# WATER SENSITIVE URBAN DESIGN

# WATER QUALITY MONITORING STRATEGY

# FINAL

Prepared for the Northern Territory Department of Planning and Infrastructure
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# 1 INTRODUCTION

Urban development in the Darwin Region is occurring without appropriate consideration of its impact on the health of the region's waterways. In order to manage the impacts of new development and redevelopment on Darwin Harbour, the Territory Government is seeking to implement Water Sensitive Urban Design (WSUD) within all new development

To facilitate the adoption of WSUD, the DPI (Department of Planning and Infrastructure) in conjunction with NRETAS (Department of Natural Resources, Environment, the Arts and Sport) have secured a grant from the Australian Government's Coastal Catchments Initiative (CCI) program to develop a WSUD Strategy for Darwin Harbour. The WSUD Strategy will create an enabling environment to ensure commitment to urban water cycle and stormwater management through a WSUD framework for Darwin. The WSUD framework will link policy to locally relevant technical design guidelines, manuals and industry tools. Development of the Strategy represents a substantial project as defined by the Workplan provided in Table 1 below.

## 1.1 Purpose of this Document

This document has been developed as part of Task 17 (Stage 6) of the Workplan. The monitoring strategy is a document to assist in the linking of the WSUD Strategy for Darwin Harbour with the Water Quality Protection Plan (WQPP) developed by the Department of Natural Resources, Environment, the Arts and Sport (NRETAS).

NRETAS has developed a receiving water quality model to quantify the impacts of various land use on the water quality of Darwin Harbour. This model has identified urban stormwater as a key contributor to pollutant loads entering Darwin Harbour. Furthermore NRETAS has identified that WSUD on new developments is an important scenario that could help to mitigate impacts of pollutant loads from new development on water quality in Darwin Harbour. Monitoring to assess the performance of WSUD is a key step in providing assurance that the future development scenarios developed by NRETAS are achievable and backed by rigorous monitoring. Monitoring is therefore a key link between the WQPP and the WSUD Strategy for Darwin Harbour.

More generally, land use managers and natural resource managers require assessment of the performance of stormwater treatment devices. This accurate assessment allows managers to assess the effectiveness of intervention measures, natural resource plans and also provides guidance on future land use.

This document outlines a strategy to assess the performance of WSUD measures to improve water quality discharged from urban development into Darwin Harbour.

Bellamack has been identified as the WSUD showcase development as a practical example of implementation of the WSUD Strategy for Darwin Harbour. A key component of Bellamack is the treatment of stormwater runoff from the system. It is proposed to monitor water quality of these treatment systems.

This monitoring strategy identifies the key components of the monitoring strategy for the Bellamack WSUD systems, including logistics arrangements

- Monitoring location and infrastructure requirements
- Monitoring costs
- design of sampling and monitoring
- organisational responsibility
- management of data generated from the programs

An assessment of the performance of these systems requires monitoring of both the inflow and treated outflow water quality. The variable nature of stormwater flows makes monitoring and associated laboratory analysis an onerous task.

There are a number of monitoring methods available including online continuous monitoring, autosampling and manual sampling. These methods are discussed in more detail in the following sections.

At this stage in the WSUD Strategy for Darwin Harbour, the monitoring strategy is dependent on the completion of the WSUD treatment measures which are currently being designed as part of the Bellamack Residential sub-division. The sub-division is currently in the process of detailed design and construction of the treatment measures will commence in 2009/2010. Construction and establishment will not be complete for several years.

This document builds on previous work undertaken as part of the WSUD Strategy project:

- WSUD objectives for new development have been put forward in the "WSUD Design Objectives for Darwin" Discussion Paper

- WSUD Showcase Development –WSUD Strategy for Bellamack

- WSUD Guidelines and Tools, in particular the development of a water quality modelling guideline and concept design and technical design guideline.

## 1.2 Outline of this Document

This document explains the logistic arrangements required to monitor the performance of WSUD treatment measures and the institutional arrangements that are required to support it.

