Darwin City Waterfront Redevelopment

SURFACE WATER HYDROLOGY

Technical Assessment for the Draft Environmental Impact Statement

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1. Objectives and Scope

1.1 Introduction

This report is a preliminary assessment of surface water hydrology issues for the Darwin City Waterfront Redevelopment. The report was prepared by URS Australia Pty Ltd (URS) for the Department of Infrastructure, Planning and Environment (DIPE) and forms part of an Environmental Impact Statement (EIS) for the development. A full project description is contained within the EIS and is not reproduced here except where directly relevant to surface water.

In broad terms, the objective of the EIS is to:

- assess the existing environment at the site and nearby;
- identify features of the proposed development that may impact on that environment (both on and off-site); and
- identify measures that will minimise any adverse impact on the environment and/or enhance any positive impact.

The surface water assessment was a desktop study based on existing available data.

1.2 Assessment Requirements

Requirements specified by the Office of Environment and Heritage (OEH) for the EIS relating to surface water issues are listed below.

1.2.1 Project Description

Provide maps showing:

- the project with respect to catchment location, watersheds and watercourses including any stormwater sources from the existing CBD; and
- Q100 flood levels.

1.2.2 Existing environment

Using the best information currently available, provide a general description of the surface water systems on-site and adjacent to the development area (to a distance reflecting potential impacts from, or to, the development) including stormwater systems, natural and artificial drainage lines, and the directions of overland flows.

1.2.3 Potential and Anticipated Environmental Impacts

Detail the potential and anticipated impacts of erosion and contamination on hydrodynamic conditions, hydrology and water quality. Include a discussion of meteorological impacts (e.g. cyclones, storm surge, and heavy rainfall). In particular:

- discuss anticipated or potential modifications to natural hydrological regimes, such as changes to the freshwater flows and flooding in the area, and interruption/interception of regular tidal flows;
- describe potential impacts of cyclonic storm surge on the foreshore of the waterfront site and potential marina facilities; and
- discuss impacts to receiving surface waters from the discharge of wastewater and site run-off.

Describe the expected stormwater discharges and patterns and outline any potential impacts caused by these discharges. Rate the risk and seriousness of each impact.

1.2.4 Mitigation, Management and Monitoring

Management requirements for the proposed development to address potential impacts will include:

- management of erosion (and potential sedimentation of waterways) during preparation, construction and operation phases of the project;
- development of an Erosion and Sediment Control Plan, to form part of the Environmental Management Plan;
- description of water management in ponds or swimming features; and
- description of stormwater management from the development area.

Monitoring will be required:

- to ensure environmental safeguards are being effectively applied; and
- to identify and measure any differences between predicted and actual impacts.

For each potential or anticipated impact, field and desktop monitoring should be comprehensively outlined at the following levels:

Baseline (pre-construction) – Detail completed or proposed baseline surveys, identifying timing of data collection and their relevance to the project.

Ongoing (construction /operational phases) – For each anticipated or potential impact, detail the proposed monitoring programs and reporting arrangements during the construction and operational phases of the development.

Monitoring should maximise the potential for:

- valid comparison with existing data sets;
- interpreting environmental information collected in the longer-term for this project; and
- collecting environmental data that will be useful (from an environmental management perspective) for future research and to the NT Government.

2. Description of the existing environment

2.1 Drainage

Surface water drainage in the development area and upslope contributing catchment has been heavily modified during development for urban and industrial uses. The area is currently drained by a network of roadside drains and underground stormwater pipes that discharge to Darwin Harbour. There are no natural drainage lines remaining in the study area.

The catchment for the development area extends above the scarp into the southern CBD area , just to the north west of the Esplanade (Figure SW1). Water from the scarp makes its way down the scarp via underground pipes and surface drains, draining toward Kitchener Bay and to the west of Fort Hill.

The following points summarise what is known about existing drainage in the development area:

- A Darwin City Council plan (no reference or date) indicates that drainage enters the site from the Esplanade with discharge directed to Kitchener Drive. Darwin City Council does not have control of drainage utilities in the wharf area.
- Cameron, McNamara & Partners Drawing No. 8348 Programme items 1969/70 *Basis of Stormwater Design and Drainage Layout* indicates that drains radiate across the Wharf Precinct site from Kitchener Drive to the harbour. At this date the Recent Reclamation Area has not been reclaimed. Drainage lines are shown running along the eastern and western sides of No. 1 Shed, across the storage area between the No. 1 and No. 2 Sheds, from the north eastern corner of the Bitumen Plant, from the south eastern boundary of the Bitumen Plant across the northern

boundary of Northern Cement Plant Area. Drainage is also shown to extend from Hughes Avenue in a westerly direction towards the ocean.

