



**Municipal Engineering
Foundation Victoria**

**2005 OVERSEAS USA STUDY TOUR
REPORT**

**Integrated Stormwater Quality Management
'A Value for Money approach for Victorian Councils'**



by

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1. Acknowledgements

I wish to acknowledge the Municipal Engineering Foundation (Victoria) for continuing to make the annual study tours available for Engineers working in the Local Government field. I thank Keith Wood, a trustee of the Foundation, whose experience and knowledge was most helpful in planning the study tour.

For some 40 years the Municipal Engineering Foundation (Victoria), or MEF, has been supporting the professional development of both individuals and the wider municipal engineering sector by offering a range of study opportunities via its awards programs. The 2005 overseas study tour award sits within this context, and I gratefully acknowledge the support of the MEF in providing the opportunity to me as one of four Victorian engineers working in the municipal sector chosen to be part of this year's program.

I would also like to take the opportunity to thank Kingston City Council for releasing me to attend the study tour, and my family for their support. Lastly, the host organisations who took the time to share their knowledge with us are acknowledged - without them, the tour would not be possible. In particular, I would like to thank the staff at the City of Atlanta and the City of Griffin in Georgia for their generosity during our visit.

2. Introduction

Our 2005 Study Topic entitled 'Integrated Stormwater Quality Management' involved attending:

- The American Public Works Association (APWA) International Congress held in Minneapolis, Minnesota and;
- A number of meetings with local Councils and consultants across five states in America. The organisations were chosen based on their experience with delivering Best Practice in the area of 'Water Sensitive Urban Design'.

The aim of my study was to investigate current best practice in the United States and compare it the current approach adopted by Local Government in Victoria.

In particular, this report concentrates on reviewing the cost and maintenance issues associated with various water quality practices. Section 10 aims to prioritise my impression of strategies and projects that represent 'value for money' to help assist Victorian Local Government departments to shape future water quality related budgets.

2.1 Tour Group Members

The 2005 study tour consisted of the following group of engineers. Whilst all tour group members were investigating the same broad topic, each member concentrated a specific element of personal interest.

- Peter Aumann, Director Infrastructure Services, Monash City Council
- Michael McGlade, Manager Roads Development, Wyndham City Council
- Chris Sfetkidis, Client Services Engineer, Manningham City Council
- Alan West, Team Leader Engineering Design, Kingston City Council and ;
- Graham Rule, Director, WBCM Group

2.2 Key Objectives

The objective of the study group was to investigate how local councils in the United States managed storm water in the following areas :

1. Management & Policy
An overview of each organisation's storm water policies, strategies, design manuals, specifications and management systems.
2. Detail & Construction Projects
An investigation of road reconstruction or drainage capital works projects incorporating water quality or water conservation/ reuse initiatives.
3. Requirements for Developers
An understanding of all requirements including contributions, planning requirements, design, construction and supervision practices and issues.
4. Maintenance Practices
An insight into how each organisation undertakes the inspection and maintenance of constructed water quality projects.
5. Evaluation
How the effectiveness of individual 'Best Management Practices' (BMPs) are evaluated and monitored.

Topics of particular interest to myself include the:

- Investigation of the design, construction and maintenance practices adopted for bioretention systems such as rain gardens and vegetated swales.
- Evaluation of the long-term effectiveness of various water quality solutions.
- Comparison and prioritisation of projects and strategies to ensure that Local Government adopts a 'value for money' approach to improving water quality.

2.3 Organisations Visited across the USA



- Locations visited
- Key water bodies driving water quality within the United States
 - (i) Chesapeake Bay (Baltimore)
 - (ii) Puget Sound (Seattle)
 - (iii) The Great Lakes (various northern cities)

Summary of Organisations

Washington State

- (i) The **City of Seattle** (pop 572,000 with 3.8 million in the greater metro area) hosted a meeting and site inspections highlighting recent water quality strategies and construction projects (including road reconstructions and a green roof).
Key Contact: Gary Schimek - Seattle Public Utilities
- (ii) The **City of Bellevue** (pop 112,000) similarly hosted a meeting and site inspections highlighting recent water quality strategies and construction projects (including wetlands and treatment systems). Bellevue is located approximately 20km east of Seattle and established the first drainage utility in the USA.
Key Contact: Damon Diessner - Assistant Director of Environment Division, Utilities Department

Minneapolis, Minnesota

A consultant working for the **Ramsey-Washington Metro Watershed District** (located on the fringe of **Minneapolis**) hosted site inspections of recent construction projects (including a chemical treatment pond, creek restoration, pervious pavement and a residential subdivision under construction).

Key Contact: Joel G. Schilling - Principal Schilling Consultant Services

Chicago, Illinois

The **Metropolitan Water Reclamation District of Greater Chicago** (pop 2.9 million with 9 million in the greater metro area) hosted a meeting to discuss their 'deep sewer' project to minimise the risk of spills from their combined sewer – stormwater drainage system.

Key Contact: Nicholas Venuso - Assistant Chief Engineer, Infrastructure Management and Budget Division, Engineering Department

Georgia

(i) The **City of Atlanta** (pop 425,000 with 4.7 million in the greater metro area) hosted a meeting and site inspections highlighting recent water quality strategies and construction projects (including a green roof and porous concrete pavements).

Key Contact: Joe Basista - Deputy Commissioner, Department of Watershed Management

(ii) The **City of Griffin** (pop 24,000) similarly hosted a meeting and site inspections highlighting recent water quality strategies and construction projects (including wetlands and treatment systems).

Griffin is located approximately 40km south-east of Atlanta and established the first drainage utility in Georgia.

Key Contact: Brant Keller - Director, Public Works & Utilities

Maryland

(i) A consultant working for the **Centre for Low Impact Development** (located in **Baltimore**, pop 636,000) hosted a site inspection to the University of Maryland car park incorporating vegetated swales.

Key Contact: Joel G. Schilling - Principal Schilling Consultant Services

(ii) **Baltimore County** (pop 754,000) hosted a meeting and site inspections highlighting recent water quality strategies and construction projects (including wetlands and a residential subdivision under construction).

