APPLYING WATER SENSITIVE URBAN DESIGN TO SUPPORT GREEN INFRASTRUCTURE IN SOUTH-WEST WESTERN AUSTRALIA

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Abstract

The south-west of Western Australia has been affected by the impacts of climate change including increased temperatures and declining rainfall and runoff into dams. These impacts are likely to continue into the future, together with the possibility of more frequent, high intensity rainfall events. The application of water sensitive urban design and water sensitive city principles is being increasingly recognized for its ability to moderate urban heat island effects and deliver more liveable urban environments that incorporate green infrastructure. This paper shares some of the approaches to water sensitive urban design that support the creation of green infrastructure in Western Australia, including some of the tools and practices that are supporting improved outcomes and fostering increased adoption.

Introduction

The Perth and Peel region continues to experience high levels of population growth. Current housing construction practices usually involve the complete clearing of sites and very limited re-establishment of tree canopy. This practice is generally the same for both large-scale greenfield development and medium density infill development. The continuation of this form of business-as-usual development is therefore likely to lead to the creation of hot, dry landscapes with poor amenity which will lead to a further decline in community and environmental health.

This conclusion is supported by recent research conducted by the Cooperative Research Centre for Water Sensitive Cities (CRCWSC) and the Western Australian Planning Commission which determined that 'without significant intervention, 'business as usual' redevelopment will have a considerable negative influence on urban hydrology, resource efficiency, urban heat, liveability and amenity' (London *et al*. 2020). The financial cost of these effects is high; for every new medium density infill development dwelling there is an additional cost of $1,460 per year to the wider community due to sub-optimal outcomes, which equates to a $29,200 capitalised cost (SGS, 2020).

The term 'water-sensitive urban design' (WSUD) was coined in Perth, WA, in the early 1990s by a collective of engineers, environmental planners and landscape architects concerned with improving urban stormwater management (Argue *et al*. 2013). It is a contemporary planning and design approach to managing the urban water cycle through integration into the natural landscape. It incorporates the sustainable management and integration of stormwater, groundwater, wastewater and water supply into the built form to achieve water and environmental outcomes as well as aesthetic, liveability, and urban cooling outcomes (Public Transport Authority *et al*. 2020).

The application of WSUD to create water sensitive cities has been a requirement of development in Western Australia since 2006. While there have been a number of issues with the adoption and implementation of WSUD solutions, the approach is being increasingly supported by the development industry to underpin the creation of green, liveable communities.

Discussion

A number of state and local government agencies and members of the development industry were active participants in the research of the CRCWSC and formed a community of practice dedicated to the creation of water sensitive cities across the state. Some of the key learnings from this program of research included identification of the principles of practice that were the most effective and/or had greatest resonance with industry and were therefore effective implementation/delivery tools. Those that had greatest relevance to the delivery of green infrastructure included:

- Understanding how water influences urban form
- Creating multi-functional places that support recreation, environmental and social values while providing critical flood protection and water quality functions
- Facilitating passive irrigation of street trees with stormwater
- Recognising the cooling benefits of water in the landscape
- Using support provided by policy and guidelines
- Project delivery through collaboration which includes asset managers

With particular focus on the delivery of green infrastructure each principle is described briefly below.

1. Understanding how water influences urban form

The natural movement of water across a low-gradient landscape is to meander. This is often at cross purposes with current design and engineering practices which are proposed to support efficient provision of infrastructure and movement patterns. Guidance for the creation of water sensitive streetscapes that incorporate areas for infiltration and vegetation was released nearly 30 years ago. Although this intent has been incorporated into current planning policy and guidelines, its delivery is at odds with contemporary urban design practices which are to create flat, regular shaped blocks to support the form of housing construction occurring in Perth (usually double brick and tile on a concrete slab). This reduces the opportunity to celebrate water in the urban landscape and supports drainage in piped networks rather than in natural, curved road layouts or meandering streetscapes. The ability to retain vegetation and mature trees is also reduced as a result of the "cut to fill" earthworks practices that are applied in order to create flat allotments. This effect has been further exacerbated by a policy decision which allowed a reduction in verge widths to 4.5m, reducing the opportunity to plant trees in streetscapes. There is now a push from the planning fraternity to increase verge widths to provide enough space for urban greening, amenity and urban cooling.

