Adelaide Design Manual

Green Infrastructure Guidelines

ADELAIDE CITY COUNCIL

Adelaide City Council

Green Infrastructure Guidelines

Final Draft Report

23 May 2014

ADELAIDE CITY COUNCIL

ASPECT Studios™

The Purpose of this Document

The implementation of Green Infrastructure throughout the city will greatly enhance city liveability and amenity whilst also providing biodiversity improvements.

This document will provide an integral tool for Council to identify and leverage strategic opportunities for greening within the public and private realm of the city. It will provide pathways to overcome barriers and guidance to assist council with coordinated implementation of Green Infrastructure elements.

This is a living document that will continue to be refined and developed as technology and practices improve.

What is Green Infrastructure?

Green Infrastructure is the web of interrelated natural systems that underpin and are integrated with our urban fabric. These systems provide a network of assets which are vital to the long term sustainability of our cities.

The primary elements of Green Infrastructure include Living Architecture, the Urban Forest, Green Streets and Water Sensitive Urban Design.

The drivers and benefits of Green Infrastructure are now well established in current literature, and are increasingly being recognised by authorities and governments worldwide.

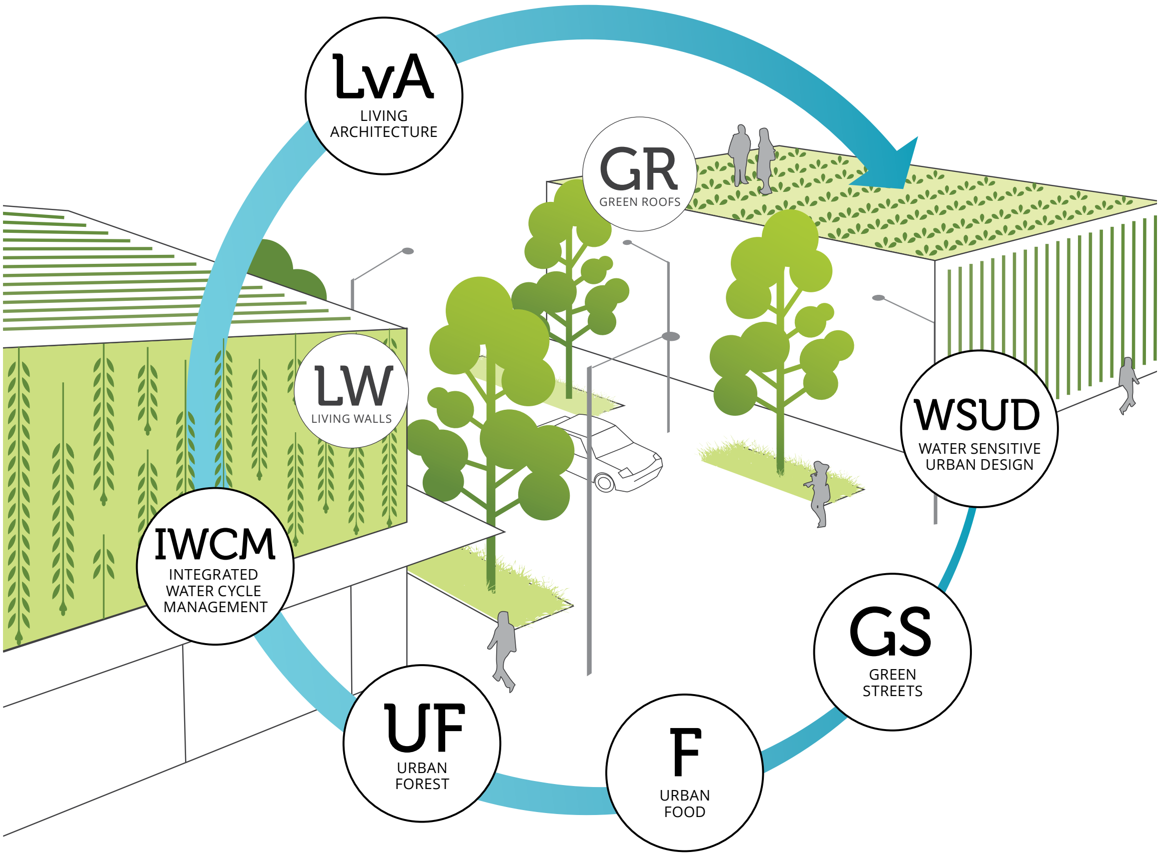


Figure 01: Green Infrastructure: An Interrelated Web

A Green Infrastructure Vision

Adelaide City Council (ACC) is committed to achieving the vision of 'One City, Many Places'; A city of great places for people.

Greening the city is recognised in the Adelaide City Council's Strategic Plan as being of fundamental importance to achieving comfortable and liveable places for people through shading and cooling the city, and providing access to nature.

Green elements are, and will increasingly be a part of the infrastructure of the city, contributing to the sense of place and reinforcing the character of the city. Green elements shall be integrated into the urban space and architecture of the city.

In light of this strategic positioning the following Vision has been adopted.

Adelaide will be:

- A vibrant and active City of great places
- A City with a high level of amenity
- A City of green streets and places
- An environmentally sustainable City
- A City with shade and human comfort
- A City that links people to the regional landscape and into the Park Lands
- A City that connects people with natural systems (plants, soil, water)

Guiding Principles

The following Guiding Principles provide a high level framework for the implementation of Green Infrastructure initiatives to achieve real and lasting benefit:

1. Involve and engage a diverse range of disciplines through an integrated design approach from the earliest stages of city planning and design.

2. Design Green Infrastructure Systems to work at a range of scales including macro (regional) level through to private allotments and gardens

3. Ensure the right conditions for Green Infrastructure are in place to enable successful implementation

4. Ensure the necessity of Green Infrastructure is promoted and understood by the wider community and through all levels of government

5. Recognise the cost benefits of Green Infrastructure from a long term asset management perspective, as well as the social and economic value of creating comfortable and inviting spaces for people.

6. Use Green Infrastructure as a tool to reinforce the unique urban design and character of the city.

7. Recognise the capacity of Green Infrastructure to value add by providing multiple benefits such as traffic calming, wayfinding and shade

8. Continue to engage with current research and update practices as Green Infrastructure technology is developed and refined

Report Structure

Section A: Context

1. Background and Framework

There are multiple tiers of policy and planning at a national, state and local government level that advocate for the delivery of Green Infrastructure within the urban environment. The following strategic documents are relevant to Green Infrastructure implementation in Adelaide. These documents are described in more detail in Appendix 3 and are listed below.

- Public Spaces & Public Life Study, City of Adelaide 2011
- Water Sensitive Urban Design – creating more liveable and water sensitive cities in South Australia, Government of South Australia Document
- The City of Adelaide Smart Move Transport and Movement Strategy 2012-2020
- Climate Change Adaptation Action Plan 2013-15
- Characterisation, Interpretation and Implications of the Adelaide Urban Heat Island, June 2013
- Botanic Gardens of Adelaide Green Infrastructure: Life Support for Human Habitats 'The compelling evidence for incorporating nature into urban environments, November 2012
- 5000+ Place Shaping Framework, Consultation Draft, September 2012
- City of Adelaide Placemaking Strategy, Stage 1 - 2013-14 & 2014-15
- Adelaide City Council Canopy Cover Studies
- Adelaide City Council Park Lands Management Strategy 'Towards 2020'
- Adelaide Park Lands Community Land Management Plans
- The Adelaide Park Lands Landscape Master Plan, 2011

The Urban Design Framework

The Green Infrastructure Guidelines forms a Chapter of the Adelaide City Council's Urban Design Framework (UDF). In its complete state, the UDF will be an evolving document that will provide Council with a comprehensive palette of materials and guidelines that will continue to shape the city, both in the public and the private domain.

The Green Infrastructure Guidelines will be intrinsically linked to the other Chapters of the Framework, providing a sound integrated basis for the ongoing greening of the City.

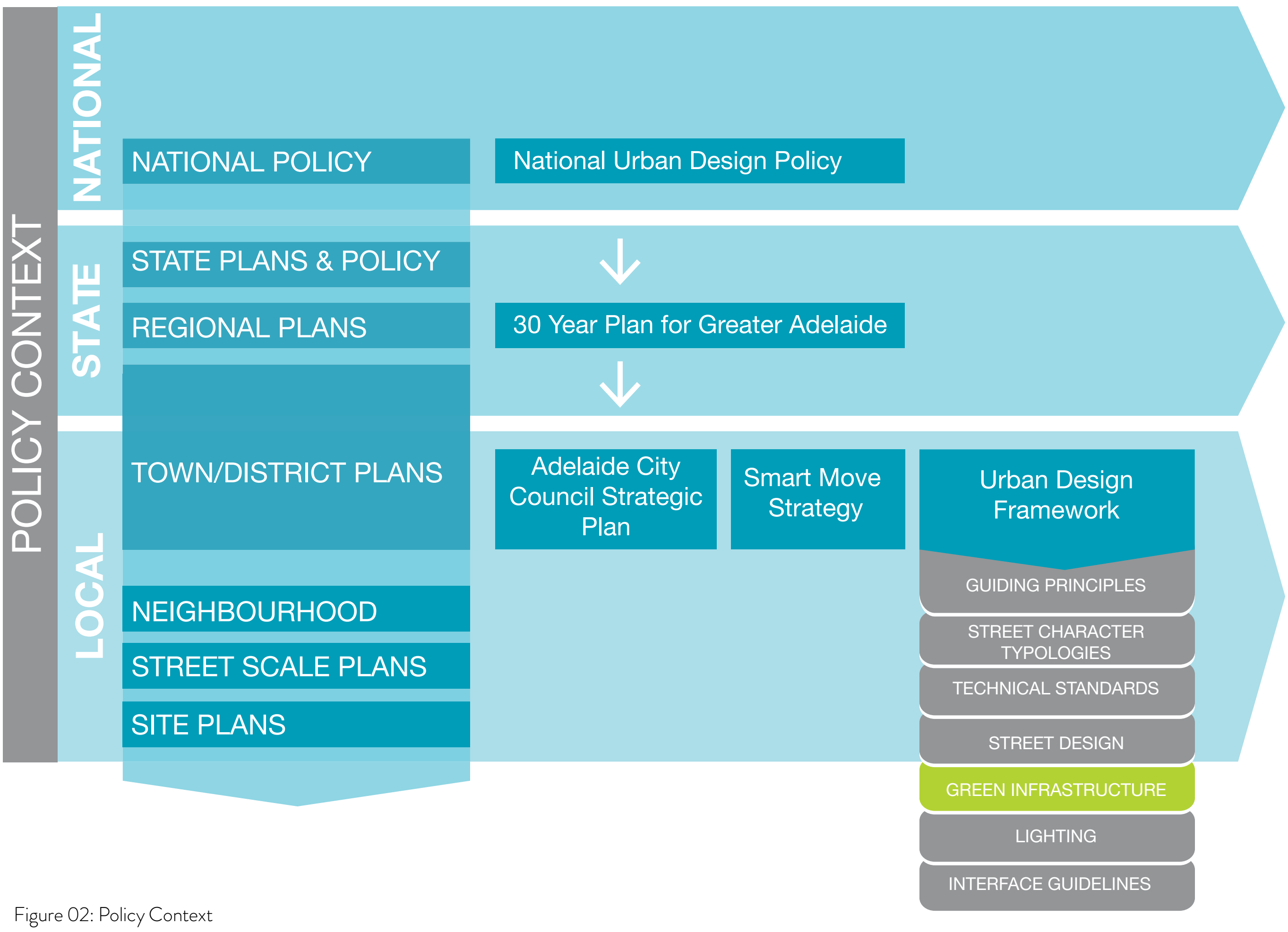


Figure 02: Policy Context

2. Adelaide Context

Adelaide has a unique character within Australia. Noted as one of the last great, planned cities, Adelaide is sometimes referred to as the 'City within a Park'. It's five inner city squares and surrounding Park Lands are vital to the identity and unique urban design of the city first envisioned and laid out by Colonel Light.

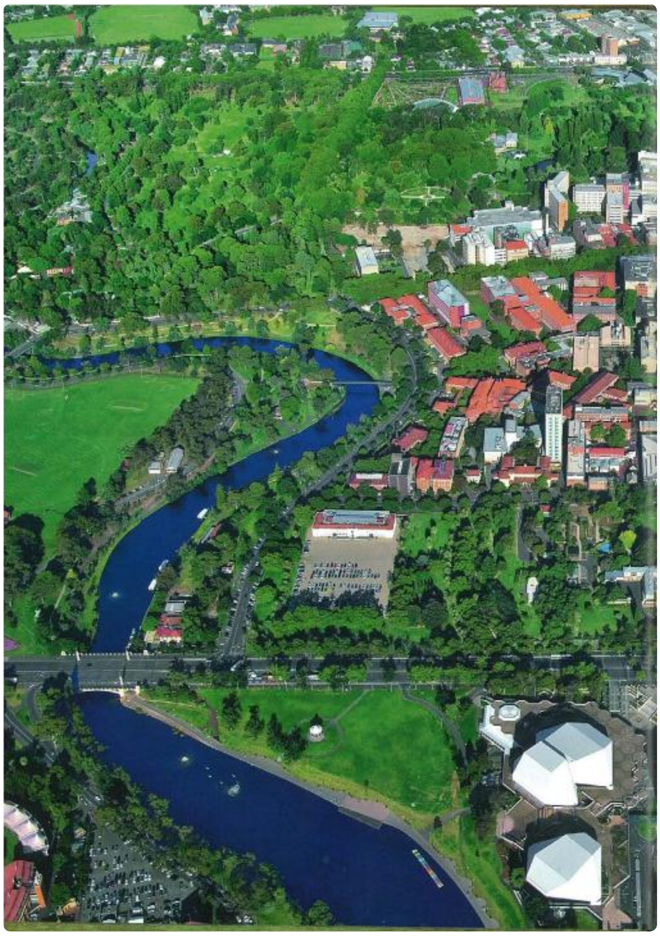
Renown for its liveability, Adelaide's grid pattern of North-South and East-West streets create a legible and easily navigable city centre consisting of a central business district, university precincts, the new Royal Adelaide Hospital, numerous shopping or 'eat' streets and substantial lower density residential areas.

North Adelaide consists primarily of residential streets characterised by numerous heritage places and two major shopping strips.

As of 2011, Adelaide CBD had a residential population of 12,760 people, with this number targeted to rise by over 50,000 people by 2038.

It is important that Green Infrastructure implemented within the city is specific to Adelaide, and the particular issues pertinent to South Australia's climate. The Green Infrastructure Guidelines for Adelaide will be a useful tool for Council to allow for genuine improvements to achieve Light's vision.

Adelaide Open Space and Reserves
(Image courtesy of the IDC)



Aerial View of Adelaide's Riverbank Precinct (Image by ACC Marketing and Creative Services, 2009, published in Sumerling, P. 'The Adelaide Park Lands - a Social History' 2011 Wakefield Press)

3. Key Issues Facing Adelaide

3.1 Introduction

The issues discussed in this chapter have been identified as the major factors effecting Adelaide's future, including its distinct climate, population and city form. Current research presents clear evidence that all of these issues can be minimised through the co-ordinated implementation of Green Infrastructure, leading the way to a healthy and resilient city.

3.2 Climate Change and Climate Modification

Climate Change

The Adelaide City Council acknowledges that global climate change is now considered indisputable. The effects of climate change are numerous and include those listed below. The risks and implications of climate change in an Adelaide context include wider social, environmental and economic impacts as well as specific impacts on Council's assets and operations.

Increase in temperatures

Over the coming years, Adelaide is predicted to see continued increases in temperatures, including an increase in extreme heat events and extreme fire risk days.

Diminishing rainfall

Adelaide is the driest of all Australian cities, with infrequent and light rainfall patterns during summer. The effects of climate change are predicted to amplify these conditions with projections for a decrease in winter and spring rains by up to 10% by 2030, and longer dry spells between rain events.

Increase in extreme weather events

Recent years have seen an increase in extreme weather events in Adelaide including heat waves and storms as well as an increase in rainfall intensity, with this trend expected to continue as climate change increases

The Urban Heat Island Effect

The urban heat island is the term given to the increased temperature of an urban area compared to rural or natural areas. As temperatures rise and areas of green space have diminished there has been a vast increase in hard surfaces which trap and radiate heat, magnifying the effect of very high temperatures in urban areas.

It is well researched and recognised that the urban heat island is a key contributor to health risks and mortality associated with extreme heat events.

Figure 03: Surface temperatures of Adelaide (Flinders University, National Centre for Groundwater Research and Training and University of Adelaide)

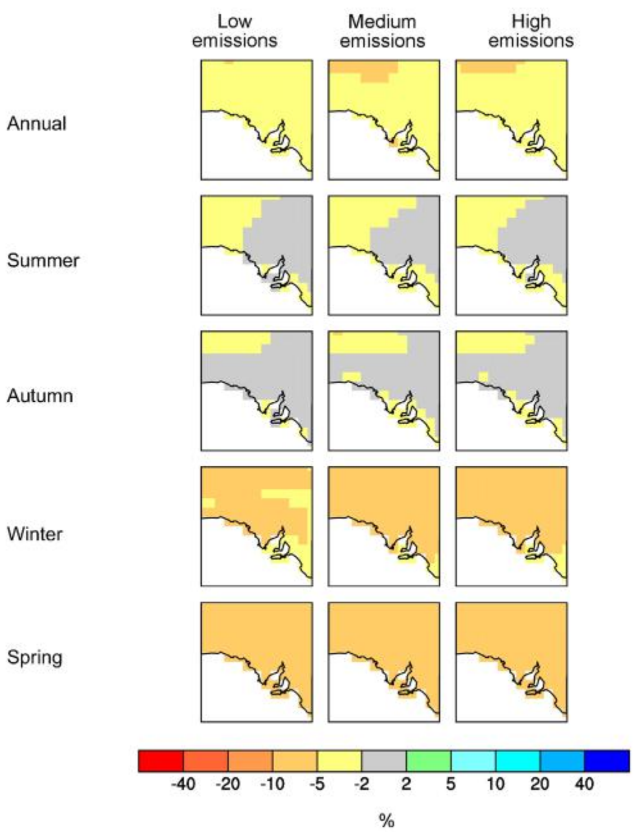


Figure 04: SA 2030 Rainfall Projections (Source: Climate Change in Australia, CSIRO,Bureau of Meteorology and Department of Climate Change and Energy Efficiency)

3.3 Existing City Form

Elements of Adelaide's existing urban fabric cause a range of issues affecting the liveability and long term sustainability of our city. It should be noted that a number of these issues are already being addressed through existing and planned Adelaide City Council and State Government initiatives.

Pedestrian Discomfort and Lack of Amenity

- Hostile pedestrian environment with heat absorbing hard surfaces and lack of connected shade
- Lack of amenity in streetscapes and public space

High Proportion of Hard Infrastructure

- Lack of pervious surfaces
- Inefficiently used road space
- Wide exposed streets

Traffic Dominance

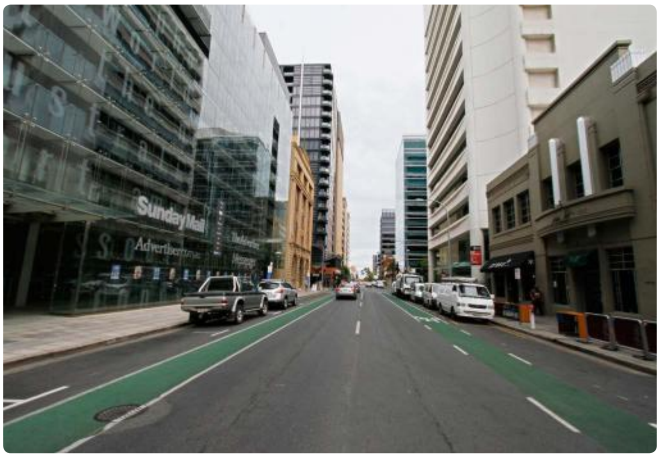
- Priority given to vehicle traffic over pedestrians and other road users
- Under developed public transport system and an incomplete bicycle network promotes vehicular traffic use
- Wide exposed streets with generous on-street parking promote vehicular traffic

Street Diversity

- Majority of streets function as traffic corridors
- Lack of street identity and way finding measures
- Lack of diversity in street planting

Planning and Implementation

- Dominance of ad-hoc and uncoordinated services infrastructure
- Insufficient allowance for soil when planting street trees leads to damage to existing assets such as roads and footpaths and poor tree establishment



Hostile pedestrian environment, Waymouth Street Adelaide

Expansive street cross section, Grote Street, Adelaide

Figure 05: Tree canopy cover on the city streets (Courtesy ACC)

3.4 Social and Economic Impacts

Increased Population Density

Although Adelaide currently has a relatively low residential population of 12,760, the Capital City Development Plan amendment ‘Vibrant Adelaide’ indicates this number is targeted to rise by 55,000 people by the year 2038. This population increase will lead to and escalation in pressure on services and will make access to high quality green public space vital for city liveability.

Obesity and Health Issues

Obesity is a common and growing problem in Australia. It is estimated that in 2011-12 49-58% of Adelaide City adult residents were obese (Overweight and obesity rates across Australia, 2011–12, National Health Performance Authority)

Obesity contributes to a range of health issues including increased rated of heart disease and diabetes. It can also add to the likelihood of heat stress and mortality during extreme heat events. It is well documented that obesity can be decreased by encouraging and facilitating active lifestyles.

Disconnection with Nature and Community

Humans are increasingly becoming disconnection from nature, with over three quarters of Australians living in urban or semi urban areas, with little access to nature. The psychological and health effects of this disconnect with nature are well researched and can partly be attributed to an increase in mental and physical health issues amongst the community, particularly among children.

Increasing social isolation and disconnection with the community is also becoming prevalent, and can also lead to health and wellbeing problems.

Liveability and Safety

Liveability and safety are vital in creating a healthy, resilient city. Inactive public spaces which lack amenity have safety issues and can lead to a slump in economic activity in the city with people favoring sheltered suburban retail areas.

Although Adelaide has many positive attributes, and some high quality public spaces, many areas of the city are lacking in basic liveability measures. For example, many city streets are heavily traffic dominated with very little shade, comfort or natural amenity, while public transport options and routes are poor and lead to increased reliance on the car.

Figure 06: Massing model highlighting development for a further 27,000 residents in the CBD (Image courtesy IDC)

Figure 07: Adelaide road traffic noise levels (Image courtesy IDC)

3.5 Ecological Change

Since the founding of the City of Adelaide in 1936, there has been dramatic ecological change both within the environs of Adelaide and across South Australia. The major changes to ecology include the issues discussed below.

Loss of Biodiversity

Biodiversity (biological diversity) describes the diverse variety of plant and animal life which is vital to a healthy and functioning ecology. Biodiversity is essential as it forms the living web which humans need to survive.

As a city, Adelaide is in a unique position, being surrounded by the Park Lands, some portions of which contain good quality biodiversity planting. However there is very little in the way of biodiversity planting within the central city zone.

Fragmentation of Wildlife Habitat

As urban sprawl and farmland have progressively increased, areas of biodiversity and habitat have become fragmented and disconnected. This is particularly the case in the most urban areas, including the City of Adelaide.

Pollution of Waterways

The dominance of hard infrastructure and traditional storm water engineering practices means that much of Adelaide's minimal rainfall is diverted into a storm water system and channeled away from the city, polluting our waterways where it has significant environmental effects.

Introduction of Exotic Plant and Animal species

Since European settlement, a wide range of exotic plant and animals species have been introduced to South Australia. Although many trees and plants have strong amenity value and cultural significance, there are also many exotic weed species which threaten the native plant population. Many of these plants are escapees from gardens. Likewise, a number of animal species such as rabbits and foxes have become feral pest species, causing widespread environmental issues across the state.

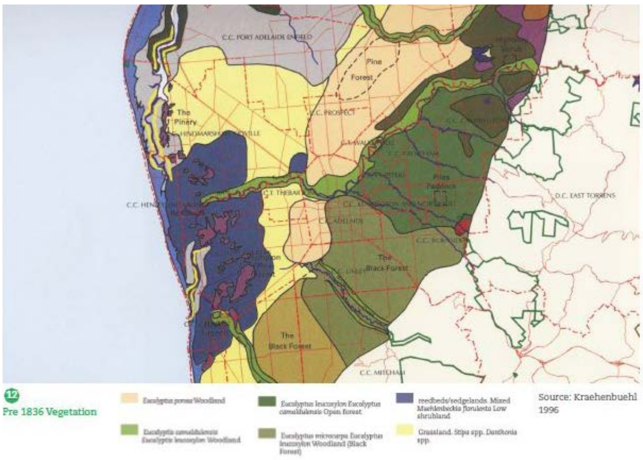


Figure 08: Pre European vegetation patterns: Adelaide and Surrounds(Image courtesy IDC. Original map sourced from Pre-European Vegetation of Adelaide: A Survey from the Gawler River to Hallet Cove by Darrell Kraehenbuehl)

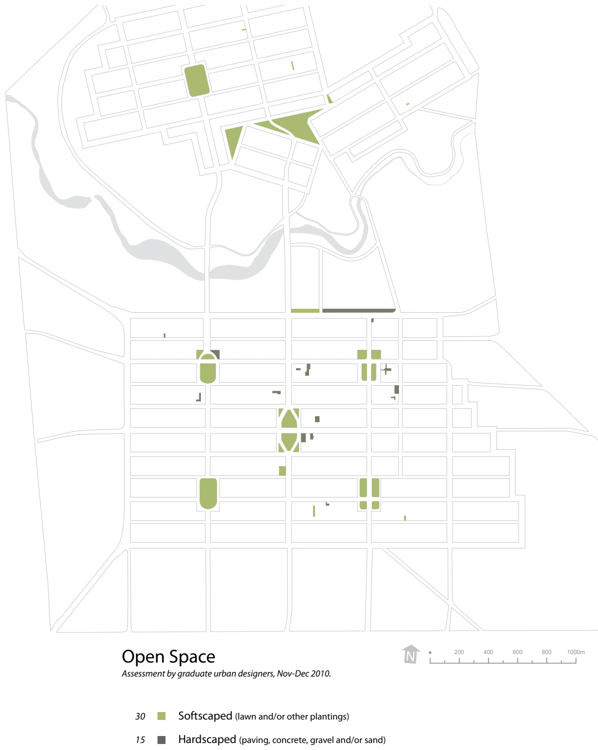


Figure 09: Existing Open Space Areas in Adelaide CBD (Image courtesy ACC)

Many areas of Adelaide are devoid of biodiversity

4. Green Infrastructure Strategies

In the face of the issues outlined in the previous chapter, a number of strategies can be adopted to facilitate Green Infrastructure implementation and enhance the liveability and resilience of Adelaide. These include:

- Utilising modern planting techniques to increase tree canopy cover for shade, amenity, traffic calming and urban biodiversity
- Maximising planting within road medians and footpaths where possible
- Developing a wider palette of tree species to ensure the function and value of the tree in any particular situation is maximised
- Modifying 'standard' storm water engineering practices through adoption of 'soft' engineering (or WSUD) solutions
- Introducing raingardens to manage storm water and provide greening
- Introducing permeable paving to capture and utilise runoff
- Harvesting rainwater for irrigation through the use of underground water tanks (minimised for detention and maximised for capture/reuse)
- Maximising opportunities for vertical gardens (highly visible, provide evapotranspiration / cooling)
- Maximising opportunities for installation of green roofs / roof top terrace gardens (act like a sponge, cool buildings, and increase the performance of PV array on hot days when they reach an output limit)

In order to successfully implement these strategies a whole of government and private sector commitment to a collaborative and integrated design approach is required.

