



MILDURA RURAL  
CITY COUNCIL

# WATER SENSITIVE URBAN DESIGN GUIDELINES

# **Mildura Rural City Council - Water Sensitive Urban Design Guidelines**

**8 August 2005**

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**Mildura Rural City Council**

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# **1. Introduction**

## **1.1 Background**

Water Sensitive Urban Design (WSUD) is a relatively new approach to water management in urban areas. The objective of WSUD is to maintain or replicate the pre-development water cycle through the use of design techniques to create a functionally equivalent hydrological landscape. When urban development occurs, the natural water cycle is altered to the extent that stormwater runoff from individual properties and roads intensify, flows usually increase and potential contaminants from residential and commercial activity and associated vehicle use flow into the streams and watercourses. Traditionally stormwater generated from urban areas is conveyed efficiently to designed trunk drainage systems to reduce stormwater ponding and flooding risk. The effect of this type of water management approach on natural systems has in the past included:

- the intensification of flows in watercourses potentially resulting in stream bank erosion and sedimentation
- an increase in contamination of receiving aquatic environments resulting in generally adverse impacts on aquatic ecosystems
- an increase in the use of water resources for domestic, commercial/industrial uses as well as outdoor irrigation of gardens and open space areas
- an increased tendency for more severe flooding and increased areas of flooding.

The importance of increasing the use of WSUD has been recognised by Mildura Rural City Council with growing acceptances of the longer-term environmental benefits of the application of WSUD principles. However, implementation of WSUD has been limited in the past due to the lack of understanding of WSUD measures available and suitable to the Mildura region as well as a lack of established procedures, standards and approvals within the council. This creates a perception that there are unacceptable risks involved in approving alternative approaches to water management.

In order to encourage WSUD implementation in the Mildura region this document aims to provide WSUD best management practice design specifications for a diverse range of WSUD measures at the subdivision and allotment scales. The WSUD measures provided in this document are based upon innovative WSUD methods which have proven environmental, aesthetic and economic outcomes and are applicable to the local environment of North Western Victoria. It should be noted, however, that the WSUD design specifications provided is not an exhaustive list of all possible WSUD measures that could be used in urban development. Nonetheless, the specifications do include those measures that are most likely to be used in the Mildura region.

The appropriate WSUD measures, procedures and products are generally well known, even though ongoing research is providing additional information. The challenge is to gain broad-based acceptance and application of WSUD. This requires a greatly increased level of awareness and understanding of the techniques involved. This

document is aimed at achieving broad application of WSUD measures by providing best practice design specifications for a number of those measures.

## 1.2 What is WSUD

WSUD is the integration of various Best Planning Practices (BPPs) and Best Management Practices (BMP) for the sustainable management of the urban water cycle. WSUD is concerned with the design of urban environments to be more “sustainable” by limiting the negative impacts of urban development on the total urban water cycle. Therefore WSUD is about:

- trying to more closely match the pre-development stormwater runoff regime, in both quality and quantity
- reducing the amount of water transported between catchment, both in water supply import and wastewater export
- optimising the use of rainwater that falls on the urban areas.

There is a wide range of approaches to WSUD, however the most commonly implemented is the improvement of stormwater management. Other approaches include management of water at the household scale such as the collection and use of rainwater from rooftops and water efficient landscape design. The key principles of WSUD as presented in the Urban Stormwater: Best Practice Environmental Management Guidelines (Victorian Stormwater Committee, 1999) are:

1. Protect natural systems (creeks, rivers and wetlands) within urban catchments.
2. Protect water quality by improving the quality of stormwater runoff draining from urban developments.
3. Integrate stormwater treatment into the landscape by using stormwater treatment systems in the landscape that incorporate multiple uses providing a variety of benefits such as water quality treatment, wildlife habitat, public open space, recreational and visual amenity for the community.
4. Reduce runoff peak flows from developments by on-site temporary storage measures (with potential for reuse) and minimise impervious areas.
5. Add long-term value while minimising development costs.
6. Reduce potable water demand by using stormwater as a resource through capture and reuse for non-potable purposes.

WSUD applications can be sized to suit most individual sites from residential house blocks through to whole subdivisions. However, appropriate planning and design are required to ensure successful outcomes. The range of applications available may be applied in the following areas:

- new road/street in large or small development areas
- existing streets and roadways



- upgrade of drainage systems or pavements
- publicly owned land
- new residential developments
- existing residential developments, redevelopments and infill areas
- commercial or industrial developments
- carparks/driveways/access ways on public or private property.

It should be noted that WSUD measures cover a range of disciplines and therefore a multi-disciplinary team approach is required to promote urban design which integrates best practice water planning and management measures with attractive streetscapes and open spaces. This integration can create attractive and sustainable urban landscapes that can provide developers with a marketing advantage.

### **1.3 Proponent of the guidelines**

This document has been prepared by Parsons Brinckerhoff Australia (PB) for the Mildura Rural City Council. The Council is working to promote WSUD in the Mildura region.

Mildura Rural City Council have produced a Management Plan for the Improvement of Urban Stormwater Quality. This plan has identified a series of management strategies for Council to meet its corporate vision of a healthy and sustainable natural environment.

Following the endorsement of the plan by Council and its various stakeholders in conjunction with the Sunraysia Drainage Strategy, funds were accessed through the Victorian Stormwater Action Program to implement strategies outlined in the plan.

Mildura Rural City Council seeks to be a regional leader in Stormwater management by working in partnership with authorities, developers, and other stakeholders to improve the quality, efficiency, and reuse of water, in residential and industrial developments.

Council aims to find ways to bring consideration of the water environment and infrastructure service design along with management opportunities earlier into the decision making processes associated with urban planning and development design.

Mildura Rural City Council has adopted the recommendations of the Management Plan for the Improvement of Urban Stormwater. The plan contains a number of Reactive Management Strategies to address the priority management issues. Objective A 8.3 states:

Determine applicability of different Water Sensitive Urban Design (WSUD) principles given unique characteristics in Mildura for all new developments (eg detention systems, re-use for watering, swales etc) and require adoption of appropriate WSUD principles for new development through reference to appropriate guidelines eg Best Practice Environment Management Guidelines.

## 1.4 Purpose and use of the guidelines

The WSUD Technical Guidelines, incorporating the WSUD Design Specifications, are intended to provide information for those proposing development within the Mildura Rural City Council Local Government Area, however they are also applicable to areas in North Western Victoria, South Western New South Wales and some areas of South Australia. The Guidelines explain how best to incorporate and design WSUD measures into urban developments. It provides guidance to councils, master planners, developers and builders through provision of best management practice design specifications for a number of WSUD measures suitable for application in the Mildura area. It does provide guidance on water quality or quantity targets, however, such targets should be confirmed with the Council or regulatory authority.

## 1.5 Melbourne Water WSUD Engineering Procedures – Stormwater

This document is intended not to replace but be used in conjunction with WSUD Engineering Procedures –Stormwater, published by Melbourne Water. This document is aimed at providing an overview of the current best practice in the management of urban stormwater quality in Victoria and guidelines to the following:

- procedures for the estimation of a range of urban stormwater contaminants
- design of stormwater quality improvement measures
- procedure for the estimation on performance of stormwater quality improvement measures
- development of an integrated urban water cycle management strategy.

## 1.6 Document structure

The technical guidelines are organised in the following sections:

<b>Section 2</b>	Physical Characteristics in the Mildura Region
<b>Section 3</b>	WSUD Measures and Applications
<b>Section 4</b>	WSUD Planning and Selection Guide
<b>Section 5</b>	WSUD Design Specifications
<b>Section 6</b>	WSUD Operation and Maintenance
<b>Section 7</b>	Life Cycle Costs for WSUD Measures

## 2. Key physical characteristics affecting WSUD in the Mildura Region

The key physical factors that affect the function, design and performance of WSUD measures in the Mildura Region are:

- climate
- geology and soils
- groundwater/salinity
- catchment water quantity and quality objectives.

### 2.1 Climate

#### 2.1.1 Rainfall

The annual average rainfall total of 289mm is fairly evenly distributed through the year, but is more concentrated in the winter and spring months. The month of October is, on average, the year's wettest, receiving 31mm, by contrast the year's driest months, March and April, receive only 19mm.

Spring and summer are when thunderstorms are most frequent, 9 of the year's 12 storms occurred during these seasons. By contrast, on average a thunderstorm affects Mildura only once every winter.

Included in Chapter 5 are charts modified to establish sizing criteria for each WSUD measure. These charts are presented in a similar format to those in the Melbourne Water WSUD Engineering Procedures manual. They have been recalculated as per the procedure outlined in Appendix A to be specific for the Mildura region. These graphs can be used in lieu of the regional sizing criteria detailed in the WSUD Engineering Procedures manual.

**Table 2.1: Average rainfall figures**

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Average (mm)	20.7	21.2	18.2	18.5	26.3	23.2	26.3	27.6	28.2	31.0	23.9	23.8
Mean number of raindays	3.6	3.2	3.4	4.2	6.9	7.8	9.3	9.2	7.6	7.2	5.6	4.3

## 2.1.2 Evaporation

Annual average evaporation in the Mildura region is over 2100mm per year.

The Table 2.2 breaks down the evaporation into monthly and daily averages.

**Table 2.2: Average evaporation figures**

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Average (mm)	325.5	274.4	229.4	138.0	80.6	54.0	62.0	89.9	132	198.4	255.0	313.1
Daily Average (mm)	10.5	9.8	7.4	4.6	2.6	1.8	2.0	2.9	4.4	6.4	8.5	10.1

The amount of evaporation compared to rainfall during the summer and autumn months indicates extended dry periods.

## 2.2 Geology

There are several geological formations and soil types within the Mildura Rural City Council's region. These geological formations and soil types are delineated into distinct groups.

### 2.2.1 Geological formations

The Woorinen geology formation is located in the northern area of the Mildura Rural City Council's boundary. The soil formation in this area is predominantly aeolian deposited dune sands and calcareous clayey palaeosols.

Lowan geology formation is located in the southern area of Council's region. The soils in this area are typically aeolian deposited dune sands with a grading classified as fine to medium grained.

However geology and soil types are not limited to these geology formation and soil types. Along the Murray River the Blanchetown clay geology formation is quite prominent. The soil deposits in this area are predominantly fluvial and lacustrine clays, sands and sandy clays.

Other smaller deposits of Yamba, Paludal and Parilla sand, formations are located in isolated regions within the council's jurisdiction. Soils in the Yamba formations are aeolian deposits of sand, silts and clays. In the location of Parilla sands formation soils are made up of marine sands and silts. The Paludal geology region is made up of lagoon and swamp soil deposits of silt and clays.

### 2.2.2 Soils

Soil types in the Mildura Rural City Councils jurisdiction vary and include Vertosols, Calcarosols, Sodosols, Hydrosols and Sandy soils. The following is an explanation of the properties of each soil type:

Vertosols soils are cracking clay soils that display significant shrinking and swelling during wetting and drying cycles. Vertosols occur on alluvium and associated lake bed deposits; along creeks and rivers, and on broad low-lying plains in the northern Mallee. (Department of Primary Industries (DPI), 2005).

Calcarosols soils are formed on calcareous aeolian sediments of variable texture in the Mallee generally has a small, gradual increase in clay content with depth. Lime is abundant in the subsoils, either in soft form, in nodules or sometimes as blocks, and it may extend to the surface of medium to heavy textured soils. The Calcarosols in the councils region vary quite considerably in terms of soil texture - ranging from those dominated by sands to those that are clayey throughout (DPI, 2005).

Sodosols have a strong texture contrast between loamy surface horizons and clayey subsurface horizons. The subsoils are sodic (ie. exchangeable sodium percentage (ESP) is 6 or greater) and not strongly acid (ie. pH 5.5 or greater). Sodosols can be separated on the basis of the colour of the upper 20 cm of the subsoil into Red, Brown, Yellow, Grey and Black groups. In the Mallee region, Red Sodosols are the most common. Red Sodosols with loamy surface horizons abruptly overlying red sodic clays occur on older alluvial terraces which have been capped with clayey aeolian sediments. In the southern Mallee, Sodosols are found near creeks and rivers (often in areas where the original vegetation of grassy Casuarina woodlands contrasts with the surrounding Mallee scrub). Erosion has frequently removed the surface horizons to expose red, somewhat saline clays that seal over on wetting (DPI, 2005).

Hydrosols occur naturally in low-lying parts of the central and northern Mallee region, where saline regional groundwater's outcrop. Surfaces are variably saline, depending largely on depth to the watertable. Soils which are saline to the surface are commonly red clay loams overlying gypsum (DPI, 2005).

Sandy Soils are widespread within the council region. The sandy soils include Tenosols and Rudosols. Tenosols are weakly developed soils, whilst Rudosols display minimal development and tend to be younger (DPI, 2005).

