MUNICIPAL ENGINEERING FOUNDATION OF VICTORIA

STUDY TOUR TO THE USA

INTEGRATED STORMWATER MANAGEMENT

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Introduction

This purpose of this study tour was to examine the policies and practices around the integration of stormwater into the management of infrastructure and the environment in the United States of America.

The tour comprised a series of visits to a variety of organisations across the United States of America, principally stormwater managers and included a consulting engineering practice, a research organisation and attendance at the annual American Public Works Association's conference in Minneapolis, Minnesota.

The study tour visited the following municipalities or organisations:

City of Seattle, Washington
City of Bellevue, Washington
Barr Engineering (City of Maplewood, Minnesota)
Metropolitan water Reclamation District of Greater Chicago , Illonois
City of Atlanta, Georgia
City of Griffin, Georgia
Land Development Institute, Maryland
County of Baltimore, Maryland

This report focuses more specifically on some of the local policies and practices adopted by the various organisations to manage their stormwater. As most jurisdictions were found to focus on water quality issues, the quantity management policies and practices are provided where information was available.

Background

Stormwater Systems

The stormwater systems that have been developed over the past 50 years in Australia are struggling to cope with the demands being placed on it by the current styles of urban development.

Existing municipal drainage systems have been generally designed to cater for an urban runoff from a 35% impervious surface, and an associated storm event of 20% probability. Little consideration was given in the design of the system for the management of flows when the system failed, or when a storm with a greater intensity than the design storm, occurred.

The onset of urban consolidation, with its associated increase in impervious area, has gradually eroded any spare capacity in the system resulting in more frequent surcharging. The current design standards give consideration to the direction of overland flows, the risk to public safety that these flows pose and the quality of stormwater being discharged into the environment.

This circumstance is typical of areas where urban development has largely occurred since the late 1950's, the style of property development allowed for a relatively low, in today's terms, runoff volume. In recent years, the changes in the style of development have resulted in not only an increase in the run-off quantity, but it is being delivered to the main tributaries, such as creeks and rivers in a faster time. This has lead to the number and location of properties being inundated and flooded greatly increasing.

Environmental Issues

The use of waterways has seen a dramatic increase in the way the community values its creeks, rivers, bays and water bodies. These water bodies, in the past, were seen as a convenient means to dispose of unwanted effluents. As a result, the aquatic life and flora along and in these features deteriorated and made them un-attractive to view and at times un-safe for recreational activities.

The quality of these water bodies is starting to be assessed and there is a desire to return them to a more 'natural' state. Stormwater run-off is seen as a major source of the contaminants that end up in these waters.

Study tour

Legislative Overview

The requirements on drainage authorities to manage stormwater comes in two parts, the quantity, or system capacity, being managed and secondly the quality of stormwater run-off.

System Capacity

The management of the stormwater quantity is a responsibility of the relevant drainage authority. The standards established are appropriate for their community, in terms of the service level and capacity to fund the program. This is similar to the arrangements in Victoria. In the broad policy context, this issue is left to the various drainage authorities to establish their own standards.

Water Quality

For the quality issues, the management is spread amongst several agencies and can be broadly defined as follows:

- Federal Government - established water quality legislation, including the Water Pollution Control Act, known as the Clean Water Act applicable to the country;

- State Governments - Establish water quality standards for the State, consistent or better than the Federal Government requirements;

- County and City's - establish water quality standards for their areas, consistent or better than the State standards

Federal Government

The United States government, in response to broad community concerns about the quality of the water in various water bodies in and around the country, enacted amendments, in 1972, to its Water Pollution Control Act, that became known as the Clean Water Act. This Act established a structure for the control of the discharge of pollutants to the country's water bodies.

The first area where improvement was sought, was to prohibit the discharge from point sources, such as industrial waste and sewerage treatment facilities, any pollutant unless a permit was obtained. This provided some improvement but was limited to these facilities. To obtain a more comprehensive and broader approach to stormwater, (many drainage systems in the USA are combined with sewer flows) amendments were made in 1987 to the Clean Water Act to include stormwater discharges from activities associated with industrial activity and for discharges from municipal separate storm sewer systems located in municipalities with a population of 100,000. This was known as Storm Water Rules Phase I and became effective in 1990.

In 1995, the Unites States Environment Protection Agency, took a further step to achieve cleaner discharges and required operators of separate storm sewer systems in urbanized areas with populations of at least 50,000 and operators of small construction sites, to comply with water quality standards through the use of a National Pollutant Elimination Discharge System permits. These are known as Phase II requirements and is intended to further reduce the impact on water quality and aquatic habitat by instituting the use of controls on the unregulated sources of storm water discharges that have the greatest likelihood of causing continued environmental degradation. The Phase II requirements took a different approach for these smaller systems and requires storm water managers to:

- *Reduce the discharge of pollutants to the "maximum extent practicable" (MEP);*
- *Protect water quality; and*
- *Satisfy the appropriate water quality requirements of the Clean Water Act.*

To assist in achieving a reduction in pollutants to maximum extent practicable, six minimum control measures have to be incorporated into their stormwater programs, which are:

1. *Public Education and Outreach*
2. *Public Participation/Involvement*
3. *Illicit Discharge Detection and Elimination*
4. *Construction Site Runoff Control*
5. *Post-Construction Runoff Control*
6. *Pollution Prevention/Good Housekeeping*

It is this requirement that is the driving the water quality practices in the State and Local jurisdictions.

State and Local

Each State and Local drainage authority has to meet the Federal legislation and this is the minimum requirement on the authority. The Federal standards can be improved upon by each State and so can vary from State to State, to meet their particular requirements. The required quality requirements for individual streams and rivers may impose additional requirements at the municipal and local level. This is used where there is a particular issue, such as a highly ecological sensitive receiving water and additional quality requirements are needed to support that environment.