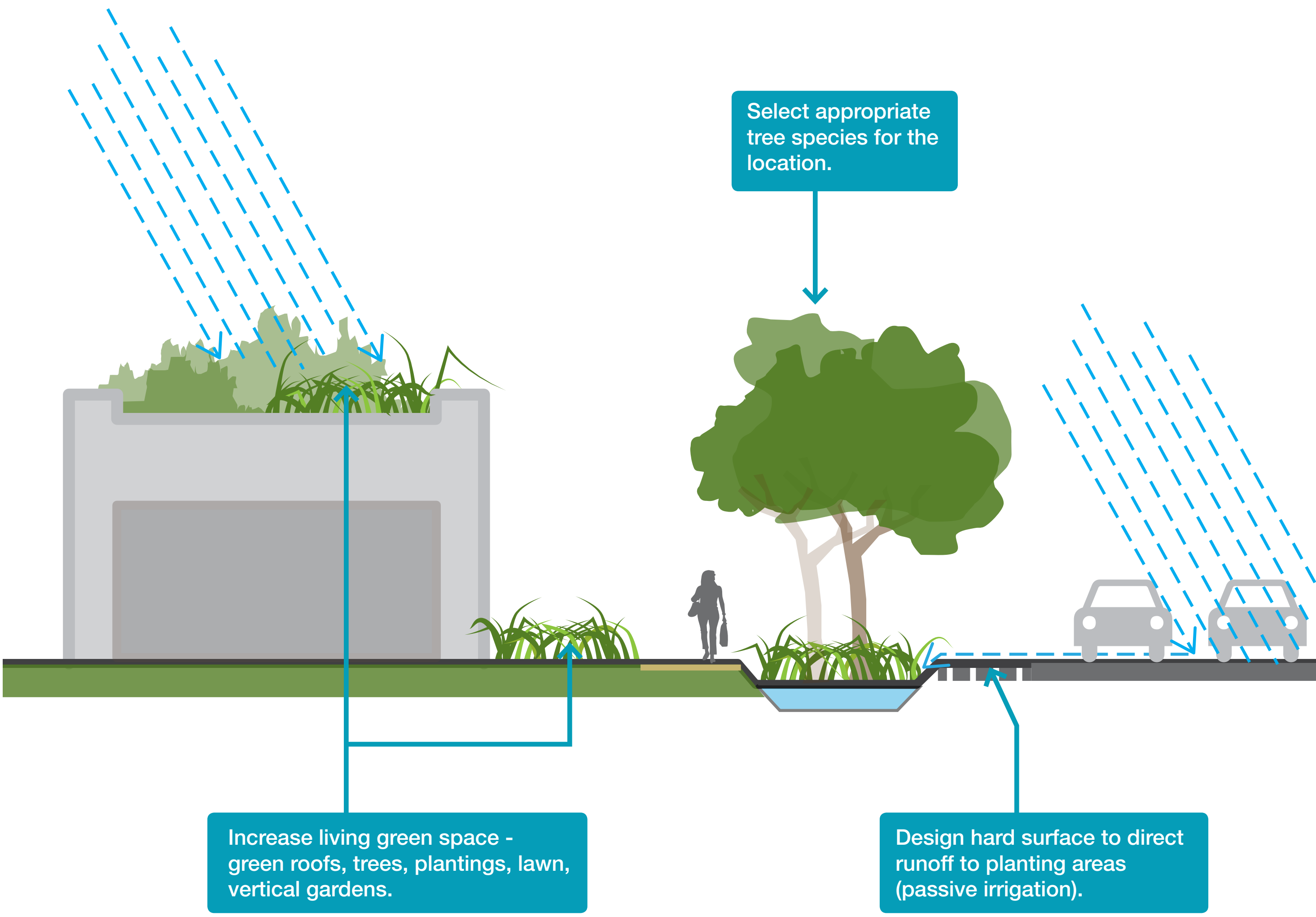


Figure 10: Integrated Green Infrastructure Strategies

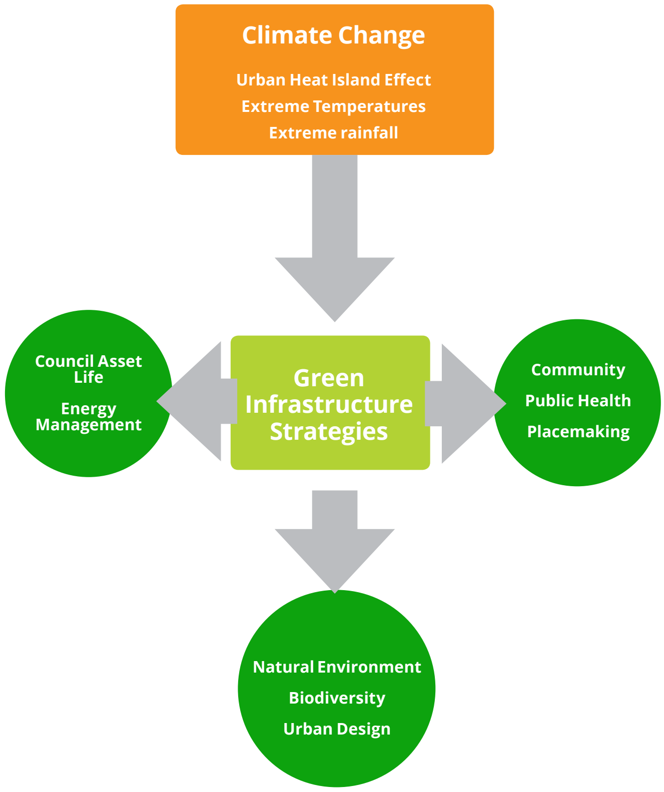
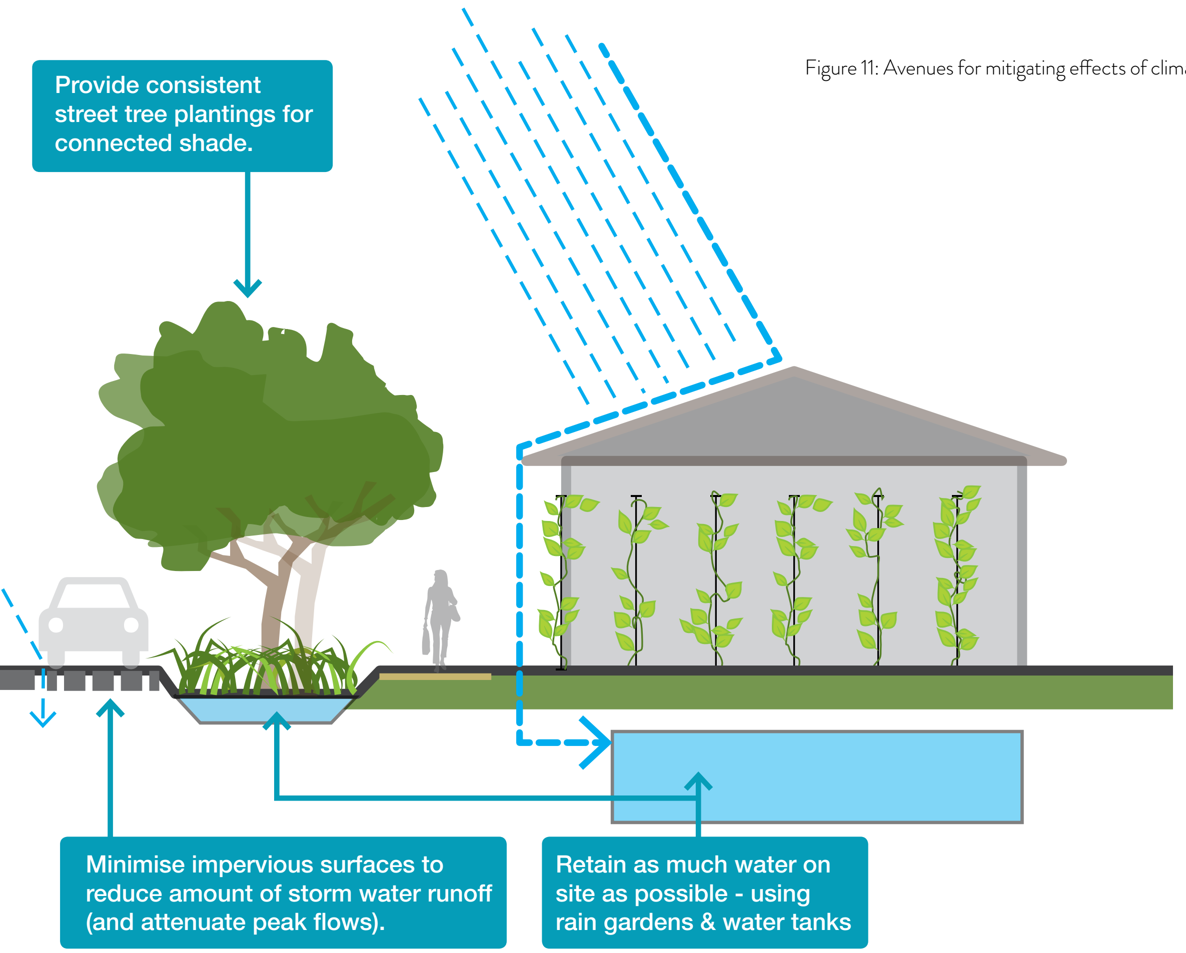


Figure 11: Avenues for mitigating effects of climate change



5. Green Infrastructure Benefits

Successful implementation of Green Infrastructure in Adelaide will provide a range of social, environmental and economic benefits that respond to the many pressures of urban places and will contribute to the long term resilience and liveability of our city. These benefits have been researched, clearly documented, and are measurable. Compared to 'grey' or engineered infrastructure solutions, which are most often single purpose solutions, Green Infrastructure solutions have the added advantage of being able to deliver multiple and connected benefits.

The primary benefits of Green Infrastructure are described below.

Improved Water Management

- Reduction in run-off volumes through increase in permeable surfaces and bioretention
- Cleaner water with reduction in nutrient loads (Nitrogen, Phosphorus, suspended solids and heavy metals)
- Improved health of waterways and water bodies
- Secure, safe and affordable supply of water (through storage, treatment and re use)

Human Health & Wellbeing

- Improved physical health through encouragement and facilitation of active lifestyles (walkable streets, cycling facilities, access to green space)
- Improved mental and spiritual health through access and connection to nature (Biophilia hypothesis)
- Improved social wellbeing and connectedness through provision of attractive and comfortable spaces for gathering and interaction

Increased Liveability

- Improved attractiveness, comfort and amenity of city places
- Cleaner air (increased plant life increased pollutant removal from the air)
- Increased Community spirit and connectedness
- Improved place making, wayfinding and enhancement of urban character

Climate Modification
(Cooling the City)

- Lowering of temperatures and mitigation of the Urban Heat Island through shade, evapotranspiration and modification of wind speed
- Improved building thermal performance with reduced energy demand for summer cooling
- Improved efficiency of photovoltaic solar systems

Economic Prosperity

- Increased commercial and residential property values through improved amenity
- Increased retail activity and improved opportunities for economic regeneration
- Improved tourism opportunities
- Potential healthcare savings by encouraging active, healthy lifestyles

Improved Urban Ecology

- Improved biodiversity through creation and preservation of habitat and ecological diversity
- Strengthening of habitat corridors and reducing habitat fragmentation
- Improved sense of place and increased human well-being through encouraging human connection with nature

6. Green Infrastructure Scales

It is important to understand that Green Infrastructure applications can be applied at a range of scales. Green Infrastructure should be considered within the context of planning framework from a strategic regional level down to the city street and individual allotment.

Through embedding Green Infrastructure within the City's Urban Design Framework, Council acknowledges that adopting these strategies will be important at a range of levels including:

- Policy and Planning: Influencing good planning and development.
- City Design: Creating livable streets and places.
- City Assets: Ensuring long term management improvement and reduction of asset renewal pressures.

Figure 12: Scales of Green Infrastructure

7. Cost Benefit Analysis

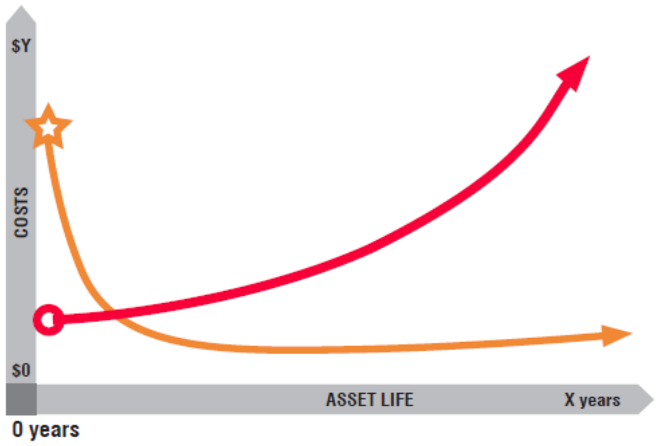
In the context of a whole-of-life-cycle cost analysis, the justification supporting a Green Infrastructure approach relies on the inclusion of a number of factors, which are both internal and external to the core operating requirements of city infrastructure.

Due to the interrelated nature of Green Infrastructure elements (and the city itself), it will often be the case that no single cost imperative will decide whether a street tree, raingarden, green roof, wall or façade will provide the immediate return on investment in terms of dollar for dollar matching of investment to return.

Notwithstanding this, there are many benefits of Green Infrastructure that are measurable by both quantitative and qualitative means. Some of these benefits will accrue to the party who has made the investment (such as a building owner who achieves an energy saving from the thermal performance improvement associated with their green roof). Others will accrue to recipients indirectly, such as the downstream water authority that has fewer contaminants and pollutants in the storm water that passes through or ends up in their environment.

Further to this, some of the benefits of Green Infrastructure will accrue to the public at large in the form of improved amenity, quality of life and general wellbeing. For example the reductions in temperature associated with mitigation of the Urban Heat Island effect may contribute to saving lives of vulnerable people during extreme weather events.

There are also less tangible and subtler benefits, such as the increased property values and economic activity associated with places that are perceived and experienced as 'green' and 'livable', which nonetheless translates as financial gain for property and business owners.



OPTION 1

Higher up-front costs associated with using high quality and robust materials and construction techniques.

This also involves investment in planning, design and coordination with other stakeholders to pre-empt and avoid unnecessary costs in future.

OPTION 2

Business as usual. Lower up-front investment in materials and construction to fit specified budget.

Over the life of the asset, there are increasing requirements for maintenance, repairs and replacement.

Impacts on materials, plant, resourcing and labour, taking into account other factors such CPI increases.

Figure 13: Comparison of Costs associated with Assets over Whole-of life (Diagram courtesy ACC)


ART GALLERY

Section B: Applications

8. Introduction

Green Infrastructure development in our cities lies primarily in the planning of a healthy growing environment for trees and plants within an urban setting. The most important factors associated with successful implementation of Green Infrastructure are;

- Provision of healthy soils,
- Provision of adequate growing environment and oxygen supply,
- Consideration of microclimate,
- Provision of a sustainable water supply and
- Appropriate species selection.

The definition and scope of the elements associated with establishing Green Infrastructure often overlap as they are inherently interrelated. These elements occur across a range of scales and applications in the urban environment including on and in buildings, within streets and in open space.

For the purposes of these guidelines, Green Infrastructure applications can be broadly defined by the following categories, which are described in more detail throughout this section:

- Living Architecture
- Green Streets
- Water Sensitive Urban Design
- The Urban Forest

Hard vs. Soft Engineering

Adopting a Green Infrastructure approach to city development is consciously different from applying standard methods and processes of urban development. The central difference as illustrated by the diagram below is the shift from an engineering based hard infrastructure approach to a natural systems or 'soft engineered' approach.

Green Facade

Median planting, Halifax Street, Adelaide

Hard Engineering

Polluted storm water run-off is repelled by impervious surfaces and directed into a gross pollutant traps, pits and pipes to filter large debris, before being transferred away to another site

Soft Engineering

Polluted storm water run-off is captured by a soft infrastructure system where a range of processes filter and cleanse the water on site, while also providing passive irrigation to plants and adding to the amenity of the city

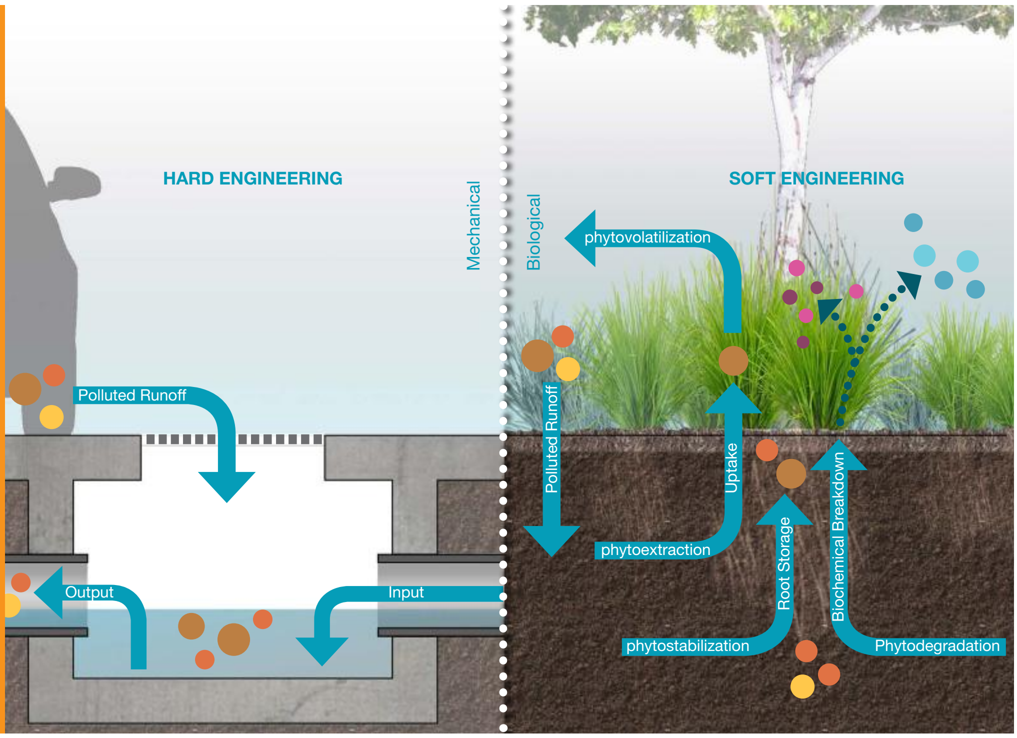


Figure 14: Hard Vs. Soft Infrastructure

9. Living Architecture

Description

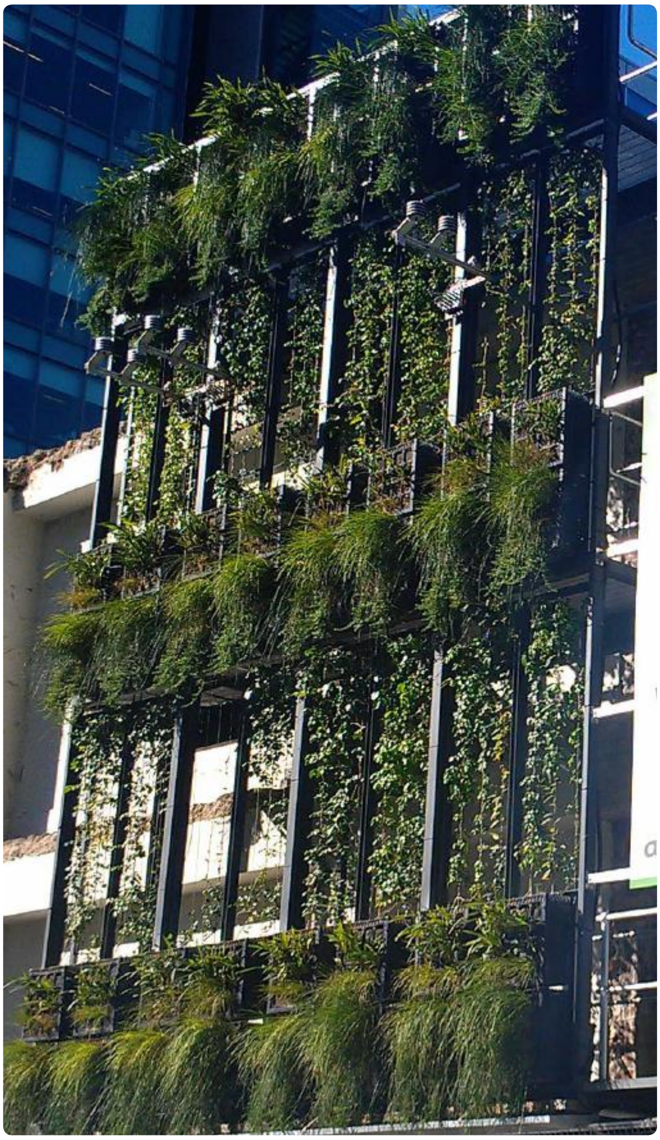
Living Architecture can be described as the integration of plants, soil and water with built form. Living Architecture includes the incorporation of green roofs, green walls, and green facades onto and into buildings and other structures.

As a component of Green Infrastructure, Living Architecture can green the city without taking up valuable on-ground space. This is achieved by utilising the vertical surfaces and roof tops of buildings which would otherwise be left devoid of living systems.

Benefits

The integration of vegetation with built form provides a number of important benefits including:

- Contribution to human wellbeing (through the provision of plants in close proximity to people within buildings)
- Improvement in the thermal performance of buildings (especially for summer cooling)
- Regulation of the Urban Heat Island effect on the wider city
- Regulation of storm water impacts at both the building scale and in the surrounding environment
- Reduced water usage in buildings and encouragement of water recycling
- Contribution to biodiversity values (green roofs can act as refuges for invertebrates and other fauna)
- Clear statements of commitment to sustainable design (being seen to be green)
- Increased property values and improved amenity for people
- Improvement in the performance and power output of PV arrays on hot days (to save energy and reduce peak demand)
- Achieving environmental 'stretch targets' such as 'net zero' water and energy (such as Green Star, LEED and the Living Building Challenge rating systems)



Adelaide Central Green Facade

Green Roof

10. Green Streets

Description

A Green Streets approach to Green Infrastructure views the street as one of the most important elements in the city's public realm. This approach prioritises the public realm experience of a street over an approach solely focused on traffic management. It emphasises the contribution good street design can make to the broader livability and sustainability of the city, including providing pedestrian amenity and the activation of commercial and retail spaces.

A Green Street includes trees, low plantings and raingardens where space allows, and provides a more balanced approach which prioritises pedestrian and cyclist movement over vehicles where practical.

Growing Environments

The success of a Green Streets approach lies primarily in the planning, design and implementation of a healthy growing environment for trees and plants within the often congested and contested right of way between property title boundaries. The primary features associated with effective implementation of Green Streets are healthy soils; an adequate growing environment and oxygen supply; appropriate species selection; an understanding and optimisation of microclimate; and the provision of an adequate water supply. The healthy establishment and maturation of trees depends on the provision of adequate soil volumes.

Passive Irrigation

Passive drainage systems that involve less-constructed in-ground works should be included where possible. This marks a distinction between 'hard' and 'soft' engineering approaches to storm water management. A 'soft' approach has potential capital cost savings with the avoidance of underground pits, pipes and other drainage infrastructure. It also provides 'add on' benefits over and above the core storm water management function including increased related asset lifespan. For example, adjacent pavements are less likely to be lifted by tree roots as they won't rise to the surface looking for water.

Maintenance

It should be acknowledged that as with all infrastructure systems, Green Streets require a level of maintenance (such as occasional removal of sediment build up in raingardens). However if a system is well planned and designed, the maintenance level will be similar to a grey infrastructure approach, and can be easily factored into the life cycle cost assessment of each project.

Adelaide Laneway Green Streets revitalisation, Leigh Street Adelaide

North Terrace Planting , Adelaide

Rundle Street Revitalisation , Adelaide

Planning, Placement and Character

Street Trees are one of the most important organising elements of a streetscape. They help create defining zones of movement, assist with traffic calming and provide shade for footpaths.

In order to achieve long term success, it is integral that upfront planning for street greening is undertaken taken as an integral component of a streetscape upgrade or development.

As a planned city, Adelaide has an ordered grid structure. To assist with wayfinding and the enhancement of city character, street tree planting should be used to reinforce the grid structure. Tree species and material selections should also take into account the spatial characteristics of the variety of different streets that occur within the Light plan.

Benefits

From a planning and development point of view, the prioritisation and enhancement of the urban streetscape will lead to an overall improvement in the quality of urban life.

Other benefits of a Green Streets approach include:

- The promotion of walking and cycling which encourage a healthy lifestyle
- Improved safety for pedestrians and children (not car dominated)
- The provision of shade for amenity, respite and human comfort
- Integrated storm water management (connects into other Green Infrastructure approaches)
- Improved urban biodiversity (with appropriate species selections)
- Reinforcement and definition of the unique urban character of the city
- Assistance with navigation and wayfinding

Mature street tree planting, Gover Street, North Adelaide


Structural soil cells can be used to achieve optimum growing conditions for street trees in restricted locations

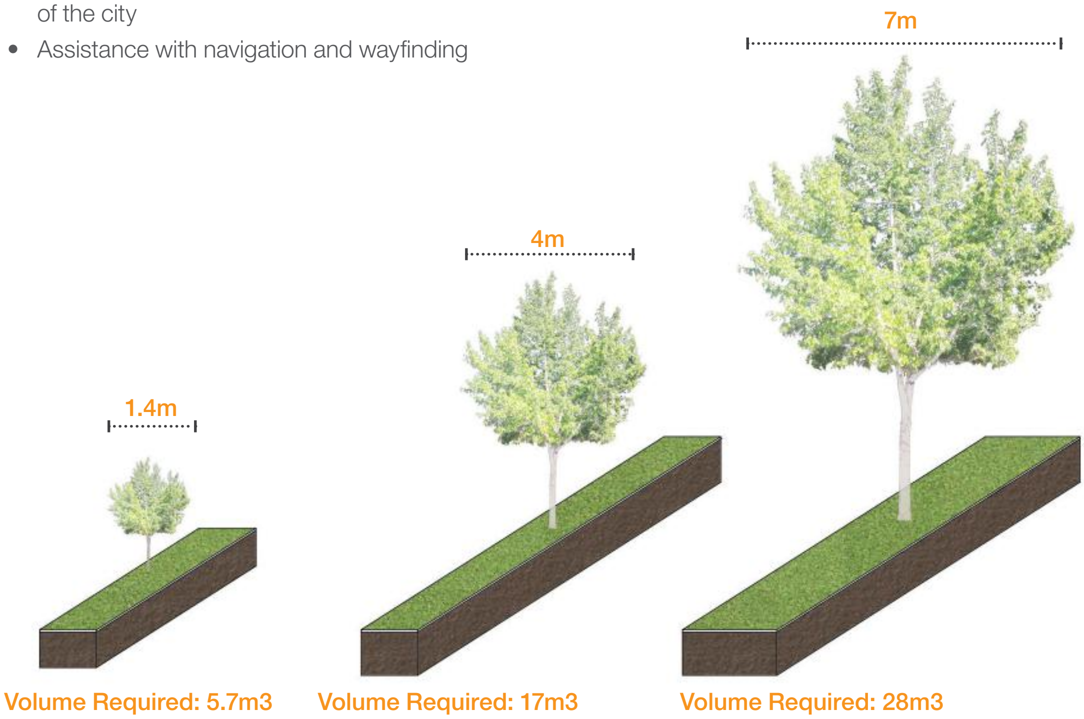


Figure 15: Optimum Soil Volumes for Tree Planting

11. Water Sensitive Urban Design

Description

Water Sensitive Urban Design (WSUD) is an approach to the way we design the infrastructure of our cities in relation to the management of the urban water cycle. A WSUD approach provides a range of elements to manage storm water, with the aim of improving the health and quality of our waterways and creating healthy resilient cities. This is achieved using a combination of elements such as raingardens, swales, permeable pavements, constructed wetlands, rainwater tanks and other measures that slow down storm water, retaining and treating on site before it enters the drainage system or infiltrates into the ground water catchment.

