Final Report

Lee Point Master-planned Urban Development – Water Quality Monitoring Plan

Prepared for

Defence Housing Australia

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1 INTRODUCTION

1.1 Background

This Water Quality Monitoring Plan (WQMP) has been prepared by Ecology and Heritage Partners Pty Ltd to support the Environmental Impact Statement (EIS) for the Lee Point Master-planned Urban Development (herein referred to as 'the Project'), including the 2CRU site and Muirhead site, located on Lee Point Road, Lee Point, Darwin, Northern Territory (Figure 1).

The primary purpose of the Defence Housing Australia (DHA) development is to provide residential housing with smaller sections dedicated for commercial purposes and potential tourism/hotel development. This report details the water quality monitoring requirements for the pre-construction (baseline), construction and occupation of the project site.

1.2 Purpose

Assessing estuary ecosystem health requires a framework for setting the objectives, selecting appropriate indicators, monitoring and reporting to measure components of the ecosystem that contribute to its overall health. The purpose of this WQMP is to determine baseline water quality conditions and natural variability in both the Sandy Creek and Buffalo Creek tidal estuaries. It also provides the framework once baseline values are obtained to conduct subsequent monitoring that will enable the detection of change in water quality and condition of these systems during the construction and occupation of the Project. The monitoring plan is designed to assist DHA in their determination on the cause of any change beyond natural variability (e.g., construction; erosion; stormwater runoff/discharge; spills) as a result of the project and what mitigation measures are required.

As no baseline data currently exists for Sandy Creek, it is advised that if any works take place prior to the implementation of this monitoring plan, that the DHA refer to the default guideline trigger values provided in Tables 3.3.4-3.3.5 for Tropical Australia in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) (herein referred to as 'the guidelines'). The guidelines recommend trigger values, which represent bioavailable concentrations or unacceptable levels of contamination, that if exceeded, trigger the incorporation of additional information or further investigation to determine whether or not a real risk to the ecosystem exists and, where possible, to adjust the trigger values into regional, local or site-specific guidelines (ANZECC, 2000). In the case of Buffalo creek, baseline data can be extrapolated from previous monitoring conducted by both the NT Government and Power and Water Corporation (PWC), as per the data described within the various Darwin Harbour, Shoal Bay and Buffalo creek report cards (2009-2016).

The ability to delineate influences on these systems from pre-, during- and post-construction activities versus other natural and human influences presents a challenge. The WQMP takes into account that no data has been collected for Sandy creek to date and Buffalo creek is influenced by multiple cumulative industry discharges. Seasonal constraints (i.e. Wet and Dry season) are reflected in how the monitoring data will be collected and used to determine baseline variability for these systems. It is important to recognise that the Sandy Creek catchment currently forms part of a slightly-moderately disturbed system, and the Buffalo Creek catchment forms part of a highly disturbed system with multiple urban and industrial (waste) point sources.

1.3 Objectives

The objectives of the monitoring plan, as per Section 5.3.1 of the Terms of Reference (ToR) for the EIS, include:

- To ensure that surface water resources and quality are protected both now and in the future, such that ecological health and land uses, and the health, welfare and amenity of people are maintained.
- Available water supplies will be sufficient to fulfil the Project needs over the predicted life of the Project, both construction and occupation, without causing environmental or social impacts.
- Ensure minimal sedimentation and turbidity increases as a result of Project activities.

1.4 Scope of Work

As per section 5.3 of the ToR, this water quality monitoring plan will form part of the overall Construction Environment Management Plan (CEMP), to:

- Identify surface water values (environmental, baseline and trigger values) within Sandy Creek estuary and Buffalo Creek estuary.
- Identify potential surface water impacts.
- Identify clear thresholds and management (contingency) measures in response to potential impacts.
- Implement the surface water monitoring plan to achieve environmental objectives and protect environmental values.
- Provide relevant water quality data and information collected to assess the effectiveness of the Erosion and Sediment Control Plan (ESCP) and Stormwater Management Plans (SMPs).

The monitoring plan will also outline contingency measures that will be implemented over the stages of the Project in the event that a significant change in the environmental values is detected.

1.5 Study Area

1.5.1 Sandy Creek Estuary

Sandy Creek estuary is located approximately 13 kilometres north north-east of Darwin city and forms part of the Darwin Harbour Watershed and Finniss River Catchment. The creek originates in the suburb of Lyons and flows past the Royal Darwin Hospital before entering the Casuarina Coastal Reserve where its channel flows parallel to the western boundary of the 2CRU site through to Darwin Harbour.

Sandy Creek's catchment area has been substantially altered by previous urban developments; however, as the water quality has not been monitored the impact of urban development is not known. As only a small portion of the Sandy Creek catchment is within the area proposed for the current development and all stormwater discharge will be managed through a detention basin shown on the master plan in the south-west corner of the 2CRU site, the developments contribution to cumulative impacts is expected to be relatively minor.

1.5.2 Buffalo Creek Estuary

Buffalo Creek is located approximately 14 km north north-east of Darwin's CBD and forms part of the Darwin Harbour Watershed (Figure 2). This tidal influenced creek flows into Shoal Bay, listed by the Northern Territory (NT) Government as a *Site of International Significance* (NRETAS, 2007) for a number of reasons including:

- Extensive tidal flats providing important feeding and roosting area for migratory shorebirds
- Small inland freshwater wetlands frequented by up to 5,000 waterbirds
- Patches of rainforest around the margin of the tidal flats
- Threatened species including three plants, ten vertebrates and one invertebrate.

Buffalo Creek is a highly disturbed tributary, as a result of a number of past and present land uses including the Leanyer-Sanderson Sewerage Treatment Plant (LSSTP) that continues to discharge secondary treated sewage directly into Buffalo Creek since 1971, untreated urban stormwater, landfills, recreational activities (including a caravan park, a water park and recreational boating), a historic quarry mine, and historical use as a military training range (Drewry, 2010).

The areas proposed for development occur across both Buffalo Creek and Sandy Creek catchments and drainage lines (Figure 2). Surface water from the western portion of the 2CRU site currently drains west to Sandy Creek via overland flows, gullies and minor drainage lines, with the main point of discharge occurring in the southwestern corner of the site to a drainage line that flows through Casuarina Coastal Reserve and into Sandy Creek. Surface water from the eastern portion of the Muirhead site currently drains east to Buffalo Creek via overland flows, gullies and minor drainage lines, with the main point of discharge occurring in the south-eastern corner of the site to a drainage line that flows through Buffalo creek management area Reserve and into Sandy Creek. Both the Sandy Creek and Buffalo Creek catchments currently receive stormwater discharge from existing urban/residential areas and Buffalo Creek also receives discharge of treated sewage effluent from the Leanyer Sanderson Wastewater Treatment Ponds approximately 5 km upstream of the mouth.