- Northern Territory Port Authority Extension to Stormwater Maintenance Workshop Area Plan of April 1982 (Drawing Number S310) indicates drainage to extend from the Sulphuric Acid Storage Areas' south western boundary beneath Kitchener Drive in a south westerly direction to the harbour. A 300 mm diameter stormwater drain is shown to extend from the western boundary of the incinerator shed and discharge beneath Kitchener Drive through a 450 mm diameter stormwater drain into the harbour. A 600 mm diameter pipe is also shown to connect into this from the western corner of the maintenance workshop building.
- Cameron, McNamara & Partners Drawing No. NTPA 189 Programme items 1969/70 Roadworks and Stormwater Drainage Plan – Stokes Hill Wharf Approach (indicates drainage along either edge of the Stokes Hill Wharf approach road. Drainage lines are shown extending from these drains in a south westerly direction towards the harbour.
- Cameron, McNamara & Partners Drawing No. NTPA 189. Programme items 1969/70 Roadworks and Stormwater Drainage Plan – Stokes Hill Wharf Approach shows an open earthen drain to be present along the northern side of Kitchener Drive in the vicinity of the Shell Bitumen Terminal. Drainage from the north eastern and south eastern corners of the Bitumen Plant is shown to run in an easterly direction towards the harbour. Drainage from the former Cockburn Cement Area is shown to drain in a southerly direction to the Fort Hill Wharf Approach Road before discharging in an easterly direction into the harbour.

Pickup survey undertaken during this study shows the underground drainage network through the development area (Figure SW1).

2.2 Receiving Water

Receiving water for all runoff from the development and upslope catchment is the Darwin Harbour. Kitchener Bay receives most of the runoff water, draining the catchment from Fort Hill to Stokes Hill. Frances Bay receives runoff from catchment to the east of Stokes Hill. The general harbour receives runoff from the catchment to the west of Fort Hill.

Anecdotal information suggests that the harbour has an approximate 8 m tidal variation. Observations made by URS staff during site visits identified that during conditions of low tide the northern portion of the harbour empties and mud flats are exposed along the boundary of the recent Reclaimed Area and the former Northern Cement Area.

The site is located on the eastern side of the central harbour. Tidal flows and runoff water from East Arm, the Elizabeth River and local catchments moves past the wharf area and mix with water from the remainder of the harbour.

2.3 Water Quality and Contaminant Loadings

2.3.1 The Development Area Catchment

There are no observed water quality data for runoff in the development area, but a number of studies have characterised runoff water quality from urban and industrial land uses around the city. Table SW1 summaries predicted quality and loadings on Darwin Harbour for the development area and contributing catchment and Figure SW2 summarises broad land-use categories.

The development area itself is made up mainly of industrial and disturbed areas with residual contamination from past activities. The area has a long history of use as a port and industrial area, with storage and transport of various products; including copper, lead and zinc concentrate, fuel and oil, bitumen, acid, and cement products. Spills of oil and fuel have occurred in the past. Servicing of machinery has been undertaken in areas. Significant areas have been filled or reclaimed from the harbour using a variety of fill materials, including old aeroplane engines, ex-army vehicles, debris from Cyclone Tracey, oil drums containing residual oils, vehicle bodies, and machine parts.

URS (2003) found that much of the site has high levels of metals in near surface soils and hydrocarbons within the smear zone of the groundwater surface. Bare areas within the site are likely to be susceptible to erosion. Trafficked and hardstand areas may currently produce elevated levels of metals and oil and grease in runoff, though runoff from some areas is treated using pollutant traps.

High levels of soil contaminants combined with poorly implemented drainage systems in parts of the existing site would indicate that runoff sourced from the development area could contain elevated levels of metals, oils and grease and hydrocarbons, and sediment.

Potential acid forming materials have been found under much of the development area. Whilst the current acidity presents a low threat, excavation and/or dewatering activities have the potential to result in the oxidation of sulfides contained in this material, and the resulting release of acidic leachate into the surrounding environment. Acidic leachate has the potential to lower the pH of receiving waters and can mobilize heavy metals.

Runoff from the catchment above the scarp, containing a small part of the CBD, may have elevated levels of metals and oil and grease from trafficked areas, pesticides (e.g. dieldrin, Padovan 2001) from residual soil stores, and pesticides and nutrients from parks and gardens.

Runoff from the scarp and vegetated areas is likely to be of relatively good quality, though flow concentrations may lead to erosion and increased turbidity of runoff water.

Table SW1

Predicted Water Quality and Loadings from the Development Area Catchment - Existing

Catchment	Area	Average annual runoff fraction (%)	Average annual runoff	Indicative Water Quality				Predicted Loadings to Darwin Harbour						
				Sediment	Metals	Oil & grease/ hydrocarbons	Nutrients/ pesticides	TSS	Total P	Total N	Arsenic	Cadmium	Lead	Zinc
	(km^2)	(m^3/s)	(ML/year)					(T/year)	(T/year)	(T/year)	(Kg/year)	(Kg/year)	(Kg/year)	(Kg/year)
Urban	0.05	0.50	40.8	L	L	L	M	372	0.6	5.5	7	2	166	431
Scarp	0.04	0.25	18.7	L	L	L	L	72	0.1	1.7	2	0	3	9
Industrial	0.18	0.70	214.5	M	M	M	L	2,714	15.4	64.4	205	29	1,074	10,562
Disturbed	0.09	0.40	59.2	H	H	H	L	1,568	13.0	62.6	220	19	784	8,114
Foreshore	0.01	0.75	7.9	M	L	L	L	10	0.0	0.2	0	0	0	1
Total loading to Darwin Harbour	**0.37**		**341.1**					**4,736**	**29.2**	**134.4**	**434**	**49**	**2,027**	**19,118**

Note: Loadings calculated from rates given in Padovan (2000); L = low levels, M = medium levels, H = high levels.

