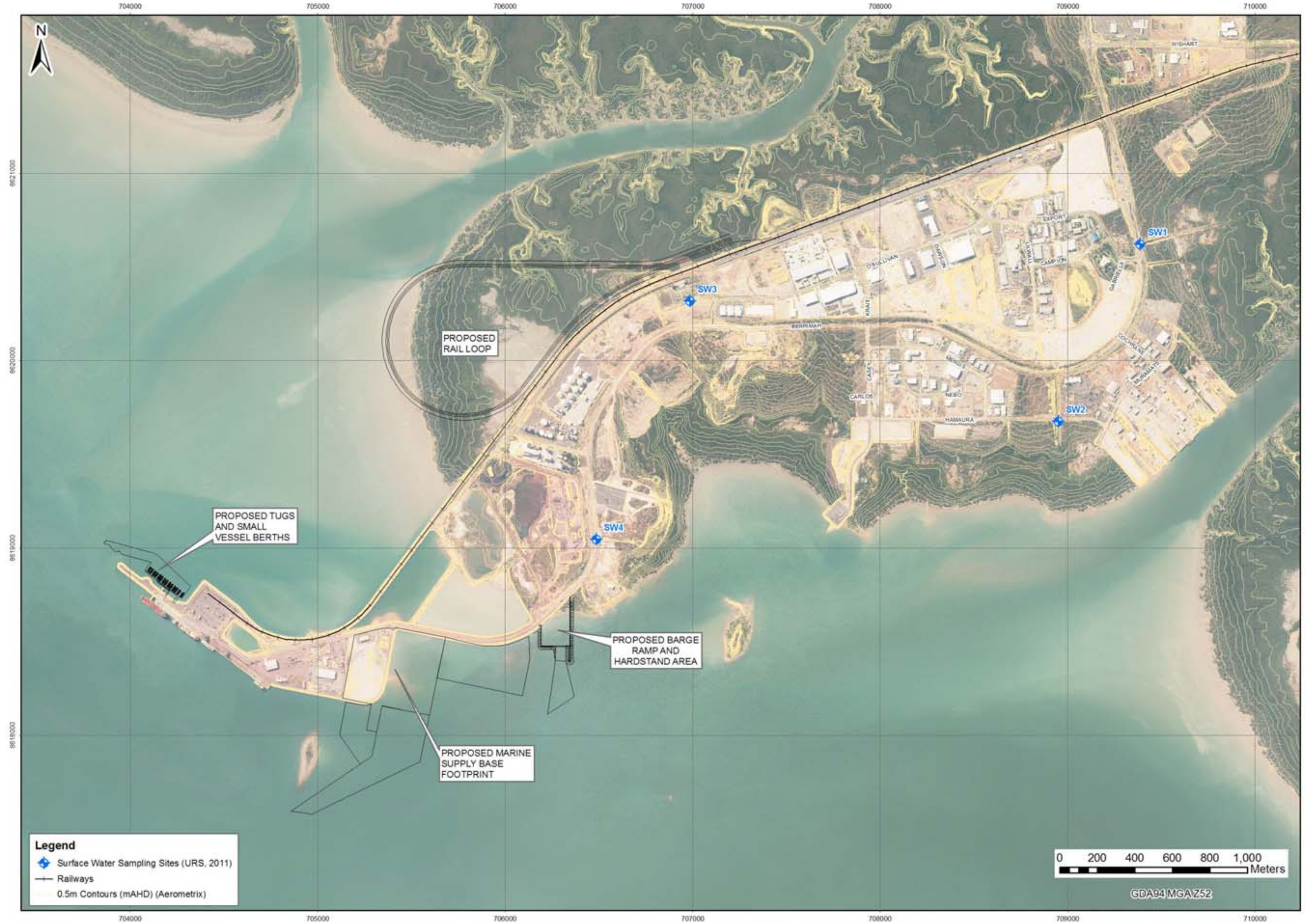

Figure 10-1 Surface Water Sampling Locations

Laboratory Analytical Results

The laboratory analytical results for water samples collected from the four surface water sampling locations are provided in **Appendix H**.