2 RELEVANT LEGISLATION AND POLICY, GUIDELINES

The principal legislative basis for water quality management in the Northern Territory is the *Water Act 1992.* The legislation includes a process for:

- Identifying and declaring beneficial uses or environmental values. These include environment, cultural and human use values; and
- Establishing corresponding water quality objectives or water quality standards to protect identified beneficial uses.

Water Quality Objectives (WQOs) can be declared under Part 7, Section 73 of the Act. This declaration allows natural resource managers and regulators to use WQOs as benchmarks for regulation to protect beneficial uses and for their use as performance measures for monitoring and reporting.

Other relevant strategies, guidelines and policies include the:

- National Water Quality Management Strategy (NWQMS) 1992;
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000);
- National Water Initiative (2005)
- *Environmental Assessment Act* 2013
- *Territory Parks and Wildlife Conservation Act 2014* (TPWC Act)

3 EXISTING ENVIRONMENT

The main coastal landforms in the Casuarina Coastal Reserve include intertidal sandflats, offshore reefs, dune, beach ridges, estuarine fringes and waterways including Sandy, Rapid and Buffalo Creeks (Parks and Wildlife, 2016). Sandy Creek is tidally influenced and is dominated primarily by mangroves and salt tolerant vegetation. The intertidal sandflats provide habitat for marine invertebrates, migratory waders and turtles. This area also receives the highest level of visitor use in the Reserve.

Buffalo Creek begins as a freshwater system gradually mixing into an estuarine tidal system consisting of a long, narrow channel gently meandering near its confluence with Shoal Bay, containing a large intertidal sand bar (Haese, et al., 2009). In its upper reaches, it splits into two tributaries, fed by stormwater drains and dominated by salt flats and fringing closed grassland / sedgeland communities. Towards the mid to lower reaches, the creek is fringed by mangroves in its intertidal zone, consisting mostly of *Rhizophora stylosa*, *Bruguiera exaristata* and *Camptostemon schultzii* closed to open forest.

The following sections describe the existing environment, potential impacts and proposed water quality monitoring and management of Sandy Creek and Buffalo Creek tidal estuary.

3.1 Climate

Darwin has a tropical monsoonal climate with distinct wet and dry seasons. Climate data has been extracted from the Bureau of Meteorology (BOM) Darwin Airport station (Site number: 014015). The dry season is typical of a semi-desert climate, which runs from April/May to October, experiencing an annual maximum temperature of 39°C with an annual mean of 32°C, which varies very little year-round and is generally recorded over 30°C most days of the year (BOM, 2017). Darwin experiences a mean annual rainfall of 1722 mm, with the highest recorded rainfall occurring over the Wet season between November and April with humidity highest in the morning at between 72-83%. The Wet season is also known as cyclone season for its cooling tropical rainstorms.

3.2 Hydrology

There is little known information regarding the hydrology of the catchment area of Sandy Creek. It is a short narrow channel situated within a mangrove-dominated coastal reserve, with a few drainage lines and no connected tributaries (Plate 1 and 2). It lies within an area with a mesotidal or low-macrotidal range (>4 m tidal range). There is no available data on the freshwater inputs and water quality data for the system.

NT Government report cards that describe the condition of Buffalo creek from 2009-2016, state an overall water quality rating of 'E', (i.e. V*ery poor water quality. No water quality indicators meet desired levels)*), where <30% of the indicators were compliant with water quality objectives. It is considered that Buffalo Creek has poor ecosystem health due to long residence times of sewage discharge, a larger nutrient load, low denitrification efficiency, and poor tidal flushing (Haese, et al., 2009). According to the Northern Territory Government Department of Natural Resource, Environment, The Arts and Sport (NRETAS), the deteriorating water quality is a direct result of the LSSTP discharge directly into Buffalo Creek (NRETAS, 2010). There are,

however, other sources of pollution including the direct discharge of untreated urban runoff directly into the creek in the upper reaches resulting in cumulative impacts.

Plate 1. Sandy Creek estuary directly below 2CRU (Ecology and Heritage Partners Pty Ltd 31/05/2016).

Plate 2. Sandy Creek estuary at Casuarina Beach (Ecology and Heritage Partners Pty Ltd 31/05/2016).

Plate 3. Buffalo Creek estuary near the LSSTP (DENR 2010).

3.3 Flora and Fauna

Sandy Creek flows into Casuarina Beach that forms part of Shoal Bay, which is listed by the NT Government as a Site of International Significance (NRETAS, 2007) for a number of reasons. Six sites in Shoal Bay are listed on the Register of the National Estate for their natural values including Casuarina Beach-Lee Point-Buffalo Creek Area (Australian Heritage Council).

There are approximately 273 native plant species, 266 native vertebrate species, and 213 species of birds recorded in the Reserve (Parks and Wildlife, 2016). This includes two threatened flora species and at least 10 threatened fauna species (DLRM, 2014; Parks and Wildlife, 2016). The Reserve supports a wide variety of coastal habitats that are typical of the area, with Lee Point, Sandy Creek and Buffalo Creek all recognised as nationally and internationally important sites for migratory and resident shorebirds (Chatto R. 2003, Parks and Wildlife, 2016). These sites are used for feeding and roosting by shorebirds, making this an important shorebird area over the dry season and especially over the wet season. The migratory shorebirds that use the Reserve

are protected under several bilateral agreements including the Convention of Migratory Species of Wild Animals (Bonn Convention), Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA), as it forms part of the East Asian-Australasian Flyway. Flatback *Chelodina depressa,* Olive Ridley *Lepidochelys olivacea* and Green turtles *Chelodina mydas* are known to use Casuarina Beach and the waters of the Reserve. These marine turtles are listed on the Bonn Convention for the Protection of Migratory Species of Wild Animals and Marine and Migratory under the EPBC Act.

Buffalo Creek provides important aquatic habitat, known to contain two species of national and regional significance, namely the Dwarf Sawfish (*Pristis clavata*) and the Green Sawfish (*P .zijsron*), listed as Vulnerable under the EPBC Act; and Vulnerable by the NRETAS (Larson, et al., 2011; Aurecon 2013). Buffalo Creek is also a known bird watching location, as one of the most important sites for migratory shorebirds in the Darwin region. It is both an important feeding and roosting location with extensive sandy beach connected to sandflats where thousands of shorebirds feed at low tide. Overall, Buffalo Creek has important Aquatic Ecosystem value as it drains into Shoal Bay, which is listed by the NT Government as being of *International Significance.*

3.4 Uses and Environmental Values

Environmental Values (EV) are those qualities of a waterway that make it suitable to support particularly aquatic ecosystems and human uses, also known as beneficial uses. These are divided into a variety of categories reflecting the types of human use (e.g recreational activities, boating, swimming etc.) while aquatic ecosystem EVs are divided into condition classes reflecting the degree of modification from natural conditions. These values can be categorised as high conservation/ecological value systems 'HCV or HEV' (e.g. national parks, conservation reserves), slightly-moderately disturbed systems 'SMD' (e.g. minor changes but are not considered so degraded as to be highly disturbed) and highly disturbed system 'HD' (e.g. degraded systems with lower levels of naturalness) (NWQMS, 1998).

