CHAPTER 1: INTRODUCTION

1.1 WHAT ARE STORMWATER BIOFILTRATION SYSTEMS AND HOW DO THEY WORK?

Water biofiltration is the process of improving water (stormwater and wastewater) quality by filtering water through biologically influenced media.

Stormwater biofiltration systems (also known as biofilters, bioretention systems and rain gardens) are just one of a range of accepted Water Sensitive Urban Design (WSUD)[1] elements (Wong, 2006). They are a low energy treatment technology with the potential to provide both water quality and quantity benefits. A typical biofiltration system consists of a vegetated swale or basin overlaying a porous filter medium (usually soil-based) with a drainage pipe at the bottom (Figure 1). Stormwater is diverted from a kerb or pipe into the biofiltration system, where it flows through dense vegetation and temporarily ponds on the surface before slowly filtering down through the filter media. Depending on the design, treated flows are either infiltrated to underlying soils, or collected in the underdrain system for conveyance to downstream waterways or storages.

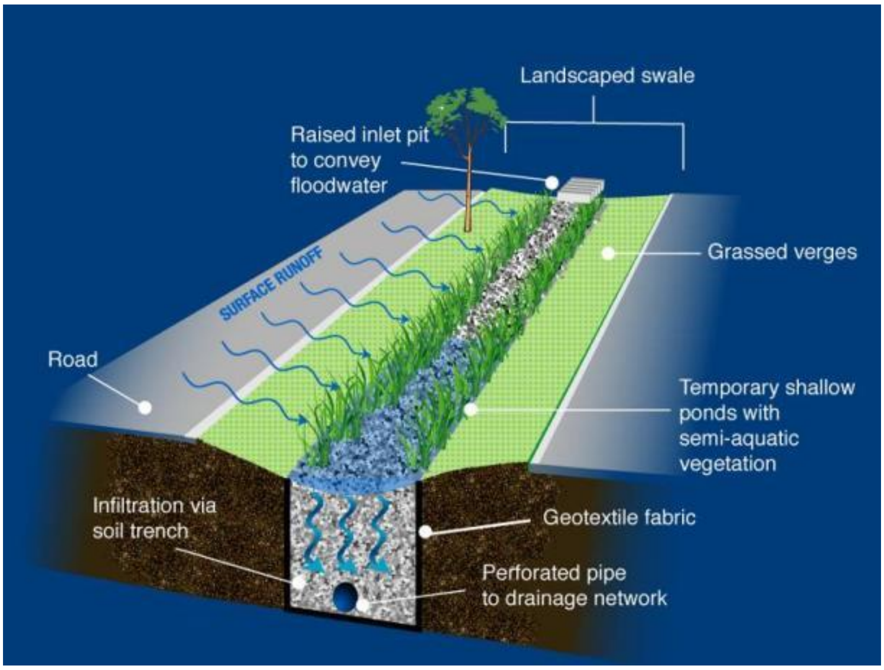

Figure 1. Schematic of a typical biofiltration system.

Small bioretention pods are often referred to as rain gardens, while linear systems are commonly referred to as biofiltration swales. Biofiltration swales provide both treatment and conveyance functions, while basins are normally built off-line to protect them from scour. The design configuration of biofilters is flexible, and possible variations include removal of the underdrain (to promote exfiltration into the surrounding soil) and the inclusion of a permanently wet zone at the bottom (to further enhance nitrogen removal). Hybrid systems are also possible, with an underdrain elevated above the base of the biofilter, to promote exfiltration, but allow discharge to the stormwater system during larger events.

[1] WSUD is "...a philosophical approach to urban planning and design that aims to minimise the hydrological impacts of urban development on the surrounding environment" (Lloyd *et al.*, 2002).