### **2.2.3 Recommendations**

The effects of these soil types within the council's area can have implications on the design of water quality treatment facilities. In the design of water quality treatment facilities within the Council boundaries designers should be mindful of the properties of different soil types within the area and the following should be considered in the design of treatment measures:

#### **2.2.3.1 Soil permeability**

In minimising water loss by infiltration into the underlying soils, it may be necessary that wetlands ponds and lakes be clay lined.

Bio-retention basins or swales may also require the use of liners to prevent ex-filtration into the surrounding soils

With a more permeable underlying soil, the potential for pondage areas in swales and buffers with flat longitudinal grades (ie less than 1% grade) will be decreased.

### 2.2.3.2 Dispersive soils

In areas of dispersive soils some consideration may need to be taken to adequately treat dispersive soils prior to use in treatment facilities such as wetlands, ponds and lakes. The use of dispersive soils in these applications can lead to highly turbid water. However the treatment of dispersive soils with gypsum can help reduce the dispersion of such soils.

### 2.2.3.3 Stability of soils

Soils with low cohesive properties can lead to structural instability when used for construction of earth structures or embankments. Structural stability of less cohesive soils can be improved by mixing them with clayey soils.

Seepage through highly permeable soils can also lead to structural instability in their application in earth structures or embankments. Seepage must be managed to ensure that flow paths through the material do not lead to structural instability and slumping.

### 2.2.3.4 Soils ability to sustainability plant growth

Plant selection for use in soils which are acidic, sodic or saline can be crucial in ensuring the long term sustainability of plants within stormwater treatment facilities. Water Sensitive Urban Design (WSUD) Engineering Procedure Manual (2004) provides suggested plant species for saline areas.

## 2.3 Groundwater/salinity

Regional studies including geotechnical investigations and hydrogeological studies have identified two groundwater systems either present in the area or that have the potential to develop. These are the deeper regional groundwater system that underlies the whole Mildura area, and localised shallow perched groundwater, which can develop on top of a low permeability clay layer, where this is present in the soil profile.

**Regional groundwater:** The geology of the Mildura area consists of about 2.0 m of Woorinen Formation surficial soils overlying up to 20 m of the very low permeability Blanchetown Clay. The Blanchetown Clay acts as a confining layer to groundwater in the underlying Parilla Sands. The standing groundwater level in deep groundwater monitoring wells represents the potentiometric level of this confined groundwater in the Parilla Sands aquifer (Gallasch, 2003).

**Perched groundwater:** In areas where a low permeability clay horizon is present in the soil profile, excess water can accumulate on top of the clay, causing a perched groundwater table to develop. Subsurface clay occurs extensively throughout the Mildura area. This clay varies 1.5 to 2.5 m below the surface (REM Figure 5). The development of a shallow perched groundwater watertable has been managed in the past by the use of tile drainage beneath irrigated vineyards and orchards.

Any WSUD treatment technique has to consider the effect of any infiltration on both the perched groundwater as well as the regional groundwater. Any detention basin or excavation within new and existing developments should not penetrate the clay layer as

regional groundwater incursion into the upper soil profiles could create more salinity issues.

Consideration will be given to using the relative impermeable clay soil layers as a base to any WSUD treatment system as long as it can be proven that the technique shall not adversely impact the local perched groundwater or the deeper regional system.

### 2.3.1 Salinity risk assessment and mapping

A risk assessment tool has been developed by REM, to characterise future urban areas according to their potential to develop shallow groundwater watertables, which would result in the salinisation of the surface soils, affecting vegetation and infrastructure. The level of risk is considered to range from low to very high according to the potential for shallow regional groundwater and/or perched groundwater to impact on urban development. REM defined the five levels of risk as follows (from Final Report – Site Salinity Management Plan, 5 August 2004):

**Low:** Groundwater below the threshold of 4 m below ground level and a clay layer does not occur shallower than 4 m below ground level. The risk of salinisation is low.

**Moderate:** Groundwater is below the threshold of 4 m below ground level and a clay layer is present in the upper 4 m of the soil profile. While the regional groundwater is not a concern in these areas, there is a potential for a perched watertable to develop on top of the clay layer, presenting a considerable hazard to urban development. Actions to manage groundwater are recommended, including the installation of subsurface drainage systems.

**High (a):** Groundwater is 2 – 4 m below ground level and the clay does not occur shallower than the 4 m threshold for perched groundwater potential. In these areas groundwater is within the zone of concern for urban development.

**High (b):** Groundwater is 2 –4 m below ground level and clay is present in the upper 4 m of the soil profile, with a potential for development of a perched watertable.

In both categories of high risk potential, regional groundwater is within the zone of concern for urban development and although not currently causing salinisation, poor water management could rapidly cause the onset of saline conditions. Actions to manage groundwater are essential.

**Very high:** Groundwater is less than 2 m below ground level, which is an immediate threat to urban development, and some land may already be salinised. No urban development should be permitted in these areas.

Each of these risk levels has a number of associated recommended specific salinity risk management actions that can ensure that urban development will not be adversely impacted in the future both onsite and offsite. Of particular relevance, it is recommended that in areas of high risk, the development of irrigated areas such as sports fields or parklands or water features in the form of lakes or wetlands, that involve the retention of water, be avoided.



## 2.4 Stormwater management objectives

### 2.4.1 Construction phase

The primary stormwater issue during the construction phase of new development is sediment eroded from exposed areas or flow paths, which lead to elevated levels of sediment and turbidity in stormwater discharges from the site (see Figure 2.1).



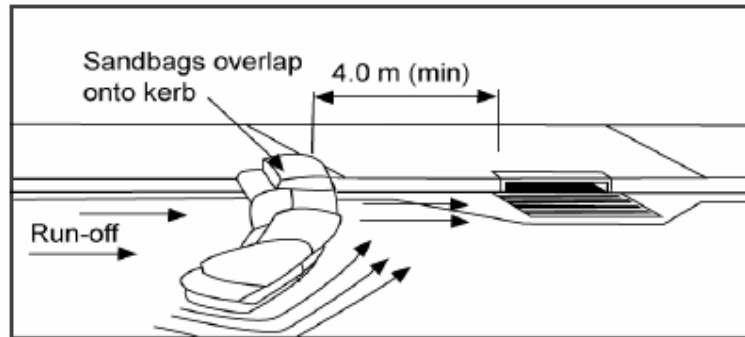
**Figure 2.1: Poorly maintained nature strip resulting in erosion of materials onto road surface.**

The current best practice performance objective (Stormwater Committee, 1999) requires a median Total Suspended Solids (TSS) concentration of 50 mg/l and prevention of litter entering the stormwater system. These objectives can be met by treatment of 90 percent of daily flows (up to the 4 month ARI event). Construction phase treatment devices that are effective measures to reduce sediment (TSS) include:

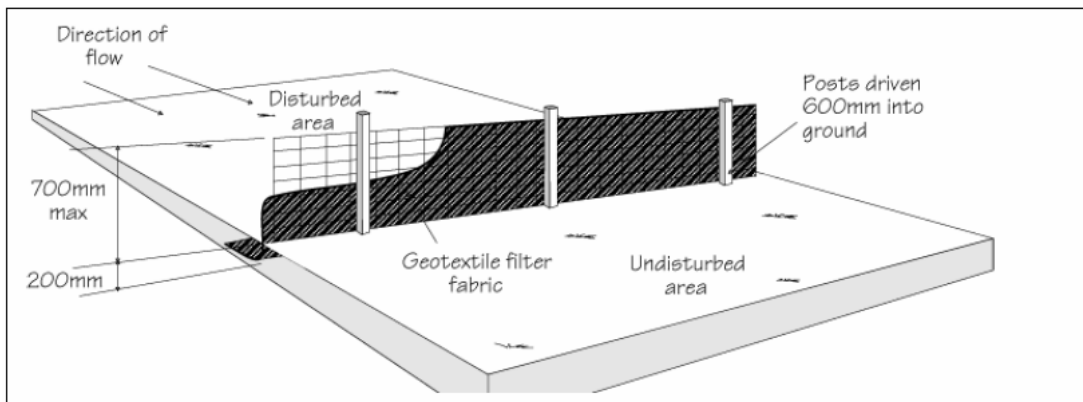
- sediment (silt) fences around areas where direct surface runoff can occur (see Figure 2.3)
- silt sausages (silt bags) in the kerb or at side entry pits (see Figure 2.2)
- hay bales in open drains (see Figure 2.4).

A construction phase stormwater management plan should be prepared by the contractor prior to the commencement of construction. The construction phase stormwater management plan should identify entry locations to the stormwater system, locations of stockpiles and sediment control measures.

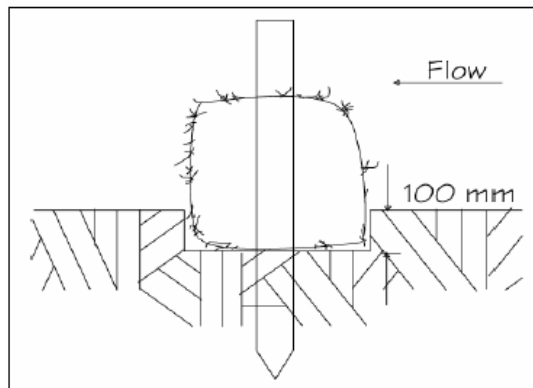
Secondary issues include chemicals (including fuels and oils) stored on site and litter generated by construction activities. Other Council programmes are in place to address the secondary issues within the municipality.



**Figure 2.2: Sediment sausage (Energex, 2002)**



**Figure 2.3: Sediment fence (Energex, 2002)**



**Figure 2.4 Sediment hay bale (Energex, 2002)**

## 2.4.2 Post-construction phase

Different types of land use typically generate specific stormwater pollutants in significant quantities. Consequently, the 'key' pollutants to be addressed from new development, and the control techniques employed, are a function of the type of development. Table 2.3 ranks the significance of pollutants likely to be generated by different land uses.

**Table 2.3: Ranking of objectives for new developments**

Development Style	Litter	Coarse sediment	Fine particles	Total phosphorus	Total nitrogen	Hydrocarbons, motor fuels, oils and grease
<b>Low Density Residential</b>	N	Y	Y	Y	Y	N
<b>High Density Residential</b>	N	Y	Y	Y	Y	?
<b>Commercial, Shopping &amp; Retail Outlets (excluding carparks)</b>	Y	Y	Y	N	N	N
<b>Industrial</b>	Y	Y	Y	?	?	Y
<b>Fast Food Outlets and Restaurants</b>	Y	N	N	N	N	?
<b>Carparks, Service Stations and Wash Bays</b>	Y	Y	Y	Y	?	Y

Key: Y – key pollutant – needs to be addressed

? – variable – requires site-specific assessment

N – not significant

The environmental objectives of the State Environmental Protection Policy (SEPP) define the required water quality conditions of urban waterways. The current Best Practice Environmental Management Guidelines (BPEMG) objectives are given in Table 2.4.

**Table 2.4: Post construction BPEMG objectives**

Pollutant	% Retention of typical urban annual load				Flows
	TSS	TP	TN	Litter*	
<b>BPEMG Objective</b>	80	45	45	70	Maintain discharges for the 1.5 year ARI at pre-development levels

\* Litter is defined as anthropogenic material larger than five millimetres

## **3. WSUD measures and application**

### **3.1 WSUD measures**

This section provides general information on various WSUD measures in terms of their application, limitations, pollutant removal efficiency and construction issues, to enable designers, engineers and planners to better understand the function of each WSUD measure and its role in the treatment train. The WSUD measures discussed in this section and for which design specifications have been prepared are:

- Bioretention Swales
- Bioretention Basins
- Sand Filters
- Vegetated Swales / Filter Strips
- Constructed Wetlands
- Rainwater Tanks.

The WSUD measures listed were chosen as they represent the key fundamental WSUD measures that are currently used in best management WSUD practices in both building and sub-division designs within the Mildura region. Other treatment techniques will be considered in the appropriate context with sufficient information to prove the long term viability of the treatment system.

Primary treatment WSUD measures, such as litter traps and gross pollutant traps (GPTs), have not been included in this document, as there are numerous proprietary manufactured devices that are currently available that provide detailed technical design manuals and guidelines. If further information is required on the design and selection of appropriate traps, refer to EPA (1997) and WBM (2003).

### **3.2 Relationship between WSUD measures**

WSUD treatment measures can be grouped into three main categories:

- Primary
- Secondary
- Tertiary.

The definition of these categories are provided in the Victorian Stormwater Committee: Urban Stormwater – Best Practice Environmental Management Guidelines, (Victorian Stormwater Committee, 1999) and typical WSUD measures appropriate to each category for Mildura are summarised in Table 3.1 below

**Table 3.1: WSUD Treatment Categories**

Category	Definition	Typical Pollutant Treatment	Typical WSUD Measures
<b>Primary</b>	Physical screening or rapid sedimentation techniques	Gross pollutants and litter, coarse sediments, free oil/grease	Gross pollutant traps (GPT's), sediment traps, oil/grit separators
<b>Secondary</b>	Finer particle sedimentation and filtration techniques	Fine particles and attached pollutants	Sand filters
<b>Tertiary</b>	Enhanced sedimentation and filtration, biological uptake, absorption onto sediments	Nutrients and heavy metals	Constructed wetlands, bioretention systems, natural stream systems

The restoration of natural features in the hydrological system is a fundamental element of WSUD philosophy. To achieve this, a series of control measures can be incorporated into the urban hydrological system at four control levels. Table 3.2 outlines the WSUD measures that can be applied to each of the four levels.

