Ten tips for creating a successful non-structural program to minimise urban stormwater pollution

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Abstract
There are numerous types of non-structural 'best management practices' that are used to improve urban stormwater quality and waterway health. Common types include town planning controls, strategic planning and institutional controls (e.g. the use of city-wide stormwater management plans), pollution prevention procedures (e.g. various maintenance practices undertaken by local government authorities), education and participation programs, and regulatory controls (e.g. enforcement of local laws).

A recent survey of urban stormwater managers across Australia by the Cooperative Research Centre for Catchment Hydrology (the CRC) found that these practices are already widely used in Australia and are increasing in use. This trend has been occurring in recent years despite a lack of sound information on whether some practices work at all, the extent of their effectiveness, their cost, and how they should be designed, implemented and evaluated.

This paper provides ten practical 'tips' for managers of programs that aim to use non-structural approaches to improve the quality of urban stormwater and the health of receiving waters. It draws primarily on three sources of information: 1) a recent international literature review by the CRC into the effectiveness and cost of relevant non-structural best management practices; 2) recent trials involving the evaluation of three non-structural best management practices in Melbourne; and 3) the author's own experiences as a urban water quality manager, consultant and researcher.

Keywords
Best management practices, non-structural, tips, urban stormwater quality

INTRODUCTION

Objective of this paper

The primary objective of this paper is to share some observations about the effective use of non-structural best management practices to improve urban stormwater quality (non-structural BMPs). These observations have been gathered as a result of recent research by the Cooperative Research Centre for Catchment Hydrology (the CRC) as well as the author's own experience, and are presented here as ten practical 'tips' for Australian stormwater managers to consider.

Background

In 2001 the CRC formed a partnership with the Victorian Environment Protection Authority to undertake research into the use, value, cost and evaluation of non-structural BMPs. Such BMPs include town planning controls, strategic planning and institutional controls, pollution prevention procedures, education and participation programs, and regulatory controls.

The primary aim of this research project was to produce monitoring and evaluation guidelines that could be used by local government authorities to assess the value and life-cycle cost of non-structural BMPs.

Secondary objectives of this research project were to help local government authorities manage urban stormwater quality by providing:

- Information from the literature and case studies on the value of non-structural BMPs.
- Information on how structural and non-structural BMPs for urban stormwater quality improvement are being used around Australia, New Zealand (NZ) and the United States of America (US).
- Funding profiles for several leading urban stormwater quality management authorities in Australia and overseas, that can be used as benchmarks when developing urban stormwater management programs.
- Information on the views of Australian and overseas stormwater quality managers on the effectiveness, efficiency and practicality of non-structural BMPs.
- A short-list of non-structural BMPs deemed to be of most value in terms of effectiveness, efficiency, practicality, acceptance and potential for future use (based on the findings of a literature review and survey of Australian and overseas stormwater quality managers).
- Recommended references relating to the design of non-structural BMPs.

Four reports have been produced to communicate this work to stakeholders:

- An **overview report** that describes the project's aims, background, methodology, and presents key findings in a condensed form (i.e. Taylor and Wong, 2002a).
- A technical report on the findings of the detailed **survey** of 36 urban stormwater managers (i.e. Taylor and Wong, 2002b).
- A technical report that presents the findings of the **literature review** on the value and life-cycle costs of non-structural BMPs (i.e. Taylor and Wong, 2002c).
- A technical report which provides guidance on **monitoring and evaluating non-structural BMPs** for urban stormwater quality improvement (i.e. Taylor and Wong, 2003). The guidelines contained in this report were trialled on three non-structural BMPs in Melbourne during 2002-03 before being finalised.

As a consequence of undertaking this project, knowledge has been generated about how best to use these measures and avoid commonly made mistakes. Some of this knowledge is shared here as ten simple 'tips' on using non-structural BMPs.

What are non-structural measures?

Non-structural stormwater quality best management practices are officially defined as "institutional and pollution-prevention practices designed to prevent or minimise pollutants from entering stormwater runoff and/or reduce the volume of stormwater requiring management" (US EPA, 1999).

They do not involve fixed, permanent facilities and they usually work by changing behaviour through government regulation (e.g. town planning and environmental laws), persuasion and/or economic instruments (Taylor and Wong, 2002a).

Taylor and Wong (2002a) define five principal categories of non-structural BMPs for urban stormwater quality improvement:

1. **Town planning controls.** Such as the use of town planning instruments to promote water sensitive urban design (WSUD) features in new developments.

