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# 1. Executive Summary

## 1.1 The Proposal

The Northern Territory University (NTU) as part of its 10th year anniversary celebrations desires to construct an ornamental lake and ceremonial entrance to the university. The site for the proposed ornamental lake and ceremonial entrance is along the southern boundary of the University's Casuarina Campus, which is situated in the northern suburbs of Darwin, approximately 12km from the city centre. Ceremonial Drive will link Lakeside Drive with the University's Southern Ring Road to the north.

## 1.2 Name and Address of Proponent

The proponent for this project is:

The Department of Transport and Works – Construction Agency
Highway House
P O Box 61
Palmerston NT 0831

Contact: Dick Norris
Phone: 8999 3474
Facsimile: 8999 4601

## 1.3 Proposal Background and Justification

The lake and ceremonial entrance were one of the key concepts of the original Master Plan for the university outlined in the first master planning exercise carried out for the university. The first Landscaping Master Plan in 1992 outlined the landscaping plans for the lake and ceremonial entrance (See **Figure 1.1** Illustrated Landscape Master Plan). The lake was identified as an integral part of the ceremonial entrance to the University providing an attractive water feature on the site of an existing stormwater drain.

One of the site opportunities identified in the Landscape Master Plan was that:

"…*Water may be retained prior to entering Rapid Creek to reduce environmental risk and create aesthetic features. Tidal change may be utilised to create a feature of dynamic effect*…" (Cloustons 1992, p20)

In 1994 all previous master planning documents were brought together and revised. The revised Master Plan confirmed the importance of the lake and drive as a key concept of the Master Plan Stage 1. Selected excerpts of the Master Plan have been reproduced and are included in **Appendix F**. Significant sponsorship has been raised through the Northern Territory University Foundation that is now enabling the project to move from the Master Plan into reality.

The lake and ceremonial entrance proposal will provide the university and the community with a landscaped and attractive grand entry to the university. Currently the subject land is a stormwater drainage area servicing the university and nearby suburbs. The stormwater drain and surrounding area is unsightly and inaccessible due to coffee bush infestation and rubbish dumping. The project will improve the amenity

of the area by providing a landscaped surround to the lake, landscaping along the ceremonial entrance with a vehicle bridge across the lake and bicycle and foot paths.

In addition to creating an aesthetically pleasing passive recreation area, the proposal will provide a cleaner environment in adjacent coastal areas as gross pollutant traps will be constructed at the stormwater outlet to the lake to remove litter from the stormwater.

The ceremonial entrance will necessitate a new access point onto Lakeside Drive. This will not be an additional entrance, as the existing entrance to NTU from Lakeside Drive will be closed. To enhance existing traffic calming mechanisms, the construction of a roundabout is proposed at the new entrance. Traffic travelling at excessive speed has been an ongoing issue on Lakeside Drive and the roundabout will assist with traffic calming and safety through reduced speed. Assessment of the proposal's impact on traffic in the area indicates that the new entrance, and closure of the existing entrance, will reduce the amount of traffic along Lakeside Drive past the proposed new entrance to Dripstone Road. While along the section of Lakeside Drive – from Trower Road to the new entrance – no increase in traffic is likely.

A ceremonial grand entrance to the university will provide an access point to the University that opens up an area for passive recreation that is currently inaccessible. It will also provide a link between the university and the Alawa Recreational Reserve currently leased by the Council to the University.

## 1.4 Description of Project

The project entails the development of a formal entrance to the university featuring a lake and "Ceremonial Drive" which will incorporate a bridge across the lake. The proposal encompasses:

- A lake, weir and associated works;
- An entry road ("Ceremonial Drive");
- A roundabout, car parking and bicycle paths;
- A bridge across the lake;
- Landscape works;
- Lighting; and
- Associated services relocation.

The lake is proposed to be approximately 350m long and have an average width of 47m and an average depth of 1.6m. Pollution mechanisms and other environmental controls will be incorporated into the design to minimise the impact of pollution ingress to the lake and on the lake environment including reducing breeding areas for mosquitos.

The entrance road, "Ceremonial Drive", is proposed to be approximately 400m in length linking Lakeside Drive and the University's Southern Ring Road via a vehicle bridge across the lake. Ceremonial Drive will be landscaped and take the form of a two-way 8m carriageway and adjacent bicycle path.

A roundabout at the intersection of Lakeside Drive and Ceremonial Drive is also proposed. The roundabout will be offset to the north and landscaped to reduce traffic noise and visual impact for lots facing Lakeside Drive.

## 1.5 Potential Environmental Impacts

The potential environmental impacts and proposed management associated with each stage of the project are summarised in **Table 1.1**.

The proposed construction phase of the proposal will extend for approximately 20 weeks and will result in a number of short term effects such as the generation of noise and dust caused by earthworks.

The operation phase of the proposal has the potential to produce long term benefits through the improvement of the quality of water entering Rapid Creek and the removal of the exotic species coffee bush.

## 1.6 Summary of Management Commitments

There are very few potential environmental impacts associated with the project, and where possible such impacts have been managed at the design stage of the project. However, the proponent has proposed several management commitments to ensure the development of an environmentally sound project. A summary of the management commitments is presented in **Table 1.2**.

## 1.7 Structure and Scope of PER

This Public Environmental Report (PER) has been prepared to satisfy the requirements of the Northern Territory *Environmental Assessment Act*. The report provides concise and comprehensive information concerning the design, construction and operation, and the potential environmental impacts of a proposed ornamental lake and ceremonial entrance at the NTU. This information will enable environmental issues associated with the proposed entrance to be considered and will ensure that unnecessary and unacceptable harm to the environment is avoided.

This document has been prepared in accordance with the guidelines issued by the Minister for Lands, Planning and Environment (DLPE) in March 2001. The guidelines are presented in **Appendix A.**

The PER includes the following main sections:

*SECTION 1: Executive Summary*
This section outlines the background and justification of the proposal.

*SECTION 2: Project Description*
This section describes the locality of the proposed development and the specific elements of the project, including the design, construction and operation of the lake and associated infrastructure.

*SECTION 3: Existing Environment*
This section describes the existing environment occurring at, and in the immediate vicinity of, the site.

*SECTION 4: Environmental Impacts*
This section predicts the potential environmental impacts arising from the construction and operation of the ornamental lake and associated infrastructure.

## Table 1.1: Summary of Potential Impacts Associated with the NTU Commemorative Lake Proposal

### Construction Phase

| Issue | Potential Impact | Environmental Management and Safeguards | Monitoring |
|---|---|---|---|
| Dust | Dust emissions from earthworks and vehicle movements reducing air quality. | If dust emission is a problem then dust suppression practices will be implemented. | Visually monitored by construction contractor.<br><br>Ambient monitoring will be undertaken in response to complaints. |
| Noise | Construction activities may generate noise. | Construction will be carried out in accordance with Section 6 of Australian Standard 2436-1981.<br>Construction Activities will be restricted to week days and daylight hours | Ambient noise monitoring will be implemented in response to noise complaints. |
| Surface Runoff and Erosion | Siltation of downstream drain and Rapid Creek from surface runoff and erosion. | Construction will occur during dry season.<br><br>A temporary coffer dam will be constructed to prevent tidal ingress during construction.<br>Stormwater flow will be divert around the construction site. | Regular inspection of downstream drain. |
| Acid Sulphate Soils | Leachate from acid sulphate soils impacting on the surrounding environment and causing corrosion and weakening of concrete foundations and sub-surface structures. | Investigate the acid forming potential of on-site soil to be disturbed .<br><br>If potential acid forming soils are identified then an acid sulphate soil management plan will be implemented. | The acid potential of soil from lake site will be monitored prior to construction. |
| Vegetation clearance | Loss of significant vegetation through clearance and disturbance<br>Loss of fauna habitat | No vegetation of conservation significance occurs on land to be cleared within the boundary of the proposed lake. A small area of remnant vegetation occurs within the proposed carpark area and will be cleared for construction.<br>Area to be cleared mainly consists of coffee bush or poorly managed and disturbed native vegetation. Cleared Coffee bush will be burned to kill seeds and prevent potential re-growth.<br>Clearance of vegetation will be limited to the extent necessary for construction works.<br>Trees and plants to be retained will be clearly identified and protected during construction.<br>Construction will be managed so as to avoid impacts to mangrove communities. | |

| Issue | Potential Impact | Environmental Management and Safeguards | Monitoring |
|---|---|---|---|
| Introduced Weeds and Pests | The importation of weed species or seed material by vehicles. | A washdown procedure for off-road vehicles to be instigated if required. | The site will be regularly visually inspected for the spread or establishment of seed species during construction. |
| Mammals | Construction activities may impact upon bats that potentially inhabit stormwater drains flowing into the NTU open drain. | Further research work on the bat colonies that might roost in the NTU stormwater drain will be conducted prior to construction.<br>Construction works adjacent to the stormwater drain that may disturb the bat colonies will be conducted later in the day. | Occurrence of bats at outlet of main drain pipes will be visually monitored by construction contractor. |
| Biting Insects | Increase in mosquitos and other biting insect numbers due to pondage of water and potential for creation of breeding sites causing potential public health problem through the transmission of diseases and public nuisance. | Construction to follow Whelan (1988) guidelines<br>Dry season construction.<br>A temporary coffer dam will be constructed to prevent tidal ingress during construction.<br>Stormwater flow will be diverted around construction activities.<br>Creation of significant habitat areas for mosquito larvae will be avoided. | Regular site inspection for potential breeding areas. |
| Social and Recreational | Increased traffic and disruption to local land users. | Local residents and NTU employees will be kept informed of any disruptions to access, traffic deviations, or changes to parking arrangements during construction. During construction, public access to NTU will continue to be via the existing entrance. Increase in traffic along Lakeside Drive due to construction activities will be minimal and not sufficient to a cause a local nuisance. | |
| Sites of Significance | Effects on any heritage or archaeological sites of significance | No historic, archaeological or sacred sites have been identified on the land proposed for redevelopment.<br>No declared Places or Objects under the *Heritage Conservation Act 1991* exist on the site or have been nominated. | |

## Table 1.1: Summary of Potential Impacts Associated with the NTU Commemorative Lake Proposal (continued)

### Operational Phase

| Issue | Potential Impact | Environmental Management and Safeguards | Monitoring |
|---|---|---|---|
| Rapid Creek | Changing hydrological conditions affecting Rapid Creek | The lake will have minimal effect on the hydrological conditions of Rapid Creek. The weir will be designed so that present tidal flows within the unlined channel that connects the lake to Rapid Creek will be unrestricted. Similarly, the weir and lake will be designed to accommodate peak wet season stormwater flows. | |
| | Changes in downstream water quality | It is anticipated that downstream water quality flowing into Rapid Creek will improve as a result of the proposed lake.<br>Gross pollutant traps will prevent floating litter entering the open drain and exiting into Rapid Creek. | |
| Stormwater Drainage System | Impact on stormwater drainage from surrounding suburbs | The lake will not adversely effect the operation of the existing stormwater drain. The lake and weir will be designed so that peak stormwater flows are not impeded. | |
| Aquatic Fauna | Restriction on the migration of aquatic fauna from Rapid Creek to where outflow from main stormwater drain enters NTU drain, due to placement of a damming structure across drain<br>Fauna may be trapped inside lake at low tides.<br>Crocodiles may be attracted to the lake. | The existing section of drain that is to be replaced by the lake, offers minimal habitat to aquatic organisms. The proposed lake development will result in an increase in the area and depth of water available.<br>Movement into and out of the lake will still be possible for estuarine fauna due to design of the weir that allows tidal intrusion.<br>A sign will be erected indicating the possible presence of crocodiles and a trap placed below the weir if required. | Aquatic fauna will continued to be monitored to ensure that movement is occurring across the weir due to tidal incursion and ingress. |
| Mammals | Colonies of bent-winged bats potentially roosting in stormwater drain flowing into NTU drain may be prevented from leaving drain. | Gross pollution traps will be designed to take into account movement of bats into and out of main stormwater water drains. | The bat colony will be monitored following development to determine impact of works and that on lake. |

| Issue | Potential Impact | Environmental Management and Safeguards | Monitoring |
|---|---|---|---|
| Biting Insects | Potential for the creation of Biting Insect breeding sites within the lake.<br>Potential public health problem through the transmission of diseases.<br>Impact on recreational uses from biting insects.<br>Public nuisance | Careful attention to design and maintenance of concrete edges of lake to avoid the creation of significant habitat areas for mosquito larvae. | The lake and surround will be monitored regularly following construction to identify any potential biting insect breeding habitat. |
| Social and Recreational | Increased traffic and associated safety issues. | The impact on the existing road network is minimal when traffic enters the existing road network at Lakeside via a roundabout arrangement. | |

## Table 1.2: Summary of Commitments

### Pre-construction and Construction

| Issue | Objective | Commitment | Timing | Whose Advice | Measurement Compliance Criteria |
|---|---|---|---|---|---|
| Environmental Management (ref 5.1) | To ensure environmental management in accordance with key objectives. | An EMP will be prepared following receipt of environmental approval. | Prior to commencement of construction | DLPE | Issue of Construction EMP. |
| Dust (ref 4.1.2) | To protect the surrounding land users such that dust emissions will not adversely impact upon their welfare and amenity. | Appropriate dust control measures will be implemented should dust levels prove to be an issue. | During construction | DLPE | Site Inspection |
| Noise (ref 4.1.3) | To protect the surrounding land users such that construction related noise will not adversely impact upon their welfare and amenity. | Any complaints related to noise will be investigated and appropriate corrective action implemented to rectify the situation. | During construction | DLPE | Site Inspection |
| Surface and Sub surface Hydrology and Water Quality (ref 4.1.4) | To maintain existing quality of surface waters during construction | All construction activities will be undertaken during the Dry Season.<br><br>Water quality will be monitored during construction to ensure it meets appropriate Australian water quality standards. | During construction | DLPE | Site Inspection and water quality guidelines met |
| Soils – Acid Sulphate Soil (ref 4.1.5) | To prevent acid generation in soils due to the disturbance during construction | Testing will be undertaken prior to construction to confirm the absence of acid sulphate soil.<br><br>Should acid sulphate soils be encountered prior to construction or at any time during construction, an acid sulphate soil management plan will be developed and implemented with approval from DLPE. | Prior to construction<br><br>During construction. | DLPE | Issue of acid sulphate assessment report. |
| Flora and Fauna – vegetation clearance (ref 4.1.6) | To minimise vegetation clearing associated with construction. | Clearance of vegetation will be limited to the extent necessary for construction works. Trees and plants to be retained will be clearly identified by the Parks and Wildlife Commission of the Northern Territory and protected during construction. | During construction<br><br>During construction | DLPE<br><br>DLPE | Site Inspection<br><br>Site Inspection. |

| Issue | Objective | Commitment | Timing | Whose Advice | Measurement Compliance Criteria |
|---|---|---|---|---|---|
| | | Construction will be managed so as to avoid impacts to mangrove communities. | | | |

| Issue | Objective | Commitment | Timing | Whose Advice | Measurement Compliance Criteria |
|---|---|---|---|---|---|
| Flora and fauna – weeds and introduced species (ref 4.1.6) | To prevent the introduction or spread of introduced species during construction | Coffee Bush and other noxious weeds will be removed wherever possible during construction and burnt to kill seeds and prevent potential re-growth.<br><br>A weed control program will be developed prior to construction for the duration of the construction phase. As part of this program, the site will be regularly visually inspected for the spread or establishment of weed species. | During construction<br><br>During construction | DLPE<br><br>DLPE | Site Inspection<br><br>Site Inspection |
| Flora and fauna – biting insects (ref 4.1.6) | To prevent creation of breeding habitat for biting insects during construction. | Regular site inspections for potential biting insect breeding areas will be conducted during construction.<br><br>Larvacides will be used where necessary to control breeding. | During construction<br><br>During construction | DLPE | Site Inspection |
| Flora and Fauna – bats (ref 4.1.6) | Minimise the impact to bats during construction. | Survey will confirm the existence of the bat colonies.<br><br>If the existence of bats is confirmed then:<br>❑ The presence of, and potential impact upon bats will be carefully monitored during the construction phase; and<br>❑ Timing of construction works will take account of potential impacts on bats. | Prior to final design and before construction<br><br>During construction | DLPE | Issue of bat monitoring report. |
| Storage and Handling of Materials and Waste (ref 4.1.7) | To ensure hazardous materials and waste are handled, stored and disposed of appropriately. | All hazardous materials will be stored and disposed of in accordance with relevant standards and legislation.<br><br>All waste materials will be removed from sites and disposed of in a manner | During construction<br><br>During construction | DLPE | Receipt of waste at DLPE approved sites. |

| Issue | Objective | Commitment | Timing | Whose Advice | Measurement Compliance Criteria |
|---|---|---|---|---|---|
| | | acceptable to the DLPE | | | |
| Social and Recreation (ref 4.1.8) | To minimise impacts to the surrounding community and employees of NTU. | Local residents and NTU employees will be kept informed of any disruptions to access, traffic deviations, or changes to parking arrangements during construction.<br><br>Any complaints will be investigated and responded to promptly | During construction<br><br>During construction | DLPE<br>DCC | No complaints are received from local residents or employees related to disruption during construction. |

| Issue | Objective | Commitment | Timing | Whose Advice | Measurement Compliance Criteria |
|---|---|---|---|---|---|
| Aboriginal Heritage (ref 4.1.9) | No impact on Aboriginal heritage sites. | In the event that a site of potential Aboriginal heritage significance is discovered during construction, all works will cease in the vicinity of the site pending consultation with the Aboriginal Areas Protection Authority and the Heritage Conservation Branch of the DLPE. | Prior to construction | Aboriginal Areas Protection Authority<br><br>Heritage Conservation Branch, DLPE | Sacred site certification has received for the site. |

## Operation

| Issue | Objective | Commitment | Timing | Whose Advice | Measurement Compliance Criteria |
|---|---|---|---|---|---|
| Environmental Management (ref 5.1) | To ensure environmental management in accordance with key objectives. | An EMP will be prepared following receipt of environmental approval. | Prior to commissioning of lake | DLPE | Issue of Construction EMP. |
| Surface Hydrology and water quality (ref 4.2.1.2) | To prevent contamination of surface and lake waters | A water monitoring program will be developed to ensure lake water does not become contaminated or depleted in oxygen. | Operation | DLPE | Water monitoring report prepared. |
| Stormwater Management (ref 4.2.1.2) | To prevent contamination of the lake and downstream areas as a result of stormwater flow | Gross pollutant traps will be used to ensure stormwater entering the lake is free from litter and other gross pollutants. | Operation | DLPE and DCC | Site Inspection |
| Flora and Fauna – vegetation clearance (ref 4.2.3.1) | Provide appropriate rehabilitation of the site following construction. | All cleared areas will be rehabilitated and landscaped in accordance with the Landscape Master Plan. | Operation | DLPE | Site Inspection |
| Flora and Fauna – aquatic fauna (ref 4.2.3.3) | Not to impact on movement of aquatic fauna into and out of lake. | The weir will be built to a height that allows tidal intrusion and thereby access for fish and other estuarine organisms. Tidal intrusions will promote water mixing and maintain a brackish water habitat during low flows. | Operation | DLPE | Design and construct documentation Site Inspection. |
| Flora and Fauna – bats (ref 4.2.3.4) | To minimise impacts of proposed lake on bats | A monitoring program will be implemented following construction to determine the impact of the development on roosting bat communities. | Operation | DLPE | Bat monitoring report prepared. |
| Flora and Fauna – biting insects (ref 4.2.3.5) | To minimise potential for creation of breeding areas for biting insects | The lake and surrounds will be regularly inspected following construction to identify any potential biting insect breeding habitat. | Operation | DLPE | Records indicating no increase in biting insect breeding. |
| Flora and Fauna – weeds and pests (ref 4.2.3.1) | To prevent the spread or establishment of weed species due to construction | The site will be regularly visually inspected for the spread or establishment of terrestrial or aquatic weed species during operation. | Operation | | Records indicating no increase in terrestrial or aquatic weed species. |

*SECTION 5* *Environmental Safeguards and Management*
This section describes the environmental management plans that will be developed for the construction and operational phases of the project and describes the monitoring programmes that will be implemented to evaluate the adequacy of these provisions.