**Table 3.2: WSUD Treatment Categories for Mildura**

Level	Description / location	Typical WSUD Measures
<b>Source control</b>	Individual allotment	Rainwater tanks
<b>Conveyance control</b>	Street or nature strip	on-line bioretention systems
<b>Discharge control</b>	Discharge from subdivision to Council system	Bioretention basins, sand filters, constructed wetlands, detention ponds
<b>Natural systems</b>	Receiving streams, lakes or rivers	Natural water courses, creeks, floodplains, wetlands and vegetation

Due to the sensitive environments to which drainage flows discharge, the use of natural systems to treat stormwater runoff is not recommended. Other treatments exist within each of the four control levels that are considered not appropriate for the Mildura environment.

If detention basins are to be incorporated into the stormwater system for a subdivision then treatments which can be included in this function or that can reduce the size of the basin should be considered. The reduction of detention basin size with an improved stormwater quality discharge is beneficial to the developer as well as the MRCC.

### 3.3 Description of WSUD measures and implementation issues

Each section below reflects Chapter 3 of the Melbourne Water Draft WSUD Engineering Procedures dated June 2004. They should be read in conjunction with the Melbourne Water procedures and other relevant documents.

Users of this manual should make themselves aware of the design procedures involved with each of the WSUD elements and to ensure they consider the advantages and disadvantages between different elements in the Mildura region.

The discussion below outlines the relevant merits of the recommended systems for the Mildura Region..

### **3.3.1 Bioretention swales**

Bioretention swales (or biofiltration trenches) are bioretention systems that are located within the base of a swale. They can provide efficient treatment of stormwater through fine filtration, extended detention and some biological uptake as well as providing a conveyance functions (along the swale). They also provide some flow retardation for frequent rainfall events and are particularly efficient at removing nitrogen and other soluble or fine particulate contaminants.

Bioretention swales can form attractive streetscapes and provide landscape features in an urban development. They are commonly located in the median strip of divided roads.

Runoff is filtered through a fine media layer as it percolates downwards. It is then collected via perforated pipes and flows to downstream waterways or to storages for reuse. Unlike infiltration systems, bioretention systems are well suited to a wide range of soil conditions including areas affected by soil salinity and saline groundwater as their operation is generally designed with impermeable layers to eliminate the likelihood of stormwater exfiltration from the filtration trench to surrounding soils.

In Mildura and surrounding areas the construction of such swales would assist in the reduction of nutrients entering receiving waterways. The limitations on constructing such systems relate to the initial installation and maintenance with possible degradation due to wind blown or washed sediment smothering plant life and filters during the establishment of houses in the subdivisions.

Vegetation that grows in the filter media enhances its function by preventing erosion of the filter medium, continuously breaking up the soil through plant growth to prevent clogging of the system and providing biofilms on plant roots that pollutants can adsorb to. The type of vegetation varies depending on landscape requirements and climatic conditions. The filtration process generally improves with denser and higher vegetation.

With low annual rainfall in Mildura watering of plants would be required during establishment.

Some thought is required during the masterplanning of subdivisions to reduce or eliminate driveway crossings of the swales. Although they can be accommodated within the swale the added maintenance and debris collection can become an eye sore.

Education of residents within the subdivision is required to ensure that activities do not damage the swale structure.

### **3.3.2 Bioretention basins**

Bioretention basins operate with the same treatment processes as bioretention swales except do not have a conveyance function. High flows are either diverted away from a basin or are discharged into an overflow structure.

Like bioretention swales, bioretention basins can provide efficient treatment of stormwater through fine filtration, extended detention and some biological uptake, particularly for nitrogen and other soluble or fine particulate contaminants.

Bioretention basins have an advantage of being applicable at a range of scales and shapes and can therefore have flexibility for locations within a development. They can be located along streets at regular intervals and treat runoff prior to entry into an underground drainage system, or be located at outfalls of a drainage system to provide treatment for much larger areas (eg. in the base of retarding basins).

A wide range of vegetation can be used within a bioretention basin, allowing them to be well integrated into a landscape theme of an area. Smaller systems can be integrated with traffic calming measures or parking bays, reducing their requirement for space. They are equally applicable to redevelopment as well as greenfield sites.

As with bioretention swales the establishment of vegetation is critical to ensure long term viability. The limiting of sediment loads to the basins is critical to ensure smothering of filters do not occur.

### **3.3.3 Sand filters**

Sand filters operate in a similar manner to bioretention systems with the exception that they have no vegetation growing on their surface. This is because they are either installed underground (therefore light limits vegetation growth) or the filter media does not retain sufficient moisture. They are particularly useful in areas where space is a premium and treatment is best achieved underground. Due to the absence of vegetation, they require regular maintenance to ensure the surface of the sand filter media remains porous and does not become clogged with accumulated sediments.

Prior to entering a sand filter, flows are generally subjected to a pretreatment to remove litter, debris and coarse sediments (typically a sedimentation chamber). Following pretreatment, flows are spread over the sand filtration media and water percolates downwards to perforated pipes located at the base of the sand media. The perforated pipes collected treated water for conveyance downstream. During higher flows, water can pond on the surface of the sand filter increasing the volume of water that can be treated. Very high flows are diverted around sand filters to protect the sand media from scour.

The absence of vegetation allows the filter to work in low rainfall areas such as Mildura. The maintenance required to ensure surface remains porous is critical to the success of the treatment system.

A sand filter may be incorporated into the base of a retarding basin with appropriate flow diversion structures to direct treatable flows through the filter and to direct major flows away from the filter into the basin.



### **3.3.4 Vegetated swales / filter strips**

Vegetated swales are used to convey stormwater in lieu of pipes and provide a desirable 'buffer' to the receiving water (eg. creek, wetland) from impervious areas of a catchment. They use overland flows and mild slopes to slowly convey water downstream. The interaction with vegetation promotes an even distribution and slowing of flows thus encouraging coarse sediments to be retained. Swales can be incorporated in urban designs along streets or parklands and add to the aesthetic character of an area.

The longitudinal slope of a swale is the most important consideration. They generally operate best with slopes of 2% to 4%. Milder sloped swales can tend to become waterlogged and have stagnant ponding, although the use of underdrains can alleviate this problem. For slopes steeper than 4%, check banks along swales can help to distribute flows evenly across swales as well as slow velocities. Dense vegetation and drop structures can be used to serve the same function as check dams but care needs to be exercised to ensure that velocities are not excessively high.

Swales can use a variety of vegetation types. Vegetation is required to cover the whole width of a swale, be capable of withstanding design flows and be of sufficient density to provide good filtration. For best treatment performance, vegetation height should be above treatment flow water levels. If runoff enters directly into a swale, perpendicular to the main flow direction, the edge of the swale acts as a buffer and provides pre-treatment for the water entering the swale.

The limitations on installing vegetated swales are per the bioretention trenches as a lot of the same issues apply. Short vegetated swales could be used in low density residential areas to treat individual allotment runoff.

### **3.3.5 Constructed wetlands**

Constructed wetland systems are typically shallow extensively vegetated water bodies that use enhanced sedimentation, fine filtration and pollutant uptake processes to remove pollutants from stormwater. Water levels rise during rainfall events and outlets are configured to slowly release flows, typically over three days, back to dry weather water levels. Wetlands generally consist of an inlet zone (sediment basin to remove coarse sediments), a macrophyte zone (a shallow heavily vegetated area to remove fine particulates and uptake of soluble pollutants) and a high flow bypass channel (to protect the macrophyte zone).

Wetland processes are engaged by slowly passing runoff through heavily vegetated areas. Plants filter sediments and pollutants from the water and biofilms that grow on the plants can absorb nutrients and other associated contaminants. In addition to playing an important role in stormwater treatment, wetlands can also have significant community benefits. They provide habitat for wildlife and a focus for recreation, such as walking paths and resting areas. They can also improve the aesthetics of a development and be a central feature in a landscape.

Wetlands can be constructed on many scales, from house block scale to large regional systems. In highly urban areas they can have a hard edge form and be part of a

streetscape or forecourts of buildings. In regional settings they can be over 10 hectares in size and provide significant habitat for wildlife

Special consideration is required in the Mildura region when constructing wetlands with permanent pool volumes due to the high amount of evaporation that can result in the wetland drying out for extended periods of time. Constructed ephemeral wetlands have a minimal amount of permanent water and may drain completely following a rainfall event. Naturally occurring ephemeral wetlands are quite common in the Mallee region, such as King's Billabong, Mildura. The correct selection of ephemeral wetland plant species is crucial to ensure successful wetland establishment.

The construction of wetlands also requires attention to the groundwater table as inflows of saline water may affect the long term viability of a wetland. Conversely the wetland has to be designed to exclude stormwater from infiltrating into the groundwater system. The cost and special design of wetlands lends them to be used on larger scale drainage schemes such as the Sixteenth Street Drain.

Wetlands are more likely to be sustainable in areas where there is the likelihood of inflows from irrigation areas either through outfalls from the supply system or relatively good quality drainage water. This will assist in replacing water lost due to evaporation in the wetland area.

### **3.3.6 Rainwater tanks**

Rainwater tanks collect runoff from roof areas for subsequent reuse. In addition, they can provide a flood retardation function provided adequate temporary storage is available either through appropriate sizing (eg small tanks that are drawn down frequently can offer significant retention of roof runoff) or through temporary detention storage.

There are many forms of rainwater tanks available. They can be incorporated into building designs so they do not impact on the aesthetics of a development. They can also be located underground or some newer designs incorporate tanks into fence or wall elements or as part of a gutter system itself.

To improve the quality of the stored water, tanks can be fitted with 'first flush diverters'. These are simple mechanical devices that divert the first portion of runoff volume (that typically carries debris) away from the tank. After the first flush diversion, water passes directly into the tank.

Collected roof water is suitable for direct use for garden irrigation or toilet flushing with no additional treatment. Tank water can also be used in hot water systems, although some additional treatment may be required to reduce the risk of pathogen depending on the design of the system. This generally involves UV disinfection and ensuring that a hot water service maintains a temperature of at least 60 degrees.

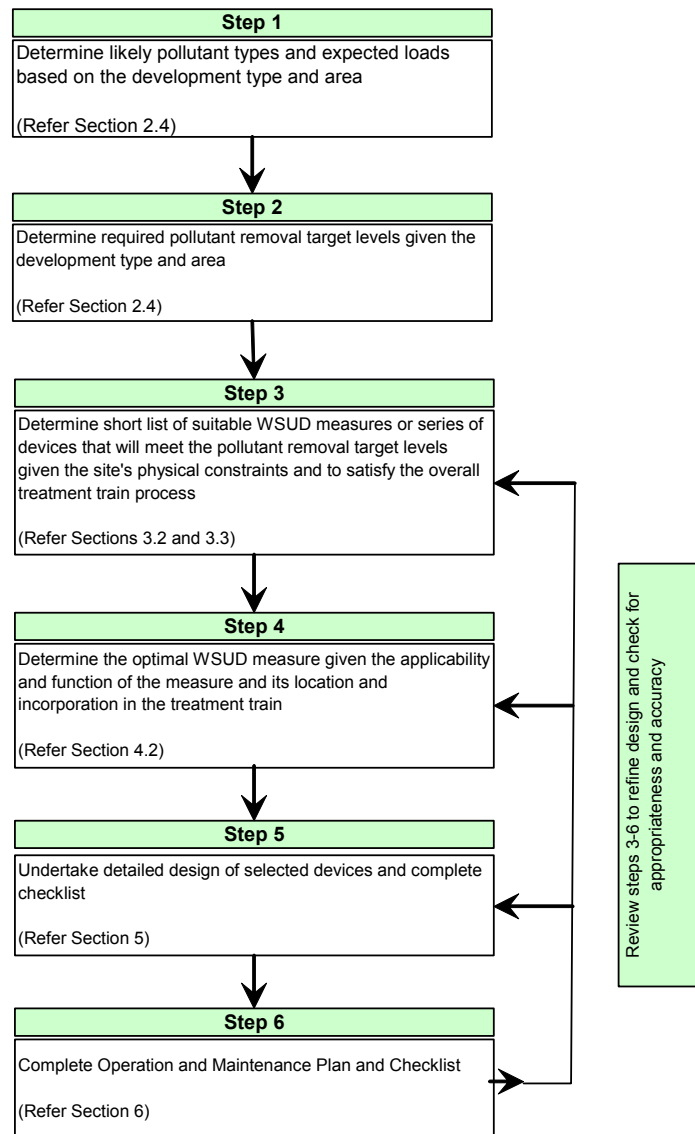
Tanks are generally sized for the demand they are intended for. For example, if tank water is intended to be used for toilet flushing and hot water systems, a desired level of reliability can be achieved with the selection of an appropriated sized tank given a site's rainfall pattern and the area of roof draining to the tank. In most cases, where potable water is available, a connection to potable water supplies is recommended to ensure a high degree of reliability and provide a secondary source of supply.

