Designing, building and maintaining WSUD assets to meet stormwater volume reduction targets; is it actually possible? 25 years of Australian industry experience

Concevoir, construire et entretenir des infrastructures de gestion durable des eaux pluviales pour atteindre les objectifs de réduction du volume des eaux pluviales : est-ce réellement possible ? 25 ans d'expérience dans le secteur en Australie.

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RÉSUMÉ

Les villes et les zones urbaines sont de véritables usines à pollution de l'eau, des déchets, de l'air, du carbone et de nombreux autres polluants. En tant que société, il est essentiel de concevoir des villes en harmonie avec la nature et d'éviter de polluer les lieux qui nous sont chers. Des décennies de recherche ont démontré que la pollution des eaux pluviales a un impact considérable sur les rivières, les baies et les plages. On sait désormais également que le volume de ruissellement provenant des surfaces imperméables en milieu urbain est presque dix fois supérieur à la capacité d'absorption des écosystèmes naturels.

Les autorités australiennes s'efforcent de créer un cadre réglementaire, des lignes directrices et des pratiques standard pour les aménagements urbains sensibles à l'eau qui réduisent considérablement le volume de ruissellement à toutes les échelles (parcelles, rues, quartiers et bassins versants entiers). Cet article passe en revue quatre projets spécifiques conçus pour réduire le ruissellement des eaux pluviales à des niveaux naturels, dans le but de concevoir des solutions ayant un « impact nul » sur les cours d'eau.

Cet article décrit comment une utilisation intégrée des ressources nécessaires permet d'atteindre cet objectif et propose une solution de conception démontrant qu'il est possible de concevoir des villes tout en respectant les objectifs de réduction du volume urbain. Cette solution requiert une application rigoureuse et méthodique des toitures végétalisées, des réservoirs d'eau de pluie, des systèmes d'infiltration, des arbres et tranchées à arrosage passif, des jardins de pluie et des terre-pleins centraux. Des exemples de réduction du volume urbain, allant de 50 à 98 %, ont été observés dans certains projets.

ABSTRACT

Cities and urban areas are pollution factories for water, waste, air, carbon and several other pollutants. As a society, it is critical that we build cities to be in harmony with nature and avoid polluting the places we love. Decades of research have shown that stormwater pollution has a significant impact on rivers, bays and beaches. Now we also know that the volume of runoff from impervious surfaces in a city is almost an order of magnitude greater than the natural system can cope with.

Authorities in Australia are grappling with how to create a regulatory environment, guidelines, and standard practice for water sensitive urban design assets that significantly reduces the volume of runoff from all scales (lots, to streets, to precincts and whole catchments). This paper reviews four specific projects designed to reduce stormwater runoff to natural levels, with the view to designing for a 'zero impact' on waterways.

This paper outlines how an integrated use of assets that are required to meet this goal and put forward a design solution that shows it is possible to design cities and meet volume reduction targets. It requires a careful and methodological application of green roofs, rainwater tanks, infiltration systems, passively watered trees and trenches, raingardens and central median strips to. Examples range from 50 to 98% volume reduction, in projects at the lot to the precinct level.

KEYWORDS

Stormwater, design, targets, volume reduction, integrated.

1 INTRODUCTION

Context

Cities are built with hundreds of thousands of hectares of imperviousness, that create several problems for the environment, community and management of drainage infrastructure and ultimately the liveability of our cities. Recognition of the impact of the volume of the runoff (Walsh et al, 2005, and Burns et al 2012), in addition to the impact of the concentration and load of stormwater pollution has resulted in a new focus on stormwater volume reduction targets (EPA Victoria, 2021).

In Melbourne (Australia) the main water authority released stormwater volume infiltration and harvesting targets, at a catchment scale (Melbourne Water, 2018).

The ongoing impact of climate change and the need for climate adaptation across all cities (IPCC (2021 and Department of Environment, Land, Water and Planning (DELWP) Victoria (2017)), water sensitive urban design or green infrastructure will have an increasingly important role to play.

While targets have been set, there is a lack of research and analysis into the method and effectiveness of achieving these stormwater volume reduction targets (Melbourne Water, 2025).

The general view of practitioners and urban developers is that it is virtually impossible, and very costly, to achieve these targets.

This paper documents four scenarios to analyse if, and how, WSUD could be designed, built, and maintained to achieve these volume reduction targets.

The design problem

Designing lots, precincts and cities to reduce stormwater volume is very much a demand problem. The demand for this excess stormwater is usually limited, and supply is usually quite large.

There is a large excess volume of stormwater from an impervious surface, the challenge is to find a use for this water, be it in open space and infiltration / absorption, or in terms of internal uses in a building.

The design problem is a spatial problem. Can we find enough space to manage this excess runoff? And the further we travel down a catchment or drainage line, the more space we need. It is well understood that managing stormwater at source (Argue, 2013 and Engineers Australia, 2016) is a preferred method, but in practice this is mostly not done and assets are built as 'end of line' solutions.

The design problem is also one of efficiency. How do we design WSUD infrastructure, across a whole catchment, to meet volume reduction targets, in a cost effective way?

2 METHOD

Overview

The method to investigate the suite of interventions to meet a volume reduction target was as follows :

1. Review of documentation and strategies that include stormwater volume reduction targets.
2. Review past projects and effectiveness from a design and maintenance perspective.
3. Set up MUSIC model to use a variety scales and climates.
4. Model natural catchments to set natural flow regime runoff targets.
5. Model natural catchments to establish a 'slow leak' rate to include in rainwater tank modelling.
6. Model all four scenarios, and review sensitivity of parameters and impact on overall runoff..
7. Reflect and add design detail from maintenance and operation of WSUD assets
8. Document results and discussion.