*SECTION 6:* *Glossary*

*SECTION 7:* *References*
This section lists the references researched in preparing the PER.

## 1.8 Studies Undertaken as Part of PER

This PER draws heavily on previously existing information. As such, no new site-specific surveys have been undertaken during the preparation of this document, with the exception of a vegetation survey in the area of the proposed weir and carpark, and a site visit to observe aquatic fauna within the drain.

# 2. Description of Proposal

*This section discusses features of the proposal in sufficient detail to allow an assessment of its environmental impact. Description of the proposal is presented together with an outline of how construction will proceed and how the facility will operate.*

## 2.1 Location and Planning Issues

### 2.1.1 Location

The site for the proposed ornamental lake and ceremonial entrance is along the southern boundary of the University's Casuarina Campus, which is situated in the northern suburbs of Darwin, approximately 12km from the city centre (see **Figure 2.1**). Ceremonial Drive will link Lakeside Drive with the University's Southern Ring Road to the north.

### 2.1.2 Land Tenure

New land tenure arrangements are part of the proposed development to place responsibility and ownership of the lake with the University. The total area of land required for the development is approximately 4.7ha.

The existing lot numbers, ownership and area of land required for the development are as follows:

- Lot 9260 Town of Nightcliff - Northern Territory University land (area required is approximately 4700m²)
- Lot 8702 Town of Nightcliff - Vacant Crown Land, drainage reserve for Department of Transport and Works (area required is all of lot 8702 which is 9230m²)
- Part Lot 8640 Town of Nightcliff- Darwin City Council land, Alawa Ovals, with existing longterm lease to the University for recreational purposes (area required is 11,500m² of which 2935m², the area encompassing the lake, is required to be consolidated with the University's land)
- Part Lot 9375 Town of Nightcliff - Vacant Crown Land, Casuarina Coastal Reserve, No 1677 (Area required is 21,100m²)

The proposed development will require consolidation of lot 8702, part lot 9375 and that part of lot 8640 which is required for the lake with lot 9260 - University land. The remainder of part lot 8640 required for "Ceremonial Drive" will remain in the ownership of Darwin City Council as part of the existing long term lease to the University of Lot 8640 (See **Figure 2.2**).

The future land tenure over the required land has been discussed with the relevant landowners and support in principle sought and received, including Darwin City Council who have given the project "in principle support" subject to the demonstration of satisfactory drainage requirements.

Land tenure requirements are being addressed by the Department of Lands, Planning and Environment (DLPE) Land Administration for the Vacant Crown Land on lot 8702 (Drainage Reserve) and part lot 9375 (Casuarina Coastal Reserve No. 1677). A drainage easement will be created in lieu of the reserve and be lodged on the title of lot 9260. Partial revocation of the Coastal Reserve, part lot 9375, is required for the project as is assessment and acquisition, if required, of any native title interests. There is a current native title claim over all of lot 9375.

### 2.1.3 Planning Issues

Rezoning and subdivision/consolidation will be required for land consolidated with NTU land. In addition, the NT Consent Authority will assess a development application for the lake and associated works.

Rezoning would be required from O1 (Open Space) to CP (Community Purposes) for any land incorporated into lot 9260, NTU land, to avoid having multiple zones over lot 9260. Both zones are for the benefit of the community and allow passive recreation.

Council will of course have the opportunity to formally assess in detail any planning scheme amendment, subdivision/consolidation or development application for the project.

## 2.2 Design Layout and Standards

The proposed lake and ceremonial entrance design layout is illustrated in **Figure 2.3**. The project has been designed incorporating the existing stormwater drainage channel that separates the Alawa Ovals from the Casuarina Campus of the NTU. This channel which currently drains the surrounding northern suburbs including the Casuarina Square Shopping Complex, is required to continue functioning as a stormwater drainage outlet. The project has been designed to improve the aesthetics of the stormwater channel area while maintaining its full functionality. Furthermore, the quality of stormwater that enters the Rapid Creek will be improved through reduction of debris by construction of gross pollutant traps at outlets from the stormwater drainage lines.

### 2.2.1 Lake

A partially concrete lined drain currently exists in the location of the proposed lake, and occupies the drainage line of a former branch of Rapid Creek. A stormwater network that services Casuarina, Nakara, Wanguri, Wagaman and a part of Woodleigh Gardens feeds the drain. The drain (often referred to as the NTU Drain) runs approximately east-west and outlets into Rapid Creek. The total catchment area contributing to flows in the drain is approximately 275ha. Flow from the stormwater system is approximately $50m^3/s$ in a $Q_2$ storm event (i.e. 50% probability of occurrence).

The proposal is to set the normal water level of the lake at an RL of 2.6 AHD (approximately 6.6m CD). The level of the lake will be controlled by a weir that outlets to the lower reaches of the drain and into Rapid Creek. The invert of the lake will be approximately RL 1.4. The average depth will be 1.2m and the lake will be approximately 350m long and have an average width of around 47m.

The height of the weir has been determined as a compromise between the requirements for visual amenity and engineering and environmental constraints. A level of RL 3.0 would produce a more attractive visual setting as the level of the lake would be higher and more visible to observers. With an RL of 3.0m the depth of the lake would average 1.6m and light attenuation might impede the growth of macrophytes. However, by lowering the height of the weir to 2.6m, the frequency of tidal flushing is significantly increased, and most importantly, the length of periods when neap tides will not cross the weir is also significantly reduced (see **Section 4.2.1**). Both of these factors will improve water quality within the lake. The growth of aquatic vegetation is not a significant factor in shallow marine waters locally and the increased frequency of tidal flushing will maintain salinities at a high level during the dry season – the time of year when macrophyte growth is typically highest as turbidities are low. The salinity of the lake will be brackish during the dry season, and it is expected that a combination of tidal flushing and evaporation will maintain salinities at a level that prohibit the growth of aquatic macrophytes.

Dry seasons flows from the catchment area are likely to result from car washing, air conditioning plant condensate and lawn watering activities. Interception of low flows at pollutant traps, is proposed. Trash racks are proposed to remove debris at stormwater outlets to the lake.

The tidal range in Darwin is approximately from RL 4.0 (HAT) to RL-4.0 (LAT) AHD. Gently sloping shorelines and a high tidal range create a large area of intertidal zone, and the diurnal and monthly variations in tidal heights, lead to the development of a range of intertidal habitats based upon frequency of inundation and soil types. In the upper intertidal zone, local variations in microtopography create ephemeral shallow pools that are sometimes flooded by tidal water, or by freshwater during the wet season, or by both. Many of these ephemeral pools are ideal for mosquito breeding and can be utilised by a range of mosquito species. Accordingly, it is proposed to provide concrete hard edging to the sides of the lake above RL 2.4 AHD. The hard edges will also include any open unlined stormwater drain into the lake, as far upstream in those drains to the point where a stable lake level will occur.

Hard edging along the bank on the northern side will consist of the existing concrete lining. The western end of the north bank will have a series of concrete steps that will function as a seating and walkway area, as well as providing a surface that will impede the breeding of mosquitos. In addition, the design of the lake will not allow the formation of isolated pools and so mosquito-breeding areas will be prevented.

#### 2.2.1.1 Pollution Control Mechanisms

Management practices for control of water quality within the lake will be put in place in order to reduce the load or concentration of pollutants. At present a number of smaller drains empty into the drain in the region where the lake will be formed. The quality of water currently entering the drain from these sources is unknown but is expected to be variable. During the wet season, these small sources would be discharging water draining from garden beds, areas of lawn, and the roadway and carparks. Apart from the potential from small spills of oil or other pollutants from motor vehicles, the potential contaminants may be pesticides, herbicides and fertilisers and sources of nutrients such as lawn clippings and leaf litter. Total loadings of potential contaminants are expected to be low, and the majority of contaminant loading will be discharged into the lake during the first months of the wet season. At

these times, the large volumes of water discharging will quickly flush through the lake and into Rapid Creek. During the dry season, water discharges from these sources would be minimal with the majority derived from runoff after watering of garden beds and lawns.

Review of current watering practices at the location would be undertaken with a view to minimising the input of contaminants and nutrients into the lake. Design of associated landscaping of the areas adjacent to the lake provides opportunities to implement management strategies that will reduce current inputs of contaminants and nutrients to the lake.

It is anticipated that a combination of tidal flushing and freshwater flows will be sufficient to flush nutrients, contaminants and bacteria from the lake over the weir and into the creek.

Gross pollution traps will be installed to remove litter from stormwater.

### 2.2.2 The Weir

A 40m reinforced concrete weir is proposed at the western end of the new lake. Water will overflow from the weir into Rapid Creek via the existing open drain. The weir level will be set at RL 2.6m. This RL will enable tidal back flush an average of 15 times per month.

The downstream side of the weir will require protection to control erosion from the overflow spillway. Protection will be designed for a 1 in 100-year storm event coinciding with a low tide and would comprise dumped rock protection.

### 2.2.3 Entry Road

#### 2.2.3.1 Ceremonial Drive

A 400m long drive linking Lakeside Drive to the south and the Southern Ring Road to the north, is proposed. The drive will be two-way with an eight metre carriageway. The drive will be kerbed to restrict vehicular access onto landscaped areas. Vehicle access points will be provided to a purpose built car-parking area in the vicinity of the community centre (see **Figure 2.2**).

#### 2.2.3.2 Roundabout

A roundabout on the intersection of Lakeside Drive and Ceremonial Drive is proposed. This will not be an additional entrance, as the existing entrance to NTU from Lakeside Drive will be closed. The roundabout will be offset to the north to reduce the impact on property access to Lots 2026 and 2027 facing Lakeside Drive.

The roundabout will enhance existing traffic calming mechanisms. Traffic travelling at excessive speed has been an ongoing issue on Lakeside Drive and the roundabout will assist with traffic calming and safety by reducing vehicle speeds.

Based on the design speed for Lakeside Drive, the distance from the roundabout to the Gove Street intersection of 70m is considered adequate. The roundabout has been constructed based on anticipated traffic volume and although located on a bend, there will be sufficient distance from both directions to sight the roundabout when travelling at the design speed for Lakeside Drive.

### 2.2.4 Carparks

#### 2.2.4.1 Carpark (North West)

The NTU Master Plan nominates a future 158 space carpark to the north west of the proposed lake and bridge. The carpark will have a single point of entry/exit onto the Southern Ring Road. The carpark has been designed to include all kerbing and drainage as well as a 14mm aggregate spray seal.

#### 2.2.4.2 Carpark (South West)

An informal carparking area exists to the south west of the site. However, patrons using the Alawa Community Hall building (which has a floor area of around 400m$^2$) between the hockey field and the football oval, currently park in the shade of the trees. No fixed carparking facilities exist in this area.

In accordance with Division 6 of the Darwin Town Plan, parking for 20 cars will be provided. The location of this proposed car park is shown in **Figure 2.2**. Note this carpark is Council and not NTU property.

While the layout of the carpark is yet to be finalised, it has been assumed that it will be spray sealed and kerbed, with stormwater drainage provisions.

### 2.2.5 Bicycle Track

The Master Plan layout shows the cycleway on the western side of Ceremonial Drive. Given that the lake will probably attract pedestrian traffic viewing the lake from the bridge vantage point, consideration will be given to placing the cycleway on the eastern side of the bridge. The changeover from west to east should occur around 70m south of the bridge.

### 2.2.6 Bridge and Associated Works

Four proposals were assessed for the new vehicle bridge over the lake, namely box culverts and a culvert arch bridge with five, four and three arches. The three arch option has been selected for design.

The culvert arch bridge will incorporate roadworks, railings and a pedestrian walkway. Flow during a $Q_{100}$ storm event have been assessed at 160m$^3$/s and the bridge must have a flow area of around 80m$^2$.

The prefabricated arch bridge will be constructed of either prefabricated spandrels or facades to provide an aesthetically pleasing end wall treatment.

### 2.2.7 Landscape Design

Landscaping for the lake and ceremonial entrance to the University has been detailed in the *Northern Territory University Landscape Master Plan, 1992*.

The Landscape Master Plan aims to integrate development across the Casuarina Campus that reflects the quality of its natural setting, whilst noting that the campus is not a greenfield site with even the adjacent mangroves comprising areas of regrowth on mudflats that were cleared earlier (Guinea 1988). In addition, the Plan aims to reflect vegetation diversity and the extremes of the dry tropics and demonstrate a

commitment to the quality of the outdoor environment in keeping with investment in campus buildings and infrastructure (Cloustons 1992, p21).

Ceremonial Drive is planned to be developed with a tree enclosed corridor which opens out with views across the lake. The Tamarind Tree is proposed for all the road corridors. The Landscape Master Plan proposes a range of vegetation, native and exotic, taking into account poor soils and maintenance issues as well as creating a campus environment that clearly articulates the pre-eminent educational role the University plays in the community.

Specifically the landscaping planting results in the removal of introduced coffee bush, while minimising the impact on the existing mangrove population.

### 2.2.8 Services

#### 2.2.8.1 Lighting

Street lighting and associated works is required in addition to decorative lighting, including special lighting under bridge handrails.

Two public lighting concepts have been considered. This segregation was required to comply with the asset owners: NTU and Darwin City Council. The roundabout intersection public lighting concept has been designed to comply with Category V, V3.

The public lighting schemes illuminating Ceremonial Drive have been designed to comply with Category V, V4.

Category V4 – Sub Arterial principal roads which connect arterial or main roads to areas of development within a region, or which carry traffic directly from one part of a region to another part. Category V4 – Used when there is a mixture of pedestrian and vehicular traffic, there is only a moderate volume of traffic (see **Appendix B**), vehicles are at low speeds and there is only low traffic generated from abutting properties.

#### 2.2.8.2 Sewerage

The NTU Casuarina Campus is serviced by a series of 150NB and 225NB internal trunk sewers. These drain into public trunk sewers from the Nakara and Brinkin areas. These public trunk sewers are located, in part, on NT grounds. A majority of the NTU flow enters the Nakara system which, in turn, feeds the Brinkin system. The system gravitates from north to south.

The existing sewer trunks have a junction just north of the existing drainage reserve. From that point, a 450NB gravity pipe feeds across the reserve, to the east of the oval and connects with the existing 600NB sewer along Lakeside Drive.

The existing sewer crosses the drain marginally above the Lake's proposed water level. Three options were considered and the proposed option is to leave the existing sewer crossing in place.. This option requires that the lake be narrowed at the crossing point in order to retain the present ability of the sewer line to self support.

## 2.3 Construction Phase

### 2.3.1 Construction Phase - Program

Construction of Ceremonial Drive and the lake will be undertaken during the dry season to allow the completion of earthworks under dry conditions. A temporary coffer dam will be constructed to prevent tidal ingress to the lake work site. The dam would be removed prior to the start of the wet season.

The staging of the various construction elements which would be arranged to match available funding, would involve:

- Construction of Ceremonial Drive, the intersection and culvert bridge over the lake;
- Construction of the temporary coffer dam with material won from borrow pits within the lake area;
- Construction of temporary sediment collection basin and low flow culvert passing through the coffer dam;
- Progressive excavation of the lake;
- Construction of the concrete weir and low flow culvert;
- Alteration of the trunk sewer and construction of the pedestrian bridge;
- Adjustments to other services;
- Construction of perimeter walls;
- Construction of the gross pollution traps; and
- Removal of the temporary coffer dam.

Standard construction equipment consisting of bulldozers, excavators, trucks, rollers and cranes would be utilised during project construction.

The duration of works involved for the construction of the lake is likely to be in the order of 20 weeks.

### 2.3.2 Construction Phase - Works

Construction works will be undertaken in standard industry specifications to ensure that the works and extent of activities meet appropriate environmental standards. The contractor will be required to prepare and implement an environmental management plan that will include an erosion and sedimentation control plan to ensure conformance with environmental commitments.

Site clearing which will be staged to suit the work schedule, will encompass land for road, lake and perimeter walling, the temporary coffer dam and reasonable adjoining strips to allow for construction activities. The construction of the temporary coffer dam will involve the clearing of an area approximately 30m wide downstream of the permanent weir. This area would be rehabilitated after removal of the coffer dam, and a strip of the creek bed immediately below the permanent weir would be protected by rocks to prevent scour.

Topsoil removed from areas affected by construction will be stripped and stockpiled for later use.

Ceremonial Drive would be constructed in accordance with the accepted practices required by Department of Transport and Works and local authorities in regard to engineering, environmental and traffic control.

## 2.4 Operational Phase

### 2.4.1 Maintenance requirements and operations

Ownership of the whole lake area has been incorporated into the NTU site to reduce complexity with regards to maintenance requirements and operations. However, the ownership of the stormwater drain will remain with the Darwin City Council and NTU will be required to set up a maintenance contract with the Council with regards to clearing of gross pollution traps and any other stormwater drain issues.

NTU will be responsible for maintenance of the lake, weir and bridge. This will be part of their ongoing facilities management program and will include:

*Road Maintenance*
Road and verge maintenance would be included in the current maintenance programmes undertaken by the NTU and DCC.

*Maintenance and operation of the lake*
Periodic inspection and removal of rubbish collected in the gross pollution traps would generally be concentrated in the wet season due to large stormwater run off flows and floating debris during this period. Floating debris could also be introduced from time to time by the tidal flushing of the lake, and may require containment through the use of a floating barrier.

Silt from overland run-off could tend to accumulate in the lake due to the slowing of the stream flow. The deposition of silt should be checked periodically, initially on an annual basis. This may require draining the lake at neap tides via the low flow culvert prior to the wet season.

