Water Sensitive Urban Design

Engineering procedures for stormwater management in Tasmania

Tasmania
Explore the possibilities

nrm SOUTH
NATURAL RESOURCE MANAGEMENT

Derwent Estuary Program

NRM North
Tamar Estuary and Esk Rivers

Acknowledgments

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Chapter 1 Introduction

1.1 Why WSUD?

Recent years have seen an increasing number of initiatives to manage urban water in a more sustainable way. These initiatives are underpinned by the key principles of sustainability: water conservation, integrated water cycle management, waste minimisation and environmental protection. Water Sensitive Urban Design (WSUD) integrates these principles within urban planning and design, and is the best management design practice standard for development across Australia.

Key elements of WSUD include managing urban stormwater as a resource and the protection of receiving waterways and aquatic ecosystems. These aims have been identified as important for effective natural resource management in Tasmania by all levels of government.

This manual sets out a framework to assist in the design of stormwater treatment systems applicable to urban landscapes throughout Tasmania. It has been adapted to be applicable for all of Tasmania from Derwent Estuary Program's WSUD Engineering Procedures: Stormwater for Southern Tasmania (2006) and Melbourne Water's WSUD Engineering Procedures: Stormwater (2004).

This document provides construction, engineering and development assessment advice for stormwater management systems. The source of urban stormwater pollution and the justification for implementing WSUD practices have been widely published and are easily accessible (see Appendix C Resource Guide).

WSUD incorporates water management features into the urban landscape and has multiple environmental and aesthetic benefits such as:

- reducing stormwater flows and pollutant loads – thereby protecting downstream waterways – by collecting and treating stormwater in wetlands, ponds, bioretention swales or grass swales
- conserving potable water by collecting roof runoff and stormwater in rainwater tanks or underground storage for reuse in gardens and toilets
- minimising impervious surfaces by use of porous pavements (e.g. for carparks, roads and driveways) and minimising housing footprints
- providing public open spaces for stormwater treatment (e.g. wetlands), recreation and visual amenity (which also increases land values).

WSUD applies to both urban and rural developments and can either be retrofitted into existing urbanised catchments or incorporated at the design stage of new developments.

This manual will help ensure that WSUD designs represent best practice and a consistent design approach. This manual also provides assessment officers with checklists to assess the adequacy of proposed works submitted for approval. The target audience consists of both design engineers and local and state government approval officers. Design guidance in this manual is intended for professionals with experience in urban hydrology and hydraulics.

While the manual is primarily directed at engineers, it is recognised that all WSUD developments require the involvement of a range of professionals including planners, urban designers, landscape architects and environmental scientists. Sections of this manual contain expert design input from such professionals, based on Derwent Estuary Program's 'WSUD Engineering Procedures: Stormwater for Southern Tasmania (2006)' and Melbourne Water's 'WSUD Engineering Procedures: Stormwater (2004)'.

1.2 The Tasmanian context

The Tasmanian State Policy on Water Quality Management 1997 (SPWQM) sets the water quality management and objectives for the State including stormwater. The purpose of the SPWQM is to achieve the sustainable management of Tasmania's surface water and groundwater resources by protecting or enhancing their qualities while allowing for sustainable development in accordance with the objectives of Tasmania's Resource Management and Planning System (Schedule 1 of the State Policies and Projects Act 1993). The SPWQM has the following stormwater provisions.

<u>Clause 31 – Runoff from land disturbance</u>

- SPWQM states that planning schemes should require stormwater management strategies for development proposals that have the potential to give rise to off-site polluted stormwater runoff.
- The stormwater management strategies should address both the construction phase and the operational phase with maintenance of water quality objectives as a performance objective.

Clause 33 – Urban runoff

- The SPWQM states that erosion and stormwater controls must be specifically addressed at the design phase of proposals in accordance with Clause 31.
- The SPWQM states that state and local governments should also develop and maintain strategies for the reduction of stormwater pollution at source.
- Where stormwater has the potential to prejudice the achievement of water quality objectives, the SPWQM states that councils should prepare and implement a stormwater management plan.

To facilitate the implementation of the stormwater provisions contained in Division 3 of the SPWQM a State Stormwater Strategy was prepared and released by the Tasmanian EPA Division in 2010. The State Stormwater Strategy sets out key principles and standards for stormwater management in Tasmania, and identifies accepted guidance documents.