An example, from the State of Washington, is provided where their stormwater program requires permits for construction sites disturbing more than one acre, industrial sites, and Municipal Separate Storm Sewer Systems (MS4s). An example of the minimum requirements in the State of Washington to meet these requirements are shown in Appendix A.

Structural treatments, known as, Best Management Practices (BMPs), in Washington must be designed to remove 80% of the Total Suspended Solids (TSS) load during the peak of the 6-month, 24-hour storm and all stormwater treatment devices must be designed so that peak discharges from the 2, 10, and 50-year, 24-hour storm do not exceed pre-development rates.

Organisational Visits

The following provides an overview of the techniques used by the drainage authorities to manage their stormwater flows.

City of Seattle, Washington

Background

Seattle, is located on the western coast of the USA, just south of the Canadian border, in an area known as Puget Sound, (Puget Sound is one of the three nationally significant water bodies in the Unites States). It was founded in 1865 in a forested land with salmon-filled waters

By 1889 the population had increased from 10,000 to 40,000 and the discovery of gold in the Yukon Territory attracted even more people to the area. Seattle today has a population of 572,600 and an area of 94 square miles, (217 square kilometres). The area is largely of urban character and with some 'hi-tech' style industries.

Seattle enjoys a climate of temperatures ranging between near freezing to the mid to high 90°F. Annual rainfall averages at 37 inches, (940mm) with some heavy rainfall storms, but commonly, the storms only have rainfall with a low intensity.

Stormwater Systems

The city's first formal drainage systems were a combined system, carrying both wastewater and stormwater in a single pipe, to the nearest receiving water body. By 1922, there were 30 outfalls discharging stormwater and raw sewage from an estimated 50,000 people into surrounding water bodies.

Today there is a mix of drainage system types and they can be summarized as:

- Combined sewer and stormwater, terminating at one of the area's wastewater treatment plants. In large storm events, combined system may overflow into a receiving water body.
- Separated or partially separated systems, wastewater goes to a sanitary sewer and storm flows is directed to a separate storm drain system. In partially separated sewer areas, rooftop drainage is generally directed to the sanitary sewer, while street runoff is directed to a separate storm drainage system.
- Ditch and culvert drainage systems constructed along the road network.

Through the 1990s, drainage work focused primarily on improving capacity of the main outfall system to reduce major flooding. In the past few years there has been increasing awareness of the adverse impacts of stormwater runoff on the health of aquatic ecosystems and this led to changes in how the city manages its drainage program. Seattle has developed a Comprehensive Drainage Plan to provide the direction for their Stormwater and Flood Control Program and have introduced

controls into their development codes to limit the discharge from sites undergoing development or redevelopment.

The development code has levels of control, based on the size of the development:

1. For sites that have new or are replacing 70m^2 of impervious area, a drainage control plan has to be prepared which shows how the site drainage will be managed.

   These sites are required to limit the peak discharge to 5.5 l/sec per 4040 m^2 for the 25 year, 24 hour design storm, or, 4.0 l/sec per 4040 m^2 for the 2 year, 24 hour storm unless the site drains to a public drain that has sufficient capacity to carry the additional discharge.

2. Sites, greater than 4040 m^2 or with the addition of or replacement of impervious area greater than 465m^2 are subject to the same discharge requirements and may also be subject to water quality treatment requirements depending on the sensitivity of the receiving waters.

3. Sites that have more than 185m^2 of new or replaced impervious surface are required to install and maintain a flow control facility.

The City provide some guidance and have suggested some ways of managing the discharge through the use of:

1. Impervious surface reduction on the site, this could include porous pavements, rain gardens
2. Detention facilities
3. Bio-engineered facilities, eg vegetated stormwater treatments
4. Infiltration facilities

The rate of (re)development in Seattle is low, 0.1% per annum, and so the effect of these limitations is not providing sufficient relief to the drainage network capacity to prevent the City from undertaking further upgrade works to the existing system.

As a means of funding stormwater programs, Seattle has established a direct charge on properties for discharge of their stormwater. This provides an incentive for property owners to limit the amount of impervious area on their site thus supporting the concept of limiting or restricting site discharges. The charges imposed by Seattle vary according to use. A single family residence is charged $121 for the property, other sites are charged based on the size of the property with the rate varying from $139 per 4040$m^2$ for open space to $1182 per 4040$m^2$ for sites with impervious areas greater than 85%.

The management programs adopted by Seattle have commenced the reduction in storm flows due to the increasing impervious area. However, as the rate of development is very low, this is will have an impact in the long term. In the short term, the city will still need to invest in improvements ‘engineered’ solutions, eg upgrading pipe sizes.

Water Quality

Seattle's approach to improve stormwater quality to meet its obligations under the Federal Clean Water Act, comes primarily from two directions – development permit conditions and their own public works.

For any new development or redevelopment, a basic stormwater treatment facility must be provided, in general, to treat 485m^2 or 4040 m^2 of impervious area, 485m^2 of new or replaced vegetation that is subject to pesticides and fertilizers. One of the following treatment facilities shall be installed and maintained – infiltration, wetpond, wetland, biofiltration swale, filter strip, media filter. The installation of these types of facilities assists in achieving the requirement to reduce pollutants to the "maximum extent practicable".

For works in public spaces, Seattle has adopted a technique to try and replicate the "natural drainage' system. This approach was adopted to try and replicate the way a storm flow would have been managed in the natural environment, prior to development and reduce the amount of impermeable surface in the street, filter pollutants from the surface water through soil and plants and slow the flow of water to improve to improve habitat in the creeks. Residential streets are being refurbished by using open, vegetated swales; stormwater cascades; and small wetland ponds.

The design principles when constructing this type of system are:

- Minimizing of impermeable surfaces
- Gentle slopes to slow water
- Enhancement or modification of soil profiles in road sides to increase capacity to absorb stormwater; and
- Addition of vegetation to the streetscape.

The photograph below shows one of the city's natural drainage systems. Natural drainage systems emphasize infiltration and decentralized treatment to more closely resemble natural hydrologic functions lost due to development.