### 2.4.2 Predicted Recreational Uses

The commemorative lake is designed for passive recreational uses as well as ornamental and aesthetic purposes. As such, predicted recreational uses include walking and cycling around the lake, thus linking into the future walking trail development as identified in the Rapid Creek Management Plan (Darwin City Council and Greening Australia, 1994).

Swimming, fishing and boating will not be permitted in the lake. Appropriate signage will be erected advising the general public of these regulations.

# 3. Existing Environment

*This section describes the existing environmental characteristics of the area to be affected by the proposal. Particular attention is focused on components of the environment that would either have a direct bearing on the proposal or could be most affected by it.*

## 3.1 Topography

The proposed lake development site overlies an existing concrete lined stormwater drainage channel that services the surrounding northern suburbs. We assume the drain overlies a former small arm of Rapid Creek into which the drain now discharges. At the upstream end of the drain there is a series of large stormwater pipes (**Figure 3.1**). Downstream of the culverts the channel drops some 30cm in height (**Figure 3.2**), and during the dry season there is a small flow of freshwater over this step. From there the stormwater drain flows through University ground (lawn areas) and then through thickets of coffee bush (*Leucaena leucocephala*) after which it drains into Rapid Creek **(Figures 3.3 – 3.5**). Rapid Creek is a mangrove-lined estuarine creek that flows through Darwin's northern suburbs and empties into the Timor Sea, at the southern end of Casuarina Coastal Reserve. The creek extends for a distance of 9.8km and drains a catchment of 28 $km^2$. Unlike many such drainage lines elsewhere in urban areas, Rapid Creek supports a number of important remnant vegetation communities and the creek channel is virtually undeveloped for its entire length (Darwin City Council, 1994). The creek has been subject to high levels of disturbance in the past. Prior to 1974 much of the mangrove around the creek was cleared for development and has since regenerated (Guinea, 1988).

The drain is also tidal with seawater moving in and out directly from Rapid Creek. The stormwater drainage system discharges urban freshwater runoff from northern suburbs. In the dry season flow from the stormwater pipes is minimal, (**Figure 3.1**) and this would mostly result from urban activities such as car washing. In the summer rainy season, heavy pulses of freshwater flows enter the drain during storm events.

## 3.2 Climate

Darwin has a tropical climate which is characterised by a hot, humid Wet Season (typically December to March) and a hot, Dry Season (typically May to September) separated by relatively short transitional periods (typically April – the Dragonfly Season and October/November - the Build-Up).

The NTU campus is one of the sites used by the Bureau of Meteorology to measure Darwin's climate since 1996. The mean annual rainfall of 1,659 mm, is highly seasonal, and reliable, reflecting both the coastal position of the site, and the location in the monsoon tropics. Monthly rainfall varies from an average of 404mm in January, the peak of the Wet Season, to 1mm in July, the middle of the Dry Season. High rainfall rates are typical during storms in the Wet Season and during monsoon events.


■ **Figure 3.1: Upstream end of concrete lined drain showing culverts. Note low dry season flow.**


■ **Figure 3.2: Step in drain downstream of culverts. Note presence of film of algae on substrate above and below step.**


■ **Figure 3.3: View looking downstream toward footbridge at low tide, dry season.**


■ **Figure 3.4: View of lower end of formed drain on rising tide, with lower footbridge in distance. Note thickets of coffee bush on both banks.**


■ **Figure 3.5: View looking upstream from lower footbridge. Here the substrate is a mixture of sand, gravel and rocks with some pieces of timber and rotting vegetation.**

Humidity varies from the Wet Season to the Dry Season as well as over the period of a day, with higher humidity in the Wet Season. For example humidity at 9am in June is a low of 62% to a high of 84% in February with humidity for later in the day, 3pm, being a low of 30% in June and a high of 71% in February.

Temperatures tend to remain within a relatively narrow range throughout the year. Ranging from a mean daily minimum of 19.2°C (July) to 25.2°C (November) and a mean daily maximum being 30.3°C (July) to 33.1°C (November).

Synoptic winds during the Dry Season tend to be dominated by the south-east trade winds, while light west to north-westerlies predominate during the Wet Season. Sea breezes from the north-west occur on most afternoons throughout the year.

Tropical cyclones are frequent in the Darwin region. Australian Standard AS 1170 Part 2-1989 specifies likely maximum gusts during cyclonic events in Darwin for purposes of structural designs. The standard indicates likely maximum gusts of 180, 205 and 252 km/h for cyclones having mean return periods of 20, 100 and 1000 years respectively (Sinclair Knight Merz, 1999 p26).

## 3.3 Surface and Sub-surface Hydrology

The gently sloping and evenly graded topography of the university campus provides for a dispersed drainage pattern over most of the area. Runoff is generally collected on the lower slopes by pits, drains or basins from where it is piped or channelled into Rapid Creek.

In the eastern half of the campus drainage falls southward and is collected by the stormwater system of the existing campus development. From here it is fed into the open drain or NTU Drain, along the southern boundary before entering Rapid Creek.

To the west, the undeveloped portion of the campus drainage is shed in a west and southwesterly direction. Much of it is directed into a broad natural basin on the western edge of the campus from where it enters Rapid Creek via a natural drainage course.

The drainage patterns outside the existing campus are major physical features on the landscape and influence the character of the University. Rapid Creek terminates into a large natural delta just south of the campus before entering the Timor Sea. The total creek covers a catchment area extending 28km inland and is, therefore, of regional significance.

The large open drainage line along the southern edge of the campus is a significant feature of the University landscape. The drain carries stormwater from adjacent suburbs as well as the campus, and discharges into Rapid Creek. The large scale of the drain, the nature of its contents, and the lack of a natural riparian corridor, make for a feature of little visual appeal.

Smaller open drains and stormwater pipes discharge runoff into Rapid Creek or the large open drain. **Figure 3.6** shows the end of a stormwater drain that discharges into the larger NTU drain in the area where the proposed lake will be sited.

**Figure 3.7** shows a unformed drainage channel with erosional features that drains a small patch of disturbed forest before entering the NTU drain just upstream of the lower footbridge.


■ **Figure 3.6: The largest formed stormwater drain that discharges into the NTU drain. Note brown stain of algae growing in effluent stream.**


■ **Figure 3.7: Large drainage channel discharging into lower end of NTU drain just upstream of lower footbridge. Note evidence of erosion of banks and presence of rubbish.**

The smaller channels are typically steep sided and deep, providing optimum conditions for weed growth and mosquito habitat if water ponds during periods of low flow. They are, therefore, undesirable features in the landscape.

The water table fluctuates widely during the wet and dry seasons. However, analysis of water extracted from surface bores indicates that the ground water has a high salt content and is not potable water.

## 3.4 Soil Characteristics

Lateritic soils are the dominant soil type of the campus. The soil is of variable thickness and is characterised by a significant proportion of gravel, poor nutrient content and minimal organic matter.

## 3.5 Flora and Fauna

### 3.5.1 Vegetation Communities

The vegetation of the site has previously been mapped and described as part of the NTU Landscape Master Plan (Clouston, 1992). That document identified the broad pattern of vegetation distribution, delineating areas of mangroves, disturbed and poorly managed vegetation and patches of significant native plant communities. However, a more detailed examination and assessment of the existing vegetation was conducted as part of the requirements for this PER. Results of the survey are presented in **Appendix C**, and summarised below.

Existing vegetation mainly comprises dense infestations of coffee bush (*Leucaena leucocephala*). A native of Central America, *Leucaena leucocephala*is is now well established in coastal settlements of the Northern Territory. Although coffee bush is a common woody weed in the Darwin region with the potential to cause serious environmental problems, it is not a declared noxious weed (Smith, 1995). It is a species characteristic of disturbed or degraded land, especially around settlements.

Overall, five main vegetation communities were distinguished within the area of interest as indicated in **Figure 3.8**.

*Planted Open Parkland*
Much of the area between the southern NTU ring road and Lakeside Drive is planted open parkland in which scattered trees and plantings occur amongst maintained grassland. The area includes two grassed ovals with planted trees including both native and exotic species. In general, trees in the open parkland area appear to be relatively young (< 20 years old), typically ranging from 9 to 14m in height and presumably represent the cumulative product of landscape works since Cyclone Tracey in 1974.

The upstream section of the draining reserve is lined with scattered *Acacia auriculiformis* (Darwin Black Wattle) with occasional Red River Gums *(Eucalyptus camaldulensis*) and Banyan Fig trees (*Ficus virens*). Exotic trees are more numerous in this area with *Khaya senegalensis* (African Mahogany), *Gmelina arborea*, *Pterocarpus indicus* (Rosewood) and *Alstonia scholaris* (Cheesewood).

Approximately 48% of the area to be cleared for the proposed lake currently comprises planted open parkland. No native or exotic species of conservation significance occur within the boundary of the proposed lake.

*Coffee Bush Infestations*
Approximately 52% of the area to be cleared for the proposed lake comprises monospecific stands of *Leucaena leucocephala* (Coffee Bush). Construction of the weir and spillway will involve further clearing of dense Coffee Bush. This species tends to exclude native vegetation and forms thickets to 6m high that extend right to the edge of the intertidal zone and overhang the canal. (See **Figure 3.9)**

*Poorly managed and disturbed native vegetation*
Small areas of native vegetation showing various degrees of prior disturbance occur within the survey area. These areas are characteristically *Eucalyptus* dominated woodland habitat (including *Eucalyptus miniata*, *E. papuana* and *E. confertiflora*) with a sparse understorey layer. This community is relatively species rich with a total of 46 species recorded in this habitat. Common mid-stratum species include *Pandanus spiralis* and *Planchonia careya* above a dense grass layer. Mission grass (*Pennisetum polystachion*), an introduced noxious weed, is common in these areas along with other native and exotic grass species. A layer of smothering introduced vines that exclude native species (eg *Passiflora foetida*, *Centrosema pubescens*, *Calopogonium muconoides*) is common in this habitat. The high proportion of introduced species (28%) is indicative of disturbance to the native vegetation from frequent fire, clearing and terrain disturbance.

*Remnant vegetation containing valuable specimen trees.*
The mangrove fringe on the southern boundary of the NTU campus comprises a narrow band of remnant vegetation. Tree species include mature *Melaleuca leucadendra* (Paperbark), *Eucalyptus papuana* (Ghost Gum) and tall *Acacia auriculiformis* (Darwin Black Wattle) in the upper stratum. Other species of interest include *Diospyros calycantha*, *Diospyros littorea*, *Guettarda speciosa* and *Timonius timon*. (See **Figure 3.10)** The vegetation in this area forms a natural buffer for mangroves in the adjacent intertidal zone and future development of the lake and carpark should maintain the integrity of this remnant littoral woodland.

A pocket of remnant vegetation including a tall stand of Ghost Gums (*Eucalyptus papuana*) and native species associated with monsoon vine forest habitats occurs close to the mangrove margin and within the proposed carpark area. It is however, surrounded by a mix of exotic species (*Khaya senegalensis*, *Leucaena leucoephala*), plantings of native species (*Ficus benjamina*, *Melaleuca* spp.), and native vegetation in disturbed condition.

Although occupying only a small area, the healthy stand of Ghost Gums occurs amongst Paperbarks (*Melaleuca leucadendra*) and tall *Acacia auriculiformis*, forming an attractive pocket of native vegetation. (See **Figure 3.11)** Beneath the canopy formed by the Eucalypts, saplings of *Carallia brachiata*, *Carpentaria acuminata*, *Terminalia microcarpa* and *Wrightia saligna* occur. This pocket of vegetation contains valuable specimen trees and should be retained as a landscape feature, providing shade to the carpark area.

■ **Figure 3.9: Coffee Bush *(Leucaena Leucocephala)* infestation.**

■ **Figure 3.10: Remnant vegetation containing valuable specimen trees.**

■ **Figure 3.11: Ghost Gums *(Eucalyptus papuana)* in the vicinity of the proposed carpark.**

*Mangroves*
Mangroves occur either as a thin band often only one tree in width, or as sporadic trees/shrubs along the main tidal channel as far upstream as the current foot bridge. Common mangrove species recorded in this habitat include *Lumnitzera racemosa*, *Avicennia marina*, *Acrostichum speciosum* and *Excoecaria ovalis*. Upstream of the bridge the margins of the channel are more formalised and mangroves do not occur in this area.

The upper reaches of Rapid Creek support extensive mangroves that extend up to the southern boundary of the NTU campus. These mangroves are dense closed canopy forests to 7m high, typically comprising a landward fringe of *Lumnitzera racemosa*, *Diospyros littorea*, *Ceriops australis*, *Acanthus ilicifolius* and *Scyphiphora hydrophyllaceae.*

### 3.5.2 Aquatic Fauna

A visual survey of marine fauna along the drain system was undertaken (21/05/01). Seven species of fishes were observed within the drain (**Table 3.1**). Mullet were the dominant species, with many schools of small individuals observed along the length of the drain. The observed fauna appeared to consist of non-resident species of opportunistic feeders moving upstream with the incoming tides.

**Table 3.1. Fish species observed during a visual inspection of marine fauna in the drain leading to Rapid Creek.**

| Species | Common name | Abundance |
|---|---|---|
| *Mugil or Liza spp.* | Mullet | Common |
| *Torquigener pallimaculatus* | Toadfish | Present |
| *Marilyna darwinii* | Toadfish | Present |
| *Selenotoca multifasciata* | Scat | Present |
| *Scatophagus argus* | Scat | Present |
| *Amniataba caudovittatus* | Yellowtail trumpeter | Present |
| *Terapon jarbua* | Crescent perch | Present |

It is likely that a number of other fish and crustacean species (not seen in this survey) inhabit the drain at times. A variety of fishes such as Gobies commonly inhabit small tidal creeks such as this one, and there was some suitable cover available for these small cryptic species. Similarly, a variety of small invertebrates including species of crabs and shrimps are probably also present. A large number of fishes and crustaceans also move upstream in shallow tidal creeks either daily with the tide, or in response to seasonal cues, such as increased freshwater flows. It is possible that crocodiles could also move upstream. Crocodiles are currently retrieved from Rapid Creek when sighted.

The section of the creek examined did not contain a high diversity of habitat types and was sandy with large pieces of gravel below the formed concrete part of the drain. The lack of aquatic macrophytes and the general lack of cover reduces the diversity of fauna that might otherwise be associated with the creek.

The drain empties directly into Rapid Creek and there is no obstruction to fish movement between the creek and drain, except for the step just downstream of the culverts at the upper end of the drain. At low tide and low flows this creates a barrier for the movement of fauna upstream and into the culverts.

A high diversity of fishes inhabit estuarine mangrove creeks in the Darwin region. Larson and Williams (1997) provide a checklist of fishes recorded in the Harbour. They list 415 species which highlights the high levels of marine diversity in the area. **Appendix D** lists species officially recorded from Rapid Creek (Larson and Williams 1997), in addition to families (representative species only shown) which these authors have recorded from estuarine Creeks and inlets in the Darwin Harbour area. These are species that could also be expected to inhabit Rapid Creek. From **Appendix D** it is evident that the diversity of marine fauna in Rapid Creek is likely to be high, but it is anticipated that many of the sedentary species recorded from Rapid Creek would not be found in the NTU drain because of a lack of suitable habitat.

Very large numbers of invertebrate species are also present in Rapid Creek and comprise two groups of species. Resident species are found in various habitats in the creek and comprise organisms such as fiddler crabs, barnacles, oysters, polychaetes, isopods, amphipods, sipunclids and echinoderms. The other large group of species migrate up and down (and into and out of) the creek with the tide, and with increased freshwater flows during the wet season.

Prawns (penaeidae) and brachyuran crabs (eg mud crab *Scylla serrata*) are common elements of tidal inlets and estuaries in the Darwin Harbour and would be likely to migrate into the drain on high tides and during significant freshwater flows. However, the lack of suitable cover, and food suggests the drain is a marginal habitat for these species. Molluscs such as *Terebralia spp* may also be present at the downstream end of the drain, and **Figure 3.12** shows a small midden of these species found in coffee bush thickets alongside the drain. Typically these animals are associated with mangroves and on the day of survey a group of aboriginal people were observed eating these species alongside the mangrove lined creek further downstream.

There is a possibility for crocodiles to enter the lake with the tide. At present, crocodiles could travel up most drains in Darwin and the open water of the lake is not likely to attract them any more than currently with the open drain. In the first instance, a sign indicating the possible presence of crocodiles will be erected and if frequent sightings are noted, a trap will be installed below the weir to capture them.


■ **Figure 3.12: Remains of the molluscs Terebralia spp and Telescopium telescopium in a coffee bush thicket along side the drain.**

### 3.5.3 Bats

The knowledge of microchiropteran (insectivorous) bats in the NT is quite limited. Records are patchy and there is little comprehensive information for many species – even relatively common ones.

Microchiropteran bats in the Top End feed nightly and do not appear to enter into torpor or hibernation as bats from other regions do. They have high metabolic rates and need to feed each night.

Microchiropteran bats are long lived with some individuals living more than 20 years. Large Bentwing Bats *Miniopterus schreibersii* (Family Vespertilionidae) and Large-

footed Myotis *Myotis moluccarum* (Family Vespertilionidae) are common inhabitants of stormwater drains in the Darwin area. Leaving their roosts on dusk, bats are noticeably active throughout the night.

Although no site-specific surveys have been conducted, it is likely that permanent colonies of both Large Bentwing Bats and Large-footed Myotis are present all year round in the NTU stormwater drain. In addition Orange Leaf-nosed Bats *Rhinonycteris aurantius* (Family Hipposideridae) may be found. These three species of bat are not considered threatened in the NT.

**Large Bentwing Bats *Miniopterus schreibersii***
With a distribution throughout the Top End and Eastern Australia, the Large Bentwing Bat is a common inhabitant of stormwater drains and other built structures. Trapping records from the stormwater drains in Leanyer, located in the northern suburbs of Darwin (Webber, unpublished) indicate that colonies may exist in the 1000's. In July 1991 a harp-trap placed over one of four drain exits caught 375 individuals in less than 30 minutes, and in May 1992 over 500 bats were trapped in under one hour. Adult male and females have been caught in reproductive and non-reproductive condition. Juveniles have been caught, but exploration up the drains for approximately 400m did not reveal the roosting sites, or any evidence of a maternal colony. It is reasonable to assume that the roosting and maternal sites are further up in the drain system.

**Large-footed Myotis *Myotis moluccarum***
With a range from the Kimberley in WA to Southern Australia, Large-footed Myotis are known to choose roost sites close to water where they feed. Although not occurring in such great numbers as the Large Bentwing Bat, the Large-footed Myotis has been present at each trapping. Adult male and females have been caught in reproductive and non-reproductive conditions (Webber, unpublished). It is thought that this species may breed all year round in the Top End.

