CRC for Water Sensitive Cities

Response to the Australian Senate Inquiry into Stormwater

Overview

In Australia, and in many cities and towns around the world, three critical drivers are affecting cities and towns: population growth and changes in lifestyles and values; climate change and climate variability; and challenging economic conditions. Population growth increases the pressure on water resources in terms of water supply security and the pollution of our waterways. Climate change gives rise to more extreme weather events such as droughts, floods, and heat waves. A tightening economic climate has led to further economic efficiency sought through micro-economic reforms that fundamentally impede efforts to deliver cross-sectorial innovation for sustainable and resilient water management in cities and towns. In concert, these three drivers are impacting the effective delivery of urban water services that underpin urban liveability; leading to reduced water security, increased flood vulnerability, and more degraded and stressed natural systems (CRCWSC, 2014).

Water management is one of a number of important elements defining the sustainability, resilience and liveability of cities and towns. Reliable supply of drinking water and provision of sewerage services are fundamental services afforded to all of Australian cities and towns. However, urban stormwater and wastewater discharges pollute the water environment and there have been substantial efforts directed at mitigating these impacts. As many Australian cities and towns experienced severe drought in recent times, we now recognise that we are entering an era where natural resources are reaching their carrying capacity limits. We need to do more with what we have. Cities and towns are water catchments and **stormwater** and wastewater are resources that are under-utilised. These resources will ultimately provide our cities and towns with a diversity of water sources that will increase water supply resilience to future droughts.

Innovation in stormwater management can deliver multiple beneficial outcomes related to the sustainability, resilience and liveability in cities and towns. However, discussions around the strategic management of stormwater ought to be within the broader framework of integrated management of all the urban water which impacts on the 'water security' of our cities and we have prepared our submission in this context. 'Water security', as defined by UN-Water (http://www.unwater.org/topics/water-security/en/) encompasses aspects of reliable access to water, provision of water sanitation services, protection from floods and preservation of natural ecosystems.

Innovative urban water management is a wise economic and environmental choice.

Encouraging innovation in urban water management, with the goal of preserving scarce resources, is increasingly seen as a wise economic and environmental choice; rather than the lofty dream of past decades. Federal, state and territory, and local governments are looking at local and international research on water sensitive cities to make the most of rainfall events, stormwater recycling and advances in intelligent urban water systems (CRCWSC, *in press*).

Water sensitive cities are sustainable, resilient, productive and liveable through a combination of physical infrastructure, governance arrangements and social engagement.

Water sensitive cities interact with the urban hydrological cycle in ways that:

- provide the water security essential for economic prosperity through efficient use of the diversity of water resources available;
- enhance and protect the health of watercourses and wetlands;
- mitigate flood risk and damage; and
- create public spaces that harvest, clean, and recycle water.

A Water Sensitive City has strategies and systems for water management that contribute to biodiversity, carbon sequestration and reduction of urban heat island effects (http://watersensitivecities.org.au/what-is-a-water-sensitive-city, 2015)

A Water Sensitive City combines physical infrastructure, such as water sensitive urban design (WSUD), with social systems (e.g. governance and engagement) to create a city where the infrastructure and systems enhance the connections people have with water and improve quality of life. Water in the urban environment, derived primarily from stormwater, is a critical aspect of place making, both in terms of environmental values, but also social amenity and cultural connection to a place, and therefore can contribute to the liveability of a city (Wong *et al.*, 2013).

Future urban water infrastructure will harvest and recycle an integrated mix of water sources (including catchment water, stormwater, wastewater, greywater and seawater) bounded by principles such as minimising ecological footprints, through a more flexible combination of centralised and decentralised systems.

Management of all parts of the urban water network, including water supply catchments, sewage management and demand management etc., are important in progressing the objectives for Water Sensitive Cities. Stormwater is one of a number water sources across a city but offers a unique opportunity, given its diffuse nature, to deliver distributed water management solutions - resulting in widespread benefits (Wong *et al.*, 2013). Bounded by principles such as minimising ecological footprints, future urban water infrastructure will harvest and recycle an integrated mix of water sources; achieved through a flexible combination of centralised and decentralised systems.

The CRC for Water Sensitive Cities is undertaking research and synthesis work that will revolutionise water management in Australia and overseas.