Managing stormwater in new developments

All new developments that create 500m^2 or more of additional impervious surface, including subdivisions, roads and other large developments, should incorporate best practice stormwater management. The following standards are recommended:

Construction stage

Soil and water management controls should be required and implemented through the Development Application process, including detailed Soil and Water Management Plans where warranted. Best practice guidance on sediment and erosion control measures is provided in the document Soil and Water Management on Building and Construction Sites (2009).

Operational stage

New developments should be designed to minimise impacts on stormwater quality and, where necessary, downstream flooding or flow regimes. Stormwater should be managed and treated at source using best management design practices (eg Water Sensitive Urban Design) to achieve the following stormwater management targets:

- 80 per cent reduction in the annual average load of total suspended solids
- 45 per cent reduction in the annual average load of total phosphorus
- 45 per cent reduction in the annual average load of total nitrogen

Best practice guidance on stormwater treatment options to achieve these targets is provided in this manual – WSUD Engineering Procedures: Stormwater for Tasmania (2012)

Managing stormwater in established urban areas

Management of urban runoff from established catchments should be based on a risk based prioritisation of catchments and stormwater pollution sources. Stormwater management plans should be prepared for high priority catchments, with a focus on ‘at source’ management. In particular, commercial areas, industrial sites and major roads tend to be significant sources of stormwater pollution. Best practice guidance on the development of stormwater management plans is provided in the Derwent Estuary Program’s A Model Stormwater Management Plan for Hobart Regional Councils – Focus on New Town Rivulet Catchment (2005).

Maintaining natural drainage systems

Urban waterways, including rivulets, creeks and natural drainage lines, provide important water quality, ecological and amenity values and should be maintained, enhanced or restored. Piping or lining of natural channels should be seen only as a last resort. It is recommended that buffer zones be established to protect the values of urban waterways, and that any development within these areas be carefully managed. Best practice guidance on managing urban waterways is provided in the document Tasmanian Waterways and Wetlands Works Manual (2003).

In light of the above policies and guidelines, it is clear there is sufficient impetus for the broad adoption of WSUD to protect waterways from the impacts of stormwater pollution.

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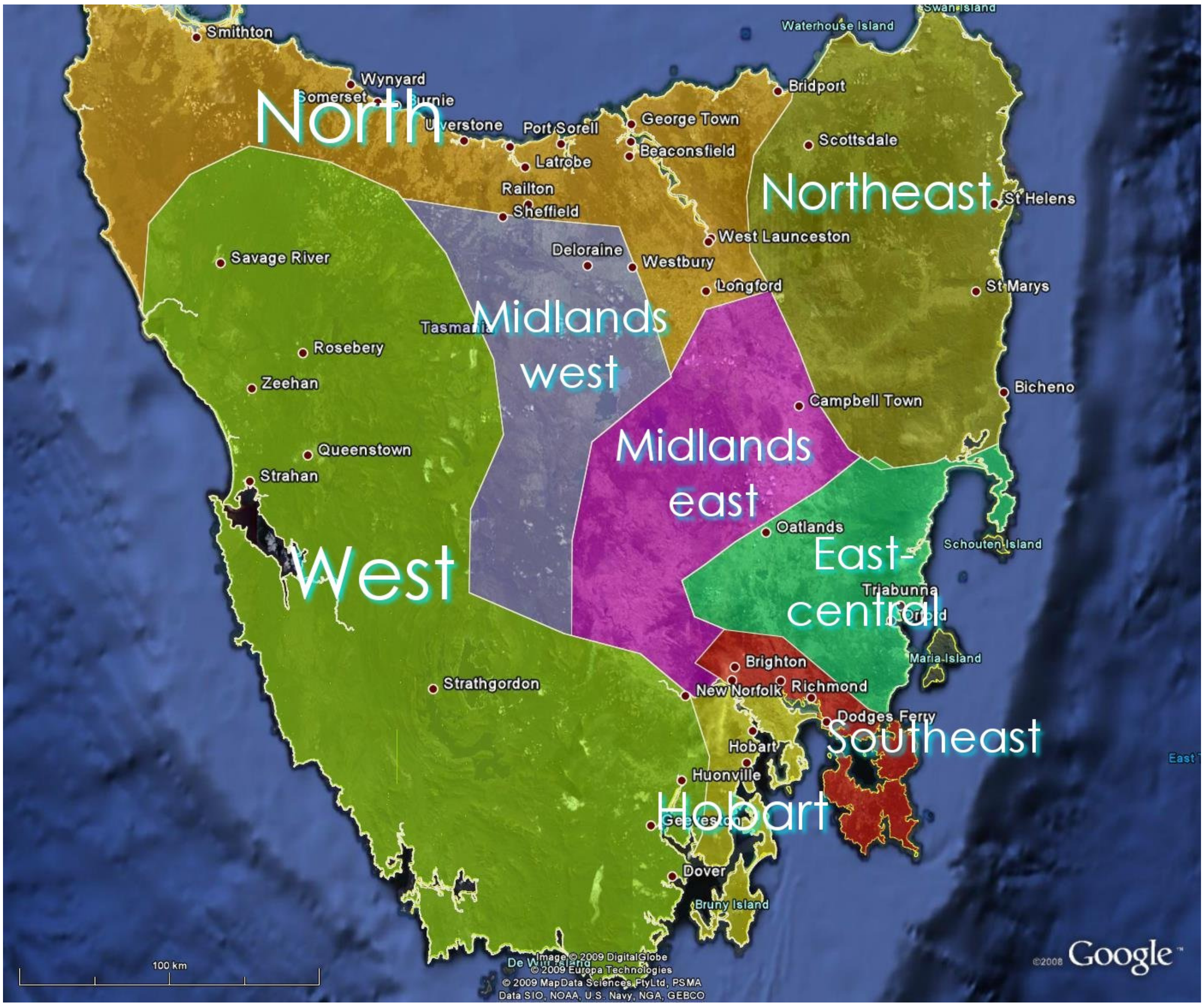