**Orange Leaf-nosed Bat *Rhinonycteris aurantius***
A third species of bat, the Orange Leaf-nosed Bat *Rhinonycteris aurantius* (Family Hipposideridae) has been trapped at the Leanyer site (Webber, unpublished). Males in non-reproductive condition were trapped in July 1991 and males recorded from this site in April 1995. Males are known to mate in July, with females giving birth in December and January. With a distribution that is restricted to the northern parts of the NT and WA, these bats are dependent on roost sites with particular climate conditions. If removed from their roost sites they die within hours, and if disturbed enough they will abandon the site. Disturbance of known roost sites should be avoided at all costs.

If Orange Leaf-nosed Bats find the Leanyer stormwater drains suitable to roost in, then the NTU storm water drains may also be a suitable roost site for them as well.

### 3.5.4 Biting Insects

Mosquitoes are a natural component of most aquatic environments.

Some species of mosquito are disease vectors and therefore present a hazard to human health. In addition biting insects, specifically mosquitoes and biting midges, can present a severe nuisance to residents and visitors to areas where they are present, which includes Darwin.

Of the some 100 or so species of mosquitoes found in the Northern Territory, 15 are considered to be carriers of disease or a general pest. They breed in the intertidal mangrove zone and low-lying zone between mangroves and terrestrial open forest from 3.3m AHD to 1.0m above maximum high tide at various times of the year (Whelan, 1988).

Biting midges, sometimes erroneously called “sandflies”, are small two winged flies of the genus *Culicoides* in the Family Ceratopogonidae. They have aquatic or semi aquatic larval stages and breed in a variety of habitats from rotting vegetation to marine mud. The various species seek blood from preferred hosts with only a few species in Australia being serious pests of people. Previous investigations conducted around Darwin indicate that C. ornatus is the principal species biting humans.

. Our observations during a field survey demonstrated the presence of biting midges at the present foot bridge over the lower end of the drain. Presumably these animals originated from populations associated with the nearby muddy banks of the tidal creek.

Further upstream no evidence of either mosquitoes or biting midges was observed and no suitable breeding habitat observed.

The main potential for the breeding of biting insects within the current stormwater drains at the University is associated with the low dry season flows. If such flows are allowed to pond rather than be free-draining, then mosquito breeding grounds can result.

## 3.6 Sites of Significance

No historic, archaeological or sacred sites have been identified on the current site. The area has been highly disturbed during the development of the surrounding suburbs which included the construction of the existing stormwater drain, Alawa oval and development of the NTU facilities.

The Aboriginal Areas Protection Authority has issued an Authority Certificate for the construction of the lake and ceremonial entrance to the university campus. A copy of the certificate is presented in **Appendix E**.

No Declared Places or Objects under the *Heritage Conservation Act 1991* exist on the site or have been nominated.

# 4. Environmental Impacts

*This section outlines the potential effects of the proposal on the physical and biological environment. Potential impacts associated with both the construction and operation phases are discussed.*

## 4.1 Construction

Construction employees will be inducted prior to commencement of work on site. Environmental awareness training will be included in the induction. Construction employees will be informed of all commitments made in the PER as well as their responsibilities under the relevant legislation.

### 4.1.1 Topography

The topography of the site will change to create the lake – fill that is removed during the process of developing the lake by widening the existing stormwater drain will be removed from the site.

### 4.1.2 Dust

Dust may be generated during the construction phase from earthworks and movement of vehicles and machinery. Wind erosion on exposed soils may also contribute to dust generation. Dust has the potential to impact on native vegetation, disrupt adjoining land users and residents and cause a nuisance to the on-site workforce and employees and students at the University.

The construction contractor will visually monitor dust levels on site during construction. The construction contractor will take into account:

- nature and location of activities on site including haulage activities
- weather conditions and direction of wind
- potential for dust nuisance on workforce and surrounding land users.

Dust suppression will be employed in the event that:

- dust generation becomes a potential nuisance
- if the potential for dust generation during the day is significant
- complaints are received about dust.

Dust suppression methods may include watering of roads or other exposed areas, covering of truck loads or stockpiles or speed restrictions on exposed areas.

**Commitment:**

| |
|---|
| Appropriate dust control measures will be implemented should dust levels prove to be an issue. |

### 4.1.3 Noise

Construction activities have the potential to generate noise from use of heavy machinery and equipment, increased heavy machinery on access roads, and from construction activities such as compacting, building, concrete laying etc.

The construction contractor will ensure that construction activities are carried out in accordance with AS2436-1981. Working hours will be restricted to daylight hours only unless with prior consultation with potentially affected residents or land users. Noise monitoring will be undertaken if required in response to noise complaints.

**Commitment:**

| |
|---|
| Any complaints related to noise will be investigated and appropriate corrective action implemented to rectify the situation. |

### 4.1.4 Surface Hydrology

Construction operations have the potential to impact on the water flowing into Rapid Creek downstream from the construction activities. Contamination of the downstream drain and Rapid Creek may result through surface runoff. Contaminants could potentially include suspended material from soil erosion and minor spilt petroleum products from construction vehicles.

Construction activities will be restricted to the dry season so that only minimal stormwater flow will be present in the NTU drain. The stormwater drain system will be diverted around the construction activities and disturbed areas, to enable the low dry season flows to continue into Rapid Creek unimpeded. The construction of a temporary coffer dam will prevent tidal ingress onto the construction site. Therefore, there will be no flow of water from the construction site into the lower reaches of the drain thus preventing suspended material from the construction activities entering Rapid Creek.

As there will be no flow of water from the construction site into the lower reaches of the drain, there will not be a pathway for suspended material from the construction activities to enter Rapid Creek.

**Commitment:**

| |
|---|
| All construction activities will be undertaken during the Dry Season. |

### 4.1.5 Soils

**Acid Sulphate Soils**

Acid sulphate soils are typically encountered within estuarine muds. Initial advice indicates that as the site is located upstream of the estuarine mudflats of Rapid Creek (DLPE Natural Resources pers.com.) it is unlikely that acid sulphate soils will be present. However, prior to construction, testing will be carried out on site to confirm that this is the case. If acid sulphate soils are identified, then an acid sulphate soil management plan will be implemented. The management practices that may be undertaken include:

- Neutralisation of the acid soils with lime during the installation of footings and sub-surface structures;
- Excavation of the acid soils and disposal of them at an appropriate site; and
- The use of a clay liner to prevent the downward percolation of freshwater and prevent exposure to the atmosphere.

**Commitment:**

Samples of soil from the NTU site will be analysed for acid sulphate potential.

If potential acid forming soils are identified, then an acid sulphate soil management plan will be implemented.

### 4.1.6 Flora and Fauna

Impacts on flora and fauna due to construction are expected to be minimal.

Some clearing of vegetation will be required during construction. This clearing will be limited to the minimum necessary for construction works. Any trees to be maintained will be clearly identified and marked by the Parks and Wildlife Commission of the Northern Territory to avoid damage to them.

Mangrove ecosystems are of recognised conservation significance due to their value as a natural, scientific and educational resource. The proposed development will not involve clearing in mangrove areas. Several mangrove trees lining the downstream tidal channel will be removed but the weir will be located 80 m distant from the main intertidal areas and therefore alterations of tidal flows will not impinge on mangrove habitats. The design of the proposed carpark will ensure that an adequate buffer exists between construction areas, the mangrove fringe and adjacent remnant littoral woodland.

The area designated for the proposed lake, the weir and immediately downstream of the spillway does not contain vegetation of conservation significance. Indeed, aside from landscaped areas, the majority of the site is disturbed and poorly maintained, largely comprising monospecific stands of Coffee Bush (*Leucaena leucocephala*). The presence of Coffee Bush species detracts from the environmental quality of the area and creates management problems. Consequently, clearing of this species will improve the amenity and visual quality of the upper Rapid Creek area.

Apart from a small pocket of remnant vegetation which occurs within the proposed carpark area, no rare or endangered species or plant communities of restricted distribution were found to occur within the site. The major potential impact on flora from the proposed development will involve clearing of dense *Leucaena* thickets and scattered specimen trees planted around the open drain. Overall, the removal of the *Leucaena* infestations will have a positive effect on the ecological and aesthetic value of the area.

An 8m high Banyan Fig located next to the main bridge (leading to carpark) has the potential to become an outstanding landscape tree. Attractive specimen trees such as this Banyan, located within the proposed lake area, could potentially be relocated to the lake edge during construction works.

**Commitments:**

Clearance of vegetation will be limited to the extent necessary for construction works and trees and plants to be retained will be clearly identified by the Parks and Wildlife Commission of the Northern Territory and protected during construction.

Construction will be managed so as to avoid impacts to mangrove communities.

**Weeds and Introduced Species**

The weed *Leucaena leucocephala* (coffee bush) which is found on the site will be targeted for removal as part of the landscaping of the site which will include native flora in keeping with the NTU Landscaping Master Plan. *Leucaena* produces vast quantities of seed and further weed control measures will be undertaken after clearing.

Regular visual inspections by the construction contractor to ensure existing weeds are removed and no new weeds become established or spread due to construction activities on the site.

**Commitments:**

Coffee Bush and any other noxious weeds will be removed wherever possible during construction and burnt to kill seeds and prevent potential re-growth.

A weed control program will be developed prior to construction for the duration of the construction phase. As part of this program, the site will be regularly visually inspected for the spread or establishment of weed species.

**Aquatic Fauna**

Construction will primarily involve clearing, excavating and concreting. These activities will produce loose material (eg. sediment/concrete powder). The main concern relating to marine fauna during construction is the possible downstream flux of such construction materials/effluent into the Rapid Creek system as a result of tidal flushing or during rain events (runoff). This would result in turbid plumes and silting which would affect water quality and benthic habitat (silting) in downstream locations. This in turn could be detrimental to marine fauna.

The works will be undertaken during the dry season to minimise runoff and erosion of materials into Rapid Creek. Surplus materials will be removed from the site. Clearing will be minimised to the extent necessary to construct the works thus limiting areas of loose top soil. The NTU stormwater drain system will be diverted around the construction activities and disturbed areas, to enable the low dry season flows to continue into Rapid Creek without being contaminated by suspended material. Furthermore, the construction of a temporary coffer dam will prevent tidal ingress onto the site during construction activities. Therefore, there will be no pathway to enable sediment generated by construction activities to enter Rapid Creek.

**Biting Insects**

One of the most significant impacts of construction in or adjacent to tidal areas is the creation of new sources of pest and potential disease causing mosquitoes. However, due to the nature of the project all major works for the lake, bridges, weir, road, footpath and bikepath are to be constructed during the Dry Season. Thus preventing ponding of rainwater and storm runoff. The stormwater drain system will be diverted around the construction activities to enable the low dry season flows to continue into Rapid Creek unimpeded.

**Commitment:**

Regular site inspections for potential biting insect breeding areas will be conducted during construction. Larvicides will be used where necessary to control breeding

**Bats**

To reduce the potential environmental impact on bats that might roost in the NTU stormwater drain further survey of the bat colonies will be carried out prior to final design and commencement of construction. Travelling up the drains in search of roost sites is not recommended due to health and safety issues, and would require the use of breathing apparatus. Trapping at the entrance will provide sufficient indication of the species and breeding biology.

If bats are identified as roosting in the drains, further survey work will be carried out during, and for a period of time after, the works are completed, to determine if the development is having any effect on the bat colonies.

Works such as drilling and associated vibrations, which may travel along the concrete structure may disturb the bat colonies. Disturbing bats during the day may lead to them flying out of the drain where they are easy targets for birds of prey. Therefore, if it is confirmed that bats are roosting in either the main or subsidiary drains, appropriate measures will be taken during construction to limit disturbance either directly or indirectly through noise. Such actions may include the timing of such works to later in the day.

**Commitments:**

Further research to confirm the existence of the bat colonies will be carried out prior to final design and commencement of construction.

If the existence of bats is confirmed then:
- the presence and potential impact on them will be carefully monitored during the construction phase; and
- timing of construction works will take account of potential impacts on bats.

### 4.1.7 Storage and Handling of Materials and Waste

Wastes likely to be generated during construction include:

- Inert waste such as excess fill
- General refuse and domestic waste such as plastics, cardboard and food scraps
- Some fluids such as waste oils
- Green waste

All waste will be removed from site and disposed of in a manner acceptable to the DLPE.

All hazardous materials will be transported and stored in accordance with relevant legislation and standards.

**Commitments:**

All hazardous materials will be stored and disposed of in accordance with relevant standards and legislation.

All waste materials will be removed from sites and disposed of in a manner acceptable to the DLPE.

### 4.1.8 Social and Recreational Issues

Construction activities have the potential to disrupt University employees and students and surrounding land users and residents through changes to access, traffic and parking patterns, as well as impacts arising from construction such as dust and noise generation.

The construction contractor will inform potentially affected persons in advance of any potential disruption during construction.

All public complaints received during construction will be responded to promptly and where necessary corrective actions put in place to ameliorate any impacts.

**Commitments:**

Local residents and NTU employees will be kept informed of any disruptions to access, traffic deviations, or changes to parking arrangements during construction.

Any complaints will be investigated and responded to promptly.

### 4.1.9 Aboriginal Heritage

No historic, archaeological or sacred sites have been identified on the proposed development site. The Aboriginal Affairs Protection Authority has issued an Authority Certificate for the construction of the lake and associated works.

In the event that a site of potential Aboriginal heritage significance is discovered during construction, all works will cease in the vicinity of the site pending consultation with the Aboriginal Areas Protection Authority and the Heritage Conservation Branch of the DLPE.

**Commitment:**

In the event that a site of potential Aboriginal heritage significance is discovered during construction, all works will cease in the vicinity of the site pending consultation with the Aboriginal Areas Protection Authority and the Heritage Conservation Branch of the DLPE.

## 4.2 Operational

The construction of the ornamental lake and associated infrastructure will be of benefit to the existing environment. The removal of the *Leucaena* infestations will have a positive effect on the ecological and aesthetic value of the area, and the installation of pollution control devices will minimise the debris and contamination travelling along the drain into Rapid Creek.

### 4.2.1 Hydrological Conditions of Rapid Creek

The existing partially concrete lined NTU stormwater drain currently flows through the south – eastern corner of the campus and empties into Rapid Creek. The drain itself is tidally flushed with seawater moving in and out directly from Rapid Creek. The stormwater drainage system discharges urban freshwater runoff from the northern suburbs. In the dry season, flow from the stormwater pipes is minimal, and this would mostly result from urban activities such as car washing. In the summer rainy season, heavy freshwater flushes enter the drain during storm events.

The lake will receive inflow of sea-water from Rapid Creek during high tides and fresh water from the stormwater drain during periods of rain and base flow conditions.

The tidal inflow will vary with the tidal cycle. Tides within Darwin Harbour are semi-diurnal (i.e. two highs and two lows per day) with a diurnal inequality (difference between successive highs and successive lows). The dominance of the semi-diurnal tides (i.e. 12 hour period) persists even at neap tides. The weir has been designed such that sea-water will flow into the lake for tide heights in excess of 2.6 m AHD. A review of the tide height data for Darwin Harbour indicates that such tides occur, on average, 15 days per month.

Stormwater recharge is seasonally dependent (wet and dry seasons). Flows during the dry months of the year will be almost zero. The base flow that does occur will originate from garden irrigation and domestic activities such as car washing etc. and potentially could carry contaminants high in hydrocarbons, heavy metals, pesticides and nutrients.

During the wet season minor storm events (1 in 2 years) are expected to generate average flows into the lake of 50 $m^3/s$. Major storm events (1 in 100 years) are expected to generate peak flows into the lake of 160 $m^3/s$.

Therefore, during the dry season, sea-water inflow from Rapid Creek will dominate. Fresh water flow from the stormwater drain will dominate during the wet season.

#### 4.2.1.1 Water Quality

The potential water quality issues associated with the lake and/or the lower reaches of Rapid Creek are:

- high turbidity due to heavy sediment loads associated with major storm events during the wet season;
- litter;
- contamination by a range of chemicals particularly during the dry season and the first flush of the wet season;
- eutrophication of the lake during the dry season due to insufficient tidal flushing.

The existing stormwater drainage system is designed such that run-off from a minor storm is carried underground and excess run-off from a major storm is carried overground. As such, flow associated with major storms will have a high turbidity with a heavy sediment load. Similarly, there is the potential for large quantities of litter to be carried by the storm water.

Overflow from the lake will be formalised by a concrete spillway. Permanent erosion prevention structures will be constructed to prevent additional silt from erosion entering the lower drainage system and ultimately the lower reaches of Rapid Creek. A silt trap will be installed in the lower reaches of the main stormwater drain prior to the flow entering the lake.

The University will manage litter entering the lake through the stormwater drain through the use of gross pollutant traps (GPT's) which will be emptied each week during the height of the Wet Season and after every heavy rainfall at the start and end

of the Wet Season. Periodical checks will be carried out during the Dry Season as well. This regime is in keeping with current Darwin City Council GPT management.

The Darwin City Council is currently undertaking monitoring of different types of GPT's that have been placed at different points in Darwin. The Baramy GPT in Doctor's Gully area is the most similar to the NTU site with a pipe of 1050mm and a catchment of 16ha. Over the 1999/2000 Wet Season (September to May) 1,550kg of rubbish was trapped by this GPT. Almost half of that was vegetation, with just over half being sand and gravel, the remainder was paper 2%, plastic 1.3% and metal 0.7% (DCC GPT's unpublished data).

If the Darwin City Council data is used to estimate the amount of litter likely to enter the NTU stormwater drain (from Catchment Area A) the following could be anticipated each Wet Season based on an averaging of litter collected at different Council GPTs:

| | | |
|---|---|---|
| Total litter: | 25,603kg | |
| Vegetation: | 54.1% | (13,851kg) |
| Paper: | 3.4% | (871kg) |
| Plastic: | 4% | (1,024kg) |
| Metal: | 1.3% | (333kg) |
| Sand/gravel: | 37% | (9,473kg) |

The NTU is unable to control the litter that enters the stormwater drainage system. A pro-active strategy of the NTU in conjunction with the Council could be to organise street cleaning (which Council already undertakes) with a community information strategy before the commencement of the Wet Season. This would assist with reducing the load on GPT's at the beginning of the Wet Season where the buildup of litter during the Dry Season ensures that the first heavy rainfall brings this litter into the stormwater drainage system – filling GPT's with extra-heavy loads.

Although the lake will be designed with a hard edge to prevent the growth of marginal semi aquatic reed and mangrove growth, there will still be a requirement for maintenance by removal of stormwater and tidal inflow flotsam that may accumulate in margin areas.

A water quality monitoring program was established in 1995 to assess the water quality of the catchment and identify possible issues affecting the health of Rapid Creek. The monitoring program includes a sampling location downstream of the NTU Drain. These results are included in **Table 4.1 – Monitoring Results from the NTU Drain**. Monitoring results indicate high median values of nitrate and phosphorous during the wet seasons, particularly following the first rains in October (Darwin Regional Waterwatch, 1997). Sources of these nutrients include soil, sewage, fertiliser, herbicide and pesticide runoff, detergents in stormwater and animal wastes. Increased phophorous values increase the chance of an algal bloom whereas nitrogen increases the chance of bacteriological pollution. Although some of these contaminants would have entered Rapid Creek upstream, comparison with upstream concentrations indicate that the flow from of the NTU Drain makes a significant contribution.