Then ANZECC Freshwater Ecosystems 95% protection guidelines for dissolved and total Cadmium, Chromium, Copper, Lead, Nickel, and Zinc were modified for each sample based on the water hardness using the hardness-dependent algorithms and factors as outline in *ANZECC 2000 Guidelines, Chapter 3: Aquatic Ecosystems, Table 3.4.3 and Table 3.4.4*. The water hardness was calculated by using the following formula;

$$[CaCO_3] = 2.5\ [Ca^{2+}] + 4.1[Mg^{2+}]$$

Summary of Results

A summary of metal concentrations that exceed the adopted trigger values is provided in Table 10-2.

Metal concentrations for marine water guidelines were exceeded for cobalt and zinc for three of the four samples tested (SW1, SW2 and SW3) and for copper in SW4.

Metal concentrations for fresh water guidelines were exceeded for copper (SW1) and manganese (SW3) only.

No samples were detected above the Limit of Reporting (LOR) for total TPH and BTEX.

Table 10-2 Analytical Guideline Summary

Sample ID	Guideline Trigger Value+	Constituent Exceeding Adopted Guideline	Unit	Value
SW1	ANZECC 2000 Marine Water - 95%	Dissolved Cobalt	mg/L	0.003
	ANZECC 2000 Marine Water - 95%	Dissolved Zinc	mg/L	0.018
	ANZECC 2000 Freshwater - 95%	Dissolved Copper	mg/L	0.006
SW2	ANZECC 2000 Marine Water - 95%	Dissolved Cobalt	mg/L	0.004
	ANZECC 2000 Marine Water - 95%	Dissolved Zinc	mg/L	0.016
SW3	ANZECC 2000 Marine Water - 95%	Dissolved Cobalt	mg/L	0.021
	ANZECC 2000 Marine Water - 95%	Dissolved Zinc	mg/L	0.023
	ANZECC 2000 Freshwater - 95%	Dissolved Manganese	mg/L	6.05
SW4	ANZECC 2000 Marine Water - 95%	Dissolved Copper	mg/L	0.002
QC01*	ANZECC 2000 Marine Water - 95%	Dissolved Copper	mg/L	0.002
QC02*	ANZECC 2000 Marine Water - 95%	Dissolved Copper	mg/L	0.003

* Field duplicate and triplicate of SW4

+-Hardness Modified Trigger Values for Freshwater

10.1.2 Hydrogeology

Groundwater Geology and Aquifer Occurrence

Groundwater information within the area (1:250 000 Hydrogeological Map of Darwin) indicates that groundwater may be encountered within unconfined quaternary sediments (sand, silt and clay) and fractured, weathered bedrock. The groundwater resources in the area are classified as minor with generally low yields (less than 0.5 L/s); however relatively higher yields with low storage may be available from sand lenses within the quaternary sediments, gravel layers that may be present at the interface of the sediments and bedrocks and fractures within the bedrock (quartz veins).

There is no historical groundwater level data from the project locality. Groundwater levels in the project locality are likely to follow ground surface topography with flow toward the sea from areas of elevation. Near-shore groundwater levels are likely to be influenced by tides, which range up to 8 m. Based on available groundwater data from monitoring bores, groundwater is generally expected to be within about 5 m of ground surface and may vary between 3 and 8 m depending on the season.

Conceptual Groundwater Model

A review of existing geological information from geotechnical boreholes in the study area identified three main hydrogeological units. These include:

- Quaternary sediments (sand, silt, clay and shells) and fill (marine dredge) material
- Weathered zone above relatively fresh bedrock, and
- Fresh bedrock and fractures within fresh bedrock.

10.2 Potential Impacts

Potential impacts to surface water and groundwater have been identified as a result of the proposed expansion in relation to activities such as dredging and land reclamation.

10.2.1 Groundwater

Potential impacts to groundwater from the proposed expansion are:

- Changes in bathymetry as a result of dredging and/or reclamation may increase groundwater flow and discharge mechanisms, particularly where fractured bedrock is intersected. This may reduce terrestrial groundwater levels and limit the availability of groundwater to dependent ecosystems. Terrestrial seawater intrusion (if present), could also progress further inland under this scenario.
- Modification of the groundwater flow regime, particularly if the hydraulic conductivity of the deposited sediments is significantly different to that of the natural soil profile of the shoreline.
- Reclamation of land may reduce groundwater discharge mechanisms, particularly where fractured bedrock is intersected. This may increase terrestrial groundwater levels and limit terrestrial seawater intrusion (if present).
- Disturbance of ASS and PASS during land reclamation or groundwater dewatering activities could lead to contamination of groundwater by acidification of groundwater, release of heavy metals and nutrients.
- Contamination from leaks and spills of fuels, lubricants, solvents or other products from operating equipment.