An Australian Government initiative, the Cooperative Research Centre for Water Sensitive Cities (CRCWSC) was established in July 2012 to help change the way we design, build and manage our cities by valuing the contributions that water makes to economic growth and development, our quality of life and the ecosystems of which cities are a part (CRCWSC, *in press*).

A brief history of stormwater in Australia

Traditional stormwater management has focused on efficient drainage and flood management. More recent history has seen a focus on water quality for the protection of receiving waters. There is an emerging recognition of the broader benefits of integrated water management across our cities, the value in expanding the uptake of WSUD technologies, and implementing appropriate governance frameworks to support wide-scale uptake.

Stormwater management has traditionally focused on stormwater drainage, with the principal (and often only) objective of conveying stormwater runoff away safely and economically to receiving waters (e.g. waterways, bays and estuaries, groundwater, seas and oceans). This is traditionally done by way of channelization and concrete lining (Wong *et al.*, 2013).

These traditional approaches have inadvertently served to efficiently convey the pollutants flushed from urban areas to the receiving waterways, particularly the iconic rivers and bays associated with many large cities. Poor water quality in urban waterways is common in towns and cities throughout the world. These traditional approaches also impact on catchment hydrology; increasing the magnitude of flow events in urban streams which quickly leads to a loss of the environmental value of urban waterways and substantial impacts on flooding, stream erosion, and public safety (Wong *et al.*, 2013).

More recent history has seen water quality concerns, particularly around nutrient and sediment pollution, become a driver for investment in assets and technologies to protect waterways and bays from urban stormwater. Bioretention swales, wetlands and raingardens are examples of this and their inclusion in the urban design of residential developments in the early 1990s has been referred to as Water Sensitive Urban Design (WSUD).

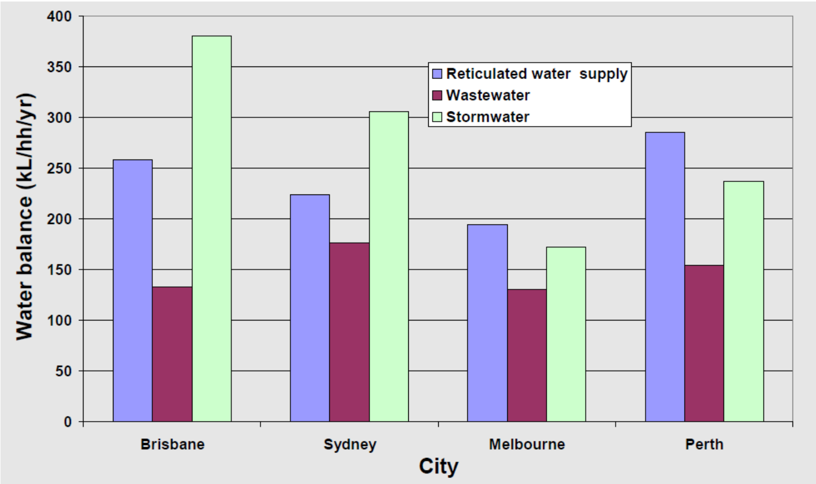
Drought conditions in many parts of Australia since the mid to late 1990's have focused Australian governments on the emerging challenge of securing reliable water supplies for urban areas. In addition to major initiatives promoting water conservation and water efficiency, stormwater harvesting has gained prominence as an alternative water source, supported by increased government funding for stormwater harvesting schemes (Wong *et al.*, 2013).

Over the last decade or more, WSUD solutions have been an increasingly accepted and adopted practice. During this time, there has also been recognition that many of these solutions can offer multiple benefits beyond water quality protection and provision of alternative water supply. These benefits can be city-wide due to the diffuse nature of urban stormwater.

1. *The quantum of stormwater resource in Australia and impact and potential of optimal management practices in areas of flooding, environmental impacts, waterway management and water resource planning.*

Urban stormwater generated across the hard surfaces of a city is often of a similar magnitude to the city's water demand.