**Table 4.1. Monitoring Results from the NTU drain.**

| Date | pH | EC (mS/cm) | T (°C) | Dissolved $O_2$ (mg/L) | Dissolved $O_2$ (% sat'n) | Reactive P (mg/L) | Nitrate (mg/L) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|
| 15/4/96 | 7.0 | 19850 | 32.0 | 6.0 | 90 | 0.07 | 0 | <15 |
| 24/6/96 | 7.0 | 52300 | 27.0 | 6.0 | 75 | 0.03 | 0.009 | <20 |
| 9/7/96 | 7.0 | 54100 | 29.0 | 5.0 | 70 | 0.03 | 0.018 | <12 |
| 12/8/96 | 7.0 | 37500 | 25.0 | 4.0 | 50 | 0.00 | 0 | <20 |
| 10/9/96 | 8.5 | 50200 | 29.0 | - | - | 0.10 | 0 | <12 |
| 16/10/96 | 8.6 | 54400 | 29.9 | 5.5 | 65 | 0.10 | 0 | <10 |
| 31/10/96 | 7.9 | 40000 | 29.2 | 5.9 | 70 | 3.50 | 1.5 | <13 |
| 12/11/96 | 9.3 | 57000 | 36.4 | 9.0 | 120 | 1.00 | 0.5 | <5 |
| 28/11/96 | 8.3 | 57900 | 34.6 | 7.8 | 95 | 0.50 | 0.5 | <6 |

The lake will provide a degree of 'filtering/dilution' of urban runoff and associated contaminants prior to entry into the Rapid Creek system.

The lake and weir will act as a runoff water storage area and there is likely to be some accumulation of the contaminants and nutrients from urban runoff in both the water and sediments on the lake bottom. Being a relatively large water body, it is possible that the lake may act as a filter and have a cleansing effect on outcoming water (flowing into Rapid Creek) from the suburbs by containing these contaminants and diluting them into the large water body. In contrast, the existing drain system would have a limited holding capacity for nutrients and contaminants with continuous release into the aquatic environment of Rapid Creek.

During the wet season (November to March) heavy rains will result in large water volumes to enter the lake via the stormwater pipes. The outlet pipes have a large capacity and at such times could cause significant flushing from the lake over the weir. At such times and particularly for the earlier rains, there may be a higher than normal levels of contaminant release over the weir that will ultimately enter Rapid Creek and coastal waterway systems. While contaminant release is a feature of the present system, the erection of the weir may result in occasional stronger pulses of contaminant release than prior to the development.

Therefore, it is likely that the lake will improve water quality entering Rapid Creek by diluting urban runoff.

The weir will allow tidal flushing and therefore gradual dilution of contaminated water.

A review of tidal prediction data for Darwin Harbour for 1999 indicates that sea water recharge of the lake will occur an average 10 days per month. On average during four of those days, sea-water inflow will occur twice per day. For the worst case, inflow only occurs on six days per month, and the longest period without sea-water inflow is 24 days. Analysis of tide heights suggests that approximately 23,000 $m^3$ of sea-water will flow into the lake in any tidal cycle (i.e. 24.5 hours). Making allowance for mixing of incoming flows with the water already resident in the lake, this inflow equates to a 50% replacement of water per tidal cycle. If prolonged periods without sea-water coincide with the dry season, then artificial flushing may be required to prevent eutrophication.

Monitoring of water quality will be undertaken to ensure eutrophication of the lake does not create an environment for algae to grow. Details of the monitoring program will be included as part of the Environmental Management Plan (EMP). Monitoring will be undertaken both pre and post construction. At this stage the parameters to be assessed are likely to include dissolved oxygen, phosphorus, nitrate, pH, selected heavy metals and petroleum hydrocarbons. Water quality will be assessed against appropriate Australian standards.

Should monitoring indicate additional oxygen is required for the lake, a fountain could be constructed creating an aesthetically pleasing feature to the lake as well as assisting with weed management and the creation of fish habitat. It is however, envisaged that the regular tidal flushing of the lake will address such issues in the Dry Season and in the Wet Season both large volumes of stormwater and regular tidal flushing will address these issues.

**Commitments**:

A water monitoring program will be developed to ensure that lake water does not become contaminated or depleted in oxygen.

Gross pollutant traps will be used to ensure stormwater entering the lake is free from litter and other gross pollutants.

### 4.2.2 Stormwater Drainage System

The Lake will not adversely effect the operation of the existing stormwater drain.

Currently surface water runs into the existing stormwater drain, which before construction of the northern suburbs was a natural drainage channel, or is absorbed into the soil. This will continue with the construction of the lake.

The location of the lake is within the primary storm surge area but outside the area of 1 in 100 year flood levels (DCC & Greening Australia 1994). As the lake will be constructed for tidal water movement, water levels will be no higher than the weir, enabling any storm water to be channelled away from the lake as currently occurs.

Sub-surface hydrology does not include any aquifiers, and as such no bores exist on the site. The nearest bore is a saltwater non-potable bore drilled by NTU for aquaculture study purposes (DLPE Darwin Hydrology Map and pers.com.DLPE Natural Resources).

Gross Pollutant Traps will filter the incoming stormwater removing litter including vegetation, sand and gravel, paper, plastic and metal. A run-off channel will also collect other contaminants such as oils. These measures will improve the quality of the surface water in the lake as compared to the existing stormwater channel where there are no GPT's. The design of the GPTs are not certain at this stage, however they will be designed and constructed such that they achieve the intended outcomes of filtering pollutants and consideration of bat movements.

Stormwater management will be undertaken in consultation, and to the approval, of Darwin City Council which is the responsible authority for the stormwater drainage system that feeds the lake. Additionally the Department of Transport and Works, will have responsibilities for the stormwater drainage easement that will lie over the lake,

and again stormwater management for this area will be undertaken in consultation, and to the approval, of DT&W. All drains leading to the lake will be properly maintained and constructed to cope with high tides and storm influx.

### 4.2.3 Flora and Fauna

#### 4.2.3.1 Vegetation

Landscaping will be carried out in accordance with the *Northern Territory University Landscaping Master Plan 1992*.

**Commitment:**

| |
|---|
| All cleared areas will be rehabilitated and landscaped in accordance with the Landscape Master Plan. |

#### 4.2.3.2 Weeds and Introduced Species

Management of weeds such as coffee bush will be part of the ongoing maintenance of the landscaped grounds at the NTU.

**Commitment:**

| |
|---|
| The site will be regularly visually inspected for the spread or establishment of terrestrial or aquatic weed species during operation. |

#### 4.2.3.3 Aquatic Fauna

The development of the ornamental lake is not considered to be a source of significant environmental impact on existing aquatic fauna.

The existing concrete drain contains a small number of transient elements of the aquatic fauna from Rapid Creek. Transient fish and crustacean species entering the drain are likely to consist of a small number of opportunistic feeders. The drain offers minimal habitat to aquatic organisms (it is largely a narrow, shallow, concrete-lined system) and providing little in the way of food and shelter compared to mangroves which have soft substrate and overhangs, prop roots.

The proposed lake will be approximately 350m long, 47m wide with a depth of 1.2 m. Thus it will be a much larger, more stable body of water than the existing system. Given the greater area and depth of the lake it can be considered to represent an increase in available habitat for marine fauna. Given the differences in habitat availability, the lake may promote a greater abundance of resident species and possibly develop a different suite of marine fauna than presently inhabits the site.
Water quality and salinity in the lake will influence the type and abundance of fauna therein.

Presently there is no restriction of access for marine fauna except that caused by decreasing depth of the drain toward the stormwater pipes, and the presence of the step in front of the culverts. Following construction of the lake, there will be some reduction of access upstream of the proposed weir. However, movement into and out of the lake will still be possible for marine fauna due to the design of the weir that allows tidal intrusion approximately 15 times per month.

The height of the weir has been calculated to provide adequate opportunities for fish and other organisms moving upstream with the tide to exit the lake. Typically, fishes such as mullet, the most common species observed on the day of survey, move upstream with the rising tide. They will gather downstream of the proposed weir until the rising tide allows them to cross it and move upstream. Once in the lake, these species will disperse over the lake area and feed, typically on the algae growing a film on hard substrates. Similarly during strong pulses of freshwater flow, predatory fishes such as tarpon and barramundi may also move up and over the weir.

All these species commonly move up and down tidal channels with the rise and fall of the tide and will do so in the drain. However, the presence of the weir will tend to trap fish upstream, as on the falling tide, the water will quickly drop until the top of the weir is exposed. Many of the fish that move upstream will not have responded to the turn of the tide by moving downstream as they will still be in water of more than a metre depth. The combination of a short period of falling tide and the depth of water will mean many fish are trapped inside the lake by the falling tide.

Given the potential presence of large numbers of fish trapped within the lake between tides, the issue of water quality during these periods becomes important. The original proposed weir height of RL 3m would have produced periods during the late dry season when tides would not over top the weir for as long as 10 days. During these periods, schools of fish trapped within the weir would be vulnerable to impacts on water quality such as spills of contaminants, and low oxygen levels. With a reduction in weir height to RL 2.6 AHD the maximum length of time between tides overtopping the weir is reduced to a few days.

Contaminants entering the system from the northern suburbs drainage system will always be a point of some concern. During storm events when large volumes of water flush through the lake there may be pulses of higher than normal contaminant discharge into aquatic environs downstream.

The existing drain is a narrow relatively shallow system with strong tidal/marine influence. The development of the lake will create a new type of aquatic habitat with probable differences in water quality, water chemistry and flow regime.

**Commitment**:

| |
|---|
| The weir will be built to a height that allows tidal intrusion thus permitting fish movement, aiding water mixing and assisting in the maintenance of a brackish water habitat. |

#### 4.2.3.4 Mammals - Bats

Advice from the Darwin City Council indicates that the proposed gross pollutant traps (GPTs) would be the first ones to be introduced into stormwater drains that are known roost sites of bats in the Darwin area. As such the GPT's will be designed to take into account movement of bats and a monitoring program of the colony will be developed to determine the impact of the works.

**Commitment:**

| |
|---|
| A monitoring program will be implemented following construction to determine the impact of the development on roosting bat communities. |

#### 4.2.3.5 Biting Insects

Design considerations will generally prevent the creation of new breeding sites for mosquitoes. Careful attention will be given to the design and maintenance of the drainage systems and lake surrounds to ensure that isolated pools are not formed and the creation of habitat areas for breeding mosquitoes avoided.

Concrete hard edging will be provided to the sides of the lake above RL 2.4 AHD. The hard edges will extend to any open unlined stormwater drains into the lake, as far upstream in the drain where a stable lake level will occur. This will prevent marginal semi-aquatic reed growth and mangrove growth that may lead to mosquito breeding.

**Commitment**:

| |
|---|
| The lake and surrounds will be monitored regularly following construction to identify any potential biting insect breeding habitat. |

### 4.2.4 Social and Recreational

Potentially, the new access to the NTU could impact on the traffic on the current traffic using Lakeside drive.

Assessment of the project's impact on traffic in the area indicates that the new entrance, and closure of the existing entrance, will reduce the amount of traffic along Lakeside Drive from the proposed new entrance to Dripstone Road. Similarly, along the section of Lakeside Drive –from Trower Road to the new entrance – no increase in traffic is likely.

The traffic projected for Ceremonial Drive is in the order of 220 vehicles per hour (total for both directions) in the afternoon peak. The impact on the existing road network is minimal when traffic enters the network at Lakeside Drive via the proposed roundabout, with a high level of service. Negligible effect on external traffic flows to 2009, is anticipated.

A full traffic study report is presented in **Appendix B.**

# 5. Environmental Safeguards and Management

## 5.1 Environmental Management Plan

An Environmental Management Plan will be developed to manage the potential environmental impacts of the proposal outlined in the PER.

An EMP will be developed for each issue identified in the PER and will define:

- Management objective
- Management strategy, responsibility and timing
- Performance indicators
- Monitoring required
- Corrective actions and contingency plans

The EMP will cover both construction and operational phases of the project.

**Commitment**:
An Environmental Management Plan will be developed, detailing the management strategies which will be implemented to address potential impacts.

## 5.2 Monitoring Program

Environmental monitoring to be undertaken during construction and operational phases of the project is detailed below:

### 5.2.1 Construction Phase

*Dust:* The site will be visually monitored by construction contractor for dust generation during construction. Dust control measures will be implemented in the event of high dust generation during construction.

*Noise:* Ambient noise monitoring will be implemented in response to noise complaints.

*Water quality*: Monitoring of water quality will be undertaken to ensure water run-off from the construction site is not harmful to the surrounding environment.

*Soils – surface runoff and erosion*: The downstream drain will be regularly inspected for evidence of high turbidity or sedimentation.

*Acid sulphate soils*: Testing will be undertaken prior to construction to confirm the absence of acid sulphate soils.

*Flora and Fauna – weeds and introduced species*: The site will be regularly visually inspected for the spread or establishment of weed species during construction.

*Flora and Fauna - biting insects*: Regular site inspections for potential biting insect breeding areas will be conducted during construction.

*Flora and Fauna – bats*: The occurrence of bats at outlet of main drain pipes will be visually monitored by construction contractor.

### 5.2.2 Operation Phase

*Surface Hydrology and Water Quality*: A water monitoring program will be developed to ensure that lake water does not become contaminated or depleted in oxygen.

*Flora and Fauna – fishes*: During periods of water quality monitoring, the fishes in the lake will be surveyed to determine the extent of entrapment upstream of the weir.

*Flora and Fauna – bats*: A monitoring program will be implemented following construction to determine the impact of the development on roosting bat communities.

*Flora and Fauna – biting insects*: The lake and surrounds will be monitored regularly following construction to identify any potential biting insect breeding habitat.

*Flora and Fauna – weeds and pests*: The site will be regularly visually inspected for the spread or establishment of terrestrial or aquatic weed species during operation.

## 5.3 Summary of Environmental Commitments

This proposal involves the construction of a commemorative lake and ceremonial entrance to the Northern Territory University. The proposal will improve the Casuarina Campus and surrounds both aesthetically and environmentally. The potential impacts to the environment during construction and operation have been identified and management procedures developed to eliminate, minimise or ameliorate the impact.

The proponent has proposed the following commitments for the construction and operational phases of the project to ensure an environmentally sound project.

### 5.3.1 Construction Phase

An Environmental Management Plan will be developed, detailing the management strategies which will be implemented to address potential impacts.

*Dust*
Appropriate dust control measures will be implemented should dust levels prove to be an issue.

*Noise*
Any complaints related to noise will be investigated and appropriate corrective action implemented to rectify the situation.

*Surface and Subsurface Hydrology and Water Quality*
All construction activities will be undertaken during the Dry Season. Water quality of surface water run-off during construction will be maintained to appropriate Australian standards.

*Soils – Acid Sulphate Soils*
Testing will be undertaken prior to construction to confirm the absence of acid sulphate soils.

Should acid sulphate soils be encountered prior to construction or at any time during construction, an acid sulphate soil management plan will be developed and implemented with approval from the DLPE.

*Vegetation clearance, landscape and rehabilitation*
Clearance of vegetation will be limited to the extent necessary for construction works and trees and plants to be retained will be clearly identified and protected during construction.

Construction will be managed so as to avoid impacts to mangrove communities.

*Flora and Fauna – weeds and pests*
Coffee Bush and any other noxious weeds will be removed wherever possible during construction.

The site will be regularly visually inspected for the spread or establishment of weed species during construction.

*Flora and Fauna – biting insects*
Regular site inspections for potential biting insect breeding areas will be conducted during construction. Larvicides will be used where necessary to control breeding.

*Flora and Fauna - bats*
Further research to confirm the existence of the bat colonies wil be carried out prior to final design and commencement of construction.

If the existence of bats is confirmed then:
- The presence and potential impact on them will be carefully monitored during the construction phase; and
- Timing of construction works will take account of potential impacts on bats. The presence and potential impact on bats will be carefully monitored through surveys during the construction phase.

*Storage and handling of materials and waste*
All hazardous materials will be stored and disposed of in accordance with relevant standards and legislation.

All waste materials will be removed from sites and disposed of in a manner acceptable to the DLPE.

*Social and Recreational*
Local residents and NTU employees will be kept informed of any disruptions to access, traffic deviations, or changes to parking arrangements during construction.

Any complaints will be investigated and responded to promptly.

*Aboriginal Heritage*
In the event that a site of potential Aboriginal heritage significance is discovered during construction, all works will cease in the vicinity of the site pending

consultation with the Aboriginal Areas Protection Authority and the Heritage Conservation Branch of the DLPE.

### 5.3.2 Operation Phase

*Surface water hydrology and water quality*
A water monitoring program will be developed to ensure that lake water does not become contaminated or depleted in oxygen.

*Stormwater management*
Gross pollutant traps will be used to ensure stormwater entering the lake is free from litter and other gross pollutants.

*Flora and Fauna – vegetation clearance*
All cleared areas will be rehabilitated and landscaped in accordance with the Landscape Master Plan.

*Flora and Fauna – aquatic fauna*
The weir will be built to a height that allows tidal intrusion thus permitting fish movement, aiding water mixing and assisting in the maintenance of a brackish habitat.

*Flora and Fauna - bats*
A monitoring program will be implemented following construction to determine the impact of the development on roosting bat communities.

*Flora and Fauna – biting insects*
The lake and surrounds will be monitored regularly following construction to identify any potential biting insect breeding habitat.

*Flora and Fauna – weeds and pests*
The site will be regularly visually inspected for the spread or establishment of terrestrial or aquatic weed species during operation.

