

Report for Conservation SA

# Water for greening in metropolitan Adelaide

June 2021

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Photo Cover: Marcus Wallis, unsplash.com

Revision	Revision Details	Author	Approved by	Date Approved
V1		J. Marchant	M. Siebentritt	30 <sup>th</sup> August 2020
V2		J. Marchant	M. Siebentritt	5 <sup>th</sup> October 2020

# Executive Summary

The importance of greenery to human health and well-being, urban cooling and ecosystem services is well documented (1). The greater Adelaide region is experiencing accelerated loss of urban greenery (2). Much of this loss is occurring in the private realm and is a result of population increase and urban consolidation (2). This discussion piece explores methods of increasing the quality and quantity of greenspace and green infrastructure across both the private and public realm in the greater Adelaide region. Further themes, raised in this piece is the recognition of the importance of water to sustain greenspace in a drying climate and the impact of climate change on greening needs and water availability and water quality.

In developing this project, input was sought from water and sustainability professionals across state government, SA Water, councils, research bodies, private enterprise and advocacy organisations. Information gained through stakeholder interviews and a stakeholder workshop form the basis for this discussion piece. Desktop research and the inclusion of information from relevant government and peer reviewed sources has complemented the insight gained through stakeholder interviews and the stakeholder workshop.

The aim of this discussion piece is to examine the causes of the loss of greenspace and the drivers that will encourage greater greening across the city. Findings from this research indicate that enablers of urban greening are complex. There is a lack of research in determining greening standards and the quantity of water required to maintain minimum greening standards across the year. Whilst there are a number of strategies that aim for increased greening through tree canopy cover and open space targets, a minimum greening standard is yet to be set. Instead greening initiatives focus primarily on public open space and primarily utilise incentive schemes to encourage the establishment of green infrastructure.

The pricing of water in South Australia varies depending on the water source, water quality and the amount of water used. Mains supply water pricing effectively punishes large consumers of water. Some councils are impacted by mains supply pricing and are discouraged from further greening as a result of high water use charges. The volume of water required to green assets is multifaceted. Different assets require different irrigation and watering needs. In determining the amount of water required for different assets, a number of assumptions have been made, due to the limited amount of research in this field. This report found that 21.25 GL of water may be required on an annual basis across both the public and private realm to maintain a low to medium standard of key asset greening across the greater Adelaide region. To maintain a high standard of greening, up to 42.5 GL may be required.

This discussion piece suggests that water delivery and greening projects are considered under a costs benefits analyses scenario during the project design and planning stages. Through this means, the non-market and market benefits of a project can be compared against the capital and ongoing costs. The value of greenspace and water infrastructure projects that lead to better quality greening outcomes are too often valued from a costs only perspective. The incorporation of systems thinking, life cycle analysis and circular economy principles are needed when assessing the value of a project that has significant social, cultural and environmental benefits.

Another focus on this discussion piece is to explore the impact of climate change on greening needs i.e. irrigation, and whether Adelaide is well placed to access fit for purpose water for irrigation. The quality of water for greening needs is variable, however, there is a large supply of treated recycled water that can be accessed to irrigate urban greenery. Mains supply water is likely to increasingly be sourced from the Port Stanvac desalination plant, whilst water sourced from Adelaide Hills reservoirs, stormwater and the Murray River will decline.

Suggested priorities for the future include urban planning reforms to ensure the quality of greenery increases in the private realm and that minimum standards are increased. The use of a costs benefits analysis for all large scale infrastructure projects and the creation of a greening standard are required.

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# 1 Introduction

Green space within our cities is under threat. The movement of people from rural to urban environments is increasing. Currently, 55% of the world's population live in cities (3). By the year 2050, this figure is expected to have increased to 68% (3). To house more people, cities have grown and consolidated (4).

85% of new housing in metropolitan Adelaide will be urban infill, that is, housing built in existing urban areas (5). This has and will continue to increase the prevalence of land subdivision and the demand for space, leading to a decrease in allotment size and an increase in the footprint of dwellings on the landscape. Ultimately, for many, this is leading to the loss of the urban front and back yard. Residents are increasingly reliant on public open space as a source of green space and contact with nature.

Green spaces are important on many levels. For humans they provide amenity, a place for recreation and physical and mental well-being (6). Animals live in green space (6). The cooling effect of shade and vegetation helps to buffer cities from the effects of heat (6). Vegetation within green spaces are carbon sinks and provide oxygen for people and animals (7).

Whilst the benefits of green space for people, flora and fauna are well documented, there is a lack of analysis to assess the current and future benefits of greenspace. Infrastructure projects that deliver water to allow for greenery, are often only viewed from the perspective of capital costs and ongoing maintenance costs (8) (9). The benefits that the infrastructure provides is too often not considered in the project scope or development. Therefore, economists and decision makers may not recognise the benefits of a project that creates or enhances green space. Without recognition of the values that green space provide within an urban environment, green spaces are under threat.

The water required to create green spaces is considerable. This coupled with the impacts of climate change places further demands on irrigation to maintain greenery (10). The impact of climate change is already being experienced with a recorded 11% decline in April to October rainfall across south-eastern Australia since the late 1990s and a decrease in stream flow (11).

This report investigates the role of policy, water pricing and water sources in determining watering regimes in both the public and private realm in Adelaide, South Australia. In assessing these factors, the report also considers the influence of climate change on watering requirements and the need to determine the drivers of water use in South Australia.

The loss of green space in Adelaide is key to framing this report. With a decline in the quality of green space and a loss of open space in the private realm, it is important that measures are put in place to support the implementation and delivery of water to greenery in order to create high quality greenspace.

How much water is required to green Adelaide? How can we better capture, store and use water to green our neighbourhoods?

## 2 Methodology

Information included in this report has been sourced through a variety of means. Interviews were conducted with stakeholders from across local and state government, research institutions and private industry. Interviews were designed to access information from a variety of specialist fields and to view the same issues from a variety of perspectives. Following the completion of interviews, desktop research was undertaken to contextualise information gained through the interview process. An online workshop further provided relevant stakeholders an opportunity to respond to information obtained through the interviews and initial stages of desktop research. Information gathered through a combination of the aforementioned primary and secondary sources informed the findings and recommendations of this discussion piece.

### 2.1 Stakeholder interviews

Interviews were sought from identified key stakeholders working in the water regulation, water research, sustainability, policy and water management fields in South Australia. Interview questions related to the use of water for greening purposes, the impact of pricing and climate change on water use and water policy in South Australia. All interviewees were asked the same seven questions (provided below). Due to the restrictions associated with the COVID-19 pandemic, interviews were conducted via phone call or via video conferencing platforms. Interviewees only provided comment on questions they felt comfortable answering.

The following questions were asked during stakeholder interviews:

- How much water is required for greening key assets in the greater Adelaide area?
- What are the potential sources, costs and quality of water for greening in the greater Adelaide area?
- What is the potential role of life cycle analysis, systems thinking and circular economy principles in supporting future policy development?
- What is the potential impact of climate change on the availability of water and greening needs?
- What policy changes, including pricing, could encourage a different approach to water use for greening in Adelaide and how does this align to the policy agenda of DEW and DIT?
- What would be the effect of a water price increase of 20% on the greening of spaces through irrigation?
- What would be the effect of a water price reduction of 20% on the greening of spaces through irrigation?

**Table 1. Stakeholder interviews were conducted with identified water management leaders in South Australia**

Organisation	Name	Title	Date of interview
SA Water	Greg Ingleton	Business Development Manager – Environmental Opportunities	7 <sup>th</sup> May 2020
Department of Environment and Water	Hannah Ellyard	Principal Policy Officer, Water Industry Act	12 <sup>th</sup> May 2020
	Tom Carrangis	Manager, Water Science	12 <sup>th</sup> May 2020
	Martin Allen	Principal Policy Officer	12 <sup>th</sup> May 2020
Goyder Institute for Water Research	Kane Aldridge	Director	12 <sup>th</sup> May 2020
City of Marion	Glynn Ricketts	Water Resources Coordinator	12 <sup>th</sup> May 2020
	Rebecca Neumann	Senior Environmental Planner	12 <sup>th</sup> May 2020
City of Salisbury	Bruce Naumann	Manager Salisbury Water	12 <sup>th</sup> May 2020
City of Adelaide	Belinda Dohring	Senior Sustainability Consultant	13 <sup>th</sup> May 2020
City of Mitcham	Dr Tim Johnson	Sustainable Infrastructure Engineer	14 <sup>th</sup> May 2020
Water Sensitive SA	Melissa Bradley	Program Manager	14 <sup>th</sup> May 2020
City of West Torrens	Nicky OBroin	Sustainability Planner	15 <sup>th</sup> May 2020
Water Technology	Michael DiMatteo	Senior Environmental Engineer	15 <sup>th</sup> May 2020
	Ben Taylor	Principal Environmental Engineer	15 <sup>th</sup> May 2020
SA Health	David Cunliffe	Manager Health Determinants and Policy	19 <sup>th</sup> May 2020
Department for Infrastructure & Transport	Jennifer Slocombe	Principal Sustainability Advisor	19 <sup>th</sup> May 2020
South Australian Council of Social Services (written response)	Georgina Morris	Policy Officer	27 <sup>th</sup> May 2020
Department for Infrastructure & Transport	Alison Collins	Team Leader Strategic Research	27 <sup>th</sup> May 2020
Department of Environment and Water – Green Adelaide	Sam Phillips	Team Leader Water Projects	9 <sup>th</sup> June 2020
Department of Environment and Water – Green Adelaide	James Peters	Senior Policy Officer/Green Adelaide Transition Team	11 <sup>th</sup> June 2020

Interviews were also sought from representatives from Port Adelaide Enfield Council and The Environment Protection Authority.

## 2.2 Online workshop

18 targeted stakeholders attended a workshop hosted on the 25<sup>th</sup> June 2020, via the online meeting platform *Zoom*. Attendees consisted of interviewed stakeholders, invited guests and representatives from state and local government.