Key Contact: Tom Vidmar - Deputy Director, Department of Environment Protection and Resource Management

3. Background

3.1 Water Sensitive Urban Design – A Broad Overview

(i) Guiding Policies

*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)**.*

*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.¹*

(ii) Previous Study Tours

A Municipal Engineering Foundation sponsored study tour undertaken by Peter McLean (Manager Assets & Development, Cardinia Shire Council) in 2003 also provides an excellent overview of this topic. Peter's report outlines the USA legislation and key challenges for advancing Water Sensitive Urban Design in Victoria. Relevant extracts from this report include:

Page 4: Out of the places visited on our study tour, it was found that America was well advanced and has a significant amount of research (since the mid 1990s) and information relating to BMPs. California was the most progressed location in relation to this study topic. In particular our visit to the County of San Diego and the inspection of the Caltrans BMP retrofit pilot sites was the most informative and provides excellent information to be able to expand on and research the 5 key outcomes.²

and Page 20: Most importantly this topic is continually and rapidly developing. Much of the research information is still being released or developed and consequently the key will be to monitor and keep in touch with current developments such as the Caltrans research website and future study tours would be of benefit in this area.

The East Coast of America, around Chesapeake Bay area, would well be an excellent future tour as its climate and conditions are very similar to Victoria.²

¹ Extract from WSUD Engineering Procedures: Stormwater (Melbourne Water 2005)

² Municipal Engineers Foundation, Victoria : 2003 Study tour to USA, Canada & UK "Review of the status and trends in best management practices for stormwater quality." November 2003, Peter McLean - Manager Assets & Development, Cardinia Shire Council

This Report

This report aims to build upon the findings from previous study tours by investigating the latest information relating to the detail design, construction and maintenance of 'Best Management Practices' across the United States.

3.2 City of Kingston's Approach to WSUD

Kingston City Council first developed a 'Stormwater Quality Plan' in consultation with Melbourne Water and EPA in 2000. The process involved:

1. Documenting the nature of Kingston's urban development.
2. Documenting Kingston's stormwater system.
3. Identifying the values of Kingston's receiving waters.
4. Identifying stormwater pollutants and potential threats to these receiving waters.
5. Evaluating and ranking the risks to the receiving waters.
6. Formulating responses to address the highest risks & develop stormwater quality management plan.

This approach provided the impetus to design and construct a number of trial Water Sensitive Urban Design projects including rain gardens, pervious pavements and wetlands over the last 5 years. A recent report ³ provides an excellent summary of ten (10) water quality improvement projects such as 'rain gardens' retrofitted into a local road reconstruction project in Stawell St, Mentone (pictured below).

A copy of this report plus associated design plans and case studies can be downloaded from the City of Kingston website at:

www.kingston.vic.gov.au

and then follow prompts to:
Environment & Works >
Environment & Planning >
Stormwater Quality >
Case Studies & Technical Reports



³ 'Water Sensitive Road Design Projects - A Snapshot of Projects within the City of Kingston, Victoria, October 2005' Alan West, Team Leader Engineering Design Department, Kingston City Council

4. Melbourne vs USA - Social & Physical Differences

The following general observations were common to a number of the cities visited. Some of these vary significantly to the typical social, physical and organisational lifestyle typically experienced within Victoria.

These 'differences' need to be considered (or modified to suit our environment) prior to trialling any water quality practices discussed in this report.

- (i) Fishable Waters – A large percentage of organisations visited indicated that their residents placed a high value on recreational fishing and the quality and quantity of seafood (e.g streams that can sustain healthy salmon and bays that can sustain oysters, crabs and fish). This 'public pressure' appears to be one of the main drivers for the acceptance of water quality initiatives and funding sources.
- (ii) Funding Arrangements – Most of the cities visited had created 'Drainage Utilities' to specifically fund their drainage improvement projects including the design, construction, supervision, ongoing inspection and maintenance of their storm water drainage projects. Typically home owners are charged a fee of between \$30 to \$50 p.a based on an average sized quarter acre block.
- (iii) Creeks and Open Spaces – The majority of suburban areas visited appeared to contain a high percentage of natural creeks, lakes and waterways. It was also very noticeable that the vegetated buffer zones beside their creeks, waterways and freeway corridors appeared considerably wider with denser planting than typically experienced within the Melbourne Metropolitan Area.
- (iv) Combined Sewer Systems – Many of the cities operate combined sewerage and stormwater piped systems discharging to large treatment plants. The treated water is then either returned to the natural waterway or a small percentage reused for irrigation. Consequently the responsible authorities place a high priority on increasing the capacity of their pipe sizes and treatment plants to cater for high intensity storm events (1 in 100 year ARI) to minimise the risk of overflow of untreated sewerage/ stormwater into their waterways. As these projects can cost tens of millions of dollars, there are often insufficient funds to construct projects that treat systems that convey stormwater only.

- (v) Fewer footpaths, kerbs & fences – Many of the residential subdivisions visited (both established and new) contained local streets without footpaths and front fences. Some established streets within 5km of the CBD (particularly in Seattle) do not have kerb and channel and have the appearance of a rural streetscape with table drains and pipe culverts.



Generally the residents are responsible for maintaining everything outside of the road pavement (including footpaths). This would appear to contribute towards the lack of footpaths and influences the feasibility of 'rain gardens' constructed within their nature strip.

- (vi) Snow Conditions – Most of the cities visited need to design and maintain water quality treatments that can cope with up to 600mm of snow. Snow impacts on the type of vegetation that can be used in bio-retention systems and the widths of road pavements. A common method used to remove the snow is to spread salt across the road. This contributes towards high concentrations of salt in their waterways and potentially different water quality strategies compared to Melbourne conditions.

5. The Clean Water Act & Best Management Practices

The U.S Federal Water Pollution Control Act of 1972 (and amended in 1977) is commonly known as the 'Clean Water Act'.

The Clean Water Act established the basic structure for regulating discharges of pollutants into the waters of the United States and gave the Environmental Protection Agency (EPA) the authority to implement pollution control programs.

Following Phase II of the Clean Water Act (released in 1999), the EPA developed the National Pollution Discharge Elimination System (NPDES) to improve water quality by regulating point sources that discharge pollutants into waters of the United States.

