



WATER CYCLE MANAGEMENT GUIDELINES

Revision 2

June 2013

TABLE OF CONTENTS:

1	EXECUTIVE SUMMARY	5
2	INTRODUCTION	7
3	SECTION 1 – CITY OF LAKE MACQUARIE’S URBAN WATER SYSTEM.....	8
3.1	City of Lake Macquarie Waterways	9
3.2	Water Management Drivers	9
3.2.1	Water supply	10
3.2.2	Water demand	10
3.2.3	Water Quality	10
3.2.4	Volume & timing	11
4	SECTION 2 – REPORTING REQUIREMENTS FOR DEVELOPMENT APPLICATIONS	12
4.1	Site Stormwater Drainage Plan.....	12
4.1.1	Additional Considerations for Single Dwellings & Dual Occupancies	13
4.2	Water Cycle Management Plan	15
5	SECTION 3 – DEVELOPING A WATER CYCLE MANAGEMENT PLAN.....	16
5.1	Guiding Principles	16
5.1.1	Steps to achieving integrated water cycle management	16
5.1.2	STEP 1 – Consider the site context	17
5.2	STEP 2 – Find ways to reduce water consumption	18
5.2.1	Water Saving Targets	18
5.3	STEP 3 – Replace potable water with an alternative water source	19
5.4	STEP 4 – Managing stormwater before discharge into waterways	20
5.4.1	Stormwater Management Targets	20
5.4.2	Stormwater treatment measures	20
5.5	Watercourse Rehabilitation	23
5.5.1	Objectives and Principles of riparian rehabilitation	23
5.5.2	Protecting Existing Vegetation & new plantings	23
5.5.3	Protect the natural morphology of the watercourse	23
5.6	STEP 5 – UNDERTAKE WATER CYCLE MANAGEMENT DESIGN.....	24
5.6.1	Modelling of design options	24
5.6.2	Considering Water Cycle Management in the broader environment	24
5.6.3	Application of WCM to development type	25
5.6.4	Single allotment and small residential subdivision	25
5.6.5	Medium and high density residential development	26
5.6.6	Large Greenfield subdivisions	27
5.6.7	Commercial and Industrial	28

5.6.8	Infrastructure	30
5.6.9	OPERATION & MAINTENANCE	31
6	APPENDICES	32
6.1	Appendix 1 - Calculating the Site Discharge Index.....	32
6.2	Appendix 2 – Using mitigation depth to calculate storage requirements.....	34

Revision History

Rev. No.	Date Changed	Modified By	Details/Comments
Master	22/03/04	LMC2 Consulting Group	Master Document - adopted by Council on 22 March 2004
01	12/12/05	LMC ² Consulting Group	<p>General amendments to the document:</p> <p>Amend the document to reference the BASIX website.</p> <p>Amend references to changed government departments names</p> <p>Practice Notes</p> <ul style="list-style-type: none"> • Page 51 deleted section preceding 'Group Plants' and relocated back to p51 under heading ' Plant Species Selection' • Page 51 deleted clause 'The following lists includes a combination of native and exotic . . .' and the following tables. • Page 52 deleted text under 'Species Selection'
02	September 2012	Sustainability	Document re-write to reflect current practice and provide comprehensive supporting information for DCP controls. Guideline changed to LM DCP 2013 format. All references to Council's Development Control Plan 2004 changed to reflect the new DCP 2013.

1 EXECUTIVE SUMMARY

The City of Lake Macquarie is committed to providing leadership in water management. Lake Macquarie, the centrepiece of the city, is recognised as being of state-wide ecological significance whilst also providing numerous scenic, recreational and economic benefits. Water management is of key importance to maintaining the values of this natural asset for the community.

This document, the Water Cycle Management (WCM) Guidelines, gives direction on how to achieve the water objectives as outlined in Council's Development Control Plan. These guidelines provide practical advice for implementing WCM principles and explore practical water management options for residents, Council, developers and business.

The principles are to:

- reduce potable water consumption;
- reduce wastewater discharge;
- maximise water reuse; and
- achieve best practice management water quality goals for stormwater before discharge to the aquatic environment.

The outcomes are achieved using the following Guiding Principles:

- demand management;
- 'fit-for-purpose' water use;
- identification and use of alternative urban water sources, and;
- applying best practice stormwater environmental management targets.

These Guidelines establish targets to measure performance against the desired outcomes.



A QUICK GUIDE TO TREATMENT OPTIONS AND THEIR APPLICATION TO DEVELOPMENT ZONES

Treatment Type	WSUD element	Water Cycle Mgt Guidelines	SQID Guidelines	Residential	Subdivision	Industrial Business & Infrastructure	Recreation & Tourism	Business	Rural	Environmental Protection Zones
Water use reduction	Appliances	Section 3.4		•	•	•	•	•	•	
Water reuse	Rain water reuse	Section 3.5	Section 4.2	•	•	•	•	•	•	
	Grey water reuse	Section 3.5		•		•	•	•	•	
	Blackwater reuse	Section 3.5				•	•	•		
	Stormwater reuse	Section 3.5			•	•	•	•	•	
Stormwater Treatment and discharge	Permeable paving	Section 3.6	Section 4.3	•	•	•	•	•	•	
	Rain garden	Section 3.6	Section 4.9	•		•	•	•	•	
	Infiltration trench	Section 3.6	Section 4.10	•		•	•	•	•	
	Vegetated filter strip	Section 3.6	Section 4.4	•	•	•	•	•	•	
	Grassed swale	Section 3.6	Section 4.5	•	•	•	•	•	•	
	Biofiltration swale	Section 3.6	Section 4.9		•	•	•	•	•	
	Tree pit filter	Section 3.6	Section 4.9		•	•	•	•		
	Gross pollutant trap	Section 3.6	Section 4.6		•	•	•	•		
	Sediment basin	Section 3.6	Section 4.7		•	•	•	•	•	
	Constructed wetland	Section 3.6	Section 4.8		•	•	•	•	•	
	Biofiltration basin	Section 3.6	Section 4.9		•	•	•	•	•	
Infiltration basin	Section 3.6	Section 4.10		•	•	•	•	•		
Waterway rehabilitation		Section 3.7		•	•	•	•	•	•	

2 INTRODUCTION

These guidelines support the Lake Macquarie City Council Development Control Plan (DCP) and aim to promote Water Cycle Management (WCM) in all development. The guidelines detail how residents, businesses and Council can achieve the water saving and water quality targets outlined within the DCP and Council's Environmental Sustainability Action Plan.

WCM utilises a range of measures that are designed to avoid, or at least minimise the impacts of urbanisation on the natural water cycle. By incorporating WCM measures in the design and planning of development, it is possible to:-

- Reduce flood risk in urban areas
- Reduce erosion of waterways, slopes and banks
- Improve water quality in the lake, creeks and groundwater
- Make more efficient use of water resources
- Reduce the cost of providing and maintaining water infrastructure
- Protect and restore aquatic and riparian ecosystems and habitats
- Protect the scenic, landscape and recreational values of streams

This document is structured into three main sections:

Section 1 examines the principles of WCM and its application to the City of Lake Macquarie's sustainability objectives.

Section 2 outlines the reporting requirements for WCM when submitting a Development Application for various scale developments.

Section 3 provides practical advice on planning and designing a WCM system.