2.3.2 Darwin Harbour

The quality of water in Darwin Harbour has been characterised during a number of studies (Padovan, 1997, Hanley and Caswell, 1995, Parry and Munksgaard, 1995). Water quality is affected by season, location within the harbour and tidal conditions, with the greatest variability seen in tidal creeks. Salinities in Darwin Harbour vary during the year and are heavily influenced by freshwater runoff from contributing catchments. The highest salinities tend to be observed in September (around 37,000 mg/L TDS), at the end of the dry season, dropping to 28,000 mg/L during the wettest part of the year, January to March, when runoff inflows are highest. Surface and bottom salinities tend to be similar.

pH tends to remain stable over time. Temperature shows strong seasonal variation, ranging between 31^{o}C in summer to 25^{o}C in July.

Turbidity and total suspended sediments are affected by depth in the water column, location in the harbour and tidal movements. Sediment levels are highest close to tidal mud flats and in shallow waters. Sediment levels are highest close to the bottom. Sediment levels throughout the harbour in general do not reflect seasonal changes, though high sediment loads in runoff during the wet season could impact on marine water quality close to the entry point to the harbour. Runoff is not likely to have any sustained or widespread impact on sediment levels in the general harbour area; the main factor affecting turbidity is tidal current causing re-suspension of sediment from the bottom.

The Darwin Wharf area is affected by tidal-induced sediments – Padovan (1997) shows an aerial photo of a turbidity plume sourced from the East Arm area moving past Darwin Wharf on an outgoing tide.

Total nitrogen and phosphorous levels tend to be relatively stable during the year, though tide action in near-shore areas can lead to elevated levels of total phosphorous. Runoff inflows can affect water quality near the inlet point. Nitrite/nitrate levels in near-shore areas can show seasonal variability due to runoff from the major rivers or the edges of the harbour.

The quality of bed sediments tends to be relatively uniform throughout the harbour and over time, except along tidal creeks and near areas with local contamination. Sediments near Iron Ore Wharf contain elevated levels of metals (Padovan 2003). URS (2003) found arsenic, cadmium, lead and zinc in excess of guideline values in marine mud near Fort Hill, the south western area of Kitchener Bay and at the outlet of the stormwater channel that collects runoff from hardstand in the Warehouse Area between Sheds No.1 and 2. In general, metal concentrations decrease with distance from shore, indicating metals are entrained in runoff throughout the development area, transported to the harbour and deposited close to shore. Contaminants in marine sediments near the wharf may have also been windblown from stockpiles and spills, particularly in the Fort Hill area.

3. Description of the proposed development

A map showing the project location within the catchment and drainage is given in Figure SW1.

A map of estimated flood levels at the existing site during a 100-year average recurrence interval (ARI) storm surge is shown in Figure SW3. An extreme high water level during a 100-year ARI event, accounting for cyclone storm surge, cyclone wave setup and astronomical tide has been estimated to be 5.1 m at Wickham Point (GHD-MacKnight, 1997). It was assumed that the high water level at the Darwin Wharf would be similar to at Wickham Point during a 100 year ARI storm surge. Surface water flows from the upslope catchment are not likely to contribute significantly to flooding in the developed area compared with the impact of the storm surge.

Drainage in the developed area will be redeveloped according to drainage best practice and will not restrict flows from the catchment above the scarp or within the developed area to the extent that flooding is caused in a 100 year ARI event.

4. Assessment of potential impacts from the proposed development

Table SW2 summarises the potential impacts of the development and indicates the importance and characteristics of each impact.

Table SW2

Impacts of the Development

Impact	Certainty	Nature of impact	Time-frame	Adverse/beneficial
Modifications to Natural Hydrological Regimes				
Changed land use composition impacting on the quality of stormwater discharged to the harbour.	Anticipated.	Direct – improved quality of stormwater.	Short to medium term – impacts will occur in proportion to the amount of redevelopment.	Beneficial – improved quality of stormwater.
Drainage system upgrade.	Anticipated.	Direct – improved stormwater management and quality.	Short to medium term – impacts will occur in proportion to the amount of redevelopment.	Beneficial – improved management of stormwater, reduced erosion and flooding risks.
Changed catchment area as a result of reclaiming parts of Kitchener Bay.	Anticipated.	Direct – increased stormwater as a result of a larger catchment.	Short to medium term – impacts will occur in proportion to the amount of redevelopment.	No net adverse impact.
Flooding				
Modifications to land use and drainage in the redevelopment area.	Anticipated.	Direct – impact on redeveloped area.	Short to long term.	No net adverse impact.
Impacts On Receiving Waters				
Erosion and elevated sediment levels in stormwater during construction.	Possible moderate elevation in sediment levels of stormwater discharged to the harbour; possible sediment deposition in near-shore areas.	Direct – impact on near-shore harbour water.	Short to medium-term – during construction.	Short-term, localised adverse impact.
Release of contaminated water.	Possible elevated metal and/or hydrocarbon levels, low PH.	Direct – impact on near-shore harbour water.	Mainly short term – during development before contaminated areas are remediated.	Potentially adverse, localised impact.
Increased runoff from a larger catchment area.	Anticipated	Direct – increased stormwater as a result of a larger catchment.	Short to medium-term – impacts will occur in proportion to the amount of redevelopment.	No net adverse impact.