Section 208 of the NPDES regulation requires municipalities to employ '**Best Management Practices**'. A **BMP** can be a technique, measure or structural control used to manage the quantity and improve the quality of storm water runoff to the maximum extent possible.

The Phase II rule describes the following six (6) minimum control measures to be implemented by applying one or more **BMPs**:⁴

	Control Measure	Example BMPs
1	Public Education and Outreach on stormwater impacts	<ul style="list-style-type: none">• water conservation, garden care and disposal of pet waste
2	Public Involvement and Participation	<ul style="list-style-type: none">• pit stencils and planting along creeks
3	Illicit discharge detection and elimination	<ul style="list-style-type: none">• Monitoring illegal connections and dumping
4	Construction site stormwater runoff control	<ul style="list-style-type: none">• Installing silt fences and silt ponds
5	Post-construction stormwater management in new developments and redevelopment	<ul style="list-style-type: none">• Constructing wetlands, ponds, swales, sand filters and porous pavers
6	Pollution prevention/ good house keeping for municipal operations	<ul style="list-style-type: none">• Managing septic tanks, road maintenance and pipe cleaning

⁴ U.S EPA, National Menu of Best Management Practices for Stormwater Phase II Website :<http://cfpub.epa.gov/npdes/stormwater/menuofbmps/menu.cfm>

6. Public Education

The 'Clean Water Act' places a requirement on all municipalities to educate the public about water quality issues.

Local Councils are required to implement a 'Public Education Plan' that incorporates the following six (6) elements:

1. Watershed Stewardship

Education of the public about their responsibility and stewardship in their watershed.

2. Storm Drainage Systems and Waterways

Education of the public on the location of residential separate storm water collection system catch basins (pits), the waters of the state where the system discharges, and potential impacts from pollutants from the separate storm water drainage system.

3. Reporting of Illicit Discharges

Encouragement of public reporting of the presence of illicit discharges or improper disposal of materials into the applicant's separate storm water drainage system.

4. Common Home and Yard Stormwater Pollutants

Education of the public on the need to minimize the amount of residential, or non-commercial, wastes washed into nearby pits (this should include the preferred cleaning materials and procedures for car, pavement, or power washing; the acceptable application and disposal of pesticides and fertilizers; and the effects caused by grass clippings, leaf litter, and animal wastes that get flushed into the waterway).

5. Waste Disposal

Education of the public on the availability, location and requirements of facilities for disposal or drop-off of household hazardous wastes, travel trailer sanitary wastes, chemicals, yard wastes, and motor vehicle fluids.

6. Riparian Land Management

Education of the public concerning management of riparian lands (green buffer strips beside waterways) to protect water quality.

As a result of the above Federal requirement, the majority of organisations visited have a very strong emphasis on creating public awareness and generating support for both water quality projects and environmentally friendly practices.

Some of the public awareness techniques adopted include:

- (i) Council Web Sites (e.g www.griffinstorm.com)
Many USA Councils have created very colourful, animated and informative web pages explaining:
 - The importance of water quality
 - What the public can do around their home
 - How to join a local group or receive regular news letters
 - The latest Council capital works projects and initiatives
- (ii) Council Newsletters & Information Brochures
Some Councils allocate a regular page in their general newspaper circulation to provide updates and reminders about water quality projects and practices. Others like the City of Seattle, allocate around \$100,000 p.a towards the publication of a water quality newsletter that is circulated to all residence on a quarterly basis.
- (iii) Education Sessions & Workshops
A number of Councils organise regular education sessions to provide practical demonstrations on how to adopt environmentally friendly gardening practices (e.g sessions run by golf course curators to explain how they maintain green fairways without the use of fertilizers and pesticides). The City of Bellevue (20km east of Seattle) takes what they call the 'Walt Disney' approach to marketing and creating public interest. Their education sessions are often held on weekends and involve entertainment, colour, music and giveaways such as balloons and T-shirts.
- (iv) Community Groups
Most Councils organise volunteer groups to remove litter from their local stream (a.k.a formation of 'Stream Teams'). Volunteers are also encouraged to register for stream planting days or to collect water samples.
- (v) Product Marketing & Sales
Some Councils actively market and promote the sale of water saving and/or water quality related household products. The City of Seattle sells around \$100,000 worth of products each year including rain barrels (refer to the photograph under section 7.6).

Further Reading

The USA's EPA department has developed a range of public education outreach material that can be used for local education campaigns. Refer:

<http://cfpub.epa.gov/npdes/stormwatermonth.cfm>

Interestingly, one American organisation referred to the following NSW website to demonstrate the international importance of storm water problems and how critical public education is:

<http://www.epa.nsw.gov.au/stormwater/hsieteachguide/index.htm>

7. Structural Treatments

7.1 Overview

The U.S EPA's website recommends a wide range of 'Best Management Practices' (BMPs) in the form of structural treatments to achieve their minimum water quality requirements.

Refer to : <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm>

Our Study Tour included site inspections to numerous construction sites with some of the most common BMP treatments evaluated within this section of the report.

The following table ⁵ provides a subjective summary of the performance and cost of common treatments. This information should be viewed as a general guide only as actual performance is dependent on individual site characteristics and maintenance standards.

Ref	BMP Type	Sediment removal Performance	Nutrient Removal Performance	Construction Cost per Ha Treated	Maintenance Cost per Ha Treated
7.2	Bio-retention Systems	High	High	Medium	Medium
7.3	Constructed Wetlands	High	High	Medium	Medium
7.4	Pervious Pavers	Low	High	High	High
7.5	Underground Sand Filters	High	Medium	High	High
7.6	Disconnected Down pipes	Low	Low	Low	Low
7.7	Silt Traps	High	Low	High	High
7.8	Green Roofs	High	High	Very High	High

Pollutant removal efficiencies specified under sections 7.2 to 7.5 of this report are abbreviated as follows :

TSS – Total Suspended Solids

TP – Total Phosphorous

TN – Total Nitrogen

HM – Heavy Metals such as cadmium, copper, lead and zinc

⁵ Information sourced from Georgia Stormwater Management Manual, Volume 2, Section 3.1

7.2 Bio-retention Systems

Description

Typically shallow landscaped stormwater detention basins that use engineered soils and vegetation to treat stormwater runoff. The treated water can either be collected via slotted pipes or allowed to infiltrate into the soil.