## ■ Table 5-1 Summary of Commitments

### Pre-construction and Construction

| Issue | Objective | Commitment | Timing | Performance Indicator |
|---|---|---|---|---|
| Environmental Management | To ensure environmental management in accordance with key objectives. | An EMP will be prepared following receipt of environmental approval. | Prior to commencement of construction | EMP approved by DLPE and implemented |
| Dust | To protect the surrounding land users such that dust emissions will not adversely impact upon their welfare and amenity. | Appropriate dust control measures will be implemented should dust levels prove to be an issue. | During construction | Dust complaints register established, all complaints investigated and corrective action taken. |
| Noise | To protect the surrounding land users such that construction related noise will not adversely impact upon their welfare and amenity. | .Any complaints related to noise will be investigated and appropriate corrective action implemented to rectify the situation. | During construction | Noise complaints register established all complaints investigated and corrective action taken. |
| Surface and Sub surface Hydrology and Water Quality | To maintain existing quality of surface waters during construction | All construction activities will be undertaken during the Dry Season.<br><br>Water quality will be monitored during construction to ensure it meets appropriate Australian water quality standards. | During construction | No contamination of downstream surface water due to construction activities.<br><br>Water quality guidelines met. |
| Soils – Acid Sulphate Soil | To prevent acid generation in soils due to the disturbance during construction | Testing will be undertaken prior to construction to confirm the absence of acid sulphate soil.<br><br>Should acid sulphate soils be encountered prior to construction or at any time during construction, an acid sulphate soil management plan will be developed and implemented with approval from DLPE. | Prior to construction<br><br>During construction. | Acid Sulphate Soils testing has been undertaken and results are available.<br><br>An Acid Sulphate Soil Management Plan is in place if required. |
| Flora and Fauna – vegetation clearance | To minimise vegetation clearing associated with construction. | Clearance of vegetation will be limited to the extent necessary for construction works and trees and plants to be retained will be clearly identified by the Parks and Wildlife Commission of the NT and protected during construction.<br><br>Construction will be managed so as to avoid impacts to mangrove communities. | During construction<br><br>During construction | No damage to vegetation outside the immediate vicinity of construction works.<br><br>No impacts to mangroves as a result of construction. |

| Issue | Objective | Commitment | Timing | Performance Indicator |
|---|---|---|---|---|
| Flora and fauna – weeds and introduced species | To prevent the introduction or spread of introduced species during construction | Coffee Bush and other noxious weeds will be removed wherever possible during construction and burnt to kill seeds and prevent potential re-growth.<br><br>A weed control program will be developed prior to construction for the duration of the construction phase. As part of this program, the site will be regularly visually inspected for the spread or establishment of weed species. | During construction<br><br>During construction | Coffee Bush has been removed or is being progressively removed from the construction site.<br><br>No weeds have established or spread as a result of construction. |

| Issue | Objective | Commitment | Timing | Performance Indicator |
|---|---|---|---|---|
| Flora and fauna – biting insects | To ensure breeding habitat for biting insects is not created during construction. | Regular site inspections for potential biting insect breeding areas will be conducted during construction.<br><br>Larvacides will be used where necessary to control breeding. | During construction<br><br>During construction | No biting insect breeding areas have developed as a result of construction. |
| Flora and Fauna - bats | Minimise the impact to bats during construction. | Further research to confirm the existence of the bat colonies will be carried.<br>If the existence of bats is confirmed then:<br>❑ The presence and potential impact on them will be carefully monitored during the construction phase; and<br>❑ Timing of construction works will take account of potential impacts on bats. The presence and potential impact on bats will be carefully monitored through surveys during the construction phase. | Prior to final design and before construction<br><br>During construction | Monitoring results indicate no significant impact to bats as a result of construction. |
| Storage and Handling of Materials and Waste | To ensure hazardous materials and waste are handled, stored and disposed of appropriately. | All hazardous materials will be stored and disposed of in accordance with relevant standards and legislation.<br><br>All waste materials will be removed from sites and disposed of in a manner acceptable to the DLPE | During construction<br><br>During construction | Hazardous materials are stored and disposed of in accordance with regulations. |
| Social and Recreation | To minimise impacts to the surrounding community and employees of NTU. | Local residents and NTU employees will be kept informed of any disruptions to access, traffic deviations, or changes to parking arrangements during construction.<br><br>Any complaints will be investigated and responded to promptly | During construction<br><br>During construction | No complaints are received from local residents or employees related to disruption during construction. |
| Aboriginal Heritage | No impact on Aboriginal heritage sites. | In the event that a site of potential Aboriginal heritage significance is discovered during construction, all works will cease in the vicinity of the site pending consultation with the Aboriginal Areas Protection Authority and the Heritage Conservation Branch of the DLPE. | Prior to construction | Sacred site certification has been received for the site.<br><br>No Aboriginal sites disturbed. |

## Operation

| Issue | Objective | Commitment | Timing | Performance Indicator |
|---|---|---|---|---|
| Environmental Management | To ensure environmental management in accordance with key objectives. | An EMP will be prepared following receipt of environmental approval. | Prior to commissioning of lake | EMP approved by DLPE and implemented |
| Surface Hydrology and water quality | To prevent contamination of surface and lake waters | A water monitoring program will be developed to ensure lake water does not become contaminated or depleted in oxygen. | Operation | A water monitoring program is in place. |
| Stormwater Management | To prevent contamination of the lake and downstream areas as a result of stormwater flow | Gross pollutant traps will be used to ensure stormwater entering the lake is free from litter and other gross pollutants. | Operation | Gross pollutant traps are in place, working effectively and cleared regularly. |
| Flora and Fauna – vegetation clearance | Provide appropriate rehabilitation of the site following construction. | All cleared areas will be rehabilitated and landscaped in accordance with the Landscape Master Plan. | Operation | Landscaping is progressing and cleared areas have been rehabilitated. |
| Flora and Fauna – aquatic fauna | Not to impact on movement of aquatic fauna into and out of lake. | The weir will be built to a height that allows tidal intrusion thus permitting fish movement, aiding water mixing and assisting in the maintenance of a brackish water habitat. | Operation | Fish migrating in and out of lake with tide. |
| Flora and Fauna - bats | To minimise impacts of operation of the proposal on bats | A monitoring program will be implemented following construction to determine the impact of the development on roosting bat communities. | Operation | A bat monitoring program is in place. |
| Flora and Fauna – biting insects | To minimise potential for creation of breeding areas for biting insects | The lake and surrounds will be regularly inspected following construction to identify any potential biting insect breeding habitat. | Operation | No biting insect breeding habitat has been created due to the proposal. |
| Flora and Fauna – weeds and pests | To prevent the spread or establishment of weed species due to construction | The site will be regularly visually inspected for the spread or establishment of terrestrial or aquatic weed species during operation. | Operation | No terrestrial or aquatic weed species have established as a result of the proposal. |

# 6. Glossary

| | |
|---|---|
| AHD | Australian Height Datum |
| DCC | Darwin City Council |
| DLPE | Department of Lands, Planning and Environment, NT Government |
| DT&W | Department of Transport and Works, NT Government |
| GPT | Gross Pollutant Traps |
| PER | Public Environmental Report |
| ha | hectare |

# 7. References

Clouston & Jane Coleman (1992) *Northern Territory University Landscape Masterplan*

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Darwin City Council and Greening Australia (1994) *Rapid Creek Management Plan* Vol 1 & 2

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DLPE Darwin Hydrology Map

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Webber (unpublished 2001) Report on the Microchiropteran Bat Fauna from the Stormwater Drains at the NTU, Casuarina, NT

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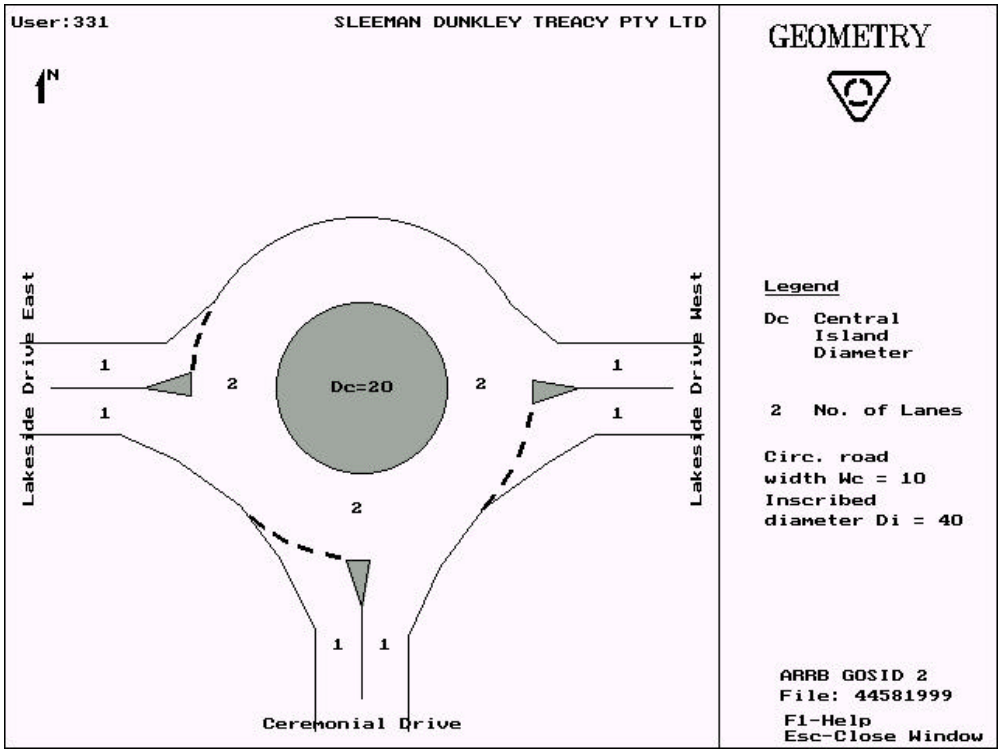
# Appendix A DLPE Guidelines

# Appendix B Traffic Study

## B.1 Introduction

A new access is proposed for the Northern Territory University intersecting Lakeside Drive adjacent to the existing Sports Oval, Lot 9260 - Town of Darwin. Sinclair Knight Merz was commissioned to assess the potential traffic impacts of the access arrangement on the existing Lakeside Drive Traffic.

The arrangement proposed is a 20m diameter roundabout with two circulating lanes. Refer to the diagram below.



## B.2 Traffic Generation

The traffic generation is based on traffic counts undertaken at the NTU in August 1996. A distribution of traffic was derived from simultaneous movement records for each of the existing University entrances.

Peak traffic data was analysed for forecast growth based on increases in the equivalent full time student units (EFTSU'S) obtained from the NTU Master Plan Traffic Study by Pak Poy Lange Pty Ltd.

The traffic volume has been updated with vehicle counts for Lakeside Drive from April 1999 and the distribution from 1996 has been adopted for vehicles using the new entrance.

The new entrance would be the second entrance off Lakeside Drive. To simulate the worst case, the distribution to the existing entrance was applied to the new entrance as if the existing one was removed.

The present traffic generation distributed per the 1996 study is shown in Table 2.1 below.

**TABLE 2.1 – PRESENT TRAFFIC GENERATION**

| MOVEMENT | am PEAK | pm PEAK |
|---|---|---|
| Left turn from Ceremonial Drive | 13 | 68 |
| Right turn from Ceremonial Drive | 53 | 150 |
| Left turn into Ceremonial Drive | 530 | 215 |
| Right turn into Ceremonial Drive | 48 | 31 |
| East bound on Lakeside Drive | 596 | 567 |
| West bound on Lakeside Drive | 408 | 515 |

# B3. Traffic Assignment - Proposed Development

## B.3.1 Access Locations

Traffic access to the development is proposed at the location as shown on the attached Illustrative Plan.

The access to Ceremonial drive from Lakeside Drive will be a roundabout arrangement. The purpose of Ceremonial Drive is to provide an alternate entrance and landscaped feature to the University to link up with the South Ring-road in the vicinity of the proposed new Great Hall.

The volume of traffic using this entrance is not anticipated to greatly affect the flow of traffic along Lakeside Drive with a 2 lane roundabout.

In view of the recent concerns regarding excessive speed and reduction of accidents along Lakeside Drive, the roundabout would be a positive traffic calming influence.

## B.3.2. Traffic Distribution Scenarios

Distribution of traffic from the University access was assessed by considering the impact of the generated traffic on existing traffic at the peak activity time for the University. As the distribution and varying the contribution to am and pm peak directions to examine the sensitivity.

To demonstrate this, 2 runs were made, one at the 1996 split between left and right turns and the second at projected 10 year volumes to enhance the worst case of opposing turn movements.

Based on projected EFTSU growth an increase of 26% is expected.

The distribution is shown in Table 3.1 below.

**TABLE 3.1 - DEVELOPMENT TRAFFIC DISTRIBUTION**

| | **Generation** | **Left Turn (from Ceremonial Dr)** | | **Right Turn (from Ceremonial Dr)** | |
|---|---|---|---|---|---|
| | | am Peak | pm Peak | am Peak | pm Peak |
| Run 1 | 1999 | 13 | 68 | 53 | 150 |
| Run 2 | 2009 | 16 | 86 | 67 | 189 |

## B.4 Perimeter Road Traffic

### B.4.1. Lakeside Drive

Traffic on Lakeside Drive, was 11,613 vehicles per day (vpd.) in April1999 (both directions) with an am peak flow of 408 v.p.h and pm peak flow of 515 v.p.h heading West and an am peak flow of 596 v.p.h and a pm peak flow of 567 v.p.h heading East.

The Lakeside Drive Street catchment is well developed under the current zoning and increases in the traffic are not expected to be great. The only source of traffic growth will be via increases in student enrolment at the University.

For this study we have adopted a nominal 2% increase in traffic for analysis purposes.

The projected traffic for the year 2009 based on this growth rate is shown in Figure E.4.1 below.

**TABLE E.4.1 – YEAR 2009 TRAFFIC PROJECTION**

| **East Bound** | | **West Bound** | |
|---|---|---|---|
| am Peak | pm Peak | am Peak | pm Peak |
| 497 | 627 | 727 | 691 |

## B.5 Intersection Analysis

The intersection was analysed using SIDRA to ascertain performance under the current and projected flows.

The heaviest traffic flows for the year 2009 were adopted for analysis.

A summary of traffic analysis definitions is presented at Appendix A and details of the SIDRA analysis are shown at Appendix B.

The critical results of the analysis predicted by SIDRA are acceptable for traffic exiting the proposed new access road onto Lakeside Drive at the year 2009. Adopting the worst case of the pm peak in the year 2009, they are:

### Lakeside Drive

Maximum Average Delay – 12.1 seconds

Maximum Queue Length – 5 cars

31m

Level of Service – A

The affect of the new roundabout on the nearby Gove St intersection is mentioned here due to its proximity to the new entrance road.

Due however to its location being some 70m away from the roundabout, (refer to the attached Sketch 4458-SK05), the worst case investigated here will not affect the flow of traffic from this street and conversely the flow of traffic from this street will not impact on the new roundabout.

### Ceremonial Drive

Maximum Average Delay – 20.5 seconds

Maximum Queue Length – 4 cars

25m

Level of Service – B

## B.6 Conclusions

The traffic generated by the proposed new access road is in the order of 218 vehicles per hour in the afternoon peak.

The impact on the existing road network is minimal when traffic enters the existing road network at Lakeside Drive via a roundabout arrangement.

The Level of Service provided by the current intersection and for the proposed development, under projected traffic regimes, is high with negligible effect on external traffic flows to the year 2009.

## B.7 Traffic Analysis Definitions

**Degree of Saturation:** The ratio usually expressed as a percentage of the number of vehicles entering a signalised intersection in a specified period, to the number which could enter if all approaches were fully saturated during that period. This definition may also be applied to other methods of control (Give-Way, Roundabout).

Acceptable Degree of Saturation ratios are:

< 0.85 Give-Way, Stop, Roundabouts; and
< 0.95 Signals

If the Degree of Saturation ratios are greater than the values indicated above, excessive delays result.

**Average Delay/Delay:** The time spent, on average by a vehicle waiting to enter a traffic stream.

**Queue:** The number, or equivalent length, of vehicles waiting to enter a traffic stream

**Level of Service:** To correlate numerical traffic volume data to the traffic operating performance of a roadway, the concept of level of service (LOS) was developed. LOS is a qualitative measure describing operational conditions within a traffic stream. Generally, there are six service levels which are designated A to F, with level A representing the best operating condition and level F the worst. Levels C or D are considered to be the generally accepted standard for planning and the design of transportation facilities in urban areas.

**Level of Service A:** Individual users are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high. The general level of comfort and convenience provided to the motorist, passenger, or pedestrian is excellent.

**Level of Service B:** Is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. There is a slight decline in the freedom to manoeuvre within the traffic stream from LOS A.

**Level of Service C:** Is in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. The selection of speed is now affected by the presence of others, and manoeuvring within the traffic stream requires substantial vigilance on the part of the user. The general level of comfort and convenience declines noticeably at this level.

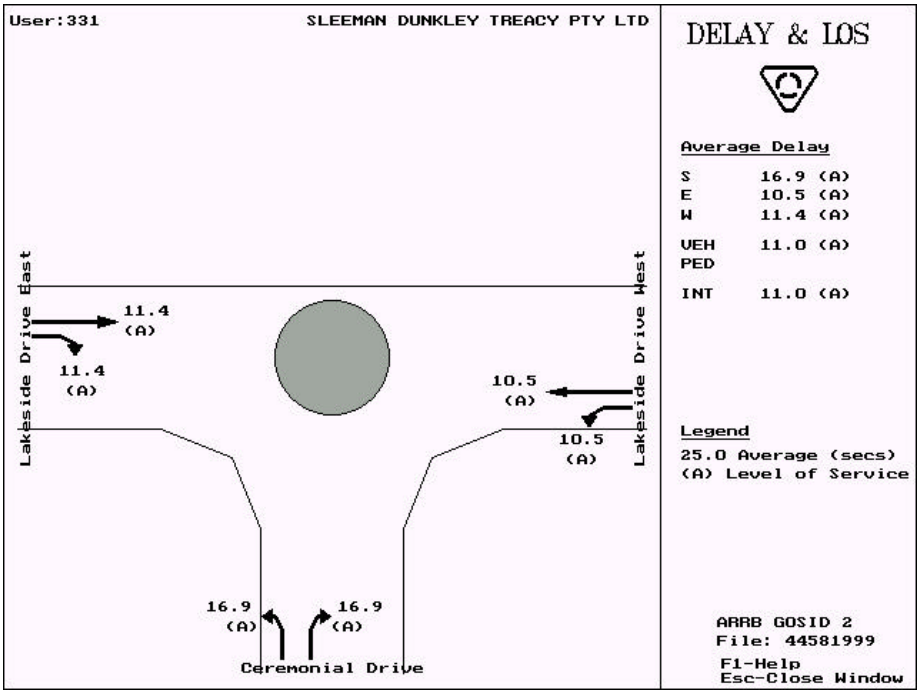
**Level of Service D:** Represents high density, but stable flow.