Seattle
Vegetated swale along local road

The appearance of these on-road facilities blend well into the streetscape when new, however, the treatments rely on resident maintenance and some residents took this task on, but others didn't and so the appearance of these treatments now detracts from the streetscape. They become untidy by not being properly maintained and when contrasted against highly maintained private gardens their lack of care is highlighted.

The implementation of these road treatments did involve extensive consultation with residents and whilst residents showed a strong level of support for the vegetation, this enthusiasm waned and the appearance of the streetscape deteriorated. Maintenance of these treatments requires a higher effort than the traditional approach of grassed verges and if this is nor provided the appearance soon deteriorates.

Acceptance by residents has to be obtained in the initial planning stage due to restrictions being placed in the roadsides and the ongoing maintenance plans developed and need to be committed, both in content and financial sense to obtain long term success.

Community Involvement

Part of Seattle's approach to manage their stormwater is to involve their residents. In addition to the consultation undertaken as part of a particular project, this is achieved in a number of ways including the establishment of a Drainage Advisory Committee, provision of information on – garden care, watering practices; and storm drain stencilling.

The Drainage Advisory Committee is a voluntary committee, which meets on a monthly basis to provide input into the various programs and activities operated by the City.

The involvement of the community with the establishment of an advisory group would help to reinforce the need to reduce the quantity of stormwater being generated from the site and to keep stormwater run-off free of the pollutants contributing to the decline in the waterways and aquatic life.

This involvement was not included in any commentary during the visit and so the success or otherwise, was not able to be determined. The involvement of the community though is an important link to improve their understanding of the issues around the quality of their waterways and the contribution they can make to the outcomes.

City of Bellevue, Washington

Background

The City of Bellevue is located just east of Seattle, on the eastern shore of Lake Washington, which is part of the broader Puget Sound.

It was established in the early 1950's, and had a population of 5,900 in 1953. The early residents predominantly came from Seattle, seeking an improvement to their lifestyle and opportunity to live in a better environment. Today it has a population of 117,000 in an area of 31 square miles (80 sq kms). The city is predominantly residential with hi-tech style industries being located in its boundaries.

The climate is the same as Seattle's and has an annual rainfall of 38 inches (960mm). The pattern of the rain is the same as Seattle, mostly falling in low intensity storms.

Stormwater Systems

Bellevue's stormwater systems comprise a system of creeks, piped drains and detention basins throughout their area. For many years though, there has been a preference for the retention of the open creek or stream to retain the environment that supported the life in and around these creeks. In particular there has been a goal to retain the salmon 'runs' as they form an important part of the ecological values of the region.

City of Bellevue
Salmon from a creek in Bellevue

Bellevue faced the pressures of development in the 1970's and the community at that time, observed the effects of increases in stormwater run-off and the decline in the creeks due to erosion, quality of water coming from development sites and caused action to be taken by the City to improve the environmental conditions of their creeks.

The approach taken by Bellevue is to retain use of 'natural' streams as the main component of the system and require or provide detention systems, both at the property and regional scale. Flooding has been alleviated with public works projects and streams protected by limiting run-off from new development. A further benefit of the natural stream concept was the costs to improve the creek to allow them to retain their 'natural' appearance ranged from four to ten times less costly than traditional piped systems.

The methods adopted to achieve the control the flow of stormwater from development sites were through their development codes. The limitations on storm flows applies to properties that new development that includes the creation or addition of 465m^2 or more of new impervious surface and/or land disturbing activity of 4040m^2 or more, except for the following:

1. Individual, detached single-family residences;
2. Individual, detached duplex residences;
3. Commercial agriculture

The limitations on the discharge from the site are:

> 2. Runoff Control for Sites That Drain to a Stream. When runoff control is required for a site that drains either directly or indirectly to a stream, such control shall be provided by detention or infiltration, as specified below:
>
> a. Detention is an approved method of providing runoff control for all sites that drain to a stream. Such detention facilities shall be designed in accordance with the following (refer to the engineering standards for design details):
>
> i. The post-development peak runoff rate from a two-year, 24-hour storm shall not exceed 50 percent of the existing peak runoff rate from a two-year, 24-hour storm.
>
> ii. The post-development peak runoff rate from a 100-year, 24-hour storm shall not exceed the existing peak runoff rate from a 100-year, 24-hour storm.
>
> iii. The post-development peak runoff rate from a 10-year, 24-hour storm shall not exceed the existing peak runoff rate from a 10-year, 24-hour storm.

Ref: City of Bellevue Storm and Surface Water Utility Code, section 24.06.130

Bellevue has also implemented a utility fee, which allows the City to charge each property for the amount of stormwater generated from the site. The fee is charged against all properties and is based on a unit of land equivalent to 2200 square feet, or 185m^2 and the amount of impervious area on the property.

Examples of the charges are:

Development Category		
Undeveloped land	0% impervious	$0.49 per 2200 sq ft; equal to $0.26 per 100$m^2$

Very heavily developed land	> 70% impervious	$8.91 per 2200 sq ft; equal to $4.82 per 100m^2

The ongoing success of the discharge from private land is governed by the development of the utility code where a utility fee is based on the amount of discharge generated from the site. This approach provides an incentive for property owners to minimise the amount of pervious area on their site, but relies on an extensive inspection system to identify changes on the property.

The preferred way to manage the discharges was considered by the staff at Bellevue was to provide facilities managed by the City, where the performance of the facility could be managed.

Water Quality

Water quality management policies and standards have been set through the implementation of their "Storm and Surface Water Utility Code". This code outlines requirements for property development to incorporate water quality improvement treatments. These requirements apply to development sites where the creation or addition of 5,000 sq ft, or 465m^2, of new, impervious area or the disturbance of one acre or more, of land. There are some exceptions to this which apply to single family homes or farmland.