Over time, Australian cities have evolved to rely almost singularly on reticulated mains water sourced from dams within forested, inland catchments. During dry periods, these dams have come under considerable supply stress. It is now well understood that, for many Australian cities, the quantity of urban stormwater generated across the impervious surfaces is of a similar magnitude, and sometimes exceeds, the reticulated mains water demand for that city (PMSEIC, 2007).



Average annual water balance from households (Brisbane, Sydney, Melbourne, Perth)(PMSEIC, 2007)

Urban stormwater treatment and harvesting represents a significant opportunity to provide a major new water source for use by cities, while simultaneously helping to protect valuable waterways from excessive pollution and ecosystem degradation (PMSEIC, 2007). The opportunities to realise this potential vary from city to city and are dependent on the seasonal variability of rainfall and corresponding demands for alternative water supply; and the availability of cost-effective storages.

Stormwater runoff has significant impacts on stream ecosystem health. Altered flow regimes and poor water quality, as a result of stormwater runoff from impervious surfaces, can render other restoration efforts ineffective.

There is now substantial research from around the world to show that as soon as urban streams receive stormwater runoff from impervious areas making up more than a few percent of the catchment, the stream ecosystem will be significantly degraded (Wong *et al., 2013*). There is also a growing body of literature demonstrating that increasing channel complexity and riparian vegetation cover has little or no effect on in-stream ecological structure and function if catchment-scale stressors remain limiting (Wong *et al.*, 2013). In undeveloped catchments and those with very low levels of direct stormwater input, the highest priority is thus to use planning controls to deliver the flow regime and water quality necessary to prevent the impacts of urbanisation (Wong *et al.*, 2013).

Stormwater harvesting combined with filtration, infiltration and irrigation can reduce runoff volumes for the vast majority of storm events to close to pre-development levels whilst also helping to restore baseflows, return natural soil moisture levels to urban landscapes and maintain water quality. Capturing and storing rainwater and /or stormwater for subsequent passive irrigation reduces runoff volumes and increases the amount of time that it takes for stormwater to reach stream channels, thereby reducing the peakiness of flows. Directing rainwater and/or stormwater into raingardens for passive irrigation can also support this outcome. In addition, stormwater treatment and harvesting systems can reduce stormwater pollutant loads and concentrations to levels appropriate for the protection of local receiving waters and downstream estuaries and bays (Wong *et al.*, 2013).

Infiltration systems located throughout the catchment, including in the riparian zone, can help to restore ecosystem functions and can contribute to stream health and public amenity. A healthy riparian zone can also help maintain floodplain engagement, reduce channel incision and maintain geomorphic stability (Wong *et al.*, 2013).

Distributed stormwater systems are most effective in protecting urban ecosystems because they help to retain pollutants within the catchment, restore base flows and provide cooling benefits, thereby achieving multiple objectives. Connecting distributed green spaces with green (vegetated) and blue (waterway) corridors also provide opportunities for the safe attenuation of flood waters through urban environments (Wong *et al.*, 2013).

Water Sensitive City infrastructure can also have a positive impact on flood risk.

In a Water Sensitive City, stormwater flow is conveyed through a network of green and blue corridors of open spaces and productive landscapes that also detain flood water for protection of downstream communities (Wong *et al.*, 2013).

Synergistic integration between the extant knowledge on WSUD together with resilience concepts, can lead to the establishment of a new model for Water Sensitive Cities which are intrinsically resilient to floods and droughts. Similarly, dealing with flooding and drought in a wise manner, can simultaneously optimise the use of all kinds of available resources and maximise the many benefits that may accrue due to the co-management of water and urban environments (Rodriguez *et al.*, 2014).

In combination with stormwater harvesting and retention in the catchment, other technologies such as riparian ‘sponges’ can be constructed to retain and filter stormwater within riparian zones, restoring both baseflows and denitrification processes in riparian soils (Klocker et al., 2009). The riparian zone also provides space to detain floodwaters along the system, reducing erosion within the channel and reducing the size of flood peaks. A demonstration of the implementation of this approach is the rehabilitation of Gum Scrub Creek and its riparian corridor with a series of ‘ecological sponges’ within the recent greenfield development at Officer, east of Melbourne.

CRC for Water Sensitive Cities Demonstration Project | Officer

An exploration and demonstration of how water sensitive knowledge, tools and technologies can be applied to urban development projects in Australia through Places Victoria's Officer development in Melbourne.