As our cities have expanded, the areas of impervious surfaces including sealed roadways, concrete footpaths and building rooftops have also increased, creating vast quantities of storm water runoff. Traditional storm water management techniques have focused on controlling this storm water and diverting it to the receiving waters as quickly as possible. However, contaminants such as nutrients (nitrogen and phosphorus), heavy metals, litter and debris are picked up and carried with the storm water, ultimately being deposited into our rivers, bays, and oceans. Pollution of our oceans and waterways not only causes significant environmental degradation, but is also a human health hazard.

Diverting water away from the city also means urban landscapes do not benefit from the majority of urban rainfall, with decreased infiltration leading to depleted ground water supplies and an increased reliance on imported water. This is a particularly pertinent issue for Adelaide as a city with low rainfall and high summer temperatures.

Roadside Raingarden, Grote Street, Adelaide

Water Savings

As water is a vital element in the success of Green Infrastructure initiatives, WSUD is an important component in other approaches to Green Infrastructure. For example:

- **A raingarden can be part of the experience of a streetscape, facilitating and integrating with a Green Streets approach to provide additional greening. It can also capture and treat storm water run off for re use as irrigation for green roofs, walls and facades.**
- **Water flowing off a road can contribute to the greening of the city by encouraging the growth of large more vigorous trees for shade and beauty,** enhancing the Urban Forest.

Small raingardens also suit a residential scale

A WSUD approach endeavors to minimise these impacts by:

- Treating storm water on site using bioretention and other measures to remove contaminants and improve water quality
- Reducing storm water run off through use of permeable pavements, rooftop gardens and green walls
- Providing passive irrigation to the urban landscape (trees and planting).

The Adelaide City Council already has a range of WSUD Strategies in place, with WSUD considered for all streetscape renewal programs. Implemented WSUD solutions can be found in a number of city streets including Hutt Street, Kermode Street and Flinders Street.

Benefits

WSUD features not only improve storm water quality, but also positively contribute to the urban environment by providing enhanced green spaces and re connecting people to the natural processes and dynamic elements of the weather.

There is clear evidence that an appropriately implemented WSUD approach leads to improved tree and plant health.

Other benefits of WSUD include:

- Provision of irrigation to the urban landscape, urban forest and living architecture elements such as green roofs, walls and facades
- City cooling through evapotranspiration
- Improved city biodiversity and creation of wildlife habitat
- Reduced capital costs and construction costs for storm water infrastructure
- Increased property values through improved amenity to streets
- Reducing peak flows, taking pressure of the drainage system and reducing flooding.

Raingardens can be incorporated into an urban public realm setting. Auckland Waterfront, New Zealand

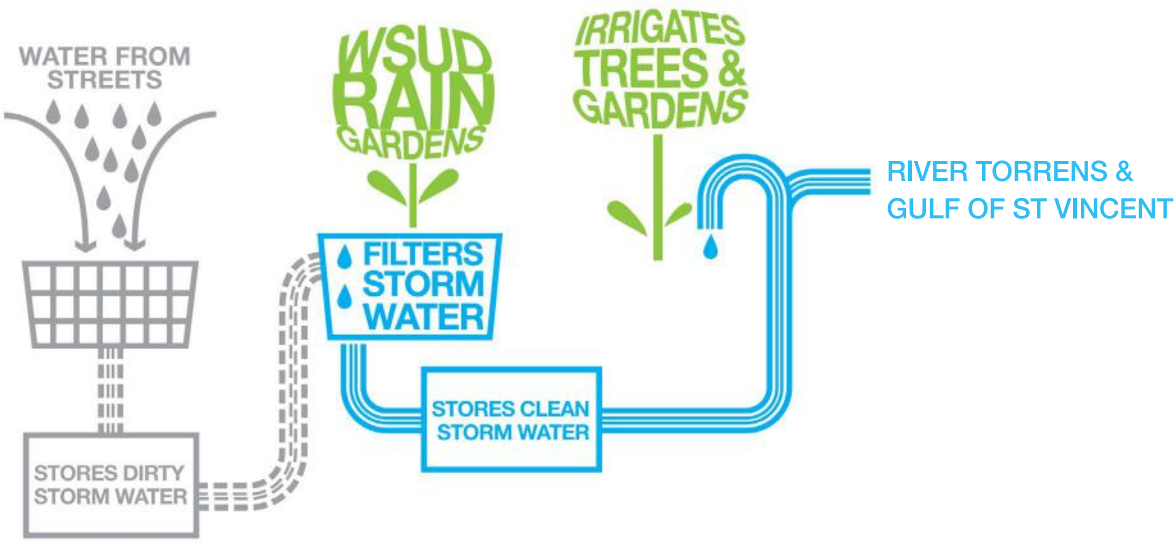


Figure 16: WSUD Processes

12. The Urban Forest

Description

The Urban Forest is comprised of the collection of trees in an urban area, including city streets, parks, reserves, individual properties, and within private gardens and public institutions. The Urban Forest also includes middle and understory plants which, combined with trees, make up a primary and essential element of a healthy urban ecosystem.

An Urban Forest approach advocates that trees should be managed in a similar way to conventional forestry, with a unified management approach, long term aims, clear goals and objectives, and decisions made strategically not reactively.

Species Selections

Considerations when developing Urban Forest planting strategies and master plans include:

- Tree species assessments based on tolerance traits specific to the relevant locations
- Consideration of long lived trees for contribution to future resilience
- Selection of individual species based on resilience in the face of climate change
- A diversity of species for resistance to disease
- Evaluation matrices to rate tree performance in terms of a range of values including tolerance, longevity, amenity, habitat value, heritage, etc
- Suitability for integration with services infrastructure and other Green Infrastructure approaches such as WSUD
- Community engagement and consultation for tree succession and replacement programs

Integrated Design

As with the other Green Infrastructure approaches, a healthy Urban Forest is promoted by incorporating other Green Infrastructure elements. For example, the WSUD principles of passive irrigation of street trees and planting within raingardens are important to a healthy Urban Forest. Opportunities for street tree planting can also be mediated with living architecture. For example, if availability of space precludes tree planting, a green wall could be considered.

Urban Forest initiatives in Adelaide

The Urban Forest - Million Trees program is a SA State Government initiative with a goal to plant 3 million local native trees and under-storey plants across the Adelaide metro area. The program has been in place since 2003, and has already provided numerous benefits including: recovery and protection of biodiversity and wildlife habitat, reduction of water consumption, and improved community awareness of sustainability issues.

See more at http://www.milliontrees.com.au

Benefits

The benefits of the Urban Forest compliment and reinforce those of other Green Infrastructure approaches, and include:

- Mitigating the Urban Heat Island effect
- Providing habitat and increasing urban biodiversity
- Contributing to the amenity of the city for people, both visually and by providing shade and creating a strong sense of place
- Increased property values through improved amenity and resultant activation of spaces

A significant and resilient Urban Forest will also promote overall social and economic vitality to the city centre and link in with the principles and benefits of a Green Streets approach.

Street Planting, North Adelaide

Established Park Lands trees, Whitmore Square, Adelaide

13. Urban Food

Description

Although not strictly an essential component of Green Infrastructure, Urban Food Production is an important and related ideology. Food growing within public areas can be beneficial in meeting Green Infrastructure objectives, and there may be opportunities to include fruit and nut bearing trees as part of the Urban Forest.

As our cities continue to grow in size and population, food production in both public and private spaces, will not only be desirable, but will become a vital element of sustainable urban development.

Urban food production can take place over a range of scales from backyard or balcony veggie gardens, to productive gardens on building walls and rooftops and large scale orchards and city farms. There is also a momentum for 'pop up' food production parks, often in the form of small scale planters, and green walls. These temporary features promote an engagement with Green Infrastructure initiatives which can flow through to more permanent works.

Key opportunities for Urban Food Production in Adelaide City include Community Vegetable Garden, pop up food gardens, Verge Gardens, Urban Orchards, rooftop vegetable gardens and food walls

Community ownership

Communities are already increasingly expressing a desire to grow their own food in the city. This includes individuals who do not have access to a back yard garden and want to grow produce, to commercial restaurants who want to promote low food miles ingredients and have access to the freshest possible produce.

For urban food initiatives in public spaces, clear definition of ownership and management is needed before the project starts. There is opportunity to develop approaches and strategies to work with the community to facilitate community ownership and management of urban food gardens in public places.

Benefits

Along with providing a most fundamental human resource, urban food initiatives provide educational opportunities, encourage engagement with and care of the city landscape and contribute to community building. Fostering this community spirit will encouraged more people to actively participate in creating and maintaining the green spaces in the city. Urban Food production encourages and espouses the following values and benefits:

- Community engagement and inclusion
- A source of fresh produce having 'low food miles'
- Contributing to food security in cities
- Activation and revitalisation of the public realm

Pop Up Urban Food Garden, Melbourne

Whitmore Square Verge Community Garden, Adelaide

Section C: Elements

14. Green Roofs and Podium Planting

14.1 Introduction

Description

A green roof is a vegetated roof surface, consisting of various layers that can be installed either in pre grown modules, or 'loose laid' over the top of the roof deck. Depending on the depth of planting substrate, a green roof can be classified as 'intensive' (deep), or 'extensive' (shallow).

Benefits

Deploying plants horizontally onto buildings has a range of benefits, including but not limited to: reducing internal building temperatures (and energy demand for cooling); cooling the local area (to mitigate the UHI effect); reducing reflection from glazed surfaces; reducing the volume of storm water run off and peak flow rates; improvement in the efficiency of PV solar arrays and HVAC systems; and protection of the roofing membranes.

With good design and appropriate species selection, green roofs can also form an important biodiversity asset, particularly on larger roofs close to natural areas.

Design Considerations

Structural Requirements

Green roofs can be installed on existing buildings provided there is sufficient capacity in the existing structure (otherwise structural augmentation will be required). In the case of a new building, a green roof can be economically accommodated in the design load, especially if the structure is a concrete roof deck. In the case of a light weight roof structure, additional structural support will be required.

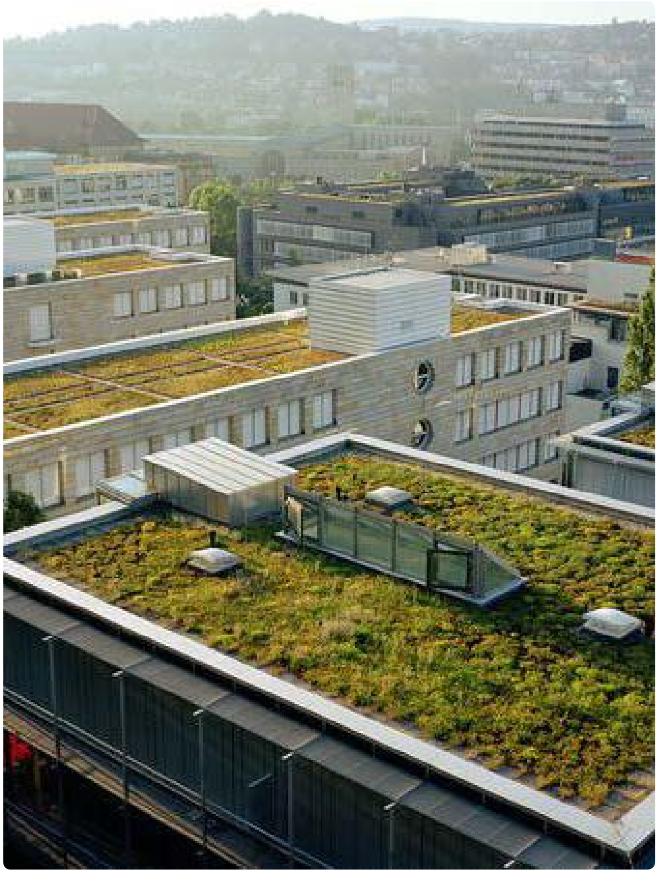
Consideration will need to be given to the ability of the support structure to accommodate the imposed loads of the substrate (when saturated) and vegetation (when fully established).

Amenity and Access

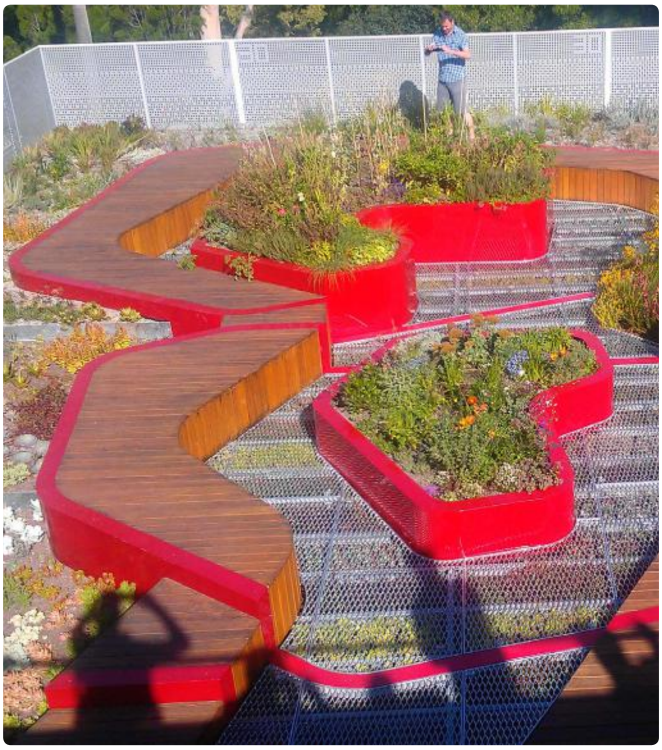
Both intensive and extensive green roofs can include the provision of hard paved surfaces, decks, seating, and shade elements to provide amenity to people occupying the spaces. If the green roof is publicly accessible, fall protection (balustrades), and fire egress (lift and stairs) will be required in line with BCA requirements.

Plant Selection

Considerations for plant selection include storm water management objectives, biodiversity objectives, aesthetic requirements, root zone requirements, drought tolerance. The tolerance of plant species to the conditions on the roof including availability of water, wind impacts, temperature fluctuations will also need to be taken into account when selecting plant species.



Green Roof ,Stuttgart



Intensive Green Roof ,Melbourne School of Land & Environment Burnley Campus

Roof Pitch

For extensive green roofs, roof pitches from zero to fifteen degrees can be accommodated without the need for additional lateral support. For pitches steeper than fifteen degrees, lateral support must be provided by way of confinement cells or some other system to provide tensile strength to avoid the assembly shearing and sliding down the roof slope.

Waterproofing and Irrigation

Design of the roof penetrations for vents, light wells, and other building services will require special attention so as not to compromise the water proof membrane.

If possible the hydraulic design of the roof run off should be directed to a rainwater storage tank for irrigation re use. This will allow recovery of irrigation run off through the roof garden and maximise the re use of harvested rain water. This is especially important in summer when rain fall is lowest and irrigation demand highest. If a green roof is planned, it is essential that water balance studies are undertaken up front and irrigation systems are integrated with water management, and include necessary features such as water sensors.

Thermal Performance Monitoring

If the objective of the green roof is to regulate the building internal temperature for a reduction in the energy demand for cooling, than a simulation of total building heat transfer will need to be undertaken by a ESD / Mechanical engineer to demonstrate compliance with the Building Code of Australia's Section J for building thermal performance. It is also possible that the green roof will eliminate the need to thermal insulation for cooling in summer. If this is the case this will also need to be modelled and simulated to meet the requirements of the BCA Section J.

Maintenance Considerations

Like any garden, green roofs will require period maintenance to keep them at optimum health and vigour. This will take the form of intermittent weed removal, fertilisation and pruning as necessary to keep drainage structures and other equipment such as air intake units, vents, skylights free from foliage. There may also be a requirement to rectify any damage that has been caused by adverse weather conditions such as high winds or deluge rain events.

It is also of critical importance that the irrigation system be periodically checked and maintained so that the water delivery, reticulation, and controller systems are all in correct working order. If the irrigation system fails it is likely that the planting will be impacted especially during warm and dry weather. Ideally, the irrigation system should have failsafe mechanisms such as communication network capability so that alerts can be sent and immediate response provded to correct a fault without risk of impact to the vegetation, or wasting water.

A well designed green roof should not require excessive maintenance and it would be usual that 6 to 9 visits per year will suffice during the establishment phase, with this level dropping off once the roof garden has matured.

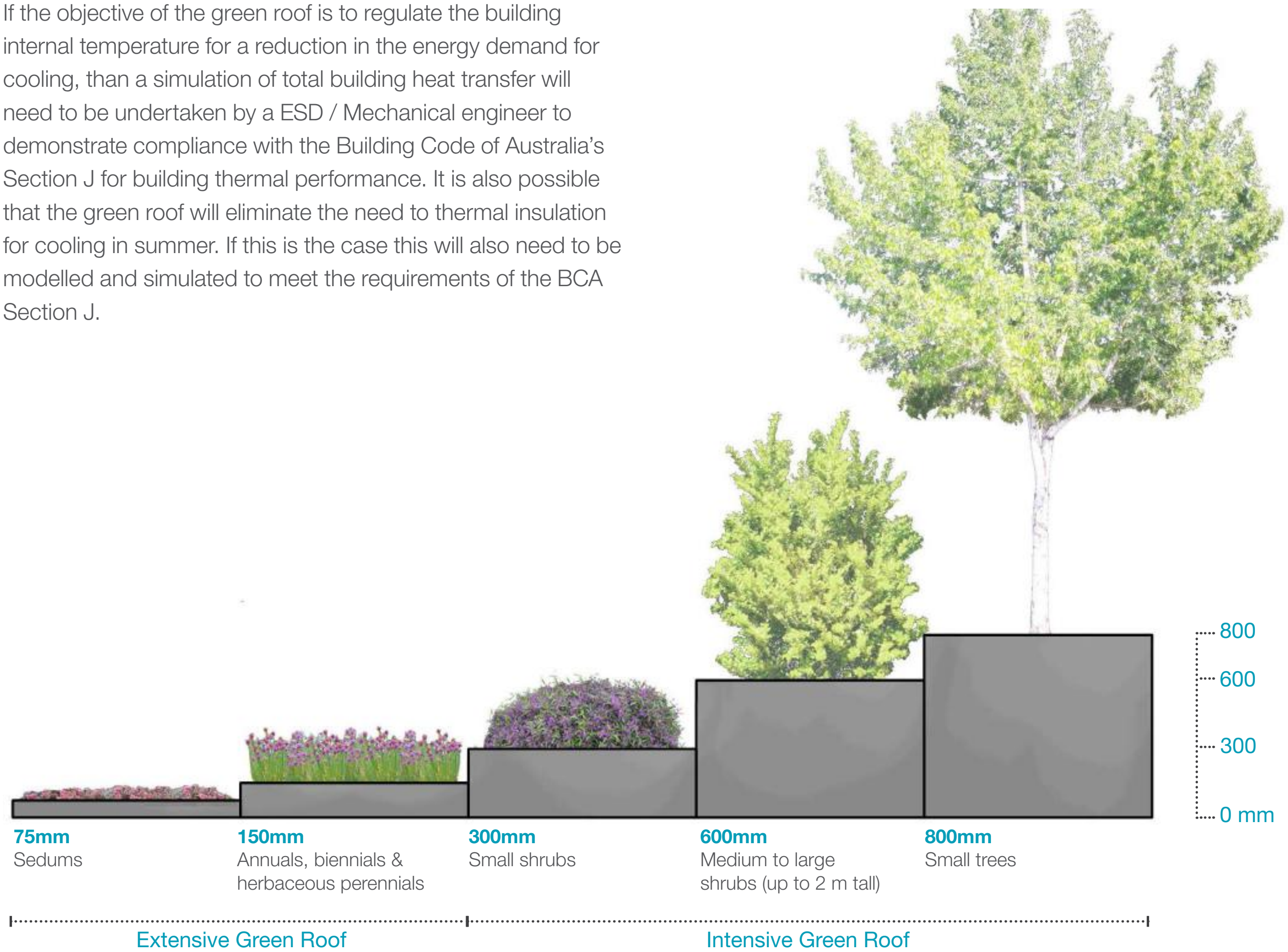


Figure 17: Green Roof Substrate Depth Diagram

14.2 Extensive & Semi Extensive Green Roofs

Description

Extensive and semi extensive green roofs are vegetated roof systems, comprising of a series of layers above the roof deck including: a waterproofing membrane; a root protection layer; a drainage layer; a filter layer; growing substrate; irrigation; ballast (mulch) and plants.

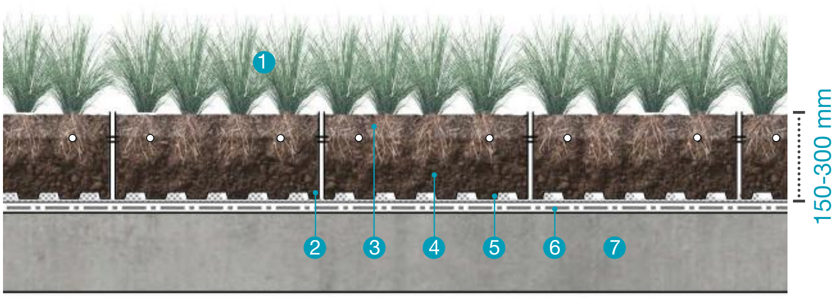
Extensive and semi extensive green roofs are shallow compared to intensive roof gardens, and can be installed either in situ or in pre grown modules.

Design Considerations

- Typical substrate depths range between 150mm to 300mm
- The associated maximum saturated dead loads are between 1.5kPa and 3.0kPa. Live loads for maintenance need to be added separately to this, and if the green roof is to be publicly accessible then additional live load allowances need to be given in line with BCA requirements.
- Due to the relatively shallow depth, extensive green roofs will usually require irrigation, primarily during warm and hot periods. Irrigation should be sourced from site captured or recycled water.

Extensive Roof Garden, Kangan Institute, Melbourne by ASPECT Studios

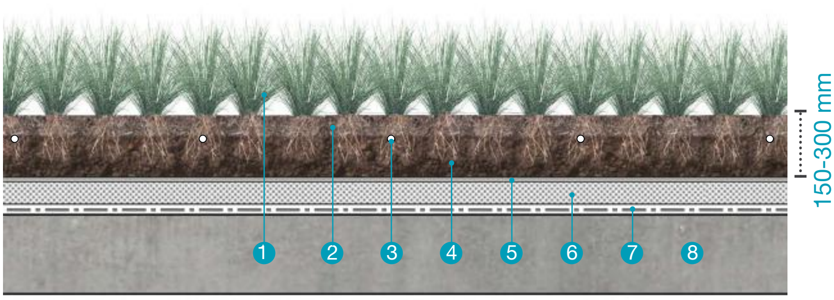
Extensive Green Roof, Victorian Desalination Plan, Melbourne by ASPECT Studios



KEY

1. Planting
2. Interlocking Modules including irrigation (approx 500 x 500mm)
3. Mulch Ballast
4. Growing Substrate
5. Integrated Filter/ Drainage Layer
6. Waterproof Membrane
7. Roof Deck

Figure 18: Indicative Modular Extensive Green Roof



KEY

1. Planting
2. Mulch Ballast
3. Irrigation
4. Growing Substrate
5. Filter Layer
6. Drainage Layer
7. Waterproof Membrane
8. Roof Deck

Figure 19: Indicative In Situ Extensive Green Roof

14.3 Intensive Green Roofs

Description

An intensive green roof is a vegetated roof system with a similar buildup of layers to an extensive green roof, but with greater soil depth to enable trees and a wider range of plants to be grown.

An intensive green roof system can also be applied at ground level over basement podium structures such as underground carparks.

Typically intensive green roofs and podium roof gardens will have substrate depths between 300mm to 600mm, with deeper areas where large shrubs and trees are to planted. Depths can be up to 1.2m to allow for the establishment of medium to large trees.

Design Considerations

- With the inclusion of large trees, dead loads of an intensive green roof can range from 3.0kPa up to 10kPa. Dead loads can reach 15kPa or more when the weight of mature large trees is factored in. These areas of high loading can be located over supporting columns and internal load bearing walls to assist with distributing the load and reducing the cost of structure.
- Intensive roof gardens and podium planters should be irrigated, especially during hot periods. As with extensive green roofs, irrigation should preferably be provided with site captured or recycled water with integrated water management systems including moisture sensors.

Intensive Roof Garden, Darling Quarter, Sydney by ASPECT Studios

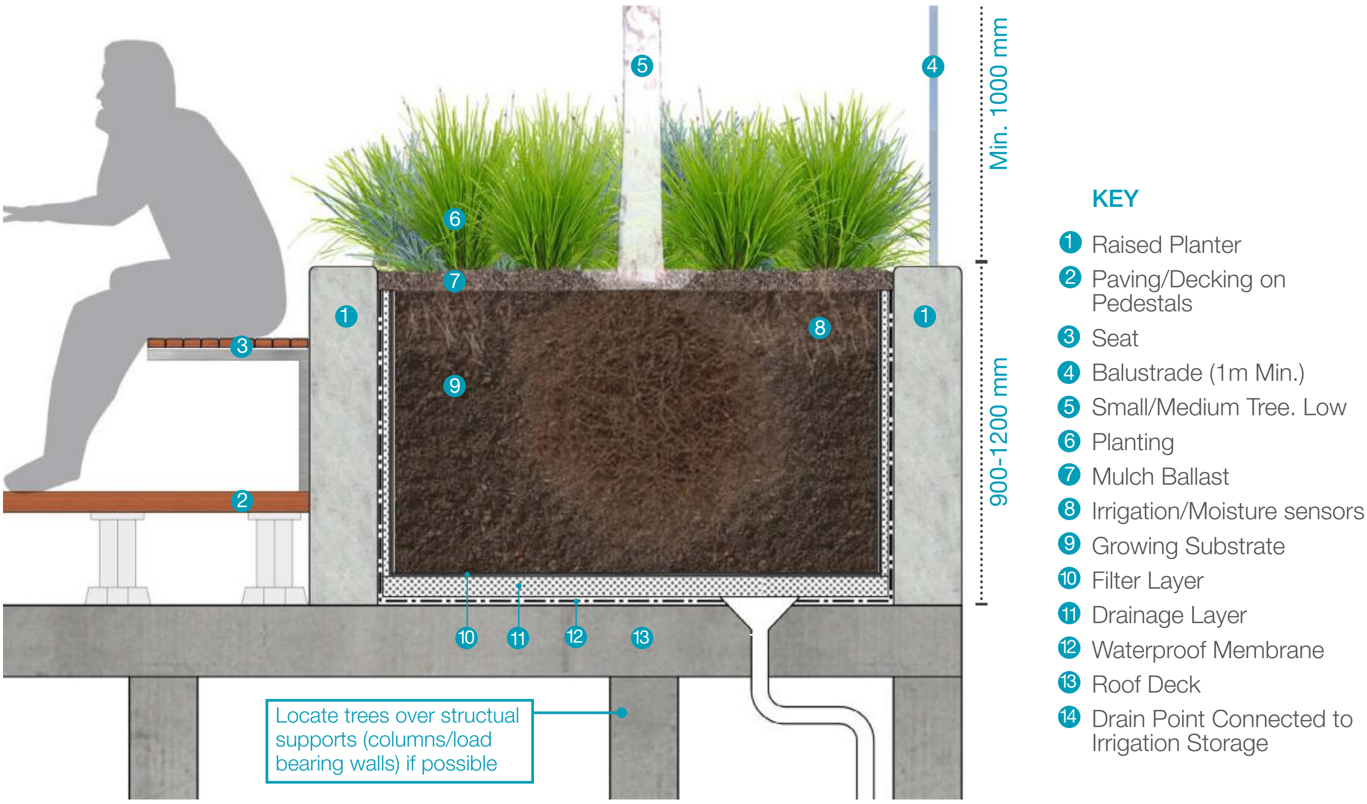


Figure 20: Indicative Intensive Green Roof

15. Green Walls

15.1 Introduction

Description

A green wall can be either a modular (containerised) system or a fabric-based growing system, that is erected directly on to building walls and supports predominantly herbaceous plants.