3 SECTION 1 – CITY OF LAKE MACQUARIE’S URBAN WATER SYSTEM

In effect, there are three separate water systems operating in the City of Lake Macquarie’s urban areas. These include:

1. potable water mains water supply – piped system delivering water treated to drinking water standard from catchments outside the urban area.
2. sewerage system – piped system collecting and transporting domestic and industrial wastewater to treatment plants and discharged to the ocean or recycled.
3. stormwater system – a mixed system including surface flowpaths and waterways as well as underground piped systems, transporting stormwater and other natural sources of water to local creeks, Lake Macquarie and the ocean.

The City of Lake Macquarie’s potable water is sourced from the Williams River catchment and the Tomago and Anna Bay sandbeds. Water from the Williams River catchment is stored at Chichester and Grahamstown Dams. Chichester Dam is located at the top of the Williams River Catchment, while Grahamstown Dam is located relatively close to the river at Raymond Terrace. The water is treated to meet drinking water standards. The treated water is reticulated to the urban area as illustrated in Figure 1.1.



Figure 1.1 – Treated water supply

Wastewater from households, commercial premises, schools, hospitals and industry enter a network of wastewater pipes that all ultimately lead to a wastewater treatment facility.

Wastewater treatment facilities within the City of Lake Macquarie include Belmont, Dora Creek, Edgeworth and Toronto. Effluent from these treatment plants is either discharged to the ocean or recycled for irrigation or industrial use.

Rainfall on urban catchments (urban stormwater) is collected by a separate network of underground pipes with the majority of the catchment area discharging directly into Lake Macquarie, the ocean or nearby receiving creeks.

Traditional water supply, stormwater and wastewater practises are largely based on centralised collection, rapid conveyance and treatment of water flows. Whilst highly effective, these methods can also have major drawbacks such as inefficient use of water resources, environmental degradation and rising infrastructure costs. By contrast, WCM is based on a more de-centralised approach that is more attuned to natural hydrological and ecological processes.

3.1 CITY OF LAKE MACQUARIE WATERWAYS

Lake Macquarie is one of the largest coastal seaboard lagoons in Australia, with a surface area of approximately 110km², and a foreshore length of 195km. The Lake Macquarie estuary has been identified in numerous State Government plans as being of State-wide ecological significance.

Specifically,

- Lake Macquarie is the largest wave dominated barrier estuary in NSW;
- Lake Macquarie contains the third largest area of seagrass in NSW, including the threatened species *Posidonia australis*;
- Lake Macquarie contains significant areas of rocky reef, sandy and muddy habitats; and
- Lake Macquarie is rated as having the largest area of significant shorebird locations in the bioregion.

In addition to its ecological attributes, Lake Macquarie provides a range of scenic, recreational and economic values to the community.

A catchment area of approximately 605 km² drains to Lake Macquarie via a network of thousands of watercourses, varying in size from large creeks such as Cockle Creek, Winding Creek and Dora Creek to small roadside drains. Dora Creek drains a relatively natural landscape from the Watagan Mountains and Martinsville, while Winding Creek drains the established and urbanised areas of Charlestown, Cardiff, and Glendale. The catchment area of Cockle Creek is progressively becoming more urbanised through residential development in Edgeworth and Cameron Park.

There are a range of water pollution and degradation issues confronting the City of Lake Macquarie's rivers, creeks and ocean. This includes pollution from urban run-off, erosion from inappropriate land and water management, and erosion caused by loss of vegetation along creek banks.

Better management of stormwater in the City of Lake Macquarie will help to improve the water quality of Lake Macquarie itself and the city's beaches. WCM provides a proactive, proven way to mitigate pollution from our city's urban development and provides strategies for continual water improvement.

3.2 WATER MANAGEMENT DRIVERS

There are a number of inter-related drivers for water management and the sustainable management of water resources. Water supply, demand, quality and volume are all driven and influenced by population, climate change, human health and environmental impacts.

3.2.1 WATER SUPPLY

The City of Lake Macquarie's demand for water is increasing with population growth. The population is expected to grow by 60,000 people over the next 25 years, creating demand for approximately 36,000 new dwellings. The City has been fortunate to avoid the recent drought experienced by much of NSW. However, water supply in the lower Hunter is highly vulnerable to drought. Water levels can drop faster than in most other major Australian urban centres during drought, because lower Hunter storages are small, or shallow and have high evaporation rates (Hunter Water website 2012).

3.2.2 WATER DEMAND

The City of Lake Macquarie residents are already efficient water users, but with a growing population these efforts need to continue. Hunter Water is addressing water security by continuing its focus on recycling and water conservation initiatives including residential and business water efficiency and loss minimization (Hunter Water website 2012).

3.2.3 WATER QUALITY

Whilst potable and wastewater are piped to treatment facilities, much of the city's stormwater flows untreated into local creeks, the ocean and Lake Macquarie itself. Houses, roads and other impervious surfaces have replaced much of the native vegetation in the city. Stormwater that was once filtered by vegetation and absorbed into the soil now flows off driveways and roads, along gutters and into stormwater drains carrying oils, litter, sediment and other pollutants along its path. These pollutants eventually enter our waterways where they can impact upon public health, recreational amenity and aquatic ecology.

Pollutant	Source	Impact
Litter	<ul style="list-style-type: none"> - Pedestrians and vehicles - Waste collection systems - Leaf fall from trees - Lawn clippings 	Unightly. Risk to aquatic fauna through digestion or entrapment.
Nutrients	<ul style="list-style-type: none"> - Organic matter - Fertiliser - Sewer overflows, septic tank leaks - Animal faeces - Detergents (car washing) - Atmospheric deposition - Spillage, illegal discharge. 	An increase of nutrients in water stimulates the growth of aquatic plants. This causes excessive growth of aquatic weeds and algae that may choke lakes and streams and lead to dramatic daily fluctuations in dissolved oxygen levels.
Sediment	<ul style="list-style-type: none"> - Land surface erosion - Pavement and vehicle wear - Building and construction sites - Spillage, illegal discharge - Organic matter (for example leaf litter, grass) - Car washing 	Reduces the amount of light in the water available for plant growth and thereby reducing the supply of food for other organisms. Can clog and damage sensitive tissues such as the gills of fish. Can suffocate organisms which live on or in the bed of lakes and streams by forming thick deposits when this suspended material settles out.

Pollutant	Source	Impact
	<ul style="list-style-type: none"> - Weathering of buildings/structures - Atmospheric deposition 	
Heavy Metals	<ul style="list-style-type: none"> - Atmospheric deposition - Vehicle wear - Sewer overflows, septic tank leaks - Weathering of buildings, structures - Spillage, illegal discharges 	Poison living organisms or damage their life processes in some other way. Persists in the environment for a long time.
Micro-organics	<ul style="list-style-type: none"> - Animal faeces - Sewer overflows, septic tank leaks - Organic matter decay. 	Contain very high numbers of bacteria and viruses. Some of these organisms can cause illnesses, including hepatitis and gastroenteritis.
Oils, detergents and shampoos (surfactants)	<ul style="list-style-type: none"> - Asphalt pavements - Spillage, illegal discharges - Leaks from vehicles - Car washing - Organic matter 	Highly toxic poison to fish and other aquatic life.

3.2.4 VOLUME & TIMING

Because impervious surfaces (parking lots, roads, buildings, compacted soil) do not allow rain to infiltrate into the ground, more runoff is generated than in the undeveloped condition. This additional runoff can erode watercourses (streams and rivers) as well as cause flooding after the stormwater collection system is overwhelmed by the additional flow. Because the water is flushed out of the watershed during the storm event, little infiltrates the soil, replenishes groundwater, or supplies stream baseflow in dry weather. This can effect ecological communities that are dependent on natural flow regimes.