On sites being redeveloped, that are larger than 4040m^2 and have 50% or more of impervious area, or discharge to a water body with water quality problems, pollutant removal treatments have to be constructed. These treatments are to achieve the improvement to the "maximum extent practicable". There area variety of devices used and these are similar to those constructed in Seattle. The following table provides a guide to the performance of the types of treatments:

Table 4.2 Ability of Treatment Facilities to Remove Key Pollutants[1],[3]

	TSS	Dissolved Metals	Soap	Total Phosphorus	Pesticides/ Fungicides	Hydro-carbons
Wet Pond	Ω	+		+	+	+
Wet Vault	Ω			+	+	+
Biofiltration	Ω	+		+	+	+
Sand Filter	Ω	+		+	+	Ω
Constructed Wetland	Ω	Ω	Ω		Ω	Ω
Compost Filters	Ω	+			Ω	Ω
Infiltration(2)	Ω			Ω	+	Ω
Oil/Water Separator	+			+	+	Ω

Notes:
Ω Major Process
\+ Minor Process

Bellevue have also constructed regional facilities have also been constructed including:

- Detention basins
- Infiltration
- Filtration systems

The effectiveness of these treatments has been reviewed and Bellevue now has a strong preference for the use of sand filtration systems. These can be located as a stand alone system or incorporated into another treatment, such as a detention basin.

The other devices provided benefit but were found to have a lower performance that expected.

Community Involvement

As part of the overall program to manage stormwater, information is provided to the community on how they can contribute to the water quality. This includes sponsoring the establishment of volunteer resident groups, known as stream teams, who assist the city to undertake or monitor water quality improvements. Some of the activities includes removing wastes, similar to the Clean Up Australia Day, revegetation of, and removal of weeds along stream corridors, production of information brochures, brochures on garden maintenance, garden chemicals and hazardous products; staff attendance at community meetings, workshops and training sessions.

City of Atlanta, Georgia

Background

The City of Atlanta has a population of 400,000 and was founded in 1837. It is the capital of the State of Georgia.

The greater area around Atlanta, on an approximate 40 mile (65km) radius has a population of 4 million people. Development of the downtown, or central part, of Atlanta is seeing the population returning to the central part and a lot of the redevelopment is conversion of the buildings to residential use. Atlanta expects an increase in the City's population of between 30-40% over the next ten years.

Atlanta was settled in the early 1800's and its infrastructure is now approximately 100 years old. The city developed combined stormwater and sewer facilities. The first means of disposing of sewerage was to allow discharge direct to the creeks and rivers and the combined sewer system replaced these creeks. The infrastructure had been allowed to deteriorate until recent times.

The climate in Atlanta varies with winter temperatures near freezing and summer temperatures in the high 80°'sF. Rainfall is consistent throughout the year with an average annual fall of 50 inches (1270mm).

Stormwater Systems

Atlanta developed their stormwater and sewers as a combined system. As the city grew, little was done to upgrade and improve the system. As a result there were many stormwater/sewer overflows occurring.

In 1998, the City settled a lawsuit by the Upper Chattahoochee Riverkeeper, the United States Environmental Protection Agency, and the Georgia Environmental Protection Division, to undertake improvements to the water quality it was allowing to discharge back into the Chattahoochee River. The City negotiated a settlement by agreeing to undertake improvement works in accordance with an agreed timeframe.

The issues Atlanta face are centred on meeting the agreed actions and timeframe of compliance by 2007.

With legislation in place, this demand placed on Atlanta demonstrates how organisations can have their priorities set for them.

Note:
The Chattahoochee River Keeper is an organisation that was established in 1994 as an environmental advocacy organisation.

Atlanta has adopted an ordinance establishing standards for stormwater. The ordinance applies to land development and redevelopment that meet one or more of the following criteria:

1. New developments that creates impervious surfaces
2. New developments on sites greater than one acre (4040m^2)
3. Redevelopment of impervious surface, or areas greater than one acre
4. Redevelopment in a hot spot, ie one where there are high pollution problems or sensitive environmental concerns.

The development sites are to limit their discharge to not more than 70% of predevelopment peak rate of discharge. There are exceptions to this requirement and include construction of single family residential buildings, with less than 5000 sq ft (465m^2) of pervious cover.

Water Quality

Atlanta provided an example of one of the Best Management Practices, BMP's, that appeared to be operating successfully. The, roof garden, located on their municipal building. (See photo below). The garden provided a green area amongst the hard surfaces of a business district environment. The roof garden was accessible, provided low level facilities ie seating, was attractive within the garden and from the room that provided the access to the garden.

City of Atlanta
Municipal Building roof infiltration garden

The construction of this roof garden demonstrates that this type of facility can be successful if incorporated into a location that has a public use, is maintained and well constructed and laid out. Use of the space encourages the understanding of the treatment, keeps the on-going maintenance to a higher standard than spaces that don't allow access and so the overall outcome is considered to be very successful.

City of Griffin, Georgia

Background

The City of Griffin was established in 1843. It is located approximately 40 miles, (65km), south of Atlanta, in the State of Georgia. The city is 13.9 square miles and has 23,000 residents.

Stormwater Systems

The issues facing Griffin were the impact of development on the quantity of stormwater being generated from properties, causing deterioration of their waterways and the quality of the water causing deterioration of the habitat.

To address these issues, Griffin has adopted a stormwater program that has policies in four areas:

These policies cover :

1. Administrative – development and administration of the program, service levels, inter-governmental/agency co-operation, public involvement and regulatory enforcement,

2. Financial – drainage rate structure, funding options, service level charges,

3. Engineering – planning, analysis, design and construction, and

4. Operations and Maintenance – maintenance of facilities to ensure they perform as intended.

Some of the more important elements of these policies are:

1. Administrative
- reporting requirements on the status of flood control and drainage services
- annual reviews required of the policies;
- development and training of staff on stormwater management practices

Co-Ordination with Other Plans/Programs
- Departments are to incorporate surface water facilities into parks whenever appropriate and cost effective.