Darwin Harbour, between Charles Point and Lee Point, is managed to maintain aquatic ecosystem protection, recreational water quality and aesthetics beneficial uses, as declared under section 73(1) of the Water Act. The management of water resources in the Reserve is consistent with the declared beneficial uses and the environmental values for Darwin Harbour and are therefore applicable to Sandy Creek (Table 1). The environmental values specific to the area of Sandy Creek would come under the slightly-moderately disturbed systems.

Table 1 Sandy Creek – applied environmental values

Environmental values of water	Examples of use	Potential application to Sandy Creek (Yes or No)	Comments
Aquatic ecosystems	Maintenance of aquatic ecosystems; Fish breeding and spawning; Biodiversity conservation; Aquaculture; Eco-tourism	Yes	Sandy creek estuary mouth provide important habitat for migratory birds of international significance
Primary industry	Irrigated agriculture; Aquaculture; Human consumption of aquatic foods; Stock drinking water	No	N/A

Recreation and aesthetics (primary and secondary)	Swimming; Recreational fishing; Boating; Visual amenity	Yes	Fishing and Boating occurs. Used as a recreation area for bird watching also.
Industrial water	Washing; Cooling; Processing	No	N/A
Cultural and spiritual	Sacred sites; spiritual use; presence of certain plant and animal communities; traditional use	No	N/A

Shoal Bay, between Lee Point and Gunn Point, is managed to maintain aquatic ecosystem protection, recreational water quality and aesthetics beneficial uses, as declared under section 73(1) of the Water Act. The management of water resources in the Reserve is consistent with the declared beneficial uses and the environmental values for Shoal Bay and Darwin Harbour and are therefore applicable to Buffalo Creek (Table 2). The environmental values specific to the area of Buffalo Creek would come under the highly disturbed systems.

Table 2 Buffalo creek – applied environmental values

Environmental values of water	Examples of use	Potential application to Buffalo Creek (Yes or No)	Comments
Aquatic ecosystems	Maintenance of aquatic ecosystems; Fish breeding and spawning; Biodiversity conservation; Aquaculture; Eco-tourism	Yes	Buffalo Creek provides an important aquatic habitat for two fish species of national and regional significance (*Pristis clavata* and *P. Zijsron*). Buffalo Creek discharges into Shoal Bay, which is listed as being of International Significance as well as provide important habitat for migratory birds listed of international significance
Primary industry	Irrigated agriculture; Aquaculture; Human consumption of aquatic foods; Stock drinking water	No	N/A
Recreation and aesthetics (primary and secondary)	Swimming; Recreational fishing; Boating; Visual amenity	Yes	Fishing does occur in the lower reaches. Buffalo creek is a recreation area, and is a known bird watching location.
Industrial water	Washing; Cooling; Processing	No	N/A
Cultural and spiritual	Sacred sites; spiritual use; presence of certain plant and animal communities; traditional use	Yes	There is a recorded sacred site, under the *Northern Territory Sacred Sites Act* at Buffalo Creek. A World WWII observation post is situated at Buffalo Creek and is listed on the Register of the National Estate.

4 POTENTIAL IMPACTS

The Project has the potential to alter local hydrology and water quality that may impact on the Casuarina Coastal Reserve and both Buffalo and Sandy Creek estuary ecosystems abutting the Reserve. Potential impacts may include but are not limited to the short-term direct effects from increased freshwater inputs to the estuaries (e.g. increased runoff of poor water quality, altered flow), followed by spatial and/or temporal changes in water quality (e.g. reduced light penetration, decrease in water temperature, alteration of mixing zones). This can result in impacts for flora and fauna both within the estuaries themselves and along the beach of the Casuarina foreshore and coastal reserve, containing protected migratory shorebird habitat.

Increased urbanisation and construction activities such as land clearing, earthworks, dewatering and establishment of a stormwater drainage system, detention basin and discharge system has the potential to increase sediment and nutrient loads entering both creeks and the reserve via runoff and discharge. Construction works could also increase the potential for environmental incidents such as hydrocarbon and chemical spills associated with the refuelling of plant and equipment or leakage from fuel storages which can temporarily impact on the quality of receiving surface waters and sensitive receptors. The Engineering Services report prepared by SMEC (2015) indicates that the design philosophy for drainage shall ensure that downstream discharges are limited to existing flows.

The main areas of erosion risk have been determined as occurring in the south-west corner of the 2CRU site in association with an existing overland flow path and along the existing low escarpment where steep slopes are present. If erosion of soils were to occur this could cause siltation and reduction of water quality in Sandy Creek with subsequent effects upon the connected shorebird habitat. To date, there is no known water quality information for Sandy Creek.

The key contaminants of concern from construction activities and urbanisation include:

- Hydrocarbons and other chemicals,
- Heavy metals,
- Nutrients; and
- Sediments.

Urban development can impact on catchment hydrology and the deterioration of local water quality. Construction activities can result in increased erosion and sedimentation issues and potential for spills, whilst post-development can result in a multitude of pollutants from stormwater runoff being introduced to aquatic ecosystems, including:

- Toxicants (heavy metals, hydrocarbons, ammonia);
- Nutrients (phosphorus, nitrogen, carbon);
- Oxygen depleting substances (organic material, sulphides);
- Physical contaminants (suspended solids);
- Trace organic compounds (insecticides, herbicides, personal care products);

- Gross pollutants (plastics products, cigarette butts, vegetation etc.); and,
- Altered hydrology (e.g. water levels, frequency).

With respect to stormwater drainage, the Project has designed a pit and pipe stormwater system that will extend along the road network, and will carry stormwater to a detention basin in the south-west corner of 2CRU (Figure 3). The detention basin will collect all post-development stormwater flow prior to discharge to an existing drainage line through to Sandy Creek and Buffalo Creek estuary. During construction, erosion and sediment control measures will be implemented to collect and direct runoff as per the ESCP.