Integrated water quality solutions are required to ensure a secure and reliable water supply, and to maintain healthy ecosystems.

4 SECTION 2 – REPORTING REQUIREMENTS FOR DEVELOPMENT APPLICATIONS

Council's Development Control Plan states that for all development requiring the establishment or modification of stormwater drainage systems, an appropriate water management plan is necessary. The type of plan required is dependent on the size and scale of the development. Generally, for single dwellings and dual occupancies to which BASIX applies, a Site Stormwater Drainage Plan only will be required. For all other developments, a Water Cycle Management Plan will be necessary.

Development Type	Reporting Requirements
Additions and extensions to single dwelling	BASIX (where required) & Site Stormwater Drainage Plan
Single dwellings	BASIX & Site Stormwater Drainage Plan
Dual occupancies	BASIX & Site Stormwater Drainage Plan
Multi-unit dwellings / Townhouse complex	Water Cycle Management Plan
Retirement Village	Water Cycle Management Plan
Subdivision	Water Cycle Management Plan
Commercial	Water Cycle Management Plan
Industrial	Water Cycle Management Plan

4.1 SITE STORMWATER DRAINAGE PLAN

For single dwellings and dual occupancies, a Site Stormwater Drainage Plan is required. Issues regarding water demand and re-use should be addressed via adherence to the NSW BASIX requirements.

The Stormwater Drainage Plan should identify

- all above and/or below ground existing and proposed features on the site including any easements or natural waterways;
- grading (contours);
- expected drainage patterns (direction of flow);
- all pervious and impervious areas (buildings and covered/paved areas, paths and driveways);
- landscaping;
- all existing Council owned and other public service infrastructure (trees, footpaths, light poles, stormwater entry pits);
- all stormwater management devices (downpipes, sumps, u/ground pipes, spoon drains, culverts, detention, retention and/or other devices);
- and clearly identify above and/or below ground stormwater discharge points into Council's existing drainage infrastructure.

Calculations will need to be provided demonstrating that the development meets council's Site Discharge Index Requirements. That is, a maximum of 10% of runoff from built

impermeable surfaces may be discharged directly to the drainage system. The remaining 90% of runoff must be captured for reuse, or managed through infiltration and retention measures prior to being discharged to the drainage system. Please refer to Appendix 1 of this guideline for further information on calculating the Site Discharge Index.

4.1.1 ADDITIONAL CONSIDERATIONS FOR SINGLE DWELLINGS & DUAL OCCUPANCIES

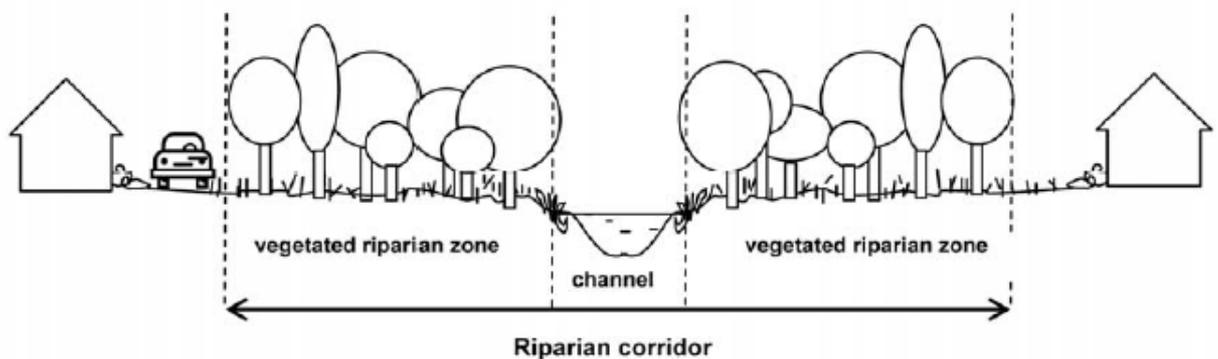
- *Protection of Watercourse and Drainage Policy*

Where a watercourse or drainage line traverses or adjoins a property, consideration should be given to Councils "Protection of Watercourses and Drainage Channels Policy". The policy states –

Watercourses and their associated vegetation should, unless extraordinary circumstances apply, be left undisturbed, without redirection, re-shaping or modification.

- *Riparian Corridor Widths*

The DCP requires that riparian corridors are protected. The development should incorporate the recommended Core Riparian Zone widths as shown in the table below.



Source: *Guidelines for Riparian Corridors on Waterfront Land* (NSW Office of Water – 2012)

Types of watercourses	VRZ Width ² (Each side of watercourse)	Total Riparian Corridor Width
Any first order ¹ watercourse	10 metres	20m + channel width
Any second order ¹ watercourse	20 metres	40m + channel width
Any third order ¹ watercourse	30 metres	60m + channel width
Any fourth order ¹ watercourse or greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40 metres	80m + channel width

- ¹ As classified under the Strahler System of ordering watercourses.
- ² Bushfire Asset Protection zones will not be permitted in the Vegetated Riparian Zone. Additional areas may need to be protected to support ecological processes.

4.2 WATER CYCLE MANAGEMENT PLAN

A Water Cycle Management Plan is required for all other development including subdivision, industrial, business, recreation and rural. A Water Cycle Management Plan is also required for residential development larger than a single dwelling or dual occupancy. This may include multi-unit dwellings, retirement villages, townhouse complexes and mobile home villages.

Section 3 of this guideline provides detail on developing a Water Cycle Management Plan, as well as the targets and objectives that must be met by the plan.

Table 2.1 outlines the individual elements that must be addressed within a Water Cycle Management Plan.

Required content	Relevant Section of this Guideline or other related guidelines
Site conditions, catchment context and land capability	Section 3.3
Estimates of all water flows	Section 3.7
Objectives and strategies for improving water efficiency, water quality, discharge volumes and concentrations, flood protection and impacts on aquatic environments	Section 3.4 to 3.6
Proposed building design practices to minimise disturbance to landforms, soil and drainage patterns	Section 3.8
Proposed stormwater source controls to manage, treat and utilise stormwater	Section 3.7 SQID Guidelines
Proposed centralised stormwater management measures to complement stormwater source controls	Section 3.7 SQID Guidelines
Proposed landscape practices to retain or restore natural landscape features, manage and treat stormwater runoff and reduce demand for water fertilisers and herbicides	Section 3.8
Water efficient fixtures, appliances and usage	Section 3.4
Water recovery and reuse strategies	Section 3.5
Wastewater reuse	Section 3.5
Erosion, sediment and pollution controls	LMCC Erosion & Sediment Control Guidelines
Maintenance, monitoring and performance evaluation	Section 3.9 SQID Guidelines

5 SECTION 3 – DEVELOPING A WATER CYCLE MANAGEMENT PLAN

5.1 GUIDING PRINCIPLES

The guiding principles of WCM are to

- reduce potable mains water demand;
- minimise wastewater disposal; and
- treat stormwater to meet water quality objectives for re-use and/ or discharge to surface waters

The overall aim is to match available water sources with the most appropriate use, whilst protecting aquatic habitats, such as Lake Macquarie. These principles can be applied in the urban landscape to maximise visual and recreational amenity.