Also known as 'Rain Gardens'
Refer to Appendix A2.8 for more photos.



Key USA Planning & Design Considerations⁵

- Pollutant removal efficiency: 80% TSS, 60% TP, 50% TN & 80% HM.
- The cost to construct is considered 'medium'.
- The cost to maintain is considered 'low'.
- Locate in landscaped islands using native plants.
- Good for small catchments & impervious areas such as car parks.
- Not recommended for areas with steep slopes.

Recommended Maintenance Requirements

- Remove surface rubbish & debris (as required).
- Prune plants and weed to maintain appearance (as required).
- Remove sediment from inflow point (every 6 months).
- Evaluate & replace dead or diseased vegetation (every 6 months).
- Test soils for pH levels and adjust with additives (annually).
- Replace mulch over entire area (every 2 to 3 years).
- Allow around 5% to 7% of construction costs as a typical annual maintenance budget allowance.

Key Study Tour Observations

- The majority of bio-retention swales investigated contained a large mixture of plants with a large percentage of weeds i.e little or no regular maintenance was apparent.
- Generally located in large landscaped areas. No rain gardens were observed in tight locations or narrow nature strips less than 5m wide.
- Rain gardens appeared to be mostly constructed along roads without kerb & channel (i.e runoff flows across a sealed shoulder or edge strip into a vegetated swale). Local engineers generally indicated that attempting to construct rain gardens in a built up area was too difficult (i.e too many conflicts with services, trees and pavements).

⁵ Information sourced from Georgia Stormwater Management Manual, Volume 2, Section 3.2.3

Bio-retention Systems

Key Study Tour Observations (Continued)

Examples:

- Refer to the City of Seattle's web site for photos, costing and details on their 'Natural Drainage System' projects in the Broadview Neighborhood (pictured below):
http://www.ci.seattle.wa.us/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Natural_Drainage_Overview/index.asp



- Refer also to section 3.2 for details on Kingston City Council's experience with constructing rain gardens as part of local road reconstruction projects.

Summary

- Bio-retention systems (either vegetated swales or rain gardens) can be incorporated into most roadwork projects, provided that sufficient room is available.
- A number of Victorian Councils (including Kingston) appear to have as much or more experience constructing rain gardens within 'built up' streetscapes (i.e located in the nature strip between the kerb and the footpath).
- Most USA councils advised that the design of rain gardens in 'built up' streetscapes was too difficult due to conflicts with services, pavements and trees.
- Gaining public support continues to be a challenge with a 'not in front of my house' mentality evident.
- Bio-retention systems can be viable, cost effective solutions but only if they have appropriate levels of monitoring and maintenance supported by an appropriate maintenance budget (allow 7% of the construction cost p.a as an indicative guide).

7.3 Constructed Wetlands

Description

The Georgia Stormwater Management Manual ⁶ describes wetlands as either shallow, extended detention shallow, pond-wetland or pocket wetlands (see the bottom of this page for details).

Refer to Appendix A2.2 for more photos.



Key USA Planning & Design Considerations ⁶

- Pollutant removal efficiency: 80%TSS, 40% TP, 30 TN & 50% HM
- The construction and maintenance costs are considered to be 'medium' compared with alternative treatments.
- Minimum recommended catchment area is 10 Ha (excluding pocket wetlands).
- Sediment control and a regular flow of water is critical to be able to sustain the wetland.

Recommended Maintenance Requirements

- Replace unsuccessful vegetation following the second growing season to ensure that plants cover at least 50% of the wetland surface area (one-time activity).
- Monitor wetland vegetation (every 6 months) and replace plants (as required). Harvest plants that are being covered by sediment built up.
- Clean & remove debris from inlet and outlet structures (3 to 4 times p.a).
- Remove invasive vegetation (annually).
- Remove hydrocarbon build up (annually).
- Monitor sediment build up (annually) & remove (after 5 years or when 25% of the wetland volume has been lost).
- Repair eroded areas (as required).
- Monitoring of all aspects is crucial during the first year, inspections should be conducted every 6 months for the first 3 years.
- Allow around 3% of construction costs as a typical annual maintenance budget allowance.

⁶ Information sourced from Georgia Stormwater Management Manual, Volume 2, Section 3.2.2

Key Study Tour Observations

- Wetlands appeared to be very common & the most preferred treatment. Residential suburbs appeared to have more open space (compared to Melbourne) providing the required room to construct wetlands.
- Council engineers in Baltimore County indicated that well-established wetlands with native vegetation required very little maintenance.
- Many of the ponds and wetlands inspected did not have any significant fencing restricting public access.

Summary

- Wetlands should continue to be the preferred option subject to available open space as they have the lowest construction and maintenance cost per Hectare of catchment treated.
- Appropriate monitoring and maintenance budgets need to be allocated especially during the crucial first 12 month establishment period.
- For more information refer to section 9 of 'WSUD Engineering Procedures: Stormwater (Melbourne Water 2005)'.

Wetland Types

Shallow Wetland – Designed so that most of the water quality treatment occurs in marshy shallow water depths. One disadvantage is that a relatively larger footprint is required to store the required volume of storm water runoff.

Extended Detention Shallow Wetland – As above with provision for extended 24 hours detention above the surface of the marsh. Plants need to tolerant both wet and dry periods.

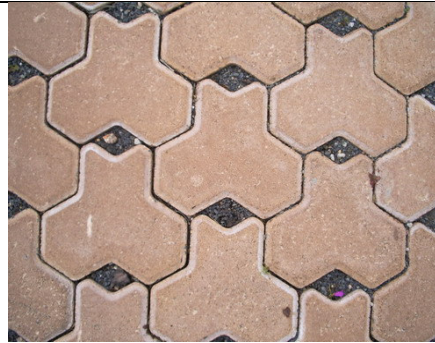
Pond-Wetland System – Designed with two separate cells; a pond to trap sediment and reduce velocities and a shallow marsh. Typically less land is required than for either of the previous types of wetlands.

Pocket Wetland – Intended for smaller catchments (2 to 4 Ha) and typically requires excavation down to the water table to provide a source of water to support the wetland system.