Green walls are continuously planted surfaces that provide a high quality visual feature. They also provide a cooling effect due to evapotranspiration of plants, and reduced heat absorption.

Benefits

Deploying plants vertically onto buildings has a range of benefits in terms of the Green Infrastructure objectives, including but not limited to reducing internal building temperatures, cooling to local area, reducing reflection from glazed surfaces and reducing the volume of storm water run off.

Design Considerations

Depending on the system used the weight will either need to be borne by the wall to which it is attached, or otherwise supported by a separate free standing structure.

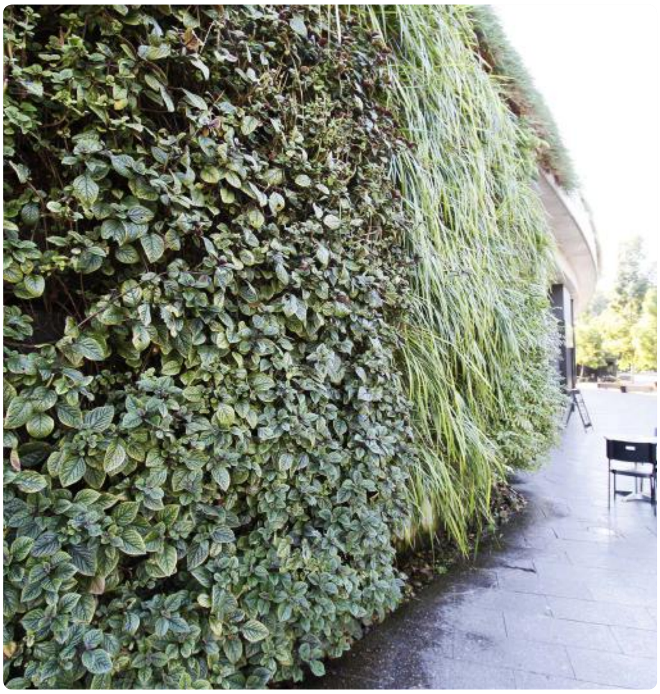
Green walls typically have relatively high water demand, and cost per square metre of planted surface when compared to green facades.

Green walls will require continuous irrigation, which, as with green roofs, should preferably be provided from site captured or recycled water.

Maintenance Considerations

Green walls have similar maintenance considerations to green roofs, with the primary difference being one of access. If an integrated Building Maintenance Unit (BMU) is not present, then mobile access will need to be provided. This could take the form of an elevated work platform, or scissor lift.

Likewise, green walls require the same consideration for irrigation system maintenance as green roofs, however with green walls irrigation is even more critical due to the high water demand and the vertical orientation of a green wall. The conveyance of water from top to bottom results in the upper zones of the green wall becoming rapidly dry in the event of irrigation failure.



Green Wall, Adelaide Zoo

Internal Green Walls

Modular Green Wall

15.2 Hydroponic Green Wall Panels

Description

A living wall system that provides full vegetative cover across an expanse of area based on a non organic textile as the growing support. This system requires intensive and continuous fertigation (irrigation with nutrients added to the water).

15.3 Modular Green Walls

Description

A substrate based living wall system that provides pre grown, fully vegetative cover across an expanse of area supported by vertically mounted, containerised planting media, and integrated irrigation.

Patrick Blanc Hydroponic Green Wall, France

Modular Green Wall, Adelaide Zoo

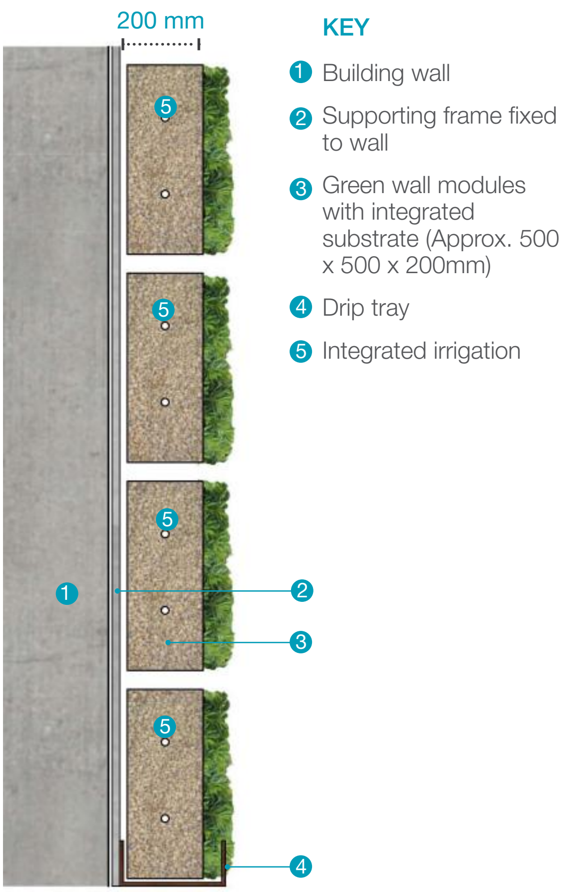


Figure 21: Modular Green Wall

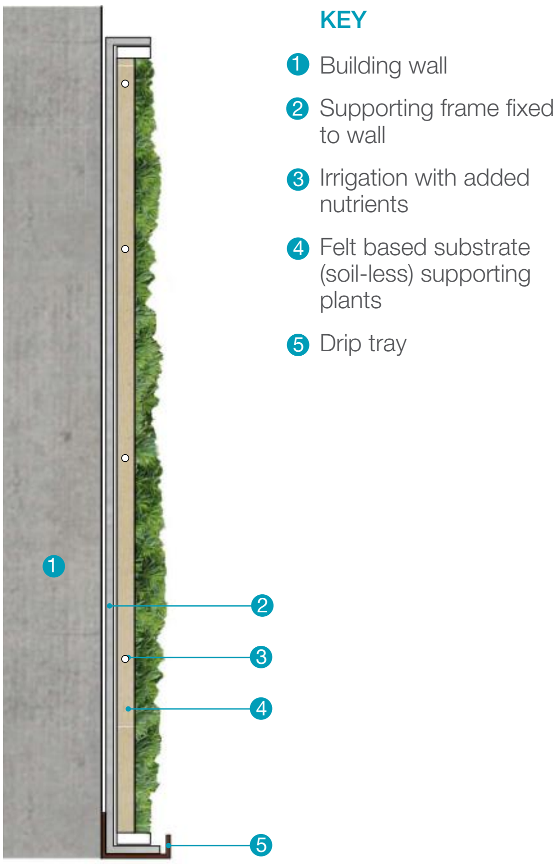


Figure 22: Hydroponic Green Wall

16. Green Facades

16.1 Introduction

Description

A green facade is a system of plants grown over a building wall (or in front of glazed areas), either climbing up or hanging down. A green façade can consist of climbing plants either directly affixed to the building wall, utilising a cabling or a trellis support structure adjacent to a wall or in front of glazed surfaces. Plants can be grown in ground or in containerised systems at height.

Benefits

The main benefit of a green facade is that it can be installed in front of glazed wall surfaces and window to directly reduce the sun incident and heat load on the building.

Other benefits include, cooling to local area, reducing reflection from glazed surfaces and reducing the volume of storm water run off.

Design Considerations

Structural Requirements

Consideration needs to be given to the ability of the support structure to accommodate the imposed loads of the substrate and vegetation. The tolerance of plant species of the conditions and exposure in terms of availability of water, wind impacts, temperature fluctuations also needs to be considered.

Plant Selection

Most climbing species will comfortably reach a height of between 3m and 5m. If the area to be planted is higher than this then planting modules or containers will need to be provided progressively up the structure to ensure full cover of vegetation. The integration of the green façade with the building structure will need to consider how irrigation and drainage is managed, as well as the provision for access for maintenance. Preferably, this will be from either from a Building Maintenance Unit (BMU), or at each level form a access walkway.

Thermal Performance Monitoring

If the objective of the green façade is to regulate the building internal temperature for a reduction in the energy demand for cooling, then a simulation of total building heat transfer will need to be undertaken by a ESD / Mechanical engineer to demonstrate compliance with the Building Code of Australia's Section J for building thermal performance.

Maintenance Considerations

As with green walls, maintenance of a green façade will require access at height to undertake pruning and check the irrigation system. Preferably this will be integrated into the building by way of a BMU, however if this is not possible then it will need to be provided by a high access contractor via abseil. Alternatively some green façades can have access provided by integrated walkways at each level.

One Central Park, Green Facade, Sydney (ASPECT Studios)

Sihlcity Carpark Green Facade, Zurich (Image credit: Tensile Design & Construct)

Render- Living Louvre System (ASPECT Studios)

16.2 Hybrid Green Facades

Description

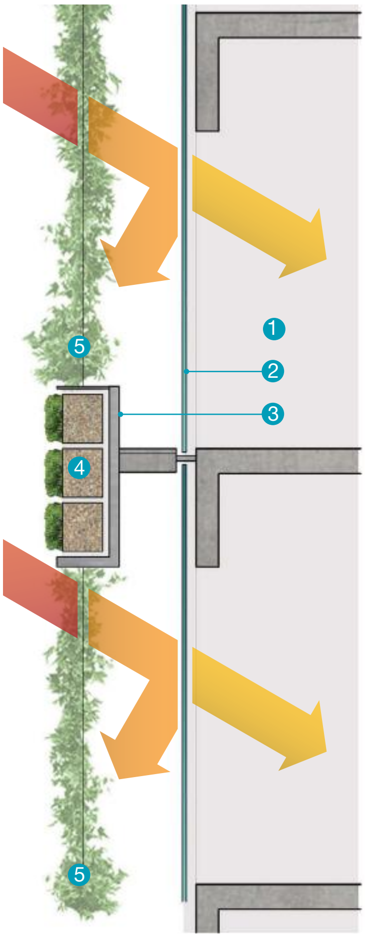
A combined system that includes both massed vegetative cover with climbing and / or trailing plants supported on lattice or cable structure, either planted insitu or pre grown. A hybrid green façade combines green wall planting modules mounted at approximately 4m height intervals, with climbers supported by stainless steel cables or mesh between these. This approach enables vertical greening to reach significant heights at relatively low cost and low water demand.

Benefits

A Hybrid green facade can economically achieve plant coverage over large areas without the need for continuous irrigation, and with relatively low water demand.

Design Considerations

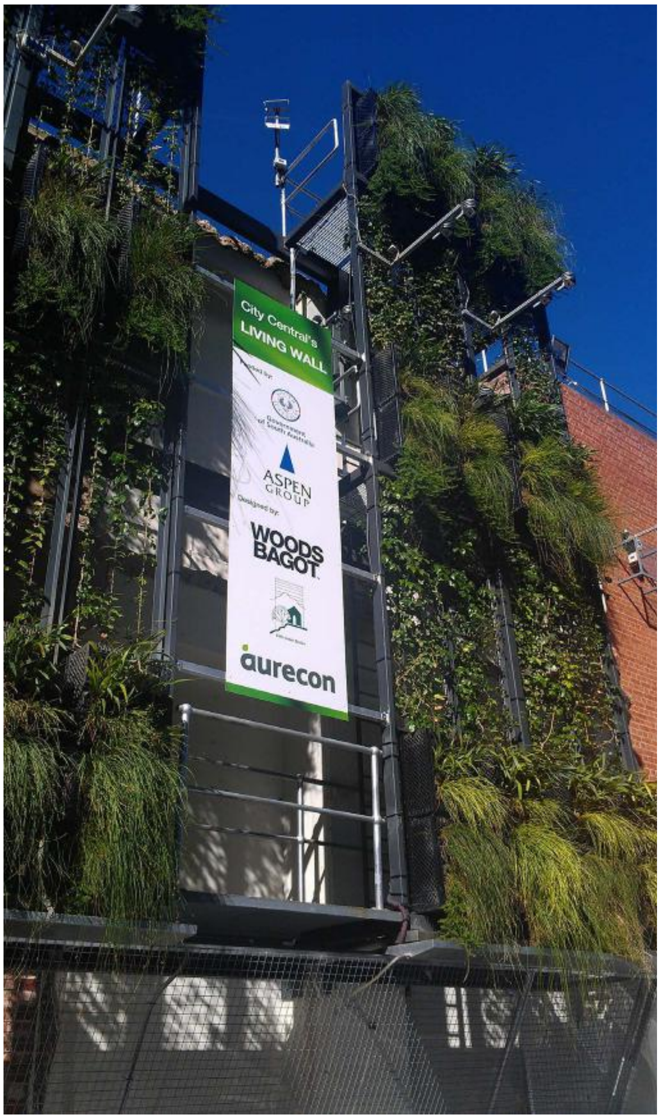
As the majority of plant coverage is by climbers, these can be set either directly in front of, or adjacent as louvres to reduce the sun incident on the glazing, thereby reducing heat loads and reflectivity.



KEY

1. Building Interior
2. Building Glazing
3. Supporting frame fixed to wall
4. Green wall modules with integrated substrate
5. Climbers

Figure 23: Hybrid Green Facade



Hybrid Green Facade, Adelaide Central

16.3 Climbers on Cables

Description

Supporting plants vertically using stainless steel cables allows coverage over large areas. The cables can take the form of linear runs (either installed vertically or diagonally). Alternatively stainless steel mesh can be used which has the advantage of functioning as both a support for plants, but also as a barrier for a balustrade or fence.

The growing volume for the plants can be on-ground, or mounted at height.

Benefits

Supporting plants vertically using stainless steel cables enables to cover large areas for relatively low cost.

Design Considerations

There is a limit to how high the planting can establish (typically 3-5m).

Climbers on Angular Cables

Climbers on cables, Halifax Street Adelaide

16.4 Climbers on Walls

Description

This approach involves attaching plants directly to the building surface. Some species of climbers such as *Ficus pumila*, and *Parthenocissus tricuspidata*, have an inherent ability to fasten themselves to flat surfaces. This trait allows them to cover a building wall without the need for any additional support.

Benefits

Due to the simplicity of the approach plant coverage can be achieved for the cost of the plants alone.

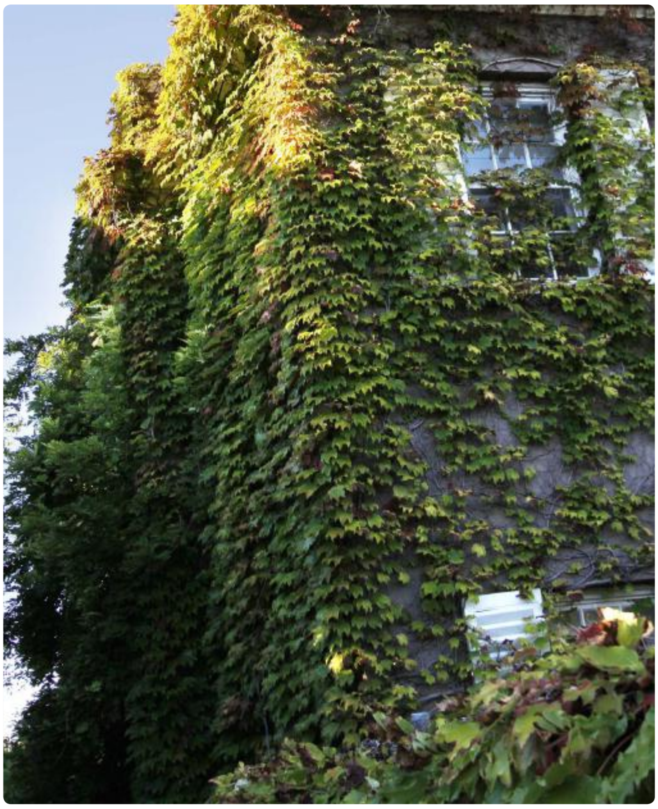
Design Considerations

Care must be taken when using climbers on heritage buildings due to potential structural implications and impacts on lime mortar.

Establishment of plants will need to be from ground based garden beds, which often need to be narrow, and may require irrigation (depending on species selection).

Some species which are appropriate for climbing directly on buildings are deciduous. If these species are to be used, consideration should be given to the aesthetic and maintenance implication of falling leaves and seasonal change.

Climbers on Wall, North Adelaide



Climbers on Wall, North Adelaide

Climbers on Wall, North Adelaide

16.5 Climbers on Verandahs/Arbours

Description

This approach uses structures that are either already in place or purpose built, to support plants. Many buildings have elements such as verandahs and balconies which lend themselves to being greened. The approach involves the use of posts to achieve vertical height and structural members such as beams to allow the horizontal spread of plants.

Benefits

Due to the simplicity of the approach plant coverage can be achieved for the cost of the plants alone.

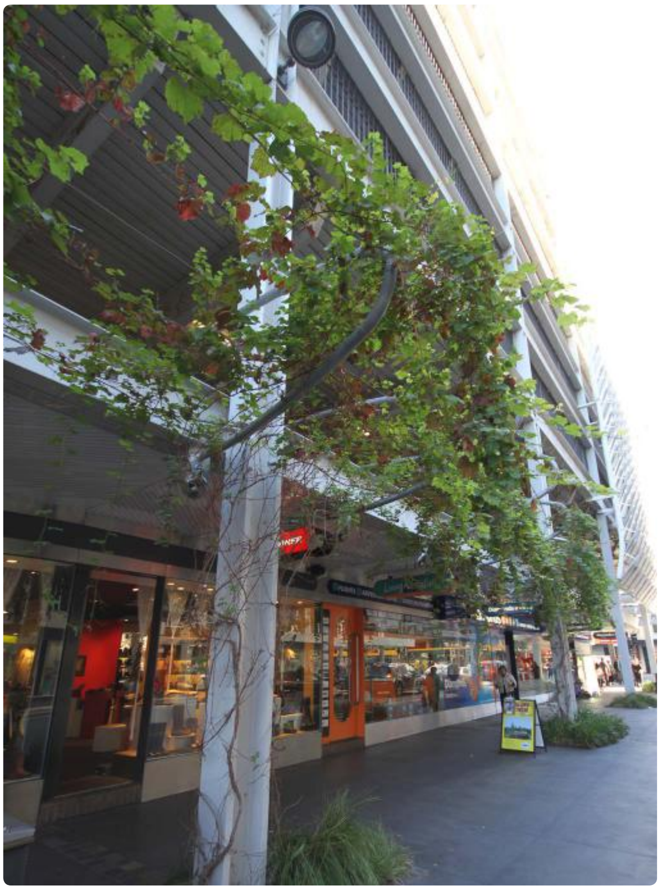
Design Considerations

Consideration should be given as to the structural capacity of the element being grown upon, as some species of plant (such as Wisteria) can reach considerable mass. If being purpose built, these loads can be taken into account in the design.

Establishment of plants will need to be from ground based garden beds, which often need to be narrow, and may require irrigation (depending on species selection).

Inclusion of cables or mesh can assist plants in reaching an even cover across the structure.

When looking at new developments, ensure adequate setbacks and coordination of structure are provided to allow for sufficient soil conditions to sustain long term growth. It is also important to consult with residents and tenants to ensure they support the project, and that the responsibility for ongoing maintenance is clear.



Climbers on Street Facade, Rundle Street Adelaide

Climber on Residential Verandah, Adelaide

Climber on Arbour, Private Laneway, Adelaide

17. Open Space Trees and Planting

17.1 Introduction

Description

This category includes trees and planting in the Adelaide Park Lands, squares, open space pockets and other leftover spaces which combined with Street planting form a large proportion of the Urban Forest of Adelaide. Open space trees and plantings should be selected for their amenity value and their contribution to urban biodiversity.

Trees planted in open space areas have access to large growing volumes and can often benefit from irrigation of surrounding lawn areas. As a result they are able to develop extensive root systems which gives them more resilience to drought and enables a much larger growing size than can be achieved with street planting.

Benefits

Open space trees and planting have numerous benefits including amenity, shade and biodiversity value. As Adelaide temperatures continue to rise, the natural shade and cooling effect of trees is becoming increasingly important for open space users and should be a primary factor to consider in any open space design.

More generally, providing a high proportion of vegetated spaces, including lawn, compared to impervious heat absorbent surfaces (paving and structures) is imperative to cooling the urban heat island across the city, as well as providing comfort and amenity in a particular site.

Design Considerations

Species Diversity

A diverse species selection is important to the establishment of an extensive and robust urban forest. There are a number of tools available to assess and rate the performance of trees in the urban environment. A matrix based selection criteria is useful in defining the desirable characteristics and tolerance traits.

Growing Conditions

Consideration should be given to the growing conditions related to each location, and whether there will be an enhanced growing zone for the tree, or whether it will be planted in a restricted conventional sized tree pit.

Trees and planting should be selected for their ability to perform in changing climatic conditions

Biodiversity Value

All trees and open space planting provide some habitat value for native fauna and aid in the development of ecological corridors. However, consideration should be given to ensuring that biodiversity plantings within areas of ecological sensitivity (i.e. Adelaide Park Lands) should be of local provenance indigenous origin.

Appearance and Amenity

The visual appearance of various species in terms of height, form, canopy spread, and trunk characteristics should be assessed. Consideration should also be given to community preferences as well as heritage and neighborhood character.

It is also important to consider the various uses of the space before selecting tree and understorey planting. Although some open spaces may be designed with events in mind, it is important that the design also considers the everyday use of that site.

Maintenance Considerations

Maintenance of trees in the open landscape is primarily a consideration of ensuring optimum tree health and vigour, and monitoring damage. A tree inventory should be produced which will allow for period assessments with the information stored in a spatial database.

Following severe weather it will also be necessary to inspect trees for damage.

During extended periods of time it may be necessary to provide supplementary irrigation using portable water storages. This is especially the case for some exotic species that may not be tolerant of extended dry periods.

Adelaide City Open Space

Adelaide Park Lands Open Space

17.2 Amenity Trees

Description

Trees are planted for amenity due to the shade that they cast, but also the visual interest they may have. Typically lush foliage and evenly structured branching lends itself to a high amenity species.

Design Considerations

Species Selection

Species selection for amenity should consider whether the shade requirement is best met from an evergreen or a deciduous species. This will be based on whether the space will benefit from winter sun, and whether a deciduous tree is favored (the bare look of a deciduous tree in winter may not meet the visual requirements for the space).

Consideration should be given to the likelihood of falling leaves and seed drop from particular tree species. In the wrong location, this can prove to be unsightly and may also block drains or the inlets to raingardens, becoming a maintenance burden.

Establishment Period

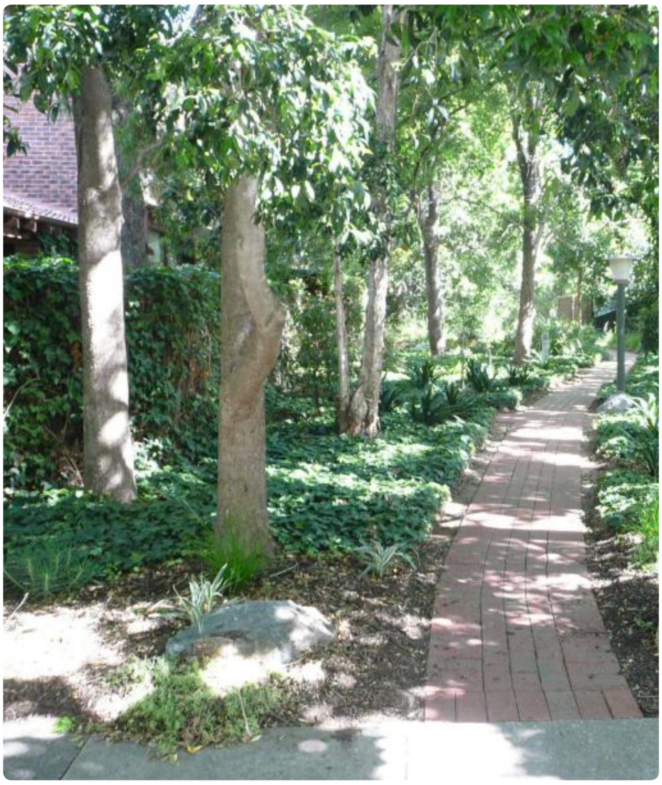
Speed of establishment is another consideration that should be taken into account. Some species, although ultimately may be desirable are slow growing, especially in urban situations.

Tree Form

The form of the tree in terms of how upright it is, how wide spreading, whether it grows symmetrically or not, and whether it has a rounded, columnar, or vase shaped canopy will determine to a large extent the level of amenity it will provide. Leaf and flower colour and form are also considerations for their visual appeal.

CPTED and Safety issues should also be considered when looking at tree form.

The various suitability traits are discussed in more detail in the Street Tree Planting Section.



Amenity trees provide shade and add character, North Adelaide

Park Lands amenity trees provide shade, create visual amenity and define path

Amenity trees help define character of North Terrace Cultural precinct

17.3 Revegetation and Biodiversity Planting

Description

Species selection for the enhancement of biodiversity is primarily based around using local indigenous plants. The vegetation communities that would have existed pre European settlement have been re composed and mapped to assist in providing a reference for the original biological diversity that would have occurred in Adelaide.

The main focus on planting for biological diversity in the city is to provide a network of vegetation with linkages to connect large areas. Where possible and appropriate re establishment of the original vegetation is encouraged as this will be the most suitable for the indigenous fauna.

Design Considerations

Species Selection

Conservation of biodiversity traditionally focusses on indigenous and threatened species, however with regard to urban biodiversity all non pest species should be considered. Generally, the presence of significant areas of diverse plantings will encourage fauna, however some considerations for maximising biodiversity include:

- Planting so that animals can gain safe refuge (i.e. inclusion of understory)
- Retaining large mature trees or nesting and hollows
- Selection of flowering plants to encourage bees and other pollinating insects (even inconspicuous flowers)

Sourcing Seed

It is important to ensure that local provenance seed is used for all revegetation planting. This requirement should be incorporated into the brief of any project involving revegetation, to avoid contamination with non local stock. The Adelaide City Council operates a seedbank which has a wide range of local indigenous seed.