2. **Strategic planning and institutional controls.** Such as the use of strategic, city-wide urban stormwater quality management plans and stable funding arrangements to support the implementation of these plans.
3. **Pollution prevention procedures.** Such as practices undertaken by local government involving maintenance (e.g. maintenance of the stormwater drainage network) and elements of environmental management systems (e.g. procedures on material storage and staff training on stormwater management at commercial and industrial sites).
4. **Education and participation programs.** Such as targeted media campaigns, intensive training programs and involving the community in the development and implementation of stormwater management plans.
5. **Regulatory controls.** Such as enforcement of local laws to improve erosion and sediment control on building sites, the use of regulatory instruments such as environmental licences to help manage premises likely to contaminate stormwater, and programs to minimise illicit discharges to stormwater.

Nonstructural BMPs are one type of 'source control' for urban stormwater pollution. In this context, source control is a defined as non-structural or structural best management practices to minimise the generation of excessive stormwater runoff and/or pollution of stormwater at or near the source (NSW EPA, 1998).

There is currently a trend in Australia towards managing stormwater pollution at the source, and using non-structural source controls. For example, the *National Water Quality Management Strategy - Australian Urban Stormwater Management Guidelines* (ARMCANZ & ANZECC, 2000) recommends the following hierarchy be applied to the management of water quality:

1. **Retain and restore valuable ecosystems:** That is, protect, restore or rehabilitate valuable elements of the natural drainage system, such as watercourses, wetlands and riparian vegetation. [Highest priority]
2. **Source control – non-structural measures:** That is, apply non-structural techniques to limit adverse changes to the quantity and quality of stormwater at or near the source.
3. **Source control - structural measures:** That is, constructed measures are installed at or near the source to manage stormwater quantity and quality (e.g. porous paving, rain gardens).
4. **In system [in transit] management measures:** That is, constructed measures are installed within, or at the end of stormwater systems (e.g. constructed wetlands) to manage stormwater quantity and quality before it is discharged into receiving waters. [Lowest priority]

Why we need to improve our use of these measures

Taylor and Wong (2002b) reported on a survey of 36 urban stormwater managers from around Australia, the US and NZ. The survey gathered information on the extent of, and trends in, the use of 70 BMPs, as well as funding profiles of leading stormwater management agencies. The primary findings of this survey were that non-structural BMPs in Australia:

- are already playing a major role in urban stormwater quality improvement;
- are increasing in use; and
- will continue to increase in use if Australian stormwater quality programs mature in a similar way to those managed by leading agencies in the US and NZ.

In addition, Australian data from the survey indicated that:

- The majority of respondents reported increasing use of 76% of the 41 non-structural BMPs included in the survey, compared to only 34% of the 29 structural BMPs.
- Nine out of the top 11 stormwater management BMPs associated with the most widespread trend of increasing use in Australia were non-structural.

It is apparent that non-structural BMPs are 'booming' in Australia as a response to urban stormwater pollution, yet for many of these measures we know very little about whether many of these measures work at all (i.e. improve stormwater quality), what magnitude of change they are likely to produce, how long they take to work (if at all), and how to design them for optimum performance. There appears to be a yawning gap between what we hope they can do - and what we know they can do.

Given the substantial and increasing level of investment in these measures across Australia, there is an urgent need to increase our level of understanding (through improved monitoring and evaluation projects), and improve the degree of rigor associated with their design and use. It is hoped that 'tips' presented in this paper can, albeit in a modest way, assist this process.

TEN TIPS ON THE EFFECTIVE USE OF NON-STRUCTURAL MEASURES

1) Seek a complimentary balance of structural and non-structural measures

Some stormwater managers promote non-structural approaches as 'the alternative' to structural approaches, as if some competition exists between them. In reality, all BMPs, whether they be structural or non-structural, or whether they be source controls, in-transit controls or end-of-pipe controls, have potential benefits and limitations. The key is finding the *best combination* of these measures to suit local circumstances.

A common finding of successful case studies is that non-structural BMPs often work synergistically with other BMPs, or are needed to deliver structural BMPs. For example, a complimentary enforcement and education program may work synergistically to alter people's littering behaviour across a large municipal area. Or a new local planning policy (with a complimentary capacity building program) may provide the framework to deliver improved stormwater management during construction activities as well as WSUD features on new developments.

2) Ensure organisational arrangements are conducive to non-structural measures

Delivering a comprehensive urban stormwater management plan within a stormwater management agency depends on a sound institutional and administrative framework (Taylor and Wong, 2002c). Finnemore and Lynard (1982) emphasised the importance of such frameworks, stating "the most promising non-structural control measures include institutional control agencies organised to adopt and enforce ordinances, conduct area wide control projects and levy stable and equitable sources of funding" (p. 1098). This perspective is supported by Lehner, *et al.* (1999), who nominated six keys to success based on their review of 100 stormwater management case studies in the US. Three of these keys were administrative in nature (i.e. a dedicated source of funding[1], strong leadership and effective administration).