Figure 1.1. Map showing that this manual applies to the whole of Tasmania

1.3 WSUD elements

To effectively manage stormwater from different land uses, a combination of WSUD elements may be required to form what is commonly referred to as a **treatment train** – a series of treatment systems in a catchment that complement one another to achieve a desired stormwater management outcome. The selection and placement of these elements within a catchment should be determined during the concept design stage of a stormwater treatment strategy. An example of how WSUD elements could be incorporated into the urban landscape is shown in Figure 1.2.

Elements discussed in this manual include:

- sediment basins
- bioretention swales
- bioretention basins
- sand filters
- swale/ buffer systems
- constructed wetlands
- ponds
- infiltration measures
- rainwater tanks
- aquifer storage and recovery.

Additionally, Chapter 13 describes other stormwater management options such as proprietary products (including gross pollutant traps - GPTs), porous pavements and other treatment devices.

In combination, the placement of WSUD elements within a catchment or development will reduce stormwater pollution loads, peak flows and can help to conserve water.

The underlying principle of WSUD Engineering Procedures: Stormwater for Tasmania 2012 is the reduction of stormwater pollution from urban developments. The following pollutant reductions from the State Stormwater Strategy (2010) are recommended for the protection of receiving waters in Tasmania:

- total nitrogen 45% reduction
- total phosphorus 45% reduction
- total suspended solids 80% reduction

Stormwater treatment systems need to be sized to achieve this level of treatment. Inflows to any treatment system are assumed to contain concentrations of suspended solids and nutrients at levels typical to urban stormwater in Australia. All sizing guidance in the document is based on modelling using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). It is suggested that to develop alternate, more specific treatment estimates, site-specific modelling is completed by the designer.