Several drains from the neighbouring suburbs, the hospital precinct and Charles Darwin University currently feed into the coastal reserve and into Sandy Creek. Whilst Buffalo Creek receives stormwater from drainage directly upstream from two main tributaries as well as secondary effluent from the LSSTP. These pollution point sources have the potential to create erosion, sedimentation or pollution issues upstream of the Projects discharge location. It is noted that water quality issues that may occur upstream can have flow on effects for downstream aquatic health and beneficial values as stated above.

Potential cumulative impacts may include:

- Deteriorated water quality from additional stormwater discharge and runoff contaminant contributions (e.g. increased sedimentation (suspended solids), high nutrient loads, bacteria, metals, hydrocarbons etc.);
- Altered hydrology (e.g. increased flow inputs);
- Altered ecosystem processes and services;
- Deterioration of habitat, shorebird feeding and roosting sites and food web dynamics;
- Landform structural failure/erosion from increased flows at inappropriate times of year (i.e. dry season) or lack of vegetation and protection;
- Spread of pest species (flora and fauna); and
- Increased mosquitoes/biting midge and breeding opportunities.

5 MONITORING PROGRAM

Water quality exhibits distinct differences between the wet and dry seasons in waterways and estuaries in the northern tropics of Australia. High rainfall in the wet season produces large freshwater inflows with associated nutrients, sediments and pathogens dispersed via high volumes of runoff resulting in poor water clarity and deteriorated water quality.

This monitoring plan has been developed to obtain data for physico-chemical and some biological parameters for monitoring the water quality within both the Sandy Creek and Buffalo Creek estuary, as well as directly at the three discharge locations.

As per Section 5.3.4 of the EIS ToR Guidelines, the Stormwater Management Plan and ESCP outline details of monitoring programs that would be implemented throughout the construction and post-construction phase. This is to determine the effectiveness of the mitigation measures including the Stormwater Management Plan and ESCP.

5.1 Monitoring Sites and Parameters

Water quality monitoring sites have been identified and defined based upon the two discharge locations situated in the north-west and south-west corner of the 2CRU site, and single discharge location situated in the south-east corner of the Muirhead site. Monitoring sites include a point source monitoring location at the discharge locations as well as both upstream and downstream monitoring locations in the affected creeks (Table 3) (Figure 3). A second monitoring point is included for the discharge location in the north-west of 2CRU as stormwater does not discharge into a permanent water bodies (Table 3) (Figure 3).

At each monitoring location, measurements will be collected *in situ* using a multi-parameter water quality meter and any other related instruments (e.g. turbidity meter, secchi disk) within the upper and lower water column within 1 hr of the slack of both flood and ebb tides. All physico-chemical parameters as stated within this plan will be recorded on a data sheet.

Baseline monitoring and sampling will be undertaken on a monthly basis at Sandy Creek for up to a period of 6 months prior to construction during the wet season and twice during the dry season (during neap spring tides). This will assist in determining current water quality values to use for tentative baseline data. If there is not sufficient baseline data collected prior to the commencement of construction, the project will revert to the default guideline trigger values provided in Tables 3.3.4-3.3.5 for Tropical Australia for reporting exceedances.

During construction, monitoring will continue at the same frequency (six times in wet season, twice in dry season). After occupation, monitoring will continue until there is at least twelve months of monitoring data with no exceedances recorded.

The monitoring field program will be undertaken before or after, but not during the slack of the tide (1 hr either side of high or low tide). Monitoring will be undertaken for both flood and ebb tidal flows during both the wet and dry seasons (if water is present). Prior to field deployment, staff will record recent rainfall (within 24 hrs), tide type (flood or ebb), time of day and weather conditions. It is important to take into account tidal

influence, time of day, stratification/mixing zones during monitoring as these can influence the data collected and compared over time.

In situ monitoring parameters will include:

- Water level (m) of upper and lower column depth
- Flow measurements
- Total depth (m)
- Temperature (°C)
- pH
- Conductivity (EC) and Salinity
- Dissolved oxygen (DO) (% Saturation) and (mg/L)
- Chlorophyll a
- Turbidity (NTU)
- Light penetration using Secchi disk

Sampling parameters for the Laboratory program include:

- The In situ measurements
- Total Suspended Solids (TSS)
- Total nutrients (TN and TP), ammonia, nitrite and nitrate
- Biochemical oxygen demand (BOD)
- Bacteria – microbiological indicators
- Total and Filtered dissolved metals

Grab samples will be taken from the middle of the water column and sent off to a NATA certified laboratory. Water quality monitoring can be used as an indicator of the environmental values likely to be supported by a system and in turn can indicate how much change is acceptable to maintain those values. This will also assist in defining Water Quality Objectives (WQOs) and site-specific guideline trigger values, where required (i.e. Sandy Creek). All data recorded on site and received from the laboratory will be maintained in a Project Database.

Table 3. Location of monitoring sites.

Site – Site Code	UTM Coordinates		
2CRU	**Zone**	**Easting**	**Northing**
Sandy Creek 1 – SC1	52L	704542.03 m	-8634075.95 m
Sandy Creek 2 – SC2	52L	704241.99 m	-8633128.98 m
Sandy Creek 3 – SC3	52L	704229.94 m	-8633909.08 m

Site – Site Code	UTM Coordinates		
Sandy Creek 4 – SC4	52L	704942.00 m	-8634734.00 m
Sandy North 1 – SN1	52L	705612.91 m	-8635152.05 m
Sandy North 2- SN2	52L	705486.73 m	-8635339.29 m
Muirhead North	**Zone**	**Easting**	**Northing**
Buffalo Creek 1 – BC1	52L	706646.96 m	-8633836.09 m
Buffalo Creek 3 – BC3	52L	707414.04 m	-8633779.00 m
Buffalo Creek 4 – BC4	52L	707657.01 m	-8634292.99 m

5.2 Quality assurance and quality control

Quality assurance and quality control (QA/QC) measures are a set of operating and sampling procedures carried out by the monitoring team that help to ensure that calibration, sampling techniques, storage, transport and analysis of samples are consistent. This is to ensure there is minimal variation in results due to incorrect procedures or contamination (e.g. handling error). The QA/QC results will be uploaded and stored in the Projects database and compared to the results from a reference site for each monitoring date.

5.2.1 Instrument calibration

Instrument calibration and records of calibration will be maintained prior to each monitoring session. Staff must follow the instructions of the instrument manufacturer to calibrate instruments. The likely range of values being measured are to be noted and calibrate accordingly. The instrument will perform better if it is calibrated for the data ranges expected in the field, which will be obtained during the pre-construction monitoring period.

5.2.2 Sampling technique

The NATA certified laboratory engaged for the Project, will provide specific instructions to follow when sampling as well as a Chain of Custody (CoC). Duplicate, field and trip blank samples will be taken at a nominated sampling site allowing results to be compared and any inconsistencies identified.