Defining 'zero impact' and a specific target for stormwater volume reduction

The definition of zero impact (from urban development) is the flow regime equivalent to a natural catchment. By modelling a 100% pervious catchment (of any size), we can calculate a 'natural flow regime'. MUSIC modelling (eWater, 2018) provides an modelled flow target (ML / ha / yr) that can be used to quantify this annual average flow from a subcatchment.

An urban catchment usually creates a 500% to 1000% increase in flow, based on MUSIC modelling results, compared to a natural catchment, so a stormwater volume reduction target is the reduction (in real terms) to reduce the worst case scenario (urban development with no interventions or assets to manage stormwater) to this natural level.

It should be noted that defining what is a natural flow regime for a precinct or lot is a relatively complex task and MUSIC only provides an estimate. There is very little hydrological monitoring data, over a long term, in urban areas, that can provide an empirical analysis of this natural level.

MUSIC modelling separates the flow constituents into impervious overland flow, pervious overland flow, evapotranspiration, baseflow, and groundwater recharge. Water that is modelled as reuse from a rainwater tank or storage is considered to exit the model and will not appear in the final receiving node.

MUSIC modelling indicates that a zero impact target is usually around 80% to 90% less runoff from an urban catchment, to keep the outflow equivalent to a natural catchment.

3 DESIGN SOLUTIONS

Classifying assets for stormwater volume reduction

Based on the experience of designing, building and maintaining WSUD assets, the industry is aware that not all WSUD assets are effective in reducing the volume of runoff. Assets are presented below into those are effective, and those that are not as effective.

- Effective assets for volume reduction
    - Permeable surfaces and permeable paving
    - Green roofs
    - Rainwater tanks
    - Raingardens – unlined
    - Infiltration zones
    - Tree pits (with extended detention and unlined)
    - Passively watered tree pits and trenches
    - Stormwater harvesting schemes
    - Ponds
- Less effective assets for volume reduction
    - Raingardens – lined
    - Swales
    - Wetlands
    - Gross pollutant traps
    - OSD

A move towards the use of the 'effective WSUD assets for volume reduction' is a significant change to the standard practice of developers and the general WSUD industry in Australia, that have relied heavily on designing and incorporating wetlands, swales, gross pollutant traps and raingardens (lined), at the end of catchments, into urban developments.

Constraints

There are several constraints in designing these assets within the urban landscape and understanding how to place them in a location that can passively absorb stormwater. The main constraints in designing and building these assets are :

- Available space. Space in the urban environment is heavily contested, and in demand for several other ruses such as passive and active open space, car parking, transport routes, housing, and retail / commercial uses.
- Slope. The slope of a site influences water flow velocity and infiltration potential.
- Soil. Soil characteristics such as permeability, compaction, and contamination affect the feasibility of infiltration and vegetation growth.
- Reuse opportunities. The potential for reusing captured stormwater varies depending on proximity to nearby sites with a demand for non-potable water.

- Regulation. Guidelines and planning clauses sometimes specific assets, that may not be the most effective in reducing stormwater volumes.
- Social acceptability. Communities need to be accepting of this type of lot and streetscape design, and appreciate the value and benefit of this design method.
- Safety. Assets must be designed to minimise risks such as drowning, slips, or mosquito breeding.
- Trafficability. In some instances the asset may impact on parking and foot traffic flows.
- Maintainability. Maintenance is often an overlooked issue in how these assets work in the long term.

4 RESULTS

The paper will present results for four different projects, both built and conceptual, and illustrate how to design appropriate WSUD assets, at the right location and scale, to reduce stormwater volumes to a natural or zero impact target.

The project presented are:

1. Single lot house with 5 kL rainwater tank, smart tank operation and one raingarden
2. Precinct urban development (20 lots) with 20 kL rainwater tanks connected to toilet and laundry
3. Precinct urban development (20 lots) with 20 kL rainwater tanks connected to toilets, laundry, hot water and slow leaks, and also central median bioswales to absorb road runoff
4. Precinct coastal village development (255 lots) with 20 kL rainwater tanks, infiltration trenches, and a parallel dual infiltration trench to manage road runoff

Results vary for these projects – with the rainwater tank project reducing volumes by up to 50%, but other projects with more advanced operations and using more than just rainwater tanks, enable volume reduction up to 98%.

The paper considers how effective the assets are as the scale of the development increases, enabling urban designs and practitioners to consider how to use different types of assets at each scale, and meet these targets.

5 DISCUSSION

Rainwater tanks alone do not meet these targets.

Wetlands and lined raingardens reduce overall annual volumes by 3 to 5% (Hatt et al, 2009 and eWater, 2018) and hence fail in meeting these new types of stormwater volume reduction targets.

But with the appropriate design and use of the 'effective WSUD assets', stormwater volume reduction is possible. There needs to be a very conscious and rigorous application of WSUD assets in both lots and streets, and applied to every lot, to meet these targets.

The increase in permeability is one of the most effective ways to meet these targets. Stormwater harvesting schemes are unlikely to be that useful, as they tend to only use water in summer months to support open space irrigation needs.

A change of mindset alongside the evidence and scientific basis for this change is required, with particular emphasis on urban designers, urban planners, and stormwater engineers seeing value in a different and more local approach to managing stormwater at source.

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