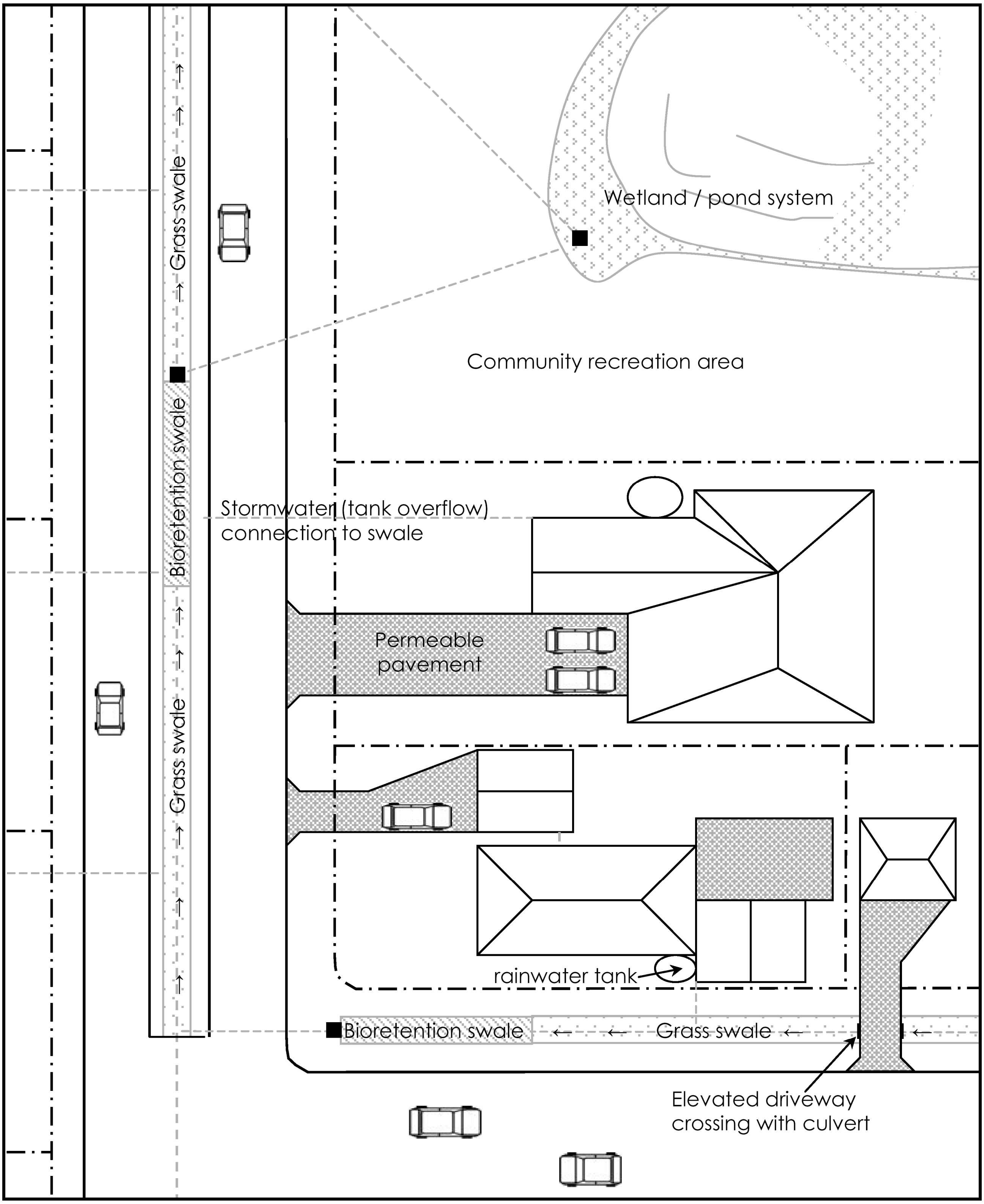


Figure 1.2. Example of WSUD incorporated into residential streetscape

1.3.1 Sediment basins

Sedimentation basins are used to retain coarse sediments (recommended particle size > 0.125mm) and are often the first element in a treatment train. Basins reduce flow velocities and encourage sediments to settle out of the water column. They can be designed to drain during dry periods (filling during runoff events) or to have a permanent pool.

Sedimentation basins are often used as pre-treatments to protect downstream WSUD elements (e.g. wetlands) from becoming loaded or smothered with sediments. They are also used for trapping sediment in runoff from construction sites.

Sediment basins can have various configurations including hard edges and base (e.g. concrete) or a more natural form with edge vegetation creating an attractive urban element. They are, however, typically turbid and maintenance usually requires de-watering and dredging collected sediments. The frequency of maintenance depends on the nature of the catchment and sediment loads.

1.3.2 Bioretention swales

Bioretention swales (or biofiltration trenches) are systems located within the base of a swale. Runoff is filtered through vegetation (e.g. grass, sedges or bushes) and 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.

Bioretention swales provide efficient stormwater treatment through fine filtration, extended detention and some biological uptake, as well as providing a conveyance function (along the swale). They provide some flow retardation for frequent rainfall events and are particularly efficient at removing nitrogen and other soluble or fine particulate contaminants.

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

Bioretention systems are well suited to a wide range of soil conditions including areas affected by soil salinity and saline groundwater, as they are generally designed to minimise or eliminate the likelihood of stormwater infiltration.

Vegetation prevents erosion, continuously breaks up the soil through plant growth to prevent clogging, and provides biofilms on plant roots that pollutants can absorb to. The filtration process generally improves with denser and higher vegetation.