4.1 Modifications to Natural Hydrological Regimes

It is expected that the redevelopment will have the following impacts on the existing hydrologic regime:

- the land-use composition of the catchment will change substantially as a result of changing from industrial/disturbed to urban/industrial and by reclaiming water and mudflats; the net impact of this will be a significant improvement in the quality of stormwater discharged to the harbour.

- the existing drainage system in the area of the redevelopment will be upgraded, with the net impact of improving stormwater management and improving stormwater quality;
- parts of Kitchener Bay will be reclaimed, increasing the surface water catchment;

A map of the expected land-use throughout the development area and contributing catchments is shown in Figure SW4. It is expected that the whole redevelopment area will be changed from the existing industrial and disturbed landscape to a predominately urban area with convention centre, parks and gardens, and retail developments. The extent of the wharf and industrial area is expected to be reduced in size.

Redeveloped areas will be constructed using best-practice techniques to manage stormwater flows and quality, including:

- capping or removing contaminated soils and fill materials to prevent contamination of stormwater;
- upgrading the drainage network to reduce the risk of flooding, erosion or contamination; and
- upgrading systems for treating flows from within the remaining industrial area as required, using best practice urban water management techniques, to improve stormwater quality prior to discharge to the harbour.

The estimated impacts of the redevelopment on stormwater flows and quality are summarised in Table SW3. The redeveloped area is likely to substantially improve the quality of stormwater discharged into the harbour. Reductions in loadings varied from 40-80%, bring the discharge into line with what would be considered best practice for the Darwin CBD.

Increase in runoff as a result of increasing the catchment area was small, only about 2%. Much of the high-runoff industrial areas will be converted to urban, which is expected to have less runoff, compensating for the increased catchment area.

Table SW3

Predicted Water Quality and Loadings from the Development Area Catchment - Proposed

Catchment	Area	Average annual runoff fraction	Average annual runoff	Indicative Water Quality				Predicted Loadings to Darwin Harbour						
				Sediment	Metals	Oil & grease, hydrocarbons	Nutrients, pesticides	TSS	Total P	Total N	Arsenic	Cadmium	Lead	Zinc
	(km^2)	(%)	(ML/year)					(T/year)	(T/year)	(T/year)	(Kg/year)	(Kg/year)	(Kg/year)	(Kg/year)
Urban	0.26	0.50	221.2	L	L	L	M	2,015	3.5	29.6	36	9	899	2,336
Scarp	0.04	0.25	19.0	L	L	L	L	73	0.1	1.7	2	0	3	10
Industrial	0.08	0.70	97.0	M	M	M	L	752	4.2	13.4	34	6	275	3,053
Disturbed	0.004	0.40	2.6	H	H	H	L	69	0.6	2.7	10	1	34	356
Foreshore	0.01	0.75	7.8	M	L	L	L	37	0.0	0.3	1	0	20	20
Total loading to Darwin Harbour	**0.40**		**347.6**					**2,946**	**8.3**	**47.8**	**82**	**16**	**1,231**	**5,776**
Change compared with existing loadings (%)			**2**					**-38**	**-71**	**-64**	**-81**	**-67**	**-39**	**-70**

Note: Loadings calculated from rates given in Padovan (2000); L = low levels, M = medium levels, H = high levels; See Table SW1 for existing loading.

4.2 Flooding

Flooding is not likely to be adversely impacted by the development. The main flood risk to the site is from storm surge and the development will not make the flood risk worse. The upstream contributing catchment is small and not likely to generate sufficient stormwater to impact the development area.

Buildings within the development susceptible to storm-surge flooding will be constructed with floors above 6.5m AHD (1000 year ARI storm surge, including a 0.3 m allowance for rise in sea level to take account of long term global warming). Other areas will be designed as appropriate to either not flood during a 100-year ARI storm surge event (5.1 m AHD), or be safely inundated and recover after the event.

Drainage infrastructure will be upgraded throughout the redevelopment area as required to safely accommodate runoff from heavy rainfall events, including cyclones, up to a 100-year ARI event.

4.3 Impacts On Receiving Waters

Risks of impact on receiving waters are likely to stem from:

- erosion during construction causing elevated sediment levels in stormwater and/or sediment deposition in near-shore areas;
- contamination with stormwater containing metals, hydrocarbons or acid leachate entrained from contaminated areas within the site; and
- increased runoff as a result of reclamation.

Impacts on the receiving environment, i.e. Darwin Harbour, are likely to be minor. The erosion risk, stemming mainly from erosion of bare areas and stockpiles during the wet season will be managed using standard soil conservation works. The likelihood of gross erosion occurring is small and moderate increases in stormwater sediment loads can be readily tolerated by the harbour. Sediment loads in near-shore and shallow areas are already high as a result of tidal actions and local runoff.

