Chapter 1 **Introduction**

1.1 Purpose of the Manual WSUD Engineering Procedures: Stormwater

Since the late 1990s there has been an increasing number of initiatives to manage the urban water cycle in a more sustainable way. These initiatives are underpinned by key sustainability principles of water consumption, water recycling, waste minimisation and environmental protection. The integration of management of the urban water cycle with urban planning and design is known as **Water Sensitive Urban Design (WSUD)**. WSUD has multiple environmental benefits including improving urban landscape, reducing pollutant export, retarding storm flows and reducing irrigation requirements.

Urban **stormwater** managed both as a resource and for the protection of receiving water ecosystems is a key element of WSUD. In Victoria, there have been many initiatives to improve the environmental management of urban stormwater. The publication of *Urban Stormwater: Best Practice Environmental Management Guidelines* (Victorian Stormwater Committee 1999) provided a framework for the development of Stormwater Management Plans by local councils. More recently, the release of *Melbourne 2030* (Department of Infrastructure 2002) in 2002, the Victorian government's planning strategy for sustainable growth in the Melbourne metropolitan area, clearly articulates the role of sustainable stormwater management.

The practice of WSUD espouses the innovative integration of urban water management technologies into the urban environment and that strategic planning and concept designs are underpinned by sound engineering practices in design and construction. Although there are several documents that provide guidance for planning and strategy development of WSUD, similar support for the next level of design detail, from concept plans to detailed plans suitable for construction, however, is not well covered; this level of support forms the focus of the current Manual.

WSUD Engineering Procedures: Stormwater complements existing resources that promote WSUD and provides advice on the design detail of WSUD elements. It is intended to provide a consistent approach to design that incorporates WSUD technologies into urban developments. It provides a set of design procedures that can be used equally by designers and by referral authorities when checking designs. These design procedures are intended to provide consistency for engineering details of WSUD elements in Victoria.

The Manual is not intended to be a decision-making guide to selecting, integrating and locating WSUD elements (i.e. site feasibility). These topics are covered by other documents, notably *Australian Runoff Quality Guidelines* (Engineers Australia 2003) and *Urban Stormwater:*

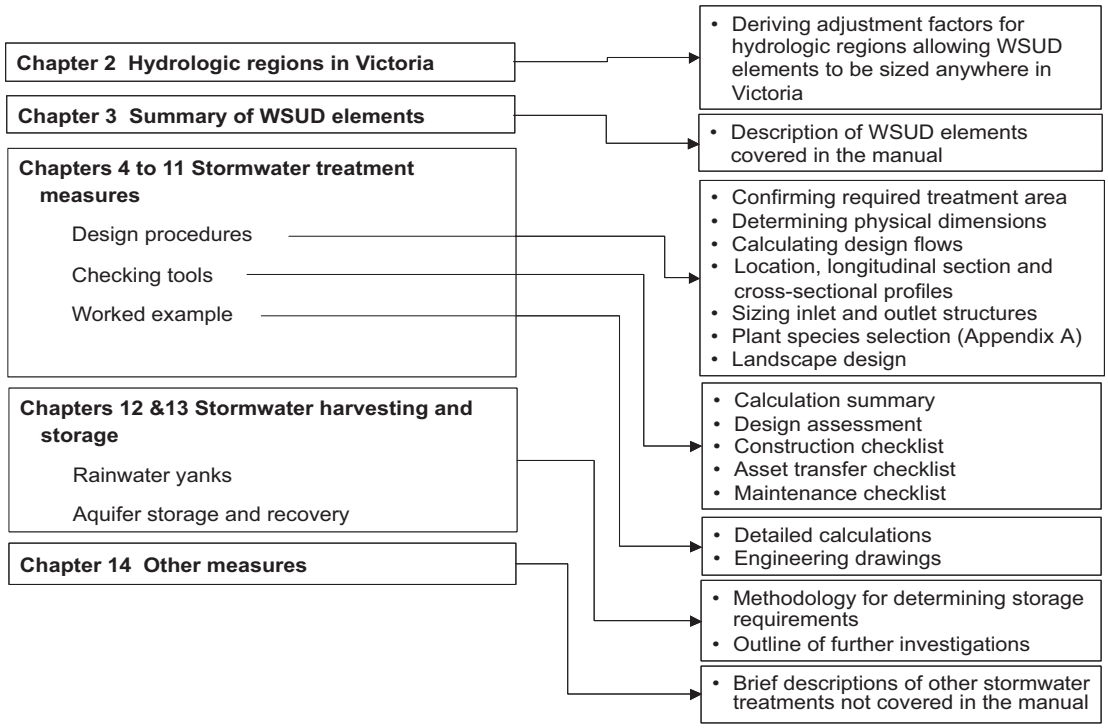

Figure 1.1 Map of manual contents.