5.2.3 Storage and Transport

Collection and storage of samples will be discussed with the laboratory to ensure adequate volumes are collected, storage is appropriate and adequate field and laboratory QA/QC procedures are in place.

5.3 Preliminary Results

Water quality monitoring commenced in February 2018. In situ parameters have been sampled on a weekly basis, while water quality parameters to be tested in the laboratory have been tested monthly. A summary of the results is provided in the Appendices.

6 WATER QUALITY MANAGEMENT

The mitigation and management measures to be implemented during construction will be included within the ESCP and CEMP and align with best practice measures. All water affected by sediment or stormwater originating from site will be treated via the detention system designed in the Stormwater Management Plans and released in conjunction with existing flows. Water quality management triggers can be specified using a three tier hierarchy management response when an exceedance from the ANZECC guideline trigger values (or tentative baseline values) is detected, including:

- Level 1: Identify, investigate and continue to monitor;
- Level 2: No change in condition, prepare to stop works and continue to monitor or investigate further; and.
- Level 3: Condition deteriorating and impacting sites of significance, act and manage accordingly.

The monitoring plan includes a reporting framework to ensure timely notification of water quality results and any identified exceedances and non-compliances of the monitoring plan. Reports will be provided to both the DHA and the relevant authorities until the relaxation of management measures as a response to recovery of the water quality.

In accordance with ToR, DHA has made a strong commitment to implementing the WQMP until the water quality returns within range of the ANZECC guideline trigger values (or the tentative baseline values, if appropriate). This can be summarised as part of an annual report including an assessment of all monitoring data collected as part of the WQMP and all exceedances and management actions implemented over the duration of the monitoring period.

In addition, the Area Plan within the Master Plan shows an area of 21.8 ha that will be zoned Conservation (CN) as part of the planning application. This area of land will be transferred to the Northern Territory Government to become part of the Casuarina Coastal Reserve. It is intended that excluding this land from development will assist in avoiding impacts to the sensitive Monsoon Vine-thicket vegetation and provide a buffer to potential storm surge inundation and biting insect breeding areas.

6.1 Water Quality Trigger Values

Water quality trigger values for all indicators will be determined by taking into account the level of protection (high, moderate or low as a result from its level of disturbance). For physical and chemical stressors and toxicants in water, the approach to deriving trigger values follows the following order:

- Use of biological effects data;
- Then local reference data (mainly physical and chemical stressors); and
- Finally (least preferred) the tables of default values provided in the ANZECC Guidelines.

When using local reference data (baseline) for physical and chemical stressors, ANZECC guidelines recommend using 3 years of data or 3-5 reference sites, from which you would determine upper (80th percentile) and lower limits (20th percentile) for upstream and downstream sites to derive a range of values. This would incorporate spatial and temporal variations (e.g. wet/dry seasons), to create site-specific guideline trigger values that

incorporates natural variability of the area. For Sandy creek estuary however there is approximately 6 months remaining prior to construction commencing on site. Sandy creek is also already potentially influenced by runoff from urban and industrial areas that may potentially discharge into the upper reaches of the creek (e.g. Royal Darwin Hospital and existing urban/commercial developments).

As such, the collection of baseline data is unlikely to be attainable in accordance with ANZECC guidelines; nonetheless, pre-construction monitoring will occur and commence in late 2017/early 2018. All data collected will be used to define the WQOs for Sandy Creek, as the derived data would be more accurate of local conditions than deferring to the ANZECC guidelines. For monitoring periods when baseline data could not be obtained, data will be compared against the ANZECC Guidelines for tropical Australia for slightly to moderately disturbed ecosystems (Table 4).

Buffalo creek has been regularly monitored and reported on by the NT Government and the Power and Water Corporation. In addition, pre-construction monitoring of Buffalo Creek will commence in late 2017/early 2018. Given the proposed staging plan envisages construction in Muirhead North would not commence until April 2019 (see Table 3 in the EIS/PER), it is possible that a full twelve months of monitoring data could be collected before any run-off from the site reaches Buffalo Creek.

In the event that pre-construction monitoring cannot be completed over a full year period, than WQOs and trigger values for Buffalo Creeks will be extrapolated from NT Government and Power and Water Corporation data. Monitoring at the discharge location before entering Buffalo Creek will be compared against the ANZECC values for tropical Australia for slightly to moderately disturbed ecosystems (Table 4).

As the second discharge location in 2CRU does not discharge into a creek or water body, pre-construction monitoring will not be undertaken. Rather, the trigger values from ANZECC guidelines for tropical Australia for slightly to moderately disturbed ecosystems will be adopted (Table 3).

Prior to the commencement of construction, DHA will notify the NT EPA and DoEE in writing of the WQOs and trigger values which will be used to compare the post-construction monitoring data for Sandy Creek and Buffalo Creek.

Table 4 ANZECC values for tropical Australia for slightly to moderately disturbed ecosystems

Type	Chl a	TP	FRP	TN	NO_x	NH_4^+	DO %Sat Lower	DO %Sat Upper	pH Lower	pH Upper	Turb NTU
Estuaries	2	20	5	250	30	15	80	120	7.0	8.5	1-20

6.2 Reporting

Water quality data collected including both field and laboratory results will be presented in a table and graph format and interpreted against the baseline values and/or ANZECC Guideline trigger values as part of an annual report. This report will contain other information as collected in the field, including weather and tidal information, limits of reporting (LOR) and measures of uncertainty, any calculations and any results that exceed the trigger values as well as a comparison against a summary of the previous month's results.

The annual report will be made available to the NT EPA and DoEE.

All monitoring reports will be been prepared with reference to the NT EPA's *Guideline for the Reporting on Environmental Monitoring* (NT EPA 2016) and the ANZECC *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC & ARMCANZ 2000b).

In the event of any exceedance, a report will be prepared and submitted to NT EPA and DoEE within one week of DHA becoming aware of the exceedance.

6.3 Contingency

Contingency measures have been developed in case of the following events which have potential to adversely affect water quality:

- Adverse weather (i.e. cyclone or severe storm causing overflow, abnormal erosion and sedimentation issues)
- Human error / accidental spills
- In effective stormwater treatment.

6.3.1 Adverse weather

Even with properly installed erosion and sedimentation control measures, overflow and higher than normal runoff events could occur as a result of unexpected extreme weather events (i.e cyclone, severe storm). This could result in collapse of silt fencing, overflow or bypass of barriers and detention basins, slope failures, and other problems which could lead to higher than expected sedimentation flowing into the creeks. If sedimentation occurs, immediate action will be taken to temporarily contain the sediment as quickly as practical. When site conditions allow, permanent protection measures will be installed on affected and potentially vulnerable surfaces. If the erosion and sedimentation resulted from a construction-related activity, the activity will cease immediately until management have rectified the situation and water quality recovers to guideline values.