Development Proposals
- new developments shall provider adequate drainage control to ensure :
i) no significant increase in flooding or erosion
ii) peak run-off rates after development do not exceed peak run-off rates prior to development
iii) runoff is not a significant source of water pollution

- new developments are to fund pubic facilities where necessary
- development sites are to have erosion and sediment control plans/measures.

Public Involvement/Education

- public awareness and public education programs, such as public presentations, information brochures, fact sheets, news articles and project booklets

2. Financial

These policies cover the funding opportunities and the establishment of the stormwater utility, which is the legislative mechanism to collect stormwater charges to fund the programs. The charges are based around two classifications – single family residential properties and multi family residential properties, commercial and industrial uses.

Single family properties are charged one unit and other properties are charged based on the amount of impervious area on the property.

Examples of the amount properties pay into the utility are:
(The basis of the calculation is around a standard unit of 2200 sq feet)

Residential:Greater than 1,600 SF (~150 sq m)
House: 1,800 SF, Driveway: 600 SF
Total: 2,400 SF (impervious area)
Charge (approx): Monthly $3.50, Yearly $42.00

Commercial: ERU = 2,200 SF
Building: 5,000 SF, Parking, etc.: 10,000 SF
Total: 15,000 SF(impervious area) (~1400 sq m)
Divide 15,000 SF by the standard 2,200 ERU = 6.81 ERUs. Round to 7 ERUs then multiply by $3.50 = $24.50 per month;
Charge :$294.00 per year

3. Engineering

A comprehensive drainage plan for stormwater has to be prepared and reviewed every five years. The Plan provides a framework for the various programs.

4. Maintenance and Operations

Detailed maintenance and day to day operational elements of the programs are to be developed, reviewed and updated annually.

A series of performance goals has also been established to support these policies. These are:

1. Utilize natural drainage systems and reduce additional run-off
2. Run-off to meet quality criteria
3. Local conditions, particularly sensitive receiving waters, may impose additional requirements on quality
4. Existing stream protection to be undertaken
5. River flood protection to be provided
6. Existing habitable structures in the flood plain to be protected
7. Effective maintenance of the devices

8. Regional facilities may be used for multiple projects
9. Developments to strive to implement non-structural pollution prevention, ie spill prevention actions

The exemptions to this requirement applies to single family home properties, undeveloped land and farm land.

The policies adopted by Griffin provide a sound structure to implement their stormwater programs. The inclusion of requirements to report on the status of drainage services, reviews of the policies and development and training of staff on stormwater practices are actions that would be of benefit to authorities in Australia.

Water Quality

Water quality treatments and practices are based on utilizing non-structural treatments, such as public space maintenance practices, storage of chemicals, types of chemical used in the maintenance practices, spill prevention plans and public education and structural treatments including:

- Detention ponds
- Wetlands
- Sand filters
- Porous pavements

The Griffin stormwater design manual provides information on the expected performance of these treatments and these are shown below

Table 8-1 Average Pollutant Removal Efficiencies for Structural Stormwater Controls

Structural Control	Total Suspended Solids (%)	Total Phosphorus (%)	Total Nitrogen	Fecal Coliform (%)	Metals (%)
Structural Controls					
Stormwater Ponds	80	50	30	70*	50
Stormwater Wetlands	80	40	30	70*	50
Sand Filters	80	50	25	40	50
Infiltration Trench	80	60	60	90	90
Enhanced Dry Swale	80	50	50	----	40
Enhanced Wet Swale	80	25	40	----	20
Limited Application Structural Controls					
Filter Strip	50	20	20	----	40
Grass Channel	50	25	20	----	30
Gravity (Oil-Grit) Separator	40	5	5	----	----

* If no resident waterfowl population present
---- Insufficient data to provide design removal efficiency
Table 8-1 is adapted from Table 3.1.2-1, Section 3.1.2 of the Georgia Stormwater Management Manual

comparison with the table used by the City of Bellevue indicates differences in the effectiveness of the facilities expected by the respective authority. The need to obtain

further data on the performance of these facilities is needed to provide authorities with confidence on the outcomes they can expect.

Some Structural Treatments in Griffin

The treatment that were most used was detention basins, both vegetated (other than grass) and grassed. The vegetated treatment was provided an added benefit of removing sediments from the detained water.

A detention basin with a vegetated floor is shown in the photo below. This was located on the edge of the urban area. The basin contains small trees and shrubs that are allowed to grow from rootstock left behind after the annual cut-back or self seeded.

The construction of this type of basin into the urban environment requires an on-going effort to retain its 'place' in the area as its appearance in a well maintained area can be seen to be out of place as the vegetation is left to grow without too much attention. Selection and maintenance of the plants needs to fit the local environment these facilities are placed.

An extensive inspection program has been developed to ensure that these private facilities are being operated and maintained as intended. This approach is not favoured as the on-going need to ensure compliance places a high resource demand on the drainage authority. The stormwater department at Griffin consider the best approach would be for these facilities to be managed by the drainage authority.

This approach requires a significant investment in the enforcement and ongoing compliance to achieve the desired outcomes.

A sample for extended detention ponds is contained in Appendix B.

Griffin also have a drainage utility to fund their stormwater program and is based on the stormwater run-off from the property. The City will discount the rate by as much as 100% if the facilities reduce or mitigate the cost to the City of providing the stormwater services to a similar extent. To achieve the full discount water quality

treatments must be included. Where it is impractical to provide these facilities, developers are able to pay a fee for the service, through the utility.

Community Education/Involvement

Program has been established. This includes activities such as production of brochures, classroom education, complaints database, local media notifications, recycling programs, stencilling of drains programs, resident surveys.

The education of the community to understand the impacts of their activities on their environment provides an important element to the long term success of any program. The community fund the programs and this can be taken for granted, and so the better understanding of the issues the more likely the prevention measures and acceptance of treatments is likely to be achieved.