Potential exists for soil and groundwater containing metals and hydrocarbons to contaminate stormwater throughout the site. This risk will be managed by capping, treating or removing contaminated materials throughout the site and by upgrading the existing stormwater management system. Best practice urban stormwater management systems will be used throughout the development to management stormwater flows and quality. The risk is greatest during early stages of the project before remediation and stabilisation of contaminated areas has occurred.

Runoff will still contain some contaminants after site development is complete, but these levels will be low and consistent with best practice management.

Areas where potential acid forming soils will be disturbed during development will be managed using an acid soil management plan, and the risk of contaminating stormwater will be low.

Runoff will increase slightly as a result of a larger catchment area after reclamation of parts of Kitchener Bay. This runoff is likely to be off good quality and not likely to adversely impact the waters of Darwin Harbour. Increased runoff from the development area will have no discernable impact on harbour salinity or tidal flows as the volume of increased stormwater is small.

5. Mitigation strategies

5.1 Mitigation of Impacts

Most impacts on surface water as a result of developing the wharf area are likely to be benign or beneficial. The largest potential risks arise from erosion during construction and contamination of stormwater with metals and hydrocarbons entrained from existing contaminated areas.

Erosion risk will be managed using an erosion and sediment control plan.

Contamination will be managed with appropriate site remediation and stabilisation. Remediation of the site will occur as part of the development process.

5.2 Erosion and Sediment Control Plan

5.2.1 Objectives

The objective of the erosion management plan is to manage on-site erosion and drainage and release of stormwater from the development area during construction so that there is no adverse impact on the quality of water in Darwin Harbour.

5.2.2 Implementation

Erosion will be managed on-site, during all stages of construction throughout the development area, using the following principles:

- protecting bare soil, slopes, topsoil stockpiles and stream lines from erosion by employing soil conservation techniques;
- managing stormwater flows to prevent erosion;
- using temporary sediment traps and settling areas to trap sediment; and
- using a monitoring and management plan to ensure water released to Darwin Harbour is of acceptable quality.

The soil conservation techniques used will include:

- Undertaking activities that may cause erosion or increased turbidity during dry periods. As far as possible, most disturbance will be undertaken during winter and works put in place to manage erosion from the disturbed areas before the onset of the wet season.
- Minimising the area of cleared and/or disturbed land that is susceptible to erosion at any one time.
- Minimising constructed land slopes and/or retaining or adding surface cover on disturbed land and excavations susceptible to erosion. Cover will take the form of temporary or permanent annual or perennial grasses, shrubs or trees as appropriate or the use of hydro-mulch or other artificial surface covers.
- Using temporary silt traps and filters such as graded channels, hay bales or shade cloth barriers and sediment traps.
- Using works in series (i.e. a treatment-train approach).
- Stabilising temporary soil stockpiles with vegetation or artificial cover, by: reducing batter slopes; reducing slope length using across-slope drains; or reducing the stockpile size. Stockpiles will not be located close to surface drains. Silt traps and filters will be installed as required at the base of stockpiles.
- Constructing temporary roadways and trafficked areas to shed water to a constructed drainage system with appropriate treatment of water quality to maintain sediment loads at suitable levels for discharge to the harbour.

Silt traps will be sized to have sufficient capacity to retain runoff from a 30-minute, 10-year ARI event for 1 h. Bunds and channels associated with the traps will be stabilised with grass or artificial cover. The traps will drain completely between rainfall events. Silt traps will be monitored and maintained as required to ensure they remain in operational condition.

Monitoring will involve characterising erosion and surface water turbidity throughout the site during construction or at times when an erosion risk is present. A monitoring plan is presented in Section 1.5.5. Should the monitoring indicate sediment levels greater than a threshold value, action will be taken to locate the source of the contamination, determine if the level is high enough or could become

high enough to impact on the receiving environment, and determine what, if any, rectification action is required. If rectification actions are needed, action will be taken to stabilise the current source and prevent reoccurrence.

Indicative thresholds for rectification action are given in Table SW4. Local conditions will be taken into account when considering potential impacts on the receiving environment. Sediment levels in near-shore environments can vary due to tidal activity, and threshold levels may need to be varied to reflect seasonal and diurnal variation.

Table SW4

Indicative Thresholds for Rectification Action

Sample location	Threshold	Action Required	Comments
Sites SW1, SW2, SW3.	TSS > 20 mg/L.	Determine if impact on the receiving environment could occur, and if so take rectification actions.	Local conditions to be taken into account when considering potential impacts.
Site MW1.	TSS > 20 mg/L.	Determine if impact on the receiving environment has occurred, and if so take rectification actions.	Local conditions to be taken into account when considering in an impact has occurred.
Throughout the site.	Evidence of erosion/deposition uncontrolled by soil conservation works.	Identify and rectify cause of erosion.	Immediate action required if uncontrolled erosion is occurring.

TSS = total suspended solids; site locations are shown in Figure SW5.

5.3 Water Management in Ponds and Swimming Features

5.3.1 Objectives

The objectives for water management in ponds and swimming features are to:

- maintain the aesthetic and functional characteristics of the features;
- maximise efficiency of water use and integration with systems for managing stormwater quality; and
- minimise adverse impacts on the environment or stormwater drainage system.