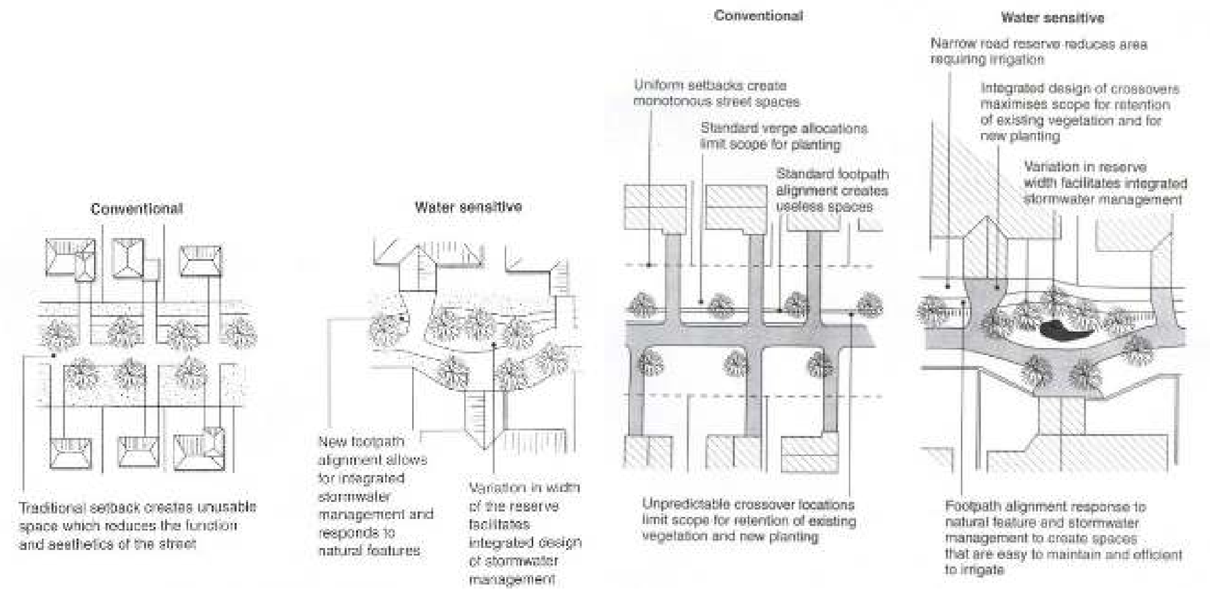

Figure 1. Conventional and water sensitive road layouts and streetscapes (from Wheelans *et al*. 1994)

2. *Creating multi-functional places that support recreation, environmental and social values while providing critical flood protection and water quality functions*

The value of land is constantly increasing so it is important that its use is maximised through smart design to accommodate a range of functions that can occur at different times. The creation of multiple-use corridors and public open spaces that effectively manage stormwater is now occurring widely, particularly in greenfield development areas across Perth and Peel. These spaces are designed so that frequent rainfall events are managed high in the catchment (preferentially on lots and in streets) in vegetated areas that deliver water quality benefits, while infrequent, larger flood events are accommodated in ovals or other areas that are used for recreation for the majority of the time. In addition, as these spaces are often in low points (so the stormwater can flow there), they can provide opportunities to retain vegetation and trees.

Figure 2. This area provides social and recreational benefits and can manage stormwater from a major rainfall event, with floodwaters draining into underground cells in 24 hours, so it can be available for recreation again quickly.

3. *Facilitating passive irrigation of street trees with stormwater*

The usual Perth practice of building large, single residential houses on rectangular 300-500m^2 blocks leaves limited room for gardens or trees. Accordingly, the streetscape is increasingly being seen as the only opportunity for greening and urban cooling.

Application of water sensitive urban design in streets provides an opportunity to enhance tree health from passive watering. This requires the street drainage systems to be designed so that stormwater will run along the streets and into tree pits or raingardens where it provides a source of water for the plants, and any pollutants in the stormwater are taken up by the vegetation or bound to the soils.

Tree health can be further improved through the use of structural cells to provide a frame for construction of road infrastructure that is then filled with uncompacted soil which promotes tree growth. These cells can also assist in managing large volumes of stormwater and enhancing groundwater recharge. The benefits of passive irrigation have been reported by the CRCWSC and are shown in figure 3.