- Section 2 summarises the objectives of the monitoring strategy

- Section 3 discusses the physical and logistical arrangements required for monitoring

- Section 4 discusses the institutional arrangements within the NT Government that are required to support the monitoring strategy

## Table 1: WSUD Strategy for Darwin Harbour - Workplan

| STAGE | TASK # | Activity |
|---|---|---|
| 1 | 1 | Refine workplan |
| | 2 | Establish project working group. |
| 2 | 3 | Develop WSUD Strategies for case studies in suitable format for communication and identify case studies for sub-catchment scale application of WSUD treatment train.<br>• *WSUD Showcase - Bellamack residential sub-division conceptual WSUD Strategy is complete*<br>• *Design development of Bellamack WSUD Strategy is about to commence (see Task below)* |
| | 4 | Identify potential WSUD objectives for Darwin<br>• *Stakeholder workshop held on 14th and 15th June 2007*<br>• *WSUD Objectives for Darwin - Discussion Paper (EDAW, Oct 2007)* |
| | 5 | Critical Analysis of WSUD/Stormwater Treatment Options for Darwin<br>• *Stakeholder workshop held on 14th and 15th June 2007*<br>• *Water Sensitive Urban Design Stormwater Treatment Options For Darwin - Discussion Paper (EDAW, Oct 2007)* |
| **3** | 6 | Prepare a stakeholder communication and consultation strategy (including establish website, fact sheets, presentations). |
| | 7 | Prepare and communicate a definition of WSUD within Darwin |
| | 8 | Review and report on policy, programme, technical and decision-support systems for WSUD in Australia (including any barriers to uptake of WSUD and respective jurisdictional responses). |
| | 9 | Identify potential barriers to uptake of WSUD in the NT. Develop strategy to address barriers. |

| STAGE | TASK # | Activity |
|---|---|---|
| 4 | 10 | Develop WSUD Strategies for case studies in suitable format for communication and identify case studies for sub-catchment scale application of WSUD treatment train.<br><br>*WSUD Showcase - Complete design development of the Bellamack WSUD Strategy*<br>*Identify and scope work associated with "retrofit" WSUD case study* |
| | 11 | Prepare detailed workplan for development of NT WSUD policy, objectives, design manual, performance standards and decision-support tools. |
| 5 | 12 | Prepare draft NT WSUD policy and objectives for Darwin including understanding existing legislation, workshops etc. |
| | 13 | Assess application of WSUD objectives and management practice options across a range of development situations and/or catchment-scale treatment-train & confirm set of objectives. |
| | 14 | Undertake consultation of draft WSUD policy and WSUD objectives to stakeholders and barriers to WSUD. |
| 6 | 15 | Define requirements of WSUD Guidelines and Tools (workshop to define design needs in detail and assess whether exiting guidelines satisfy this need) |
| | 16 | Document Draft WSUD Guidelines and Tools in including High Level and Conceptual Design Guideline, Technical Design Guideline and Design Tools (MUSIC Guidelines, Deemed to Comply Solutions, Standard Drawings etc.) |
| | 17 | **Prepare Draft WSUD decision support tools for Darwin Harbour, consistent with WQPP, linking policy, objectives and guidelines** |
| 7 | 18 | Undertake stakeholder consultation of WSUD Policy, WSUD design manual and performance standards, and decision support Tools and seek approval. |
| | 19 | Finalise WSUD design manual, decision support tools and performance standards |
| 8 | 20 | Seek NT Government approval for WSUD Policy, WSUD design manual and performance standards and decision support tools. |
| | 21 | Develop and publish stormwater management plans for key subcatchment in Darwin to illustrate application of WSUD Policy/Framework, design manual and decision support tools. |
| 9 | 22 | Develop an implementation strategy for incorporating policies and provisions for WSUD within NT planning policies, strategic plans and development approval processes as well as local government instruments |
| | 23 | Ongoing communication and website management |
| | 24 | Capacity Building and Training including government, local authorities, developers and industry practitioners |
| 10 | 25 | Incorporate policies and provisions for WSD into NT government planning policies, strategic plans and development approval processes, as well as relevant local government instruments. Implement agreed strategy to address barriers to uptake of WSD. |

# 2 OBJECTIVES

Water Sensitive Urban Design is a relatively new tool in water resource management. Over the last decade WSUD has gained widespread acceptance in south-eastern states of Australia and currently WSUD is being adopted in Darwin. As WSUD is a relatively new field in Darwin, uncertainty over the performance of WSUD measures in the wet/dry tropics was identified as a major *technical barrier* to the widespread adoption of WSUD in the wet/dry tropics in general and Darwin in particular. Monitoring the performance of WSUD measures adopted as part of the Bellamack Residential Sub-division was identified as a key measure in addressing this barrier to WSUD.