- Reduction in groundwater recharge to aquifers as a result of compaction and sealing of ground surfaces during construction of roads, railways, buildings and hardstands. This can also lead to a reduction in groundwater levels, flow and discharge mechanisms.

10.2.2 Surface Water

Potential impacts to surface water from the proposed expansion are:

- Interruption to or reduction of natural drainage flows.
- Increase of suspended sediment loads in surface water systems/marine environment during construction.
- Release of metals and nutrients by disturbance of ASS/PASS materials via surface water systems.
- Surface runoff/pond seepage may exceed water quality objectives for Darwin Harbour or relevant standards.

10.3 Management of Impacts

10.3.1 Objectives and Standards

Potential groundwater and surface water impacts will be managed in accordance with relevant standards, including as set out in the following:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)
- Darwin Harbour Strategy (DHAC, 2010)
- DPC Environmental Management Plan
- Draft Stormwater Management Strategy for the Darwin Harbour Catchment
- *Marine Pollution Act*
- *Waste Management and Pollution Control Act.*
- Water Quality Objectives for the Darwin Harbour Region, and
- *Water Act.*

10.3.2 Management Requirements

Management Hierarchy

The environmental management process will follow a general hierarchy of:

- Impact avoidance
- Impact assessment
- Impact minimisation
- Identification of mitigation measures
- Assessing mitigation measure effectiveness
- Mitigation plan selection
- Monitoring and adaptive management.

Key aspects of groundwater and surface water management are discussed below. It is noted that following completion of the EIS process, EMPs will be developed for both the construction and operational phases. These EMPs will be forwarded to NRETAS for comment prior to finalisation.

10 Terrestrial Water

Groundwater

Groundwater can be impacted during some operation contain pollutants from loading operations, leaks and spills. Sources can include:

- Unsealed hardstand, terminals roads and parking lots
- Fuels and hazardous materials storage areas (unsealed hardstand areas)
- Seepage from ponds (pollution and sedimentation)
- Unsealed storage and handling areas, and
- Unsealed maintenance and vehicle fuelling areas.

A number of mitigation and control measures may be implemented to increase the potential for groundwater quality to meet relevant standards. These include:

- Storing oils, hydrocarbons and other hazardous materials in designated locations with specific measures to prevent leakage and release of their contents, on an impermeable base.
- Engineer water pollution retention ponds to mitigate seepage to groundwater.
- Reduce or eliminate rainfall infiltration to storage stockpiles in unsealed hardstand areas.

Surface Water

Stormwater runoff from paved surfaces may contain pollutants from loading operations, leaks and spills. Sources include surface runoff/drainage from:

- Hardstand, terminals roads and parking lots
- Fuels and hazardous materials storage areas
- Storage and handling areas, and
- Maintenance and vehicle fuelling areas.

A number of mitigation and control measures may be implemented in order to ensure that relevant standards are met. These include:

- Storing oils, hydrocarbons and other hazardous materials in designated locations with specific measures to prevent leakage and release of their contents, including the location of the storage areas away from surface water drains, and on an impermeable base that has no outflow and is of adequate capacity to contain more than 100% of the contents.
- Minimising the amount of run-off entering oily wastewater and wastewater treatment systems through appropriate grading, drainage designs and other means.
- Provision of spill response equipment to contain and clean-up spills.
- Installing and maintaining waste management structures appropriately around the maintenance workshop, vehicle washdown bays, refuelling depots. Waste management structures may include, but are not limited to: protective bunding, skimmers, silt traps, fuel and oil traps, drains and sealed collection sumps. These measures could be used to recover spills, and allow treatment to remove contaminants within impervious containment structure prior to discharge.
- Installing and maintaining sediment retention ponds, vegetated buffer strips or other effective measures at all potential off-site stormwater discharge points.
- Controlling overland drainage to prevent channelling and sediment transport by diverting flows away from areas that are exposed.
- Collecting all stormwater from areas through surface drainage channels and directing them into sedimentation structures before flowing off-site.