County of Baltimore, Maryland

Background

The County of Baltimore is located in the state of Maryland, which is the north eastern part of the United States, and was first settled in the 1600's. The boundary of the County has evolved where today it comprises 682 square miles (1766 sq km) and a population of 754,000.

The weather in the region ranges from 18°F to 90°F, with an annual rainfall average of 40 inches, (1000mm) spread relatively evenly across the year.

Baltimore falls within the Chesapeake Bay region, which is one of the three United States water bodies of national significance and has provided a rich source of fishing, commercial and recreational, and related industries over many years. The water quality in the Bay had deteriorated and greatly affected the fishing and general enjoyment of the recreational waters. This was due to discharges direct from industrial sources, including sewer, and from increases in stormwater runoff.

To improve the stormwater quality, the governing bodies around the Bay have responded and commenced implementing improved stormwater practices. Baltimore is one of the authorities around Chesapeake Bay that have implemented changes to the management of stormwater.

Stormwater Systems

Baltimore's drainage systems are similar to 'traditional' facilities, ie underground pipes. These systems are now unable to cope with the expansion of the areas being developed. To reduce the demand on these facilities, Baltimore has implemented policies for development sites, through their development codes, to limit their site discharge. These codes apply to land being developed or redeveloped for uses excepting single family detached homes, farming, or developments not disturbing more than 465m^2.

The performance standards that have to be met. These include:

*Standard No. **1** Site designs shall minimize the generation of stormwater and maximize pervious areas for stormwater treatment.*

*Standard No. **4** Water quality management shall be provided through the use of structural and/or non-structural practices.*

*Standard No. **5** Structural BMPs used for new development shall be designed to remove 80% of the average annual post development total suspended solids load (TSS) and 40% of the average annual post development total phosphorous load (TP). It is presumed that a BMP complies with this performance standard if it is:*
sized to capture the prescribed water quality volume (WQ_v),

designed according to the specific performance criteria outlined in this manual, constructed properly, and maintained regularly.

*Standard No. **7** To protect stream channels from degradation, Cp_v shall be provided by 12 to 24 hours of extended detention storage for the one-year storm event. Cp_v shall not be provided on the Eastern Shore unless the appropriate approval authority deems it is necessary on a case by case basis.*

*Standard No. **8** Stormwater discharges to critical areas with sensitive resources [e.g., cold water fisheries, shellfish beds, swimming beaches, recharge areas, water supply reservoirs, Chesapeake Bay Critical Area (see Appendix D.4)] may be subject to additional performance criteria or may need to utilize or restrict certain BMPs.*

*Standard No. **9** All BMPs shall have an enforceable operation and maintenance agreement to ensure the system functions as designed.*

*Standard No. **10** Every BMP shall have an acceptable form of water quality pretreatment.*

Development sites are required to detain the one year storm event for 12 to 24 hours, depending on the classification of the receiving stream. (12 hour detention is the maximum for streams supporting trout as the longer detention time was found to increase the water temperature and this affected the trout).

For sites being redeveloped, site discharge has to be limited to:

(1) A redevelopment site shall reduce the site impervious area by at least 20%.

(2) If a redevelopment site reduces the site impervious area by less than 20%, a combination of impervious surface reduction and BMPs that provide water quality storage volume for the difference between 20% and the actual impervious surface reduction may be provided.

Ref: County of Baltimore Ordinance 33-4-105. REDEVELOPMENT SITES.

These on-site treatments are supplemented by regional facilities, such as detention basins. They are used on sites being developed, to control site discharge and assist in the water quality requirements.

The effort needed to ensure that these private facilities are high. Baltimore have adopted the approach where home owners associations, comparable to body corporate arrangements in Australia, construct stormwater treatments, then the County will take over the responsibility of the on-going management. On commercial or industrial properties the property owner remains responsible for the ongoing maintenance.

Water Quality

The water quality in Chesapeake Bay had deteriorated to an extent that it was affecting the economic and leisure activities in the region. To improve the quality, a collective agreement was reached by drainage authorities around the bay to improve the quality of the water being discharged into the Bay.

To achieve this goal, Baltimore introduced a requirement to have the first half inch of rain treated before it leaves the site. To achieve this some of the treatments used were infiltration trenches, but these were not successful due to the soil profiles. These were not as successful so the extended detention basins treatment was then tried. The time of detention in the basin was one of the design criteria, as the time affected the water temperature, which then has an impact of the fish stock in the creeks. The criteria established to meet this requirement was for creeks supporting trout, the detention basins had to release the detained water within 12 hours. Other creeks the water could be detained for 24 hours.

The use of detention ponds is extensive and 700 ponds have been constructed, with more being planned. The base of detention ponds are being vegetated to help reduce the sediment load and reduce the pollutants in the detained water. These types of treatments can appear unkempt in the urban setting. To improve their appearance, considerable maintenance effort is needed to keep their appearance consistent with the level of private residential maintenance surrounding the facility.

Vegetated swales have have been constructed, but their success has been low. The photo below shows what can be achieved, however it is the remaining swale across one property in the street. This treatment was located in a highly maintained residential area. Private property maintenance was to a very high standard.

County of Baltimore
Vegetated Swale alongside local road
(only one remaining in street)

The maintenance effort to keep these facilities attractive in the urban setting is considerable and resident acceptance can be low if this doesn't occur.

Conclusions

The various actions taken by drainage authorities vary according their local community and conditions. There are some elements that are transportable back to Australia and I feel that there are three main outcomes:

1. The integration of stormwater management into a community's activities commences at the source – on land where the rain falls. Responsibilities start here. Property owners are at the start of the stormwater cycle, providing the funds, through drainage utilities, or charges, paying for the amount of stormwater they discharge. Property developers are limited by the development codes to the pre-development discharges, or reductions in the impervious areas on the property.