Officer is a 340 ha greenfield urban development site located in Melbourne's south-east growth corridor, approximately 50 kilometres south-east of central Melbourne. The 10-15 year project will ultimately incorporate homes for approximately 15,000 people and employment opportunities for approximately 5,000 people. As a CRC for Water Sensitive Cities precinct-scale demonstration project, the 30 hectare Officer Town Centre and adjacent Gum Scrub Creek corridor represented opportunities for the exploration, adaptation and implementation of water-sensitive knowledge and green-infrastructure initiatives.

Gum Scrub Creek was a degraded agricultural drain. It's transformation to an engaging and multi-functional urban waterway and biodiversity corridor provided opportunities to test and provide proof-of-concept for urban design and green-infrastructure initiatives for managing the negative impacts of urban stormwater on stream-health in ways which respond to the local environmental context and enhance the urban environment.

Extension of the waterway corridor, up into the urban areas, enabled (i) a reduction in the length and maximum depth of underground stormwater pipes – particularly important in developments on relatively flat sites, (ii) passive treatment of stormwater prior to it entering Gum Scrub Creek, and (iii) opportunities to redefine and re-orientate residential lots and dwellings toward this green space (to leverage economic and social benefits associated with proximity and access).

This pilot application of bio-sponges (an urban interpretation of the Koo-Wee-Rup swamp which extended across this area prior to its clearing and draining for agricultural uses) demonstrated how the impacts of stormwater on the in-stream health of local waterways might be mitigated. Bio-sponges are vegetated stormwater filters integrated with the urban landscape. They incorporate dense plantings of endemic sedges and shrubs (Melaleuca) in a high infiltration soil surrounded by a low bund that encourages temporary storage, evapotranspiration and infiltration (although the latter is limited in the clay soils of Officer) prior to the slow release to the local waterway via sub-surface flow. More widespread application of bio-sponges at Officer (representing 5-8% of the developments impervious area) would reduce flow volume, sediments and nutrients to levels approaching that of a natural catchment with significant benefits to the in-stream health of local waterways.

Future urban water infrastructure will harvest and recycle an integrated mix of water sources (including catchment water, stormwater, wastewater, greywater and seawater), bounded by principles such as minimising ecological footprints, through a more flexible combination of centralised and decentralised systems.

A more complex systems approach to urban water management will enable a more sophisticated suite of social and ecosystem services such as water supply security, flood management, water quality protection of waterways, urban heat mitigation, enhanced biodiversity, amenity, social cohesion, catchment repair and overall improved system resilience – or coping capacity for future uncertainties.

Stormwater provides an additional and abundant source of water to support the greening of cities, which in turn provides benefits through the creation of more liveable and resilient urban environments, including:

- improved human thermal comfort to reduce heat related stress and mortality;
- decreased total stormwater runoff and improved flow regimes (more natural high-flows and low-flows) for urban waterways;
- sustaining a healthy waterway through maintaining ecological complexity and channel stability;
- productive vegetation and increased carbon sequestration;
- improved air quality through deposition; and
- improved amenity of the landscape.

2. The role of scientific advances in improving stormwater management outcomes and integrating these into policy at all levels of government to unlock the full suite of economic benefits;

3. The role of stormwater as a positive contributor to resilient and desirable communities into the future, including 'public good' and productivity outcomes;

Responses to both Terms of Reference points 2 & 3 are combined below.

Several approaches to managing and using water more effectively and comprehensively are documented worldwide and the once contradictory vision that flood risk, water stress management and other uses of water have to be managed separately is being replaced by an integrated view that now sees the water cycle as a coherent and many faceted system to be utilised in harmony by humans and ecosystems (Rodriguez *et al.*, 2014).

As mentioned in the previous section of this submission, stormwater harvesting ultimately provides an additional and abundant source of water to support the greening of cities (Walsh et al., 2012). Green infrastructure provides benefits by creating more liveable and resilient urban environments. Water sensitive planning and design of urban stormwater systems can facilitate the creation of attractive public spaces that promote social engagement and cultural expression involving the water environment.

Technologies and supporting research now exist to substantially reduce the impact of stormwater on local waterways, while providing other beneficial outcomes to surrounding landscapes.