Best Practice Environmental Management Guidelines (Victorian Stormwater Committee 1999). The purpose of the current Manual is to ensure that when an element is planned, its configuration will satisfy the engineering requirements of a stormwater system.

1.2 Target audience

As the aim of this Manual is to help ensure that engineering details of WSUD measures represent best practice and a consistent approach to their design is implemented, it will be used by referral authorities and assessment officers. It provides simplified tools and checklists to assess the adequacy of proposed works submitted for approval. The target audience, therefore, consists of both design engineers and local and state government approval officers. It is intended for professionals with some experience in urban hydrology and hydraulics and assumes a basic knowledge in these fields.

While primarily directed at engineers, it is, however, recognised that all WSUD developments require the involvement of a range of professionals to find a sustainable solution. Typically this would include planners, urban designers, landscape architects, environmental scientists and engineers to select and place WSUD elements. Sections of this Manual contain input from landscape architects, scientists and planners to reflect their expertise for components of a detailed design.

The Manual is applicable across Victoria.

1.3 Manual contents

The contents of this manual are grouped into four sections as shown in Figure 1.1.

All areas of Victoria are covered in the Manual through the use of **hydrologic design regions** (see Appendix B). The regions (see Chapter 2) are intended to allow the size of a particular WSUD element to be converted from that required at the reference site (i.e. Melbourne) to any location in Victoria in order to achieve the same level of pollutant reduction. Melbourne was selected as the reference site as it has the largest amount of collected performance data on WSUD elements.

Continuous improvements in sizing WSUD elements developed for the reference site can be applied to other areas using the **adjustment factors** provided for the various regions. Plots of adjustment factors for the nine regions of Victoria are provided.

In Chapter 3 an overview of the WSUD elements covered in this manual is presented, largely grouped into stormwater treatment measures, stormwater harvesting measures and other measures not covered in detail in this Manual.

In Chapters 4 to 11 the engineering design procedures for eight types of WSUD elements are presented: sediment basins, bioretention swales, bioretention basins, sand filters, swale/buffers, constructed wetlands, ponds, and inflitration systems. The format in each of the chapters follows a standard layout that includes a worked example to illustrate the design procedure, with associated design drawings. Checklists for design, construction and maintenance are provided to summarise key information related to the WSUD element to facilitate the design approval process.

The eight types of WSUD elements are described in the following paragraphs.

Confirming required treatment area: For each element covered typical configurations of the elements have been modelled to estimate their performance in removing pollutants. Expected pollutant reductions for Total Suspended Solids (TSS), Total Phosphorous (TP) and Total Nitrogen (TN) are presented for different sizes of WSUD elements (presented as a percentage of impervious **catchment**). The plots can be used during either designing or checking of a design. The curves, based on Melbourne data, can be adjusted for other areas in Victoria by using the hydrologic design regions. Should more local rainfall data be available, the performance for that specific treatment can be estimated through modelling more accurately.

Design procedure: For each element, a step-by-step process to perform detailed design calculations is presented. The procedures outline what equations should be followed as well as providing general commentary on the approach to design. The commentary emphasises important components that are critical to treatment performance and should not be compromised. Calculation summary sheets are provided to help ensure that designers follow each step in the design process. In addition, a section on construction advice is provided that summaries experiences from designing, building and maintaining WSUD elements around Australia.

Worked examples: A worked example is provided for each WSUD element to illustrate the use of the design procedure. The example goes through the steps from a concept design to a detailed design and discusses design decisions that are required as well as performing the calculations outlined in the design procedures. Working drawings that detail key elements of the system are also presented as examples.

Checking tools: A series of checking tools are provided for each WSUD element to guide referral agencies as well as designers. Checking tools for use during the construction process are provided for different stages of a WSUD element design.

Checklists: Checklists for design, construction, asset transfer and maintenance checklists are provided for checking the integrity of designs of each WSUD element prior to construction. Construction inspection forms are provided to allow checks of key elements on-site both during and after construction. In addition, an *Asset Transfer Checklist* is provided to ensure the WSUD element is functioning as designed following a defects period.

To aid maintenance of WSUD elements, *Maintenance Inspection Forms* are also provided for each element to highlight the important components of a system that should be routinely checked. These can be used as templates to develop more site-specific maintenance inspection forms.

Landscape designs: Illustrations of the WSUD elements showing possible landscapes are also provided. These help to show how the elements can fit into an urban landscape and are used to visualise the operation of a particular element.