Although the use of rainwater tanks is a viable WSUD design technique the uptake and maintenance is left to the individual householder, which can mean that a subdivision has infrastructure designed to suit tanks being installed. Later when houses are constructed on the subdivision the tanks may be omitted or not connected eliminating the benefits of the tanks. Tanks may also not be installed in allotments due to the space required.

## 4. WSUD planning and selection guide

### 4.1 WSUD planning process

Figure 4.1 below illustrates the recommended process to be followed in the planning and design of WSUD measures in the Mildura Region:



**Figure 4.1: WSUD planning process**

### Step 1

The pollutant types for a particular land use can be determined from Table 2.3. The determination of expected pollutant loads is based on the level of detail being undertaken in the analysis. Section 5.2 details the Design Process based on the size of the development.

For single or small developments the treatment facility can be sized using adjustment factors in Table 2.1 of Melbourne Water's *WSUD Engineering Procedures: Stormwater*. No estimate of pollutant loads is required for this design method.

For larger developments Section 5.2 recommends the use of the design nomographs in Section 5.3 to 5.7. No estimate of pollutant loads is required for this design method however the designer needs to determine the impervious catchment area. If further optimisation of the treatment facility is required the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) can be adopted. MUSIC is used to determine expected loads from development areas. Section 5.2.1 outlines the recommended input values for MUSIC.

### Step 2

The required pollutant removal target levels will be agreed with Council. In most instances the target levels will be the Best Practice Environmental Management Guidelines objectives as outlined in Section 2.4.1. Council may reduce these objectives for brownfield developments or developments where significant retrofit of stormwater treatment facilities would be required.

### Steps 3-6

The type of stormwater pollutant treatment device will be governed by economics, site constraints, aesthetics, safety requirements, buildability and maintenance access. The adopted stormwater treatment facility will best satisfy each of these requirements. The design checklists for the design (Step 5) and operation and maintenance (Step 6) are published in Melbourne Water's *WSUD Engineering Procedures: Stormwater*.

## 4.2 Applicability and function of WSUD measures

Prior to selecting the WSUD measures it is important to recognise the scale of the application and the primary role of the measure. Table 4.1 outlines the treatment scale of each of the applicable WSUD measures as well as the performance of the treatment based on water quality and flow attenuation.

**Table 4.1: WSUD treatment applicability and performance**

WSUD Measure	Application Scale of Treatment			Performance of Treatment	
	Allotment	Subdivision	Regional	Water Quality	Flow Attenuation
Bioretention Swales				HIGH	MEDIUM
Bioretention Basins				HIGH	MEDIUM
Sand Filters				HIGH	MEDIUM
Vegetated Swales / Filter Strips				HIGH	MEDIUM
Constructed Wetlands				HIGH	HIGH
Rainwater Tanks				LOW	HIGH

The above table indicates that only rainwater tanks are restricted to use on the allotment scale. It also shows that secondary treatment of rainwater caught in tanks may be required to achieve the BPMSG water quality objectives. Further treatment of rainwater may also be required if the rainwater is to be used for domestic purposes (see Section 5.8).

The table also shows other systems that can be applied on an allotment scale. With the installation of allotment scale only treatments in a subdivision the onus for operation and maintenance is placed onto the landholder. Any allotment scale treatments require education of residents on the treatment to ensure the ongoing effectiveness is maintained. Any WSUD Measure should also take into account the implementation issues outlined in Section 3.3

### **4.3 WSUD selection and treatment train**

The restoration of natural features in the hydrological system by forming a hierarchy of allotment-level, subdivision-level and catchment-level solutions is a fundamental feature of the WSUD philosophy. Each WSUD measure should not be considered in isolation, but an element forming a continuous “Treatment Train” through the urban development catchment. The Treatment Train is based on achieving the desired outcomes within a system of stormwater management measures, for example, gross pollutant, coarse to medium sediment, fine sediment removal and soluble pollutant removal (as described in Table 3.1).

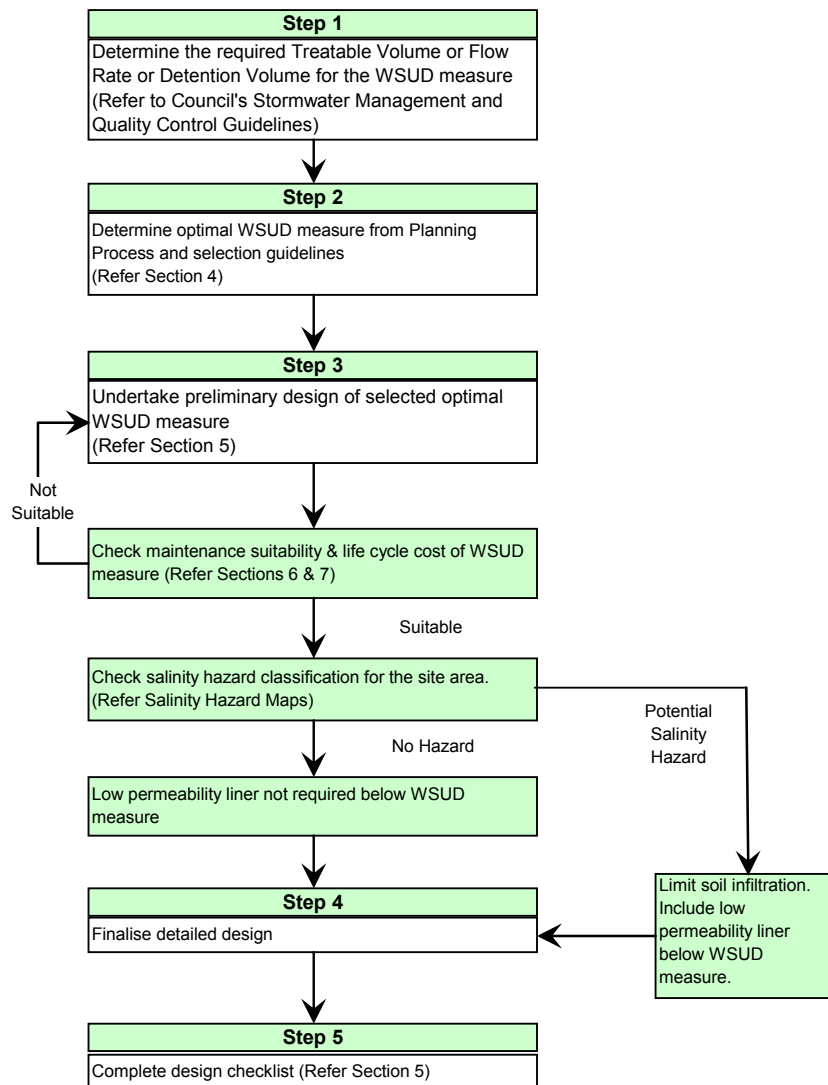
WSUD measures located as close as possible to the source pollutants is desirable to treat runoff and associated pollutants generated from impervious areas. This minimises the requirement for end-of-pipe or downstream catchment treatment measures. The pollutant removal mechanisms associated with each measure involves physical, biological and absorption processes. Physical removal methods are often used first in the treatment train. Physical processes involve initially trapping gross pollutants and coarse sediments (i.e. primary treatment) followed by finer sediment particles and attached pollutants (i.e. secondary treatment). Once coarse pollutants are removed, pollutant removal mechanisms involving biological and absorption processes can be applied (i.e. tertiary treatment). The optimal WSUD measure/s incorporated in the system is dependent on the following:

- the type of pollutants likely to be generated from the development (refer Table 2.4)
- pollutant reduction objectives (refer Table 3.1)
- location within the development catchment (i.e. allotment, subdivision or catchment level)
- role, function and effectiveness of the treatment measure (refer Section 3.3)
- individual site assessment, physical constraints and design issues (such as soils, salinity, groundwater and space – refer Table 4.1)
- operation and maintenance issues (refer Section 6)
- life cycle cost considerations (refer Section 7).

## 5. WSUD design specifications

### 5.1 Introduction

The flow chart in Figure 5.1 below illustrates the recommended process to be followed in the design of WSUD measures. In Step 1 the Council's *Stormwater Management and Quality Control Guidelines* refer to this document and the MRCC Subdivision Development Design Guidelines (MRCC, 2001).



**Figure 5.1: WSUD design process**



## 5.2 Design process

This chapter has to be read in conjunction with the Melbourne Water WSUD Engineering Procedures document. The discussion in each of the following sections outlines what modifications are required for each WSUD Measure to adapt them for use in the Mildura Region.

The Melbourne Water document includes worked examples of each of the measures to assist the designer in establishing the level of detail required.

The Melbourne Water WSUD Engineering Procedures document identifies hydrologic regions to enable WSUD treatment facilities sized for Melbourne to be factored for use in other regions. The factors are applicable for small development projects (single or small clustered allotment development type). Table 2.1 of the Melbourne Water WSUD Engineering Procedures document lists the Northern adjustment factors applicable for Mildura. It is recommended that these relationships be used for the purpose of sizing treatment facilities for small projects.

For larger projects it is recommended that the design nomographs in Section 5.3 to 5.7 be used or site specific water quality models are developed. The design nomographs in Section 5.3 to 5.7 have been derived using set parameter values in the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). The treatment facility designed using the nomographs will only conform to the pollutant removal performance stated if all parameter values in the derivation of the nomographs are adopted in detailed design. Further optimisation of the treatment facility can be undertaken by water quality modelling. MUSIC is the recommended water quality model to simulate the pollutant removal capabilities of treatment facilities.

### 5.2.1 MUSIC design process

Melbourne Water has produced a document entitled MUSIC Input Parameters. This document provides advice to practitioners on the appropriate input data for use when simulating stormwater treatment facilities in MUSIC. To avoid the use of large sets of rainfall data, Melbourne Water has identified an appropriate reference year for 10 gauging stations across Melbourne. This reference year is the closest fit to the average rainfall. Monthly evapotranspiration (ET) has also been provided for each of the 10 reference sites. A similar analysis has been undertaken by Parsons Brinckerhoff for Mildura. The results of the analysis are described in Appendix A.

The climatic data in Appendix A has been used in MUSIC to derive the design nomographs in Section 5.3 to 5.7.

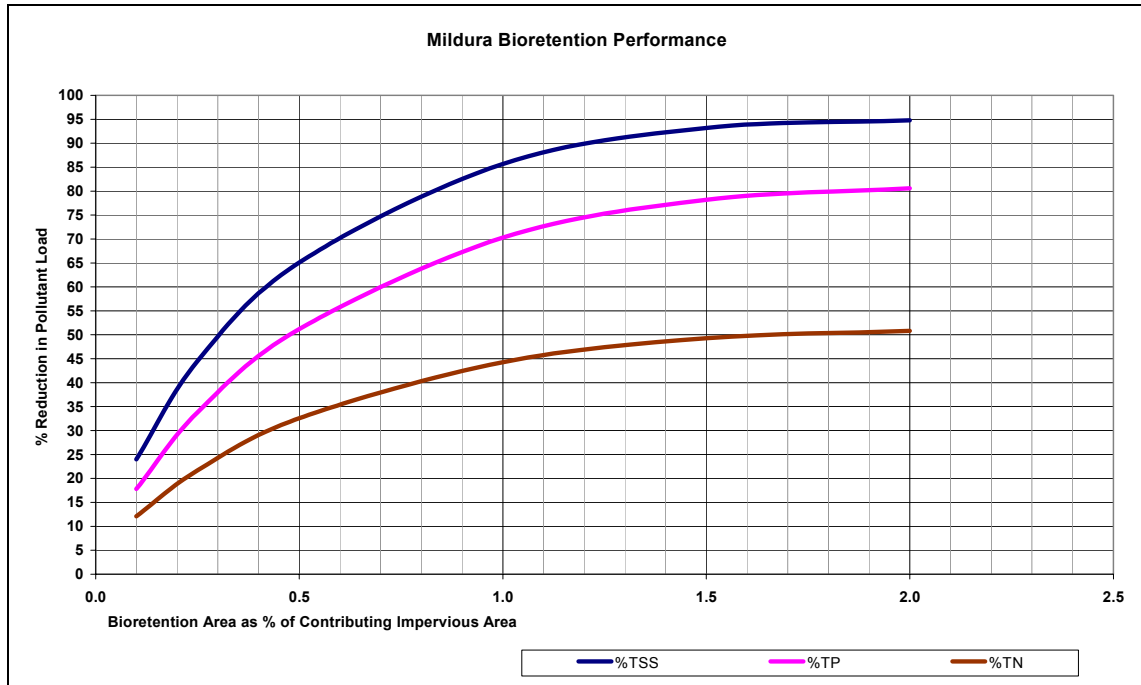
The fraction impervious for different land uses is tabulated in Appendix B.