Technologies and supporting research now exist to substantially reduce the impact of stormwater on local waterways, while providing other beneficial outcomes to surrounding landscapes. Ongoing advancements in technological and architectural design of green, passive ecological landscape systems for stormwater management will further deliver positive outcomes towards transforming Australian cities and towns into more sustainable, resilient and liveable water sensitive cities.

A suite of water sensitive urban design tools developed by the CRCWSC, including for stormwater quality improvement and harvesting, allow us to reduce the impacts of urbanisation and support integration of many stormwater-based green infrastructure into urban landscapes and buildings.

Notions such as 'liveability' are emerging as common narratives for city planning. Research has been, and will continue to be, vital in order to characterise and define the benefits and advantages of urban water management; to make them useful for framing and shaping investment in, and design of, urban water systems into the future.

The economic benefits of innovation in stormwater management are poorly and narrowly defined. The notion of 'liveability' has wide ranging connections to the economy of a city and it is necessary to have these benefits, many of which are non-market benefits, understood and quantified.

Research indicates that there is a hedonic **property price value** associated with proximity to natural systems (Tapsuwan et al, 2007). Research by CRCWSC has indicated that this is also the case for WSUD infrastructure, including rainwater tanks, raingardens and stream restoration or 'living streams'.

A hedonic house price analysis in Perth suggests there is a premium of up to AU$18,000 built into the sale prices of houses with tanks installed. The premium is likely to be greater than the costs of installation, even allowing for the cost of time that home owners must devote to research, purchase and installation. The policy implication is that government need not rely on financial incentives for installation of rainwater tanks, but instead use information provision as their main mechanism for promoting uptake (Zhang et al, 2015).

In many locations, work is under way to restore urban drains and create fully functioning wetland ecosystems and 'living streams'. Restoration work involves substantial costs, and if Water Sensitive Urban Design concepts, such as the creation of living streams, are to be widely adopted it is important to show that the benefits from restoration are greater than the costs. Recent research involving a Perth-based case study has shown that eight years after a restoration project the median home within 200 m of the restoration had increased in value by an additional $17,000 to $26,000. If the estimated benefit across all homes within 200 m of the restoration project is summed the amenity benefits capitalised into local homes is many times the cost of the restoration project (Fogarty et al, 2015).

The health costs related to the effects of **urban heat** on community morbidity and mortality can be broadly quantified. A study by Monash University in partnership with the National Climate Change Adaptation Research Facility (NCCARF) has identified threshold temperatures above which mortality and morbidity increases in all Australian capital cities. The reduction in surface and air temperature attributed to WSUD and green infrastructure can be broadly extrapolated to corresponding reductions in community morbidity and mortality, and associated costs of health care.

System resilience has intrinsic economic value that could be quantified through a combination of real option analysis for water security, flood management and aquatic ecosystem health in combination with scenario modelling. The latter being the comparison of overall system performance and recovery (and consequential costs) between a business-as-usual system configuration and that of the new paradigm under a number of future scenarios of system shocks.

There are other economic benefits that are widely acknowledged as being positive but difficult to monetise. These include increased **biodiversity** and **ecological health** of the aquatic ecosystem, improved **physiological health** and recovery of people that are more connected with green space and being more physical active (such as walking through green corridors in their suburbs).

The current economic value of stormwater is too narrowly defined. The full suite of economic benefits needs to include a value applied to externalities and accounting for hedonic value. There is a business case when resources are integrated and infrastructure delivers multiple benefits; investment is now required to reformulate economic valuation frameworks to facilitate this transition to more liveable, sustainable and resilient cities.

Historically, investment decisions have generally been based on water conceptualised as an undifferentiated commodity. This has been underpinned by a reductionist economic valuation approach, with a small number of benefits and beneficiaries included for project viability assessments. Such valuations have been largely financial rather than economic and they have not served us well. This legacy has contributed to our current state of institutional and system fragmentation; leaving us ill prepared to meet the challenges of sustainability and resilience in our urban water systems in the face of diminishing resources and environmental assimilative capacity. Responding to the critical water supply shortages and acute flood events during the last decade has highlighted the fundamental limitation of the traditional calculus of both value and risk across all levels of urban water infrastructure investment decision making. Critical to addressing this challenge is a clear acknowledgement and better understanding of the non-market costs and benefits (values) related to alternative approaches such as, decentralised stormwater harvesting, the role of green corridors for stormwater treatment and safe detention and conveyance of floodwater, creation of community amenities associated with these ecological stormwater landscapes, and contingency planning activities.