Recommended plant species: Lists of recommended species are provided for different WSUD elements as well as for different zones within some WSUD elements (see Appendix A). Appendix A provides basic lists of plants that will enhance water quality. Recommended regions for each species across Victoria are also presented. Although these species will all improve water quality, the lists are not exhaustive and local indigenous species may be more appropriate.

Chapters 12 and 13 relate to stormwater harvesting and storage. They describe what needs to be investigated to design stormwater harvesting schemes at the allotment and regional levels.

Some additional treatment measures not specifically covered in this Manual are discussed in Chapter 14.

1.4 How to use this Manual

This Manual focuses on how to develop a WSUD strategy to ensure that the objectives of a stormwater system are maintained. In a typical project involving WSUD, the design process often starts with the development of a WSUD strategy. This would normally involve a series of workshops among the various stakeholders and include inputs from professionals from relevant disciplines. Some level of modelling is often involved to assist the workshop participants in arriving at a preferred WSUD strategy. In the case of stormwater management, further modelling is often undertaken to determine notional sizes of selected WSUD elements. Guidance in this process is provided by other documents such as *Australian Runoff Quality Guidelines* (Engineers Australia 2003) and *Urban Stormwater: Best Practice Environmental Management Guidelines* (USBPEM Guidelines) (Victorian Stormwater Committee 1999).

1.4.1 Designers

Once a WSUD element has been selected, detailed engineering calculations are required to size the various hydraulic components of the element, connection details to accommodate site constraints and to confirm the notional size (required to meet stated water quality objectives) determined during concept design. Calculations are also needed to demonstrate that a system is able to convey flood flows while maintaining treatment performance. Steps normally taken by a design engineer using this Manual would be as follows:

1 Refer to Chapter 2 to determine the appropriate design adjustment factors for the selected WSUD elements corresponding to the location of the specific site. This factor is used in subsequent chapters to confirm the selected size of treatment measures.
2 Refer to the relevant chapters for guidance in the detailed design of the components of a WSUD element. The steps are:
   a determine physical dimensions after confirming the required size of the treatment measure
   b calculate **design flows**
   c determine location, longitudinal section and cross-sectional profiles to suit the site characteristics
   d size inlet and outlet hydraulic structures
   e design the landscape
   f compile calculation summary sheets where basic information from the design process can be recorded and submitted as part of a development application.

1.4.2 Referral authorities

The current Manual is also intended to help when checking development submissions by ensuring that sufficient level of detail is presented for their assessment by referral authorities. The manual provides *Design Assessment Checklists* in each of the chapters on stormwater treatment measures (see Chapters 4–11) that can be followed to assess proposed design of WSUD elements.

There are also performance graphs that present relationships between the size of various WSUD elements and expected pollutant reductions. These graphs, based on Melbourne rainfall data, can be converted, however, into equivalent areas in other parts of Victoria with the use of the hydrologic design regions (see Chapter 2).

Following acceptance of a design, a project moves into construction, defects periods and ultimately a transfer of the asset to an owner. The inspection forms, asset transfer checklists and maintenance schedules can be used to help ensure WSUD elements are built as designed, are maintained and are in good operating condition prior to asset transfer to an authority.

1.5 Relevant WSUD guideline documents

Some existing documents are directly relevant to design detail of WSUD measures. The most relevant is the *Stormwater Management Devices: Design Guidelines Manual (TP10)* (Auckland Regional Council 2003). The Auckland Manual has many aspects relevant to Victorian practice and these are drawn upon here where appropriate.

Some recent relevant documents are described below.

1.5.1 Guidelines for Treatment of Road Runoff from Road Infrastructure

The *Guidelines for Treatment of Road Runoff from Road Infrastructure* (Austroads 2003) describes likely pollutants from road runoff, reviews design standards around Australia and describes a range of appropriate treatments. In addition, several case studies are presented that illustrate the design procedures as well as the required calculations.

Many of these case studies and the procedures directly relevant to this Manual and there is strong consistency between the approaches taken in both documents. Both demonstrate the application of a design procedure with real examples for design of **swales**, bioretention systems, infiltration systems and **wetlands**. Although specifically intended for road runoff, the procedures are equally applicable to other urban situations.

1.5.2 WSUD: Basic Procedures for 'SourceControl' of Stormwater Handbook

The Stormwater Industry Association and Urban Water Resources Centre (2002) draft of their document outlines detailed design considerations and procedures for stormwater detention and retention systems. These WSUD elements and much from the draft Handbook are relevant to the current Manual.