Stochastically generated data are recommended in MUSIC. In the absence of recorded data the mean and standard deviation of pollutant concentrations for different land uses can be determined from information provided in Appendix B (after Duncan, 1999).

### 5.3 Design specification – Bioretention swales

The design shall generally follow Chapter 5 – Bioretention swales of the WSUD Engineering Procedures. The variations required to suit the Mildura Region are:

- Replace figures 5.3 to 5.5 with the following sizing chart for use with larger projects. The nomograph has been developed using a bio-retention swale with a 600mm deep silty sand filter ( $d_{50} = 0.45\text{mm}$  with hydraulic conductivity of 180mm/hr) and extended detention depth of 300mm.



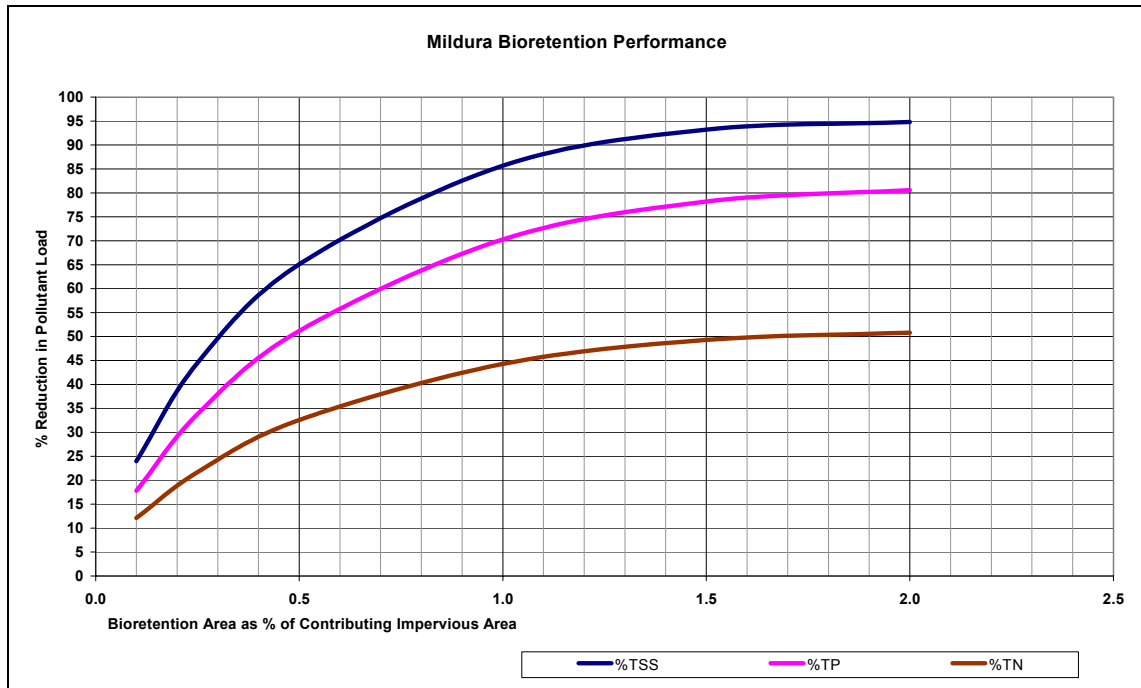
**Figure 5.2: Bioretention swale sizing chart**

- Section 5.3.5.4 - Bioretention swales will need to have impervious layers installed.
- Section 5.3.8 – Local species suitable for bioretention systems should be used where available.

### 5.4 Design specification – Bioretention basins

The design shall generally follow Chapter 6 – Bioretention basins of the WSUD Engineering Procedures. The variations required to suit the Mildura Region are:

- Replace figures 6.2 to 6.4 with the following sizing chart for use with larger projects. The nomograph has been developed using a bio-retention swale with a 600mm deep silty sand filter ( $d_{50} = 0.45\text{mm}$  with hydraulic conductivity of 180mm/hr) and extended detention depth of 300mm.



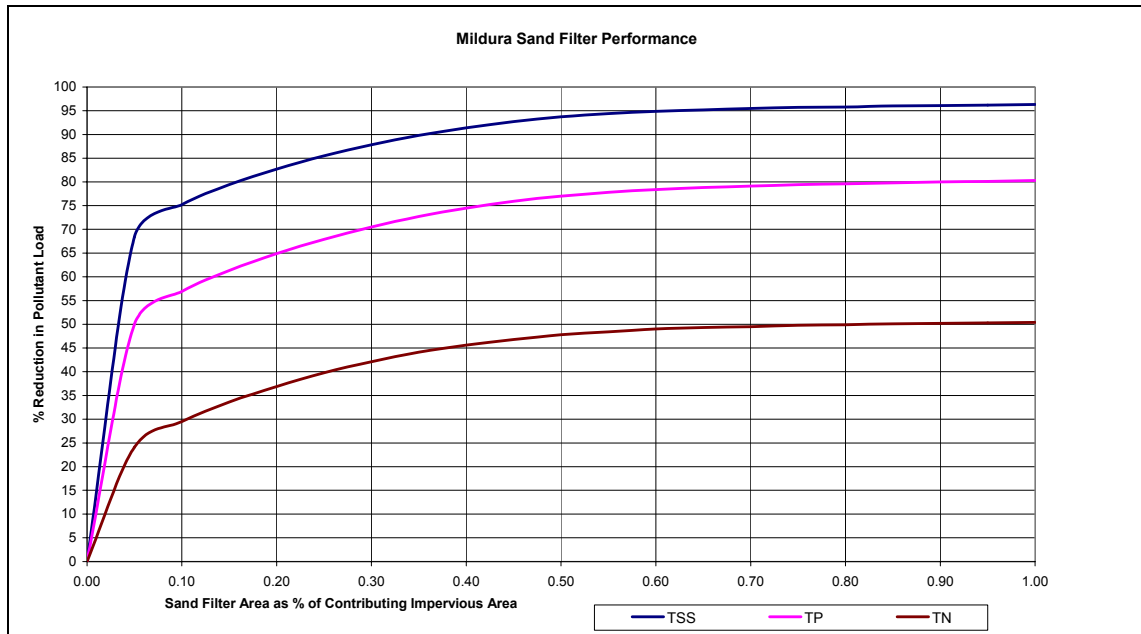
**Figure 5.3: Bioretention Basin Sizing Chart**

- Section 6.3.4.4 - Bioretention basins will need to have impervious layers installed.
- Section 6.3.7 – Local species suitable for bioretention systems should be used where available.

## 5.5 Design specification – sand filters

The design shall generally follow Chapter 7 – Sand filters of the WSUD Engineering Procedures. The variations required to suit the Mildura Region are:

- Replace figures 7.2 to 7.4 with the following sizing chart for larger projects. The sand filter nomograph has been developed assuming an upstream sedimentation pit designed to remove 90 percent of 125Fm particles. The design nomograph has been developed assuming a 600mm deep sand filter ( $d_{50} = 0.75\text{mm}$  with hydraulic conductivity of 360mm/hr) and extended detention depth of 200mm.



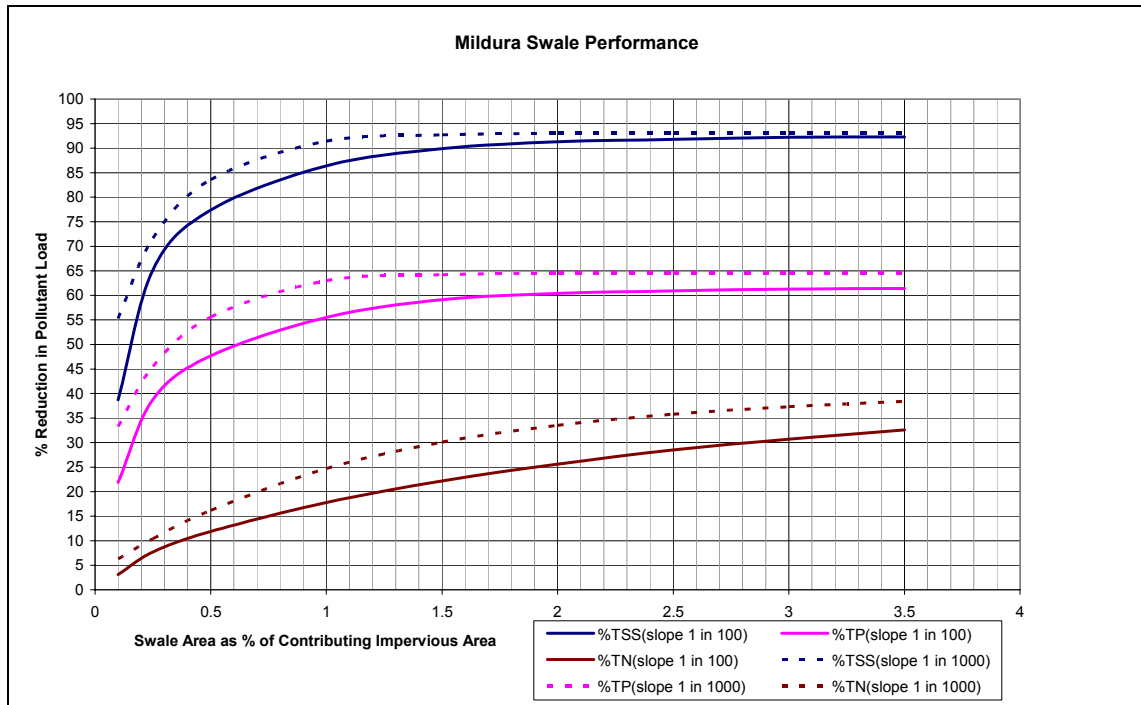
**Figure 5.4: Sand filter sizing chart**

If a designer can prove that an open sand filter can operate adequately in the local conditions, the Council will consider the installation in place of other treatments.

## 5.6 Design specification – vegetated swales / filter strips

The design shall generally follow Chapter 8 – Swales and buffer strips of the WSUD Engineering Procedures. The variations required to suit the Mildura Region are

- Replace figures 8.3 to 8.5 with the following sizing chart for larger projects. The vegetated swale nomograph has been developed for swales with a 1m bed width and 1 in 5 batters. The curves have been developed for longitudinal slopes of 1 in 100 and 1 in 1000. The swale depth is 500mm with a vegetation depth of 250mm;

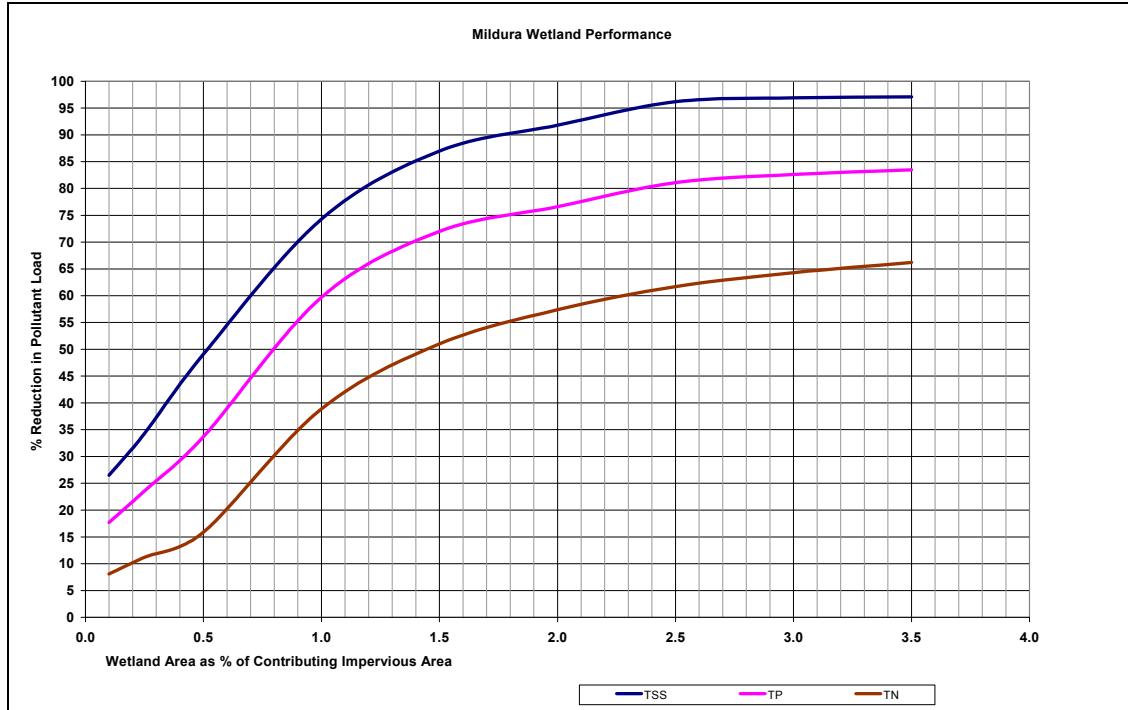


**Figure 5.5: Vegetated swale sizing chart**

## 5.7 Design specification – constructed wetlands

The design shall generally follow Chapter 9 – Constructed wetlands of the WSUD Engineering Procedures. The variations required to suit the Mildura Region are

- Replace Figure 9.1 with the following sizing chart. The wetland nomograph was developed for a wetland with an extended detention depth of 500mm, a permanent pool volume equal to 300mm over the total wetland area, and a notional detention time of 72 hours.