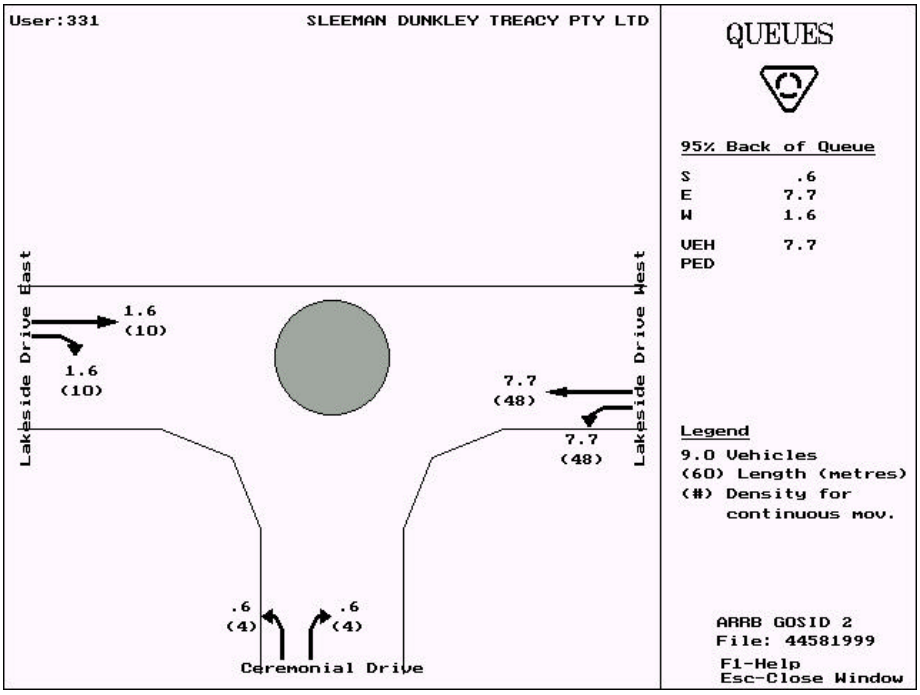
**Level of Service E:** Represents operating conditions at or near the capacity level. All speeds are reduced to a low, but relatively uniform value. Freedom to manoeuvre with the traffic stream is extremely difficult. Comfort and convenience levels are extremely poor. Operations at this level are usually unstable, because small increases in flow or minor pedestrian movements within the traffic stream will cause breakdowns.

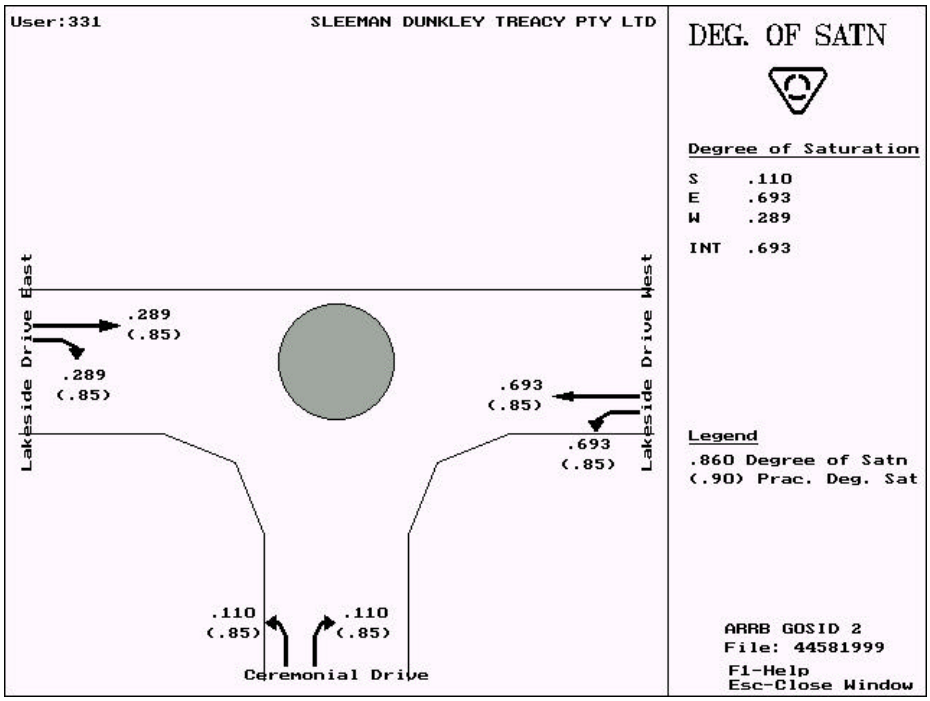
**Level of Service F:** Is used to define forced or breakdown flow. This condition exists wherever the amount of traffic approaching a point exceeds the amount which can traverse the point. Queues form behind such locations. It is the point at which arrival flow exceeds discharge flow which causes the queue to form, and level of service F is an appropriate designation for such points.

**SIDRA Analysis Summaries**

## Roundabout with 1999 traffic distribution Run 1 am peak

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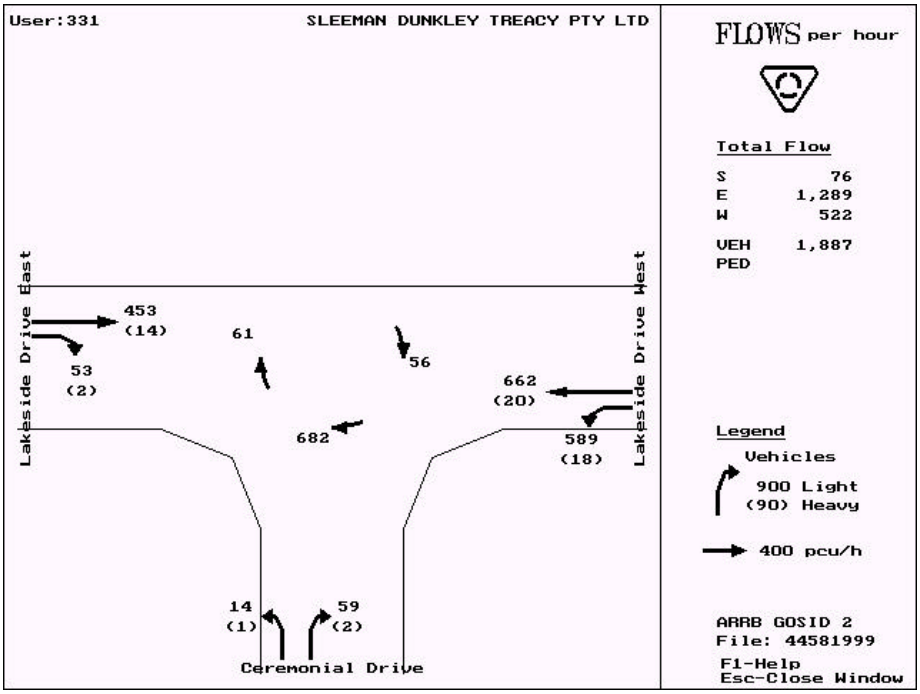
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W 522
VEH 1,887
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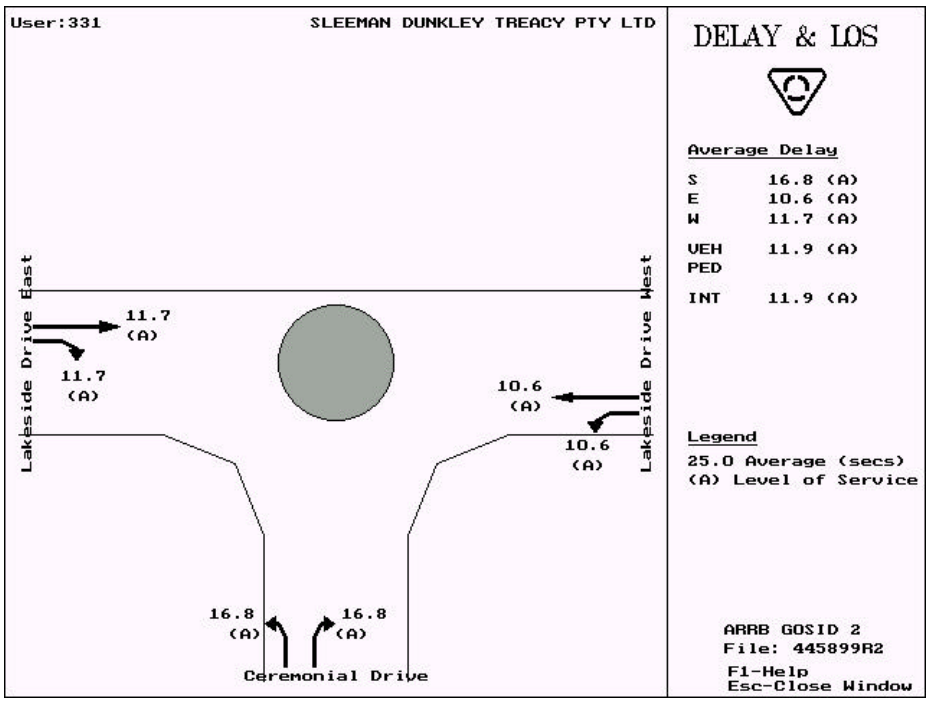
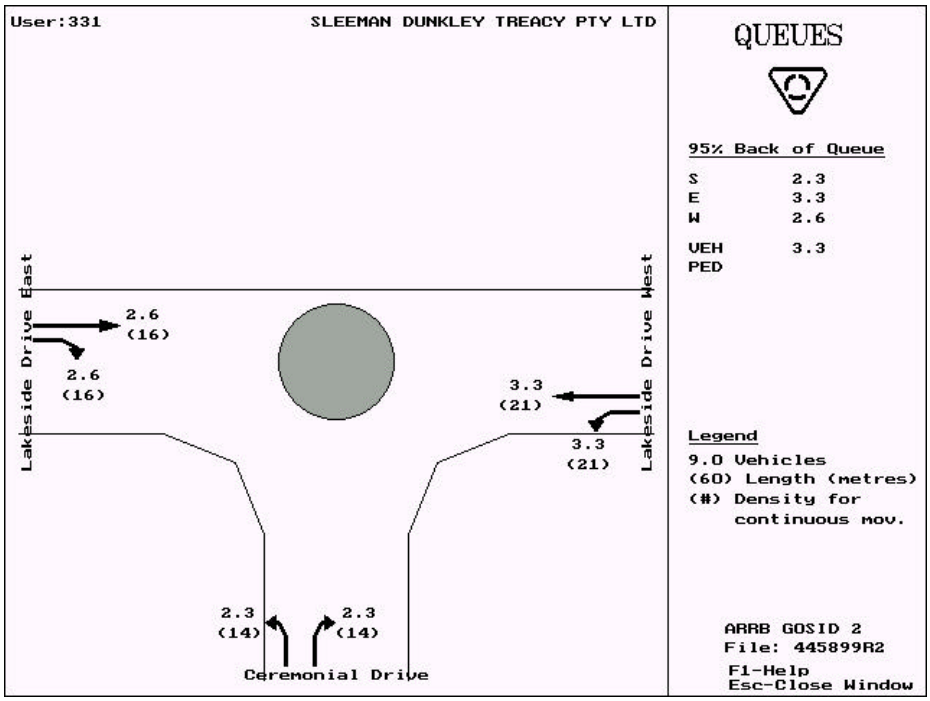
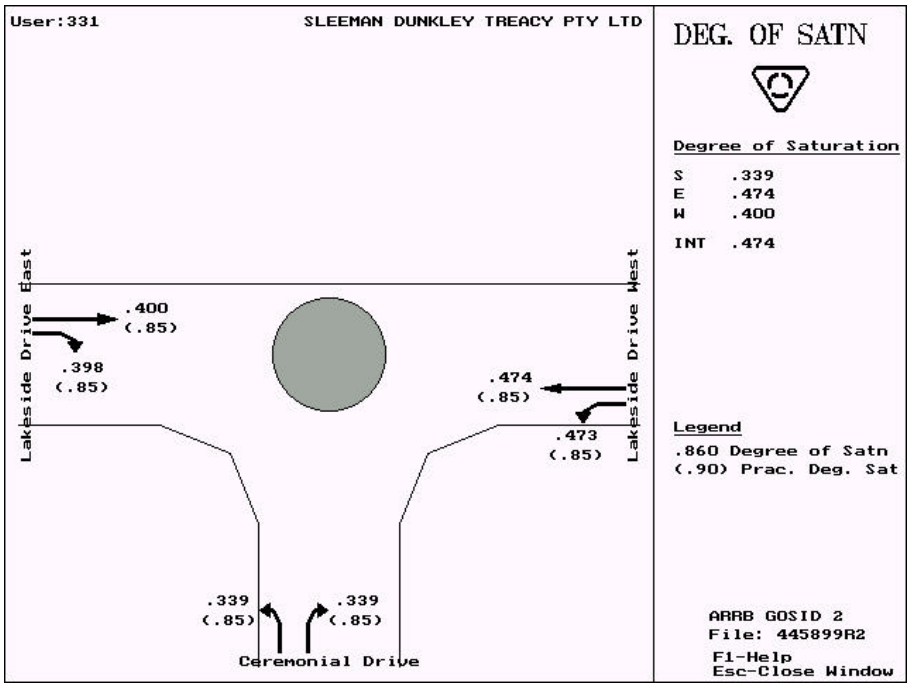
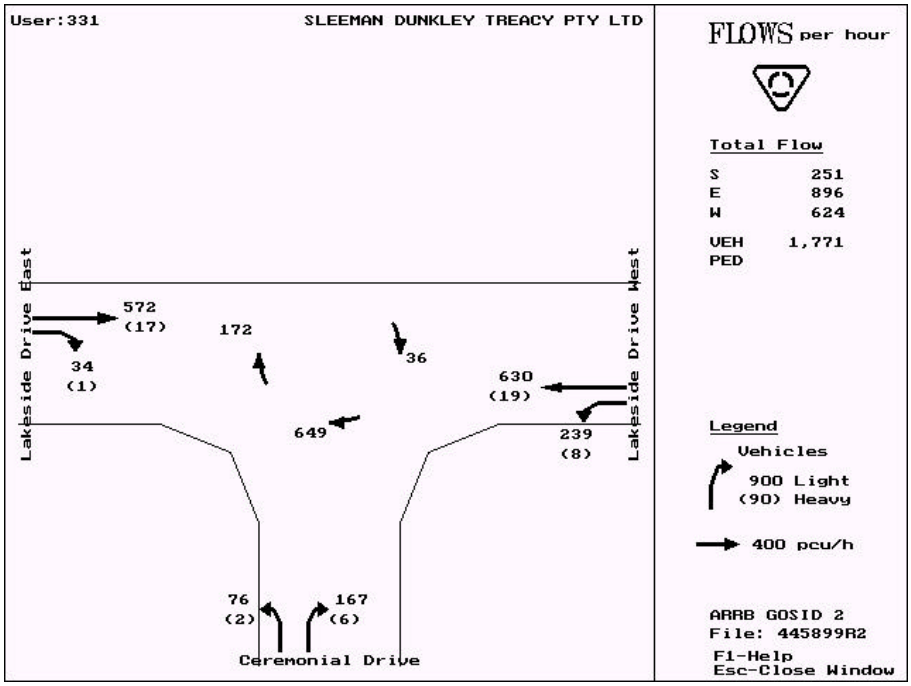
F1-Help
Esc-Close Window



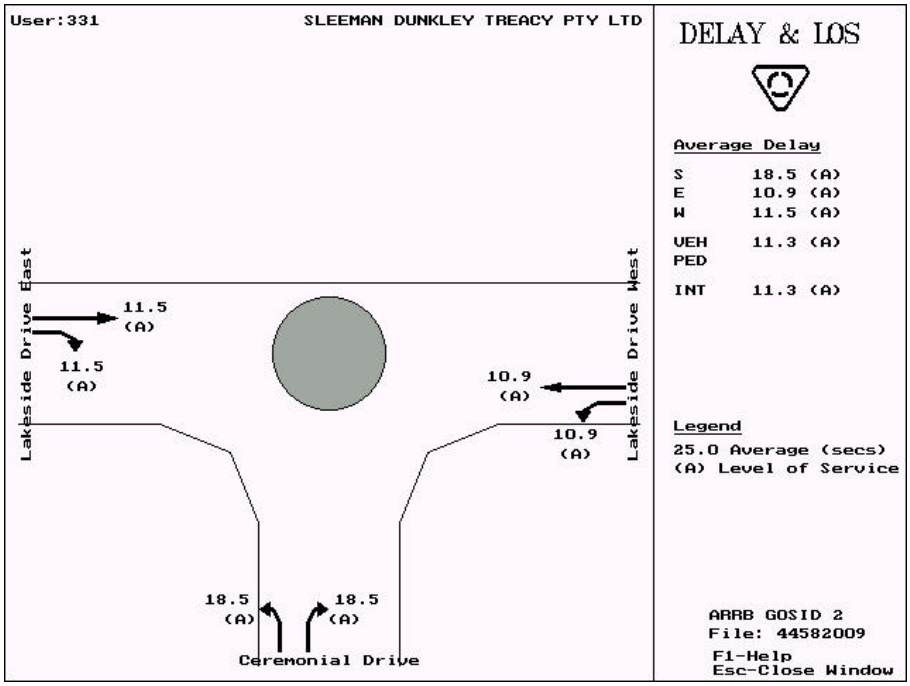

Roundabout with 1999 traffic distribution Run 1 pm peak

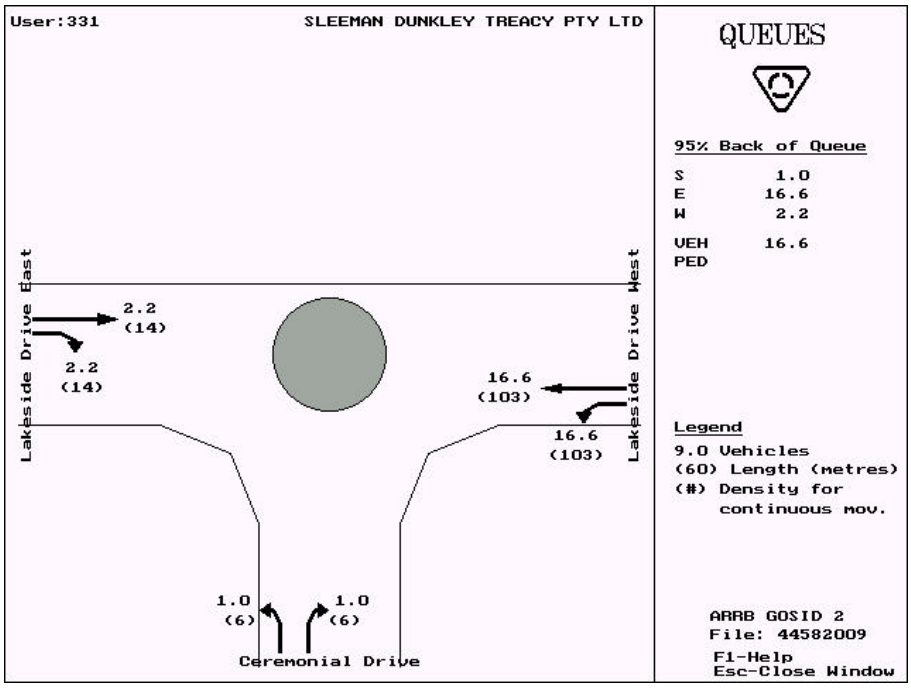


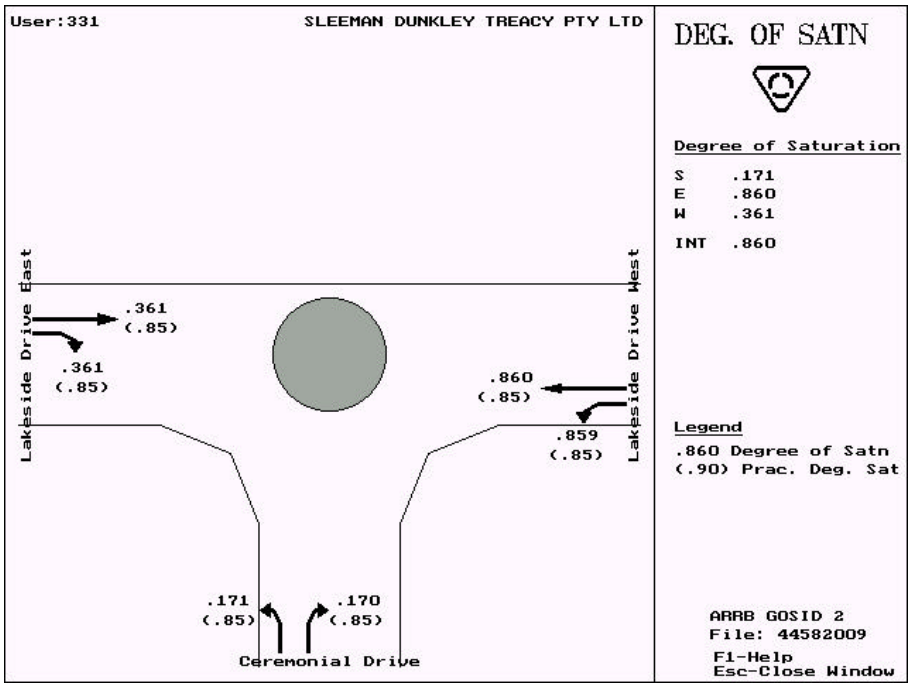

User:331
SLEEMAN DUNKLEY TREACY PTY LTD
DEG. OF SATN
Degree of Saturation
S .339
E .474
W .400
INT .474
Lakeside Drive East
Lakeside Drive West
.400
(.85)
.398
(.85)
.474
(.85)
.473
(.85)
.339
(.85)
.339
(.85)
Ceremonial Drive
Legend
.860 Degree of Satn
(.90) Prac. Deg. Sat
ARRB GOSID 2
File: 445899R2
F1-Help
Esc-Close Window