The application of WSUD in the wet-dry tropics, and Darwin specifically, has required a number of changes in the standard designs of WSUD treatment measures that have been developed in temperate climates. Monitoring will provide an assessment of the effectiveness of these design changes. Furthermore monitoring will provide guidance to future design modifications to WSUD treatment measures. Thus, a key secondary objective is to test the design assumptions and to provide guidance to the design process in the future.

As WSUD has had very little adoption and uptake in the wet/dry tropics in Australia there is no information or data on the key design parameters that are required to design WSUD systems in the wet/dry tropics. Currently many of the design parameters that are used in developing designs have been based on monitoring of systems in temperate climates. A third objective of monitoring is to provide guidance on appropriate design parameters for WSUD treatment systems.

WSUD uses a range of different options to improve stormwater quality discharging to receiving waters. Different treatment measures have different treatment processes and design features. Monitoring will assist in an evaluation of the performance of different treatment measures to determine if certain treatment measures are more appropriate than others in the wet dry tropics

Treated stormwater has been identified as a key resource that may be beneficial to ensuring that groundwater extractions from the dolomite aquifer (mainly for irrigation of sports fields) are sustainable over the medium to long term. If stormwater treatment is implemented successfully, this will create an opportunity to undertake aquifer recharge to balance groundwater extraction. Prior to injection into the aquifer, water quality sampling should be undertaken to ensure that injection of stormwater will not impact on the existing water quality of the aquifer.

NRETAS has previously done significant monitoring work on pollutant loads from urban stormwater. Monitoring of a new residential subdivision will provide continuity with this data collection and data analysis. Furthermore it will extend the monitoring program by providing field measurements of a newly developed residential area.

In summary the objectives of monitoring WSUD treatment measures in the Darwin region are to:

- Monitor the performance of WSUD measures to address the uncertainty over the performance of WSUD measures in the wet/dry tropics
- test key design assumptions for WSUD treatment measures and to provide guidance to the design process in the future
- provide guidance on appropriate design parameters for WSUD treatment systems
- evaluate the performance of different treatment measures in the wet/dry tropics
- determine the quality of treated stormwater prior to injection into aquifer storage
- improve knowledge of urban stormwater runoff quality and contribute to the existing body of data on urban stormwater runoff quantity and quality in the Darwin region

The key objective of this monitoring strategy is to facilitate and document the key requirements in implementing the monitoring strategy. The monitoring strategy outlines the:

- details of the physical requirements for implementing a monitoring program
- institutional arrangements required in implementing the monitoring program.

# 3 MONITORING PROGRAM ARRANGEMENTS

The following sections outline the logistics involved in undertaking the monitoring program. It provides an overview of what parameters are to be monitored, what treatment systems are to be monitored, where monitoring is to occur, when and how frequent monitoring is to be undertaken and provides some guidance on how monitoring is to be undertaken.

## 3.1 Monitoring Parameters

Monitoring a stormwater treatment system requires accurate assessment of two key parameters:

- the *flow rates* entering and leaving the treatment system
- the *concentrations* of the water quality parameters that enter and leave the treatment system.

Both of these parameters need to be monitored over time. Monitoring of these two key parameters over the duration of a single storm event enables a determination of the total pollutant loads for that event by multiplying the event mean concentration (EMC) by the total runoff. This will enable an assessment of the total loads that the treatment system has removed in that event. If a large number of events are monitored, this allows a comparison to the predicted design performance.