Biodiversity planting in the Adelaide Park Lands

Fallen logs provide important habitat for native animals, Adelaide Park Lands

Indigenous trees provide high biodiversity value as well as amenity

18. Street Trees and Planting (Passively Irrigated)

18.1 Introduction

Description

Street trees and planting form a significant part of the Urban Forest network. For an integrated Green Infrastructure approach, all street trees should be passively irrigated where practical. This involves configuration of tree planting pits to take advantage of road runoff. These tree pits also provide a water quality treatment function and reduce overall runoff volumes and peak flows contributing to the objectives of WSUD. In cases where road profiles do not allow for passive irrigation, other forms of irrigation should be considered to ensure the long term success of the tree.

Passively irrigated tree pits can either be situated in the footpath, with a side entry pit type inlet, or within the roadway with a vertical inlet of a permeable tree surround.

Benefits

Planting trees in streets has numerous social, environmental and economic benefits which are outlined in Chapter 10: Green Streets. Additionally, using passive irrigation to maximise the availability of water to the tree root zone will ensure that the street tree will establish more quickly and be more resilient in the long term.

Design Considerations

Structural Loads

For both trees within footpaths, and trees within roadways consideration should be given to provision of a structural load bearing tree root growth volume that can accommodate the pavement loads, as well as the live loads of pedestrians and vehicles. If tree pits are to be located in the road way, the higher loads (fire trucks etc.) will need to be accommodated by use of innovative systems such as soil supporting modules, or structural soils.

Services Coordination and Management

Consideration will need to be given to underground and overhead services and how these can be accommodated in the tree pits design, or located in a suitable services zone adjacent to the tree pit. In some instances it may be necessary to co-locate services within the tree growing zones, in which case consent from the relevant authority will be required. Tree root barriers may be an option in some circumstances to protect adjacent pavements, and services.

Species Selection

It is important that the selection of tree species takes into account the character and spatial characteristics of the street, as well as the amenity and biodiversity value the tree may provide. Refer to the Adelaide City Council Street Tree Hierarchy selection guide (Appendix 2) for further information on Tree Species appropriate for various city streets.

Maintenance Considerations

As with trees in the open, trees within passively irrigated tree pits will need to be monitored for health and vigour. Due to the increased fluctuations in the moisture conditions of the sites, it is important that any factors that adversely impact the tree are picked up early and adjustments made. If the drainage layers of the passively irrigated tree pit are compromised due to build up of sediment it may be that the tree will suffer 'wet feet', and depending on the species selected this may not be optimal for tree health.

Also the inlet structures of the passively irrigated tree pits should be inspected and any debris removed that may be hindering the ingress of water.

Passively Irrigated Street Trees, North Terrace, Adelaide

18.2 Street Trees in Footpaths (Rigid Paving)

Description

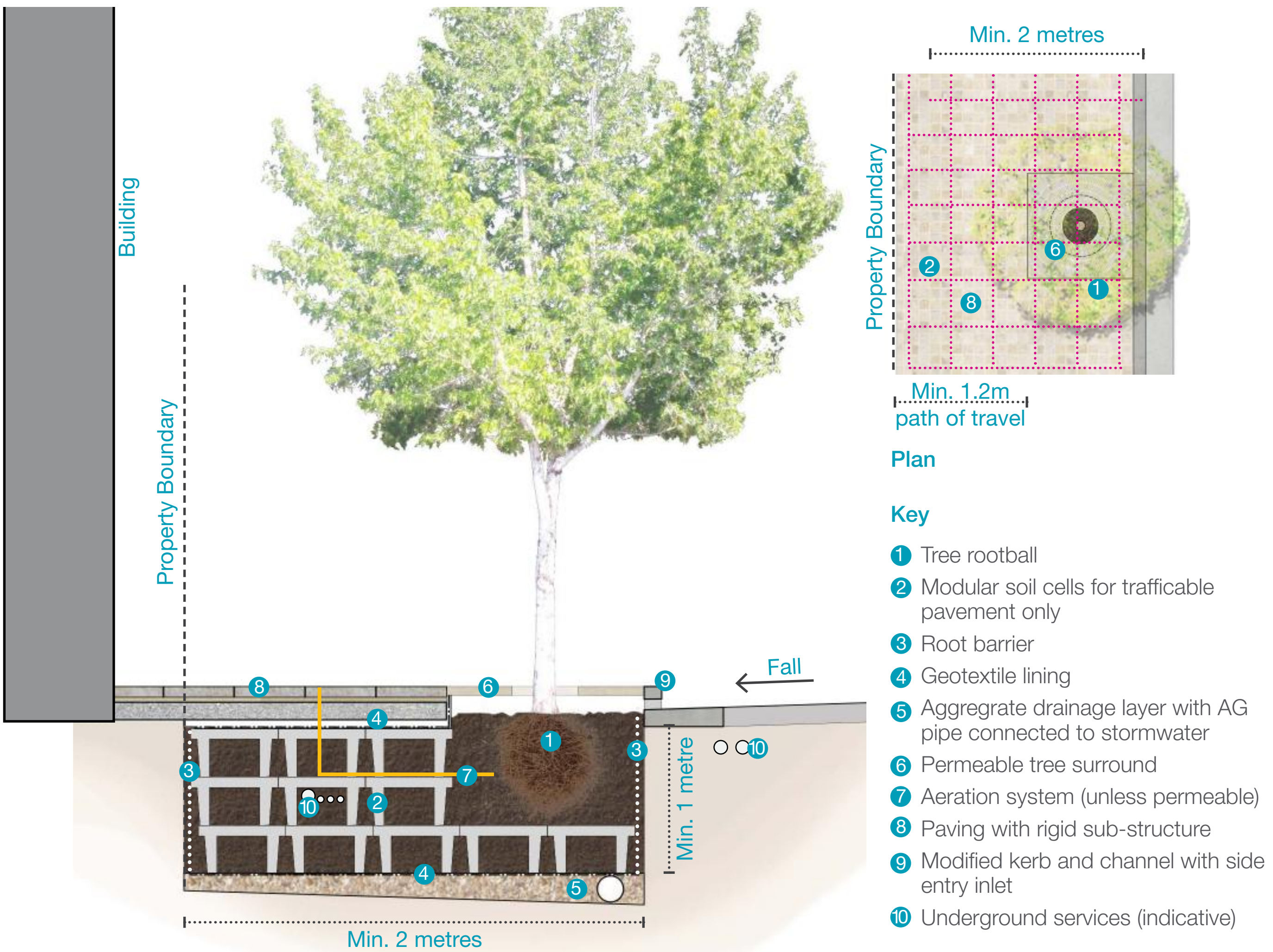
Trees planted in footpaths are constrained by the property boundary on one side and to the roadway on the other. There will also invariably be the presence of overhead and underground services.

Paving is determined as 'rigid' where the surface paving has a rigid sub structure, such as a concrete slab. In this situation, structural soil or modular soil will be required for tree planting.

Design Considerations

Depending on the width between the property boundary and the back of kerb, there may be only a limited width for the tree root growing zone. If this width is less than 1.5m, it is advisable to provide an extended tree root growing zone. This will need to be load bearing to take the pavement and pedestrian loads.

Stratacell Structural Cells in Footpath (Image courtesy of CitiGreen)



Note: Approval from the relevant authority will be required when locating services within the tree root growing zones.

Figure 24: Passively Irrigated Street Tree in Footpath (Rigid Paving)

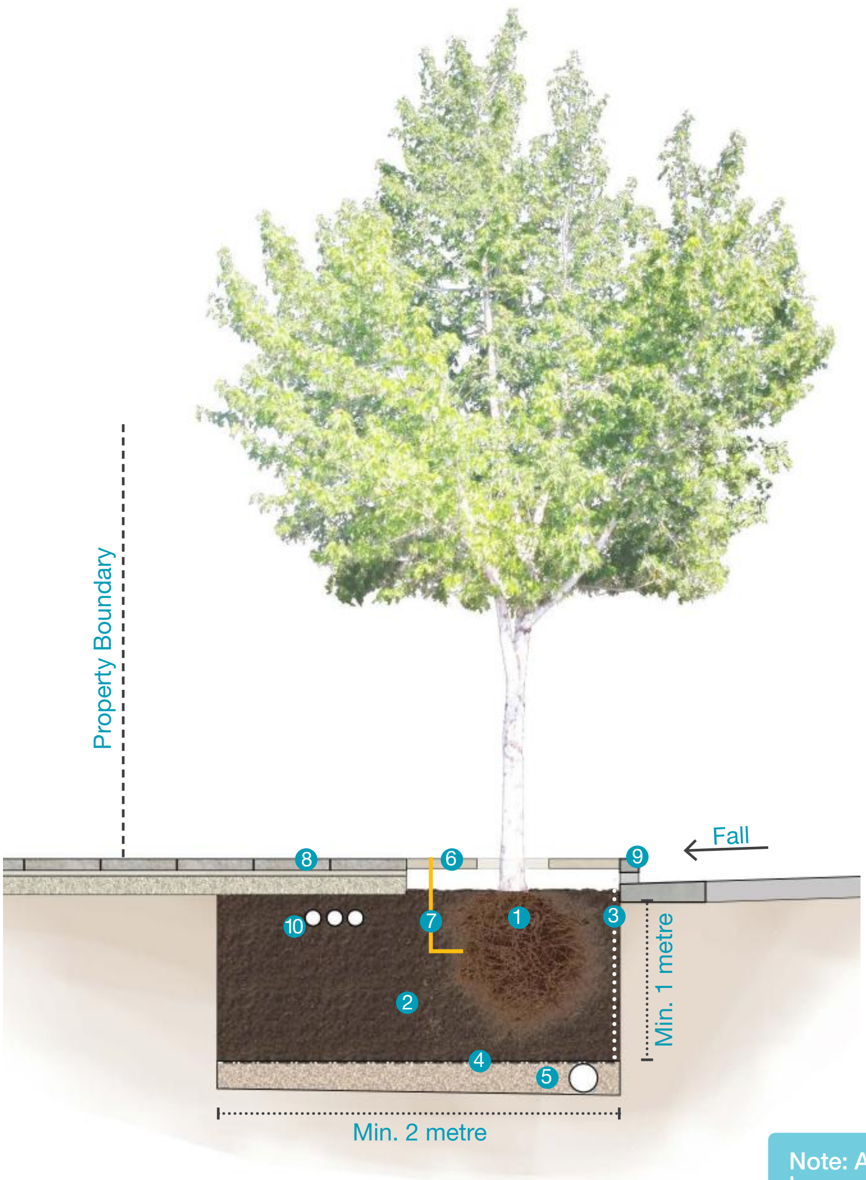
18.3 Street Trees in Footpaths (Flexible Paving)

Description

Trees in flexible paving are the most common type of tree planting in Adelaide, as the majority of city paved areas have a flexible sub structure. In some situations such as locating trees around existing services, modular soil cells may be required

Design Considerations

To optimise tree health and longevity, it is important to maximise the tree pit area . Ideally the tree pit should be 2 metres wide.



KEY

1. Tree rootball
2. Tree vault with structural soil or convetional soil with modular cells
3. Root barrier
4. Geotextile lining
5. Aggregrate drainage layer with AG pipe connected to stormwater
6. Porous surface
7. Aeration system
8. Paving with flexible substructure
9. Modified kerb and channel with side entry inlet
10. Services

Note: Approval from the relevant authority will be required when locating services within the tree root growing zones.

Figure 25: Passively Irrigated Street Tree in Footpath (Flexible Paving)

18.4 Street Trees in Roadway

Description

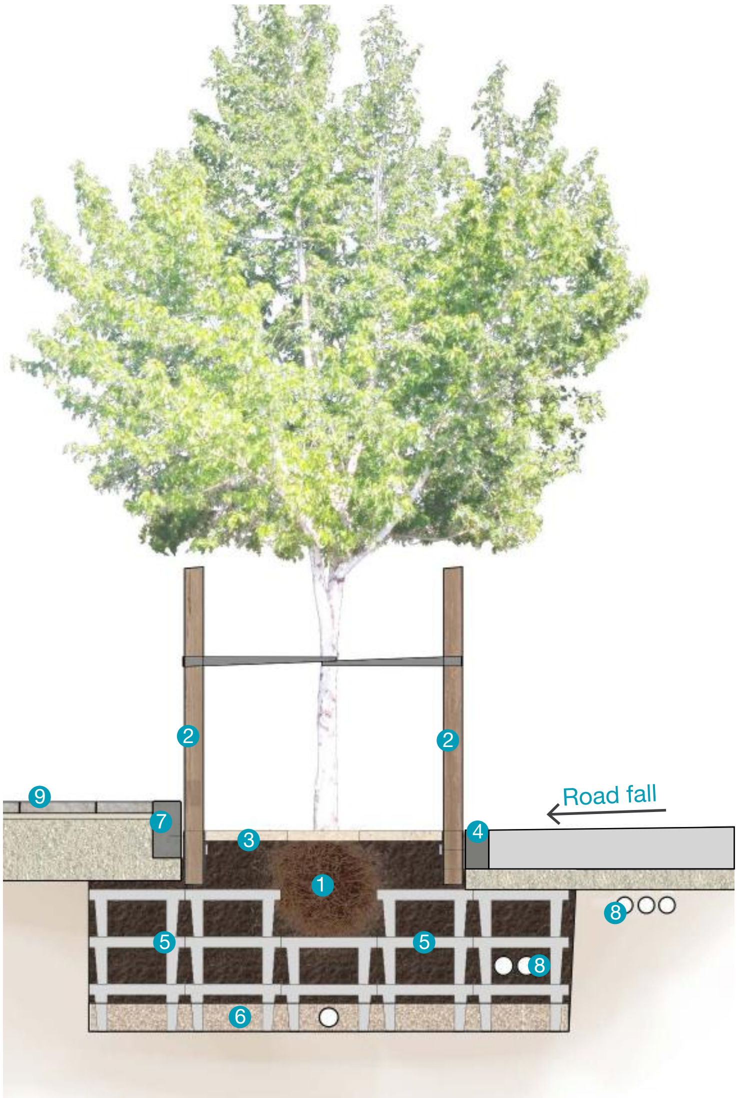
In circumstances where trees are located within the parking zones, they can be designed to maximise the tree root growing zones and passive irrigation from the road run off.

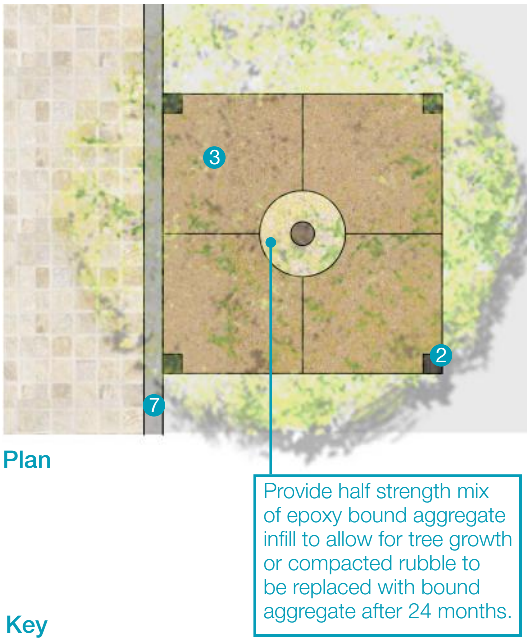
Design Considerations

Where trees are planted within the parking zones, in order to provide sufficient root growth zones, the sub base of the roadway will need to be both vehicular load bearing. Due to the limited load bearing capacity of structural soils, it may be preferable to provide a physical load bearing structure such as 'Strata Cells'. These are installed into the tree growth zones, with conventional soil provided within them. They allow the tree to prosper whilst also providing the necessary pavement sub base support.

Bollards may be used as an interim measure for the establishment of trees in roadways.

Street Tree in Roadway (ASPECT Studios)





Key

1. Tree rootball
2. Frangible guards (alternate options are available)
3. Permeable tree surround
4. Concrete edge strip
5. Structural soil or conventional soil with cells
6. Aggregrate drainage layer with AG pipe connected to stormwater if practical
7. Modified kerb and channel
8. Underground services (indicative)
9. Adjacent footpath

Figure 26: Passively Irrigated Street Tree in Roadway (ASPECT Studios)

18.5 Street Trees in Raised Planters

Description

In circumstances where tree planting in ground cannot be achieved due to underground services or other constraints, trees can be planted in raised planters. Due to the containment of tree roots, the size of trees will be inherently restricted; however it is possible to establish good sized trees in this manner.

It is important to note that trees in raised planters should only be provided only when all other in-ground tree planting options have been ruled out. Technologies such as root barriers should be explored and investigations with all service authorities should take place before any decision to plant trees in planters is made.

Design Considerations

Similar considerations to establishing trees on green roofs and podium gardens apply to raised planters, as these situations are all inherently planting into confined spaces.

It is important to select tree species which can tolerate the confined soil volume of a planter, while still attaining sufficient height and canopy. The composition of the planting media is also important in providing good growing conditions and water retention to ensure horticultural success.

Drainage and irrigation are also very important considerations. Care should be taken to ensure run off does not impact the pavement the planter is situated on. The provision of adequate water (especially during hot weather) is of prime importance. It may not be adequate to rely upon hand watering, however the provision of an automatic irrigation system may be difficult unless conduits in the pavement can be installed as part of the

Trees in raised planters add amenity to narrow streets and laneways

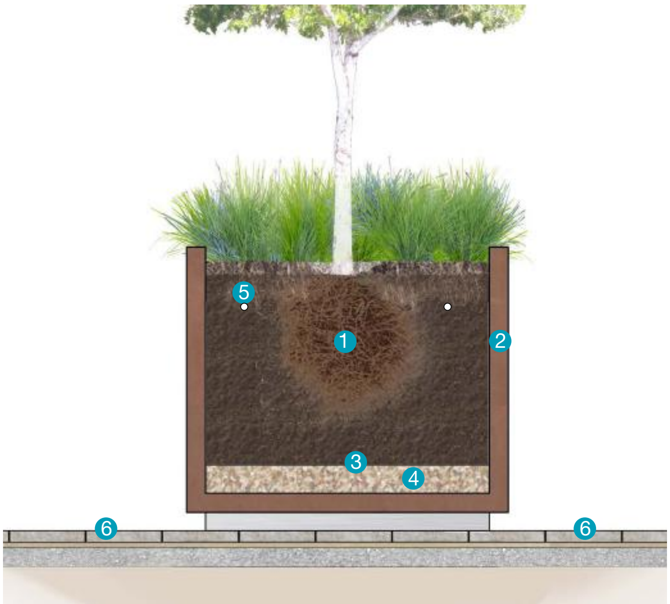


Figure 27: Surface Mounted Street Tree in Raised Planter

KEY

1. Tree rootball
2. Single structure raised planter
3. Geotextile lining
4. Aggregate drainage layer
5. Irrigation
6. Adjacent paving

18.6 Street Understorey Planting

Description

The provision of low planting is an important part of a Green Infrastructure approach. In many situations there is space within nature strips or garden beds within medians for understory planting in companionship with trees.

Low cover planting is also an important part of a raingarden, as it performs biological uptake of nutrients and contaminants. When planted in this arrangement there is the added benefit of the plants being passively irrigated by the storm water run off from pavements.

Design Considerations

Space is normally the primary restriction to the installation of low planting. Another perception is that low planting requires has a higher level of maintenance, even when compared to turf grass. This is not necessarily the case if hardy, self re-generating, drought tolerant species are selected.

Planter beds should provide a variety of species for visual interest. Plants with similar growing characteristics and water requirements should be grouped together.

Safety should also be considered and attention paid so that understory planting does not create screens that will be a barrier to passive surveillance.

If planting is undertaken adjacent carparks, access and egress to and from adjacent cars, should be considered. Provision of space for bins, park benches and other amenities should also be considered when designing roadside planting.

Mixed understorey verge planting, Whitmore Square, Adelaide

Formal understorey planting, North Terrace, Adelaide

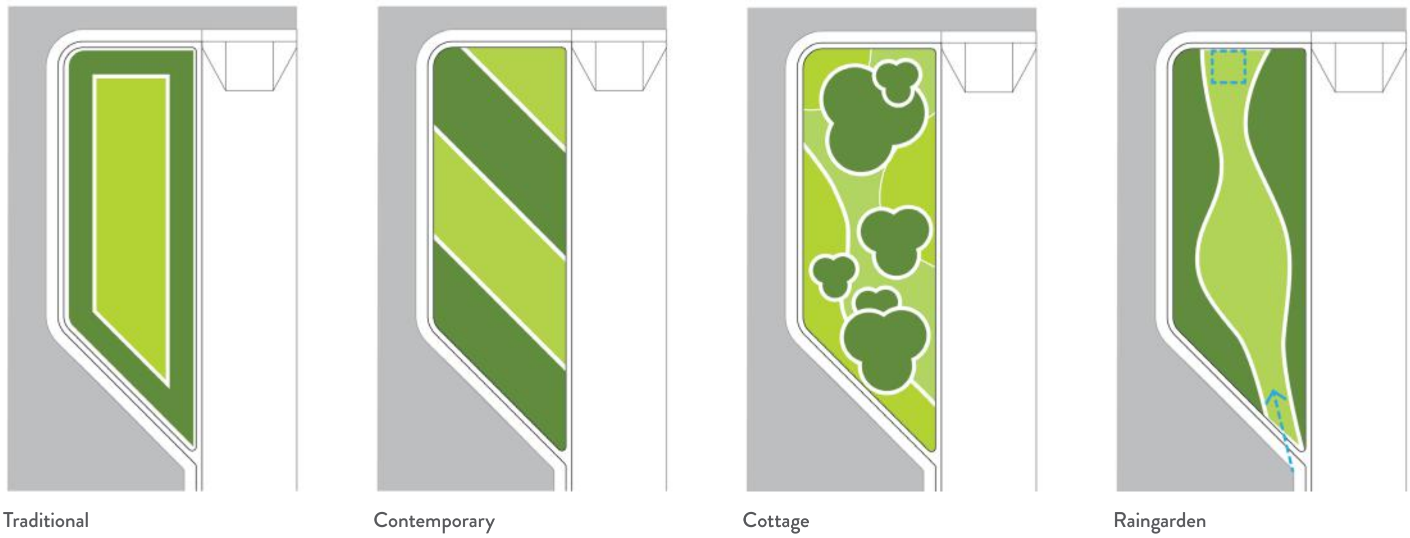


Figure 28: Example Street Planting Typologies

19. Permeable Pavements

Description

Permeable pavements are comprised of materials which facilitate infiltration of rainwater and transfer it to the underlying subsoil.

Permeable pavements can also be used as drainage features in lieu of strip drains and grated pits. They can also be used as tree surrounds to promote passive irrigation and bioretention of contaminants, and for bike lanes where structural loads are not high.

Permeable pavements can take the following forms:

- Unit permeable pavers
- Bonded materials including aggregate, recycled rubber, decorative elements and permeable asphalt)

Design Considerations

Infiltration requirements

The permeability of the wearing surface must have sufficient hydraulic conductivity to provide adequate infiltration. Similarly the sub base must also provide suitable permeability to meet the drainage performance requirements. The sub base can also be connected to the storm water drainage system via a perforated pipe (depending in the infiltration rates of the underlying sub grade and whether it is clay or sandy).

Loadings and Access

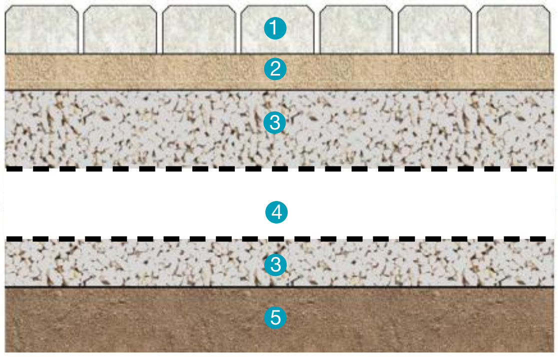
It is important that the anticipated loadings on the pavements are understood prior to assessing if a permeable pavement option is suitable. For example, before choosing a material it should be established whether the pavement will have vehicle access or be pedestrian only. Turning vehicles and street cleaning equipment can have an impact on the integrity of certain permeable pavements, which would not be appropriate in a situation where vehicles will be likely to have access.

Maintenance Considerations

The main maintenance requirements for permeable pavements are inspection to ensure that sediment build up has not occurred. As such, permeable pavements may not be suitable for areas of high traffic and sediment loads.

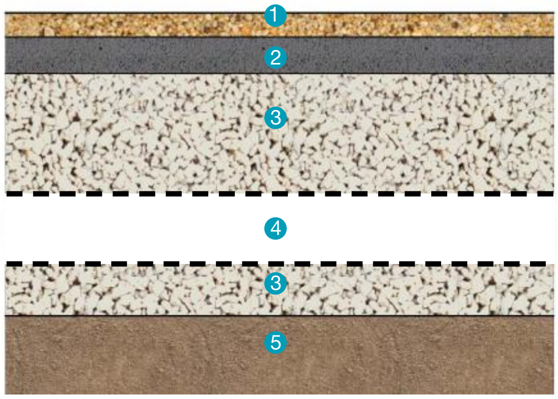
Permeable pavement panel insert (Designed by ASPECT Studios & Waterpave)

Interlocking Permeable pavers, Mordialloc Inductrial Precinct



KEY
1. Segmental permeable pavers
2. Crushed rock bedding course (no fines)
3. Compacted clean stone (unbonded). Overall depth to engineer's requirement.
4. Slotted PVC drain wrapped in geotextile connected to stormwater system
5. Approved compacted sub grade

Figure 29: Unit Permeable Pavers



KEY
1. Aggregate bonded with epoxy resin to manufacturer's recommendations
2. Granulated recycled rubber bonded with epoxy resin to manufacturer's recommendations
3. Compacted clean stone (unbonded). Depth to engineer's requirement.
4. Slotted PVC drain wrapped in geotextile connected to stormwater system
5. Approved compacted sub grade

Figure 30: Bonded Aggregate

20. Water Filtration and Treatment Systems

20.1 Introduction

Description

Water filtration and treatment systems are a primary component of WSUD and, on an urban scale, include raingardens and bioretention swales. Where space permits, constructed wetlands can also provide very effective water treatment.

Maintenance Considerations

There are common misconceptions that water filtration systems are difficult to maintain and add to the burden of maintenance staff.

However, if these systems are designed properly and with input from the staff who are maintaining the public realm, such as street sweepers and open space maintenance workers, maintenance facilities such as litter traps can be effectively integrated into the design in a holistic way at the design stage. It designed properly, the ongoing maintenance requirements of a filtration system will be very similar to standard landscaping. It is vital that maintenance is considered at the design stage when it can be inexpensively incorporated, rather than having to undertake expensive retrofits later in the project life.

The highest level of maintenance required for raingardens and other water treatment systems will be in the first two years following construction during the establishment period. It is important that the correct filter and drainage media is installed and that the planting is established successfully. Removal of weeds may also be necessary, and any mulch that has displaced should be returned to it correct position.

Frequent pruning of vegetation can promote vigour, however if pruning is excessive, it can damage the plants.

It may be necessary to periodically remove sediment build up. The frequency of this will depend on the specific situation of the installation. Under normal circumstances it would not be expected that sediment removal would be required more than every 5 years.

Raingarden

VCA forecourt raingarden, Melbourne

20.2 Raingardens (Bioretention Basins)

Description

A bioretention basin or raingarden is a planted basin designed to clean incoming storm water by promoting infiltration into the underlying medium. Raingardens are comprised of a series of layers of media with varying infiltration rates, and a perforated pipe that collects the cleaned infiltrated water and conveys it to the stormwater system.