5.3.2 Implementation

Ponds and swimming features will be constructed and managed according to the following guidelines:

- any ponds, pools, artificial beaches and swimming features not open to the sea will be designed to accommodate rainfall or stormwater inflows up to a 100-year ARI without flooding, scouring or discharging water of poor quality to Darwin Harbour;
- where possible water supply for each feature will access water recycled from within the development area, accounting for the level of treatment necessary to maintain adequate quality for the purpose of the feature and considering evaporative concentration of salts; and
- where possible, ponds will be incorporated into and supplement the stormwater quality treatment system.

Ponds and swimming features will be monitored as required by local and national guidelines and in accordance with their intended use.

5.4 Stormwater Management

5.4.1 Objectives

The objectives of stormwater management structures and management systems are to:

- minimise erosion on site, particularly during construction;
- ensure underground pipe and surface channel structures are adequate to convey runoff from the redevelopment site and contributing catchments during all events up to a specified size without causing flooding nor entraining sediment or contaminants in transit; and
- use best practice urban stormwater techniques to maintain water sourced from within the redevelopment site at a suitable quality to be discharged to Darwin Harbour.

5.4.2 Implementation

The surface water management plan will address these objectives by specifying construction specifications and water management and maintenance procedures.

Erosion risk will be minimised by ensuring:

- potential erodible areas are managed according to the Erosion and Sediment Control Plan;
- channels and outfalls are erosionally stable by accounting for likely flow rates and the condition of the channel bed and banks and outfall area;
- temporary channels and flow management structures for use during construction are designed to accommodate flows up to a 10-year ARI without flooding or scouring; and
- permanent channels, pipes and flow management structures are designed to accommodate flows up to a 100-year ARI without flooding or scouring.

Drainage throughout the redevelopment site will be redesigned and constructed to convey runoff from the redevelopment site and contributing catchments during heavy rainfall events without causing flooding or entraining sediment or contaminants in transit. This will involve considering the location and nature of any potential contamination sources, and designing a stormwater conveyance system to suit.

Best practice stormwater techniques will be used to maintain water sourced from within the redevelopment site at a suitable quality to be discharged to Darwin Harbour. This will be done by:

- matching treatment measures to the nature and severity of contaminants in the stormwater;
- installing a series of treatments in-line and treating water as close to the source as possible; and
- maintaining structures in good operating condition.

Treatment measures that will be employed, as necessary, will include:

- bunding, oil, grit, litter and gross pollutant traps to remove trash, oils, sediment and other contaminants from industrial, hardstand, roadway and trafficked areas;
- grass swales and buffer strips to remove coarse sediment and nutrients;
- street sweeping to remove dust, organic matter and pollutants; and
- management systems to control the rate and timing of application of pesticides and nutrients to parks and gardens.

5.5 Monitoring

Table SW5 summarises the surface water monitoring that will be undertaken for baseline (pre construction) and construction/operational phases of the project. Figure SW5 shows sample locations.

Baseline and during construction monitoring operations are effectively the same. Sampling at the surface water (SW1, SW2 and SW3) and marine (MW1) sites and general monitoring for erosion is only required during the wet season (typically November to May) or during periods of rainfall outside those times and only when there is a risk of contamination. Contamination risks occur when bare areas or stockpiles or other erodible areas are present, as a result of decontamination activities, or from spills. The time of commencement of baseline sampling will be determined by the project timeline, but it should aim to characterise at least one wet-season data. Sampling should continue until construction activities in the catchment above the sample point is complete.

Monitoring of ponds and swimming features will commence when they are constructed and in use and will continue indefinitely.

Table SW5

Monitoring Methodology – Baseline and During Construction/Operation

Sample location	Sample method and frequency	Analysis Required	Comments
Sites SW1, SW2, SW3.	Hand sample for water quality, weekly during the wet season/periods of rain and when there is an erosion or contamination risk in the catchment above the monitoring point.	TDS, TSS, pH, metals, nutrients, oil and grease, hydrocarbons.	Required to characterise the quality of water discharged from the project area to the receiving environment (Darwin Harbour).
Site MW1.	Hand sample for water quality, weekly during the wet season/periods of rain and when there is an erosion or contamination risk in the catchment above the monitoring point.	TDS, TSS, pH, metals, nutrients, oil and grease, hydrocarbons.	Required to characterise any impacts on the receiving environment (Darwin Harbour).
Throughout the site.	Visual observation of erosion after heavy rainfall events.	Visual observation.	Required to characterise any erosion problems.
Ponds and swimming features	As required by local and national guidelines and in accordance with their intended use.	Salinity, chlorine, microbiological activity, alkalinity, nutrients, sediment.	Required to characterise the ongoing condition of ponds and swimming features.
Operations	Record general activity in the development area, including areas and timing of construction/ disturbance and remediation activities.	Diary notes.	Required for consideration when evaluating monitoring results.