**Figure 5.6: Constructed wetland sizing chart**

Designers need to ensure that an adequate impervious layer is provided around the wetland to eliminate water exfiltration into the groundwater as well as limiting any groundwater intrusion.

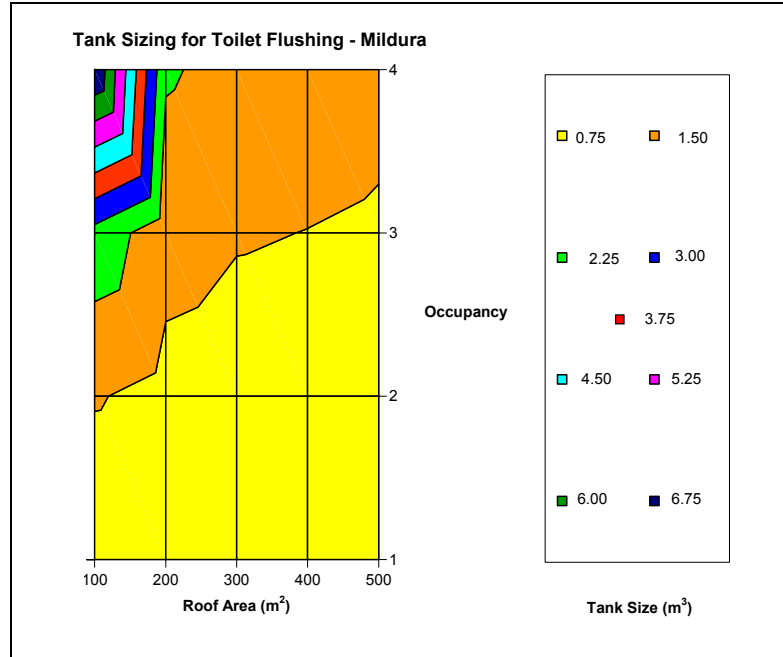
The designer will have to show how the wetland vegetation will be sustained during potential extended dry periods.

## 5.8 Design specification – rainwater tanks

The design shall generally follow Chapter 12 – Rainwater tanks of the WSUD Engineering Procedures.

The variations to the WSUD Engineering Procedures required to suit the Mildura Region are to replace figure 12.5 with the following sizing chart.

This rainwater tank sizing chart has been developed using a daily water balance for Mildura rainfall from September 1946 to February 2005. The rainwater tanks have been sized assuming a 70 percent security of supply and average daily demand per person for dual flush toilets.



**Figure 5.7: Rainwater tank sizing chart for toilet flushing**

The above chart should be applied to determine the required tank size for a given roof area and occupancy per dwelling.



## **6. WSUD operation and maintenance**

### **6.1 Introduction**

Melbourne Water WSUD Engineering Procedures document provides details on the maintenance requirements for each WSUD facility. Additional information for the maintenance of wetlands is available from Constructed Wetland Systems – Design Guidelines for Developers.

### **6.2 Operation and maintenance plan for stormwater treatment facilities**

Most WSUD facilities have little or no mechanical components and accordingly the operation of the facility can be detailed on design drawings. The critical operational details to be provided on the plans include Normal Top Water Level (NTWL), plant types and densities, and the Extended Detention Depth.

An agreed Maintenance Plan between the Mildura Rural City Council and the developer is required for a period of between 12 and 24 months. Maintenance checklists for WSUD facilities are provided in Melbourne Water's WSUD Engineering Procedures document.

A typical maintenance plan will include the following aspects:

- removal of litter, debris and sediment
- re-planting of vegetation and removal of weeds
- structural works to repair flood damage or vandalism.

The most intensive period of maintenance is during the establishment period.

#### **6.2.1 Facilities with vegetation**

For facilities that contain vegetation water level management in the establishment period is very important. Approximately 20cm of water is generally adequate during establishment for larger species, as complete inundation restricts oxygen supply to the plant. A schedule for planting and raising levels needs to be established as part of the design plans.

Following establishment water level management is important in vegetation maintenance. An operational plan should include a water level management program that includes a drying cycle. Including a dry regime in (part of) the facility increases the diversity of plant life. Some common species, such as Typha (cumbungi), have an optimum growth environment in permanently wet conditions, and therefore varying water depth can help control invasion.

Typha are quick colonisers of wetlands, in absence of strong competition, and the most effective form of control is to remove plants as soon as they are observed (Csborne 1995).

### **6.2.2 Facilities without vegetation**

For facilities without vegetation the establishment period is also important. Often WSUD treatment facilities are constructed and operational during the continued construction or establishment of a development. The pollutant load during these times often far exceeds the design loading of the treatment facility due to construction activity, lawns still establishing and the intensive use of fertilisers.

The maintenance of the WSUD facilities during the establishment period requires monitoring of sediment build up. The monitoring of the facilities on a monthly basis (initially) enables the loading of the facilities to be determined and provides a schedule for the routine maintenance.

## **6.3 Rainwater tanks**

The onus of maintenance for rainwater tanks typically rests with the householder. Public education regarding the routine cleaning of tanks, gutters and filters is required to ensure facilities are maintained at optimum operating level.

## **7. Lifecycle for WSUD measures**

### **7.1 Introduction**

Life cycle costing should be considered in the design of WSUD facilities. MUSIC (version 3) released in May 2005 incorporates a life cycle costing module which is recommended for this purpose. The sections below describe critical activities for each stage of the life cycle.

### **7.2 Construction**

During the construction period the loading on WSUD facilities is the highest for the total design life. The use of construction devices such as silt fences around development sites and silt 'sausages' at side entry pits prevent high pollutant loading of treatment facilities or receiving waters during construction.

### **7.3 Commissioning**

The commissioning of treatment facilities containing vegetation requires a water level management plan and often protection of the vegetation from birds. The treatment facilities require monitoring to assess loading and requirements for routine maintenance.

### **7.4 During design life**

The implementation of a routine maintenance schedule for the treatment facilities is paramount to ensuring the facilities have the desired design life. The primary mechanism for treatment of pollutants in the WSUD facilities described is capture. The only way to ensure optimum performance from any facility is to remove captured sediment. The loading rate of facilities will vary based on catchment type and activity. An estimate of pollutant load for a catchment can be determined from MUSIC or empirical relationships, however the best way to determine load is to continually monitor the treatment devices.

### **7.5 Decommissioning**

Up to 70 percent of heavy metals (Lead, Cadmium) that runoff from catchments are attached to sediment. As the primary means of treatment in WSUD facilities is capture, it is recommended that soil testing be undertaken to assess any mitigation of contamination prior to facilities being decommissioned.

## 8. References

CRCCH (2003) *MUSIC User Guide Version 2.0*, CRCCH

Duncan, H.P. (1999) *Urban Stormwater Quality: A Statistical Overview*, Report 99/3, CRCCH

Eco Eng, WBM, PB (June 2004) *WSUD Engineering Procedure: Stormwater*, DRAFT, Melbourne Water

Lawrence, I & Breen, P (1998) *Design Guidelines: Stormwater pollution control ponds and wetlands*, CRCFE

Melbourne Water (July 2003) *Constructed Wetland Systems – Design Guidelines for Developers*

Osborne, P.L., (1995) *Operation, Monitoring and Maintenance of Constructed Wetlands*. Water Research Laboratory, University of Western Sydney

SKM (1999) *Design Guidelines for Constructed Wetlands in Northern Tasmania*, Launceston City Council

Wong, T., Breen, P., Somes, N. & Lloyd, S (1998) *Managing Urban Stormwater using Constructed Wetlands*, Report 98/7, CRCCH

## **Appendix A**

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MUSIC Climatic Data

## Introduction

Parsons Brinckerhoff was contracted by the Mildura Rural City Council to develop Water Sensitive Urban Design (WSUD) Guidelines for Mildura. As part of this study Parsons Brinckerhoff were required to determine pollutant types, concentration and loading for the catchments. The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was recommended for this task.

Melbourne Water has produced a document entitled MUSIC Input Parameters. This document provides advice to practitioners on the appropriate input data for use when simulating stormwater treatment facilities in MUSIC.

To avoid the use of large sets of rainfall data, Melbourne Water has identified an appropriate reference year for 10 gauging stations across Melbourne. This reference year is the closest fit to the average rainfall. Monthly evapotranspiration (ET) has also been provided for each of the 10 reference sites.

A similar analysis has been undertaken by Parsons Brinckerhoff for Mildura. The results of the analysis are described in this report and digital data provided on the disk enclosed.

## Rainfall

MUSIC recommends that the computation timestep must be equal to or less than:

- i. the Time of Concentration of the smallest sub-catchment
- ii. the shortest detention time (under design flows) of the treatment measures being modelled.

Melbourne Water suggests that if (i) or (ii) above is less than 6 minutes, the model should be run using a 6 minute interval.

Given that the catchments being modelled are typically small urban catchments the time of concentration is usually in the order of minutes. The Bureau of Meteorology maintains rainfall data records from pluviographs in 6-minute intervals. Pluviograph records available for Mildura Airport (076031) (1946 – Present) were used for the analysis.

The average rainfall reference year was determined by an analysis of long-term daily rainfall data for two rainfall gauges in the area of interest:

076031 - Mildura Airport 1946 - Present

076032 - Mildura Post Office 1934 - 1994

Monthly data were obtained for Mildura for the period of record and the average annual rainfall determined. A year within  $\pm 10\%$  of the annual average rainfall for each site was selected for further assessment. The sum of the absolute value of the percentage differences was used to assess each year's monthly rainfall totals against the average monthly rainfalls (see equation below).

$$Y_n = \sum_{i=1 \rightarrow 12}^n \frac{|X_i - \mu_i|}{\mu_i} \times 100$$

Where  $Y_n$  = sum of the absolute value of the percentage differences for monthly rainfall from the average rainfall for month, i for year, n

$\mu_i$  = average rainfall for month, i

$X_i$  = rainfall for month, i

i = January, February November, December.

A regression analysis was undertaken to determine the correlation between Mildura Airport and Mildura Post Office. The regression showed a relationship close to unity (0.994). The results are shown graphically in Figure A5.

The strong correlation indicated that data from Mildura Post Office 1934 – 1946 was an accurate representation of rainfall data for Mildura Airport. Mildura Airport and Mildura Post office data were combined to provide daily rainfall data for 1934 – Present.

The minimum  $Y_n$ , was determined for all the selected years at Mildura. Table A1 shows the results of the analysis.

**Table A1: Results of monthly rainfall comparison**

Rainfall gauging station	Period of record	Annual average (mm)	4 years with smallest departure from the average
Mildura Airport, Post Office (Combined)	1934 – Present	283.1	1968, 1987, 1981, 1966

The analysis shows that 1968 is the 'most' average year on record. Comparative hyetographs for each year are depicted in Figures A1 to A4.

The 1968 pluviograph data from Mildura Airport (076031) gauge is available for the full year. Given its close proximity it is concluded Mildura Airport gauge is suitable for all sites considered.

Rainfall data from the Mildura Airport (076031) pluviograph for 1968 is provided on the enclosed disk. The files include 6-minute, hourly and six hourly rainfall data in MUSIC file format.

## Evapotranspiration

Melbourne Water has provided average monthly evapotranspiration values for 10 reference sites across Melbourne. The monthly evapotranspiration (ET) values for Mildura have been taken from the former Department of Conservation and Natural Resources publication Derivation of mean monthly evapotranspiration estimates for Victoria (Nathan & Pamminger, 1995). Table 2 lists the average monthly ET values.