The concept that 'our cities are water supply catchments' necessarily reframes what our water governance arrangements could look like. There are great opportunities for cities to harness the full potential of wastewater and stormwater emanating from our cities to reduce their dependency on externally sourced water, including desalination of seawater.

The Changing Role of the Urban Water Sector

The changing role of the urban water sector is highly likely to see the emergence of a new type of water retailer, operating at a highly decentralised scale and a consequential reworking of city water-based governance arrangements more broadly. There have been a number of 'minor' water retailer licences issued to local government organisations in the greater city of Adelaide owing to the significant expansion of aquifer storage and recovery schemes around stormwater harvesting. The recent establishment of the company Flow System based in Sydney is worthy of a special mention. This company is delivering an integrated urban water cycle management solution at the precinct-scale. Their Central Park project is a good example of the creation of a precinct-scale water retailer Central Park Water who will own, operate and maintain all water related infrastructure (including its green infrastructure) within this 5.8 hectares development; effectively taking over the management of the water cycle within the precinct and servicing 5,000 residents and more than 15,000 workers and visitors daily. Water will come from seven sources, combining on-site rainwater and stormwater harvesting, wastewater recycling, collection of groundwater seepage from basement drainage with sewer mining of public sewers and water supply from Sydney Water mains. Central Park Water will bill customers directly and is subject to the same licensing requirements as Sydney Water. There is clearly a business case when resources are integrated and infrastructure delivers multiple benefits; the entrepreneurs' have identified this, and now it is time for governments to invest in reformulating their economic valuation frameworks to facilitate this transition to more liveable, sustainable and resilient cities.

4. Model frameworks to develop economic and policy incentives for stormwater management;

Discussion on the inadequacies of current economic frameworks for assessing urban water management, including that of stormwater, has been covered in a previous section in this submission. The model framework for better, more integrated, urban water governance goes hand-in-hand with the requirement for a more robust economic valuation framework. There is a need to readjust the socio-institutional framework for urban water management in the 21st century. This is the century where the earth's natural resources are reaching or exceeding ecosystem services capacity to support a growing global population. Australian communities are a microcosm of these challenges.

Advances in understanding effective governance frameworks are crucial in order to ensure that policy does reflect the latest scientific research outcomes.

The CRCWSC, through a specific research program, is examining the socio-technical dimensions of contemporary urban water management, including organisations and professionals, citizens and communities, and socially constructed rules and structures, to deliver knowledge, tools and strategies that help cities and towns advance water sensitive technologies and practice. These endeavors are in their infancy. Ongoing government support and receptivity to urban water governance reform is essential to achieving the expected outcomes.

5. Model land use planning and building controls to maximise benefits and minimise impacts in both new and legacy situations;

Best practice stormwater management can be applied at a range of scales. The adopted configuration of allotment, precinct and regional scale measures will often reflect the opportunities and constraints of the development project, it's governance structure for ongoing operation and maintenance, and the range of benefits derived from such practices. A land use planning and building control model that facilitates flexible delivery of best practice stormwater management is desirable. A stormwater offset scheme developed for the Association of Bayside Municipality (ABM, 2004) in Melbourne, provides significant flexibility for developers to meet their obligation in stormwater quality control for the protection of Port Phillip Bay. The scheme involved participation of the regional water authority Melbourne Water, local councils and the developers and provided the opportunity for developers to contribute towards Melbourne Water's regional stormwater wetlands in lieu of meeting all of its stormwater quality treatment obligations through on-site works. A similar scheme is currently being considered by Blacktown City Council in Sydney.

Support for improving the approach to, and business case for, infill development is important to maximise benefits and minimise impacts with regard to urban water management.