Within a streetscape raingarden, the contaminated storm water enters the system from the adjacent roadway by way of an inlet structure (often comprising a simple kerb cut out), where contaminants are trapped in the filter layers. Bio-remediation of these contaminants is provided by the plants growing in the media. The water eventually moves through and out of the system having been treated to remove Nitrogen, Phosphorus, and Potassium, as well as heavy metals, sediments and gross pollutants such as litter.

Raingardens can be created in a range of situations:

- In courtyards
- In open space
- In footpaths and nature strips
- In traffic islands and car parks

Design Considerations

Design, Installation and Main tenance

It is important that regular check and hold points are established during the design and installation phase to ensure that the design intent of the raingarden is being realised, and the correct materials are being used. It is important to note that if designed correctly with zones to capture litter and sedimentation, the ongoing maintenance requirements of a raingarden will be very similar to a standard garden bed.

Inlet and Outlet Structures

Another important consideration is the design of the inlet and outlet structures so that the correct detention time can be established to provide the required treatment function. An overflow grated pit is also required to bypass high volume flows straight through the system.

Filter Media Requirements

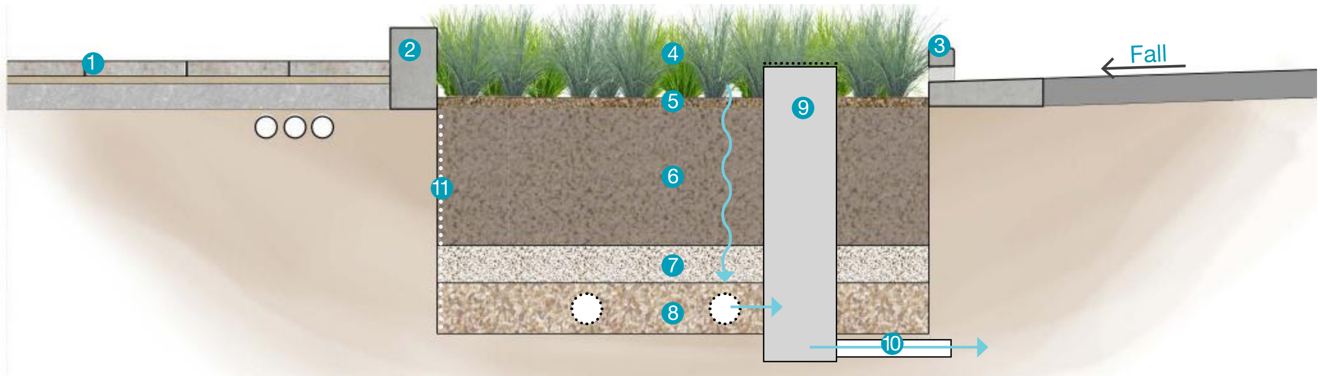
The most critical aspect to the design of raingardens is the specification and selection of suitable filter media. This media is effectively a washed sand, but must have the appropriate particle size distribution and composition of fines and large aggregates, with an absence of clay. The organic content of the media must also be well balanced to provide sufficient nutrients to establish the plants, without excess nutrients contributing to the nutrient loads of the discharge. It is also important that the mulch ballast used is inorganic (such as washed rock), with an appropriate weight to stop wash away during rain events. There are detailed guidelines available for further information on biofiltration methods including resources produced by the Facility for Advancing Water Biofiltration (FAWB).

Pedestrian Experience

Design of Raingardens should consider pedestrian experience and streetscape character. Elements such as edge protection should be integrated as part of any design adjacent a public space.

Species Selection

Appropriate species selection of grass and plants is also important. Species with strong nutrient removal properties that are capable of tolerating periodic inundation and dry periods are critical to the success of the raingarden.



KEY

1. Pedestrian path
2. Edge protection
3. Kerb with cut out for inlet
4. Planting
5. Inorganic ballast mulch
6. Filter media
7. Transition layer
8. Drainage layer with perforated pipes connected to outlet pit
9. Overflow/outlet pit with grate
10. Pipe connection to stormwater system
11. Impervious protection layer

Figure 31: Roadside Raingarden

20.3 Swales

Description

The primary difference between raingardens and swales, is that swales move water along the drainage system.

Swales can be grassed or vegetated and promote infiltration into the underlying medium. A bioswale incorporates a filter media (as with a raingarden) and a perforated pipe collects the infiltrated water and conveys it to the drainage system. Flows are also conveyed along the surface of the swale (especially during peak rainfall events) prior to being infiltrated.

Design Considerations

Swale Profile

The slope of the side batter and longitudinal fall along the swale are the two most important design considerations so that water quality improvement and conveyance performance, can be maximised with the control of slowing and erosion. It is also important to consider flow control measures such as check dams, for steeped systems.

Species Selection

Appropriate species selection of grass and plants is also important. As with raingardens, species capable of tolerating periodic inundation and dry periods are critical to the success of the vegetated swale.

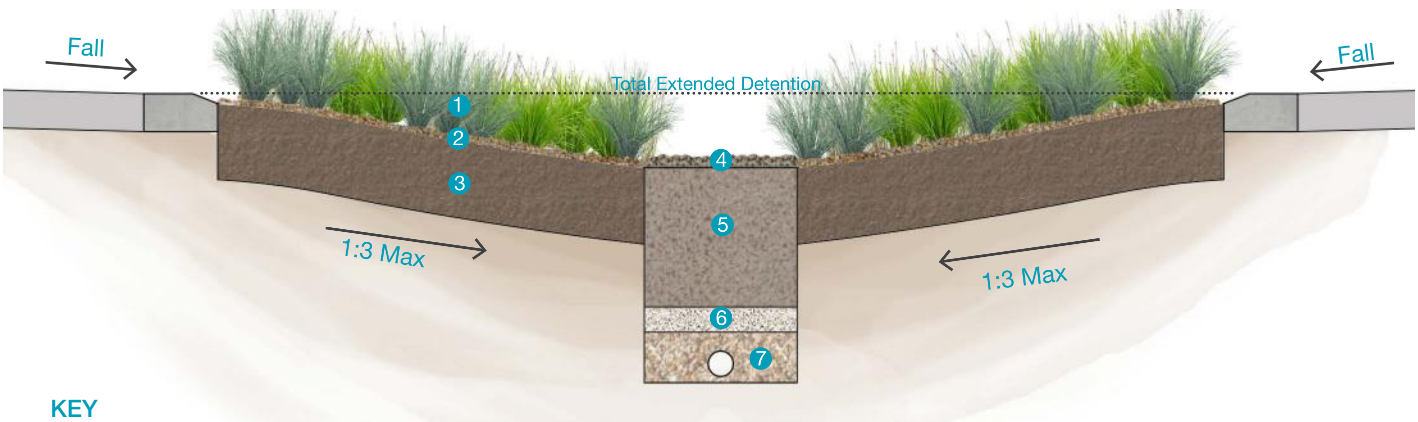
Erosion Control

Prior to the establishment of the vegetation, erosion of the substrate (topsoil), and rock mulch is also an important consideration. The timing of installation of plants is most critical so that establishment can be achieved in between significant storm events. In some circumstances it may be necessary to include a geotextile at the surface to control erosion.

Planning and Installation

It is important that regular check and hold points are established during the design and installation phase to ensure that the design intent of the swale is being realised, and the correct materials are being used. As with raingardens, if the swale is designed correctly with litter traps etc, maintenance requirements will be reduced.

Large scale planted bioretention swale Chirnside, Vic (ASPECT Studios)



KEY

1. Planted or grassed swale bank
2. Small rock ballast mulch
3. Topsoil
4. Larger rock ballast mulch to invert
5. Filter media (sandy loam)
6. Transition layer (course sand)
7. Drainage layer with perforated pipe connected to storm water

Figure 32: Vegetated Swale

20.4 Constructed Wetlands

Description

Wetlands are permanently or temporarily inundated areas that detain storm water for a period of time. Constructed wetlands are specifically designed for water treatment, and may be created in a range of scales and styles. They may consist of standing open water zones and shallower zones and can be ephemeral. Depending on the depth and duration of inundation wetlands will be planted with a range of aquatic, and ephemeral plant species, from deep, to shallow marsh, to terrestrial ecologies.

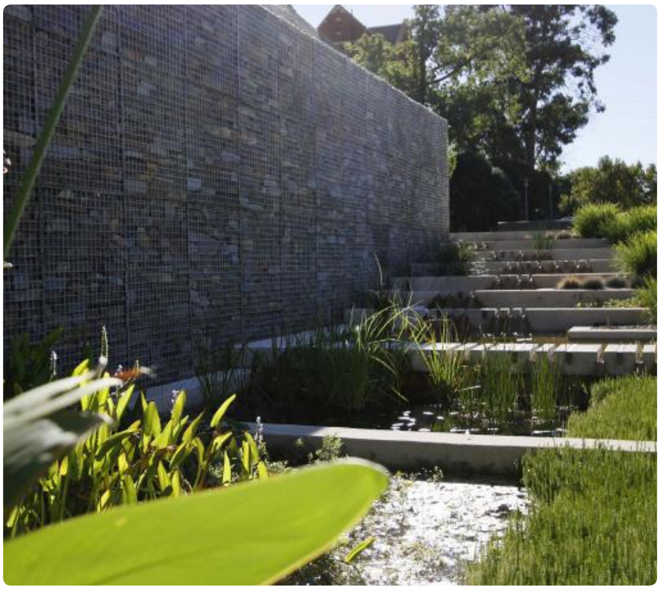
Design Considerations

Consideration should be given to the following design parameters:

- Verifying required size and configuration for treatment
- Determining design flows
- Designing the inlet zone
- Layout of macrophyte zone including zonation, as well as longitudinal and cross sections
- Design of hydraulic structures such as outlet structures, connection to the inlet zone, and bypass weirs and channels
- Recommending plant species and planting densities

The depth of water will determine the suitable species. Local indigenous species should be selected where possible to maximise ecological value.

Consideration should be given to the slope of batters into the any open water, with regard to public safety in meeting the Life Saving South Australia's requirements.



Constructed Wetland, Adelaide Botanic Garden

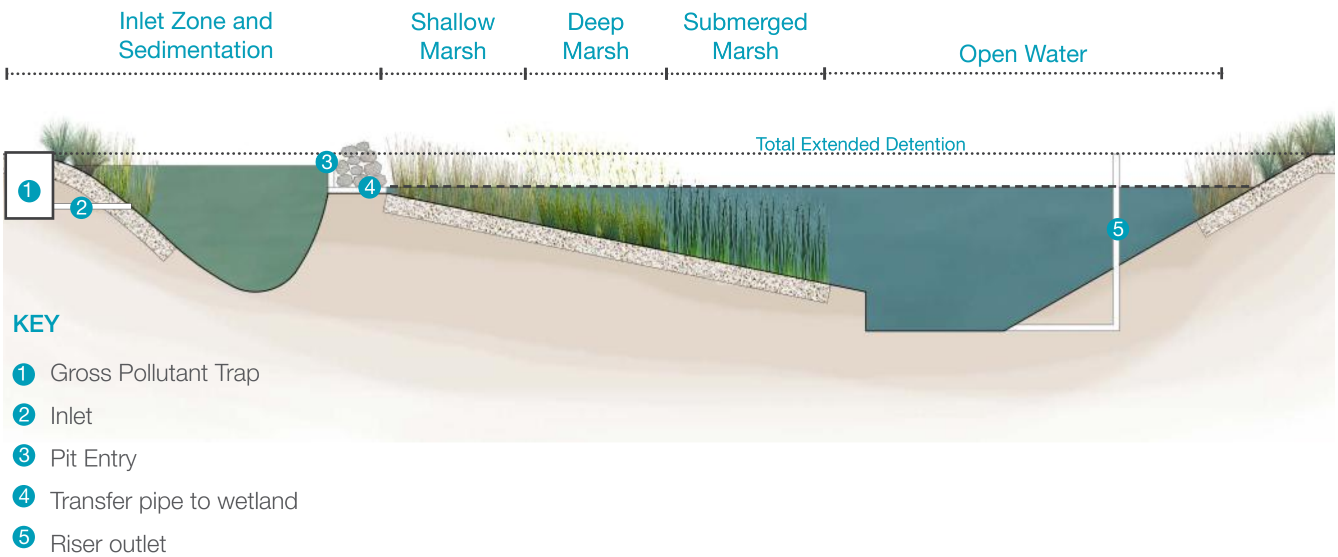


Figure 33: Constructed Wetland

21. Recycled & Collected Water

20.5 Introduction

Given the importance of the availability of adequate water supply for all Green Infrastructure elements, the provision of recycled water is of critical significance.

Recycled water can be sourced from site captured run off from roofs, pavements and other impervious surfaces. There is also a supply of treated recycled waste water from the Glenelg Water Treatment Plan which is reticulated to points within the Adelaide CBD. Known as the Glenelg to Adelaide Park Lands recycled water project or GAP, this water is currently used for approximately 95% of the irrigated Park Lands. In some locations, the salinity level of the recycled water will need to be considered when selecting plants species.

Rainwater can be collected and stored on site, and depending on the availability of space can be either above or below ground, as well as located in basements. Private residences are strongly encourages to capture rainwater on site for reuse prior to discharging into the public storm water system.

There are a number of proprietary products available for storage of rainwater including:

Above ground

- Bladders
- Plastic tanks
- Steel tanks

Underground

- Concrete tanks
- Pipes
- Modular cells

In situ concrete tanks can also be constructed to a customised design. These are often economical when access for lifting large pre cast tanks, or difficult spatial requirements preclude use of off the shelf products.

Design considerations

Above Ground

The most important consideration will be the various areas of roof surface available for run off capture, and how the guttering system and down pipes are arranged to maximise the area of roof that will feed into the tank.

It is preferable to locate an above ground water storage tank on a concrete slab or plinth in order to provide a level and secure bearing surface. The position of the tank will also need to consider circulation around the building and the location of the water delivery. If the water demand is away from the tank a pump will be required.

A new initiative is to include ‘Smart’ controller features that will purge the tank of water prior to a large rain event. For example, the ‘Talking Tanks’ initiative developed in conjunction with South East Water in Melbourne assists in storm water management so that a rain water storage tank can effectively operate as a storm water detention system in attenuating peak storm water loads and reducing the impact of run off on the environment.

Below Ground

The design of underground water storages is a much more involved exercise than that of above ground installations. Depending on the nature of the surface above the tank, the load bearing capacity of the storage system may need to be engineered to accommodate vehicles (potentially heavy vehicles such as fire trucks). There are a number of products available that can bear these loads. Alternatively, an engineered concrete structure can be designed.

Pumping and over flow structures will also need to be considered in the design, as well as access for inspections and maintenance.

GAP Purple Pipe, Adelaide Park Lands

Above ground plastic tanks

Underground water storage

22. Water Infiltration Systems

22.1 Introduction

Description

Water infiltration systems are designed allow accumulated water, such as storm water, to infiltrate into surrounding soils and eventually percolate through the subsoil and into groundwater supplies. Water infiltration systems can include soakage trenches, soak wells, retention basins and infiltration basins.

Benefits

Water infiltration systems have a range of benefits including improved storm water management, recharge of depleted ground water, and improved heath of adjacent planting. When applied in private properties, these systems can take the pressure off public stormwater infrastructure, as stormwater is directed back into the ground water table rather than straight into the street stormwater system.

Design Considerations

Water infiltration systems should be designed in conjunction with other water treatment measures, such as raingardens, and act as the final step to discharge cleansed water into the soil substructure. Before entering an infiltration system, water should have already been pretreated to remove sedimentation.

It is important to ensure that site conditions are appropriate before installing an infiltration system. Sites with compacted or high clay content soils, or high groundwater levels will not be appropriate due to the risk of flooding.

Street surface infiltration trench (Image credit: The Green Roof Consultancy)

Residential scale infiltration trench(Image credit: City of Bellingham, Washington)

22.2 Infiltration Pits and Trenches

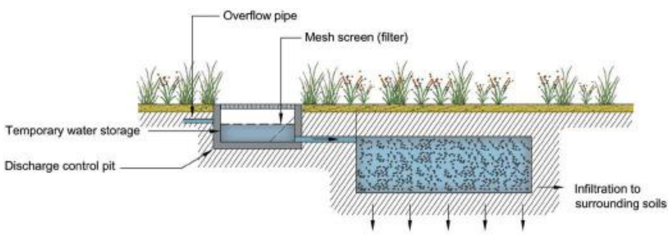
Description

Infiltration pits and trenches can be designed in a variety of ways and range simple gravel filled trenches, to complex systems incorporating bioretention for maximum sediment removal. They can be implemented at a range of scales, from regional and street level to individual allotments.

22.3 Perforated Pipe Systems

Description

Perforated pipe, or 'leaky pipe' systems are key component of water infiltration as well as being used for conveyance in raingardens and swales. Composed of perforated pipes installed in gravel beds, the perforated pipes work by allowing infiltration into the surrounding gravel as the water moves through the system. In the right conditions and locations, perforated pipes can be used in replacement of conventional storm water pipes.



Gravel Filled Soakage Pit (Image credit: Melbourne Water WSUD Engineering Procedures: Stormwater)

22.4 Managed Aquifer Recharge

Description

Managed Aquifer Recharge (MAR) is the description for schemes where water is deliberately placed or injected into an underground aquifer either for future human use, or for environmental reasons. Aquifer recharge is important in helping to replenish depleted groundwater supplies, while Aquifer Storage and Recovery schemes can also be instrumental in providing adequate water supplies during dry periods, when water which has been collected and stored can be recovered for a wide range of uses.

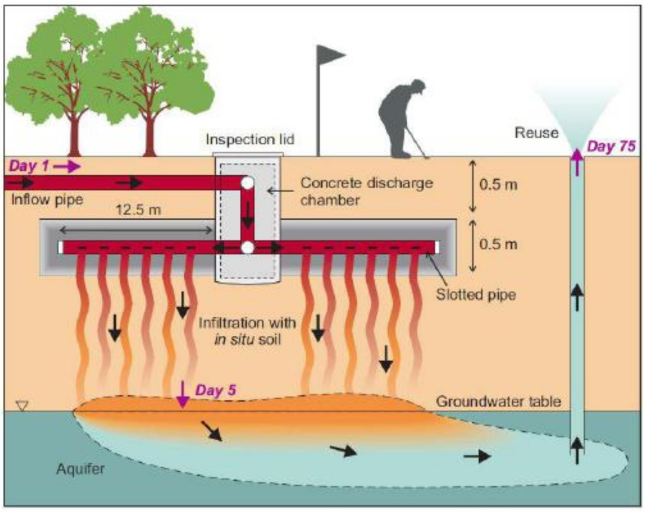
Sources of water for aquifer recharge can include treated stormwater and waste water, with MAR Schemes often being integrated with wetland systems. Managed Aquifer Recharge schemes can be implemented on a range of scales, from private allotment to regional level.

There are a number of projects in South Australia which include MAR schemes, including Waterproofing North Adelaide, Waterproofing the West and Waterproofing the South.

Design Considerations

MAR schemes will not be suitable for all sites, and can potentially attract hazards such as ground water contamination.

Careful planning, design, construction and ongoing management are essential to ensure the project is successful.



Managed Aquifer Recharge Processes (Image Credit: CSIRO: Water for a Healthy Country National Research Flagship)

Section D: Implementation

23. An Integrated Design Approach

Council acknowledges that the challenges and complexities of implementing Green Infrastructure cannot be underestimated. This will require a range of measures from storm and irrigation water management, tree pit and substrate design, plant species selection, as well as co-ordination with engineering and services infrastructure design.

Encouraging the adoption of Green Infrastructure will require prioritisation of greening (i.e. trees, planting, raingardens and vertical gardens), as at least equal to, if not more important than, other infrastructure elements (i.e. pavements and underground or overhead services).

This guide recognises that the key to the successful implementation and widespread up take of Green Infrastructure is through the integrated design collaboration of a diverse group of professionals, from landscape architects to engineers, policy makers, asset managers, architects, ecologists, soil scientists, horticulturists and authorities.

Successful implementation of Green Infrastructure will also require a collaborative effort between Council, developers, building owners, private residents, design consultants, and contractors as well as the operations and maintenance personnel and utility providers responsible for the range of assets in the city. All of these stakeholders need an appreciation of the requirements for this specialised approach.

Rundle Street, Adelaide

SA Water Forecourt, Wakefield Street Adelaide

North Terrace, Adelaide

24. Pathways to Implementation

As described in the previous chapters, the adoption and implementation of Green Infrastructure assets is reliant on a multidisciplinary approach to the planning and design of the built environment. As a result, it is critical that Green Infrastructure is identified as being at least as important as other infrastructure assets (i.e. grey or 'hard' engineered infrastructure) and that the co-ordination and planning for greening is adopted at the earliest stage of any project.

There are two main avenues through which Green Infrastructure can be implemented. These avenues are;

- New Urban Developments (under Public or Private Ownership), these projects are generally on private land, but often have a public realm interface.
- Asset or Infrastructure Renewal (e.g. services upgrades, open space upgrades or streetscape renewal programs). - These projects are generally in the public realm.

To facilitate the best Green Infrastructure outcomes, the following strategies can be put in place. These strategies have been provided as a preliminary response and are intended to guide discussion on the topic within Council's management teams.

Establishing Policy

The development of a policy instrument that requires any new development to demonstrate its ability to achieve a set target for the inclusion of Green Infrastructure, will give Council a high degree of control in both private developments, and within works initiated by Council and other authorities.

The Green Infrastructure Guidelines document provides a range of measures that can be employed in meeting these policy objectives and which can be used as a measurable tool to leverage integrated design outcomes from early on in the project inception phases.

These policies could include incentives for further leveraging the highest quality greening. Incentives could come in the form of an increase in the developable land area if Green Infrastructure elements are provided. Alternatively they could be contributions from Council on the cost of services relocations or a requirement for developer contributions towards Green Infrastructure elements themselves if they are situated in the public realm when a development abuts Council land.

Establish a Green Infrastructure Rating Tool (GIRT)

One potential pathway to facilitate and encourage the implementation of Green Infrastructure development is to establish and utilise a Green Infrastructure Rating Tool (GIRT) so that the relative merit of any project can be assessed against the Green Infrastructure objectives.

One model for comparison of this type of approach as it relates to sustainable development is STEPS Sustainable Tools for Environmental Performance Strategy that has been developed by a number of inner Melbourne local governments.

This initiative has been set up by CASBE The Council Alliance for a Sustainable Built Environment and developed by Port Philip and Moreland City Councils to enable designers and Council officers to assess all building types with the view of reducing their environmental impacts. These easy to use self-assessment tools are free and available for anyone anywhere to use.

A similar rating tool could be developed by the Adelaide City Council to assess Green Infrastructure developments. This could be modeled on STEPS and tailored to Green Infrastructure objectives, elements, and benefits.

For example scores could be awarded for the six most important benefits of Green Infrastructure, namely:

- Improved storm water management
- Cooling the city
- Cooling buildings
- Biodiversity
- Visual amenity
- Improved air quality

Each of the Green Infrastructure elements would be analysed in the effectiveness that it contributes to the above benefits and points awarded based on how these are incorporated into the design proposals. These points will be awarded with the inclusion of the following, either on their own or in combination:

- Living Architecture
- Green Streets
- Water Sensitive Urban Design
- The Urban Forest

A target number of points would be determined based on an evidenced based approach in achieving the benefits of Green Infrastructure.

Evidence Based Design

In order to comprehensively assess Green Infrastructure elements for the contribution they provide to achieving the benefits it will be necessary to undertaken further research and development using an evidenced based approach to demonstrate that the intended outcome will be realised.

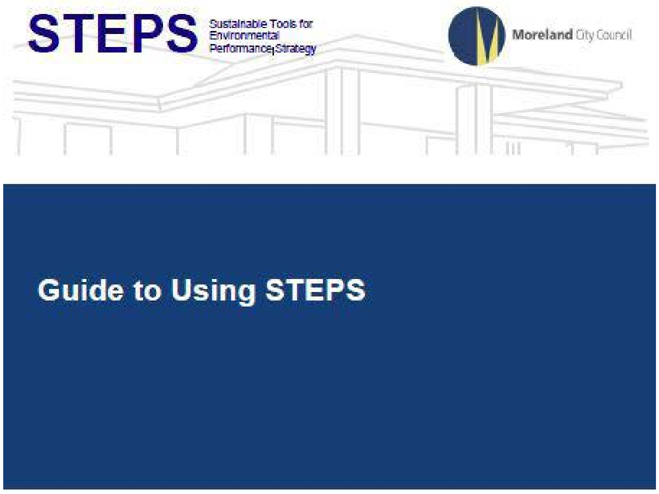
Substantial work has already been completed with regard to this evidence base, for example published research is available on the following:

- The effects of shading from trees and green walls on mitigation of the urban heat island
- The contribution of green roofs to the thermal performance of buildings
- Quantification of the contaminant removal of WSUD elements
- The water quality improvement function of green roofs
- The improved health outcomes for reducing temperatures in the city

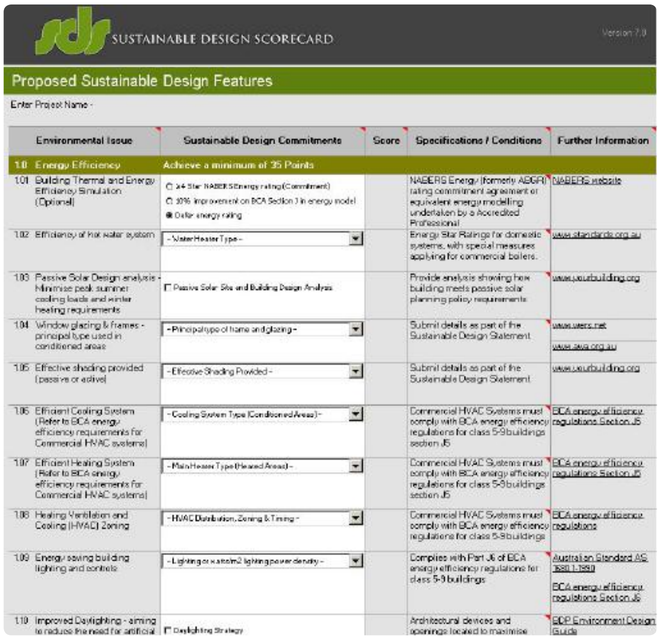
Compliance and Net Gain

Once a rating tool has been established and target points determined, it will be possible to set up a compliance base for project to ensure they meet the Green Infrastructure policy objectives. This can be a mandatory requirement for a minimum point score.

It may also be possible to enforce a Net Gain and Offset strategy so that even if the minimum points are not met on site, then overall Green Infrastructure objectives can be increased by transferring compliance to other sites. For example if a particular development cannot achieve a minimum GIRT score due to inherent site constraints, then a contribution can be made either off site or by way of a dollar developer contribution for a future project.