The workshop provided an opportunity to summarise the findings from the interviews and the desktop research thus far. Presentations from Dr Sayed Iftekhar (CRC Water Sensitive Cities, Griffith University) and Dr Tim Johnson (City of Mitcham) provided background information on the need to capture the future market and non-market values of water related projects and the innovative urban cooling and water sensitive urban design (WSUD) works occurring within the City of Mitcham.

Group discussions focussed on gaps in policy, the risks and opportunities presented by climate change and the need to capture non-market values when assessing future projects.

Invitations to attend the workshop were extended to a range of stakeholder groups. Unfortunately, representatives from the following organisations were unable to attend:

- City of Campbelltown
- City of Port Adelaide Enfield
- City of Tea Tree Gully
- The Goyder Institute for Water Research
- SA Health
- South Australian Council of Social Services
- Water Sensitive SA

A list of stakeholders who attended the workshop is provided below:

**Table 2. Attendees of the online *Water for Greening in Adelaide* workshop, hosted on the 25th June 2020.**

Name	Role	Organisation
Belinda Dohring	Senior Sustainability Consultant	City of Adelaide
Rebecca Neumann	Senior Environmental Planner	City of Marion
Glynn Ricketts	Water Resources Coordinator	City of Marion
Dr Tim Johnson	Sustainable Infrastructure Engineer	City of Mitcham
Ben Leonello	Project Officer Natural Environments	City of Mitcham
Mason Willis	Manager Open Space	City of Mitcham
Jenni McGlennon	Sustainability Coordinator	City of Onkaparinga
Bruce Naumann	Manager Salisbury Water	City of Salisbury
Nicky O'Broin	Sustainability Planner	City of West Torrens
Dr Sayed Iftekhhar	Environmental Economist	Cooperative Research Centre for Water Sensitive Cities
Martin Allen	Principal Policy Officer	Department of Environment and Water
Tom Carrangis	Manager, Water Science	Department of Environment and Water
Hannah Ellyard	Principal Policy Officer, Water Industry Act	Department of Environment and Water
Brenton Gear	Director – Green Adelaide	Department of Environment and Water – Green Adelaide
James Peters	Senior Policy Officer/Green Adelaide Transition Team	Department of Environment and Water – Green Adelaide
Matt Waltho	Senior Advisor, Sustainability	Department for Infrastructure & Transport
Tim Gubbin	Senior Environment Protection Officer	Environment Protection Authority
Greg Ingleton	Business Development Manager – Environmental Opportunities	SA Water

## 2.3 Desktop research

Desktop research was conducted post interviews. A horizon scan of literature relevant to the Adelaide and South Australian scenario was conducted. Information was sourced from peer-reviewed journal articles, peer-reviewed reports, government websites and reports and research bodies.

# 3 Findings

## 3.1 The importance of green space

The Clean Air and Urban Landscapes Hub define urban green space as “all the vegetated areas that occur in cities” (6). Put simply, green space covers an array of green infrastructure assets that occur within cities and towns (outlined further in Table 1).

The human need for greenspace and more broadly contact with nature and green infrastructure in cities is well documented. Many studies indicate the positive relationship between green space and human health benefits (12) (6).

The effects of climate change are predicted to place further stress on green infrastructure assets and greenspace (13) (14). At the same time, there is recognition that green infrastructure assets can help cities buffer the effects of climate change and the urban heat island effect (14). As such, it is important that green space expands across cities and continues to be managed in a manner that ensures greenery throughout the year.

The value of greenspace differs depending on the metrics used to assess the value. There is recognition that green space provides benefits beyond aesthetics and amenity. Some of the reported benefits of green space include (6):

- Physical health benefits
- Mental health and wellbeing
- Social cohesion
- Biodiversity and conservation
- Cooling and air quality
- City resilience

Under the United Nations Sustainable Development Goal (SDG) of Sustainable Cities and Communities, the following target outlines the importance of greenspace for urban communities:

“By 2030 (governments should) provide universal access to safe inclusive and accessible green and public spaces in particular for women and children, older persons and persons with disabilities” (15).

## 3.2 Green and blue space

As noted in the *Creating Greener Places for Healthy and Sustainable Communities* report, urban infill in Adelaide is expected to reduce the amount of private open space available to residents across Greater Adelaide (5).

This highlights the need to provide not just high quality public open space but high quality public green space. It can be seen that green space in Adelaide includes a range of categories (Table 1). The groups responsible for the management of green infrastructure in Adelaide include private property owners, local government, state government and the Australian Government.

Greening can refer to a range of different land use types and include various plant species and structural layers. The use of blue space (water bodies) is critical to this discussion as often spaces such as wetlands, ornamental lakes, creeks and rivers are present amongst green space. Blue space can also support cooling and ecological functions associated with green infrastructure (16). Blue space can be defined as any inland water body (16). For the purpose of this report, greening refers to vegetation in an urban and semi-urban context. It includes land managed in the public and private realm and both large and small areas. The table below (Table 1) includes a list of greenspace types identified within the greater Adelaide region.

Findings of the report, focus on the green infrastructure types that offer the greatest public benefit, either through scale or prevalence and the infrastructure types that offer the greatest improvement opportunities. This includes large open spaces, street trees and the suburban home.

**Table 1. Green space covers a variety of green infrastructure**

Green infrastructure		Description
Street Trees	 <p>Source: The Advertiser</p>	<p>Trees planted in soil either on the road verge or road medium strip. Trees are traditionally managed by councils, watered over the first few years after planting. After this time, trees rely on rainfall or roots tapping into other water sources for watering needs.</p>
Parks	 <p>Source: City of Burnside</p>	<p>Public open spaces, designed for recreation and enjoyment. In Adelaide parks are irrigated from mains supply water, captured recycled stormwater, treated wastewater and underground water.</p>
Sports grounds	 <p>Source: City of Marion</p>	<p>Large open spaces, specifically set aside for active recreational activities. These spaces may be irrigated from mains supply or alternative water supply sources.</p>
Permeable space around private residences (back yard, front yard)	 <p>Source: realestate.com.au</p>	<p>Any permeable and living space in the private realm that exists around buildings. It can include lawn, garden, bare earth, trees.</p>
Wetlands	 <p>Source: City of Marion</p>	<p>A mix of green and blue infrastructure. Wetlands are used to help retain or detain and slow water movement and can be used to treat stormwater. Wetlands are either natural features or man-made.</p>
Ponds and Lakes	 <p>Source: The Advertiser</p>	<p>In Adelaide, these areas are typically constructed for aesthetic purposes and provide multiple ecosystem services benefits.</p>
Green corridors		<p>Long and narrow pieces of vegetated land, typically containing highly vegetated land. In Adelaide found along rivers and riparian zones.</p>

<p>Swales</p>	<p>Source: Walking SA</p>  <p>Source: Ecoscape</p>	<p>Narrow areas of greenspace designed as a natural drain. Used to slow water movement, provide drainage and to treat stormwater.</p>
<p>Rain gardens</p>	 <p>Source: Water Sensitive SA</p>	<p>Garden beds that capture and treat stormwater through a soil or gravel medium. Rain gardens are incorporated into the stormwater network.</p>
<p>Green roofs</p>	 <p>Source: WeekendNotes</p>	<p>Roofs that allow for plant growth, through the addition of soil to the roofspace. Includes roof spaces with specifically designed garden beds and pots</p>
<p>Green walls</p>	 <p>Source: Flytgreen Australia</p>	<p>Vertical gardens that grow along walls. Not common in Adelaide due to difficulties with establishment and maintenance.</p>
<p>Urban agriculture</p>	 <p>Source: Campbelltown City Council</p>	<p>Food production in the urban environment. It can include commercial and community gardens.</p>
<p>National Parks</p>	 <p>Source: Walking SA</p>	<p>Adelaide has several National Parks in the urban environment and many along the urban fringe.</p>
<p>Abandoned infrastructure corridors</p>	 <p>Source: Time Out</p>	<p>Abandoned state or local government managed land. This could include vacant railway corridors and underutilised land.</p>

### 3.3 Loss of green space in Adelaide

From 2009 to 2017, South Australia recorded an increase in hard surfaces of 2.57% and a tree canopy cover loss of 1.92% (2). South Australian (SA) councils record a minor or major loss of urban tree canopy cover from 2009 to 2017, with 43% of SA urban councils experiencing a significant loss in tree canopy cover (2). Increasing tree canopy is not an impossibility, with some councils around Australia increasing tree canopy across their city in the same 2009 – 2017 time period (2). Five of metropolitan Adelaide's local councils are included in a list of nine councils listed nationally as the most vulnerable LGAs to heat, poor health, economic disadvantage and access to green space (2). These councils are primarily centralised in the western and northern suburbs of Adelaide.

The distribution of greenery across metropolitan Adelaide is uneven (2) (17). Local government areas (LGA) in the Eastern and inner Southern areas contain a greater percentage of tree canopy cover and shrubbery cover, when compared to the western, northern and southern LGAs (2). As such, the residents of the eastern and inner southern suburbs have greater access to greenspace and the associated benefits of greenspace. Residents of other areas of Adelaide have comparably reduced access to greenspace.

Due to increased urban infill development, there is significant loss of tree canopy cover and shrubbery cover in the private realm across metropolitan Adelaide (5).

### 3.4 Water and greenery

The links between water and greenery are clear. Plants require water to survive and water is required to maintain the greenery of plants (18). However, through the investigation of this discussion piece, it is clear that there is a lack of peer reviewed research that links innovative water use and greenery in the urban setting. Much of the literature focuses on policy failures and the challenges of maintaining greenery under urban infill conditions (13) (14) (7). Alternatively, Government plans aim to encourage greening through incentives and education schemes (19) (20) (21) (22). There is a lack of a recognised "greenness" standard required to provide the benefits that the community and government wish to benefit from. There is also a lack of evidence of how much water is required to maintain an accepted minimum level of greening. This may be due to the complexity of different plant species watering requirements and variation of soil water holding capacity.