7.4 Pervious Pavers

Description

Modular pavers (usually concrete) with gaps that are filled with pervious material such as stones or coarse sand. The pavers are installed over a crushed rock base to provide temporary storage until the runoff can infiltrate into the underlying soils.



Refer to Appendix A2.12 for more photos.

Key USA Planning & Design Considerations⁷

- Pollutant removal efficiency: TSS (N/A), 80% TP, 80% TN & 90% HM.
- Pervious pavers should not be used to remove sediment.
- Construction costs compared to conventional pavements are 'high'.
- There is the potential for high failure rates (i.e clogging) if they are not adequately maintained.
- Potential for groundwater contamination.
- A minimum of 40% of the surface area to consist of open voids.
- Crushed rock base to consist of a 255mm (minimum) depth layer of 40mm to 60mm diameter aggregate.
- Suited to areas with sandy soil (high infiltration rate required).
- Locate pavers a minimum of 3m away from buildings.
- Recommended for low trafficked areas only.

Recommended Maintenance Requirements

- Check that the pavement is free of sediment and does not hold water after rainfall events (monthly).
- Vacuum sweep pavement surface to remove sediment (3 to 4 times p.a).
- Inspect the surface for deterioration or spalling (annually).
- Replace sections of pavers and base coarse upon failure (as required).

Key Study Tour Observations

- Only one site was inspected which appeared to be operating successfully.
- Numerous discussions with Council engineers indicated that modular pervious pavers are effective in areas that have sandy soil, whereas porous concrete or asphalt pavements are less likely to be successful.

Summary

- Pervious pavers can be used in low trafficked areas such as car parks and laneways provided that high sediment loads are not anticipated.
- Based on typical levels of municipal maintenance, the voids are likely to 'silt up' with a gradual reduction in water quality effectiveness over time.
- Pervious pavers are worthy of further trials and ongoing review in order to further evaluate their long-term practicality (i.e review the structural integrity after 10 or more years).

⁷ Information sourced from Georgia Stormwater Management Manual, Volume 2, Section 3.3.8

7.5 Underground Sand Filters

Description

Stormwater runoff is directed into a three-chamber structure (often a precast concrete proprietary product) containing a sand bed to filter out pollutants. The initial pre-treatment chamber utilizes a wet pond to capture sediment and restrict oil from the sand filter chamber. The treated water is then discharged back into the conveyance system.



Refer to Appendix A2.4 for more photos.

Key USA Planning & Design Considerations⁸

- Pollutant removal efficiency: 80%TSS, 50% TP, 25% TN & 50% HM
- The construction cost is considered to be 'high'.
- Sand filters are likely to require frequent maintenance.
- Suited to small highly impervious sites without space for alternative (less expensive) treatments.

Recommended Maintenance Requirements

- Monitor the water level in the chamber (quarterly).
- Remove oil and rubbish from the sedimentation chamber (typically every 6 months).
- Clean out the sedimentation chamber when sediment depth exceeds 300mm (as required).
- Allow around 13% of construction costs as a typical annual maintenance budget allowance.

Key Study Tour Observations

- USA Council engineers suggested that they be used sparingly, however they have a role in tight locations. Some Councils specify them as a pre-requisite for planning applications involving service stations.

Summary

- Sand filters may be a suitable option for small highly impervious sites with a high pollution risk (e.g oil spills).
- Only install sand filters if they are supported by appropriate maintenance budgets and sufficient monitoring procedures (allow 13% of the construction cost p.a as an indicative guide).

⁸ Information sourced from Georgia Stormwater Management Manual, Volume 2, Section 3.3.4

7.6 Rain Barrels & Disconnected Downpipes

Description

The photographs shown below represent common USA practice of not connecting roof runoff to underground pipes.



Key USA Planning & Design Considerations

- Ensure that design plans incorporate overland flow paths and swales to cater for high intensity storm events.
- Consider locating swales within drainage easements.
- Direct down pipes onto rock garden beds or rain gardens to avoid erosion.

Recommended Maintenance Requirements

- Install reinforced grass along overland flow path to limit scouring.
- Install temporary filter socks on down pipes whilst grass is establishing.

Key Study Tour Observations

- Council Development Approval engineers appear to encourage the use of disconnected downpipes to reduce runoff volumes.
- Some poor building design practices were evident at one of the subdivisions inspected (e.g discharging onto paved driveways, beside electrical appliances such as air conditioners and locations with no overland flow path).
- Small rain barrels are retrofitted to down pipes, however, rain water tanks do not appear to be common and are not used to flush toilets.

Summary

- The Australian practice of using rainwater tanks for a variety of re-use applications appears to be more sophisticated than current USA practice.
- The practice of disconnecting down pipes could be considered (cautiously) provided that landscaping, soil infiltration, runoff grades and overland flow paths were all designed, constructed and maintained appropriately.

7.7 Miscellaneous

The following BMPs were observed to a lesser extent, however they are worthy of further discussion.

Green Roofs

Landscaped roofs are still regarded as experimental in North America (compared to 13.5 million sq metres constructed in Germany during 2001).

Refer Appendix A2.5 for more photographs and www.greenroofs.net > About Green Roofs for an excellent overview and a section on Frequently Asked Questions.



Grass Swales

Grassed swales can provide an effective low cost pre-treatment measure by bio-filtering coarse sediment and capturing gross pollutants. Whilst they don't remove finer suspended solids, they can still play an important low cost role. Managing parking in residential streets remains the biggest obstacle.

Refer Appendix A2.8 & 2.10 for more photographs.



Porous Concrete

A mixture of coarse aggregate, cement and water that allows for water infiltration through to an underlying stone reservoir for temporary storage prior to infiltration or point of discharge. The surface has a rough texture and appearance, which makes it unlikely to be accepted by the general public.

Refer Appendix A2.11 for photographs of a porous concrete car park and residential driveway in Atlanta.



Porous Asphalt

No engineering staff that we spoke to supported the use of porous asphalt pavements. The primary concern is the potentially high maintenance cost as surfaces are easily clogged by clays, silts and oils. Rehabilitating a porous asphalt pavement is also difficult, as it cannot easily be resurfaced to prolong its design life. High temperatures can also reduce the porous properties of the pavement's surface.

Refer to www.epa.gov/owm/mtb/porouspa.pdf for an informative facts sheet on the advantages and disadvantages of porous asphalt pavements.