There are three key water quality parameters that need to be monitored:

- total phosphorous (TP)
- total nitrogen (TN)
- total suspended solids (TSS)

Subject to funding, monitoring the speciation of total phosphorous (total dissolved phosphorous, dissolved organic phosphorous and particulate phosphorous) and total nitrogen (total Kjeldahl nitrogen, nitrate/nitrite, dissolved organic nitrogen, and ammonium nitrogen) would also be undertaken. However the cost of monitoring individual species is more expensive due to the extra laboratory analysis that is required as well as the cost of providing a refrigerated autosampler.

Also subject to funding, other parameters of interest are pathogens and heavy metals (including zinc, cadmium, copper and lead).

Online continuous monitoring is available for some water quality parameters. These are typically parameters that are easily measured using electronic probes and include DO, turbidity, pH, conductivity, and temperature. It is recommended to undertake continuous online monitoring of, as a minimum, electrical conductivity and turbidity. Online monitoring of dissolved oxygen levels is also recommended for wetland systems. Electrical conductivity is important to understand any impacts of recharging treated stormwater into aquifers, from where it may be reused for irrigation.

Rainfall stations are not required for monitoring in the urban area of Darwin. Due to the proximity to the Bureau of Meteorology Darwin Airport pluviograph and uniformity of rainfall in the region, this rainfall station is sufficient to estimate rainfall at urban areas in Darwin and Palmerston.

## 3.2 Instrumentation, Monitoring Systems Frequency and Data Transmission

The sampling needs to be event based and the total event needs to be sampled. For this reason manual sampling is not an option. Manual sampling is unable to 'catch' the full hydrograph as it is difficult to accurately predict when rain will occur and to organise someone to be on site during the entire rainfall event.

Thus, an autosampler will be required. Autosamplers automatically collect stormwater samples at set intervals or in response to set flow rates, and are able to vary the volume of the sample based on a pre-determined flow rate. The samples are then collected manually after each event and sent to a laboratory for analysis.

To reduce the cost of laboratory analysis it is recommended that composite samples be taken. Composite samples are individual samples during a single event which are mixed. Composite samples are adequate to determine the EMC.

The number of events that are required to obtain a statistically meaningful EMC, that incorporates natural variability, is a key criterium for any water quality monitoring program. Work undertaken by Fletcher et al (2003) has determined that an event based sampling program which takes only 5 or 10 samples can only give a broad indication of likely EMCs. At least 50 samples are required to determine useful catchment EMCs and their variability. Furthermore the entire length of the wet season needs to be monitored from the beginning of the dry (as early as October) until the end of the wet season (as late as May). This will ensure that any seasonal variation in water quality concentrations, due to the build up during the dry season and gradual wash off during the wet season, can be identified.

To monitor all of the wet season, monitoring will need to be undertaken for a period of typically 6 months although it may be shorter or longer depending on the particular wet season in which monitoring is undertaken. Considering the nature of rainfall in the wet season, with almost daily rainfall it is recommended to regularly collect composite samples which can be considered as one event. Collection every two to three days will ensure that at least 50 composite samples representing fifty 'events' will be collected.

Autosamplers which are able to take a high frequency composite sample based on flow rates are recommended. It is recommended that at least 6 samples be taken over a given daily rainfall event. If possible more samples during an event should be taken as accuracy improves with an increased frequency of sampling.

Also either a pressure transducer or an ultrasonic device is required to measure flow rates. Flow rates are required to determine pollutant loads. Flow rate measurements are for all intents and purposes continuously monitored.

Due to the proximity of urban sites to Palmerston and Darwin telemetry is not required. It is proposed to use manual collection of data, including frequent downloads of flow meter data loggers and collection of composite samples. This is discussed in more detail in section 3.4.

Housing of instrumentation and other equipment is likely to require the installation of temporary instrumentation shelters. Due to the relatively easy access to these shelters, the design of these shelters needs to ensure that the shelters are secure from vandals and theft. In consideration of this design requirement, it may be preferable to house some of the equipment, such as flow meters and data loggers entirely within the pit and pipe system. An example of a flow monitoring station, housed within a small enclosed box, is shown in Figure 1.