6.3.2 Human error / accidental spills

During construction, an accidental spill of fluids may occur, of which the impact of the spill will depend upon the magnitude and extent, and the environmental and socio-economic conditions in which it takes place. Upon accidental release of any hydrocarbon-based construction fluid, DHA in conjunction with the site contractor will immediately determine the magnitude and extent of the spill and immediately take measures to contain it. Release of sediment will also be treated as a potential spill depending on the magnitude and extent. Spills will be immediately reported to the head contractor.

Spill containment equipment will be readily available, especially near watercourses such as Sandy creek and Buffalo creek. Personnel will be trained in the use of spill containment equipment.

6.3.3 Ineffective stormwater treatment

Stormwater Management Plans have been developed for the project, and have been designed to comply with relevant Guidelines for treatment of stormwater. Testing of the Stormwater Management Plans show they would adequately remove sufficient quantities of Total Suspended Solids, Total Nitrogen, Total Phosphorous

and Gross Pollutants. In the event that exceedances of water quality are detected, ineffective stormwater treatment will be considered (provided all other reasonable factors have been ruled out).

As part of the monitoring and reporting program (see Section 6.2), any detected exceedances will include a review of the effectiveness of stormwater treatment. In consultation with a hydrologist, the following changes to the stormwater treatment may be required:

- Bioretention/Detention Basin size.
- Replace Ecosol Net Guards.
- Construct additional WSUD treatments such as bioswales and rain gardens.

7 REFERENCES

ANZECC & ARMCANZ (2000a). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy Paper No. 4, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra ACT.

ANZECC & ARMCANZ (2000b). *Australian Guidelines for Water Quality Monitoring and Reporting.* National Water Quality Management Strategy Paper No. 7, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra ACT

Aurecon 2013. Buffalo Creek Water Quality Improvement Plan, Project: Muirhead Residential Development. Reference: 38110. Prepared for the Defence Housing Australia, Revision 0. 25 January 2013

Australian Heritage Database. Darwin Foreshores, Darwin NT, Australia – Register of the National Estate. Place ID 16107.

Bureau of Meteorology (2017). Climate statistics for Australian locations; Darwin Airport. Viewed 26 May 2017 online:http://www.bom.gov.au.

Chatto R. (2003). The distribution and status of shorebirds around the coast and coastal wetlands of the Northern Territory. Technical Report 73. Parks and Wildlife Commission of the Northern Territory, Northern Territory Government, Darwin.

DLRM (2013) Darwin Harbour Region Report Card 2013 [Report]. - Palmerston, NT, Australia: Department of Land Resource Management., 2013. Online: https://denr.nt.gov.au/__data/assets/pdf_file/0010/254755/Darwin-Harbour-Report-Card-A4-March-2014_13.3.14_online.pdf.

DLRM (2014) Darwin Harbour Region Report Card 2014 [Report]. - Palmerston, NT, Australia: Department of Land Resource Management., 2014. Online: https://denr.nt.gov.au/__data/assets/pdf_file/0006/397509/Darwin-Harbour-Report-Card-A4-Feb-19.pdf

DLRM (2015) Darwin Harbour Region Report Card 2015 [Report]. - Palmerston, NT, Australia: Department of Land Resource Management., 2015. Online: https://denr.nt.gov.au/__data/assets/pdf_file/0020/262127/darwin-harbour-region-report-card-2015.pdf

DENR (2016) Darwin Harbour Region Report Card 2016 [Report]. - Palmerston, NT, Australia: Department of Environment and Natural Resources., 2015. Online: https://denr.nt.gov.au/__data/assets/pdf_file/0010/397108/Darwin-Harbour-Report-Card-2016_V2_lowres.pdf

Haese R R., and Smith J. (2009). The role of sediments in nutrient cycling in the tidal creeks of Darwin Harbour [Journal] // Geoscience Australia, AusGeo News. - 2009. - 95.

Harrison L., McGuire L., Ward S., Fisher A., Pavey C., Fegan M. and Lynch B. (2009). An inventory of sites of international and national significance for biodiversity values in the Northern Territory. Department of Natural Resources, Environment, The Arts and Sport, Northern Territory Government.

Fortune, J (2015). Supplement to the 2014 Darwin Harbour Region Report Card. Report No. 01/2015D. Aquatic Health Unit, Department of Land Resource Management. Palmerston, NT. Website: www.nt.gov.au/lrm/water/aquatic/index.html (Online: https://denr.nt.gov.au/__data/assets/pdf_file/0007/397510/RC-supp-2014.pdf)

Fortune, J and Patterson, R (2016). Darwin Harbour Region 2015 Report Card Water Quality Supplement. Report No. 4/2016D. Aquatic Health Unit, Department of Land Resource Management. Palmerston, NT. Website: http://www.lrm.nt.gov.au/water/darwin-harbour/reportcards (Online: https://denr.nt.gov.au/__data/assets/pdf_file/0003/262128/darwin-harbour-water-quality-supplement.pdf)

Fortune, J. (2016). Darwin Harbour Region 2016 Report Card Water Quality Supplement. Report No. 22/2016D. Aquatic Health Unit, Department of Environment and Natural Resources. Palmerston, NT. Website: http://www.denr.nt.gov.au/water/darwin-harbour/reportcards (Online: https://denr.nt.gov.au/__data/assets/pdf_file/0011/397109/WQ-Supp-2016_V0.pdf)

Mauraud, N. (2013): Darwin Harbour Water Quality: Supplement to the 2013 Darwin Harbour Region Report Card. Report No 12/2013D. Aquatic Health Unit, Department of Land Resource Management, Northern Territory Government.

NRETAS (2009) Shoal Bay and Buffalo Creek Report Card 2009 [Report]. - Palmerston, NT, Australia: Department of Natural Resources, Environment, The Arts and Sport., 2009. Online: https://denr.nt.gov.au/__data/assets/pdf_file/0007/254725/shoalbay_buffalocreek.pdf

NRETAS (2010) Shoal Bay and Buffalo Creek Report Card 2010 [Report]. - Palmerston, NT, Australia: Department of Natural Resources, Environment, The Arts and Sport, 2010. Online: https://denr.nt.gov.au/__data/assets/pdf_file/0009/254736/reportcard_shoal_bay_buff_ck.pdf

NRETAS (2011) Shoal Bay and Buffalo Creek Report Card 2011 [Report]. - Palmerston, NT, Australia: Department of Natural Resources, Environment, The Arts and Sport., 2011. Online: https://denr.nt.gov.au/__data/assets/pdf_file/0003/254748/Shoal-Bay-and-Buffalo-Creek.pdf

NRETAS (2012) Shoal Bay and Howard Creek Report Card 2012 [Report]. - Palmerston, NT, Australia: Department of Natural Resources, Environment, The Arts and Sport., 2012. Online: https://denr.nt.gov.au/__data/assets/pdf_file/0011/254765/2012-11-shoal-bay-report-card.pdf

NRETAS (2007) Sites of Conservation Significance in the NT [Online] // Natural Resources, Environment, The Arts and Sport. - 2007. – Accessed Online: July 2017.

