Capturing the potential of stormwater

"Capturing the potential of stormwater by resolving the responsibilities and accountabilities of government agencies, water utilities and local government for stormwater is essential " (Water Services Association of Australia, Vision and Outcomes to 2030).

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Iouri is a civil – construction engineer with over 20 years extensive professional experience in the water industry both in Australia and internationally. His experience encompasses planning, design, project management and operation of water reuse and recycling schemes including stormwater harvesting, sewer mining, grey water and effluent reuse, stormwater management strategies and hydraulics studies, drainage and Water Sensitive Urban Design.

Iouri is a well-respected member of many professional bodies such as Stormwater Industry Association, AWA, IEAUS and has been actively involved in the training and professional development of the industry on the issues of stormwater harvesting, testing and validation of WSUD components, Integrated Urban Water Management, etc.

Iouri designed and project managed eight currently operational water reuse schemes in Australia including stormwater harvesting, sewer mining, grey water and effluent reuse schemes.

Management of the urban water cycle in Australia has changed significantly over the past few decades. As we lived through a series of droughts and floods, we adapted our water systems to cope with our ever changing environment. Australia's variable climate means that droughts and floods are inevitable – we just don't know when they will next occur, or how severe they will be. Today, we know much more about our water cycle than ever before and we have markedly improved our knowledge about water system management.

The water cycle includes all forms of water – recycled water, rainwater, stormwater, wastewater, groundwater, potable water and water contained in our rivers and bays. The notion of the whole-of-water-cycle management and planning (also known as Integrated Water Cycle Management IWCM) has become an accepted fact and the common practice amongst water experts and within the various levels of government and general public.

Living in the dry country we need to value and use the rain that falls on our land and the stormwater runoff generated by that rainfall.

Stormwater management philosophy in most developed countries has evolved over the last decades from the conventional, but still important, flood mitigation paradigm, to the current runoff quality control approach. It is now progressing towards the harvesting and reuse concept whilst retaining the previous two targets.

Urban Stormwater Harvesting (SWH) is one of the essential components of Integrated Water Cycle Management (IWCM) that offers multiple solutions to urban water systems such as mains water demand reduction, water quality improvement and in many cases creek ecosystem health protection. A number of SWH projects have been implemented in Australia to date and the number of SWH schemes is expected to grow with wider uptake of the IWCM encouraged by the State's and Federal Government.

In this paper the author presents the key observations gained through his involvement in the planning, design, construction and operation of the stormwater harvesting schemes and the practitioner's view on some of the key issues that need to be addressed.

Urban Stormwater Harvesting and its major components

Urban Stormwater Harvesting can be defined as the collection, treatment, storage and use of stormwater run-off from urban areas.

Stormwater harvesting requires a number of physical facilities. These include infrastructure for capture, storage, appropriate treatment, maintenance and supply to end users in cost effective ways. Sufficient runoff must be available and sufficient space be available to permit storage or retention, depending on whether the aim is water supply or to manage stormwater quantity and quality.

Typical urban stormwater harvesting schemes include all or a combination of the following components (Figure 1):

1. Catchment providing the run off volume
2. Diversion structure (DS)
3. Primary screening device
4. Buffer storage
5. Transfer facilities from buffer storage (e.g. pump and rising main)
6. Treatment facilities
7. Transfer facilities to the clear water storage
8. Clear water storage
9. Distribution pumps
10. Disinfection and supply rising main
11. End use