One of the potential institutional impediments to effective use of non-structural measures in a balanced urban stormwater management program is that they require skills not normally found in those sections of traditionally structured organisations that manage urban stormwater (e.g. traditional 'Works Departments'). Ideally, the section managing the organisation's urban stormwater quality program would be in a position to draw upon a wide range of skills to design

[1] In this context, a dedicated source of funding means a sustainable, secure funding mechanism (such as a permanent local government 'environmental levy' or stormwater-related fee on all properties), rather than short-term government grants or year-to-year budget bids.

and implement the program, including skills in town planning, law, civil engineering, community consultation, marketing, environmental management, psychology, statistics and ecology.

Some of the new directions in urban stormwater quality management can represent a threat to some stormwater managers. For example, there is an increasing trend towards engaging the community via deliberative participation methods to identify issues to be managed, priorities and management strategies. Techniques such as citizen juries are now being used that greatly enhance the community's role in urban stormwater management. Such an approach is sometimes called a 'bottom-up', community driven approach, which contrasts with the more traditional 'top-down', technocratic approach to managing urban stormwater quality (see Ryan and Brown, 2000). Where new approaches are being used, it is important to ensure that the organisational structure and culture (as well as key staff) are amenable to such strategies, so that the new approaches have the best chance of success.

Another organisational challenge is to address the fact that some non-structural BMPs have an elevated risk of failure compared to more established structural measures. Using the philosophy of 'adaptive environmental management', stormwater managers need to be prepared to engage in responsible risk-taking, which should lead to improved understanding, program modification and ultimately better outcomes. To adopt this philosophy however, often requires a new culture to be established within an organisation (i.e. one of responsible risk-taking), which typically requires strong leadership and continual reinforcement.

3) Undertake research and use expertise in their design and evaluation

Non-structural BMPs can be deceptively difficult to design and evaluate primarily because most of these BMPs work by altering people's behaviour. How people will behave in a particular context is difficult to predict, as such behaviour can be affected by many variables. Similarly, confirming with a reasonable level of confidence whether behaviour change has occurred, stormwater quality has improved and/or waterway health has improved can be a challenging exercise (see Taylor and Wong, 2002).

When designing a non-structural BMP and/or a plan to evaluate its effectiveness, spend time to undertake research into how effective such BMPs have been in other contexts, how similar BMPs have operated, the features of successful case studies, and lessons learnt from other case studies. For example, case studies from similar contexts may demonstrate that it typically takes five years to see on-the-ground outcomes from new town planning controls for urban stormwater quality improvement. Such knowledge is important, as it may be inconsistent with stakeholder expectations or funding timeframes for BMP evaluation. The CRC's literature review into the value and cost of non-structural measures for stormwater quality improvement (Taylor and Wong, 2002c) provides a good starting point for such research.

In the same way that various multi-disciplinary experts would be consulted when designing a constructed wetland, expertise should also be sought when designing and evaluating non-structural measures. Increasingly, Australian professionals are developing high levels of expertise in specific aspects of urban stormwater management, such as deliberative community participation methods, the design of town planning controls, litter management and evaluation methodologies.

4) Develop a contingency plan in case of failure

There are many potential benefits of using non-structural BMPs (see Taylor and Wong, 2002a). One disadvantage however is that there is often a significant risk of failure associated with their use. This is because of uncertainty regarding their effectiveness and/or their effectiveness is context-dependent.

A consequence of this risk is that stormwater managers should have contingency plans in place in case the BMP fails. For example, an educational program may be prepared to advise residents on the use of lawn and garden fertiliser to minimise stormwater and groundwater contamination by nutrients. If associated evaluation activities find this campaign is not successful, contingency options may include:

- Altering the educational messages, products, method of delivery, coverage, intensity, etc.
- Shifting from a traditional educational program to a more intensive and interactive community participation strategy.
- Implementing supporting regulatory measures (e.g. local laws) and enforcing these measures.
- Implementing supporting economic instruments (e.g. subsidised slow-release fertiliser).

This example highlights the need to have a sound monitoring and evaluation program for the BMP.

5) Clearly state and document the objectives at the start of the project

It is a common mistake of many non-structural BMPs to poorly define the objectives of the BMP, to allow these objectives to evolve as the project is implemented, or define objectives that are impractical to measure. Like all projects that need to demonstrate success (or otherwise), the objectives should be specific, measurable, achievable, relevant, and linked to a timeframe.