Also see www.betterroads.com/articles/nov04e.htm for an article on a large car park in North Carolina.

Whilst support for porous asphalt was low, there was support for the use of pervious pavers and to a lesser extent porous concrete.

Chemical Treatment

Liquid alum is mixed with piped runoff prior to discharge into a wet pond. Refer Appendix A2.3 for photographs on a project in the Ramsey – Washington watershed near Minneapolis where alum is used to reduce the high phosphorous content naturally occurring in the soil.

This project required high capital costs (around \$600,000) and high ongoing maintenance costs (\$30,000 p.a).



8. Maintenance & Monitoring Practices

Introduction

The long-term success of water quality treatments is depended upon the effectiveness of the asset management systems adopted by the responsible authority, including:

- Recording the location and description of each treatment (ideally using a GIS computer system);
- Documenting clear maintenance specifications for each system;
- Monitoring in accordance with a documented schedule;
- Regular maintenance supported by an appropriate budget and;
- Recording of monitoring and maintenance history.

The approach to maintenance and monitoring adopted by some American authorities is discussed below:

8.1 Private Property

The City of Seattle's stormwater management program places a significant emphasis on ensuring privately owned water quality treatment measures are working effectively (including on-site detention). Their program (resourced by two full-time engineering staff) includes:

- Annual correspondence advising owners of their responsibilities and Council's inspection program;
- Site inspections to identify maintenance issues, provide advice and generally educate property owners and;
- Follow up inspections and enforcement as required.

The City of Atlanta also recognises the need to monitor drainage systems on private property. Atlanta, however is planning to introduce a system that requires property owners to lodge an annual declaration stating that they have fulfilled their maintenance obligations (enforced via spot inspections).

Owners Responsibility

The City of Seattle's Municipal Code requires the owners of private drainage systems to:

- Inspect drainage control facilities at least annually;
- Inform future purchasers of the type of drainage system, the limitations of the system and inspection/ maintenance responsibilities.
- Execute a permission form granting the Council the right to enter the property to inspect the drainage system.
- Obtain a copy of the as-built plans from the Council and retain the records of the installation, maintenance and repair works for at least ten (10) years. These records shall be made available to Council staff during inspections.

Recorded Deficiencies

The City of Seattle's 2004 Annual Report on stormwater program activities summarises the findings from their 'Drainage System Inspection Program'. This report highlights that, of the 271 privately owned sites inspected during 2004, 42% were in need of some level of maintenance or repair.

The removal of excessive sediment was the most common deficiency (25%) followed by damaged flow control system (9%, e.g orifice or small pipe outlet).

Seattle's report highlights the importance of regular monitoring and maintenance to ensure the drainage system remains effective.

IF IT IS NOT MONITORED IT WILL NOT BE AN EFFECTIVE SOLUTION !

Enforcement Options

The 'California Stormwater BMP Handbook'⁹ outlines a range of critical regulatory components and recommends the use of 'Maintenance Agreements' to help enforce compliance.

An effective Maintenance Agreement should define the responsibilities of both parties, include maintenance schedules, maintenance requirements and explain non-conformances. Enforcement may involve Council undertaking the necessary maintenance at the owner's cost.

To ensure long-term maintenance, the Californian Handbook recommends recording the agreement against the 'local deed' (or property title as a 173 agreement or similar encumbrance on the property title).

8.2 Public Works

The EPA department in the United States outlines the recommended 'Best Management Practice' approaches to the Inspection and Maintenance of water quality projects. Important aspects of the EPA 's website have been reproduced under Appendix A1 of this report.

Section 7 of this report also provides a good indication of typical maintenance requirements and indicative costs for a range of common treatments.

⁹ The California Stormwater BMP Handbook, Section 6. Long term Maintenance of BMPs available via their website at www.cabmphandbooks.com

9. How do we compare ?

The following table represents a subjective comparison between 'Best Management Practices' in the United States versus current Best Practice adopted by progressive municipalities within Victoria (based on my personal observations):

The ratings used are an indication of relativity and do not take into consideration 'best value' or each organisations 'ability to fund' similar works or programs.

<p>Rating Scale: 5 - Excellent, 4 – Good, 3 - Average, 2 – Below Average, 1 - Poor</p>
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Water Quality Topic	USA Local Government	Victorian Local Government
Policies & Standards		
Guiding documents	4	4
Design & construction specifications	4	3
Maintenance specifications	4	1 *
Preventative Measures		
Public Awareness including information brochures, workshops & advice.	5	2 *
Marketing & sales of products such as rain water tanks, water wise equipment, mulch, etc	4	3
Site Inspections		
Industrial & commercial compliance	4	4
Short-term compliance with planning Permit requirements	4	2 *
Long-term compliance with Planning Permit requirements	4	1 *
Structural measures		
Wetlands	4	4
Sand Filters	3	1 *
Siltation Basins	4	3
Vegetated swales	4	4
Rain gardens along roads without K & Ch	4	3
Rain gardens along roads with K & Ch	2	4
Green roof	3	1 *

* Room for improvement

10. A 'Value for Money' approach

Best Management Practices

The U.S Federal Government approach to water quality concentrates on the implementation of a range of 'Best Management Practices' (BMPs) to achieve the required standard. As the construction cost, maintenance costs and even long term viability of each practice varies significantly, not all strategies can claim to be '**Best**' Practice, nor can they all represent a '**Value for Money**' approach.

A number of U.S Local Government authorities have, however reviewed the list of BMPs and identified the most cost-effective practices for their local region.

Best Value Principles

The Victorian Local Government Act 1989 was amended in 1999 to incorporate Best Value Principles. If these general principles were applied to managing stormwater quality, then authorities would need take into consideration factors such as the :

- Long-term water quality improvement benefit derived from each project or strategy ;
- 'Whole of life' cost of each project including planning, construction, maintenance & replacement costs ;
- Overall cost effectiveness (based on \$ per unit area of catchment treated) ;
- Ability to asset manage the maintenance burden and risk created by each project and the ;
- Level of community support for each approach.

Prioritising Strategies & Projects

The following sections discuss strategies and types of projects that are most likely (in my opinion) to deliver a 'value for money' approach to achieving water quality improvements (i.e getting the most bang for your municipal buck).