- Designing and implementing sediment control measures within drainage lines downstream of active work areas and other disturbance areas.

As noted also in Section 9.3, DPC are currently implementing the following interim measures to capture run-off from the existing wharf areas:

- Diversion of the stormwater drain from the wharf ship loader area to the settling pond behind the wharf area (Figure 10-1). This was completed in October 2010.
- Diversion of the hardstand catchment east of bulk loader to the same settling pond. This work was completed in December 2010.
- Developing a “cut off drain” along the edge of the wharf berth in front on the bulk loader, to minimise run-off in this area to the harbour.

These interim measures will be integrated into the design of the drainage system for the proposed EAW extension.

10.3.3 Monitoring and Reporting

A monitoring network will be required for both groundwater and surface water for long-term monitoring program to comply with objectives and standards.

Drilling, logging and installation of groundwater monitoring bores will allow understanding of the site groundwater hydrology and hydraulics. Groundwater monitoring bores would be located in unsealed hardstand areas (over reclaimed and natural land surface) to determine if seepages from the areas meet water quality objects. Bores would also be located near existing pollution and sedimentation ponds to determine seepage quality.

The groundwater monitoring program would be analysed initially for the following parameters; the number and frequency of analyses would be reviewed periodically, and also amended in accordance with future operational environmental management plans: pH, conductivity, temperature, total dissolved solids (TDS), chloride, fluoride, sulphate, alkalinity, major ions, boron, metals (arsenic, cadmium, chromium, cobalt, copper, selenium, nickel, manganese, iron, lead, mercury, tin, uranium and zinc), total anions, total cations, nitrate, nitrite, phosphorus, polycyclic aromatic hydrocarbons (PAH) and total petroleum hydrocarbons (TPH).

The surface water monitoring program should monitor both sediment and water quality, in key locations at collection points throughout the surface water management system. These will include; drains, pollution retention ponds, sediment retention ponds, and other area of potentially contaminated surface water run-off.

The surface water monitoring program would be analysed initially for the following parameters; the number and frequency of analyses would be reviewed periodically, and also amended in accordance with future operational environmental management plans: pH, conductivity, temperature, TDS, chloride, fluoride, sulphate, alkalinity, major ions, boron, metals (arsenic, cadmium, chromium, cobalt, copper, selenium, nickel, manganese, iron, lead, mercury, tin, uranium and zinc), total anions, total cations, nitrate, nitrite, phosphorus, PAH and TPH.

Regular monitoring of groundwater and surface water will assist in implementing and assessing water management strategies.

Annual water quality reporting on monitoring performance will be aligned to existing and future construction and operational EMPs.

10.4 Commitments

- *Mitigation and control measures would be implemented as required to ensure that relevant groundwater and surface water standards are met.*
- *Interim measures for stormwater management will be integrated into the design of the drainage system for the proposed EAW extension.*
- *A surface and groundwater monitoring program would be implemented, which would be periodically reviewed for the number and frequency of analyses, and also amended in accordance with future operational environmental management plans.*
- *Groundwater and surface water monitoring performance would be reported to NRETAS annually.*
- *A drainage strategy is being developed for East Arm Wharf for existing and new areas. Existing areas will have management improved to further reduce contaminants that can enter the stormwater system, drainage will be altered to collect stormwater and various retention and treatment systems are to be installed to ensure stormwater discharged off the site will be of acceptable quality.This strategy identifies "management actions" to prevent contaminants finding their way into stormwater. This will be applied to new areas to ensure the design and daily operations minimise stormwater contamination. Final detailed design is to ensure such management actions can be undertaken and Environmental Management Plans and operational procedures will also be developed. Areas such as General Cargo will have Gross Pollutant Traps (GPT) that remove some heavier sediment, litter and oil. Whereas areas vulnerable to greater volumes of contaminants, or more difficult to capture contaminants (such as bulk minerals) will have sediment ponds. Stormwater discharges are also to be monitored to verify the systems in place are adequately treating stormwater to an acceptable standard. Stormwater found not to be of acceptable quality will have management actions reviewed and stormwater treatment infrastructure modified where required."*

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