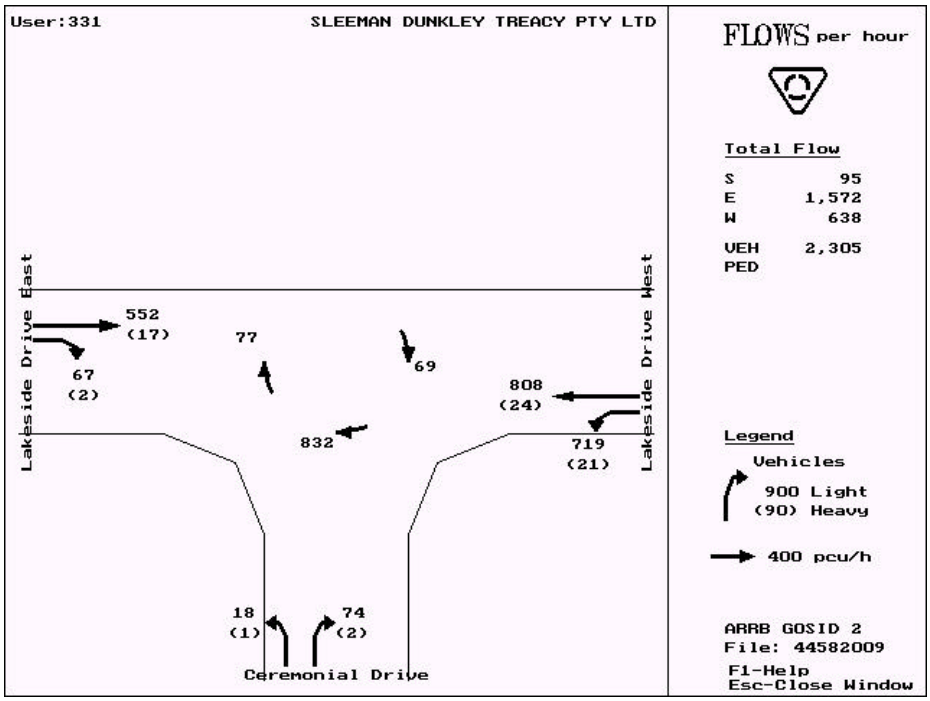

User:331
SLEEMAN DUNKLEY TREACY PTY LTD
FLOWS per hour
Total Flow
S 251
E 896
W 624
VEH 1,771
PED
Lakeside Drive East
Lakeside Drive West
572
(17)
34
(1)
172
36
630
(19)
649
239
(8)
76
(2)
167
(6)
Ceremonial Drive
Legend
Vehicles
900 Light
(90) Heavy
400 pcu/h
ARRB GOSID 2
File: 445899R2
F1-Help
Esc-Close Window

# Roundabout with 2009 traffic distribution Run 2 am peak

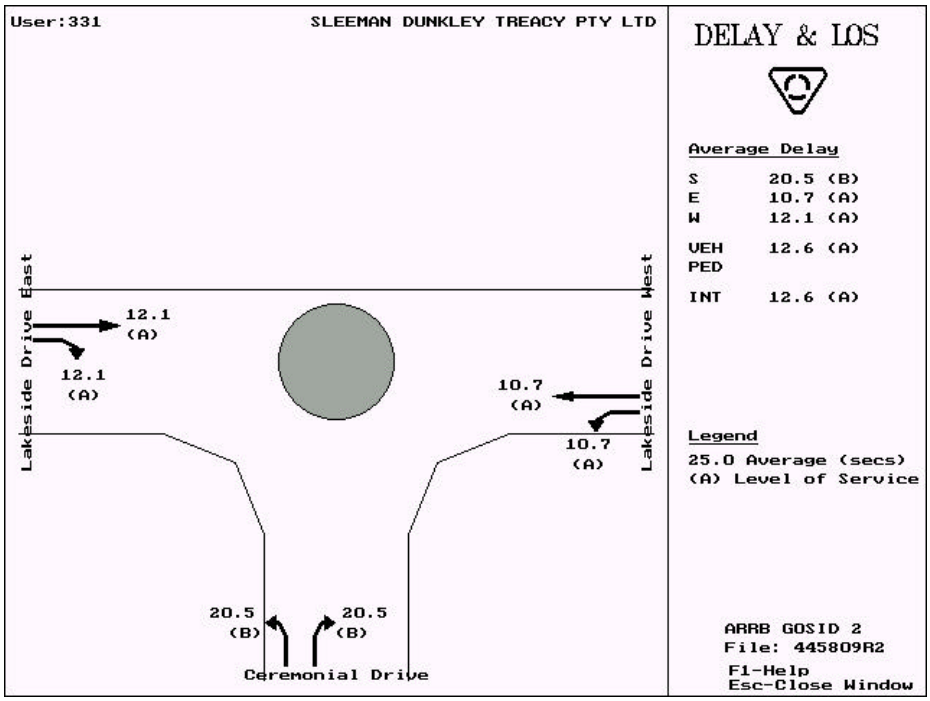


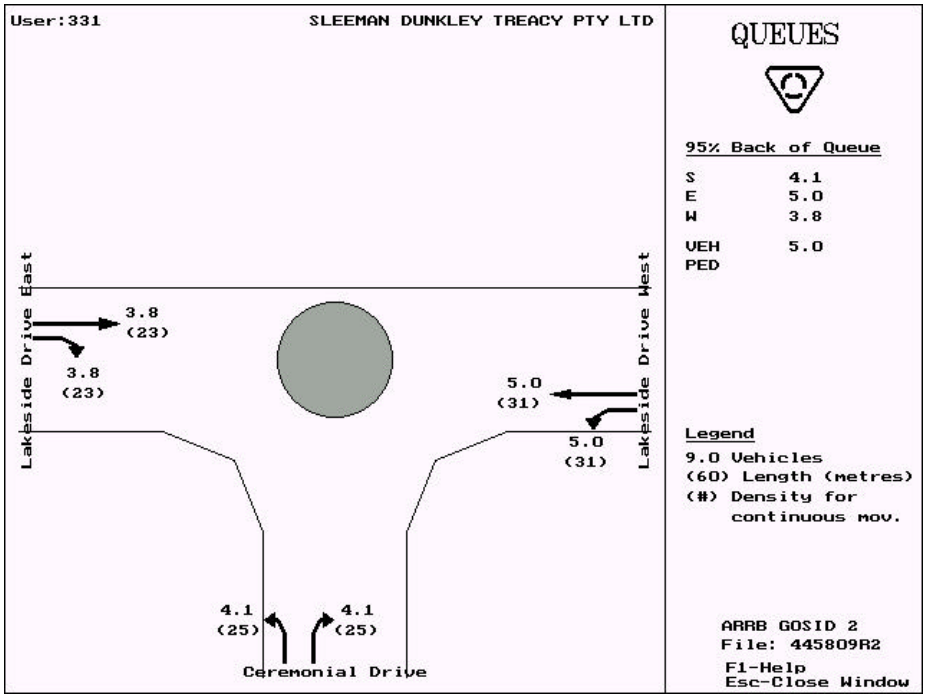



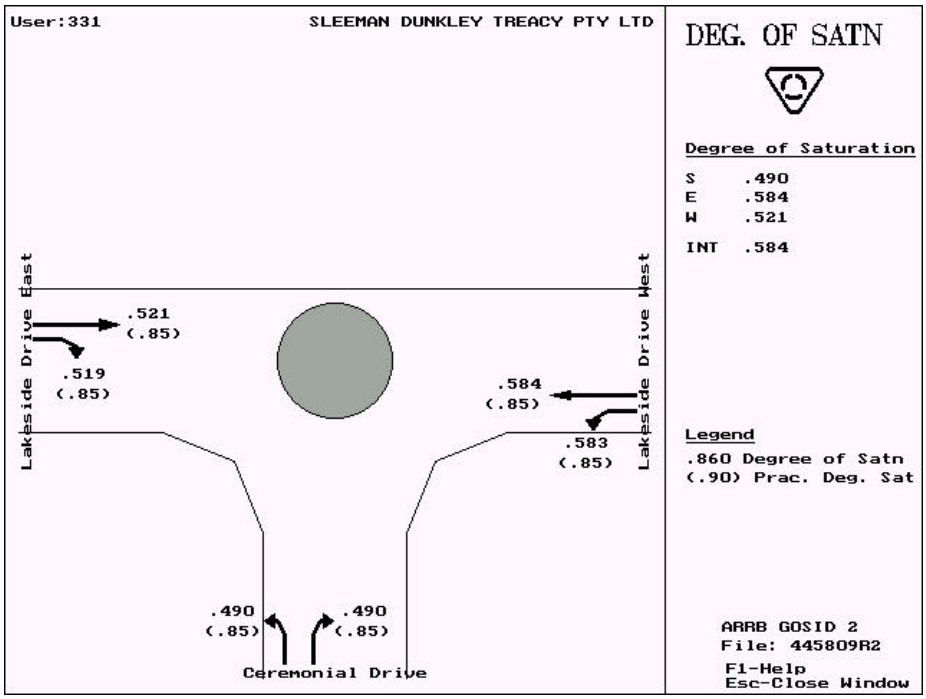

User:331
SLEEMAN DUNKLEY TREACY PTY LTD
DEG. OF SATN
Degree of Saturation
S .171
E .860
W .361
INT .860
Lakeside Drive East
Lakeside Drive West
.361
(.85)
.361
(.85)
.860
(.85)
.859
(.85)
.171
(.85)
.170
(.85)
Ceremonial Drive
Legend
.860 Degree of Satn
(.90) Prac. Deg. Sat
ARRB GOSID 2
File: 44582009
F1-Help
Esc-Close Window

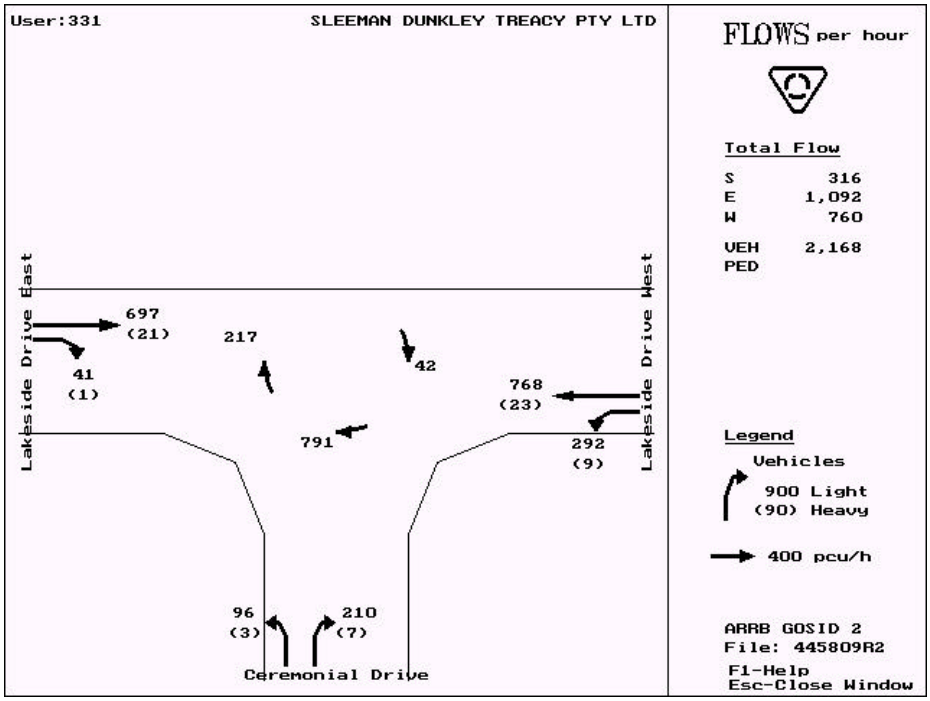

User:331
SLEEMAN DUNKLEY TREACY PTY LTD
FLOWS per hour
Total Flow
S 95
E 1,572
W 638
VEH 2,305
PED
Lakeside Drive East
Lakeside Drive West
552
(17)
67
(2)
77
69
808
(24)
832
719
(21)
18
(1)
74
(2)
Ceremonial Drive
Legend
Vehicles
900 Light
(90) Heavy
400 pcu/h
ARRB GOSID 2
File: 44582009
F1-Help
Esc-Close Window

# Roundabout with 2009 traffic distribution Run 2 pm peak




User:331
SLEEMAN DUNKLEY TREACY PTY LTD
DEG. OF SATN
Degree of Saturation
S .490
E .584
W .521
INT .584
Lakeside Drive East
Lakeside Drive West
.521
(.85)
.519
(.85)
.584
(.85)
.583
(.85)
.490
(.85)
.490
(.85)
Ceremonial Drive
Legend
.860 Degree of Satn
(.90) Prac. Deg. Sat
ARRB GOSID 2
File: 445809R2
F1-Help
Esc-Close Window


User:331
SLEEMAN DUNKLEY TREACY PTY LTD
FLOWS per hour
Total Flow
S 316
E 1,092
W 760
VEH 2,168
PED
Lakeside Drive East
Lakeside Drive West
697
(21)
41
(1)
217
42
768
(23)
791
292
(9)
96
(3)
210
(7)
Ceremonial Drive
Legend
Vehicles
900 Light
(90) Heavy
400 pcu/h
ARRB GOSID 2
File: 445809R2
F1-Help
Esc-Close Window

# Appendix C Flora Survey

# Appendix D Aquatic Fauna

Marine fish species recorded from Rapid Creek and families (with 1 representative species listed) present in estuarine creeks in the vicinity of Rapid Creek and expected to inhabit Rapid Creek (from Larson and Williams 1997).

| **Family** | **Species** |
|---|---|
| **Recorded in Rapid Creek** | |
| Dasyatididae | *Pastinachus sephan* |
| | |
| Ophichthidae | *Pisodonophis sp.* |
| | |
| Lutjanidae | *Lutjanus russelli* |
| | |
| Gobiidae | *Boleopphthalmus birdsongi* |
| | *Periophthalmus argentilineatus* |
| | *Acentrogobius viridipunctatus* |
| | |
| **In nearby Creeks** | |
| Leiognathidae | *Leiognathus sp.* |
| | |
| Melanotaeniidae | *Pseudomugil spp.* |
| | |
| Terapondiae | *Terapon puta* |
| | |
| Sillaginidae | *Sillago maculata* |
| | |
| Clupeidae | *Nematalosa come* |
| | |
| Gerreidae | *Gerres sp.* |
| | |
| Haemulidae | *Pomadasys sp.* |
| | |
| Carcharhinidae | *Carcharhinus dussumieri* |
| | |
| Ophichthidae | *Muraenichthyes laticaudatus* |
| | |
| Ariidae | *Arius graeffei* |
| | |
| Batrachoididae | *Batrachomoeus trispinosus* |
| | |
| Antennariidae | *Lopiocharon sp.* |
| | |
| Hemiramphidae | *Zenoarchopterus rasori* |
| | |
| Syngnathidae | *Festucalex cinctus* |
| | |
| Platycephalidae | *Inegocia japonica* |
| | |
| Pegasidae | *Pegasus volitans* |
| | |
| Centropomidae | *Lates calcarifer* |
| | |
| Ambassidae | *Ambassis interruptus* |
| | |
| Apogonidae | *Apogon rueppellii* |
| | |
| Echeneididae | *Echenus naucrates* |
| | |
| Carangidae | *Alepes vari* |

Marine fish species recorded from Rapid Creek and families (with 1 representative species listed) present in estuarine creeks adjacent to Rapid Creek and expected to inhabit Rapid Creek (from Larson and Williams 1997).

| **Family** | **Species** |
|---|---|
| Nemipteridae | *Pentapodus porosus* |
| | |
| Gerreidae | *Gerres filamentosus* |
| | |
| Sciaenidae | *Nibea micrgenys* |
| | |
| Monodactylidae | *Monodactylus argenteus* |
| | |
| Ephippidae | *Drepane puncuata* |
| | |
| Scatophagidae | *Scatophagus argus* |
| | |
| Chaetodontidae | *Chelmon muelleri* |
| | |
| Mugilidae | *Liza subviridis* |
| | |
| Opistognathidae | *Opistognathus papuensis* |
| | |
| Blenniidae | *Omobranchus ferox* |
| | |
| Callionymidae | *Dactylopus dactylopus* |
| | |
| Microdesmidae | *Parioglossus palustris* |
| | |
| Bothidae | *Pseudorhombus arsius* |
| | |
| Soleidae | *Aseraggodes sp.* |
| | |
| Tricanthidae | *Triacanthus biaculeatus* |
| | |
| Monocanthidae | *Anacanthus barbatus* |
| | |
| Ostraciidae | *Rhynchostracion nasus* |
| | |
| Tetraodontidae | *Chelonodon potaca* |
| | |

# Appendix E Authority Certificate issued by Aboriginal Areas Protection Authority

# Appendix F Excerpts from Landscape Master Plan