6. References

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BENNETT

SMITH

STREET

ESPLANADE

DRIVE

KITCHENER

MCMINN STREET

FRANCES BAY DRIVE

WAREHOUSE AREA

SHED NO 1

SHED NO 2

RECENT RECLAIM AREA

FORMER STOKES HILL POWER STATION

STOKES HILL FUEL TANKS

POWER AND WATER CORPORATION

STOKES HILL CARPARK

JETTY AND STEAM PUMPHOUSE AREA

FORMER TIPPING SHED AREA

SHELL BITUMEN PLANT

FORMER COCKBURN CEMENT AREA

NORTHERN CEMENT PLANT AREA

QUARENTINE INCINERATOR

ROUGH GROUND

FORMER IRON ORE AND ZINC CONCENTRATE STORAGE AREA

SULPHURIC ACID TANK

SHIPPING CONTAINER STORAGE AND HANDLING AREA

Fort Hill Wharf

LEGEND

- Boundary for Redevelopment
- Catchment Boundary
- Surface Drains
- Stormwater Pipes
- (1) Catchment Number

Catchment Areas (square metres)	
1	232,132
2	20,142
3	47,916
4	71,921

N

0 40 80 120 160 200

METRES

Job No.	36909-007-562	
Prep. By	RC	18 Feb 04
Chk'd By	PL	18 Feb 04
Revision No.		0

Department of Infrastructure, Planning and Environment

DARWIN WATERFRONT REDEVELOPMENT PROJECT
ENVIRONMENTAL IMPACT STUDY

EXISTING SITE DRAINAGE

Figure 4.1

URS

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BENNETT

SMITH

STREET

MCMINN STREET

FRANCES BAY DRIVE

ESPLANADE

DRIVE

KITCHENER

WAREHOUSE AREA

SHED NO 2

SHED NO 1

RECENT RECLAIM AREA

FORMER STOKES HILL POWER STATION

STOKES HILL FUEL TANKS

POWER AND WATER CORPORATION

STOKES HILL CARPARK

JETTY AND STEAM PUMPHOUSE AREA

FORMER TIPPING SHED AREA

SHELL BITUMEN PLANT

FORMER COCKBURN CEMENT AREA

NORTHERN CEMENT PLANT AREA

QUARENTINE INCINERATOR

ROUGH GROUND

FORMER IRON ORE AND ZINC CONCENTRATE STORAGE AREA

SULPHURIC ACID TANK

SHIPPING CONTAINER STORAGE AND HANDLING AREA

Fort Hill Wharf

LEGEND

- Boundary for Redevelopment
- Catchment Boundary
- Urban
- Industrial
- Escarpment
- Disturbed
- Foreshore

Area of land use (square metre)	
Urban	48,358
Industrial	180,325
Escarpment	43,958
Disturbed	87,010
Foreshore	6,182

N

0 40 80 120 160 200

METRES

Job No.	36909-007-562	
Prep. By	RC	18 Feb 04
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Revision No.		0

Department of Infrastructure, Planning and Environment
DARWIN WATERFRONT REDEVELOPMENT PROJECT
ENVIRONMENTAL IMPACT STUDY

EXISTING LANDUSE

Figure 4.2

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BENNETT

SMITH STREET

ESPLANADE

MCMINN STREET

FRANCES BAY DRIVE

KITCHENER DRIVE

WAREHOUSE AREA

SHED NO 1

SHED NO 2

FORMER STOKES HILL POWER STATION

STOKES HILL FUEL TANKS

POWER AND WATER CORPORATION

STOKES HILL CARPARK

JETTY AND STEAM PUMPHOUSE AREA

RECENT RECLAIM AREA

FORMER TIPPING SHED AREA

SHELL BITUMEN PLANT

FORMER COCKBURN CEMENT AREA

NORTHERN CEMENT PLANT AREA

QUARENTINE INCINERATOR

ROUGH GROUND

FORMER IRON ORE AND ZINC CONCENTRATE STORAGE AREA

SULPHURIC ACID TANK

SHIPPING CONTAINER STORAGE AND HANDLING AREA

Fort Hill Wharf

LEGEND

- Stokes Hill Area
- Bitumen Plant Area
- Fort Hill Area
- Northern Cement Plant Area
- Recent Reclaimed Area
- Warehouse Area
- Boundary for Redevelopment
- Catchment Boundary
- Q100 Storm Surge Inundation (5.1mAHD)

N

0 40 80 120 160 200

METRES

Job No.	36909-007-562	
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Revision No.		0

Department of Infrastructure, Planning and Environment
DARWIN WATERFRONT REDEVELOPMENT PROJECT
ENVIRONMENTAL IMPACT STUDY