The Handbook describes the broad principles of WSUD and also various treatment measures (similar to the Victorian Stormwater Committee 1999). It distinguishes between measures intended for water quantity from those intended for water quality management. It divides descriptions into four categories of those intended to: reduce runoff quantity, remove particulate matter, harvest runoff and be used for multiple purposes.

The most relevant sections for the current Manual are the design procedures for infiltration and **Aquifer Storage and Recovery (ASR)** systems, which show a lot of rigour. The Handbook outlines detailed equations, sometimes with derivations from first principles. The information contained in the Handbook was reviewed and user friendly design tools were developed from this for the current Manual.

1.5.3 Stormwater Management Manual

The *Stormwater Management Manual* (City of Portland 2002) comprehensively describes the environmental management of stormwater as well as providing detailed technical guidance for many WSUD elements. Much of the material and procedures are directly relevant to the current Manual although simplified prescriptive design procedures (for North American conditions) are provided.

The *Stormwater Management Manual* is designed for developers requiring approval for stormwater treatments from new developments. The Manual uses a scoring system for a range of relatively simple WSUD elements to determine if compliance has been met (called the 'Presumptive Approach' as the systems are 'presumed' to comply if designed in accordance with the guidelines). Scores are based on the area of impervious surfaces of a development and the developer gets a credit for different treatment measures. In a similar way, this Manual compares the area of impervious surface draining to a WSUD element to determine the size required (depending on the location in Victoria) for a particular level of treatment.

To enable other WSUD elements to be used, and to encourage innovation, the *Stormwater Management Manual* allows a 'Performance Approach' that sets specific treatment levels for water quality and flow management that developers must demonstrate.

For a variety of WSUD elements, general design requirements are specified. In addition, specific design criteria are given as well as design curves for some elements. These are of a similar

level of design detail as described in the current Manual and may be useful when designing elements that are not covered here.

The *Stormwater Management Manual* provides advice on maintenance of each WSUD element and presents templates for maintenance plans of the facilities. There are also some typical drawings of WSUD elements that show the general arrangements and landscaping requirements of specific WSUD elements. These features have also been included in the current Manual.

1.5.4 Stormwater Management Devices: Design Guidelines Manual (TP10)

The *Stormwater Management Devices: Design Guidelines Manual (TP10)* (Auckland Regional Council 2003) is intended to provide a common approach for selecting and designing stormwater management measures. It provides an overview of the effects of uncontrolled stormwater in urban areas and then sets out a framework to address the impacts. Some sections outline procedures to select a WSUD element showing suitable and unsuitable site conditions and pollutant removal rates. It then provides detailed design procedures for a range of WSUD elements that are most relevant to the proposed Technical Manual.

Topics include **ponds**, wetlands, filtration and infiltration systems, swales, oil and water separators, **rainwater tanks** and green rooftops. All these systems and the design approach adopted are relevant to the current Manual.

For each treatment system a broad description is provided, water quality performances are predicted and detailed design guidance with typical drawings presented. In addition, recommendations for construction are made, with the staging of elements outlined, recommended plant species suggested and comments of maintenance and operation outlined.

Case studies are used to illustrate the design concepts and inspection forms, for both the construction period and for routine maintenance, are given. This information was reviewed as part of the development of the current Manual and drawn upon (with author consent) for many checklists contained in the Manual.

1.5.5 Summary of existing WSUD manuals

WSUD Engineering Procedures: Stormwater provides more detailed design guidelines and engineering checks than the USBPEM Guidelines. There are no available Australian guidelines that cover the breadth of issues in sufficient detail that this Manual is intended to. Thus, the purpose of the current Manual is to address this gap in the industry knowledge.

1.6 References

Auckland Regional Council (ARC) (2003). *Stormwater Management Devices: Design Guidelines Manual* (TP10), 2nd edn, Auckland Regional Council, Auckland.

Austroads (2003). *Guidelines for Treatment of Road Runoff from the Road Infrastructure*, Publication Number AP-R232/03, Austroads Inc, Sydney.

City of Portland (2002). *Stormwater Management Manual*, City of Portland, USA.

Department of Infrastructure (2002). *Melbourne 2030: Planning for Sustainable Growth*, State Government of Victoria, Victoria.

Engineers Australia (2003). *Australian Runoff Quality Guidelines*, Draft, June.

Stormwater Industry Association and Urban Water Resources Centre (2002). *Water Sensitive Urban Design: Basic Procedures for 'Source Control' of Stormwater, A Handbook for Australian Practice*, 1st edn, Draft, November. Final version published November 2004.

Victorian Stormwater Committee (1999). *Urban Stormwater: Best Practice Environmental Management Guidelines*, CSIRO Publishing, Melbourne.