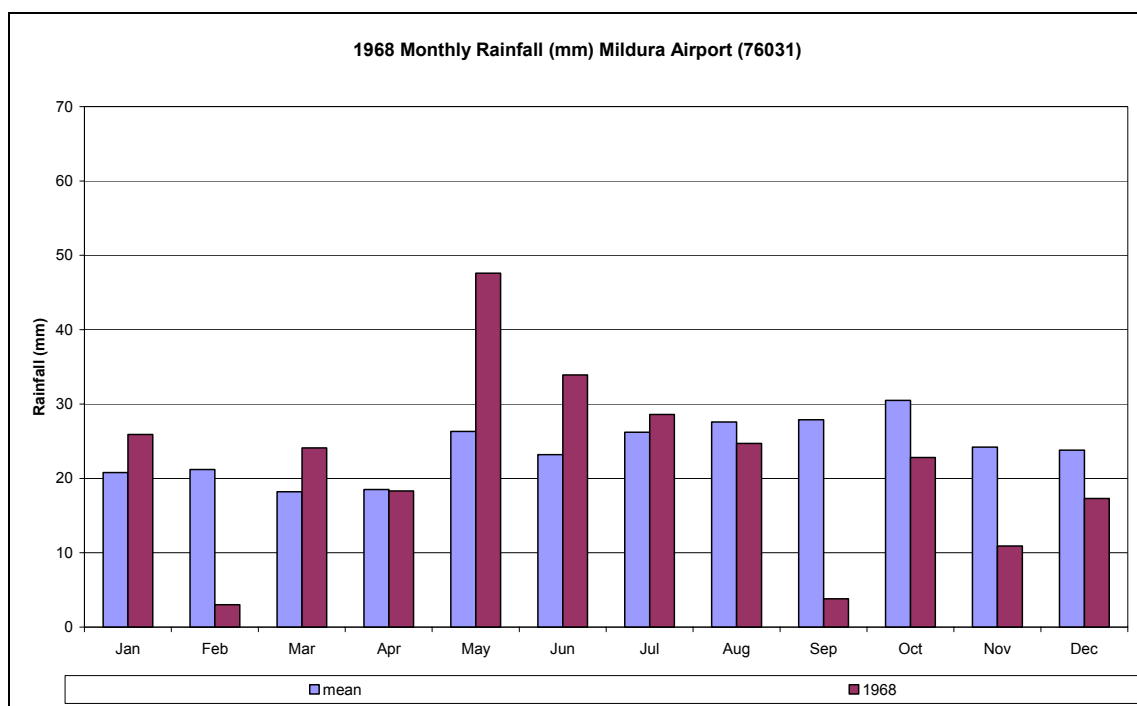
**Table A2: Monthly ET Values for Mildura**

Mon th	Jan	Feb	Mar	Apr	Ma y	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET	175	135	105	65	40	25	30	45	70	115	140	155

The 6-minute, hourly and six hourly MUSIC files enclosed include disaggregated evapotranspiration data for each timestep based on the averages in Table A2.

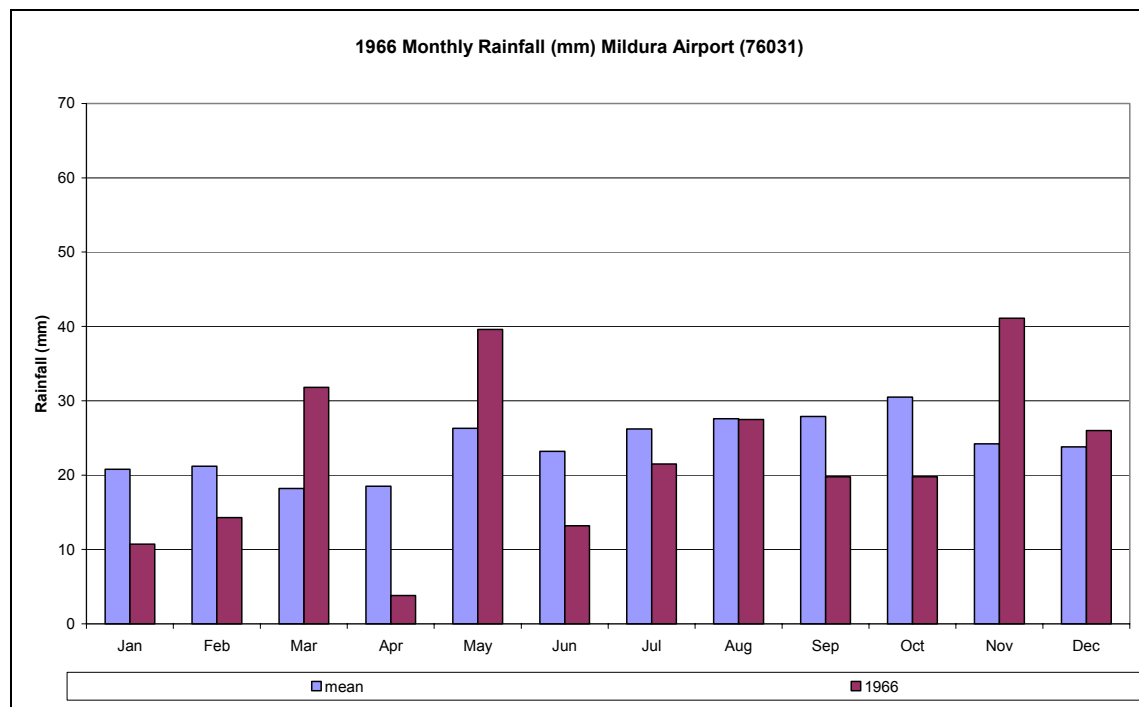
## Recommendations

The MUSIC climatic files provided in Appendix B will be adopted for pollutant load estimation for the Mildura project. It is also recommended that these files be adopted for any further MUSIC modelling for this project and other large development studies in Mildura.

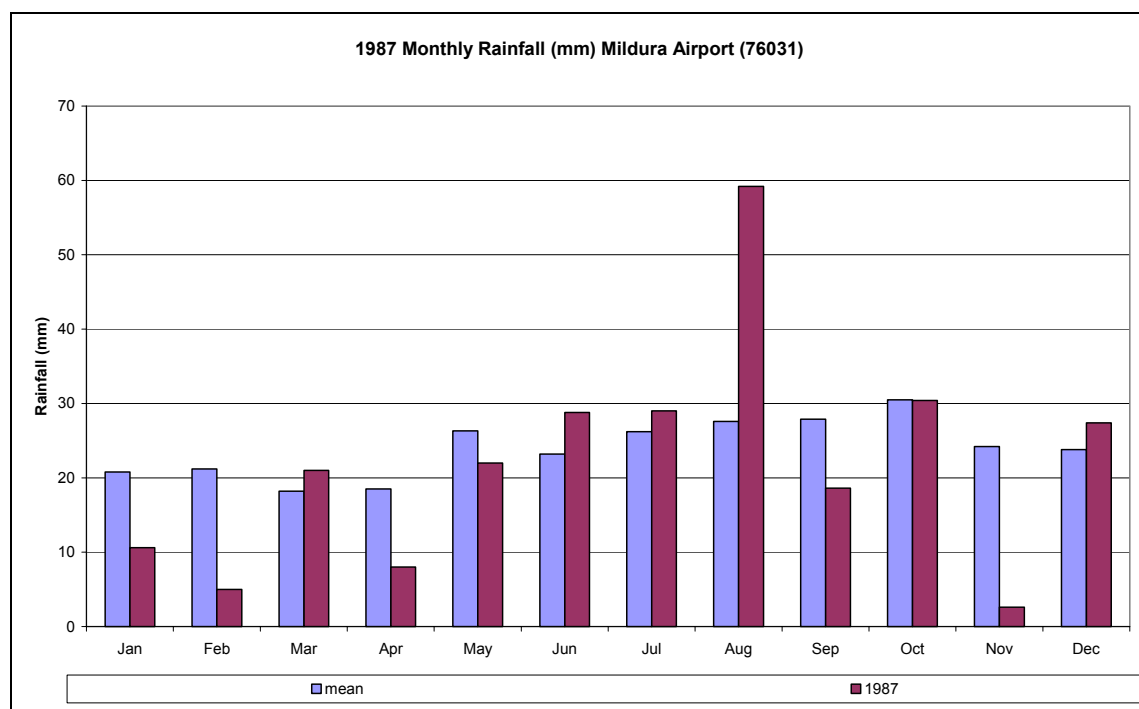


**Figure A1: 1968 Monthly rainfall compared to mean monthly rainfall**

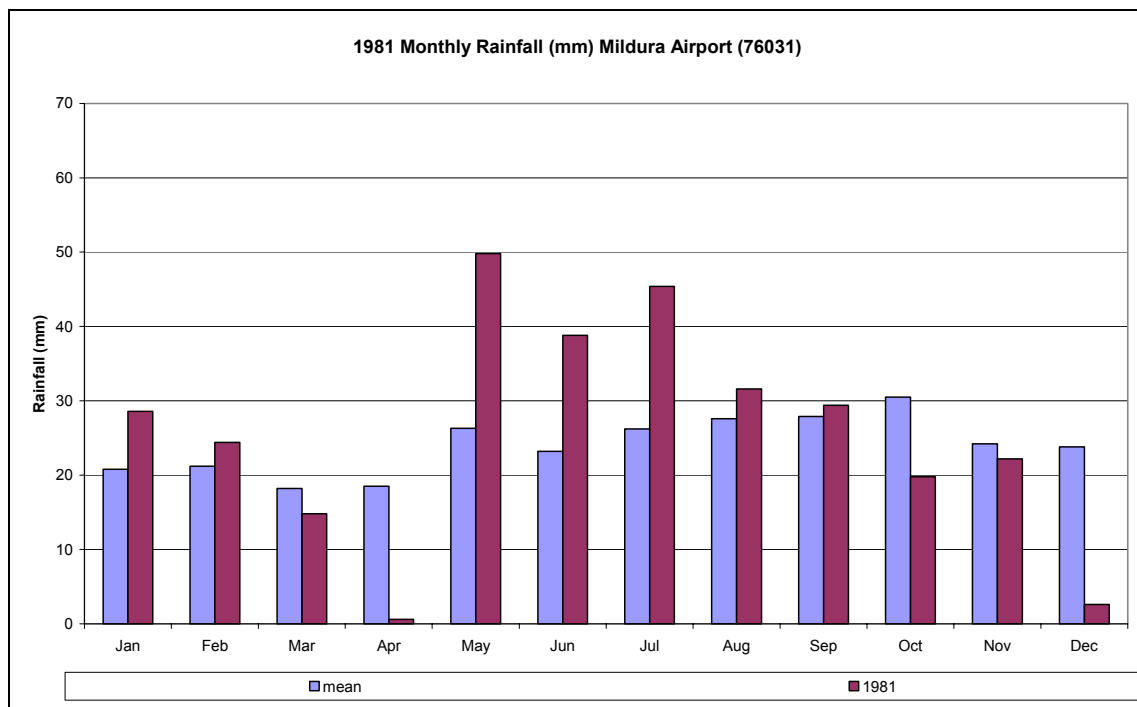




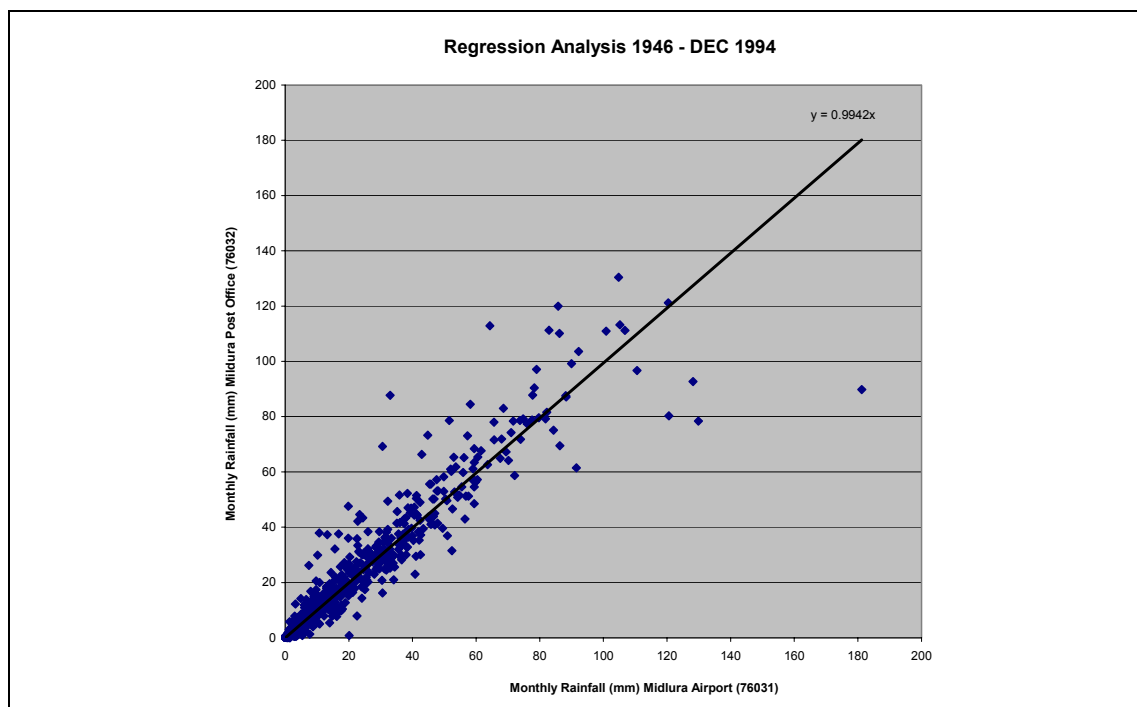
**Figure A2: 1966 Monthly rainfall compared to mean monthly rainfall**