There is a need to quantify the benefits of urban greenery in order to present a business case for the development of greenspace.

Greenery not only takes many forms, it also can be categorised across a spectrum. A recognised method of quantifying "greenness" as a measure of vegetative condition, is through the Normalised Difference Vegetation Index (NDVI) (23). Aerial heat mapping of metropolitan Adelaide conducted from 2016-2018, highlighted urban heat islands across the city (24). The heat mapping utilised aerial imagery to capture heat data. The project was funded by different Adelaide climate resilience bodies (Resilient South, Adapt West, Resilient East, Adapting Northern Adelaide) in partnership with the Government of South Australia (24). Some areas of metropolitan Adelaide also recorded NDVI data as part of this mapping process (24).

NDVI is recorded as a value between -1 and 1 (23). Vegetation in Australia typically ranges from 0.1 to 0.7 (23). In order to define "greenness", it is important to determine the level of greenness required to offer the ecosystem services, urban cooling, human health and previously listed benefits that green infrastructure provide. NDVI is only one measure of greenness and NDVI can be influenced by other factors that are not correlated with irrigation requirements and greenness. It may not be the most appropriate measure of greenness and the irrigation requirements to achieve greenness. However, there is a need to define a method of determining greenness and standardising the amount of greenness that is required to deliver the required standards to maximise the environmental, economic and human health benefits of greenspace. What is an acceptable greening value for urban greenery and how do we ensure that the level of greenness is maintained throughout the year? How much water is required to ensure that the standard that we require is achieved? These are questions that need an answer in order to maintain effective levels of greenery across Adelaide.

### 3.5 Evaporative cooling of the home

The evaporation of water can draw heat from the air (25). The presence of water bodies around a home can greatly reduce the air temperature, hence the cooling effect felt by those who live close to the sea in Adelaide.

Smaller scale blue space, such as ponds, pools and fountains can increase evaporation rates and cool air before it enters a house (25). SA Water promoted the results of a 2018 trial which compared the costs of cooling a metropolitan Adelaide house through air conditioning with cooling the garden around the house using water. The trial although purely for demonstration purposes, aimed to show the heat mitigation value of water when applied to green infrastructure.

In the demonstration trial, the temperature of the air was recorded in the area near a pergola, adjacent to a house in metropolitan Adelaide over the course of 140 minutes on a hot summer evening (26). Every 30 minutes plants around the pergola were watered for one minute. A water misting system was used for 120 minutes to cool the air (26).

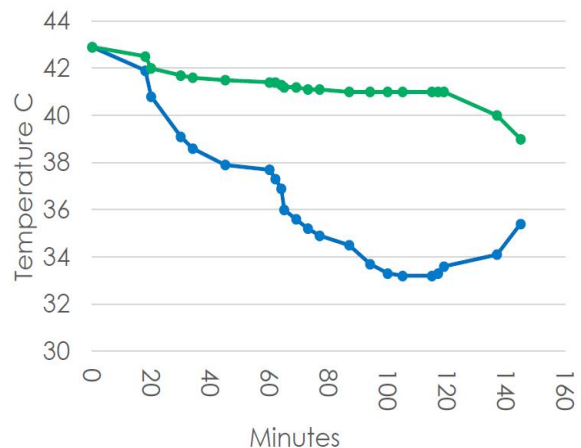
Across the course of two hours in the evening, the recorded air temperature reduced from 43° C to below 34° C (26). When watering ceased and the misting system was turned off (at the 120-minute mark), temperatures began to increase again (26). The blue line in Figure 1 represents the temperature decrease achieved through watering of the garden and using a misting system. The green line in the graph below represents the reduction in temperature without watering over the same period. It was noted that across a two-hour period, utilising 90 litres of water, the cost of water was \$0.30, this compared to 4.8 kWh of power and a cost of \$1.80 electricity for air-conditioning (26) . This trial is for demonstration purposes only and does not necessarily accurately represent the cooling benefits of water compared with air-conditioning, however it is a useful example of an alternative way to view water for localised cooling.

This example demonstrates the potential of small-scale watering to mitigate heat. It is recommended that a trial of this nature is broadened to a block/development scale to assess the benefits of water use in buffering Adelaide neighbourhoods from the effects of heat. A trial of this nature would seek to assess the financial benefit of a reduction in electricity use for homes in the trial location. What are the broader financial implications of using water to maintain greenery and mitigate heat, instead of using air conditioning in the suburban Adelaide home?

## Cooling at home



- Cooling during hot weather:
- Use misting system
  - One minute of hosing every 30 minutes



Cost comparison:

90 litres of water = \$0.30 for two hours

4.8kWh of power = \$1.80 for two hours – no other power cost included (lights etc.)

Figure 1. Utilising water and vegetation to cool the air surrounding a home (26)

### 3.6 How much water is required for greening key assets?

#### Open space

In determining the amount of water that is required to “green” environmental assets, it is important to recognise that greenery can take many forms (See Table 1). For the purpose of this discussion piece, there is a need to separate the desired open space requirements per capita from other forms of urban greenery, such as vertical gardens, rooftop gardens and indoor plants. This discussion piece is focussed on greening of large pieces of open space or smaller areas that are prevalent throughout the urban landscape, such as backyards. These assets are owned and managed either by local, state or federal government or by private entities and individuals.

Nouri *et al.* (2019) suggest that ideally cities should allocate an area of 50m<sup>2</sup> of open space per capita (27). The latest Australian Census population statistics for the Greater Adelaide region collected in the 2016 Census, quote the population of Greater Adelaide as 1,295, 714 (28). In order to meet the target of 50m<sup>2</sup> of open space per person, Adelaide requires an open space area of 64, 785, 700m<sup>2</sup> or 6,479 hectares (Ha) of open space across both the private and public realm.

Many interviewed stakeholders recognised that the greening of key assets is highly subjective, complex and has not yet been thoroughly researched (29) (30). Greening needs are dependent on many factors. The following are just some of the factors that influence the amount of water required for greening needs of vegetation:

- Species of plant and the drought tolerance of particular species
- Weather and climatic conditions
- Soil type
- The use of mulch and other measures to protect soil from evaporation, sunlight and solar radiation.
- The age of plants
- The health and vitality of individual plants
- The interaction of other factors, such as disease, pests, tolerance to salinity and other elements, soil compaction, competition for available water etc.
- The location of plants in relation to permeable and non-permeable surfaces (access to rainfall)
- Rooting depth
- The quality of water used for irrigation
- Access to sunlight and shading
- Irrigation method
- Infrastructure capacity

In order to improve efficiencies and standardise irrigation methods and timing, the State Government and SA Water developed the Code of Practice for Irrigated Public Open Space (IPOS). The code helps open space managers to better manage irrigated land and to ensure that even in drought years the impacts of low water availability can be managed (31).

Perhaps the best data available to model the greater Adelaide area comes from the Nouri *et al.* (2019) study of the Adelaide Parklands (27). This study investigated the amount of water required to maintain 10 hectares of high quality greenery in Veale Gardens, in the southern Adelaide parklands (27). In the study, the authors separate water provided by irrigation (blue water) from precipitation (green water) (27). Results from the study indicate that in order to maintain greenery, a total of 11,140 m<sup>3</sup> (11.14 ML) of water per hectare per year is required to maintain high quality green space (27). This includes precipitation and irrigation. Of this amount, a total of 6,560 m<sup>3</sup> (6.56 ML) per hectare per year, sourced through irrigation, is required to maintain the greenness of this high quality space. Based on figures gathered through this research, the authors found that 59% of the total water required for greening is from irrigation and 41% from rainwater averaged across a year. This highlights the dependency of

vegetation in Adelaide on irrigation. Irrigation use across the year, ranged from 49% in October to 67% in March. Even during the cooler months of the year (May-August), irrigation was still utilised. To compare this rate to other scenarios, the average use of water for the irrigation of vineyards in South Australia in 2008 was 2.7 ML per hectare per year (32).

It must be noted that this is a perfect scenario, where greenery is maintained to the highest standard. The authors of this study do not declare the species of turf that is watered. Warm season turf grasses can use 30-50% less water than cool season turf grasses (31). The quoted figures from the *Nouri et al.* (2019) study may not necessarily be extrapolated to other vegetation types, and it may be possible to maintain a reduced level of greenery of turf by using a greatly reduced amount of water.

If half of the *Nouri et al.* (2019) quoted irrigation requirements (6.56 ML) were applied generically to the amount of open space recommended for Adelaide (6478.57 ha), a total irrigation demand of approximately 21.25 GL would exist for greater Adelaide. There are many assumptions made as part of these calculations, however, it does provide an estimate of water required to maintain greenery across greater Adelaide throughout the year.

Greening of the environment is a complex issue. The majority of land in greater Adelaide is owned by private residents (33). For the purpose of this discussion, only public land including public schools are included in the following stated statistics.

The irrigation of vegetation in the greater Adelaide metropolitan area occurs with water obtained from the following sources:

- SA Water mains supply potable water – sourced from Adelaide Hills Reservoirs, The River Murray and the Adelaide Desalination Plant
- SA Water recycled wastewater (non-potable)
- Council operated stormwater Managed Aquifer Recharge (MAR) schemes (non-potable)
- Native groundwater (non-potable)
- A shandy mix of the above listed sources

In the greater Adelaide area there is currently between 10 and 15GL of water used for the irrigation of public spaces, including public schools (33). Water use for irrigation changes each year, depending on rainfall and the alteration of irrigation regimes (33) (8). One stakeholder estimated that there is between 40-50% of public land that is currently unirrigated (33). Many stakeholders noted the impact of the Millennium Drought on irrigation practices (8) (9). Over this time period, many public greenspaces were not irrigated or under irrigated (9) (33). Some smaller parks remain unirrigated due to the water saving measures implemented during the Millennium Drought. One stakeholder noted that since the Millennium Drought water use has dropped by up to 40GL per year (33). Consumption has returned to some degree, however, only by 5-10GL per annum (33). This is not limited to Adelaide, with declining per capita water consumption also observed in Melbourne and Perth (34).