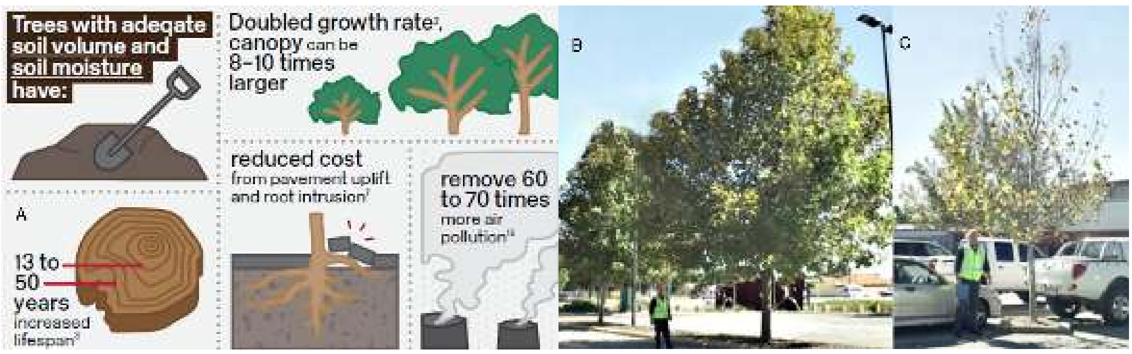

Figure 3. A: benefits of passive irigation of trees, B: trees after 4 years groth in a car park built with structural cells, C: trees after 15 years growth in a conventionally engineered car park (Source CRCWSC, 2020).

4. Recognising the cooling benefits of water in the landscape

The sixth assessment reports released by the Intergovernmental Panel on Climate Change (IPCC) (Climate Change 2021, 2022a, 2022b) highlight the critical need for our cities to address urban heat to mitigate impacts on the health and wellbeing of the community and the environment. The CRCWSC has documented the cooling benefits realised from the application of water sensitive urban design in urban landscapes (see https://watersensitivecities.org.au/urban-heat/), noting that

> *WSUD reduces air temperature by retaining water in the urban landscape and increasing soil moisture. This promotes evapotranspiration and leads to a cooling effect, much like an evaporative cooler. The other critical role of WSUD is that it increases water availability for vegetation to strengthen the cooling effect of vegetation and keep it healthy. For trees and vegetation to provide maximum cooling capacity, it must have sufficient access to water to support transpiration and maintain a healthy canopy to provide shade. WSUD also supports a range of multiple benefits. Integrating WSUD and vegetation, especially trees, should be a key component of any urban heat mitigation strategy (Coutts et al, 2015).*

Further work by the CRCWSC demonstrated a water sensitive urban precinct under heatwave conditions was 2 to 4 degrees centigrade cooler than a conventional precinct (figure 4), with most benefit arising from increased permeable surfaces, trees and vegetation, and irrigated open spaces (London *et al*. 2020).

Figure 4. Modelled human thermal comfort temperatures resulting from conventional urban design (left) and cooler temperatures of WSUD and green infrastructure (from London *et al*. 2020)

5. Using support provided by policy and guidelines

The requirement for planning proposals to address water resources and incorporate water sensitive urban design approaches was introduced in WA in 2008 through the gazettal of *State Planning Policy 2.9: Water Resources* (WAPC, 2008). A review of the implementation of this policy was undertaken by the Department for Planning, Lands and Heritage in 2019, leading to the release of a revised policy for public comment in 2021. The draft *State Planning Policy 2.9: Planning for Water* (WAPC, 2021) now requires that "*Planning and development enhances amenity and sense of place associated with water resources, which in turn protects public health and increases resilience of the community*." The application of these policies is supported by guidelines which outline how water resources should be addressed at each stage of the planning and development approvals process.

The creation of green infrastructure to deliver amenity is further supported by the design principles contained in *State Planning Policy 7.0: Design of the Built Environment* (2019) and the related guidelines which require deep soil zones and implementation of water sensitive urban design. It is noted, however, that the lack of specific criteria for green infrastructure, particularly for trees in streets, can result in a focus on delivering other criteria that have been long established, such as the standard stormwater management criteria set out in the *Decision Process for Stormwater Management in Western Australia* (DWER, 2017).

6. Project delivery through collaboration which includes asset managers

The management of water resources is the shared responsibility of landowners/proponents, government, service providers, industry and the community (WAPC, 2021). Accordingly, it is critical that the full range of disciplines involved in designing, constructing and maintaining our urban landscapes are engaged as part of the design process. This will ensure that competing perspectives are understood and outcomes can be optimised rather than compromised. It is also vitally important that the eventual asset manager, usually the local government parks or natural areas team, supports the strategies that are being proposed and that consideration has been given to the ongoing maintenance requirements of the proposed landscapes. This can be achieved through establishing early collective agreement on the vision for the site and demonstration of how this is achieved at each stage of decision-making.

Conclusion

Early attempts to gain support for WSUD focused on the management of stormwater and flooding, delivering water efficiency and providing appropriate water and wastewater services. Recent awareness of climate change and the value of trees and other vegetation in the urban landscape has provided a more powerful platform for the delivery of WSUD including a focus on green infrastructure, particularly in our streetscapes. This contemporary focus requires multi-disciplinary thought, collaboration and application to ensure water management strategies support delivery of improved climate, ecological, social and economic outcomes, rather than just meeting the standard stormwater management (water quantity and quality) criteria.

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