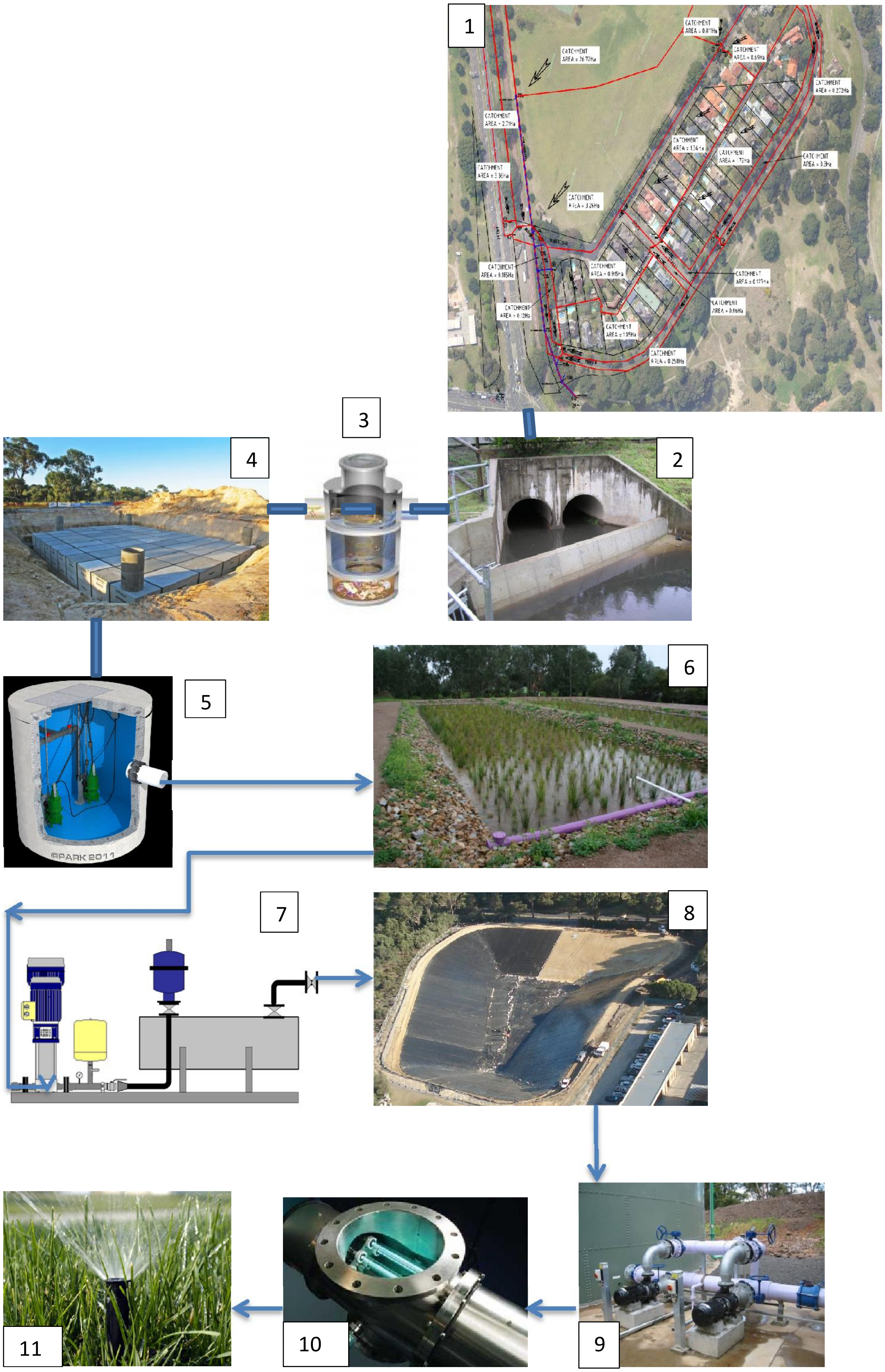

Figure 1 Functional Diagram - Stormwater Harvesting System components

Typical mode of operation for Stormwater harvesting scheme (Figure 1):

a. Designated volume of run off from the catchment (1) is diverted by the diversion structure (2) installed on the existing drainage system
b. The diverted run off is screened to remove gross pollutants and coarse sediment (3)
c. Screened run off gravitates into the buffer storage (4); the aim of the buffer storage is to level out the variance in the incoming flows and optimize the operational parameters of the pump that supplies water to the treatment component
d. Water from the buffer tank is transferred/pumped (5) into the treatment component e.g. wetland/bio retention (6) were the required quality of product water is achieved
e. Treated water is transferred to the clear water storage typically via a pump (7)
f. The treated water is stored in the Clear Water storage (8) for intended use; in many of the schemes involving irrigational use of product water a relatively large storage is required due to the temporal difference between the rainfall (collection) and irrigation (usage)
g. Product water is distributed to the end users via a system of pump(s) and lilac pipes (9)
h. Distribution process typically includes the disinfection of product water (10) e.g. with the on line UV system
i. Fit for purpose water is delivered to the end users (11)