The use of water for greening purposes, differs by council. The City of Marion use an average of 250 ML per year for greening purposes (9). This is a mix of ground water, Managed Aquifer Recharge (MAR) scheme water and potable mains water. The City of Marion also noted the decline in irrigation since the Millennium Drought. Water use for the City peaked in 2005 and 2006 at approximately 400ML per annum and has not recovered since this time (9).

This demonstrates the long-term and ongoing influence of drought on water use behaviour. Water conservation is desirable however, there is a need to ensure that greening of spaces continues and that councils increase the amount of spaces that are irrigated.

The City of Salisbury supply approximately 2.5 GL of stormwater to customers (8). Approximately 1.25GL is used to for City of Salisbury purposes, including irrigation of green space, such as sporting ovals, parks and gardens (8). This does not include the irrigation of street trees and greening of the streetscape. The City of Salisbury has a MAR licence to capture up to 5GL per year (8).

The City of Adelaide utilise potable mains water and recycled wastewater through the Glenelg to Adelaide pipeline (35). 3 GL of mains water is utilised for all purposes, whilst 400-800 ML of wastewater is used for irrigation purposes, mainly for use in the Adelaide Parklands (35). Water use alters from year to year and will change based on rainfall and monitoring of soil and ground water condition.

Water can be obtained from a number of sources in South Australia. Prior to the construction of the desalination plant, water was primarily obtained from reservoirs located in the Adelaide Hills and the Murray River. The desalination plant has reduced the reliance of Adelaide on traditional water systems. However, due to the increased ongoing costs of operating the desalination plant, water prices were expected to increase (36). SA Water is now investing in solar photovoltaic panels to power the desalination plant (36). This is part of a sustainability push to make the desalination plant carbon neutral and to reduce the ongoing costs of powering the desalination process (36).

### Household water use

A Goyder Institute report released in 2014 researching water use in owner occupier detached houses, i.e. excluding units, townhouses and apartments, found that average water use for households in Adelaide was 245 L/p/day in 2012/2013 (37). Seasonal impact was significant, ranging from 153L/p/day in winter to 498 L/p/day in summer (37).

Household outdoor water use averaged 110 L/p/day over the study period. Seasonal water use was higher for households with larger permeable outdoor areas, such as gardens and lawn (37). A study conducted in Melbourne revealed that if a city were to adopt a more consolidated urban form that water consumption would reduce by 100 GL/year by 2045 (38).

With this in mind, the challenge is to increase greening through smarter design in the private realm and increasing WSUD and irrigation of greenspaces in the public realm.

### Street Trees

Street Trees in Adelaide are managed by councils. The amount of water required to sustain a tree, is a very different prospect to the amount of water required for a street tree to thrive. There are many complexities associated with accurately quantifying the amount of water required for street trees. The factors outlined above, under the *Open Space* title, demonstrate the variables involved with calculating water demands of street trees.

In the life of a street tree, the tree is usually watered through the first few years after planting. Beyond this time, the trees are solely reliant on rainfall or watering from the adjoining residency. Typically, the land surrounding street trees are comprised of impermeable surfaces – sealed roads, kerb and gutter and footpath. This limits the area that water can enter the soil and the roots of the street tree. Approximately 15% of the footpath to footpath area is permeable in most urban environments (39). The amount of water available to a street tree is greatly reduced due to the lack of permeable surfaces surrounding the tree. A tree may only receive 75 mm of rainfall per year (39) compared to Adelaide's annual average of 536 mm.



Figure 2. A typical footpath, street verge, road, gutter and water table area only contain approximately 15% permeable surfaces (40)

The tree canopy in greater Adelaide is disproportionately spread, with high tree canopy typically concentrated throughout inner southern and eastern suburbs councils (2). However, the number of street trees in the greater Adelaide area is unknown. Many councils do not know the amount of street trees in their LGA. A 2019 audit revealed 77, 676 street trees existed within the City of Salisbury (41). The trees are spread across a distance of 1281 kilometres (inclusive of DPTI managed roads) (41) (42). That is an average of approximately 60.63 street trees per kilometre. Applying this generic assumption to the 11,416 kms\* of road network across the greater Adelaide area, we can assume there is approximately 692,232 street trees in the greater Adelaide area. Whilst the City of Salisbury, has over 1,855 hectares of roads, there is a canopy cover of approximately 22% (43). This is due to a high proportion of semi-mature and mature street trees existing within the City of Salisbury area (43). Unfortunately, many councils do not have the same proportion of semi-mature and mature trees in the City of Salisbury area.

A TREENET inlet is a WSUD device that is designed to direct stormwater from roads into the verge or nature strip (see the case study below). If each of the street trees in Adelaide were installed adjacent to a TREENET inlet or equivalent and a permeable or semi-permeable in-site retention infiltration system that could contain 500 litres at a time, there is the possibility of diverting thousands of KL of stormwater to trees across Adelaide. If we assume that each tree inlet and permeable infiltration system collects a modest figure of 2,000 litres per year to be used by the tree or stored in the soil, that would amount to 1,384,464 KL (1.384 GL) of stormwater a year diverted from the Greater Adelaide stormwater network, thus greatly reducing flood risk, nutrient and stormwater pollution into Gulf St Vincent. There are many assumptions and limitations, including limiting soil types, included in this scenario. However, it does demonstrate the need to further research the use of WSUD to increase tree canopy cover and reduce stormwater flows into Gulf St Vincent. This scenario may not be appropriate for councils that utilise MAR schemes and further research and quantification is required.

## TREENET Inlet – City of Mitcham

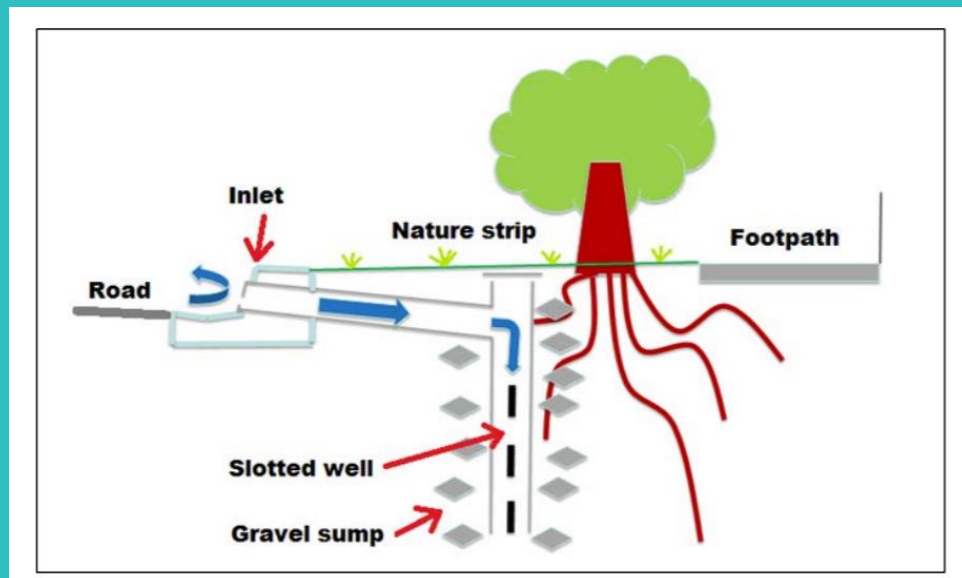
The City of Mitcham is pioneering the use of the TREENET Inlet designed by Space Down Under, (pictured below) which allows for water travelling along the street water table (gutter) to enter the soil surrounding a street tree via an inlet (39) (44).

Water from the water table is gravity fed into a plastic tube that deposits the water into a slotted vertical pipe that allows water to move from the pipe into the street verge soil (39). Water percolates into the gravel medium surrounding the vertical pipe and then into the soil of the street verge, providing a street tree with captured rainwater (39). This system captures stormwater that would otherwise be destined for the sea, and in the process provides street trees with much needed water.

Research currently being conducted indicates that trees with access to stormwater via a TREENET Inlet system have thicker canopy providing greater shade, higher rates of sap flow and create a cooler microclimate through evapotranspiration (39).



Above images: A TREENET Inlet (pictured above) designed by Space Down Under delivers water to the soil of the street verge (nature strip), providing added water supply for street trees (39).



Above image: A cross section diagram of a TREENET Inlet (44).



## Permeable Pavement – City of Mitcham

Adelaide is experiencing the loss of green space and the loss of permeable surfaces. That is, surfaces that allow water to enter the soil (45) (13). With an increase in impermeable surfaces, such as roofs, driveways, courtyards, roads and footpaths, the City of Mitcham is trialling the use of permeable pavement on some footpaths and roads within the council area (39).

Permeable pavement allows for the movement of water into the soil medium, providing street trees with additional and much needed water.

The rainwater tanks in the image below have been photoshopped into the image to demonstrate the incredible water storage capacity of soils (39). The light grey coloured paving surrounding each of the immature street trees, in the image below, is permeable pavement. Based on an average annual rainfall of 500mm, each of these street trees can access an additional 4000 litres of water per annum. This is based on the 8m<sup>2</sup> of permeable pavement surrounding the tree (39).

Capturing rainwater where it falls and utilising the water for street tree growth, diverts water from aging stormwater infrastructure networks and allows street trees to access more water throughout the year. Recent studies indicate that the use of permeable pavement allows water to percolate further into the soil medium (39). This encourages tree roots to grow deeper to access water that is deeper in the soil (39). Tree roots can cause uplifting of traditional footpath pavement types and the remediation of this is an added cost for councils.