**Figure 1: Monitoring station installed in a swale at Coomera Waters, Qld**

It is proposed that the power supply for the instrumentation be a fixed battery. Good access to the monitoring sites is available and thus remote power is not required.

Detailed instrumentation requirements and arrangements need to be documented closer to the time of monitoring and will need to ensure they refer to and are consistent with NRETAS (2008) Hydrographic Gauging Station Scoping Document.

## 3.3 Monitoring system locations

It is proposed to monitor two WSUD treatment sites. The two sites will be located in the new residential subdivision of Bellamack, a site selected as the first WSUD showcase development. As part of the Bellamack sub-division three treatment systems are being constructed; two bioretention systems and one wetland treatment system. It is proposed to monitor one bioretention system and the wetland treatment system. Locations of these treatment systems and individual monitoring points are shown in Appendix A.

In most cases the location of sampling and monitoring points will be in closed conduits and access to these points will be from access chambers. The exact locations of proposed monitoring will be at access pits upstream and downstream of the inlet and outlet of the treatment systems.

These sites are due to begin construction in 2009/2010. It should be noted that the timing of the construction of these sites is dependent on the staging of the urban development of Bellamack.

Ideally there would be three flow rate and EMC measurement points:

- the inflow

- the outflow
- the bypass of the treatment system

Depending on funds available the performance of the treatment system *relative* to the inflows is the minimum requirement. Depending on funds available it is possible to measure only the flow rate at the bypass of the treatment system. The composite sample of the inflow can be assumed to be equal to the untreated bypass and thus applied as the EMC for the bypass. It is important to monitor the bypass flow rate as this allows for monitoring of total losses within the treatment system.

### 3.4 Monitoring Costs

The cost of an autosampler would be approximately $5,000 and a minimum of two autosamplers would be required (three if the bypass was to be monitored as well).

The cost of a flow rate measuring device is in the order of $2,000 to $3,000 and a minimum of three flow measuring devices would be required

There is also a cost in collecting the samples from the autosampler. This includes a typical fee of approximately $200 per event which would include the time to collect the sample as well as materials handling.

The samples collected by the autosampler need to be analysed in the laboratory. The lab analysis costs include monitoring the inflow and outflow concentrations for four samples per event. This requires eight analyses at the rates identified above per event. To sample 50 events to monitor TP, TSS and TN would cost approximately $30,000. If heavy metals and pathogen indicators are added the cost would increase by another $35,000. Typical costs of analysing individual samples are shown in Table 2 while the overall estimated cost of monitoring is summarised in Table 3.

The total cost for the monitoring program would be in the order of $55,000 or $90,000 if heavy metals and pathogens were included.

**Table 2 Lab Analysis Costs**

| Parameter | Approximate Cost per sample |
|---|---|
| Total Phosphorous | $25 |
| Total Nitrogen | $30 |
| Total Suspended Solids | $20 |
| Faecal and Total Coliforms | $40 |
| Heavy Metals (Zn, Cd, Cu, Pb) | $50 |

**Table 3 Summary of Monitoring Costs for an individual treatment system**

| Item | Cost |
|---|---|
| Provision and management of two autosamplers and associated housing facility for six months | $10,000 |
| Provision and management of three flow measurement devices for six months | $5,000 |
| Collection of samples | $10,000 |
| Lab Analysis of TSS, TP and TN | $30,000 |
| Lab Analysis of heavy metals and pathogens (optional) | $35,000 |
| **TOTAL COST (excl heavy metals and pathogens)** | $55,000 |
| **TOTAL COST (incl heavy metals and pathogens)** | $90,000 |

## 3.5 Additional Monitoring Strategies

The following sections outline some simple monitoring activities which can be undertaken to confirm that stormwater treatment systems are operating as expected. These monitoring activities will not provide information on stormwater pollutant concentrations or loads, but will provide valuable information on the functioning of stormwater treatment systems. Each of these activities is relatively simple and cheap to undertake on site.

### 3.5.1 Monitoring Drawdown and soil sample – bioretention systems

For bioretention systems measuring the hydraulic conductivity through the filter media is a key parameter to monitor. Timing the drawdown of water in the extended detention after rainfall is a good indicator of hydraulic conductivity. This allows a quick and cost effective assessment of the overall hydraulic performance of the filter media.