FLOOD INUNDATION, 100 YEAR STORM SURGE

Figure 4.3

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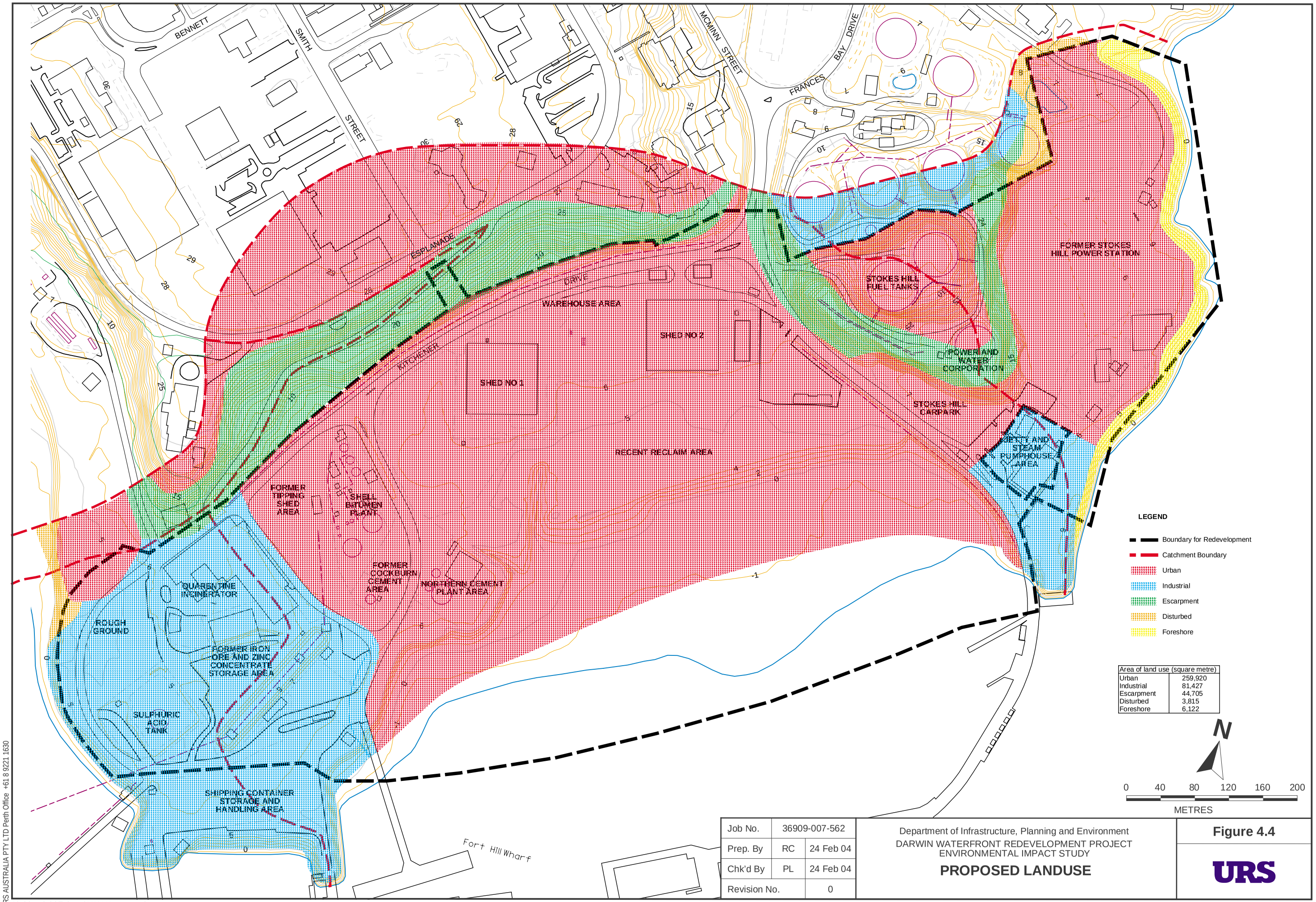

Job No.	36909-007-562	
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Chk'd By	PL	24 Feb 04
Revision No.		0

Department of Infrastructure, Planning and Environment
DARWIN WATERFRONT REDEVELOPMENT PROJECT
ENVIRONMENTAL IMPACT STUDY

PROPOSED LANDUSE

Figure 4.4

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BENNETT

SMITH STREET

ESPLANADE

MCMINN STREET

FRANCES BAY DRIVE

KITCHENER DRIVE

WAREHOUSE AREA

RECENT RECLAIM AREA

FORMER STOKES HILL POWER STATION

STOKES HILL FUEL TANKS

POWER AND WATER CORPORATION

STOKES HILL CARPARK

JETTY AND STEAM PUMPHOUSE AREA

FORMER TIPPING SHED AREA

SHELL BITUMEN PLANT

FORMER COCKBURN CEMENT AREA

NORTHERN CEMENT PLANT AREA

QUARENTINE INCINERATOR

ROUGH GROUND

FORMER IRON ORE AND ZINC CONCENTRATE STORAGE AREA

SULPHURIC ACID TANK

SHIPPING CONTAINER STORAGE AND HANDLING AREA

Fort Hill Wharf

SW1

SW2

SW3

MW1

N

LEGEND

- Stokes Hill Area
- Bitumen Plant Area
- Fort Hill Area
- Northern Cement Plant Area
- Recent Reclaimed Area
- Warehouse Area
- Boundary for Redevelopment
- MW1 Sampling Location

0 40 80 120 160 200

METRES

Job No.	36909-007-562	
Prep. By	RC	20 Feb 04
Chk'd By	WD	20 Feb 04
Revision No.		7

Department of Infrastructure, Planning and Environment

DARWIN WATERFRONT REDEVELOPMENT PROJECT
ENVIRONMENTAL IMPACT STUDY

SURFACE WATER SAMPLING LOCATIONS

Figure 4.5

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