1.1.1 Hydrologic function

Stormwater runoff from urban areas tends to have short, sharp peak flows and substantially larger volumes in comparison to runoff from undeveloped areas. A primary goal of best-practice stormwater management is to reduce runoff peaks, volumes and frequencies. Biofiltration systems can achieve this, for two reasons:

- Depending on their size relative to the catchment, and their infiltration properties, they may reduce below 1-year Average Recurrence Interval (ARI) peak flows by around 80%. Instead of runoff being delivered directly to the local waterway via the conventional drainage network, it is collected on the surface of the biofiltration system and slow filters through the soil media; and
- They reduce runoff volumes by typically around 30%, on average: a portion of every runoff event is retained by the filter media – this will then be lost via evapotranspiration and/or exfiltration, depending on the design of the system. Small runoff events may even be completely absorbed by the biofiltration system (i.e., there is no discharge from the underdrain). Therefore, and particularly in the case of unlined systems with an elevated underdrain or no underdrain at all, they may substantially reduce runoff frequency to receiving waters, thus protecting aquatic ecosystems from frequent disturbance.

1.1.2 Treatment processes

Stormwater runoff from urban areas contains pollutants that are detrimental to the health of receiving waters. Therefore, the other goal of stormwater management is to improve the quality of water being discharged to urban waterways. Biofiltration systems aim to replicate the following natural treatment processes:

- Physical: as stormwater enters the basin or trench, the dense vegetation reduces flows, causing soil particles and particulates to settle out (sedimentation). In addition, particulates are filtered from the water as it percolates down through the soil media (mechanical straining);
- Chemical: soil filter media contains clay minerals and other chemically active compounds that bind dissolved pollutants (sorption); and
- Biological: vegetation and the associated microbial community take up nutrients and some other pollutants as growth components (eg., plant and microbial uptake).

1.2 WHY MIGHT WE CHOOSE A BIOFILTRATION SYSTEM?

There have been a number of successful applications of biofiltration, but also many poor outcomes owing to inappropriate utilisation of the technology, and poor construction, operation, and maintenance practices. There has also been insufficient understanding and dissemination of guidance on biofiltration borne out of successful applications, and research and development.

When used appropriately, biofiltration systems have been found to be viable and sustainable as a water treatment measure. In addition to reducing the impacts of urbanization on catchment hydrology and improving water quality, biofiltration systems:

- Have an acceptably small footprint relative to their catchment (typically ranging from 2 − 4%, depending on climate);
- Are attractive landscape features;
- Are self-irrigating (and fertilising) gardens;

- Provide habitat and biodiversity values;
- Are an effective pre-treatment for stormwater harvesting applications;
- Are potentially beneficial to the local micro-climate (because evapotranspiration causes cooling of the nearby atmosphere);
- Are not restricted by scale; and
- Can be integrated with the local urban design (streetscape).

1.3 RESEARCH UNDERPINNING THE DESIGN OF BIOFILTRATION SYSTEMS

The Facility for Advancing Water Biofiltration (FAWB) was formed in mid-2005 as an unincorporated joint venture between the Institute for Sustainable Water Resources (ISWR), Monash University and EDAW Australia (previously Ecological Engineering). The following industry collaborators were also involved:

- Adelaide and Mount Lofty Ranges Natural Resources Management Board (succeeding The Torrens and Patawalonga Catchment Water Management Boards) (SA);
- Brisbane City Council (Qld);
- Landcom (NSW);
- Manningham City Council (Vic);
- Melbourne Water (Vic); and
- VicRoads (Vic).

FAWB's mission was to ***provide proof of concept by developing and field-testing a range of biofilter systems that can be applied to specific market-based needs***. This included the needs of catchment managers, environmental regulators, public utilities, local governments, land developers, and design engineers.

FAWB was primarily funded through the Victorian State Government's Science, Technology and Innovation (STI) grant, industry cash contributions and a direct cash contribution from Monash University. The total value of the activities within FAWB, including both cash and in-kind contributions, was $4.3 million over three years.