Above image: The rainwater tanks represent the annual amount of water (4000 litres) delivered to the soil through 8m<sup>2</sup> of permeable pavement. Photograph taken 29 October 2010 (39).



**Table 3. Total length of roads across metropolitan councils in the greater Adelaide area (source: Data SA (42))**

\*Note: total length of roads includes all public and private navigable roads

Local Government Area	Total length of roads in each Council area (kms)
Adelaide	196
Burnside	325.7523995
Campbelltown	318.0030869
Charles Sturt	733.9530363
Holdfast Bay	210.6403359
Marion	639.4508585
Mitcham	634.1068672
Norwood Payneham and St Peters	238.2224718
Onkaparinga	2521.150788
Playford	1531.547328
Port Adelaide Enfield	1033.314405
Prospect	124.7602226
Salisbury	1281.756129
Tea Tree Gully	912.9624775
Unley	222.3462035
Walkerville	58.95214663
West Torrens	433.121259
<b>Total</b>	<b>11,416.18</b>

### **3.7 What is SA Water’s current pricing model and how does it allow for broader consideration of costs and benefits across the community?**

Water is often priced according to differing objectives. Typically, the service provider prices water so as to cover the costs of operating and maintaining the water delivery and water disposal service and the debt associated with the service (46). Water can also be priced so as to encourage consumers to conserve water (46). Another factor to consider in water pricing is the need to ensure that it is considered fair by the consumer and that the consumer will utilise water for essential needs, i.e. drinking, bathing etc (46).

In South Australia water pricing is complex. Pricing of water is highly political and not necessarily based on water availability or the value that water provides to the consumer or society (30) (45). Water pricing is influenced by consumer expectation (46). This can be seen in the approximate 18% price reduction of SA Water mains supply water from 2019/2020 to 2020/2021 period, as outlined in Tables 4 to 9. It can be seen that water pricing is highly variable and the cost of water seemingly does not consider the non-market benefits associated with water used for greening purposes. The SA Water website states that the state government is committed to statewide pricing and the principles outlined in the National Water Initiative (47).

The National Water Initiative Pricing Principles are (48):

- Principles for the recovery of capital expenditure
- Principles for urban water tariffs
- Principles for recovering the costs of water planning and management activities
- Pricing principles for recycled water and stormwater use

The greening of public assets, including public school grounds, arises from a variety of sources in South Australia. Mains water and wastewater are supplied by utilities company SA Water (33). The pricing of mains potable water in South Australia is set by the regulator, the Essential Services Commission of South Australia (ESCOSA) (33) (29). Water is charged according to a three tiered pricing structure for all “residential” customers (see Table 2) (49) (9). Water use charges increase as consumption increases, according to averaged quarterly thresholds. This is regardless of the location of the end water user or the distance the water has travelled to reach the end user (49) (33).

The costs and quality of water for irrigation vary depending on where the water is sourced from. Mains supply is sourced from the River Murray, the Adelaide Desalination Plant and catchments in the Adelaide Hills. Water captured in the Adelaide Hills catchments are stored in a series of reservoirs. Table 2 outlines the costs of water according to different sectors and across the three-tiered pricing structure. Non-residential water is considered water delivered to areas outside of city and town boundaries and is not residential or commercial (50). The primary use of this water is for farmland and watering of livestock (50). Commercial water use rates are for commercial properties, such as retail, including shops, shopping centres, department stores and general stores (51). Residential rates are charged to residents and other entities that do not fall into the non-residential or commercial category (9). This includes Councils (9). Due to the need, desire and expectation of the community to green public spaces, those councils that use mains supply water are charged the highest water rate of \$3.699/kL in 2019/20 and \$3.007/kL to irrigate open space assets (9) (49). Supply charges for councils’ water use is the same as other “residential” properties, charged at \$75.40 (49).

The three-tiered system effectively penalises high water consumers, who use more than 130 kL per quarter. For many, this includes councils.

At the time of writing this report the cost of SA Water mains water supply reduced for the 2020/21 FY across the tiered pricing structure by approximately 18% in response to an SA government enquiry into water pricing.

**Table 4. SA Water 2019/20 water use prices (Source: SA Water)**

Sector	Tier	Usage Charge	Price per litre	Indicative Quarterly Threshold	Daily Threshold
Residential	1	\$2.392/kL	\$0.002392	0 to 30 kL	0 to 0.3288 kL
Residential	2	\$3.413/kL	\$0.003413	30 to 130 kL	0.3288 kL to 1.4247 kL
Residential	3	\$3.699/kL	\$0.003699	Above 130kL	Above 1.4247 kL
Commercial	N/A	\$3.413/kL	\$0.003413	N/A	N/A
Non-residential	N/A	\$3.413/kL	\$0.003413	N/A	N/A

**Table 5. SA Water Residential 2020/21 water use prices (Source: SA Water)**

Sector	Tier	Usage Charge	Price per litre	Daily Threshold
Residential	1	\$1.945/kL	\$0.001945	0 to 0.3836 kL
Residential	2	\$2.775/kL	\$0.002775	0.3836 kL to 1.424 kL
Residential	3	\$3.007/kL	\$0.003007	Above 1.4247 kL
Commercial	N/A	\$2.775/kL	\$0.002775	N/A
Non-residential	N/A	\$2.775/kL	\$0.002775	N/A

**Table 6. SA Water 2019/20 water supply charge (Source: SA Water)**

Sector	Quarterly Supply charge	Minimum supply charge
Residential	Set rate of \$75.40 regardless of property location	\$75.40
Commercial	\$0.17125 per \$1000 of property value	\$75.40
Non-residential	Set rate of \$75.40 regardless of property location	\$75.40

**Table 7. SA Water 2020/21 water supply charge (Source: SA Water)**

Sector	Quarterly Supply charge	Minimum supply charge
Residential	Set rate of \$67.85 regardless of property location	\$67.85
Commercial	Set rate of \$67.85 regardless of property location	\$67.85
Non-residential	Set rate of \$67.85 regardless of property location	\$67.85

Wastewater treatment plants located at Bolivar in Adelaide's northern suburbs, Glenelg in the south-west and Christies Beach in the southern suburbs provide recycled water for the greening of public assets and irrigation for food and wine production (33). Water is transported to greenspace via a network of underground pipes and pump stations and used to irrigate public open space. Wastewater price is not subject to ESCOSA regulation and therefore SA Water determine the price of wastewater (29) (8). However, SA Water must abide by SA Health, EPA and Irrigated Public Open Space regulations and code of practice (29). Agreements are made with customers for the use of wastewater and the price is set according to volumes and location of use (33) (35). Wastewater price can be and is subsidised (8).

One stakeholder commented that SA Water offered a discount for recycled wastewater if the council were to increase their use of wastewater (35). Wastewater is treated prior to use in irrigation. It is fit for purpose water and not potable. The salinity of wastewater is typically higher than potable water (33). Salinity levels need to be monitored to ensure the water is fit for irrigation purposes (33).

Some councils have access and utilise recycled wastewater for irrigation purposes, whilst others utilise potable mains water supplied by SA Water for the majority of their irrigation needs (35) (9) (8). All councils have some form of water sensitive urban design, that helps with retention and detention of stormwater flows. Two of the interviewed council stakeholders operate Managed Aquifer Recharge (MAR) schemes (9) (8). MAR schemes allow for the collection and cleansing of stormwater through reed beds and the storage of stormwater in underground aquifers. Water collected through this means, is pumped below ground and drawn out of the aquifer throughout drier periods of the year for irrigation and other select use purposes (8). Water managed through the MAR schemes must meet certain legislative requirements, outlined by the Environmental Protection Authority (EPA) (8). Water drawn from the aquifer is typically good quality water for irrigation. It is not suitable for drinking or bathing.

**Table 8. SA Water 2019/20 Recycled Wastewater price (Source: SA Water)**

Usage Charge	Price per Litre	% of residential tier 1 price
\$2.147/kL	\$0.002147	90%

**Table 9. SA Water 2020/21 Recycled Wastewater price (Source: SA Water)**

Usage Charge	Price per Litre	% of residential tier 1 price	Quarterly rate
Subject to commercial agreement	Not stated	Not stated	\$1.751

The price for potable mains water is set by the regulator, ESCOSA (29) (33). The Water Industry Act 2012 dictates the management, including the pricing of water in South Australia (8). A state-wide price applies for potable water supply (33) (29). The statewide pricing model for potable mains water allows for South Australians to pay a standard price for potable water, regardless of the location of where people live. Pricing for residential properties is dependent on water use (See Table 4). There are limitations, and not all South Australian residences and businesses are connected to mains water supply. Costing of mains water is a means of revenue raising (29).

The price of potable and wastewater does not truly reflect the cost of water treatment and transport or the water itself. The low cost of wastewater provides a low cost, fit for purpose water option that is attractive to some councils and farmers (8). Wastewater one of the cheapest water sources for irrigation, second only to groundwater, however due to salinity issues, the quality of water is not considered to be as high as stormwater (8). MAR schemes and captured stormwater are not always price competitive as the full costs of water management and transport need to be passed on to the customer to recoup costs (8). This is not necessarily true of wastewater.

Those councils that are reliant on potable mains water are charged a premium for water for irrigation (9). Discounts are typically not applied for these large water users, and this may impact on the ability of councils to increase the amount of water they use for irrigation and increase the areas that they currently water (9). Effectively councils are not afforded the same discount rates as commercial operators and are not stimulated by price or by law to increase the amount of land they irrigate or the quantity of water supplied to smaller pieces of land, such as pocket parks.