5.1.1 STEPS TO ACHIEVING INTEGRATED WATER CYCLE MANAGEMENT

Step 1	Consider the site context and land capability
Step 2	Find ways to reduce water consumption <ul style="list-style-type: none"> - water saving targets - demand management
Step 3	Replace potable water with another water source <ul style="list-style-type: none"> - water recycling and reuse targets - identify available water sources
Step 4	Manage stormwater before discharge <ul style="list-style-type: none"> - stormwater management targets - determine pollutant loads - stormwater treatment measures
Step 5	Undertake design <ul style="list-style-type: none"> - consider water management in the broader environment (urban design, safety, heritage, greenhouse gases, land capability) - application to land-use zoning - modelling and evaluating design options
Step 6	Operation, maintenance and monitoring

5.1.2 STEP 1 – CONSIDER THE SITE CONTEXT

This important step in the WCM process allows identification of site assets, opportunities and constraints. Allowing the site context to inform the development design ensures that existing natural features are utilised as a resource to achieve WCM objectives. Table 3.3 provides an outline of the issues that should be addressed in the initial site analysis.

Landform	<ul style="list-style-type: none"> ▪ Topography ▪ Existing natural features ▪ Orientation of site
Water	<ul style="list-style-type: none"> ▪ Sources of water flowing onto the site and the existing water quality ▪ Drainage patterns, areas of concentrated run-off, ponding, flood prone land ▪ Characteristics of downstream waterways (bushland creek, constructed stormwater channel)
Soils	<ul style="list-style-type: none"> ▪ Depth of topsoil and subsoil ▪ Soil condition, fertility, whether it has been compacted, cut or filled. ▪ Erosion problems, contamination, potential acid sulphate soils or salinity
Flora / fauna	<ul style="list-style-type: none"> ▪ Existing vegetation ▪ Noxious weeds ▪ Trees listed as significant on council register ▪ Any threatened species or ecological communities present on the site ▪ Habitat present on the site and adjoining land
Existing site features	<ul style="list-style-type: none"> ▪ Existing overhead and underground utility services (electricity, gas, telephone, sewer and stormwater) ▪ Easements, rights-of-way and their restrictions ▪ Existing improvements ▪ Archaeological and heritage sites
Planning controls	<ul style="list-style-type: none"> ▪ The zoning of the site and the zone objectives as specified in the Local Environment Plan ▪ Restrictions on development due to hazards such as flooding and land contamination

5.2 STEP 2 – FIND WAYS TO REDUCE WATER CONSUMPTION

5.2.1 WATER SAVING TARGETS

The City of Lake Macquarie aims to achieve the following water savings targets by 2018 (compared to a 2007-8 baseline)	
Council	10 percent reduction in potable water use from council operations
Residential	5 percent reduction per resident

The national Water Efficiency Labelling and Standards (WELS) scheme provides consumers with information about the water efficiency of products. The WELS scheme requires certain products sold anywhere in Australia to be registered, rated and labelled for their water efficiency in accordance with Australian/New Zealand Standard AS/NZS 6400:2005. The Standard currently covers showers, dishwashers, clothes washing machines, lavatory equipment, urinal equipment, tap equipment and flow controllers. The water efficiency rating is displayed on WELS products in the form of a blue 'star rating label'. Labels for different categories of products differ slightly, but all share two key pieces of information:

- The star rating – the stars indicate water efficiency. The more stars, the more water efficient.
- The water consumption or flow figures.
- The average water consumption per use (dishwashers, washing machines, toilets, urinals).
- The average water flow per minute (taps, showers).

A product search database that enables consumers to compare the water efficiency of products is available at <http://search.waterrating.com.au>

Hunter Water offers residents and businesses a range of fact sheets on saving water. These may be sourced at www.hunterwater.com.au and include

- Reducing energy and water use
- Washing machines
- Showerhead Fact Sheet
- Saving water – Pools & Spas
- Guide to Water Efficient Gardening
- Drought tolerant plant list
- Saving water for Hotels & Motels
- Save water tips – Hospitality industry
- Tips for nurseries

5.3 STEP 3 – REPLACE POTABLE WATER WITH AN ALTERNATIVE WATER SOURCE

Currently, potable mains water is the primary water source for the City of Lake Macquarie. To decrease the use of potable mains water, alternative water services must be considered. The urban water cycle identifies a range of potential alternative sources; roofwater runoff, stormwater runoff, greywater, and blackwater, depending on the water that is 'fit-for-purpose'. Water quality and typical treatment required for urban water sources are summarised below. All proposed water reuse systems should meet the appropriate Federal and NSW guidelines.

Water	Source	Treatment required	Legislation & Guidelines
Roof runoff	Rainwater roof runoff	Low level – typically sedimentation occurs within a rainwater tank	Department of Health Guide to Watertanks Australian Guidelines for Water Recycling: Stormwater Harvesting and ReUse Rainwater tank Maintenance Tips
Greywater	Shower, bath, bathroom basins, laundry basin, washing machine	Moderate to high levels treatment required to reduce pathogens and organic content	NSW Guidelines for Greywater Reuse in Sewered, Single Household Residential Premises (NSW Office of Water) NSW Water Industry Competition Act (Independent Pricing and Regulatory Tribunal)
Blackwater	Kitchen and toilet	Advance treatment and disinfection required	Australian Guidelines for Water Recycling – Managing Health & Environmental Risks NSW Water Industry Competition Act (Independent Pricing and Regulatory Tribunal)
Stormwater runoff	Catchment runoff including roads and pavements	Moderate treatment to remove litter and reduce sediment and nutrient loading	Managing urban stormwater – harvesting and reuse (NSW Office of Environment & Heritage) Australian Guidelines for Water Recycling: Stormwater Harvesting and ReUse NSW Water Industry Competition Act (Independent Pricing and Regulatory Tribunal)

5.4 STEP 4 – MANAGING STORMWATER BEFORE DISCHARGE INTO WATERWAYS

5.4.1 STORMWATER MANAGEMENT TARGETS

To protect the ecology of Lake Macquarie, stormwater pollutants and nutrient loading should be minimised. The following table provides the targets adopted by council for specific development types.

Development area	Targets	Definition
Urban areas (residential, commercial, industrial)	Best practice load-based reduction targets	<ul style="list-style-type: none"> - 80% total suspended solids reduction - 45% total phosphorus reduction - 45% total nitrogen reduction <p>When compared to the unmitigated developed scenario.</p>
Greenfield	No net increase	For rural and forested sites, modelling must be used to estimate current site performance, and the modelled performance will be the target for urban (residential, commercial, industrial areas) and dense rural residential development.

In addition to pollutant loads

- Total volume and peak discharges should be maintained at predevelopment levels
- Calculations will need to be provided demonstrating that the development meets council's Site Discharge Index Requirement of 0.1. That is, a maximum of 10% of runoff from built impermeable surfaces may be discharged directly to the drainage system. The remaining 90% of runoff must be captured for reuse, or managed through infiltration and retention measures prior to being discharged to the drainage system. Please refer to Appendix 1 of this guideline for further information on calculating the Site Discharge Index.

5.4.2 STORMWATER TREATMENT MEASURES

Best practice urban stormwater management aims to meet multiple objectives including:

- Providing flood conveyance to reduce velocities;
- Prevent damage to properties and loss of life;
- Protecting downstream aquatic ecosystems;
- Removing contaminants; and
- Promoting stormwater management as part of the urban form.

A fundamental requirement of a stormwater system is to provide infrastructure to avoid flooding and flood damage to public and private property. In contrast to this requirement, a stormwater system should also provide on-site stormwater retention and detention to protect downstream aquatic ecosystems from increased flow volumes and rates associated with urbanisation.