Planning, Design, Construction and Operational Considerations

While it is beyond the scope of this article to discuss the particular detail of stormwater harvesting schemes, a few general comments based on practical experience should prove useful for stakeholders contemplating a stormwater harvesting scheme.

The tasks/disciplines required for the successful delivery of a stormwater harvesting scheme are diverse and would typically include the following:

1.0 Environmental Considerations

- Flora & Fauna
- Heritage & Cultural
- LCA (Land Capability assessment)
- Environmental Risks Assessment

2.0 Planning/Approvals

- Statutory & land acquisition, planning zone, dam permit
- Diversion and water use licenses from water authorities
- Other utilities (e.g. electricity, communication)

3.0 Public Consultation

4.0 Site Investigations

- Geotechnical
- Services and Surveying
- Water quality sampling and flow monitoring
- Others

5.0 Detail Design of Stormwater harvesting scheme

Typical Components:

- Diversion works incl. primary screens
- Raw water transfer infrastructure
- In line detention
- Raw water storage (open dam or underground tanks)
- Water treatment
- Clear water storage
- Distribution infrastructure

Tasks/Disciplines involved:

- Hydraulics design (diversion rates, detention and storage volumes, intake/outlet structures, pipes, pumps)
- Mechanical (pipes, pumps, tanks)
- Structural engineering (soil mechanics/retaining structures, dams, concrete structures, pits, pump stations)
- Civil structures (open storages, access roads, drainage, waste disposal)
- Electrical engineering (extension of services, switchboards)
- Process treatment part 1 – natural systems (e.g. wetlands, bio filtration)
- Process treatment part 2 - conventional (e.g. media filtration, UV)
- Instrumentation & Controls (e.g. SCADA)

6.0 Landscape architecture (some projects)

7.0 Irrigation design (some projects)

8.0 Estimation of Construction Costs/QS

9.0 Project management, reporting and QA

10.0 Construction Management

11.0 Commissioning and scheme validation

12.0 Post Commissioning scheme performance assessment, audit and reporting

13.0 Operation & Maintenance

Development of stormwater harvesting practice

The robust engineering basis for the planning, design, construction, operation and maintenance of urban stormwater harvesting is yet to be developed. This is because it is a relatively new engineering concept, despite being used in some form or another in various places around the world for centuries.

In the absence of the established design basis for stormwater harvesting – designers of these schemes frequently resort to the approaches borrowed from the more traditional disciplines such as municipal drainage and water sensitive urban design (WSUD). A number of leading Australian stormwater professional have commented on this issue e.g. Hatt, Deletic, Fletcher wrote in their article 'Integrated treatment and recycling of stormwater: a review of Australian practice' Journal of Environmental Management, vol.79, issue 1, April 2006:

"Existing stormwater recycling practice is far ahead of research, in that there are no technologies designed specifically for stormwater recycling. Instead, technologies designed for general stormwater pollution control are frequently utilized, which do not guarantee the necessary reliability of treatment. Performance modelling for evaluation purposes also needs further research, so that industry can objectively assess alternative approaches. "

However, as the practice of stormwater harvesting is continued and more projects are commissioned in the years to come, the design paradigm for stormwater harvesting should be further developed and validated.

Stormwater Harvesting guidelines

One of the major barriers to the wider uptake of SWH particularly by Local Government is the absence of comprehensive SWH guidelines. Such a guideline would allow the proponents of the schemes (Councils, regulators, consultants, contractors and other stakeholders' groups) to have a uniform reference document outlining current best practice including legislative framework, design / functionality, construction, operation and maintenance.