Example rating System: STEPS (Malvern City Council)



SUSTAINABLE DESIGN SCORECARD

Version 7.0

Proposed Sustainable Design Features

Enter Project Name -

	Environmental Issue	Sustainable Design Commitments	Score	Specifications / Conditions	Further Information
1.0	Energy Efficiency	Achieve a minimum of 35 Points			
1.01	Building Thermal and Energy Efficiency Simulation (Optional)	≥4 Star NABERS Energy rating (Commitment) 10% improvement on BCA Section J in energy model Dollar energy rating		NABERS Energy (formerly ABGR) rating commitment agreement or equivalent energy modelling undertaken by a Accredited Professional	NABERS website
1.02	Efficiency of hot water system	- Water Heater Type -		Energy Star Ratings for domestic systems, with special measures applying for commercial boilers.	www.standards.org.au
1.03	Passive Solar Design analysis - Minimise peak summer cooling loads and winter heating requirements	Passive Solar Site and Building Design Analysis		Provide analysis showing how building meets passive solar planning policy requirements	www.yourbuilding.org
1.04	Window glazing & frames - principal type used in conditioned areas	- Principal type of frame and glazing -		Submit details as part of the Sustainable Design Statement	www.wers.net www.awa.org.au
1.05	Effective shading provided (passive or active)	- Effective Shading Provided -		Submit details as part of the Sustainable Design Statement	www.yourbuilding.org
1.06	Efficient Cooling System (Refer to BCA energy efficiency requirements for Commercial HVAC systems)	- Cooling System Type (Conditioned Areas) -		Commercial HVAC Systems must comply with BCA energy efficiency regulations for class 5-9 buildings section J5	BCA energy efficiency regulations Section J5
1.07	Efficient Heating System (Refer to BCA energy efficiency requirements for Commercial HVAC systems)	- Main Heater Type (Heated Areas) -		Commercial HVAC Systems must comply with BCA energy efficiency regulations for class 5-9 buildings section J5	BCA energy efficiency regulations Section J5
1.08	Heating Ventilation and Cooling (HVAC) Zoning	- HVAC Distribution, Zoning & Timing -		Commercial HVAC Systems must comply with BCA energy efficiency regulations for class 5-9 buildings	BCA energy efficiency regulations
1.09	Energy saving building lighting and controls	- Lighting or watts/m2 lighting power density -		Complies with Part J6 of BCA energy efficiency regulations for class 5-9 buildings	Australian Standard AS 1680.1-1990 BCA energy efficiency regulations Section J6
1.10	Improved Daylighting - aiming to reduce the need for artificial	Daylighting Strategy		Architectural devices and openings located to maximise	EDP Environment Design Guide

Example rating System: The Sustainable Design Scorecard

25. Staged Implementation

By it's very nature, Green Infrastructure strategies will require implementation in a staged manner over a number of years.

Initially it is envisaged that a number of strategic insertions of Green Infrastructure elements will be made to high priority locations. These locations will be selected based on their potential impact for reward over expenditure (the easy gets). Through their establishment it is anticipated that further intensification and enhancement of urban greening to these locations will engender an appreciation of the benefits of this approach which will result in further increased demand.

For example a temporary 'pop up' food garden could be associated with a café development which if based on the sustainable principles inherent in the Green Infrastructure approach may encourage a larger development that could include permanent green wall food production gardens.

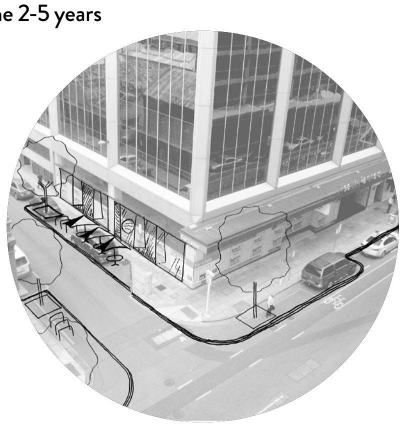
Following this street trees and enhancement of the pedestrian zone could be provided in space made available through the relocation of overhead and underground services. This could then initiate further streetscape enhancement works which would take advantage of the reduced confinement of services to provide even more expansive green space based on Water Sensitive Urban Design and Urban Forestry principles.

The diagrams to the right illustrate this staged implementation strategy.

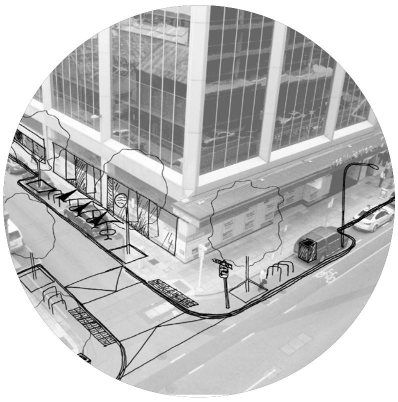
Timeline 0 years

Timeline 0 - 2 years

Timeline 2-5 years



Timeline 5-10 Years



26. Implementation Challenges

Successful Green Infrastructure projects will require responses many challenges. These challenges range across a number of entities including internal departments within the City of Adelaide, as well as external stakeholders, authorities, and the development industry generally.

A summary of some of these challenges is provided below.

Capacity Building

Successful implementation of Green Infrastructure will be dependent on how well it is embraced and adopted by the Adelaide City Council and the stakeholders responsible for capital works, maintenance and renewal projects.

For Adelaide City Council representatives it is imperative that a whole-of-organisation approach be taken to ensure that a Green Infrastructure approach is taken from a high level strategic planning point of view right through to finance, funding, accounting, and into design and implementation, as well as maintenance.

Many of these elements are not only novel, but also represent a distinctive departure from the business-as-usual approach to urban development. A capacity building program will need to be developed and implemented with a focus on communicating the imperative behind a Green Infrastructure approach, and educating and informing the people who will be responsible for conceiving, resolving and rolling out Green Infrastructure projects.

For example, a capacity building program could be developed within Council to include a WSUD stream that will show how a raingarden should be installed and maintained, and illustrate the conditions that passively irrigated street trees will experience and what factors need to be considered to ensure success.

Capacity building and training - Clearwater raingardens maintenance session (Image credit: Clearwater)

Underground services can have a major impact on ability to install trees

Utility Infrastructure

The amount of underground and overhead services in the city poses many challenges when it comes to physically fitting Green Infrastructure elements into limited space, particularly in the vicinity services that are commonly found within the street. These include:

- High voltage electrical
- Telecommunications (including copper and NBN)
- Gas
- Mains (potable) water
- Recycled (GAP) water
- Sewer

It may be the case that some of these services will require modification or relocation into common service trenches. This may need to be staged and coordinated with medium to long term planning, and within larger scale capital works and asset renewal projects.

Construction and Project Management

It is important that the design be fit for purpose, but it is also necessary that the contractor who undertakes the work has the expertise to realise the design intent. In some instances design and construction can take place in the absence of design standards, meaning clear design documentation and ongoing training are essential. For example there are currently no standard in Australia for roof gardens or vertical gardens. Similarly although there are guidelines for WSUD treatments, these are still evolving and are often updated frequently, meaning that any standard specifications may need review and revision on a regular basis.

It is also necessary to ensure coordination with service authorities, agencies, and importantly, maintenance and asset management personnel, to ensure the longevity of the project.

It is important that optimum planting and establishment times are considered when planning a project that involves planting. In Adelaide, where Summer can be extremely hot and dry, planting in Autumn and Winter will provide the optimum establishment time for plants. Despite this, projects are often planted in Summer, which can lead to plant failure.

Maintenance

As with all built infrastructure, Green Infrastructure will require a level of maintenance. This need not be onerous provided that it is considered in the design, and factored into the business case for the project.

In many instances maintenance will be the same as for traditional elements (for example weeding, pruning, fertilisation etc). In other situations maintenance may be more specific and targeted (for example periodic removal of sediments in raingardens, or adjustments to irrigation systems on a green roof or facade).

Growing Conditions

Due to the competition for space, many locations where greening is required will have minimal volume available for soil to support the growth of plants. Accordingly, in many instances the growing zone is constricted resulting in poor tree health and extended periods of establishment. The substrate or soil media will need to have good water holding capacity, while maintaining the ability to take the imposed loads of adjacent pavements and traffic.

The design of tree planting pits needs to optimise volume, weight, as well as water holding capacity and soil structure to support plant growth with low water use.

Failure of a green roof like this can be avoided by ongoing monitoring and maintenance, especially of the irrigation system

The necessity for irrigation to be kept up to green roofs and living facades

Water for Irrigation

An irrigation system is essential as a risk management measure to enable good plant establishment and on going viability of the planting. It is common that irrigation will only be needed in the summer months, however sufficient volumes of water will be needed during these periods, which needs to be balanced with the space constraints of a project.

Three types of water systems are possible with in the city:

- Stormwater Management (detention of peak flows to meet Council requirements)
- Harvesting and Re-use (irrigation, toilet flushing, wash downs using as much harvested water as possible)
- Water Features (closed system, recovered treated with as much harvested water as possible)

The potential to capture run off from adjacent pavements and roofs for storm water collection is critical, while the design of Green Infrastructure elements needs to balance the requirement for healthy plant use within the potential limitations of water availability.

Plant Selection and Horticultural Requirements

Plant selection including species tolerances to exposure (wind, sun) is paramount.

Other issues such as maintenance requirements and life cycle expectations also need to be considered. It is possible to design the planting for a roof garden so that it will self-regenerate and require little maintenance, but this needs to be done correctly otherwise there may be ongoing failure.

WHS and Safety in Design

In the context of green roofs, walls and facades, as these elements are relatively new approach to urban design, the risks and safety aspects are not yet fully covered by the Building Code of Australia or other relevant documents. The requirement to provide a safe work place under the WHS legislation means that safety in design is a legal obligation.

This is for both construction, and operation / maintenance periods, as well as for the general public.

Care must be taken with design to ensure growing conditions are adequate

Choosing the right tree for the right place is critical

Replacing the Moreton Bay Fig, Hindmarth Square

27. Adelaide Streetscape Opportunities

27.1 Introduction

As the single most beneficial areas for the adoption of Green Infrastructure, the following chapter demonstrates the implementation possibilities within Adelaide city streets using a series of before and after diagrams. The six streets selected represent the range of street sizes and typologies within the city, from laneways to wide residential streets and large scale boulevards. The case study streets used are:

- Waymouth Street (Major Street - Central Mixed Use)
- Ward Street (Major Street - Residential, Historic)
- Halifax Street (Major Street - Residential)
- Grote Street (Boulevard)
- Gray Street (Minor Street- Laneway)
- Flinders Street (Major Street - Central Commercial)

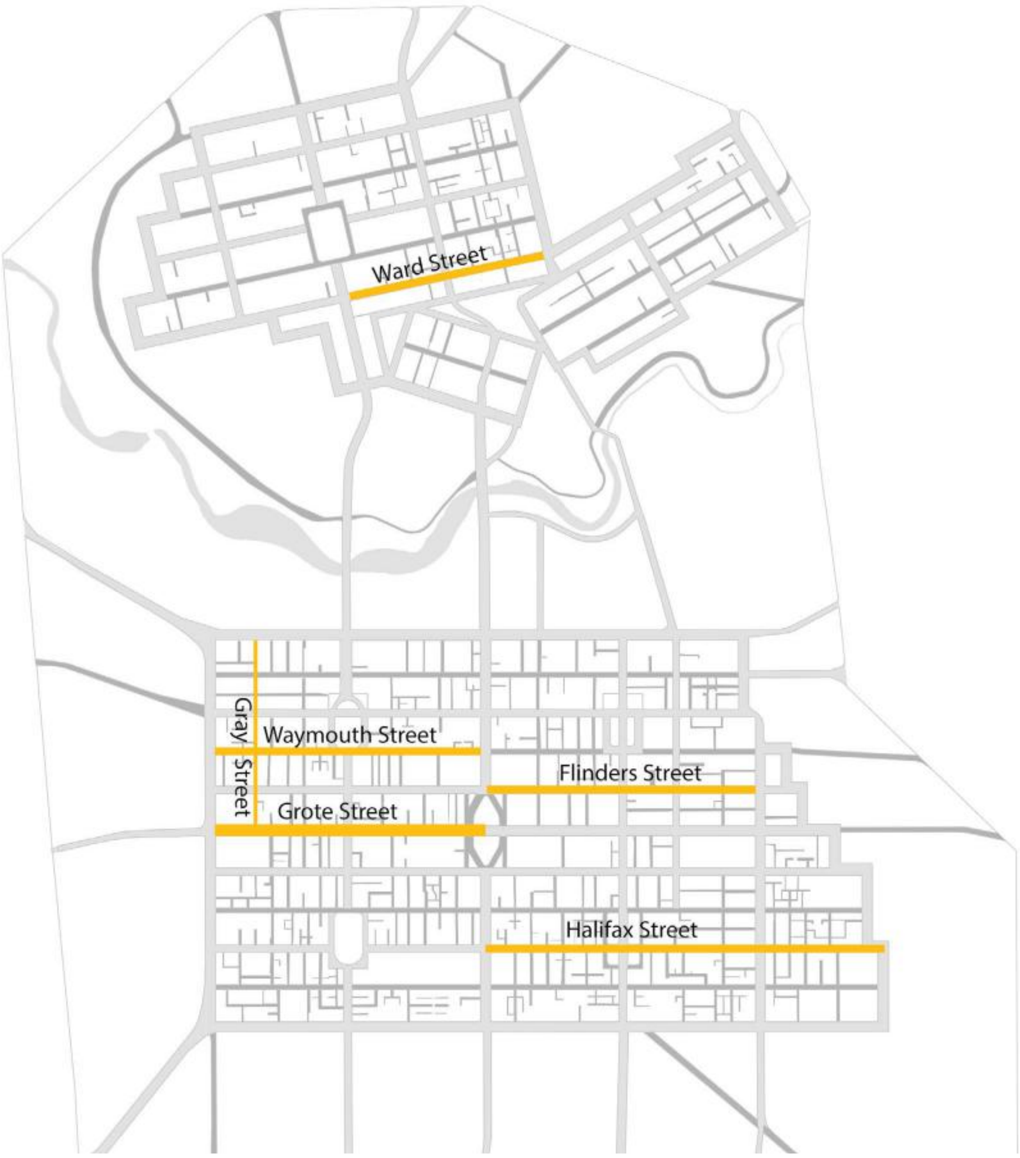


Figure 34: Example Street Locations

27.2 Waymouth Street

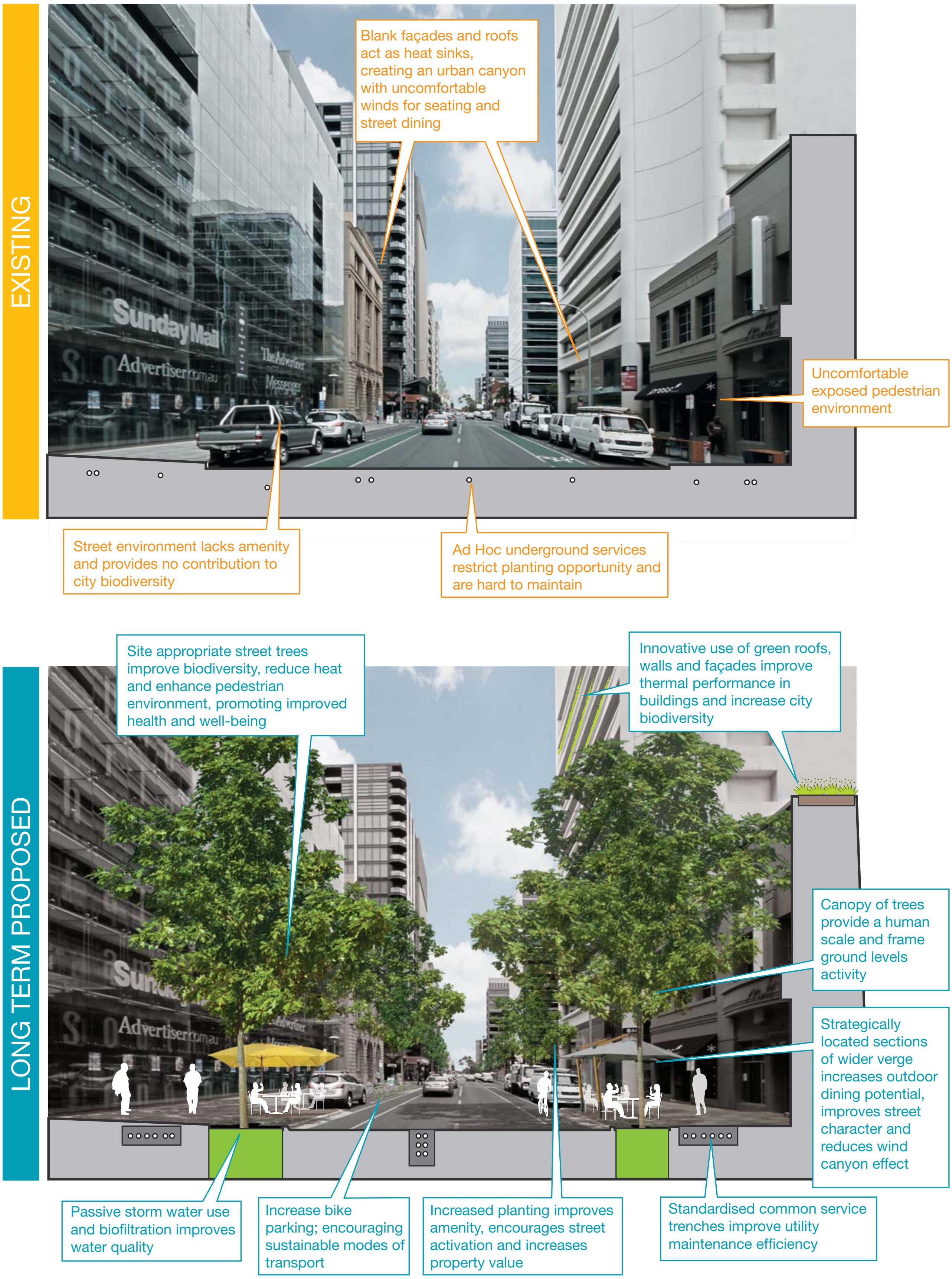


Figure 35: Waymouth Street - Green Infrastructure Opportunities

27.3 Ward Street

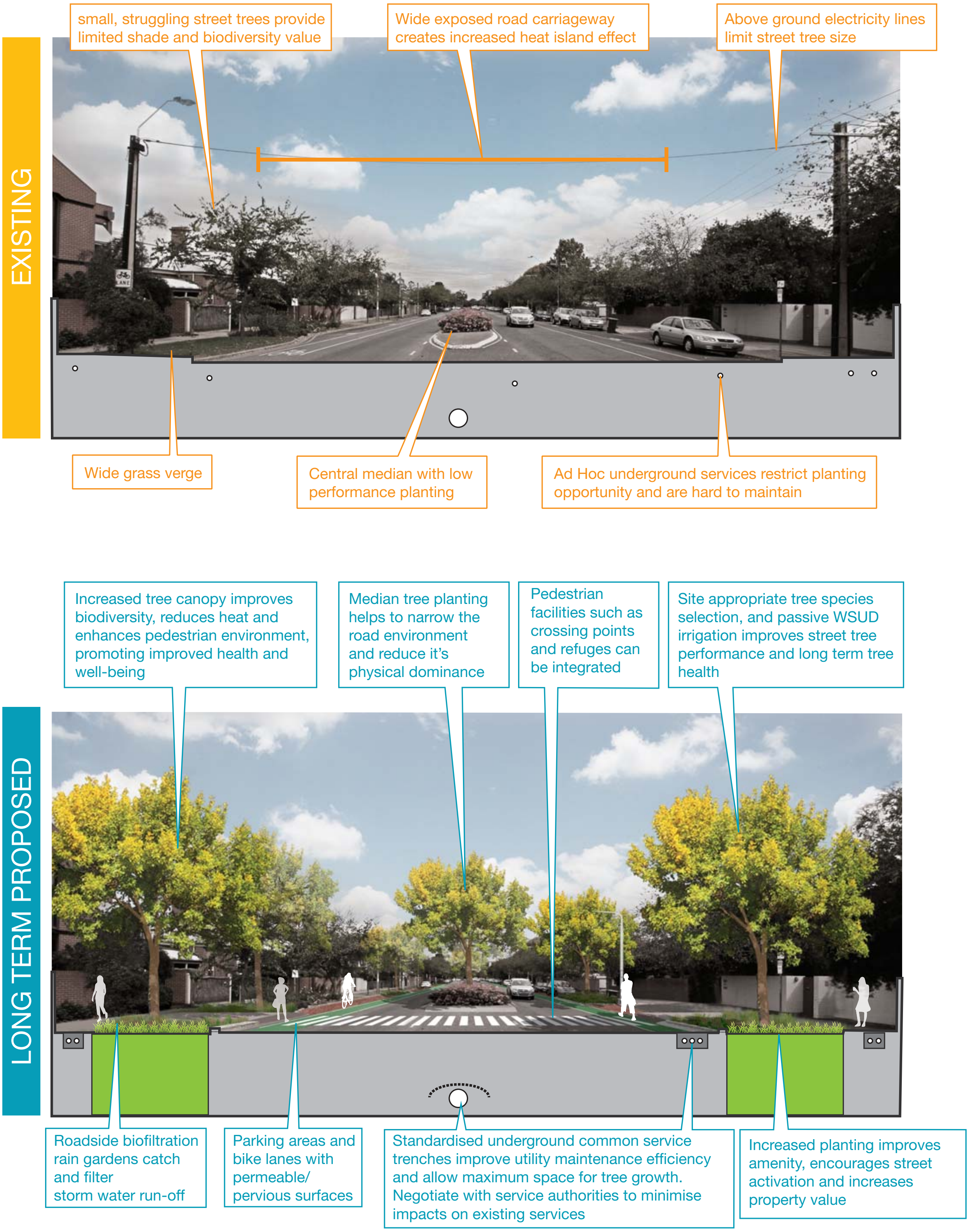


Figure 36 : Ward Street - Green Infrastructure Opportunities

27.4 Halifax Street

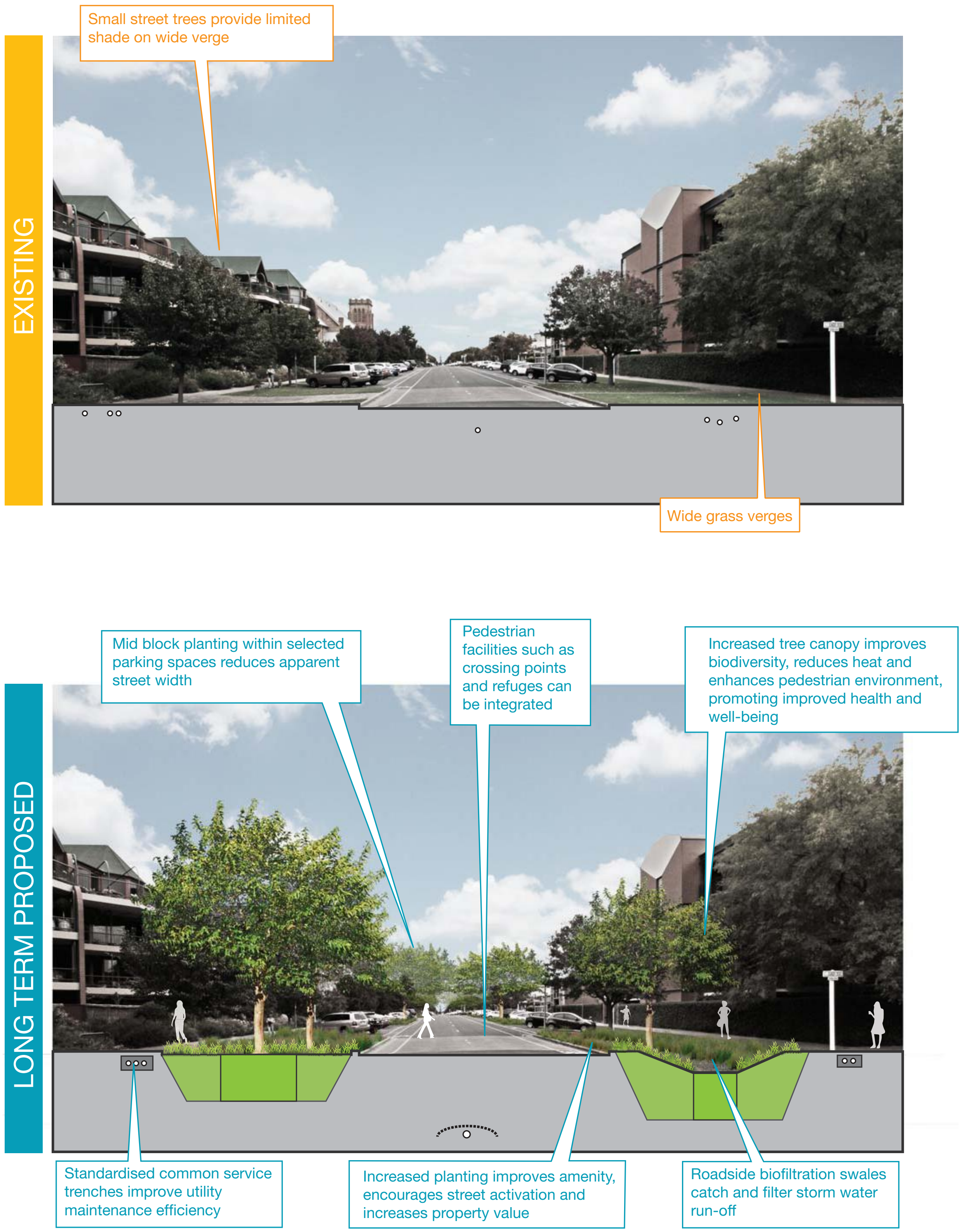
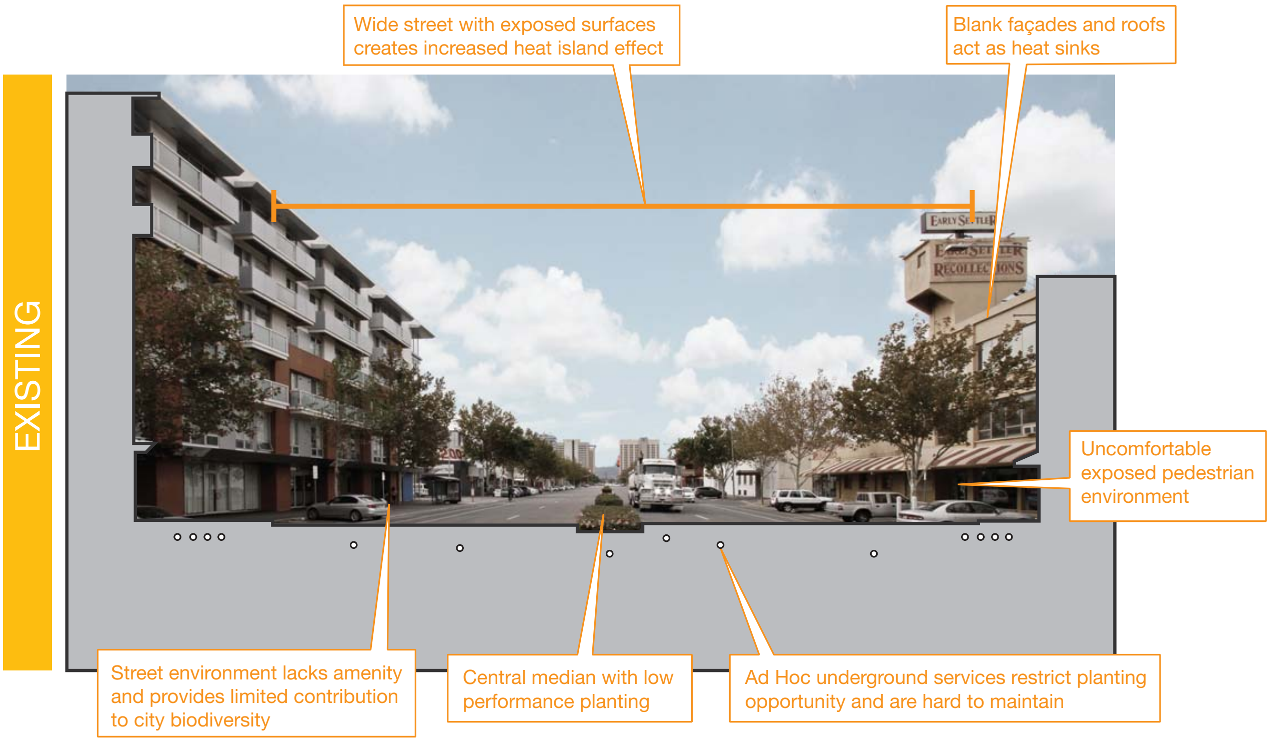