Typical urbanisation produces many contaminants that can be blown or washed into waterways and affect the health of streams and waterways. Best practice stormwater

management provides for treatment of runoff to remove water borne contaminants and provide protection to the environmental, social and economic value of receiving waterways.

Stormwater can carry a wide range of pollutant types and sizes, with no single treatment measure able to effectively treat all pollutants carried by stormwater. A combination of treatments, known as a treatment train, is therefore required to reduce the suite of pollutants contained in stormwater. The selection and order of treatments is a critical consideration in developing treatment trains. Essentially these treatment processes can be divided into five broad categories that target particular stormwater pollutant types including:

- Screening – Coarse filtering of stormwater to separate the bulk of large organic debris, litter and some coarse sediment. Typically these are GPTs installed with screens, racks, baskets, nets etc to separate coarse matter from stormwater.
- Filtration – Vegetation and media filtering to separate organic debris, litter and coarse to medium sediment.
- Retention – Storage of stormwater for extended periods of time enabling pollutants including coarse to fine sediments and heavy metals to settle. These measures can also be configured to control flow rates and volumes during frequent storm events. Where the storage has no gravity outlet, stored stormwater can potentially be harvested for appropriate uses.
- Biochemical - Biochemical treatment of stormwater to reduce dissolved pollutant loads through transformation to solid or gaseous forms. Fine sediment loads can also be removed through extended retention periods and interception on vegetation. Measures typically also function to control flow rates and volumes through retention and/or detention of stormwater.
- Infiltration – Storages where the primary outlet for stormwater is infiltration into the surrounding soils. Typically these measures will have limited application except where insitu soils have high permeability and infiltration of stormwater would not result in additional seepage, excessive groundwater table rise, weakening of structural foundations or other implications for downslope properties.

The treatment series should be configured to achieve the treatment processes in the order outlined above. Typically a development applicant should select a series of measures that will collectively perform all of these functions. Council's preferred SQIDs and the relevant main stormwater treatment processes are summarised in Table 3-2. Table 3-2 outlines the ideal range of pollutants for optimal maintenance.

TABLE 9.2 Stormwater Treatment Processes

SQID	Stormwater Treatment Process				
	Screening	Retention	Filtration	Biological	Infiltration
Rainwater tank					
Permeable paving					
Raingarden					P
Infiltration trench					
Vegetated filter strip					
Grassed swale					
Biofiltration swale					P
Tree pit filter					P
Gross pollutant traps					
Sediment basin	P				
Constructed wetland					
Biofiltration basin					P
Infiltration basin					

P – Potential to achieve treatment by modification of the typical SQID configuration or where site conditions are appropriate.

** Constructed wetlands should not be proposed by development applicants if the same water quality targets can be achieved by bio-infiltration devices. Sediment basins will only be considered where their life cycle operations and maintenance costs can be shown to be less than that of GPT's with equivalent capacity.

For detailed design, operation and maintenance requirements of stormwater quality improvement devices (SQIDS), refer to Council's 'SQID Guidelines'.

5.5 WATERCOURSE REHABILITATION

Maintenance of healthy watercourses is assisted by the retention and management of healthy streamside (riparian) vegetation. Benefits of riparian vegetation extend not only to waterways themselves, but the landscape and amenity values of adjacent land. Please refer to section 2.1.1 of this document for required riparian buffer widths.

5.5.1 OBJECTIVES AND PRINCIPLES OF RIPARIAN REHABILITATION

- Always protect existing native vegetation
- Protect the natural morphology of the watercourse
- Use streamside vegetation to maximise local landscape and aesthetic values.

5.5.2 PROTECTING EXISTING VEGETATION & NEW PLANTINGS

Protecting existing stands of riparian vegetation will often be the easiest and most cost-effective method of meeting vegetation objectives. The following provides key actions to maximise the retention of existing vegetation:

- Avoid removing vegetation wherever possible, particularly mature and sound stands.
- Avoid removing dead trees, either standing or fallen, unless they are a safety hazard, as they provide valuable habitat
- Integrate any new plantings with existing vegetation
- Limit access to riparian zones for protection of sensitive vegetation, promote regeneration and for public safety reasons

Revegetation may be necessary to replace previously cleared areas, or to ensure that riparian vegetation communities are relatively continuous. The following should be considered for new plantings:

- Always use indigenous plants – refer to the Lake Macquarie Streambank and Foreshore Planting Guide.
- Good weed control is essential to promote the survival and establishment of native vegetation. A well planned and funded maintenance regime for a minimum of two years is required .
- Use erosion control matting in conjunction with revegetation to enhance survival rates, as well as stabilising soils
- Always consider temporary fencing and tree guards to protect new plantings from vermin and human interaction.

5.5.3 PROTECT THE NATURAL MORPHOLOGY OF THE WATERCOURSE

Through the impact of increased flows and removal of riparian vegetation, the bed and banks of waterways can become highly susceptible to erosion. This in turn may result in increased turbidity, smothering instream vegetation and ultimately increasing sediment loads in Lake Macquarie. Increased erosion also undermines remnant indigenous vegetation in adjoining parkland and threatens assets such as bridges and path systems. Soft engineering solutions are preferred to prevent further erosion and should be sympathetic to the watercourse environment.

Technical detail on soft engineering solutions may be found in Brisbane City Council's ["Natural Channel Design" Guidelines](#).

5.6 STEP 5 – UNDERTAKE WATER CYCLE MANAGEMENT DESIGN

5.6.1 MODELLING OF DESIGN OPTIONS

Urban stormwater quality improvement systems in urban areas are predominantly driven by climatic factors – the occurrence of storm events or dry weather conditions. These are highly variable in terms of the seasonality of occurrences, their magnitude, and duration. The performance of an urban stormwater quality improvement strategy is not determined by an individual storm event, but is the aggregate of a continuous period of typical climatic conditions. Monitoring and water quality sampling of a small number of storm events are normally not sufficient to define system performance.

Performance assessment of stormwater treatment strategies will often be based on estimating mean annual pollutant loads exported from a catchment following development. Modelling using well established computer models of urban stormwater management systems is a recognised method for determining their long-term performance. Modelling will involve the use of historical or synthesized long-term rainfall data and algorithms that can simulate the performance of stormwater treatment measures to determine stormwater pollution control outcomes.

The Cooperative Research Centre for Catchment Hydrology (now eWater) has developed stormwater evaluation software named MUSIC (Model for Urban Stormwater Improvement Conceptualisation). The software serves as a planning and decision support system, and packages the most current knowledge of the performance of a range of stormwater treatment measures into an easily used tool. Importantly, MUSIC allows a first estimate on the expected pollutant load from catchments following development in the absence of any stormwater treatment initiatives. It can be then used to compare alternative treatment strategies from compliance to Council's stormwater quality objectives. Whilst there are a range of other computer models available MUSIC appears to be the most widely used tool for modelling urban stormwater quality improvement systems. The preferred MUSIC parameters for use within the City of Lake Macquarie's catchments are available on Council's website.

5.6.2 CONSIDERING WATER CYCLE MANAGEMENT IN THE BROADER ENVIRONMENT

In applying water cycle management principles to development, the goal is good design incorporating treatment elements. Planning needs to be considered at the initial phases of an urban development and can enhance the aesthetic, amenity and recreation opportunities of an area as well as protecting its environmental values.

Open Space Layout

Integration of open space with conservation corridors, stormwater management systems and recreational facilities is a fundamental objective of the WCM strategy. Open space areas can potentially incorporate stormwater conveyance and treatment systems as landscape features.