This document, once developed could offer comprehensive guidelines for implementation of storm water harvesting schemes in Australia as part of an Integrated Water Cycle Management (IWCM) approach, based on current legislation, best available engineering science and practical lessons learnt during planning, design, construction and operation of existing SWH schemes.

The SWH Guidelines will provide the clear path for implementation of the best practice stormwater management related to SWH and re-use in Australia, contributing to:

- better management of stormwater (balancing the harvesting to maximum aquatic and terrestrial benefits)
- improved water quantity and quality management
- reduced local flooding
- maximising the sustainable utilization of stormwater as a resource
- greater uptake of stormwater harvesting
- improved green space in urban areas contributing to livability
- improve allocation and harvesting of stormwater and integration with water sensitive urban design
- better landscapes and parkland managed with available stormwater
- informed strategic directions and policies for stormwater management and integrated water management across communities, councils and catchments

By providing the knowledge and confidence to implement sustainable well designed SWH projects the Guidelines will set the bench-mark for best practice SWH and provide the know-how to achieve it, overcoming many concerns and lack of knowledge currently associated with stormwater harvesting. The SWH guidelines will also assist in de-mystifying operational concerns and build confidence in managing "Harvesting Storm-water".

The development of SWH Guidelines is a complex and multidiscipline project requiring good coordination, adequate resources, extensive stakeholder's consultation and sufficient time and funding.

The resultant document should be based on "four pillar" (Figure 2):

1. Current regulation & legislation
2. Best engineering practice
3. Consideration of operation & maintenance issues
4. Case studies and practical examples