NRETAS (2010) Water Quality Objectives for the Darwin Harbout Region - Background Document [Report]. - Darwin : Northern Territory Government, 2010.

NT EPA (2016). Northern Territory Environment Protection Authority *Guideline for the Reporting on Environmental Monitoring.* May 2016. Version 1.0

Parks and Wildlife (2016) Casuarina Coastal Reserve Management Plan, April 2016. Parks and Wildlife Commission of the Northern Territory

Skinner, L., Townsend, S., and Fortune, J. (2009). The impact of urban land-use on total pollutant loads entering Darwin Harbour. Department of Natural Resources and Environment.

FIGURES

Figure 1

Location of project area

Environmental Impact Statement water quality monitoring plan, Lee Point, Northern Territory

Map Scale: 1:50,000
Coordinate System: MGA Zone 52 (GDA94)

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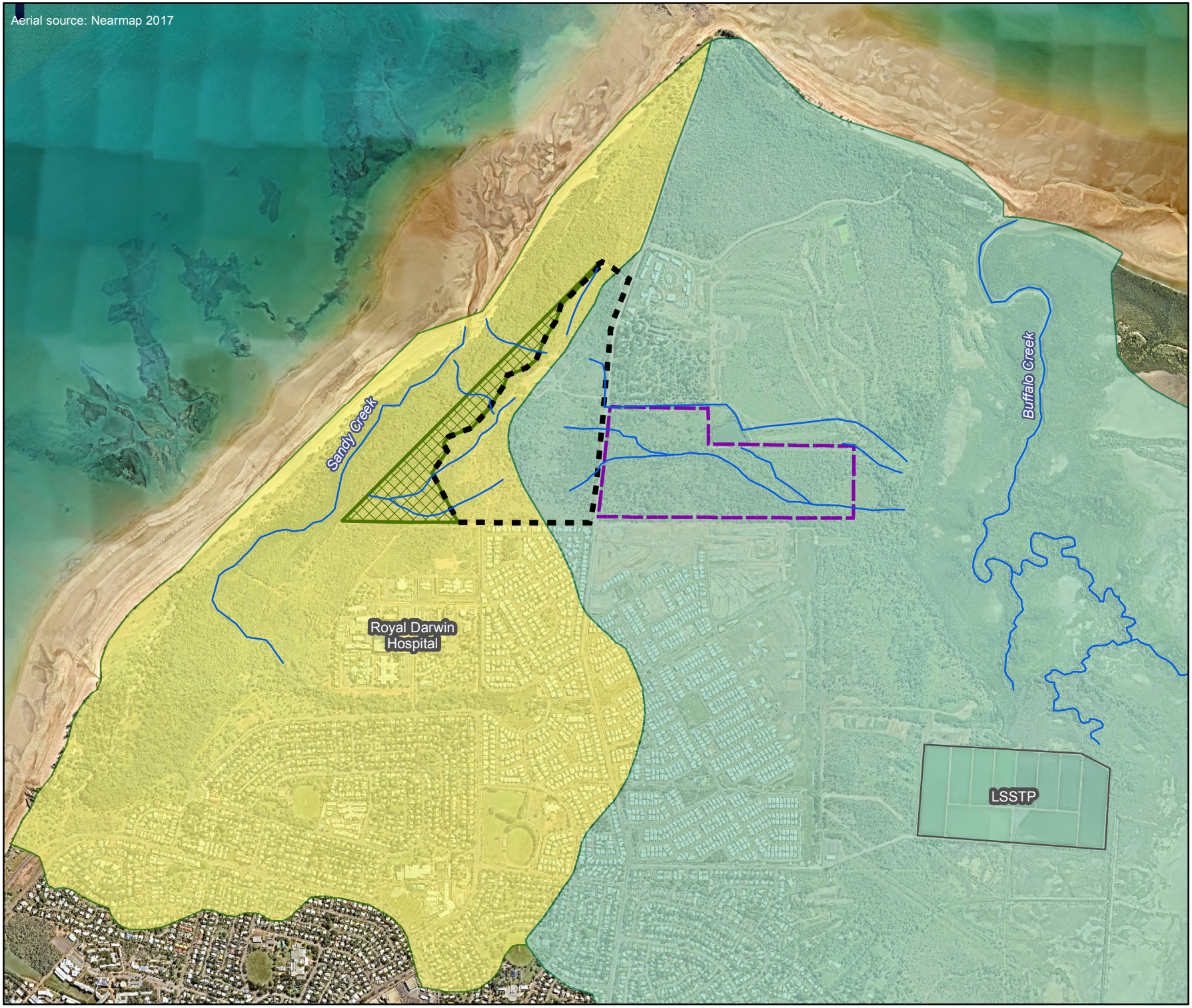

Legend

- Area Zoned Conservation

Proposed development areas

- 2CRU
- Muirhead North

Catchments

- Buffalo Creek
- Sandy Creek
- Waterways / assumed drainage lines

Figure 2

Site location and surface water sensitive receptors

Environmental Impact Statement water quality monitoring plan, Lee Point, Northern Territory

0 400 800
Metres

Map Scale: 1:24,000
Coordinate System: MGA Zone 52 (GDA94)