**Figure A3: 1987 Monthly rainfall compared to mean monthly rainfall**



**Figure A4: 1981 Monthly rainfall compared to mean monthly rainfall**

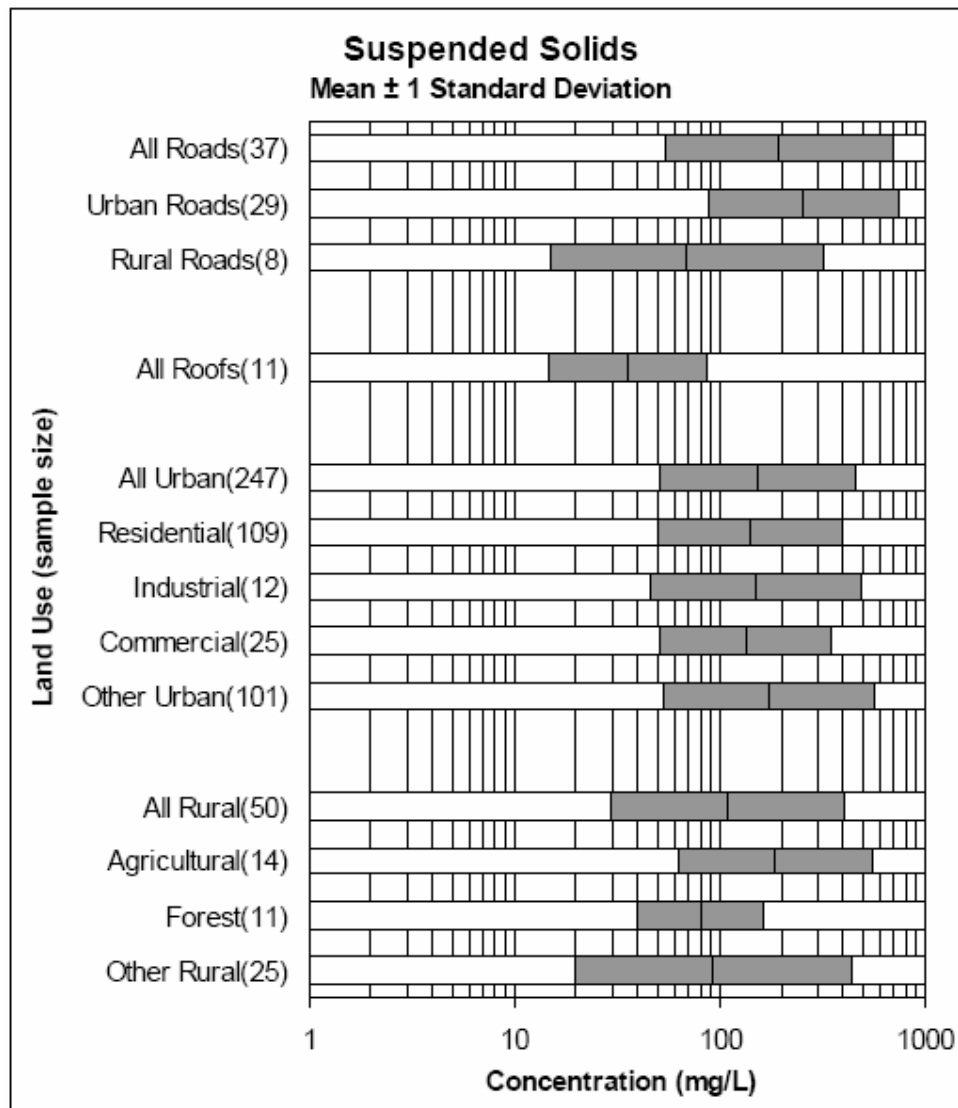


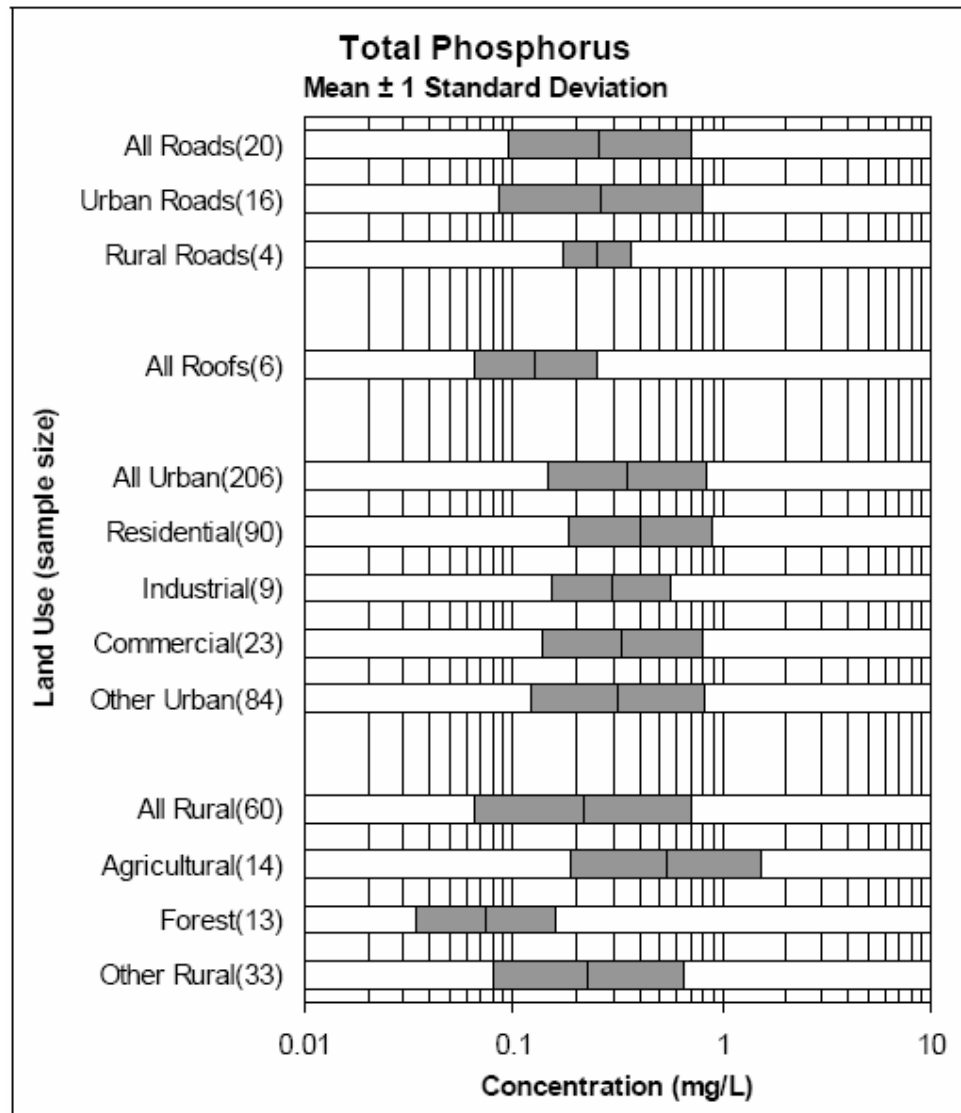
**Figure A5: Monthly rainfall regression of Mildura PO and Mildura Airport**

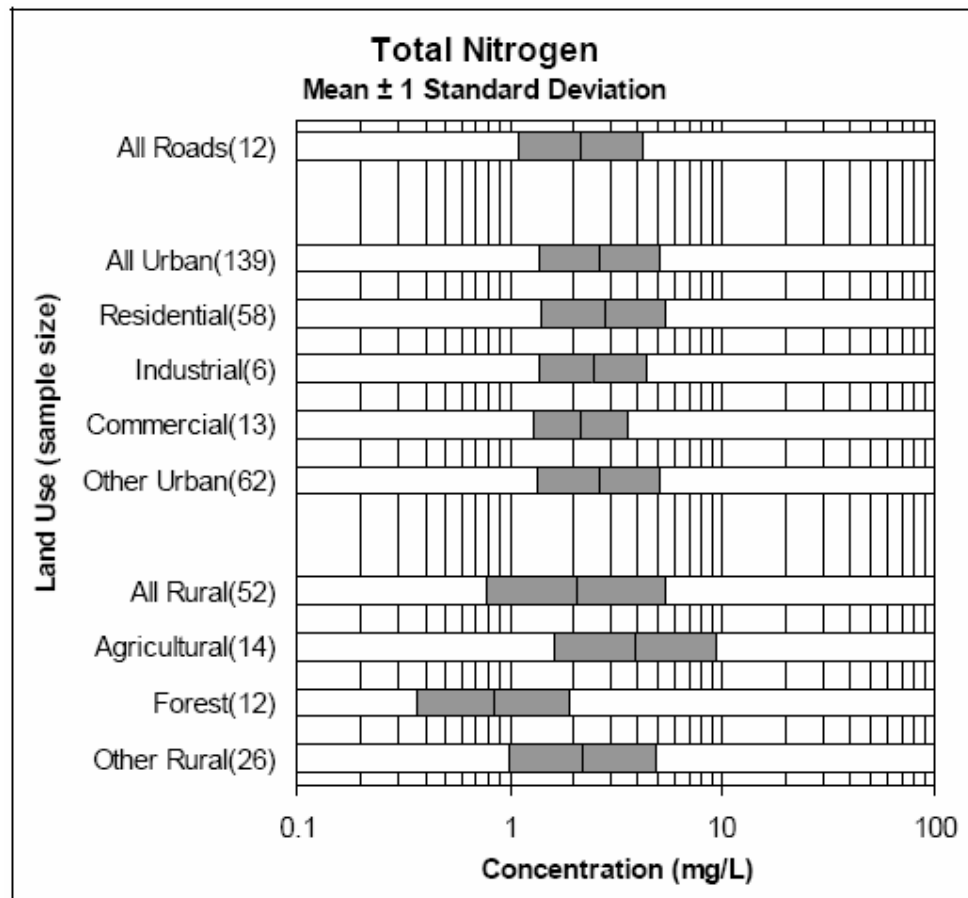
## **Appendix B**

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MUSIC Water Quality Data







Zone	Brief Description / Examples	Normal Range	Typical Value
<b><u>Residential Zones :</u></b>			
Residential 1 & 2 Zone	Normal range of densities.	0.40 - 0.50	0.45
	Medium density	0.50 - 0.70	0.60
	High density	0.70 - 0.90	0.80
Low Density Residential Zone	0.4 ha min.	0.10 - 0.30	0.20
Mixed Use Zone	Mix of residential, commercial, industrial & hospitals.	0.40 - 0.60	0.50
Township Zone	Small townships with no specific zoning structures.	0.50 - 0.70	0.60
<b><u>Industrial Zones :</u></b>			
Industrial 1 Zone	Main zone to be applied in most industrial areas.	0.70 - 0.95	0.90
Industrial 2 Zone	Large industrial areas away from residential areas.	0.70 - 0.95	0.90
Industrial 3 Zone	Buffer between Zone 1 and Zone 3.	0.70 - 0.95	0.90
	- for garden supplies/nurseries.	0.30 - 0.60	0.50
	- for quarries.	0.10 - 0.30	0.20
<b><u>Business Zones :</u></b>			
Business Zone	Main zone to be applied in most commercial areas.	0.70 - 0.95	0.90
Business 2 Zone	Offices and associated commercial uses.	0.70 - 0.95	0.90
Business 3 Zone	Offices, manufacturing industries & associated uses.	0.70 - 0.95	0.90
Business 4 Zone	Mix of bulky goods retailing & manufacturing industries	0.70 - 0.95	0.90
Business 5 Zone	Mix of offices & multi-dwelling units.	0.70 - 0.95	0.80
<b><u>Rural Zones :</u></b>			
Rural Zone	Main zone to be applied in most rural areas.	0.05 - 0.20	0.10
Environmental Rural Zone	Rural areas with specific environmental considerations	0.05 - 0.20	0.10
Rural Living Zone	Predominantly residential use in rural environment.	0.10 - 0.30	0.20
<b><u>Public Land Zones :</u></b>			
Public Use Zone	Use of land for public purposes		
- Service and Utility	- power lines, pipe tracks and retarding basins.	0.00 - 0.10	0.05
	- reservoirs	0.40 - 0.60	0.50
- Education and Health	- schools and universities. hospitals.	0.60 - 0.80	0.70
- Transport	- railways and tramways.	0.60 - 0.80	0.70
- Cemetery/Crematorium	- cemeteries and crematoriums.	0.50 - 0.70	0.60
- Local Government	- libraries, sports complexes and offices/depots.	0.50 - 0.90	0.70
- Other Public Use	- museums.	0.50 - 0.80	0.60
Public Park and Recreation Zone	Main zone for public open space, inc golf courses.	0.00 - 0.20	0.10
Public Conservation and Resource Zone	Protection of natural environment or resources.	0.00 - 0.05	0.00
Road Zone – Category 1	Major roads and freeways.	0.60 - 0.90	0.70
Road Zone – Category 2	Secondary and local roads.	0.50 - 0.80	0.60