2. Responsibility for water quality also starts at the individual property level, with development codes also being utilized to require the construction of water quality improvement devices, or the local authority constructing their own treatment devices and undertaking public education, and/or public involvement activities, such as 'adopt-a-stream' to enhance the community understanding of the results of their actions.

3. The use of a legislative approach needs to be avoided as it can result in the legal system dictating to a drainage authority where their priorities will be placed.

Some other general conclusions made from the tour:

4. The requirement for property owners to install and maintain facilities, requires a regular audit program to ensure its on-going effectiveness. The amount of resource to undertake this audit could be considerable depending on how the audits would be undertaken and so would need to be evaluated to ensure these costs don't exceed the benefits.

5. The integration of facilities into the surrounding environment to reduce the flows into he receiving streams are typically 'engineered' solutions and so there still needs some development of the way these facilities are placed in the urban environment. Some other methods, such as infiltration treatments, eg porous road pavements, vegetated swales, rain gardens of building roofs, infiltration trenches have been installed, but the reduction in flows is still small compared to the capacity of detention basins.

6. The treatments implemented to improve stormwater quality have had a varied success in terms of resident support and on-going maintenance. The acceptance is largely governed by the impact it has on the abutting property owners enjoyment of the same space.

Conclusions (continued)

7. The performance of quality improvement treatments has not been evaluated to provide a fully objective outcome, but guides to their performance have been established. This information is a useful tool for designers to assess the applicability of a treatment device for their circumstance. Objective evaluation is still needed, however, to enable the successes to be replicated.

8. The ‘user pays’ principle that has been implemented in some authorities has some merit, where the funding has not been provided for this type of activity. However, where the authority’s activities have already been incorporated into the general funding programs, the extraction of a drainage charge and justification of this ‘new’ charge would need to be considered and may be difficult to implement.

Recommendations

There are some opportunities that could be applied to the approaches to stormwater management in Australia and the following recommendations are made to drainage authorities and drainage practitioners:

1. That Drainage Authorities and Councils establish and regularly review policies and service levels for their drainage infrastructure, in consultation with their community. The service levels to include site discharge limitations, drain surcharge frequencies.

2. That each body responsible for stormwater, take **some** actions, such as a treatment as simple as a vegetated swale, to ensure that the quality of the stormwater they convey in their systems is being improved.

3. That each stormwater manager make the link for their community, between the quality of the stormwater flows and the quality of the receiving waters, creeks, wetlands or bays, to increase awareness of the effects of their actions on water quality.

4. That education and training be provided to the infrastructure planners, designers, constructors and maintenance staff on the concepts, details and outcomes being sought from the stormwater treatments to improve the construction and maintenance standards. This education needs to be provided on a broad scale and the most appropriate organisations are Drainage Authorities or the co-operative Research Centres.

5. That the provision of drainage service being linked to a ‘user pays’ principle be further examined, by each drainage organisation, to determine if the separate identification of such a charge could be reasonably explained to their community and introduced.

6. Limitations on the site discharge be placed on (re)development sites, by Statutory Planning Authorities, through the Planning Schemes, to reduce the need to increase the capacity of the existing drainage facilities. This action starts to reduce the impact of stormwater generation at its source.

7. Research is undertaken to quantify the performance characteristics of the various water quality treatments, to enable assessment by designers of the appropriate treatment for the particular situation. This work needs to be undertaken by Universities or Co-Operative Research Centres to ensure its credibility.

8. That maintenance specifications be developed by the design organisation for the ongoing management of facilities, particularly vegetated swales and bio-retention cells.

9. That the design and constructing organisations ensure that landscape professionals are included in the development of the vegetated treatments to improve the likelihood of the long term success of the treatment.

Appendix A

Example of the Requirements for Stormwater Discharges – State of Washington

Taken from Stormwater Management Manual for Western Washington

2.5 Minimum Requirements
This section describes the minimum requirements for stormwater management at development and redevelopment sites.

2.5.1 Minimum Requirement #1: Preparation of Stormwater Site Plans

All projects meeting the thresholds in Section 2.4 shall prepare a Stormwater Site Plan for local government review. Stormwater Site Plans shall be prepared in accordance with Chapter 3 of this volume.

2.5.2 Minimum Requirement #2: Construction Stormwater Pollution Prevention (SWPP)

All new development and redevelopment shall comply with Construction SWPP Elements #1 through #12 below.

Projects in which the new, replaced, or new plus replaced impervious surfaces total 2,000 square feet or more, or disturb 7,000 square feet or more of land must prepare a Construction SWPP Plan (SWPPP) as part of the Stormwater Site Plan (see 2.5.1). Each of the twelve elements must be considered and included in the Construction SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP.

Projects that add or replace less than 2,000 square feet of impervious surface or disturb less than 7,000 square feet of land are not required to prepare a Construction SWPPP, but must consider all of the twelve Elements of Construction Stormwater Pollution Prevention and develop controls for all elements that pertain to the project site.

2.5.3 Minimum Requirement #3: Source Control of Pollution

All known, available and reasonable source control BMPs shall be applied to all projects. Source control BMPs shall be selected, designed, and maintained according to this manual.

Appendix A

Example of the Requirements for Stormwater Discharges – State of Washington (continued)

2.5.4 Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls

Natural drainage patterns shall be maintained, and discharges from the project site shall occur at the natural location, to the maximum extent practicable. The manner by which runoff is discharged from the project site must not cause a significant adverse impact to downstream receiving waters and downgradient properties. All outfalls require energy dissipation.

2.5.5 Minimum Requirement #5: On-site Stormwater Management

Projects shall employ On-site Stormwater Management BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible without causing flooding or erosion impacts.
Roof Downspout Control BMPs, functionally equivalent to those described in Chapter 3 of Volume III, and Dispersion and Soil Quality BMPs, functionally equivalent to those in Chapter 5 of Volume V, shall be required to reduce the hydrologic disruption of developed sites.