Hydraulic conductivity can also be tested during dry weather with a standard method. Monitoring of the hydraulic conductivity of the soil involves measuring the length of time that ponding occurs on the surface of the bioretention system. This gives a measurement of the performance of the filter media and its hydraulic conductivity. Monash University has developed a simple test for in-situ hydraulic conductivity that involves drilling a 150mm diameter metal tube through the bioretention system, filling it with water and timing how long it takes to draw down (FAWB, 2008).

In the short term it is recommended to undertake this hydraulic conductivity testing

- immediately after construction
- monthly during the first wet season
- at the beginning and end of the first complete dry season

Over the long term it is recommended to do tests on a yearly basis.

A single measurement of the hydraulic conductivity would cost approximately $500 to $1,000. The test can be performed in the field with 2 people in half a day to a day, where the measurement is repeated at 5-10 locations within the treatment system. The materials to undertake the testing will cost less than

$100. The in-situ permeability testing could be feasibly undertaken by NRETAS or Council. Furthermore, this type of testing is of educational value to the wider community and allows the community to participate in the testing.

### 3.5.2 Monitoring water level variation– wetlands

For wetland treatment systems measuring the water level of the deep pools and seasonally inundated zone is a key parameter to understand the performance of the wetland treatment systems. Water level variation is a key variable in residence times, the selection of appropriate vegetation as well as in understanding the impact on mosquito breeding sites. Thus to better understand water level variation, monitoring is recommended.

Monitoring of the water level variation of the two regions of the wetlands involves measuring the depth of water in both the deep pools and in the seasonally inundated zone. To undertake this measurement simple water level recorders using a submersible pressure transducer and datalogger should be suitable. Monitoring over an hourly time step is likely to be sufficient although monitoring over a finer time step should be conducted if equipment capacity, especially data loggers, allow. Data should be collected as required by the data logger or at the end of the wet season and at the beginning of the dry season.

The installation of two water level recorders and data loggers and housing of the appropriate equipment will cost in the order of $10,000. To minimise cost the collection and handling of data should be undertaken in conjunction with water quality monitoring and other testing.

### 3.5.3 Monitoring permanent pool water quality during the dry season- wetlands

For wetland systems measuring the water quality of the deep pools is recommended to better understand the condition of the wetland treatment system during the dry season. Water quality of the deep pools is important in the design of the wetland – the deep pools provide a refuge for fish and other macroinvertebrates as well as submerged aquatic vegetation. Thus to better understand the state of the wetland during the dry season, monitoring during the dry season is recommended.

Monitoring of the deep pools' water quality involves taking grab samples and water quality measurements using water quality probes in the deep pools during the 6 months of the dry season (from May to October). A multi-purpose water quality probe(s) should monitor

- Electrical conductivity
- Temperature
- DO
- pH
- Turbidity (preferably)

Grab samples should monitor:

- TN, TP and TSS
- Chlorophyll a
- Mosquito Larvae
- Speciation of nitrogen and phosphorous (preferably)

Monitoring should be conducted on a fortnightly (preferably) or monthly basis. Preferably monitoring of both permanent pools would beundertaken. Handheld portable water quality probes are likely to cost in the order of $3,000 to 5,000. Lab analysis for one dry season will cost in the order of $3,000 to $5,000 including collection.

### 3.6 Water Quality Model Calibration

Monitoring is the first step in attempting to calibrate water quality models such as MUSIC. Due to the limited adoption of WSUD measures in the wet dry tropics there is a significant need for collecting locally relevant stormwater quality and stormwater treatment performance data to refine both the stormwater mean and standard deviation values and pollutant removal parameters that are currently adopted in MUSIC. While studies into stormwater runoff quality from urban areas have been undertaken (For example see Padovan (2001) and Townsend (1992)) there have been no laboratory or field studies on the performance of treatment systems in the wet/dry tropics in Darwin.

After monitoring has been undertaken it is recommended that water quality models be calibrated and updated to reflect the water quality treatment performance determined in the field. This will require statistical analysis of the data collected as well as calibration of the model to the data and satisfactory calibration results.