1.3.3 Bioretention basins

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

They can form attractive streetscapes and provide landscape features in an urban development. Bioretention basins are extremely flexible in scale and shape making them a practical addition to any landscaping feature.

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.

A wide range of vegetation can be used within a bioretention basin assisting integration into a landscape theme of an area. Smaller systems can be integrated into traffic calming measures or parking bays, reducing their requirement for space. They also suit retrofit scenarios.

Traffic, deliveries and washdown wastes need to be kept from bioretenion basins to reduce any potential for damage to the vegetation or the filter media surface.

1.3.4 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 lack of available 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 pre-treatment to remove litter, debris and coarse sediments (typically a sedimentation chamber). Following pre-treatment, 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 collect treated water for conveyance downstream.

During higher flows, water can pond on the surface of the sand filter increasing the volume of water treated. Very high flows are diverted around sand filters to protect the sand media from scour.

1.3.5 Swale/ buffer systems

Vegetated swales use overland flows and mild slopes (generally 2% to 4%) to slowly convey water downstream. The interaction with vegetation promotes an even flow distribution and reduced velocities thus encouraging coarse sediments to be retained.

Swales can convey stormwater instead of pipes and provide a desirable 'buffer' between receiving waters (e.g. creek, wetland) and impervious areas of a catchment. They can be incorporated in urban designs along streets or parklands to add to the aesthetic character of an area.

The longitudinal slope of a swale is the most important consideration as slopes under 2% can tend to become waterlogged and have stagnant ponding (although the use of underdrains can alleviate this problem). Slopes steeper than 4%, may require the use of check banks 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.

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.

1.3.6 Constructed wetlands

Constructed wetland systems are shallow extensively vegetated water bodies that use enhanced sedimentation, fine filtration and biological pollutant uptake processes to remove pollutants from stormwater.

Wetlands provide some flow retardation for frequent rainfall events and are particularly efficient at removing nitrogen and other soluble or fine particulate contaminants. They provide habitat for wildlife and a focus for recreation, such as walking paths and resting areas.

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). 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 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.

In addition to playing an important role in stormwater treatment, wetlands can also have significant community benefits. They can also improve the aesthetics of a development and be a central feature in a landscape.

1.3.7 Ponds

Ponds can be used for water quality treatment in areas where wetlands are not feasible (e.g. very steep terrain). Ponds (or lakes) promote particle sedimentation, adsorption of nutrients by phytoplankton and ultra violet disinfection. They can be used as storages for reuse schemes and urban landform features for recreation as well as wildlife habitat.

Ponds can provide some flow retardation for frequent rainfall events and are well suited to steep confined valleys where storage volumes can be maximised.

Ponds should be designed to settle fine particles and promote submerged macrophyte growth. Fringing vegetation contributes little to improving water quality but is necessary to reduce bank erosion. Ponds still require pre-treatment such as a sediment basin that needs maintaining more regularly than the main open waterbody.

1.3.8 Infiltration measures

Infiltration measures encourage stormwater to infiltrate into surrounding soils thereby reducing runoff and trapping pollutants. They are highly dependent on local soil characteristics and are best suited to sandy soils with deep groundwater. All infiltration measures require significant pre-treatment of stormwater before infiltration to avoid clogging of the surrounding soils and to protect groundwater quality.

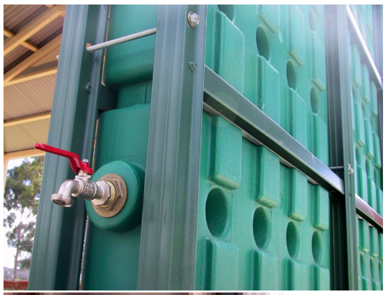
Infiltration measures generally consist of a shallow excavated trench or 'tank' that is designed to detain a certain volume of runoff and subsequently infiltrate to the surrounding soils. Generally these measures are well suited to highly permeable soils, so that water can infiltrate at a sufficient rate. Areas with lower permeability soils may still be suitable, but larger areas for infiltration and detention storage volumes are required. In addition, infiltration measures are required to have sufficient set-back distances from structures to avoid any structural damage, these distances depend on local soil conditions. Careful design is crucial on slopes to prevent nuisance throughflow.

Infiltration measures can also be vegetated and provide some landscape amenity to an area. These systems provide improved pollutant removal through active plant growth improving filtration and ensuring the soil does not become 'clogged' with fine sediments.