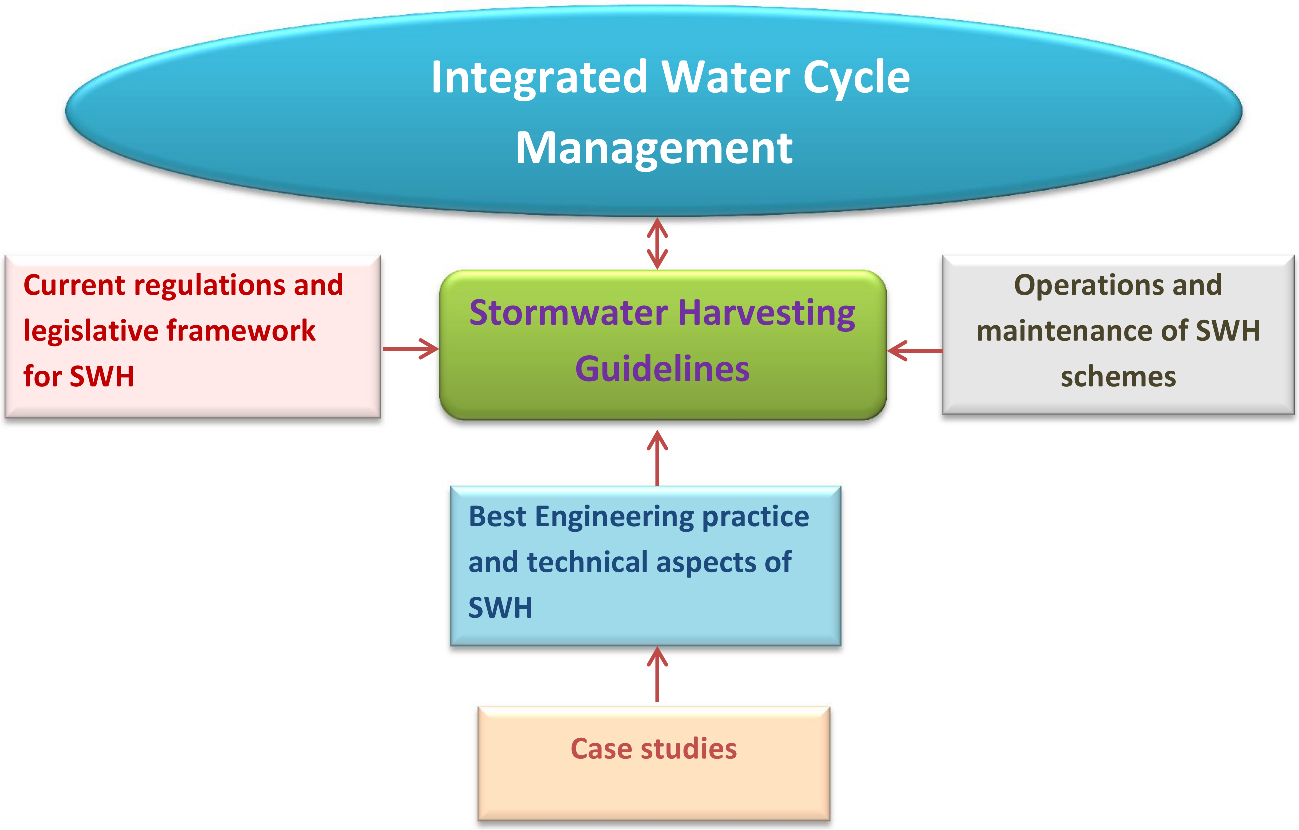

Figure 2 Stormwater Harvesting Guidelines development – major components

More detail flowchart on topics and structure of the guidelines is presented in Figure 3.