Road layouts and streetscaping

Roads account for a significant percentage of the overall impervious hard surfaces created within a typical urban development, and have a significant impact on the way water is transported through an area. These areas also generate water borne stormwater contaminants that can adversely impact on receiving waterway health. Consequently, it is important to mitigate the impact of stormwater runoff generated from road surfaces. By carefully planning road alignments and streetscapes, drainage elements such as bioretention systems and vegetated swales can be used to collect, attenuate, convey and treat the runoff before it is discharged to receiving waterways.

Opportunities exist for incorporating stormwater elements into roadways by diverting the flow from the road to a treatment system. This requires that traditional road features such as medians, traffic calming bays, street tree sand car parking nodes are designed to be lower

than the road level to collect run-off from the road. Other features such as kerb and gutter may be replaced with grass swales.

When implementing street tree planting, bioretention tree pits can be applied, and road runoff filtered through a specified soil media prior to discharge to the stormwater system. Traffic medians can be retrofitted to become raingarden / bioretention systems.

Lot Layouts

Water Sensitive Urban Design promotes the use of smaller more compact housing lots adjacent to open space that typically have high amenity value. This allows greater community access to open space as well as natural and landscaped features that form the local stormwater drainage system. Where practicable, natural landscape features such as remnant vegetation and natural waterways should be incorporated within open space, with housing lots configured around the open space. Views and access should also be considered in the design. The connectivity of the lots to the open space allows the creation of smaller lots, due to the need for less private lawn and garden area. Experience would suggest that lots with direct access to open space and water features have elevated values compared to conventional designs.

5.6.3 APPLICATION OF WCM TO DEVELOPMENT TYPE

The six steps to water cycle management help developers apply a demand management and fit-for-purpose approach to water management. The following summaries show generally the WCM strategies that are useful for different development types.

5.6.4 SINGLE ALLOTMENT AND SMALL RESIDENTIAL SUBDIVISION

This category describes the bulk of residential suburban houses, dual occupancy and small scale sub-divisions such as townhouses and attached dwellings. These developments typically comprise a single detached dwelling and associated buildings such as garages and sheds. These allotments will often include such features as driveways and front and rear yards. The size of the allotments may be typically between 500 to 1000 m² but can be larger in rural residential areas. The impervious surfaces associated with single allotments include the roofs, driveways, paths, and other hard surfaces such as patios. Pervious areas of the site include any garden or lawn areas. A medium-sized lot may have a site imperviousness of 40 to 60%. The water used on single allotments comprises:

- potable water requirements such as drinking and food preparation
- non-potable water requirements such as toilet flushing, clothes washing, hot water systems, pools, and garden irrigation.

Treatment type	Opportunities	Constraints	Options
Water use reduction	Demand for non-potable water exceeds supply		Installation of water efficient appliances and fixtures
Water re-use	Many non-potable water demands can be met using alternative water supplies such as treated wastewater, rainwater and/or groundwater Space is often available for rainwater tanks	May be insufficient capacity to treat waste water to appropriate public health standards	Roof runoff may be collected in rainwater tanks and reused for internal uses such as toilets and washing machines Grey water from the laundry and bathroom may be used for garden irrigation.

Treatment type	Opportunities	Constraints	Options
Stormwater Treatment	Space is typically available for small scale treatment systems Rainwater tanks provide some water quality treatment	The maintenance of stormwater treatment devices on single allotments may not be sufficient to ensure satisfactory performance	Rain-gardens, vegetated swales and permeable paving

5.6.5 MEDIUM AND HIGH DENSITY RESIDENTIAL DEVELOPMENT

This category includes medium and high rise development such as large blocks of units, and highrise apartment residential buildings. The size of the development may range from relatively small footprints of 2000 m² to more than a hectare. The impervious surfaces associated with multi-dwelling residential developments include the roofs, driveways, car parks, access ways, paths and other hard surfaces. Pervious areas of the site include any garden or lawn areas. Multi-unit residential developments are expected to have a much higher imperviousness than single allotments due to the high density dwellings and intensive use of space. Site imperviousness is expected to be between 60% and 80%. The water used in multi-unit residential developments comprises:

- potable water requirements such as drinking and kitchen uses
- non-potable water requirements such as toilet flushing, clothes washing, gas hot water, pool filling and garden irrigation.
- irrigation requirements of public open spaces

Treatment type	Opportunities	Constraints	Options
Water use reduction	Demand for non-potable water exceeds supply Types of garden plants used can substantially influence irrigation demands Private open space can utilise the latest in irrigation technology including drip irrigation, irrigation schedulers and irrigation timers	Individual dwellings in medium to high rise developments may not be metered	Demand management through low water use appliances and fittings Large single water users such as cooling towers in high rise buildings can be metered to detect leakage Reducing the garden irrigation demand for potable water by adopting low water use landscapes.
Water re-use	Many non-potable water demands can be met using alternative water supplies such as treated wastewater, rainwater and/or groundwater	Space for rainwater tanks can be limited Limited roof stormwater capture per number of households	Centralised hot water systems and cooling towers can be supplied with roofwater in cases where sufficient roof area exists

Treatment type	Opportunities	Constraints	Options
Stormwater Treatment	<p>There is the potential to incorporate stormwater treatment measures in the common spaces of formally maintained gardens within medium to high-rise developments</p> <p>The regular maintenance of stormwater treatment devices is more likely to be sufficient to ensure satisfactory performance</p>	<p>Large impervious areas associated with these developments generate more runoff and pollutant loads than less impervious sites</p> <p>Space for treatment systems and infiltration measures can be limited</p>	<p>A range of stormwater treatment measures, such as bioretention systems, infiltration systems, vegetated swale sand GPTs are suitable to address water quality objectives.</p>

5.6.6 LARGE GREENFIELD SUBDIVISIONS

This category includes large greenfield development with predominantly single dwellings, areas of public open space including parkland and sporting fields and typically includes small proportions of mixed and multi-purpose uses. The size of such developments is usually greater than 2 hectares. The impervious surfaces associated with large subdivisions include the roofs, driveways, car parks, paths and other hard surfaces of the individual allotments in addition to the roads, paths, and commercial spaces. Pervious areas of the site include any garden or lawn areas and public open space. Large subdivisions are expected to have a site imperviousness in the order of 40% to 60%. The water used in large subdivisions comprises:

- potable water requirements such as drinking, and kitchen uses
- non-potable water requirements such as toilet flushing, clothes washing, hot water systems, pools and garden irrigation.
- irrigation requirements of public open spaces

Treatment type	Opportunities	Constraints	Options
Water use reduction			<p>Demand management through low water use appliances and fittings</p> <p>Reducing the garden irrigation demand for potable water</p> <p>by adopting low water use landscapes in public parks and</p> <p>encouraging low water use gardens on private allotments</p>
Water re-use	<p>Construction of services throughout the subdivision offers greater potential to install dual reticulation plumbing that can facilitate the use of</p>		<p>Supplementing water supplies – with alternative non-potable sources such as wastewater, groundwater for external uses and/or rainwater tanks</p> <p>Maximising the use of treated wastewater and groundwater for</p>

Treatment type	Opportunities	Constraints	Options
	treated wastewater or groundwater to meet non-potable water demands		non-potable end uses, in particular landscape irrigation which constitutes more than 50% of residential water demand Maximising the use of rainwater for internal non-potable uses
Stormwater Treatment	<p>Intensive site analysis by specialists and urban designers during the master planning process allows for greater consideration for the incorporation of WCM into large subdivisions</p> <p>There is the potential to incorporate stormwater treatment measures in the formally maintained public open spaces and road reserves. The regular maintenance of stormwater treatment devices is more likely to be sufficient to ensure satisfactory performance</p>	<p>Large subdivisions must also deal with runoff from roads and paths</p> <p>There is greater complexity in the planning and design process in order to incorporate the requirements for WCM with those authorities responsible for the services such as transport, electricity, water and sewerage</p> <p>A range of site constraints may be encountered including steep sites, acid sulphate soils, and groundwater levels</p>	A range of stormwater treatment measures, such as bioretention systems, infiltration systems, vegetated swale sand GPTs are suitable to address water quality objectives.