1.3.9 Rainwater tanks

Rainwater tanks collect runoff from roof areas for subsequent reuse that reduces the demand on potable mains supplies and reduces stormwater discharges. In addition, they can provide a flood retardation function provided adequate temporary storage is available either through appropriate sizing (e.g. even small tanks can offer significant retention of roof runoff if drawn down frequently) 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 pathogens 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.

Roof runoff that is reused also prevents stormwater pollutants (generated on roofs) from washing downstream.

1.3.10 Aquifer storage and recovery

Aquifer storage and recovery (ASR) is a means of enhancing water recharge to underground aquifers through either pumping or gravity feed. It can be a low cost alternative to store water compared to surface storages. Excess water produced from urban areas during wet periods (e.g. winter) can be stored underground and subsequently harvested during dry periods to reduce reliance on mains supply.

Harvesting urban runoff and diverting it into underground groundwater systems requires that the quality of the injected water is sufficient to protect the beneficial uses of the receiving ground water. The level of treatment required is dependent on the quality of the groundwater. In most instances the treatment measures described in this manual will provide sufficient treatment prior to injection.

The viability of an ASR scheme is highly dependent on the underlying geology of an area and the presence and nature of aquifers. There are a range of aquifer types that can accommodate an ASR scheme including fracture unconfined rock and confined sand and gravel aquifers. Detailed geological investigations are required to establish the feasibility of any ASR scheme. This manual provides an overview of the main elements of the system and directs readers to more specific guidance documents.

1.4 Document framework

This document provides design and development guidance and is structured in the following manner:

Chapter 2 describes the concept of 'hydrologic regions' each of which have allocated a set of 'adjustment factors' that allow required sizes of treatment systems for anywhere in Tasmania to be calculated from the sizes provided for the reference site used in this document, i.e. Hobart.

Chapter 3 onwards outlines the design process of each WSUD element while providing siting, management and construction advice along the way.

Comprehensive guidance on designing a treatment train or assessing the requirements for stormwater treatment is not covered thoroughly in this document. However, Appendix C Resource Guide contains references and some commentary on where to find this information. The list is by no means exhaustive but contains a broad variety of relevant literature that will help in this area.

1.5 Acknowledgment

WSUD Engineering Procedures for Stormwater Management Tasmania (2012) is an adaptation of Derwent Estuary Program's WSUD Engineering Procedures: Stormwater for Southern Tasmania (2006) and Melbourne Water's WSUD Engineering Procedures: Stormwater (2004).

Chapters one and two in this document are loosely based on Melbourne Water's WSUD Engineering Procedures: Stormwater. The content of these introductory chapters have been rewritten to better suit Tasmania, its climatic, policy and regulatory environments.

Textual content in Chapters three to thirteen have been modified only minimally in the adaptation. Maps and algorithms within this document have been developed using all available, suitable, Tasmanian rainfall data. The modelling software and methodology used in this process is based on those used in Melbourne Water's WSUD Engineering Procedures: Stormwater.

1.6 Disclaimer

The purpose of this document is to provide guidance only in the design and implementation of Water Sensitive Urban Design elements and should be used as a part of a holistic and rigorous design process by a qualified designer experienced in the field.

In the adoption of the guidelines within this document, the user acknowledges and agrees that –

1. Whilst the Crown in right of Tasmania (including the Department of Primary Industries, Parks, Water and Environment) has made every effort to ensure the accuracy and reliability of this document, the Crown does not accept any responsibility for the accuracy, completeness, or relevance to the user's purpose, of the information in this document. Those using it for whatever purpose are advised to verify its accuracy and to obtain appropriate professional advice. The Crown, its officers, employees, agents

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2. The worked examples provided in the document and the figures/information included therein are not to be used as actual design data. Designers are to use site-specific data and adhere to the requirements defined by the relevant Local Authorities and recognised industry standard procedures for the design being undertaken.
3. Rainfall data specific to the area of study is to be used where possible. Where such data is not available, IFD curves are to be derived from standard procedures as defined in Australian Rainfall and Runoff (2003).
4. The mean annual rainfall and adjustment factor methodology should be used in all cases where more detailed modelling is not performed, even in close proximity to the reference site. Sizing calculations have been developed using current industry-accepted data and software, however, treatment performance for any given size cannot be guaranteed due to the inherent variability in natural systems.