### **3.8 What is the potential role of life cycle analysis, systems thinking and circular economy principles in supporting future policy development?**

One of the key findings from this research is the lack of accepted means of valuing water as a resource and benefits of greening associated with water use (9) (35). The benefits of greening are not captured in the design, construction or maintenance of water infrastructure and green infrastructure projects. The capital costs associated with the construction and maintenance of water sensitive urban design technology are accounted for, however the flood mitigation, watercourse management, aquatic and marine water quality benefits associated with stormwater management and to a lesser degree wastewater management are not factored into whole of life costings (35) (9). Often only the capital costs of a project are considered, whilst the long-term non-market benefits, including cooling, mental health, physical health and well-being are not considered (8) (13).

This has resulted in certain projects not being funded as the benefits associated with the project are either not fully understood, not valued or undervalued or only considered in terms of economic costs and output. This could also be said of water pricing.

An example of this, is the consideration of water from the Northern Adelaide Irrigation Scheme (NAIS). Treated wastewater could be and is utilised for use in agriculture. However, it is not known whether the water is better utilised for greening purposes across northern metropolitan Adelaide or better used as an alternative water source for agriculture due to the lack of a quantifiable and rigorous assessment to guide the best use of water in South Australia.

Stakeholders noted a need to examine the benefits of a product, technology or system and compare these to the impact of not having these systems in place (8). Other stakeholders commented that life cycle analyses were considered for some schemes and that the total costs over the entire lifecycle of an asset were considered and factored in to the cost of water (8). Whilst this may be true for some

projects, i.e. Managed Aquifer Recharge schemes and the Glenelg to Adelaide Pipeline, the establishment costs of these projects have only been possible through funding from the state and federal government (33) (35). As such, the costs recouped through water pricing are only for maintenance, operation and extension and do not for project establishment.

One of the most accepted methods of assigning non-market values to a green infrastructure project is through the use of a cost-benefit analysis (CBA). A CBA assigns monetary value to non-market values, i.e. leisure, recreation, aesthetics, and allows for the future value of a proposed project to be determined. This method has been used over the world in an attempt to capture the true value of green infrastructure projects (52) (53) (54).

Workshop participants noted the benefits of this system in assigning a monetary value to a non-market value (9). However, there was consensus that this method is not always recognised by funding bodies and therefore further work is needed in this field to ensure that CBAs are promoted as a tool to increase urban greenery (39) (55) (9).

Whilst policy has traditionally not recognised the role of systems thinking, life cycle analysis and circular economy principles, there are increasingly plans by the Government of South Australia that recognise the linkages between greenery and human health and well-being (17) (5) (56). Examples of this can be seen in the *Health Parks Healthy People* strategy. This strategy has been co-developed by the Department of Environment and Water and the Department of Health and demonstrates the cross-departmental collaboration to recognise the benefits of connecting people with South Australia's National Parks and more broadly nature (56).

Whilst this strategy is non-binding and targeted at National Parks, rather than just open green space, it does demonstrate that the state government recognise the health benefits that parks provide for people. This extends beyond mental and physical health to children's development and the cultural value of Country for Aboriginal people's health and well-being.

To further strengthen this recognition, there is a need to capture the non-market benefits of greenspace and promote these benefits when applying for funding that will help to deliver more greenspace or better quality greenspace.

### **3.9 What is the potential impact of climate change on the availability of water and greening needs?**

All stakeholders recognised that under a warming climate, the demand for water consumption to maintain current levels of greening will increase (30) (33) (29). This is a direct result of a hotter and drier climate (11). This includes a general drying trend, highlighted by a reduction in April to October rainfall and an increase in evaporation across South-Eastern Australia (11). Under this scenario, stakeholders expected reduced autumn, winter and spring rainfall and an increase in intense summer rainfall (30) (29) (33).

Reduced rainfall is likely to result in reduced water capture through the Adelaide Hills reservoirs, the River Murray and the council managed stormwater and Managed Aquifer Recharge (MAR) schemes. This has a direct effect on current greening supply systems. Councils expect to harvest less water through the MAR schemes as a result of climate change and this may limit the ability of councils to irrigate with MAR water (8). The expected increase in extreme weather, including storm events, is expected to negatively influence the ability of MAR schemes to capture stormwater. This is due to the current design of the systems that are not built to capture peak flow events (57). This is likely to result in a decrease in the amount of water captured and an increase in the amount of stormwater entering Gulf St Vincent. This is likely to result in marine environmental degradation along Gulf St Vincent and an opportunity lost to capture and repurpose stormwater for urban greening.

Some stakeholders indicated that there is likely to be a change in water sources as a result of climate change (57) (55). Water extracted from the River Murray and the Adelaide Hills Reservoirs is expected to reduce, due to reduced rainfall throughout the Murray-Darling catchment and the Adelaide Hills catchments. Water sourced from the desalination plant is expected to increase over this time to replace the water lost from the previously listed sources (29).

Although more rain may occur during summer when plants require water, summer rainfall may not penetrate the soil and instead is expected to run-off the surface and enter the stormwater system (29). This has the result of providing little greening benefits to vegetation, causing erosion of creek lines,

leading to damage of stormwater systems and overwhelming council stormwater capture systems. A change in the intensity of rainfall and associated storm events is already overwhelming traditional council stormwater capture systems that have been designed for a traditional South Australian scenario of steady rainfall from Autumn through to Spring (9) (33). Options that capture rain where it falls are required to reduce the need to upgrade stormwater systems and to ensure greenery can survive in an altered climate regime.

The reduced annual rainfall expected in the Adelaide area, may be offset by an increase in the amount of impermeable surfaces, as a result of urban consolidation (45) (57).

Groundwater is considered a relatively stable source of water for the near future (50 years) (57). The appeal of using groundwater may increase over time, due to the low ongoing costs and the relatively low establishment costs of drilling and maintaining a well (57). This may lead to added pressure on the groundwater resource in the medium to long term. Whilst the extraction of groundwater is expected to increase, the recharge of groundwater systems is expected to suffer, due to reduced rainfall and increased evaporation (57). Groundwater quality is variable (33). Increased demand for the resource and extraction may influence the quality of the water further, if not managed correctly (57).

One stakeholder indicated that the changes in rainfall pattern may alter soil types and change the surface water / ground water interaction (57). This is likely a result of altered runoff regimes. Associated with a change in the rainfall pattern is the change in the intensity of rainfall. Several stakeholders were concerned about the impacts on riparian zones caused by erosion and damage to stormwater infrastructure (45) (9) (8).

Since metropolitan greenery usually consumes a mix of rainwater and irrigation (water abstracted from rivers, lakes, reservoirs, ponds, and aquifers), greening a city may come at a price of rising water scarcity (27).

As a result of these predicted changes, all stakeholders recognised that the amount of water required to maintain the vitality of plants and open spaces at current levels would require improvement under the current irrigation practices. Most stakeholders indicated that increased irrigation is required to maintain current levels of greening in an expected hotter and drier environment. It is important to note, that there are increases in water use efficiencies that are readily available and can help open space managers to better utilise water (33).

The great lifeline for Adelaide is the desalination plant at Port Stanvac. The desalination plant can provide up to 100 Gigalitres of potable water to South Australians (58). This can be used to offset the loss of water from reduced rainfall. The question, is whether the cost of the water is provided at a price that is economically feasible to councils, residents and other private water users in order to irrigate vegetation to a point that maintains the required level of greenery.

As discussed in previous sections, the current SA Water mains water supply pricing model is considered cost prohibitive for some councils to green all of their open spaces to the level they would like.

Coupled with the decline in water availability is the expected increase in vegetation water demand. This is expected as a result of increased length and intensity of heat waves, increased average temperatures and higher evaporation rates (11). Put simply, the water required to maintain current levels of greenery will increase and the sourcing of this water is likely to come from a mixture of rainfall, stormwater, recycled water, groundwater and mains supply.

Notably however, whilst there may be a shift in the mix of available water sources (e.g. desalination plant/River Murray/Reservoirs), consumptive water use by greater Metropolitan Adelaide is likely to increase over time, therein increasing the volume of wastewater generated through the Bolivar water treatment plant and creating a greater available resource for reuse (also noting the projected use for Agriculture through the NAIS scheme). Recycled water, although more saline than other water sources, can, if required, be further treated to reduce salinity and increase irrigation to green the city. There is a greater supply of recycled water than demand.

### 3.10 What policy changes, including pricing, could encourage a different approach to water use for greening in Adelaide and how does this align to the policy agenda of the State Government?

Governments across the world have attempted to introduce mechanisms to ensure that cities either remain green or increase their greenness whilst undergoing infill development. Often the approach to increasing urban greenery is to introduce an incentives program or alternative “carrots” to encourage greening (13). The loss of private urban green space is rarely offset by the creation of more public green space (13). There are however, many means by which the quality of green space can be improved, particularly through the use of incentive schemes (13).

The responsibility of ensuring that a city remains green in Australia is too often left to local government (1). The extent to which councils can influence the greening of a city is limited to the areas that the council directly manages (1).

The ways that cities manage greenery is varied. Many councils seek to influence the community and the actions of developers through education campaigns, strategy establishment and policy reform that will guide the operations of council and advocate for change through planning and building code reform (21) (22). The issue of greenness is something that is being considered by many cities outside of Australia. It can be seen that cities such as London, Chicago, Toronto and Seattle all have developed urban canopy targets (1).

In cities where open space is limited and buildings dominate the landscape, such as central business districts and high-density living communities, governments are seeking to green cities through alternative greening means. This includes the use of living infrastructure, such as green roofs, vertical gardens, climbing plants and potted plants. In Singapore, the government incentivises the use of “skyrise greenery” through funding schemes that aim to increase urban greenery attached to or on top of buildings (59). This includes the installation of rooftop greenery and vertical greenery (59). In this particular scheme, the government will fund up to 50% of installation costs (59). Existing buildings and buildings undergoing alteration or additions are eligible (59).

Within Australia, urban councils have created policy, education and awareness campaigns and invested in infrastructure (i.e. Water Sensitive Urban Design measures) to encourage greening (21). The City of Melbourne has developed a strategic action plan to green the city. A focus of the plan is to increase vertical gardens and green roofs through the city (22). In 2012, the City of Sydney developed a Greening Sydney Plan. The plan, which sits under the Environmental Action Plan 2016 – 2021, establishes a greening vision for the city and policy to support the implementation of the plan (21).