The National Housing Supply Council, in its 2nd State of Supply report, notes that in Perth, South East Queensland and Melbourne by 2030 an additional 1.68 million dwellings are required - and states a target that 875,000 of these will be infill dwellings. A significant shift from amenities focused around private open spaces to a focus on public spaces will result and the role of water in defining the quality of public spaces will become more prominent. Stormwater management for green infrastructure will play a significant role in creating high quality public realms.

Increased urban densities offer synergies in integrated decentralized water management innovations. For example, stormwater harvesting could be cost-effectively harvested at a precinct-scale and returned to individual dwellings for non-potable uses. Such precinct-scale stormwater harvesting schemes are associated with the public realm that also provides for connected green corridors for flood detention and conveyance of runoff from high intensity storm events. Increased urban densities also present opportunities for local sewage recycling and decentralized energy production, where the waste heat from energy production could be used to disinfect recycled sewage, as well as harvested stormwater, to produce hot water that is reticulated to individual homes.

The CRCWSC is working towards developing an urban infill development design, planning and implementation toolkit. The toolkit aims to guide innovative urban water management practices in infill development scenarios in order to mitigate the negative impacts of stormwater run-off, promote and enhance micro-climate environments and mitigate urban heat island impacts.

6. Funding models and incentives to support strategic planning and investment in desirable stormwater management, including local prioritisation

Many developed cities are often encumbered by 'path-dependent lock-in' owing to institutional legacies which limit the range of acceptable solutions and interventions to allow only those that would fit into the existing institutional paradigm.

Many solutions are directed at simply improving the efficiency of the urban water system owing to significant weight given to the 'sunk cost' associated with the legacy of past decisions. Yet in so doing, we limit the diversity of solutions that are so important in facilitating future resilience of our water system to future climatic extremes. Managing stormwater as a resource is one such example of the impediment caused by institutional lock-in to 20^{th} century paradigm that stormwater is a hazard that should be rapidly conveyed to the waterways of our cities. Its management is not in the remit of the majority of water utilities in Australia, and is largely the responsibility of local government. There are very few incentives for water authorities/utilities to co-develop water resource management strategies with local government, and local governments have limited resources and jurisdictional role in delivering public space strategies around the cleansing of stormwater and managing it as a resource.

Learning through experimentation and demonstration of stormwater management innovations and associated co-governance arrangements is important for breaking out of this path dependent lock-in. This requires investment of seed funding to enable water utilities, local government and other organisations to work together in new ways for implementing water sensitive solutions.

At the strategic planning scale, partnerships between governments, research institutions, government business enterprises and the private sector are necessary to deliver the macro-economic reform necessary for transforming Australian cities and towns into water sensitive cities. Funding for the development of whole-of-government responses to this issue is necessary to facilitate coordinated and aligned action across multiple organisations for the ongoing successful implementation of water sensitive cities and the implementation of water sensitive approaches and technologies.

Dedicated and transparent funding for stormwater management is a desirable model for local government to harness the full potential of stormwater in delivering multiple benefits to communities.

Prioritising liveability outcomes as one of the central goals of stormwater management necessarily means understanding the needs and values of local communities. Water sensitive stormwater management requires development of strategies that are not only sensitive to the built environment, but also sensitive to the local community context, including landscape preferences, cultural identity and social connections. It is therefore important that funding is available to support community participation in envisioning and strategic planning activities to ensure the values and aspirations held by people living and working in a local area can be made explicit for guiding investment planning and decision-making on stormwater management strategies.

7. Asset management and operations to encourage efficient investments and longevity of benefit;

Green infrastructure for stormwater management is infrastructure fundamental to effective water services in cities and towns. This is not widely recognized amongst the majority of local governments who currently have responsibilities for stormwater management (drainage). This is because the existing underground stormwater pipe system has the appearance of being of low maintenance notwithstanding the fact that the existing approach to drainage causes environmental pollution and the resulting loss of a valuable water resource. The business case for maintaining green infrastructure for stormwater drainage is weak when compared to the conventional system of stormwater pipes; as a consequence maintenance of green infrastructure is often not supported by local governments. Unless the notion of stormwater management for multiple community benefits is embraced across institutional jurisdictions, stormwater asset management and operations will remain poorly funded and many of these benefits will not be realized.

In New South Wales municipalities, there is now provision for local government to levy a charge for stormwater management, however these may be largely directed at capital works.