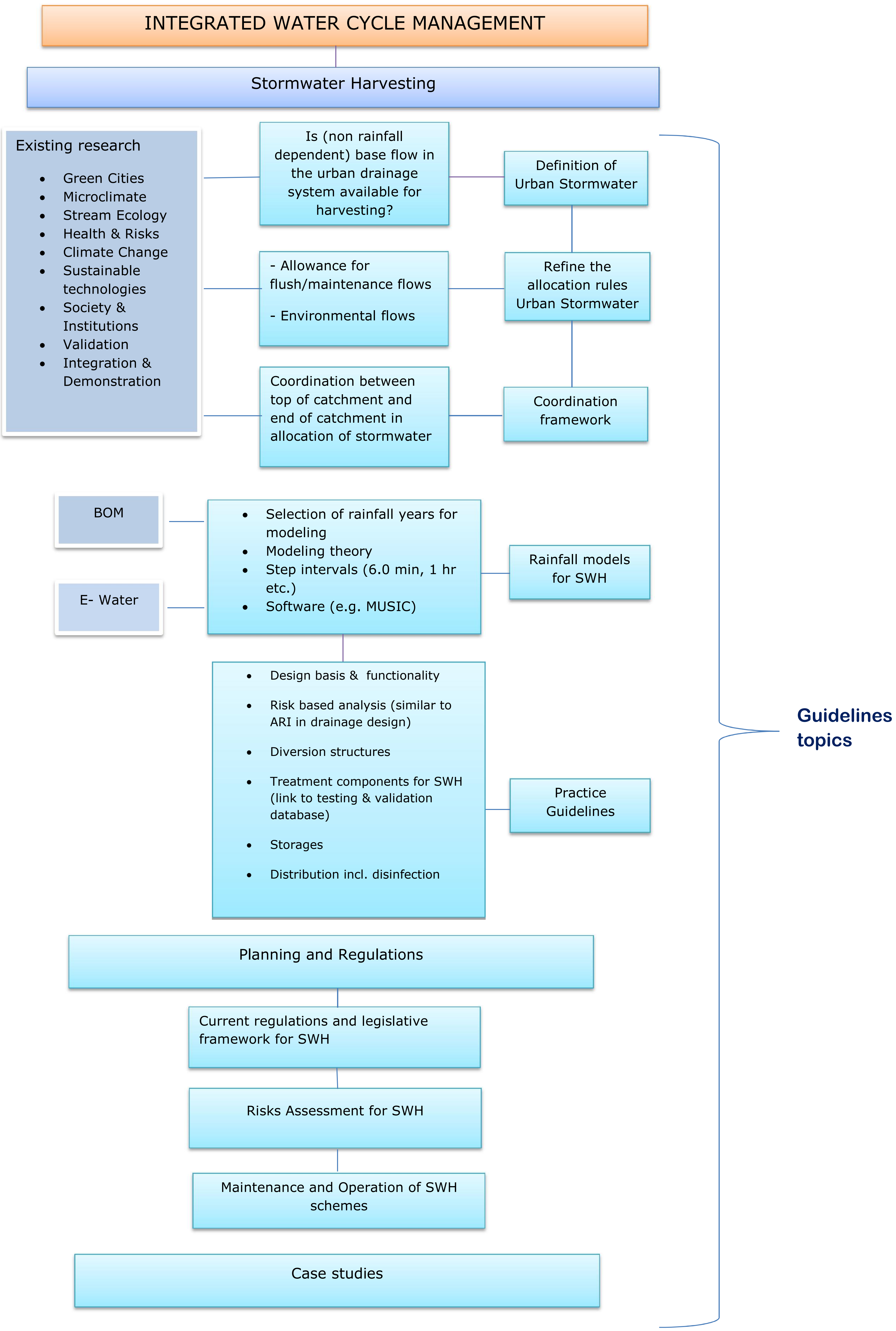

Figure 3 Stormwater Harvesting Guidelines – detailed components

Also, an indicative *Table of Contents* (TOC) for the SWH Guidelines is presented in Table 1

Table 1 Indicative Table of Contents for Stormwater Harvesting Guidelines document

	SWH GUIDELINES - INDICATIVE TOC
1.	**Overview**
1.1	Purpose and aim of guideline
1.2	Overview structure/outline
1.3	Integration with other relevant guidelines
2.	**Planning your SWH project**
2.1	Planning and Regulations
2.1.1	*Relevant legislation*
2.1.2	*Approvals and Licencing*
2.2	Drivers & objectives
2.3	Risk based analysis of SWH project
2.3.1	*Assessment framework (AGWR)*
2.3.2	*Assessment tools*
2.3.3	*Risk Management Plan (RMP)*
2.4	Demands, Supplies and Water balance
2.4.1	*Water balance approach & major principles*
2.4.2	*Water balance tools & software*
2.5	Selection of sites
2.5.1	*Locating and ranking suitable SWH sites in urban area*
2.5.2	*Assessment tools (GIS based etc.)*
2.6	Options Assessment
3.	**Design of SWH project**
3.1	Design basis & functionality
3.2	Major components and functions
3.3	Rainfall and stormwater flow modelling
3.3.1	*Selection of Rainfall years for modelling*
3.3.2	*Modelling tools*
3.3.3	*Balancing Demands and Supplies*
3.3.4	*Downstream impacts from harvesting*
3.4	Diversions
3.5	Treatment train for SWH
3.5.1	*Water quality objectives*
3.5.2	*GPT and pre- screening*
3.5.3	*Secondary Treatment*
3.5.3.1	*Bio - filtration & wetlands*
3.5.3.2	*Engineered solutions (media filtration etc.)*
3.5.3.3	*Disinfection*
3.6	Storage of water
3.6.1	*Balance storage or raw water storage*
3.6.2	*Product water storage*
3.6.3	*Wetlands*
3.6.4	*Aquifer Storage and Recovery*

3.6.5	*Other (tanks etc.)*
3.7	Distribution to end users
3.8	Associated Infrastructure
3.8.1	*Pumps*
3.8.2	*Gravity pipework*
3.8.3	*Rising mains*
3.9	Controls & Electrical Equipment
3.10	Documentation of the Design solution
4.	**Construction of SWH project**
4.1	Selection of project delivery mechanism
4.1.1	*Principle contractor (traditional)*
4.1.2	*Design & Construct*
4.1.3	*Design, Construct & Operate*
4.2	Performance guarantee & liabilities
4.3	Assets ownership
4.4	Planning and timelines
4.5	On-site work
4.6	Commissioning and proof of performance
5.	**Operations & Maintenance**
5.1	Assets life
5.2	Maintenance requirements
5.3	Monitoring requirements
5.4	Risk Management Plan Audit and Review
6.	**Economics of SWH project**
6.1	General principles
6.2	Estimation of costs for capital works
6.3	Estimation of running costs
6.4	Life expectancy & Net Present Value of assets
6.5	Non tangible values (e.g. green infrastructure)
6.6	TBL analyses
6.6.1	*Life cycle costs*
6.6.2	*Carbon sensitivity*
6.6.3	*Environmental impacts*
7.	**Appendices**
7.1	Design Tables & References
7.2	Decision Support Tools
8.	**Case Studies**

Performance assessment for stormwater treatment devices

Selecting the right treatment train to meet the water quality objectives is essential for the successful and sustainable operation of SWH systems.