### 3.7 Mosquito Monitoring

The risk of WSUD treatment increasing mosquito breeding sites has been identified as a key technical barrier to the future adoption of WSUD in Darwin. Furthermore, the Bellamack area has been identified as an area with high existing uncontrolled mosquito breeding sites (Medical Entomology, 2008). Preliminary investigations by the Medical Entomology Unit (2008) have revealed a high prevalence of mosquito breeding sites for some species in the upper tidal area of Mitchell Creek and at stormwater discharge points into Mitchell Creek as well as unmaintained silt traps on the edge of Mitchell Creek.

Monitoring of mosquitoes is recommended to increase understanding and knowledge of impact of WSUD options on mosquito populations and to also assist in the design of WSUD systems to minimise and reduce the prevalence of mosquito breeding sites.

Currently there are 5 ovitraps in Palmerston which are monitored fortnightly for mosquito larvae and eggs and three adult monitoring stations in Palmerston. These are shown in Figure 2. The Darla Estate monitoring station is the only station which is in close vicinity to Bellamack.

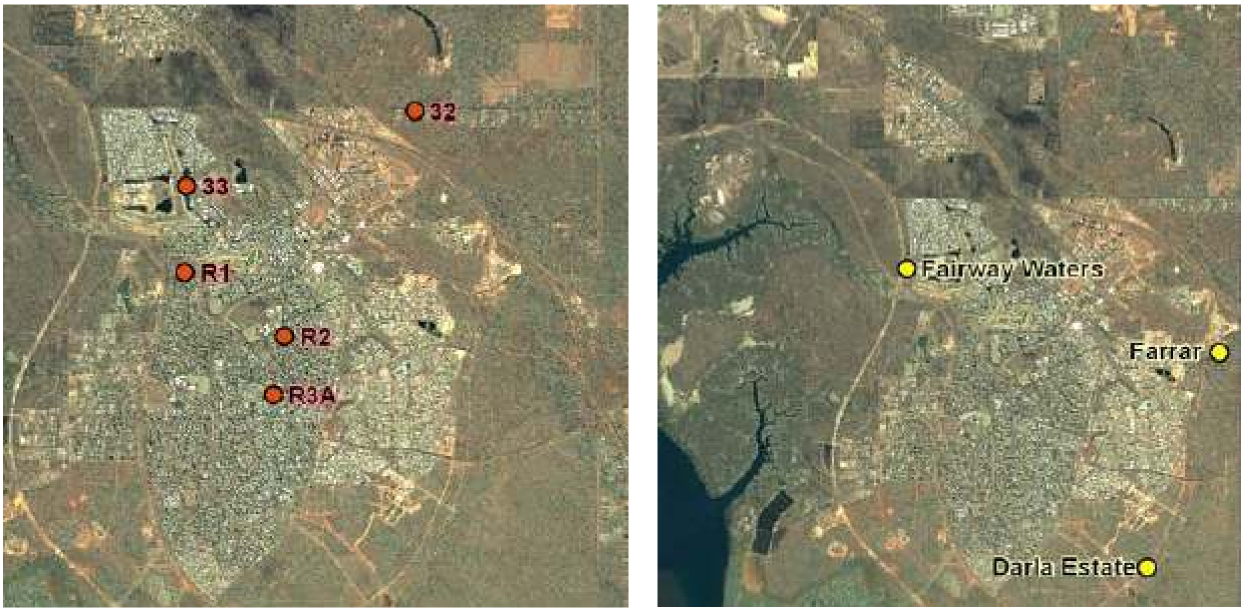


**Figure 2: Location of ovitrap stations (red) and adult mosquito monitoring stations (yellow) in Palmerston**

To monitor the impact of mosquitoes it is recommended to utilise the existing monitoring stations, especially R3A and R2 and Darla Estate, in Palmerston to determine any changes after the development of the Bellamack WSUD systems. It is also recommended to install a new ovitrap and adult monitoring station in the area of Bellamack to monitor changes pre and post development. The existing and new stations should be used to compare mosquito populations and numbers and temporal distribution of mosquito numbers.