10.1 Public Education

The long-term success of most water quality strategies and projects is heavily dependent on the level of public awareness and support for 'environmental' issues.

Arguably, the cumulative day-to-day actions of the general public have a bigger impact on overall water quality than localised expensive structural treatments. Similarly public support is required to encourage politicians, developers and responsible drainage authorities to allocate sufficient funds towards water quality improvements.

Compared with the approach in Victoria, Local Government throughout the United States has taken a more thorough approach to educating the public (supported and enforced via the requirements of their 'Clean Water' Act). This appears to be a sensible and cost effective approach, as increased awareness should:

- Improve compliance with maintaining water quality devices on private property;
- Increase acceptance of new subdivision incorporating water sensitive urban design initiatives;
- Increase public involvement with maintenance of vegetated treatments retrofitted into nature strips in established areas;
- Increase the use of rainwater tanks and decrease impervious surfaces and;
- Reduce the use of fertilizers and control pet waste.

The cost associated with a public education campaign should be shared across all levels of government with the Victorian State Government continuing to be responsible for the main marketing campaign and general literature.

Refer to Section 6 for more ideas on this topic.

10.2 Long term Monitoring & Maintenance

Ideally the responsible authority should become fully aware of the long-term asset management demands of each category of project prior to construction. If an authority cannot commit to a project's long term financial and resource demands, then it may be more cost effective (from a 'big picture' water quality improvement prospective) to adopt alternative approaches that are affordable and achievable.

Private Property

All drainage devices (e.g detention tanks, vegetated swales, porous pavements and rain water tanks) require regular inspection, cleaning, repair and eventually they need to be replaced.

Treating stormwater on-site (in lieu of a developer contribution) needs to be reconsidered if the drainage asset cannot be effectively managed. At the very least, it would be wise for Councils to record details in one database (ideally in a GIS), post reminder notices and educate new property owners.

10.3 Setting Design & Construction Standards

Councils should ideally aim to document local standards that clearly specify appropriate water quality design and construction requirements for developers and ensure compliance during and following construction. Requirements for developers should include:

- Integrated design standards for both stormwater quantity and quality (e.g requirements for managing 1 in 6 month, 5 year and 100 year ARI storm events including requirements within flood plains). Include references to appropriate state government documents such as 'WSUD Engineering Procedures: Stormwater';
- The type of environmental management plans expected;
- Specifications for the construction and maintenance of 'Water Sensitive Urban Design' treatments and stormwater reuse treatments. Refer also to sections 6 and 8.2 a for recommended maintenance practices and;
- The need to document all post construction management activities and provide a formal handover to Council.

10.4 A Holistic Approach to Water Management

A number of Melbourne Metropolitan Councils (including Kingston City Council) have developed Stormwater Management Plans that aim to specifically address storm water quality issues such as the identification of pollution sources and prioritisation of risks to receiving waters. These plans have significantly increased awareness and have resulted in action plans for both structural and non-structural strategies for improving stormwater quality.

The next step is for Councils to investigate the most appropriate way to asset manage 'water' in a more holistic manner. Potential strategies for integrating water quality objectives into the tradition approach to stormwater management could include:

Policy Development

Documenting a local 'water management policy' that includes a broad range of inter-related topics such as:

- flood plain management
- storm water retardation and conveyance
- water quality objectives
- protection of waterway buffer zones
- water conservation and reuse
- monitoring and maintenance activities

Co-ordination

Adopting a more holistic approach to managing (and training) the various areas of Council that are involved in stormwater activities. Typically this would involve the co-ordination of the following departments and/or areas:

- Environmental management & strategic planning
- Planning, design, construction & asset management of capital works
- Planning approvals, design standards & supervision of developments
- Maintenance of road & drainage assets including street sweeping
- Maintenance of park & waterway assets
- Flood plain management
- Building approvals and inspections
- Local law and planning permit enforcement

Catchment Management Plans

Developing water quality catchment area plans that take into consideration the water quality risks, opportunities and locations of existing water quality treatment measures (both public and privately owned). These plans should be used to:

- Guide long-term strategic planning objectives and development approval requirements for each catchment;
- Identify the need to acquire land or plan for future regional or precinct treatments such as wetlands and retarding basins and;
- help guide and prioritise future capital works projects based on their potential to have the most cost-effective impact on the overall 'big picture'

10.5 Structural Treatments

Based on the findings from the study tour, the following types of structural treatments represent 'good value for money' as they are more likely to involve lower maintenance cost and fewer risks:

Type A Projects – Low Maintenance

Type of Treatment	Proviso
Constructed wetlands	Need to be supported by an intensive maintenance program during at least the first 3 years. Refer to section 7.3 for details.
Grassed swales	Require sufficient ground coverage to prevent eroded soil washed into downstream pipes.
Bio-retention systems (e.g within parks)	Locate within parks, traffic islands and areas where landscaping is traditionally accepted by the public and maintained by a government authority. Refer to section 7.2 for details.
Grassed retarding basins	Need to be designed so that they capture & infiltrate low flows (1 in 3 month ARI storm events).

Type B Projects – Medium Maintenance

Type of Treatment	Proviso
Bio-retention systems (e.g along nature strips)	Locate within areas where landscaping may not be traditionally accepted by the public and maintained by a combination of property owners and Councils. Must be supported by an appropriate maintenance program. Refer to section 7.2 for details
Gross Pollutant Traps	Use sparingly at high-risk locations and supported by an appropriate maintenance program.

Type C Projects – Further Trials Worthwhile

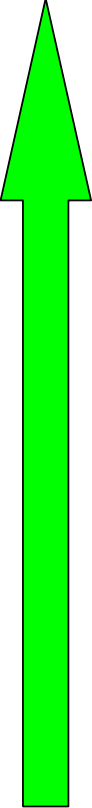
Type of Treatment	Proviso
Permeable pavers	Locate within low trafficked areas such as car parks and laneways provided that high sediment loads are not anticipated. Refer to section 7.4 for details
Sand filters	Use sparingly at small high-risk locations such as petrol stations and supported by an appropriate maintenance program. Refer to section 7.5 for details
Disconnected down pipes	Use cautiously at appropriate locations Refer to section 7.6 for details

10.6 A Summary of ‘Value for Money’ Strategies

Table 10.6 summarises the strategies and types of projects evaluated as part of the Study Tour that are most likely (in my opinion) to deliver a ‘value for money’ approach to achieving water quality improvements.