In Western Australia, stormwater management of main drains by the Water Corporation is entirely devoted to the single objective of drainage; resulting in waterways that are virtually devoid of any ecological and amenity values. This is despite substantial funding resources available for a more water sensitive approach to waterway/drainage management.

In South Australia's metropolitan areas, stormwater is recognized as a significant resources with construction of 'water factories' around constructed wetlands for stormwater treatment and subsequent injection into underlying aquifers for storage in a process referred to as Aquifer Storage and Recovery (ASR). There is a clear recognition in this case that wetlands for stormwater treatment are infrastructure associated with the water factories and the relevant councils have given due asset management and operational attention to these green infrastructure.

There needs to be a financial commitment for maintenance and operation of green infrastructure.

With the exception of the ASR schemes prevalent in SA municipalities, maintenance of green infrastructure is poorly supported. WSUD and green infrastructure must be part of regular asset registers with appropriate maintenance budgets allocated. Regulation (such as EPA licensing) would help to ensure systems are maintained, bringing the importance of contemporary stormwater management to the fore.

To date, maintenance of WSUD assets has been inconsistent. In many cases, corrective maintenance works to rectify poorly designed or constructed systems has been considered part of the ongoing/annual maintenance requirements – making maintenance budget requirements seem excessive. A clear distinction between planned and corrective maintenance must be demonstrated and communicated.

8. The role of innovation in supporting desirable outcomes and transparent decision making, including access to information and novel technologies for planning, design and implementation

Stormwater management in cities of the future will be different from the conventional approach and current design practices are changing, albeit hampered by existing design standards and administrative/governance frameworks.

The evidence from research and case studies on the merit of a water sensitive urban design approach to stormwater management is compelling and innovation in design and practice is now needed to mainstream this approach.

Innovation in design and practice in stormwater management will come from both the private sector (design and construction innovation) and the public sector (enabling policies, integrated initiatives across government agencies and departments, planning approvals, regulatory reform etc).

Innovation in design and practice will be supported by partnerships with research institutions to establish ready adoption pathways of new methods and novel technologies for planning, design and implementation of WSUD. Evidence-based, and thus transparent, policy making by governments and government agencies is fundamental to good governance, and science-policy partnerships between governments and research institution will greatly strengthen the agility and rigour of enabling policies for widespread adoption of water sensitive urban design.

9. In conclusion…

Traditional stormwater management has focused on efficient drainage and flood management with more recent history seeing a focus on water quality for the protection of receiving waters as well as the use of stormwater as an alternative water source. Stormwater runoff has significant impacts on stream ecosystem health, causing altered flow regimes and poor water quality that can render other restoration efforts ineffective.

Technologies and supporting research now exist to substantially reduce the impact of stormwater on local waterways, while providing other beneficial outcomes to surrounding landscapes. Notions such as 'liveability' are emerging as common narratives for Australian cities and towns. There is a ongoing need to characterise and define 'liveability', and the contributions of best practice stormwater management in realising these 'liveability' benefits. In so doing, there will be a clearly defined framework for shaping investment in, and design of, urban water systems.

The evidence from research and case studies, on the merits of a water sensitive urban design approach to stormwater management, is compelling and innovation in design and practice is now needed to mainstream this approach. There also needs to be financial commitment for the maintenance and operation of green infrastructure.

The current economic value of stormwater is too narrowly defined and is the key impediment to innovative water sensitive stormwater management practices that can fully realise the potential of stormwater in delivering a sustainable and resilient urban water system that underpins urban liveability. The full suite of economic benefits of stormwater as a resource needs to include a value applied to externalities and accounting for hedonic value. Examples from within Australia case studies and research show there is a business case when resources are integrated and infrastructure delivers multiple benefits; investment is now required to reformulate economic valuation frameworks to facilitate this transition to more liveable, sustainable and resilient cities.

Advances in understanding effective governance frameworks are also crucial in order to ensure that policy does reflect the latest scientific research outcomes.

Evidence-based, and thus transparent, policy making is fundamental to good governance, and science-policy partnerships between governments and research institution will greatly strengthen the agility and rigour of enabling policies for widespread adoption of water sensitive urban design.

10.References

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