The facility was run by a Board of Management, which was chaired by Professor Russell Mein. The research was carried out by over 25 staff and postgraduate students, and was managed by the following team:

- Chief Executive Officer: Professor Tony Wong, EDAW
- Research Manager: Professor Ana Deletic, Monash University
- Business Manager: Mr John Molloy, Monash University
- Project Leaders: Associate Professor Tim Fletcher, Monash University (*Project 1: Technology*), Associate Professor Rebekah Brown, Monash University (*Project 2: Policy and Organisational Receptivity*), Dr Belinda Hatt, Monash University (*Project 3: Adoption Tools*), and Mr Justin Lewis, Monash University (*Project 4: Demonstration and Testing*).

FAWB also actively collaborated through ongoing joint research projects with INSA Lyon, a leading engineering university in France, and with Luleå University of Technology in Sweden.

1.3.1 Structure of the Research Program

To refine the design of biofilters and facilitate widespread adoption of these systems, the following research questions were posed:

1. Technology questions:
   - How do biofilters work?
   - How should we design biofilters to work efficiently in a wide range of applications (eg. pollution control, flow management, stormwater harvesting) and site characteristics (eg. different climates, pollutant loading rates)?
2. Adoption questions:
   - What are the factors (policy, regulation, risk, etc.) that advance their widespread implementation?
   - How do we quantify these factors and their relative significance?
3. To test the technology and enable its uptake, FAWB also committed to:
   - Develop adoption tools, such as design methods and adoption guidelines; and
   - Demonstrate and test the technology, by supporting construction of a number of full-scale systems.

The entire Research Program was divided into four highly interlinked Projects:

- *Project 1: Technology*, which aimed to overcome technical barriers to widespread adoption of the technologies, and to optimise the performance and lifespan of biofiltration systems;
- *Project 2: Policy and Organisational Receptivity*, which aimed to develop methodologies and strategies to overcome institutional and social barriers to widespread adoption of the technologies;
- *Project 3: Adoption Tools*, which aimed to develop design and implementation tools for practitioners; and
- *Project 4: Demonstration and Testing*, which aimed to demonstrate and monitor the wide capability of novel, multi-functional biofilter designs.

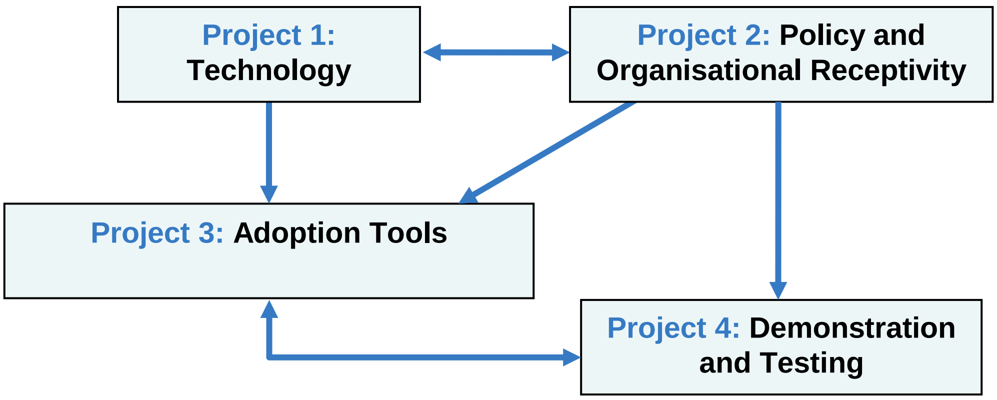

Figure 2. Structure of FAWB's Research Program.

The aims and activities of each of the projects are described in detail elsewhere (FAWB, 2008). The research outcomes have been extensively peer-reviewed by both the Australian and international scientific community; a list of publications that report on the details on the various research activities can be found in Appendix A. This gives confidence that these guidelines are based on sound science.