These strategies are listed in order of priority (highest to lowest) to help assist Victorian Local Government departments to shape future water quality related budgets.

Table 10.6

<ol style="list-style-type: none">1. Increase Public Education - Refer to sections 10.1 & 6.0 of this report.2. Long term monitoring & maintenance of privately owned water quality treatment systems - Refer to sections 10.2 & 8.13. Setting appropriate water quality design & construction requirements for developers & ensuring compliance during and following construction - Refer to section 10.34. Strategic planning for holistic water quality solution across all catchments within each municipality to input into long-term capital works plans, land acquisition/ land use & requirements for future developments - Refer to section 10.45. Implement water quality treatments that require a lower level of maintenance - Refer to section 10.5 : Type A Projects6. Implement water quality treatments that require a medium level of maintenance - Refer to section 10.5 : Type B Projects	 <p>Greater Value & Lower Risk</p>
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11. Conclusions

Based on the experiences gained on the study tour, it is my conclusion that a significant number of individual Victorian Councils (and local consultants) have as much expertise as our American colleagues with the design and construction of water quality improvement projects.

There is however, an opportunity to learn from their experience and improve in a number of other key areas including:

- Further enhancements to Victoria's approach to public education programs to gain further support for stormwater quality, conservation and reuse initiatives (refer to sections 10.1 and 6.0 for more ideas);
- The importance of monitoring and maintenance programs for water quality projects. This includes developing strategies for effectively asset managing water quality projects that are the responsibility of government authorities, developers and individual property owners (refer to section 10.2 and 8.0 for specific details);
- The need to increase maintenance budgets to maintain bioretention systems located within road reserves to the satisfaction of local residents. i.e Residents have an expectation that their nature strip will be maintained to a higher standard than a wetland.
- The need to document local standards that clearly specify appropriate water quality design and construction requirements for developers and ensure compliance during and following construction and;
- The need to develop an integrated approach to stormwater management that incorporates a broad range of issues including flood mitigation, pipe maintenance, water conservation, stormwater quality and reuse. Section 10.4 outlines a number of strategies such as:
 - developing an integrated stormwater policy;
 - developing strategic plans to cater for each catchment and;
 - the need to co-ordinate a range of Council departments.

12. Recommendations

The United States approach to water quality concentrates on the implementation of a range of 'Best Management Practices'. Not all of these strategies can claim to be '**Best**' Practice, nor can they all represent a '**Value for Money**' approach.

I strongly recommend that Victorian Councils adopt more of a '**Best Value**' approach to water quality. This involves comparing and prioritising competing projects based on their whole of life cost, funding constraints, maintenance burdens and level of community support (i.e getting the most bang for your municipal buck!).

To achieve a Best Value outcome, I recommend that Councils undertake the following approach to improve stormwater quality:

1. Place a greater emphasis on increasing **public awareness**, as the cumulative day-to-day actions of the general public are likely to have a bigger impact on overall water quality than localised structural treatments.

The cost associated with a public education campaign should be shared across all levels of government with the State Government continuing to be responsible for the main marketing campaign and general literature. Councils should:

- (i) Encourage Melbourne Water and the EPA to develop marketing campaigns and brochures that will assist Councils with gaining public support for bioretention systems (a.k.a rain gardens) located within the road reservation and;
- (ii) Implement their own public awareness campaigns including developing informative Council websites and newsletters that focus on local initiatives.

Ongoing public support is also required to encourage politicians, developers, drainage authorities and Councils to allocate additional funds towards water quality improvement projects and strategies.

2. Councils need to **increase their maintenance budgets** and develop monitoring procedures to enable them to effectively asset manage water quality improvement projects (including new subdivisions and capital works projects). Section 10.5 of this report provides a list of the type of projects that are more likely to have lower maintenance costs and be more cost effective.

If individual Councils are unable to increase their annual maintenance budget due to fiscal constraints, they should seriously consider reprioritising their water quality funds towards non-structural strategies such as those summarised under Section 10.6 of this report.

Treating stormwater on-site (in lieu of a developer contribution) also needs to be reconsidered if Councils cannot ensure that privately owned drainage asset are monitored and appropriately maintained.

3. Councils should (as a standard design practice) integrate '**Water Sensitive Urban Design**' into all construction projects that would normally include landscaped areas. Landscaped areas within car parks, traffic treatments, parks and retarding basins represent ideal low risk opportunities that require little or no public support or additional maintenance (i.e from a public perspective they represent only a subtle change from the traditional approach to landscaping).

In addition to the above approach, I also support the design, construction and monitoring of **trial projects** as a means of building local knowledge. Most Councils will have experienced maintenance staff who currently question the practicality of WSUD projects. It is essential that these staff attend training sessions, be involved in trial projects and develop informed views. Once experienced Council staff are informed, they can then debate the merits of individual projects based on facts using real examples and their experiences.

4. Councils should review, update and combine their existing stormwater plans, strategies, standards and procedures (and review their departmental inter-relationships) to develop an integrated approach to stormwater management including:

Co-ordinating Council Departments

Co-ordinate activities and provide training for all departments involved in stormwater activities including strategic & statutory planning, design & development approvals, construction supervision, maintenance, local laws and planning permit enforcement;

Developing an integrated stormwater policy

Document a local 'stormwater management policy' that incorporates water quality and reuse objectives, storm water retardation and conveyance, flood plain management, protection of waterway buffer zones, monitoring and maintenance procedures and;

Developing Catchment Management Plans

Investigate and document catchment area plans that take into consideration water quality risks, the locations of existing water quality treatment measures (both public and privately owned), opportunities and future needs. These plans can then be used to establish development approval requirements, plan for future regional or precinct treatments such as wetlands and prioritise future capital works projects.

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Appendices

The appendices are not attached to this document as it contains approximately 40 photos (3Mb). Please refer to another document entitled 'Integrated Stormwater Quality Management - A Value for Money approach for Victorian Councils: Appendices' or request the author of this report for details.

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