Unfortunately, much of the work that councils dedicate to the greening of cities is limited to the land and assets that are controlled by councils. Often this is offset by the development of buildings that have little regard for urban greening, as demonstrated by the statistics provided in section 3.3, outlined in the RMIT developed report, “Where should all the trees go?” (2). Australian cities are losing tree canopy, shrub canopy and are experiencing an increase in hard impermeable surfaces (2). This has implications for stormwater runoff and associated aquifer recharge. However, it also provides an opportunity to further capture and redistribute stormwater to areas where it can be best utilised for greening purposes.

State governments have also focussed on greening cities, particularly through the use of community plantings and planting on public land or private agroforestry land. An example of a current tree planting program is the New South Wales *Greening our City* priority (20). The focus of the scheme is not just to green public land, with participants of the program encouraged to register a tree for planting on their own private property (20).

More locally, some councils in metropolitan Adelaide have long held a mandatory one street tree per property frontage, where possible (60) (61). The 30 Year Plan for Greater Adelaide 2017 update outlines a plan for a green liveable city. The goals of this target are to increase urban green cover by 20% in metropolitan Adelaide by 2045 (17). To achieve this target, the plan suggests that a focus will be on increasing tree canopy in areas of urban infill development (17). How this will be achieved is not described.

The South Australian Government offers incentive schemes through grants programs, such as the Open Space and Places for People Grant Program and the Greener Neighbourhood Grants (62) (19). Both of these grant programs offer funding to improve and increase greenery in the public realm.

Councils are the targeted recipients of this funding and are expected to use the funding to create or improve green corridors (19) (62).

In order to increase greenery in the private realm, there is a need to innovate and create design solutions that allow for urban consolidation without compromising greenery.

Clearly there is a need for legislation to ensure that greening is considered across the city. However, legislation is only part of the solution, as greenery not only requires a soil medium to grow in but water to support the vitality of the plant. The challenge for planners is ensuring that mandated tree planting creates the urban design that they have envisioned. Trees require water, nutrients and sunlight to prosper. Without adequate access to these resources, trees may die. The success of any given tree is dependent on access to these key resources, and often this requires human intervention. Trees and vegetation more generally reliant on human intervention are more likely to fail, as humans may not inherently value and care for the vegetation that was forced upon them by a planning system.

Stakeholders did not necessarily agree upon the need to introduce more policy. Some saw policy as a driver, whilst others viewed policy as a soft lever to drive change. It is noted that policy must be supported by guidelines, leading practice, incentives and if necessary consequences (45) (30) (29). There are already clear strategies and policies that drive greening across the city (29). However, these policies in some circumstances clash with other drivers of urban planning, such as the need to consolidate cities and services (45).

Councils would like to see transparency on the true costs of water (8). The price of wastewater varies depending on the customer. Councils argue that this does not truly reflect the cost of treatment and transport of water. If a standard wastewater price existed, councils state that subsidies could still exist, however, these would need to be publicly stated (8).

From an SA Water perspective, there is a need to educate and upskill water managers in the use and deliverance of water in order to have more efficient watering regimes. Many councils are overusing water and could benefit from evidence based watering, such as the use of soil moisture probes and an understanding of the best times to water and the best methods of delivering water where it is needed (33). There may be significant infrastructure and cost barriers to implementing “smart irrigation” systems, however technology advancements and the Internet of Things (IoT) are providing mechanisms to lower cost and use technology monitoring solutions.

Other stakeholders agreed that policy changes may not necessarily result in behaviour change. Greening of the urban landscape is an issue that extends beyond water availability and the cost of water (9) (33). The bulk of land in Adelaide is privately owned. As allotment sizes decrease and the average dwelling size increases, we are witnessing a loss of the urban back yard. This has significant effects on green space availability, the management of stormwater, the Urban Heat Island (UHI) effect and access to open space. Access to low cost water is only one consideration in the greening of Adelaide (9). The maintenance of greenspace is primarily left to councils with some volunteer groups also playing a key role (9). The application of more water to reserves may increase maintenance costs for councils (64) (9).

Although greening may be considered a priority by some, there are significant barriers to greening of private space. The development of the suburban block, and the planning regulations currently allow for and to some extent encourage the subdivision of blocks and the associated loss of private greenspace and tree canopy.

### **3.11 What would the effect of a water price reduction by 20% be on the greening of spaces through irrigation?**

During the course of writing this discussion piece, water pricing for SA Water mains supply water in South Australia reduced by approximately 18% (See Tables 4 – 9). This has resulted in significant changes to SA Water prices for supply and more importantly use. The results of the price reduction are yet to be seen. An increase in irrigation rates or extension or irrigation networks to more open space areas, requires constituents and elected members to be educated about the effects of urban heat and the benefits of irrigation of greenspace in reducing the urban heat island effect.

The US Environmental Protection Agency notes that the pricing of water services should reflect the true costs of providing high-quality water and wastewater services (65). It is noted that price signals value to consumers (65). If pricing is too low, consumers are likely to place a low value on water and

are encouraged to use more of it. In the case of increasing water used for greening, this may be desirable. The difficulty arises in encouraging consumers to use more water for the purpose of greenery, as opposed to other services.

Many water regulators use an increasing block tariff (IBT) to structure water pricing and as a means of conserving water (66). SA Water use an IBT through structuring residential water price across a tiered system (50). Pricing is structured across a threshold.

Pricing of mains supply water across all jurisdictions in Australia is relatively stable (66). Unlike other goods, the price of water is nominally low. In the case that there is a water shortage, such as the Millennium Drought, governments response is typically to introduce water use restrictions, rather than increasing the price of water. There are many reasons for this, primarily water delivery is considered an essential service and consumers pay for water after they have used it. Therefore there may be a lag time between consumer water use and altered behaviour change.

Water collected through council managed MAR schemes is considerably more expensive than wastewater, at approximately \$3/KL (8). MAR scheme water is cheaper than mains supply water, although the mains network is spread throughout metropolitan Adelaide and gaining access to the network is relatively cost effective. The investment required to extend council managed MAR schemes is considerable. For this reason, a council such as the City of Marion, although owning and operating a MAR Scheme, only irrigates roughly half of their geographic area with MAR scheme water.

The asset owners who use mains supply water for irrigation, noted that a decrease in the price of water would allow for an increase in the amount of water applied to greenspaces. Those who rely primarily on wastewater mentioned that although a decrease in price would be favourable, that there are limits to the pipe network. There are significant costs associated with improving water pressure, flow and extending the wastewater pipe network. These factors were considered greater barriers to increasing greening of public spaces, than the cost of water (35).

The cost of water although considerable is not the only cost associated with greening. Maintenance and fertilisation costs are substantial. There are also specialised skills needed to effectively manage certain plants. Asset owners also noted that there are challenges to greening related to the capacity of council staff to manage green spaces. Councils prioritise particular areas to effectively manage, such as high use spaces, parks and gardens and sporting ovals.

A reduction in the price of wastewater by 20% or mains supply water by 20% would likely cause some council managed MAR scheme customers to switch to SA Water for water supply (8) (9). In some instances, this would reduce the commercial viability of MAR schemes. Flow-on effects from this may be that councils are unlikely to reinvest in a more costly MAR scheme and may choose to reduce the running of the MAR schemes. This would likely result in reduced stormwater quality and an increase in the volume of stormwater entering Gulf St Vincent.

### **3.12 What would the effect of a water price increase of 20% be on the greening of spaces through irrigation?**

Price is not the sole determinant of irrigation use. An increase in price of mains supply water, may encourage some councils to seek out and invest in alternative water supply, such as wastewater or recycled stormwater (30) (9). Stakeholders suggested that it was unlikely that the price would drastically increase over a small time period, as water is considered to be fairly secure, due to the variety of water sources, including the desalination plant (29).

If wastewater were to increase in price by 20%, it is still likely to be cheaper than alternative sources. However, the result may be that the volume of water used to irrigate spaces may be reduced (33) (35). This is likely to occur in sites seen a low value, such as pocket parks and low amenity spaces. Councils are unlikely to reduce watering of community sports grounds or high use areas. Communities expect spaces that have always been green to remain green. As such, there may be some risks to councils from a reputational standpoint.

Ultimately an increase in cost would likely lead to a decrease in the quality of greening. However, an increase may encourage some councils to extend alternative water infrastructure to more areas of the city (9).

## 4 Potential strategies

The following recommendations outline a path to increasing greenery in the greater Adelaide region. There is a focus on increasing not just the quantity but also the quality of greening using a variety of water sources, in particular harnessing stormwater to better cool suburbs.

### 4.1 Recommendation 1 - Encourage watering of greenspace around houses and in streets to cool homes

Water can be better used to cool homes and streets. Watering vegetation around homes and in the street can create a microclimate, and buffer residents against the effects of heat.

Innovative trials by the City of Mitcham and SA Water demonstrate the urban cooling benefits of using water around homes and streets. Trees with access to water create their own microclimate, by releasing tiny droplets of water into the air, reducing the temperature of the air locally.

Watering vegetation around the home can help to provide the same benefits. Watering vegetation around homes during a heat wave reduces temperatures locally and helps to create a microclimate.

It is suggested that the State Government prioritise projects that actively cool streets and supply street trees with stormwater, through both Open Space and the Places for People Grant Program and the Greener Neighbourhoods Grants. Incentivise councils to invest in projects that will allow street trees to prosper, reduce human intervention and actively cool and green neighbourhoods. See section 4.2 for further information.

SA Water could play an active role in providing incentives for residents to water vegetation around homes through reducing the cost of water over peak summer periods (January to March). This is to be developed in conjunction with an advertising campaign to increase the use of water for the single purpose of irrigating gardens in order to reduce the effects of urban heat.