Consider an educational program. The program's objectives could relate to simply implementing the program in accordance with a project plan, raising awareness within a target audience, changing their attitudes or beliefs, changing their self-reported behaviour, changing their actual behaviour, changing stormwater quality (in terms of pollutant loads and/or concentrations), or changing the health of receiving waters. The choice of program objectives has significant implications for the effort required to determine the success of the BMP.

6) Be patient and plan for the long-term

Some non-structural BMPs take many years to operate at peak efficiency. For example, it is thought that it takes approximately a decade for city-wide erosion and sediment control programs that have strong, sustained enforcement elements to produce compliance levels of approximately 90 percent[2] (Taylor and Wong, 2002c).

Two of the consequences of such long timeframes are that:

- the expectations of stakeholders (e.g. local government councillors and community groups) may need to be adjusted, as they may be expecting outcomes within a shorter timeframe; and
- the organisation's funding and evaluation arrangements for the BMP may need to be reviewed, so that they can be sustained over the BMP's entire life cycle.

7) Develop a sound monitoring and evaluation plan at the start of the project

Monitoring and evaluation of non-structural BMPs is often not done, or done poorly. To better utilise limited funds to improve the state of urban waterways, such evaluations are needed, as the effectiveness of many BMPs is still either unknown or uncertain.

As an example of a poorly designed and/or reported monitoring and evaluation strategy, consider an award-winning Australian local stormwater quality education program that initially stated its objective was to change people's *attitudes* towards stormwater management. Unfortunately the evaluation strategy involved measuring changes in people's stormwater *awareness* (rather than

[2] That is, approximately 90% of randomly audited construction sites would be complying with the region's erosion and sediment control requirements.

attitudes). This evaluation was inconclusive. Despite this, staff running the educational program claimed that the program was successful, based solely on unsubstantiated anecdotal evidence.

Unfortunately this case study is not unusual. It highlights the need to design a sound monitoring and evaluation plan at the start of the project (utilising expertise when necessary), implement it fully, and impartially report the results.

8) Report honestly and openly, regardless of success

As much, if not more, can be learnt from a BMP 'failure' as from a BMP 'success'. Knowledge gained from evaluating non-structural BMPs that have failed to fully meet their objectives needs to be communicated within the stormwater industry, so that similar mistakes can be avoided in future and subsequent funds can be used more wisely. Consequently, any substantial monitoring and evaluation report should be impartial, preferably peer reviewed, and communicated to the industry.

9) Recognise that non-structural BMPs also require maintenance

Concern over the cost to government of maintaining large, structural BMPs such as gross pollutant traps and wetlands has been one of the drivers for an increased focus on source controls and in particular non-structural BMPs (Taylor, 2000). However, it is a mistake to assume that non-structural BMPs do not require maintenance.

Common non-structural BMPs such as educational programs, stormwater management plans, local laws, town planning controls and enforcement programs all require some work over their life cycle to ensure that they remain effective. Long term educational programs are perhaps the most difficult to maintain, as messages and strategies need to be regularly refreshed to effectively engage the target audience. In addition, funding may become hard to obtain as the campaign begins to age and lose its political appeal.

10) Don't get mesmerised by the 'feel good factor'

It is easy to believe that some non-structural BMPs are effective just because segments of the community appreciate their use and/or they are politically popular. However, if the initial objective of the BMP is to change people's behaviour and/or improve stormwater quality, one must not be sidetracked from using these aspects as the principal measures of success. This is particularly the case for educational programs.

An example of a BMP where this *could* easily occur is the use of stormwater drain stencilling programs. Such programs are commonly used as mechanisms to engage the community, raise awareness of stormwater issues, foster positive attitudes towards stormwater management, help change people's behaviour with respect to stormwater management, and reduce stormwater pollution. A recent literature review by Taylor and Wong (2002c) found that some evaluation exercises have reported a positive correlation between seeing the stencils and levels of stormwater awareness/knowledge (e.g. Morison and Hargans, 2002), but no studies were identified that demonstrated stormwater drain stencilling raises people's awareness or induces behavioural change.

CONCLUSIONS

Non-structural measures for improving urban stormwater quality include town and strategic planning instruments, institutional controls, educational and participatory programs, and regulatory instruments.

The use of these measures is common in Australia. Such use has been increasing in recent times and is likely to continue to increase if Australia follows trends in the US and NZ.

If we are to realise and maximise the *potential* value of these measures we have to address some current shortfalls. These include a lack of good information on their effectiveness and a lack of rigor concerning their design and use.

The simple 'tips' presented in the paper are offered as some points to consider to help urban stormwater managers prevent commonly made mistakes in order to use public resources more wisely and ultimately improve the health of the Nation's waterways.

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