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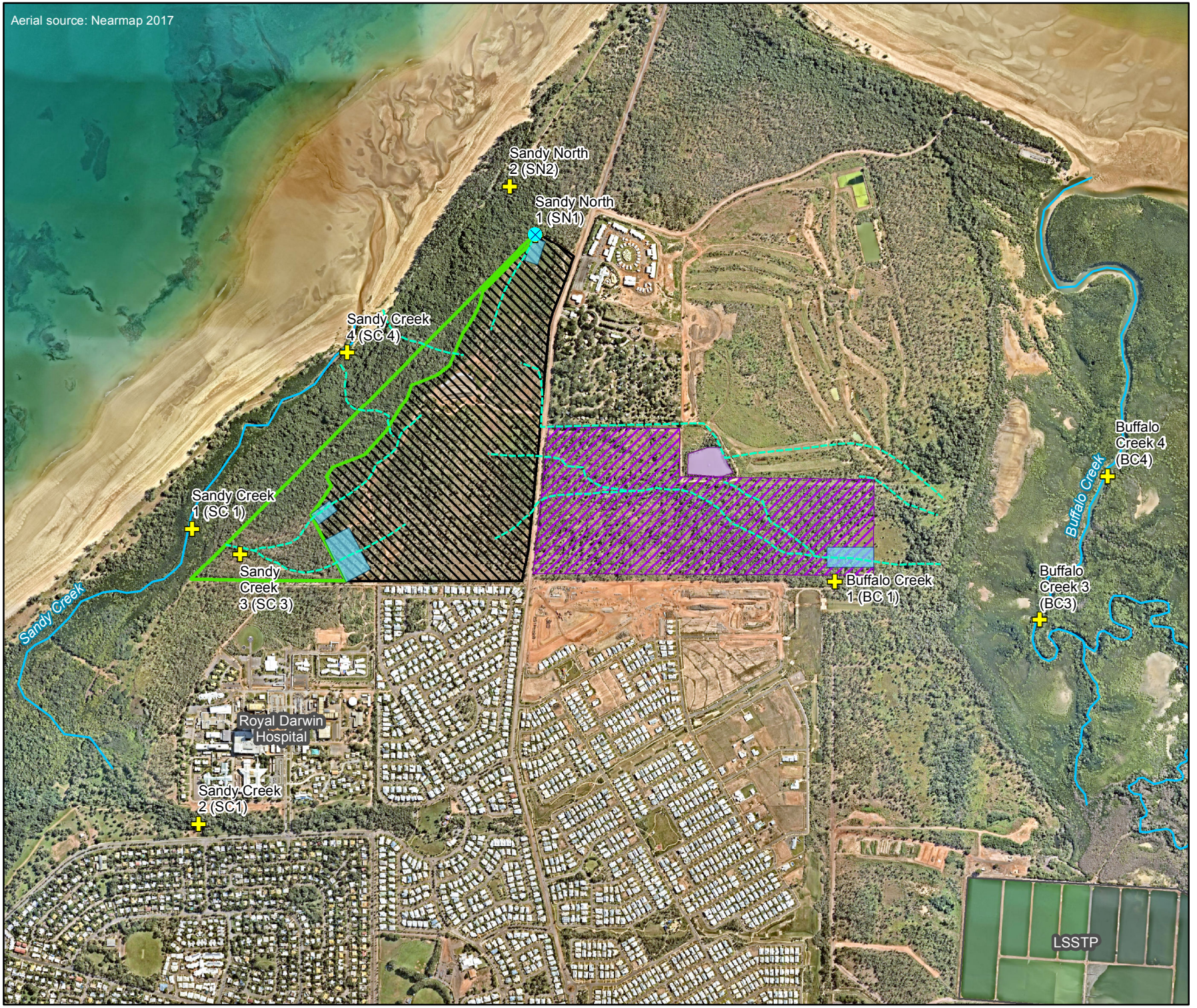

Legend

- Monitoring point
- Area Zoned Conservation
- Detention basin
- Dam
- Waterway
- Assumed drainage lines

Proposed development areas

- 2CRU
- Muirhead North

Figure 3

Surface monitoring locations

Environmental Impact Statement water quality monitoring plan, Lee Point, Northern Territory

0 250 500
Metres

Map Scale: 1:18,000
Coordinate System: MGA Zone 52 (GDA94)

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Table 5. Preliminary water quality monitoring results (February 2018)

Site	Date	Temp (°C)	EC (ms/cm)	DO (%)	DO (mg/L)	pH (pH units)	Turbidity (NTU)	Salinity (PSS)	Total Suspended Solids (mg/L)	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)
SC1	8/02/2018	30.12	140	78.7	5.88	6.35	4.26	0.07	<5	0.42	0.015
	15/02/2018	29.6	181	56.0	4.42	7.36	8.81	0.09	<5	0.38	0.011
	22/02/2018	31.6	214	68.2	4.66	6.75	12.10	0.1	<5	0.50	0.017
SC2	8/02/2018	28.18	4320	80.0	8.12	7.21	20.60	2.32	14	0.25	0.078
	15/02/2018	27.86	1302	49.1	3.69	7.56	17.30	0.67	14	0.22	0.04
	22/02/2018	31.5	3270	52.1	3.76	7.27	28.30	1.71	27	0.38	0.04
SC3	8/02/2018	28.42	50	78.1	0.03	6.23	23.30	0.03	<5	<0.01	0.017
	15/02/2018	28.41	26	63.3	5.01	7.36	41.90	0.02	6	0.03	0.012
	22/02/2018	32.92	151	68.2	4.92	7.53	16.50	2.02	<5	0.15	0.011
SC4	8/02/2018	28.76	14580	73.6	5.61	7.44	15.30	8.17	<5	0.30	0.035
	15/02/2018	27.8	6160	58.3	4.6	6.7	14.30	3.35	10	0.26	0.023
	22/02/2018	30.43	6870	66.8	5.09	7.57	16.10	2.02	12	0.28	0.012
SN2	8/02/2018	32.52	7600	90.3	6.87	7.66	3.72	4.22	<5	0.47	0.078
	15/02/2018	28.79	3240	58.0	4.81	7.24	7.63	1.7	5	0.26	0.04
	22/02/2018	29.12	4430	59.7	4.57	7.18	2.02	2.36	<5	0.28	0.04
BC1	8/02/2018	32.96	80	96.6	6.81	7.11	26.60	0.04	<5	0.20	0.014
	15/02/2018	32.01	77	76.5	5.67	7.18	61.80	0.04	8	0.09	0.021
	22/02/2018	30.32	68	96.4	7.44	6.75	10.70	0.04	<5	0.37	0.015

Site	Date	Temp (°C)	EC (ms/cm)	DO (%)	DO (mg/L)	pH (pH units)	Turbidity (NTU)	Salinity (PSS)	Total Suspended Solids (mg/L)	Total Nitrogen (mg/L)	Total Phosphorous (mg/L)
BC3	8/02/2018	30.11	3300	32.1	2.4	7.05	23.20	1.74	10	1.46	0.344
	15/02/2018	27.22	1570	58.0	4.46	6.90	67.80	0.79	48	1.00	0.220
	22/02/2018	29.21	16300	42.2	3.11	7.44	26.60	9.77	19	2.07	0.133
BC4	8/02/2018	30.73	12830	33.4	2.35	7.24	23.60	6.24	16	1.72	0.328
	15/02/2018	27.43	1690	58.1	4.46	6.85	62.00	0.85	41	0.97	0.199
	22/02/2018	29.35	21100	52.2	3.79	7.57	14.30	9.77	15	2.61	0.139