5.6.7 COMMERCIAL AND INDUSTRIAL

This category includes a wide range of development designed to meet commercial and industrial needs. The buildings associated with this category may include warehouses, factories and retail outlets. The impervious surfaces associated with commercial and industrial developments typically include large roof areas, driveways and extensive car parking or paved and hard ground surfaces used as work areas. Many sites have limited landscaping. Site imperviousness may be as high as 80% to 100%. The water used in commercial and industrial areas is highly industry specific and may range from very small quantities to very high quantities. Typically there are:

- Low potable water demands such as drinking, and kitchen uses
- Higher non-potable water demands associated with the nature of the industry or use on site
- Limited requirements for garden irrigation.

Treatment type	Opportunities	Constraints	Options
Water use reduction	Dependent on industry type	Dependent on industry type	Adoption of latest water efficient production, cleaning, washing etc devices in high water using industries

Treatment type	Opportunities	Constraints	Options
			<p>Adoption of low water using fixtures and appliances in commercial and retail areas.</p> <p>Multiple uses of water within a manufacturing site</p>
Water re-use	<p>Large roof areas or extensive impervious ground areas generate large volumes of runoff that can be reused on site</p> <p>Where an industry has high internal water demands there may be a financial incentive to harvest rainwater or stormwater.</p> <p>Rooftop runoff management can be very effective in industrial areas due to the large roof areas</p>		<p>Maximising the use of wastewater rainwater and groundwater for non-potable end uses</p> <p>The use of reclaimed water for process cooling applications</p> <p>Use of stormwater runoff to landscaping within hard stand area such as car parking.</p>
Stormwater Treatment	<p>A wide range of stormwater treatment measures, may be suitable to address water quality objectives.</p>	<p>The large amounts of impervious area generate large volumes of runoff which require larger treatment system areas to achieve the pollutant load reduction targets</p> <p>Industrial areas are associated with a wide range of chemicals and other potential pollutants and can discharge a more toxic and wider range of industrial chemicals In general it is likely that space for stormwater management will be limited</p> <p>Many large retail areas contain minimal landscaping areas and are highly impervious reducing the options available</p>	<p>Structural separation in industrial areas. Structural separation is a form of source control which isolates industrial pollutants from the stormwater drainage system. This is achieved by activities such as covering work areas, directing wash down to sewer discharge and control of activities discharging to stormwater drains.</p> <p>Direct stormwater into landscaping to reduce connectivity of hard surfaces. Examples include recessed gardens or kerb inlets within and adjoining carparks.</p>

Treatment type	Opportunities	Constraints	Options
		for effective treatment of stormwater runoff	

5.6.8 INFRASTRUCTURE

Transport infrastructure, particularly roads, are the principal type of infrastructure that requires consideration in WCM. Transport infrastructure includes parking areas for vehicles. In many urban areas, stormwater runoff from roads and other transport infrastructure contains a high proportion of the pollutants. Roads form extensive parts of the landscape and thus influence the quality of stormwater in many areas. Where roads are used frequently this can lead to a build-up of many pollutant particles on the road surfaces i.e. brake dust, fuels and oils, rubber, dust soil, debris and litter. The imperviousness associated with the transport corridors and road reserves depends on the proportion of area dedicated to bitumen or concrete. Site imperviousness typically range from 50% to 100% of the road reserve.

Treatment type	Opportunities	Constraints	Options
Water re-use	Road surfaces generate large volumes of runoff		Passive irrigation for landscaping
Stormwater Treatment	<p>A variety of stormwater treatment devices are available and can be configured to accommodate the road runoff drainage network</p> <p>Space available for stormwater treatment</p> <p>Treatment of road runoff removes a significant source of oil and grease, heavy metals and other toxic pollutants from urban stormwater runoff</p>	<p>Many services are associated with transport corridors and road reserves (i.e. electricity, gas, sewer, water) and these can restrict the space available for stormwater treatment</p> <p>Road networks are extensive and it is not practical to treat all road runoff, therefore specific locations should be targeted</p> <p>Road surfaces generate large volumes of runoff</p> <p>Strict controls regarding flooding, safety, facilities and access requirements</p>	<p>Pre-treatment of road runoff using gross pollutant and coarse sediment removal techniques such as gross pollutant traps, and road side swales</p> <p>Infiltration systems may be used in some areas with appropriate pre-treatment of stormwater and a suitable buffer from infrastructure to protect road pavement.</p> <p>Stormwater treatment measures appropriate for transport infrastructure include swales, bioretention systems and basins to address water quality and objectives.</p> <p>Stormwater run-off from key pollutant generating areas should be subjected to stormwater treatment</p> <p>Future opportunities for the detention, treatment and infiltration of road runoff should be investigated for key pollutant generating areas</p>

5.6.9 OPERATION & MAINTENANCE

For information regarding the operation and maintenance of SQIDS, please refer to Section 6 of Council's SQID Guidelines.

For information regarding the operation and maintenance of rainwater tanks, please refer to [Council's website](#).

6 APPENDICES

6.1 APPENDIX 1 - CALCULATING THE SITE DISCHARGE INDEX

What is the site discharge index?

Site discharge index is a numerical value that relates the total area of a development site with the area of impermeable surface that drains directly to a drainage system.

In order to satisfy the criteria, designers need to incorporate sufficient measures to manage stormwater runoff from impermeable surfaces within the development site.

Why are impermeable surfaces important?

Impermeable surfaces are hard surfaces through which rainwater cannot infiltrate to the underlying soil. Examples of impermeable surfaces include roofs, driveways and paving. All rainwater falling on these surfaces produces runoff. In conventional stormwater systems, runoff from impermeable surfaces is collected by simple drains and conveyed directly to the street drainage system. In contrast, WCM seeks to reduce the direct flow of runoff from impermeable surfaces.

What does the site discharge index measure?

Site discharge index provides a very general indicator of the extent to which a development proposal will create unmanaged flows from impermeable surfaces. The greater the area of impermeable surface that is not managed by stormwater source controls the higher the site discharge index will be (up to a maximum of 1.0 on a site that is totally covered by impermeable surfaces). Using conventional drainage, typical low and medium density development will score a site discharge index of approximately 0.4-0.6. However, by incorporating appropriate measures a site discharge index of 0.0 -0.1 can readily be achieved. Under the Lake Macquarie City Council Development Control Plan, development proposals need to satisfy a site discharge index of 0.1.

How is site discharge index calculated?

The site discharge index for a development proposal can be readily calculated using the information contained in ordinary building and site plans.

Step 1: Site Area – calculate the total site area (S)

Step 2: Roof Area – calculate the total roofed area (R)

Step 3: Paved area – calculate the total paved area (P)

Step 4: Calculate the total impermeable area (I)

$$I = R + P$$

Step 5: Manage impermeable area.