Saving water in the home is good for reducing the burden on the River Murray. Any targeted education campaign will need to focus on amplifying water saving behaviours associated with everyday living, whilst encouraging residents to use more water for their gardens. SA Water customers may opt-in to the program to receive reduced water costs, for the express purpose of watering greenspace around the home, over certain times of the day. Reduced water costs would be timed to correlate with the most appropriate times to water to increase greening, reduce water loss through evaporation and assist with urban cooling at the times that most people are in their homes (i.e. evenings). Targeted messages (email, text message) would inform customers of the most appropriate times to water. SA Water education and communications teams to develop a marketing and education campaign outlining the most efficient methods of cooling the suburban home through watering of gardens, lawns and trees.

### 4.2 Recommendation 2 - Department of Environment and Water, Green Adelaide, to develop a greening master plan for Adelaide

More research is needed to define a greening quality standard that will buffer the city from heat. The master plan should be the result of research and focus on:

- Developing a greenery quality minimum standard. The standard should be represented as a quantifiable value i.e. NDVI. The minimum standard should consider the degree of greenery required to actively cool the city, maximise physical and mental health and wellbeing, ecosystem services, biodiversity and conservation. When considering NDVI or other quantifiable values, other greening limiting factors, such as plant disease, soil condition and heat are to be included in the assessment. This may be modelled on the City of London Urban Greening Factor.
- Determining the amount of water required to maintain the minimum greening standard for the most common turf, tree and shrub varieties across metropolitan Adelaide. Consideration of changes to watering requirements based on weather and climatic conditions should be included

- Preparing guidelines for open space asset managers. Guidelines to include watering requirements to maintain minimum greening standards
- Encouraging and incentivising projects that cool streets and urban areas through the Greener Neighbourhoods fund

### **4.3 Recommendation 3 - Council bulk purchase water pricing**

In this scenario councils are incentivised to develop a local greening strategy and submit the strategy for review to Green Adelaide and SA Water. Upon completion of the review process, councils enter into an agreement with SA Water. The agreement states that councils that can demonstrate the use of smart watering systems whilst maintaining required public greening standards are offered a bulk water discount through a rebate scheme. The reduced cost water is only to apply for water use beyond a minimum stated threshold.

Councils are required to demonstrate how savings from reduced cost water are spent. Only councils that can demonstrate that water savings have been spent on water delivery infrastructure or the cost of water are eligible to continue to receive reduced cost water through the rebate scheme.

Water discounting would be reviewed annually by SA Water and Green Adelaide. Continued water price discounting would be subject to meeting greening and water delivery targets, as outlined in the agreement.

### **4.4 Recommendation 4 - Department of Treasury and Finance and other state government departments to incorporate cost benefit analyses for water infrastructure projects**

When considering water infrastructure projects that will result in improved greening, a cost benefit analysis allows for the quantification of the future benefits of the project.

State government departments need to better incorporate non-market values into the project review process. This needs to occur in the planning and design stage of the project and should be used to determine the true value that a project will bring to the community.

It is recommended that a mandatory cost benefit analysis is included for all water infrastructure projects above the value of \$ 180,000.

### **4.5 Recommendation 5 - Increase the mandated greening for new developments**

The loss of greenspace in the private realm is stripping metropolitan Adelaide of greenspace. Whilst large scale developers are mandated to either set aside an amount of land as open space or contribute funds into a public greening fund, the overall result is a loss of greenspace. Public greening funds may increase the quality of greenspace in the public realm, however, the scope to create more area of greenspace is severely limited. There are many ways to increase greening of new developments. Clearly well-designed guidelines and support for urban planners to correctly interpret guidelines is needed. It is suggested that the Centre for Cooperative Research Water Sensitive Cities *Infill typologies catalogue* be utilised as a guiding document to draft guidelines to support urban planners.

The following recommendations are based on the planning categories for infill development established under the *Development Act 1993* i.e. developments that create more than 20 allotments, 5 to nineteen allotments or one to four allotments. However, the newly established Planning and Design Code has recently been released. As such, the recommendations stated below apply to the Planning and Design Code.

Greater than 20 allotments

- Increase the minimum open space requirements from 12.5% to 15% open space

- Increase the compulsory developer contribution to open space greening funds by 10% to incentivise developers to incorporate high quality green space into large scale developments
- Develop guidelines to assist urban planners and developers to better understand their obligations and assist with decision making when designing medium and high-density allotments. Guidelines should include examples of global best practice and offer innovative solutions, such as green walls, rooftop gardens and water sensitive urban design measures to support greening

#### Five to Nineteen allotments

- The development of guidelines to assist urban planners and developers to better understand their obligations and assist with decision making when designing medium density allotments.
- Tree plantings are to be planted in spaces that require a minimum mandatory offset of 4 metres from impermeable infrastructure
- Mandatory inground stormwater retention systems that provide water to trees planted in the five to nineteen allotment spaces. Mandatory minimum water holding capacity of 500 litres per tree is required. Stormwater systems to be designed according to best practice Water Sensitive Urban Design measures to ensure flood protection and groundwater recharge.
- Mandatory permeable pavement or living infrastructure options for driveways. This will increase aquifer recharge and reduce pressure on stormwater management systems
- Mandatory allocation of three trees per development
- The development of tree species selection guidelines to ensure maximum tree canopy cover, tree vitality and longevity and appropriate biodiversity across different developments.

#### One to four allotments

- The development of tree species selection guidelines to ensure maximum tree canopy cover, tree vitality and longevity and appropriate biodiversity across different developments.
- The development of guidelines to assist urban planners and developers to better understand their obligations and assist with decision making when designing medium density allotments.
- State Government to develop 20 innovative designs that allow for increased greening and open space across different size and shaped blocks. Designs are to be fully costed, made publicly available and promoted to developers as preferred standards. Designs must include options for blocks on different soil types and landslopes, size, shape and place. The aim of the design guide and examples should be to avoid “cookie cutter” development and showcase how to best increase greenery whilst increasing urban density
- State Government to utilise aforementioned design to construct demonstration sites of innovative design solutions that allow for open space and greening. Developments are to occur on a variety of differs sized and shape blocks. Eight demonstration sites are to be developed (two in the Northern suburbs, two in the Western suburbs, two in the Southern suburbs, two in the Eastern suburbs). Demonstration homes are to be designed in a manner that meets the needs of consumers (home buyers), demonstrates innovative greening solutions and offers cost transparency. Examples should be designed to make a profit, thus demonstrating the financial viability of the designs to developers.

#### **4.6 Recommendation 6 - Fund cool suburbs trials using City of Mitcham research**

Councils in metropolitan Adelaide are leaders in the WSUD research and implementation field. The establishment of larger WSUD schemes, such as MAR schemes requires significant financial input and is not financially or technically feasible for many council areas.

The uptake of more affordable WSUD measures at the street and allotment scale is needed.

The work being undertaken by the City of Mitcham in partnerships with research bodies is a prime example of projects that can be undertaken by every Adelaide metropolitan council and will have tangible benefits for residents.

Research indicates that the work being undertaken by the City of Mitcham could help alleviate many of the urban heating issues in low tree canopy areas of metropolitan Adelaide, such as the western suburbs and certain northern suburbs locations.

It is recommended that DEW, SA Health and DIT invest in demonstration projects across some of the hottest streets in Adelaide. Utilising the urban heat mapping tool, identify the areas that would benefit most from tree planting and the delivery of significant quantities of stormwater to individual street trees. Large scale revegetation of the streetscape in heat vulnerable neighbourhoods is required now to reduce the impacts of heat-related climate change on these communities. By targeting heat vulnerable communities for this work, it is possible to demonstrate the changes that can occur in



**Figure 3. Permeable pavement has been used to great effect in both residential roads and foot paths within the City of Mitcham (Photo: TecEco, 2020 (67)).**

#### **4.7 Recommendation 7 - All street renewal programs and new developments to utilise on-site infiltration systems or permeable pavement to support the growth and vitality of street trees**

The benefits of capturing large volumes of stormwater and feeding the water into the root zone of street trees has been shown to have significant urban cooling benefits (39).

It is recommended that all streetscape renewal programs, funded either through DIT or council, use permeable pavement for footpaths or on-site infiltration systems, to support the growth and health of street trees. A greater proportion of council funding needs to be allocated towards mitigating the effects of heat, especially considering the future climate projections. Investments of this nature are

required to aid in urban cooling, create exercise corridors and assist in cooling road and footpath infrastructure.

#### **4.8 Recommendation 8 – Streetscape renewal of major arterial roads to place electricity infrastructure underground**

It is recommended that funding to the ESCOSA Power Line Environment Committee is increased to allow for the undergrounding of power lines throughout main roads and areas surrounding major shopping, dining and entertainment precincts, with the aim of creating “green tunnels” of street trees to shade and cool select locations.

There are multiple examples of infrastructure hubs in Adelaide and other Australian cities where street trees are allowed to thrive without excessive pruning because power lines have been placed underground. Currently, many trees are pruned when the tree canopy comes in contact with above ground electricity infrastructure. This not only reduces canopy cover but also encourages councils to plant street trees that will not interfere with above ground electricity infrastructure and that offer reduced shade.

The relocation of power lines underground has been successful along major infrastructure roads, such as the newly created sections of South Road at Darlington and the Torrens to Torrens and Regency to Pym projects. The relocation of power lines underground has also been a priority for certain metropolitan councils, with the City of Prospect and the District Council of Mount Barker relocating power lines underground throughout many residential and commercial areas.

The removal of power lines and support infrastructure from the street and footpath allows tree canopy to grow and thrive without being excessively pruned when the tree grows to a height that is deemed to interfere with the above ground power lines. This allows councils and the state government freedom to plant street trees that offer broad canopy cover, providing greater shade to the streetscape.



**Figure 4. The main street of Nairne had power lines relocated underground in 2014 (68)**

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