# 4 INSTITUTIONAL ARRANGEMENTS

## 4.1 Agency responsibility

The monitoring of the performance of WSUD treatment measures is of key importance to the NT Government agencies of Department of Planning and Infrastructure and Department of Natural Resources, Environment, The Arts and Sport. Both agencies therefore share responsibility for the development of the monitoring strategy, implementation of the monitoring strategy and analysis and evaluation of the monitoring strategy.

NRETAS has key technical skills, expertise and equipment all of which are key requirements to a successful monitoring program. Furthermore NRETAS has good back-end support systems including information databases tailored to storing water data of a time series nature. Based on this expertise it is recommended that NRETAS play a key role in facilitating and implementing the technical components of the monitoring strategy.

DPI has key influence in the strategic release and sustainable long term use and development of land in the NT. DPI plays a key role in ensuring that land release occurs in an environmentally responsible way through planning and site analysis. Furthermore DPI works closely with the land developer and as part of its commitment to sustainable long term land use has secured a commitment for the land developer to implement WSUD as part of the Bellamack land release. DPI thus has a strong interest in contributing resources, in kind and other contributions, to ensure that the intent of its requirement for WSUD is being met.

A secondary agency which has interest in undertaking monitoring of the WSUD systems is the Medical Entomology Unit in the Centre for Disease Control within the Department of Health and Families. The Medical Entomology Unit has key technical skills and equipment required to carry out surveillance and monitoring of mosquitoes and biting midges. Based on this expertise it is recommended that the Medical Entomology Unit play a key role in implementing the technical components of the mosquito and biting midges monitoring strategy. However it should be noted that the Medical Entomology Unit (2008) has identified the lack of comprehensive survey and control operations for Palmerston with insufficient resources to undertake the work required as one of its most important ongoing issues.

## 4.2 Monitoring Program Timing

Water quality monitoring cannot be undertaken until the treatment systems are constructed. It is expected that construction in Bellamack will begin in 2009. In the early stages of the construction, key components of the WSUD treatment systems will be constructed (civil works, bulk excavation and earth movement). However to protect the WSUD systems from sediment and erosion impacts during the construction period the WSUD systems will not be fully functional until after the majority (greater than 75%) of the construction has finished. Thus the treatment systems may not be fully operational until late 2010 or early 2011.

The medical entomology unit undertook detailed monitoring for biting insects for Bellamack and Palmerston Eastern Suburbs. This data and any subsequent future monitoring data collected over the next few years will provide a baseline for comparison of biting insect populations pre and post development. The Medical Entomology Unit should be supported in its collection of this data to ensure high quality data is available.

## 4.3 Data Storage and Reporting

NRETAS operate and maintain a water resource database which contains information on rainfall, river levels and flows, groundwater levels and water quality. Information in the field from field notes, data loggers and telemetry sites is transferred to the Hydstra database. Some information is also transferred into NRETA Maps which is available via the internet. Hydstra has data and graphical reporting functions.

It is recommended to utilise this existing database information storage system to store information collected from monitoring treatment systems in Bellamack. To minimise issues with data transferability any data logging equipment needs to be compatible and standardised with data collection and storage requirements of NRETAS' Hydstra database.

This data should be accessible to other NT Government departments and reporting on the performance of the treatment systems should be made available to the public.

## 4.4 Regional Partnerships

It is strongly recommended that this project form part of a longer term program and pool information with other monitoring projects being undertaken by both the NT Government and other projects focussing on the tropics such as the Creek to Coral water management in the dry tropics project in northern Queensland. This is recommended due to the synergies of sharing data and knowledge and reducing overall costs associated with monitoring and calibration of data. The pooling of information between projects will benefit both projects focussing on urban water management in tropical environments. Universities and organisations that are currently undertaking this work and similar assessments could also from part of this collaborative effort.

# 5 REFERENCES

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## Appendix A

Bellamack Plan of Treatment Systems

Elrundie Wetland Monitoring Points

Owston Bioretention System Monitoring Locations

# Appendix B – Hydrographic Gauging Station Scoping Document