At present, there are no standard methods or guidelines for the testing, validation and performance assessment of stormwater treatment devices in Australia. The wider uptake of IWCM and WSUD and growing number of stormwater treatment devices pose a need for the consistent and verifiable performance database to inform the fair and technically robust assessment and selection processes for treatment of stormwater. As the market for stormwater treatment devices' expands - the lack of published data on their performance becomes more apparent (Victorian Stormwater Committee 1999), while detailed field monitoring is also very scarce (Wong et al. 2000). The combination of a large number of devices, a lack of reporting protocols and standard methods and only a small number of detailed monitoring studies has resulted in a large uncertainty in stormwater treatment devices selection. Local government, which is largely responsible for the implementation and management of stormwater infrastructure in Australia, is dependent on in-house expertise and manufacturer's advice in selecting appropriate stormwater treatment strategies. Independent discussions with local government, water authorities and stormwater industry professionals have revealed interest in the documentation and development of guidelines and frameworks to assist in the system design, product selection and evaluation to ensure adequate stormwater treatment and management.

Development of the protocols on the performance assessment for stormwater treatment devices will greatly assist in the adoption and utilization of Integrated Water Cycle Management (IWCM) approach in Australian towns and cities via the:

- Increased certainty in the performance of stormwater treatment devices and resultant water quality delivered by IWCM projects
- Consistent and structured approach to the selection of stormwater treatment devices with the direct benefit to the proponents (e.g. councils/developers), designers, asset owners and other stakeholders of a stormwater projects
- Sharing the legacy of knowledge in stormwater treatment with the industry

In recognition of this industry need a number of research projects have been commissioned by various organizations with a view to assess the options available for independent verification of stormwater treatment devices in Australia, both at the state and federal level.

In this article I'd like to acknowledge the initiatives and support of Melbourne Water Corporation (MWC) and Stormwater Australia (SIA) and their respective work in this area that resulted in two reports produced and now displayed for public consultation via the SIA website, namely:

1.0 Independent Verification Scheme for Stormwater Treatment Devices – Road Map Discussion Paper

2.0 Literature Review on Performance Testing Approaches of Gross Pollutant Traps

Practitioner view

Practicing in the area of integrated water cycle management and seeing through the delivery of both waste water and stormwater projects I have noticed some significant differences between those two groups affecting the choice of its delivery mechanism, namely:

- Stricter and more defined regulations in the wastewater market including treatment standards, roles and responsibilities of various stakeholders, approval processes etc.
- Wider adoption of the Design and Construct and Design, Built and Operate contract types as a waste water project delivery mechanism, generally with the Performance Guarantee provided by the Contractor
- Established practice of performance validation and verification in the waste water market

Given the current interest in the uptake of stormwater as a resource (stormwater harvesting) and the on-going commitment to control and treat the run off prior to its discharge into the natural environment by application of WSUD – the Australian stormwater market is likely to grow in the years to come.

The pace that the stormwater market in Australia grows will, to a large degree, depend on the certainty that it can offer to the public, the clients and the government in delivering the stated objectives. Which requires, amongst other things, the clear path on how to achieve the stated objectives (i.e. Stormwater Harvesting Guidelines) and the means to verify that it actually works (i.e. validation and verification protocols).

The increased certainty in the requirements for and the performance of the stormwater treatment components delivered by these guidelines and protocols should allow the market to offer/request a guarantee of performance. This guarantee should open more opportunities for funding, delivery, operation and maintenance of stormwater projects, leading to the greater uptake of stormwater treatment and utilization as a resource.

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