1.4 HOW TO USE THESE GUIDELINES

The purpose of this document is to provide guidance on how to apply FAWB's research findings in practice. The target audience includes planners, engineers, landscape architects, developers, constructors, and all other parties involved in urban design.

These guidelines are presented as a series of chapters, each addressing a different aspect of implementation of biofiltration systems, as follows:

- Chapter 2 (*Planning for Biofiltration*) outlines the planning aspects associated with implementing biofiltration systems, and reviews the planning instruments and initiatives to facilitate biofiltration in each state and territory of Australia. After identifying the gaps in the policy frameworks across the nation and highlighting the successful initiatives to endorse the implementation of biofiltration, interim performance measures for the technology that may be used in the absence of state or territory policy are presented;
- Chapter 3 (*Technical Considerations*) provides guidance on conceptual design considerations and linking design outcomes to identified management objectives, a key step in biofilter design that is often overlooked. It then describes the main components of biofiltration systems, as well as five fundamental design configurations. The design considerations for the overall configuration and each component are identified and, finally, specific site and application considerations are discussed; and
- Chapter 4 (*Practical Implementation*) provides general guidance on the construction, establishment, maintenance, and monitoring of biofiltration systems in Australia. The recommendations are based on the experience and observations of ecologists and engineers who have been actively involved in the design, on-site delivery and monitoring of at-source and end-of-line biofiltration systems. In addition, it provides example checklists and sign-off forms for designers and local government development assessment officers as well as practice notes for monitoring the performance of biofiltration systems.

In preparing these guidelines, we have attempted to be concise and avoid repetition, however, given that the chapters are required to be stand-alone to some extent, some overlap between chapters is necessary; this reiteration should be interpreted as an emphasis of the importance of these issues.

Note: Like all other WSUD elements, biofiltration technologies are most easily and successfully included in urban design when considered in an integrated manner i.e., in conjunction with all other elements of the urban layout. Therefore, in the case of greenfield and infill developments, these guidelines should be considered ***before*** any detailed planning and design occurs.

1.5 OTHER RELEVANT DOCUMENTS

These guidelines are intended to be relevant at the national scale and therefore cannot be a stand-alone document, as the final detailed design of biofiltration systems will be dictated by local site conditions (eg. soil type, rainfall intensity) and stormwater management requirements.

Other external documents including, but not limited to, the following should also be referred to in the design of biofiltration systems:

- Local planning policies and regulations
- Local development guidelines
- Local stormwater management guidelines
- Local construction guidelines
- MUSIC modelling documentation (see www.toolkit.net.au/music)
- Australian Runoff Quality (see http://www.engaust.com.au/bookshop/arq.html)
- ANZECC Water Quality Guidelines

  (see http://www.environment.gov.au/water/publications/quality/index.html#nwqmsguidelines)

Examples of successful and not-so-successful (which are, in some ways, more valuable) implementation and operation of biofiltration systems are a valuable source of information. They can also provide creative ideas for sites that are constrained in some way. Many local water authorities and other related organisations compile this information, some of which is available from their websites. Useful websites include:

- Water Sensitive Urban Design (http://wsud.melbournewater.com.au/)
- Water by Design (www.waterbydesign.com.au)
- Water Sensitive Urban Design in the Sydney region (http://www.wsud.org/)
- urbanwater.info (www.urbanwater.info)

It is also important to consult with the local water authority, particularly where design solutions are required for “problem” sites.

1.6 REFERENCES

FAWB (2008). *2007 – 2008 Annual Report*. Facility for Advancing Water Biofiltration, www.monash.edu.au/fawb/publications.

Lloyd, S. D., T. H. F. Wong and C. J. Chesterfield (2002). *Water Sensitive Urban Design: A Stormwater Management Perspective*. Cooperative Research Centre for Catchment Hydrology.

Wong, T. H. F. (Ed.) (2006). *Australian Runoff Quality: A Guide to Water Sensitive Urban Design*. Sydney, Engineers Australia.