Identify runoff paths from each impermeable surface. Identify each component that is managed by an acceptable stormwater source control. That is, the runoff must pass through a source control prior to discharge to the street drainage system. Calculate the total area of impermeable surface that is managed by acceptable stormwater source controls (M)

Step 6: Directly-connected impermeable area

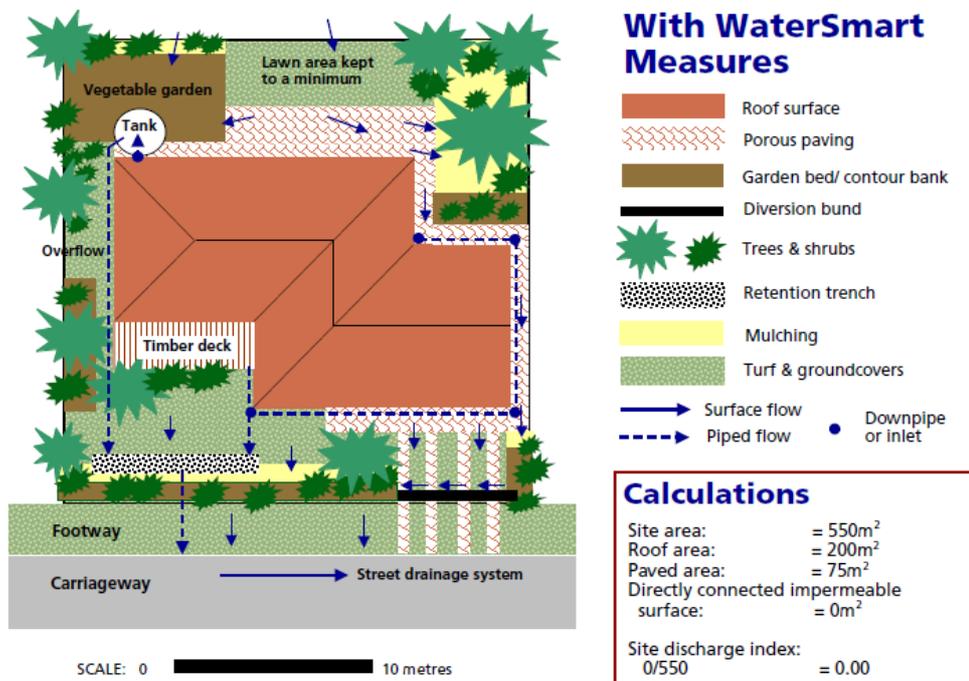
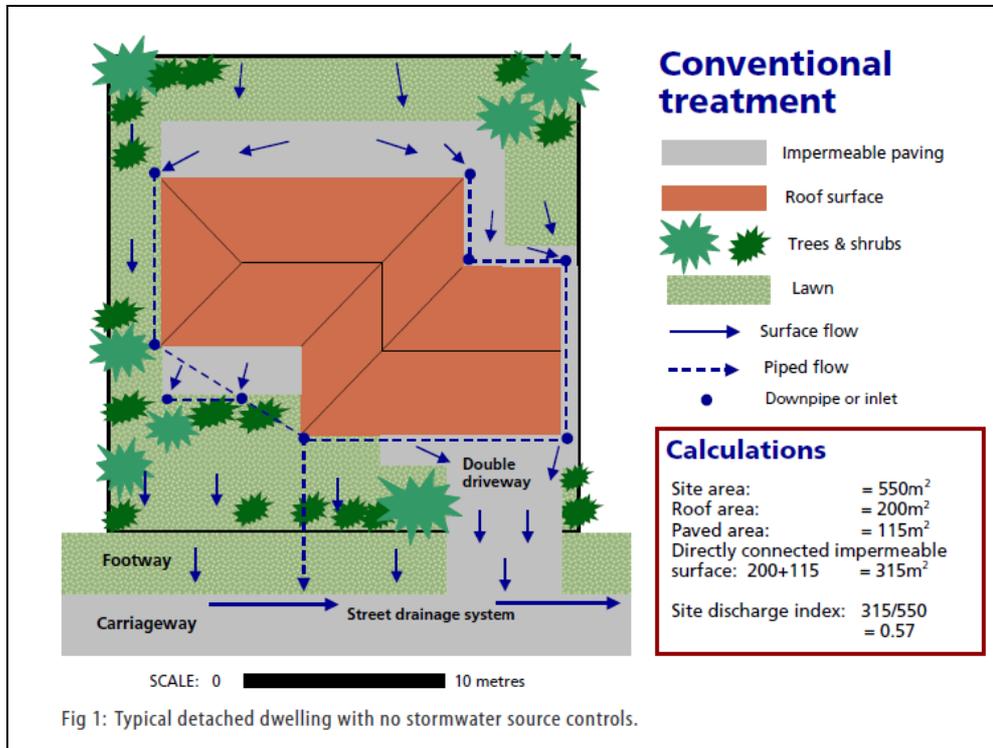
Calculate the area of impermeable surface that discharges directly to the street drainage system or interallotment easement without passing through an acceptable stormwater source control (DC).

$$DC = I - M$$

Step 7: Site discharge index

Divide the directly-connected impermeable area by the total site area.

$$SDI = DC / S$$



6.2 APPENDIX 2 – USING MITIGATION DEPTH TO CALCULATE STORAGE REQUIREMENTS

Whilst the SDI can be used to determine the area of impervious surfaces that must be managed by stormwater harvesting (the ‘managed impermeable area’), it cannot determine how much capacity those controls should have.

By providing temporary storage of runoff from impermeable surfaces, stormwater harvesting can be used to mimic the natural (pre-development) balance between runoff and infiltration. Storage capacity needs to be sufficient to accommodate increased runoff from permeable surfaces to ensure the level of runoff from impermeable surfaces does not exceed the level of runoff equivalent of that once permeable (natural) surface during a rainfall event with an Average Recurrence Interval (ARI) of 3 months or less.

The amount of storage required to mimic natural conditions varies with soil type. More storage is required on sandy soils (as a high proportion of rainfall naturally infiltrates to the soil), whereas less storage is required on heavy clay soils (as rainfall largely runs off to nearby streams).

Calculating storage requirements using mitigation depth

The storage requirement for a harvesting measure must be calculated separately, based on the actual area of impermeable surfaces that drain to a harvesting measure.. This will ensure that impervious surfaces on the site are adequately managed.

The amount of stormwater runoff that must be captured to mimic natural permeability during a 3 month ARI rainfall event is termed the Mitigation Depth (MD). It is expressed in millimetres and is equivalent to the number of litres of storage capacity that must be provided for each square of impermeable surface that drains to a stormwater harvesting measure.

Mitigation depth varies from site to site according to the rainfall characteristics and soil texture. The calculation can be broken down into the following steps.

Step 1: Soil texture

Determine the relevant soil texture class for the site (sand, sandy loam, clay loam or clay). This can be determined by a simple soil test.

Step 2: Mitigation depth

Using the information from Step 1 read off the required Mitigation Depth (MD) for the site from the table below.

Soil Texture			
Sand	Sandy loam	Clay loam	Clay
14	14	10	7

Step 3: Managing impermeable catchment

Determine the area of impermeable surfaces that drains to the proposed stormwater harvesting measure in square metres. This is termed the ‘Managed Impermeable Catchment’ (MIC) for that stormwater harvesting measure.

Step 4: Mitigation storage

Using the information from Steps 2 and 3 calculate the mitigation storage for the stormwater harvesting measure using the following formula:

$$MS = MIC \times MD / 1000$$

Where:

MS = mitigation storage (kilolitres)

MIC = managed impermeable catchment (m²)

MD = mitigation depth (mm)