2.5.6 Minimum Requirement #6: Runoff Treatment

The following require construction of stormwater treatment facilities (see Table 2.1):
• Projects in which the total of effective, pollution-generating impervious surface (PGIS) is 5,000 square feet or more in a threshold discharge area of the project, or • Projects in which the total of pollution-generating pervious surfaces (PGPS) is three-quarters (3/4) of an acre or more in a threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site.

2.5.7 Minimum Requirement #7: Flow Control

Projects must provide flow control to reduce the impacts of stormwater runoff from impervious surfaces and land cover conversions.
(shortened)

Appendix A

Example of the Requirements for Stormwater Discharges – State of Washington (continued)

2.5.8 Minimum Requirement #8: Wetlands Protection

The requirements below apply only to projects whose stormwater discharges into a wetland, either directly or indirectly through a conveyance system. These requirements must be met in addition to meeting Minimum Requirement #6, Runoff Treatment.

2.5.9 Minimum Requirement #9: Basin/Watershed Planning

Projects may be subject to equivalent or more stringent minimum requirements for erosion control, source control, treatment, and operation and maintenance, and alternative requirements for flow control and wetlands hydrologic control as identified in Basin/Watershed Plans. Basin/Watershed plans shall evaluate and include, as necessary, retrofitting urban stormwater BMPs into existing development and/or redevelopment in order to achieve watershed-wide pollutant reduction and flow control goals that are consistent with requirements of the federal Clean Water Act. Standards developed from basin plans shall not modify any of the above minimum requirements until the basin plan is formally adopted and implemented by the local governments within the basin, and approved or concurred with by Ecology.

2.5.10 Minimum Requirement #10: Operation and Maintenance

An operation and maintenance manual that is consistent with the provisions in Volume V of this manual shall be provided for all proposed stormwater facilities and BMPs, and the party (or parties) responsible for maintenance and operation shall be identified. At private facilities, a copy of the manual shall be retained onsite or within reasonable access to the site, and shall be transferred with the property to the new owner. For public facilities, a copy of the manual shall be retained in the appropriate department. A log of maintenance activity that indicates what actions were taken shall be kept and be available for inspection by the local government.

Appendix B

City of Griffin – Storm Water Manual

Example of the information contained in their Stormwater Design Manual

Extended Detention Ponds

Standard Specifications For Extended Detention Ponds

Required Specifications

Extended detention ponds shall be designed with a detention time of 48 hours. If the extended detention pond is to be designed for only water quality purposes, then the pond should be designed to capture the first 1.2 inches of runoff for the entire drainage area above the facility.

- Pilot channel of paved or concrete material for erosion control (alternately use turf if there is little low flow). Size such that any event runoff will overflow the low flow channel onto the pond floor.
- Side slopes shall be no greater than 3: 1 if mowed.
- Inlet and outlet located to maximize flow length.
- Design for full development upstream of control.
- Rip-rap protection (or other suitable erosion control means) for the outlet and all inlet structures into the pond.
- One and one-half (1 l/ 2) foot minimum freeboard above peak stage for top of embankment.
- Emergency spillway designed to pass the 100-year storm event (must be paved in fill areas).
- Maintenance access minimum of 25 feet wide.
- Trash racks, filters or other debris protection on control.
- Anti-vortex plates.
- Insure no outlet leakage and use anti-seep collars.
- Benchmark for sediment removal.

Recommended Specifications

- Two stage design (top stage -dry during the 1 inch rainfall event, bottom stage -inundated during storms equal to or less than the 1 inch storm event.)
- Top stage shall have slopes between 2% and 5% and a depth of 2 to 5 feet.
- Bottom stage maintained as shallow wetland or pool (6 to 12 in.).
- Manage buffer and pond as meadow.
- Minimum 25-foot wide buffer around pool.

City of Griffin – Storm Water Manual
(Continued)

- On-site disposal areas for two sediment removal cycles.
- Anti-seep collars on barrel of principal spillway.
- Impervious soil boundary.
- Design as off-line pond to bypass larger flows.
- Design as sediment settling basin for pretreatment of the larger particles.

Operation And Maintenance Recommendations

A stormwater management easement and maintenance agreement shall be required for each facility.

- Extended dry ponds are used where lack of water or other multi-use considerations preclude the use of wet ponds or constructed wetlands.
- Operation and maintenance is the same as for detention ponds (see storage chapter).
- Maintenance activities include keeping the outlets unclogged, controlling of vegetation, removing sediment deposits, and keeping aesthetics of area acceptable.

Performance Standards

- Soluble pollutant removal rates are low for extended dry detention ponds but can be enhanced either with greatly increased detention time, through the use of shallow marshes to increase biological uptake, or through using an infiltration device downstream from the outlet orifice.
- Average annual pollutant removal capability of extended detention ponds are as follows:

Pollutant	1 Inch Rain Detained 24 hours	Same as Previous W/ Shallow Marsh
Sediment	80-100%	80-100%
Total Phosphorus	40-60%	60-80%
Total Nitrogen	20-40%	40-60%
BOD	40-60%	40-60%
Metals	60-80%	60-80%

References

Some useful web sites for further information on stormwater in the USA are:

General
http://www.epa.gov/OST/stormwater/
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp
http://www.lid-stormwater.net/
http://www.lowimpactdevelopment.org/sitemap.htm

Funding
http://www.seattle.gov/util/Services/Drainage_&_Sewer/Rates/DRAINAGER_20031202090054 5.asp

Bioretention Systems

http://www.ence.umd.edu/~apdavis/LID-Publications.htm
http://www.ucd.ie/dipcon/docs/theme04/theme04_11.PDF

Rainwater Gardens

http://www.dnr.state.wi.us/org/water/wm/nps/rg/links.htm
http://www.cleanwatercampaign.com/resources/raingardenbrochure.pdf
http://www.ci.maplewood.mn.us/rainwatergardens

Rainwater Harvesting
http://www.southface.org/web/resources&services/publications/factsheets/27_rainwater-recovery-v2.pdf