Figure 37: Halifax Street - Green Infrastructure Opportunities

27.5 Grote Street



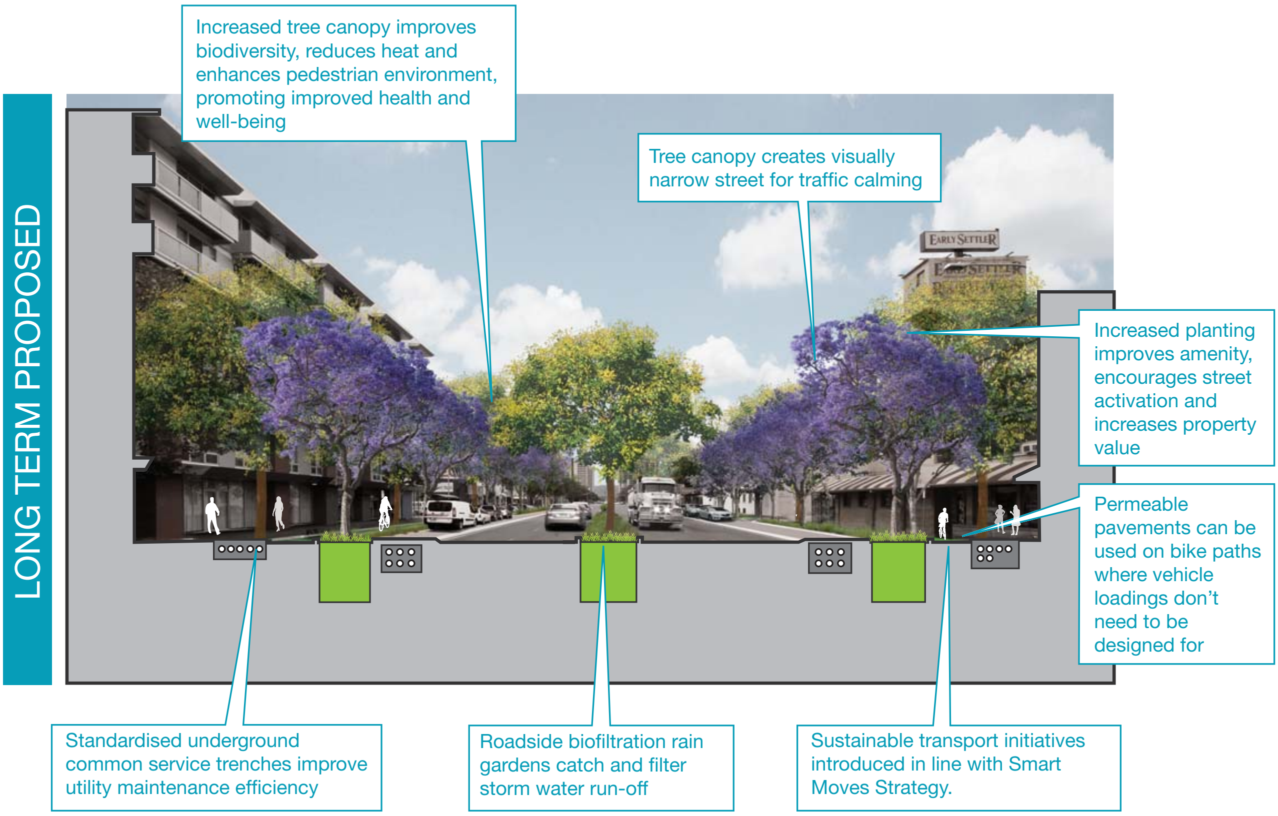


Figure 38: Grote Street - Green Infrastructure Opportunities

27.6 Gray Street

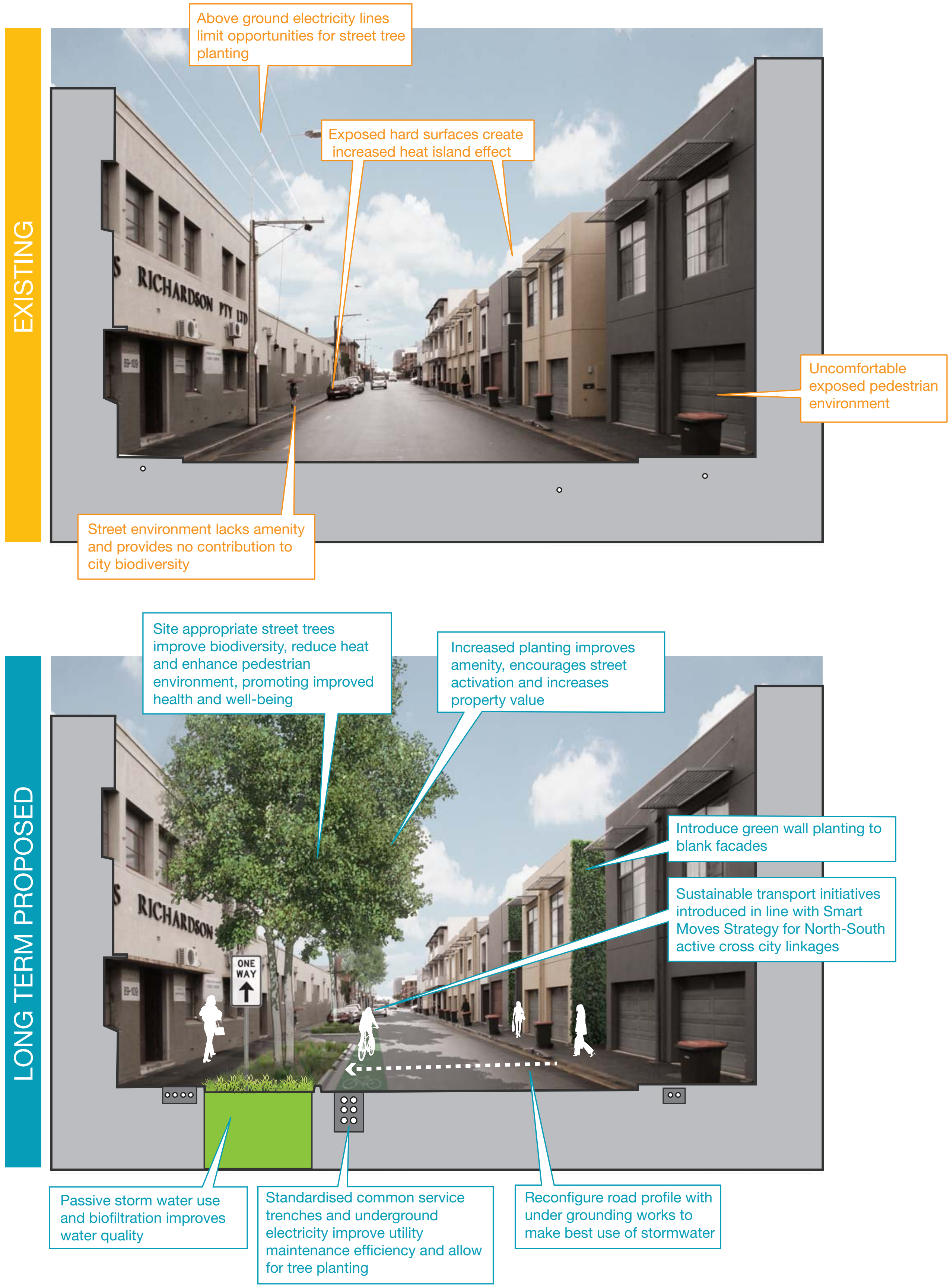


Figure 39: Gray Street - Green Infrastructure Opportunities

27.7 Flinders Street

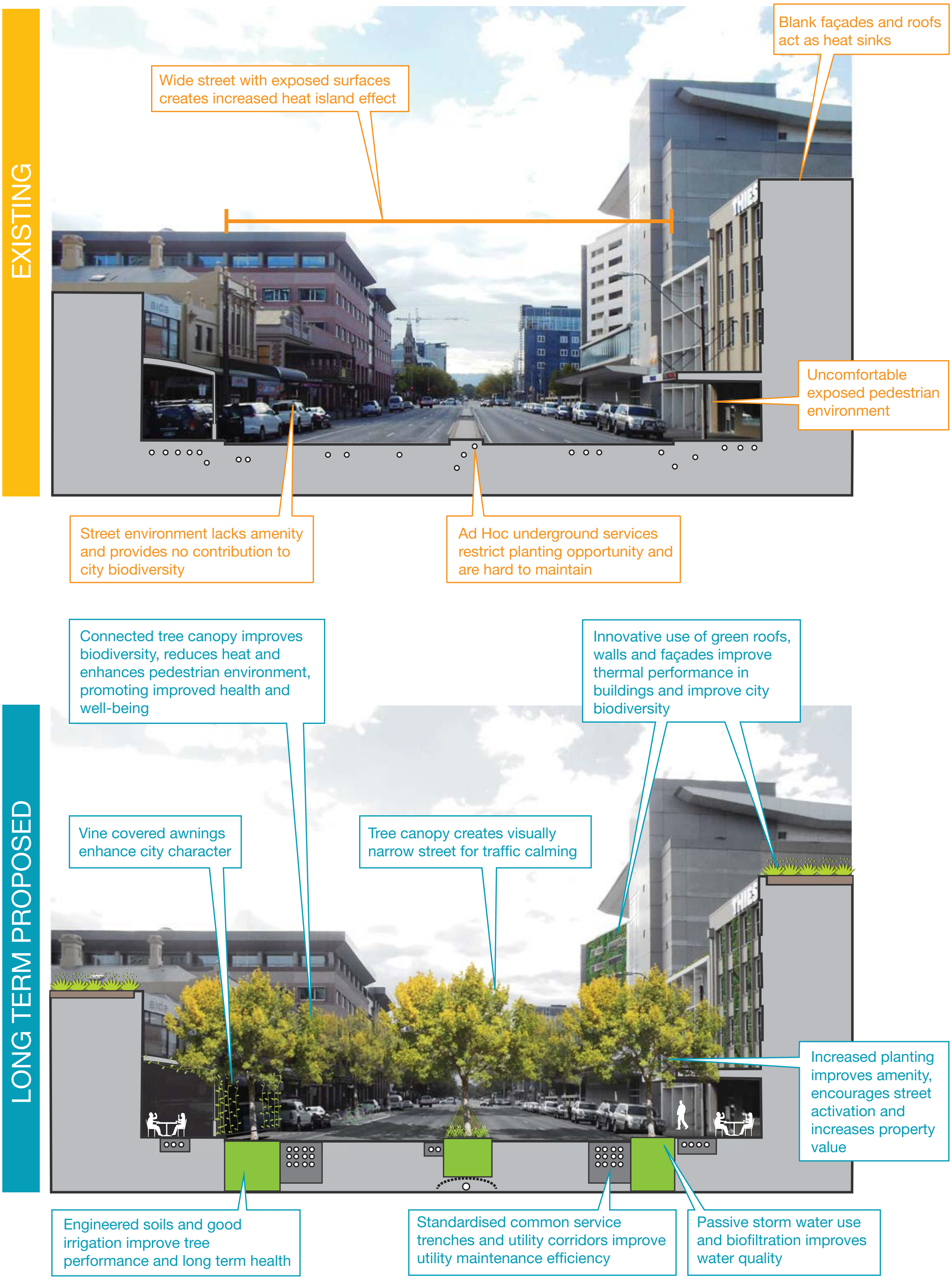


Figure 40: Gray Street - Green Infrastructure Opportunities

References

5000+ 'Context and Issues Report: Understanding Inner Adelaide, Government of South Australia, Adelaide, 2012

Adelaide City Council, 'Climate Change Adaptation Action Plan 2013-15', 2013

Balston JM, Kellett J, Wells G, Li S, Gray A & Iankov I, 'Quantifying the costs of climate change on local government assets', National Climate Change Adaptation Research Facility, Gold Coast, 2013

Department of Environment, Water and Natural Resources SA, 'Water Sensitive Urban Design: Creating more liveable and water sensitive cities in South Australia'

Department of Environment and Primary Industries Vic, 'Growing Green Guide: A Guide to Gren Roofs, Walls and Facades in MElbourne and Victoria, Australia' 2014

Cantor SL, 'Green Roofs in Sustainable Landscape Design', WW Norton & Co, 2008

Carpenter S, 'Green roofs and vertical gardens' International Specialised Skills Institute, 2008

Connellan G, Water Use Efficiency for Irrigated Turf and Landscape, CSIRO Publishing, Collingwood, 2013

Dunnett N, Kingsbury N, 'Planting Green Roofs and Living Walls', Timber Press, 2004

Fassman-Beck EA, Simcock R, 'Living Roof Review and Design Recommendations for Stormwater Management', Auckland Council Technical Report 2013/045, 2013

Gehl Architects, 'Public Spaces & Public Life Study: Adelaide 2011' 5000+ and Adelaide City Council, Adelaide, 2011

Guan H, Bennett J, Ewenz, Benger S, Vinodkumar, Zhu S, Clay R, Soebarto V. 'Characterisation, Interpretation and Implications of the Adelaide Urban Heat Island', Adelaide, 2013

Handreck KD, Black ND, 'Growing Media for Ornamental Plants and Turf', University of New South Wales Press, 4th edition, 2010

Hitchmough JD, 'Urban Landscape Management', Inkata Press, 1994

Hopkins G, Goodwin C, 'Living Architecture', CSIRO Publishing, Adelaide, 2011

Hopkins G, Goodwin C, Milutinovic M, Andrew M, 'Feasibility study: living wall systems for multi-storey buildings in the Adelaide climate', Report for the Government of South Australia, 2010.

Hui S, 'Guidelines for the design and application of green roof systems' ,The Chartered Institution of Building Services Engineers Hong Kong, November 2013

Land and Water Constructions for the City of Kingston; Melbourne Water; Clearwater; Victorian Department of Sustainability and Environment - 'Review of Street Scale WSUD in Melbourne'

Luckett K, 'Green Roof Construction and Maintenance', McGraw Hill, 2009

Norton BA, Coutts AM, Livesley SJ, Williams NSG, 'Decision principles for the selection and placement of green infrastructure', Victorian Centre for Climate Change Adaptation Research, 2013

Melbourne Water, 'WSUD maintenance guidelines – inspection and maintenance activities', 2013

Melbourne Water ,'WSUD maintenance guidelines – A guide for asset managers', 2014

Melbourne Water, 'WSUD Engineering Procedures: Stormwater', CSIRO Publishing, 2005

National Health Performance Authority, 'Healthy Communities: Overweight and obesity rates across Australia, 2011–12' (In Focus), 2013

Perkins M, Joyce D, 'Living Wall and Green Roof Plants for Australia', RIRDC Publication No. 11/175, Rural Industries Research and Development Corporation, 2012

Pitman S, Ely M 'Green Infrastructure: life support for human habitats; The compelling evidence for incorporating nature into urban environments', DEWNR & Botanic Gardens of Adelaide, Adelaide, 2012

RMIT, 'The Matter of Landscape: Sustainable Design Strategies for RMIT City Campus', 2013

SA Department for Environment and Natural Resources 2013, 'Backyards For Wildlife; Conserving Adelaide's Biodiversity', Viewed 19 May 2014, <http://www.backyards4wildlife.com.au>

Snodgrass EC & Snodgrass LL, 'Green Roof Plants', Timber Press, 2006

Snodgrass E, McIntyre L, 'The Green Roof Manual: A Professional Guide to Design, Installation and Maintenance', Timber Press 2010

Snodgrass EC, Dunnett N, Gedge G & Little J, 'Small Green Roofs: Low-tech Options for Greener Living', Timber Press, 2011

Sumerling P, *The Adelaide Parklands, a Social History*, Wakefield Press, Adelaide, 2014

Tan A, Chiang K, 'Vertical Greenery for the Tropics', CUGE Singapore, 2011 reprint.

Treelogic, 'Where is the Spacde for New Trees', 2014, http://treelogic.com.au/facts/wp-content/uploads/2011/06/Fact-sheet_space_for_trees.pdf

Weiler SK, Scholz-Bar th K, 'Green Roof Systems', John Wiley & Sons, 2011

Appendix 1: Best Practice Examples

Best Practice Examples: USA

EPA's Low Impact Development (LID) policy

http://water.epa.gov/polwaste/green/

EPA's Green Infrastructure policy:

http://water.epa.gov/infrastructure/greeninfrastructure/

Seattle Green Factor

https://www.seattle.gov/dpd/cityplanning/completeprojectslist/greenfactor/whatwhy/

Portland Oregon

http://www.oeconline.org/our-work/water/stormwater/low-impact-development

San Francisco

http://sfwater.org/index.aspx?page=667

LID Centre – Green streets

http://www.lowimpactdevelopment.org/greenstreets/links.htm

Best Practice Examples: Australia

Victoria

Clearwater – Water Sensitive Cities Capacity Building (funded by Melbourne Water)

http://clearwater.asn.au/about-us/who-we-are.php

http://www.clearwater.asn.au/resource-library/policy-and-guidelines/water-sensitive-urban-design-guidelines-south-east-growth-Council.php

Melbourne Water

http://www.melbournewater.com.au/wsud

Office of Living Victoria

http://www.livingvictoria.vic.gov.au/

City of Melbourne

http://www.melbourne.vic.gov.au/Sustainability/SavingWater/Pages/Watersensitivedesign.aspx

Victorian Centre for Climate Change Adaptation Research

http://www.vcccar.org.au/

Green Infrastructure Research Group

http://www.land-environment.unimelb.edu.au/research/research-groups/green-infrastructure-research-group/

NSW

WSUD in the Sydney Region

http://www.wsud.org/

Botany Bay water Quality Improvement Program - WSUD

http://www.sydney.cma.nsw.gov.au/bbcci/WaterSensDesign.html

Queensland

Brisbane City Council WSUD

http://www.brisbane.qld.gov.au/planning-building/planning-guidelines-and-tools/guidelines/subdivision-development-guidelines/water-sensitive-urban-design/index.htm

Healthy Waterways

http://waterbydesign.com.au/

Gold Coast City CouncilCouncilCouncilCouncilCouncil

http://www.goldcoast.qld.gov.au/documents/bf/music_modelling_guidelines.pdf

Western Australia

Government of Western Australia Department of Water

http://www.water.wa.gov.au/Managing+water/Urban+water/Urban+water+management/default.aspx

http://www.water.wa.gov.au/PublicationStore/first/85823.pdf

South Australia

Government of South Australia WSUD

http://www.sa.gov.au/topics/housing-property-and-land/building-and-development/land-supply-and-planning-system/water-sensitive-urban-design

Water Sensitive South Australia

http://www.watersensitivesa.com/document/water-sensitive-urban-design-creating-more-liveable-and-water-sensitive-cities-south

http://watersensitivesa.com/sites/default/files//user/documents/SA_WSUD_Capacity_Building_Program_Business_Case.pdf

Kitchen Gardens SA

http://www.kitchengardenssa.com.au/index.php/running-your-garden/community-garden-news

Appendix 2: Policy & Background Research

Policy Drivers and Background

There are multiple tiers of policy and planning at a national, state and local government level that advocate for the delivery of Green Infrastructure within the urban environment. For the purposes of establishing the Green Infrastructure Guidelines for Adelaide, the following summary of strategic documents specific to the Adelaide context highlight these main drivers.

Public Spaces & Public Life Study, City of Adelaide 2011

A follow up study to the Public Spaces & Public Life in Adelaide 2002 document by Gehl Architects, the study uses Jan Gehl's 'Public Spaces and Public Life' methodology to collate survey data for Adelaide, compare this date to the 2002 study and provide actions and recommendations for the public spaces and life of Adelaide City for the future.

Vision statements identified in the study are linked to the Green Infrastructure Guidelines and include;

- A strong green identity and awareness…linking to green surroundings and creating a green city profile
- A city with great squares for recreation
- A lively and liveable city
- An attractive city

Actions identified in the study relevant to green Infrastructure include;

- Re-integrate the River Torrens.
- Celebrate the Parklands
- Reclaim the Streets

Water Sensitive Urban Design – creating more liveable and water sensitive cities in South Australia, Government of South Australia Document

This document sets out the South Australian Government's position on WSUD in a local context, and provides guiding principles for WSUD implementation state-wide as well as objectives and targets for WSUD implementation in new urban developments and infrastructure.

The City of Adelaide Smart Move Transport and Movement Strategy 2012-2020

The Smart Move Strategy outlines Council's desired transport and movement outcomes for the City, and the strategies to achieve these over the next ten years. The focus of the strategy is the creation of a people-friendly City by improving conditions for pedestrians, cyclists and those using public transport while also balancing the needs for parking, loading and car accessibility.

The report identifies key strategies relating to Green Infrastructure including the need for a city where walking is easy, comfortable and safe

Recommendations in the Green Infrastructure Guidelines relating to roads, parking and movements corridors are aligned with the Smart Move Strategy

5000+ Place Shaping Framework, Consultation Draft, September 2012

This document sets the benchmark for the strengthening of a

diverse city of places.

Climate Change Adaptation Action Plan 2013-15

ACC policy document outlining Climate Change data and impacts in an Adelaide context as well as Council strategies and actions for the integration of Climate Change adaption into all Council activities.

As a part of the Urban Design Framework (City Design), the Green Infrastructure Guidelines will directly link to the Climate Change Adaption Plan

The Green Infrastructure Guidelines will form a key part of implementing the Climate Change Adaption Plan Strategy '1.4 Increase adoption of measures such as WSUD and green infrastructure initiatives (e.g via integration with asset planning and city design processes'.

ACC Streetscape Improvements- Roads in the Residential District Action Project 1, December 1977

This planning document details opportunities and actions for streetscape improvements within the City of Adelaide. It includes a number of recommendations relating to the design of street scapes including road widths and materials, landscaping and street trees, and on street parking.

Adelaide City Council WSUD Options Final Report, 21 June 2013

A report outlining WSUD opportunities within the City of Adelaide, with a particular focus on stormwater treatment opportunities

The report includes information and research on storm water catchment and WSUD implementation on a precinct basis

Characterisation, Interpretation and Implications of the Adelaide Urban Heat Island, June 2013

This research document, conducted by Flinders University, the National Centre for Groundwater Research and Training and the University of Adelaide details and interprets research into the Adelaide Urban Heat Island including extensive modelling, field research and remote sensing.

It contains substantial data and implications for the future of urban planning and development in Adelaide in relation to climate change and the Urban Heat Island effects which reinforces the necessity to consider ways of investigating climate change and heat in the city.

Botanic Gardens of Adelaide Green Infrastructure: Life Support for Human Habitats 'The compelling evidence for incorporating nature into urban environments, November 2012

A research document which provides an overview of the relevant literature relating to Green Infrastructure as well as key findings by specific research topics including Human hHealth and Well-being, Community Livability, Economics, Climate Modification, Water Management and Food production

Experiences From Elsewhere

The initiatives presented within this guide are by no means novel to Adelaide, or even Australia. These measures have been refined, developed, incentivised, and widely adopted in many cities throughout the world. Relevant examples include:

City of Melbourne Urban Forest Strategy

In Australia, for example the City of Melbourne has a released an Urban Forest Strategy that provides a strong vision, and realizable objectives to enhance and expand its urban forest over the next 30 years. Its primary stated objective is to achieve "provide a greener and cooler city for those who live, work and play in our municipality. Most importantly, it articulates how we can enhance our urban forest to reflect and respond to the needs of the community and the city."

The strategies and targets proposed to achieve this vision are:

Strategy 1: Increase canopy cover
Target: Increase public realm canopy cover from 22% at present to 40% by 2040.

Strategy 2: Increase urban forest diversity
Target: The urban forest will be composed of no more than 5% of any tree species, no more than 10% of any genus and no more than 20% of any one family.

Strategy 3: Improve vegetation health
Target: 90% of the City of Melbourne's tree population will be healthy by 2040.

Strategy 4: Improve soil moisture and water quality
Target: Soil moisture levels will be maintained at levels to provide healthy growth of vegetation.

Strategy 5: Improve urban ecology
Target: Protect and enhance a level of biodiversity that contributes to a healthy ecosystem.

Strategy 6: Inform and consult the community
Target: The community will have a broader understanding of the importance of our urban forest, increase their connection to it and engage with its process of evolution.

Growing Green Guide

Recently the Growing Green Guide for Melbourne has been launched which provides a comprehensive guide to developers, designers, and the general community on the whys and hows of incorporating green roofs, walls, and facades into the city of Melbourne. This guide is a valuable resource that is also accompanied by policy directions and feasibility and demonstration project that seek to improve the resilience of the city to climate change and maximize the sustainability of development.

Greening the West

This initiative espouses the vital contribution that green infrastructure needs to play in one of the fastest growing municipalities in Australia – Melbourne's outer West. This includes the area from Footscray to Geelong where the pace of development, and unique regional climate results in a huge discrepancy between annual rainfall and evapotranspiration (not dissimilar to Adelaide's'). These factors conspire to create a local where urban development is intensifying at rates not seen elsewhere, under the pressures of low rainfall and increasing temperatures.

The Greening the West initiative seeks to link Councils, water authorities, and developers with the principles and measures needed for long term sustainable develop in terms of economic, social and ecological sustainability.

Other initiatives relevant to a green infrastructure approach are:

Melbourne Water's - Best Practice Engineering Guidelines for Water Sensitive Urban Design

The work undertaken by Melbourne Water through the Monash University's Centre of Cooperative Research, and furthered by many local government municipalities has been instrumental in establishing Melbourne at the forefront of water Sensitive Urban Design world wide. This includes the formulation of the Municipal Urban Storm Water Improvement Conceptualization modelling software (MUSIC) which can simulate the contaminant removal function of a variety of WSUD measures as a benchmark for performance compliance. This tool has resulted in a Best Practice standard of treatment which is legislated for urban storm water quality improvement in Melbourne.

Office of Living Victoria

The state government agency has at it disposal a $50 million fund to encourage innovation in Integrated Water Cycle Management. This is in response to the recognition that the costs of storm water impacts and water supply to Melbourne over the next 50 years will be exorbitant under business-as-usual approached to development.

Victorian Centre for Climate Change Adaptation

This body is specifically investigating the contribution of the urban forest and other green infrastructure elements to reductions in the impacts iof the urban heat island in the face of climate change

Appendix 3: Workshop Summary

A Workshop Approach

In March 2014, representatives from Adelaide City Council's Green Infrastructure working group were assembled in a workshop environment with the aim to establish an aligned direction and purpose for the Green Infrastructure Guidelines. The group comprised representatives from the City Design, Vibrant City, Sustainability, Asset Management and Infrastructure teams within council. The aims identified by the group were recorded as follows;

Primary Aims

- Assist with the delivery of high quality and sustainable public spaces
- By Maintaining and increasing the level of green infrastructure across the city, the attraction of and resultant visitation to the city will be greatly improved.
- Promote the value of Green infrastructure as an essential asset for the city
- Through advocacy, Council will promote the adoption of green infrastructure within both the public and private sector, ensuring that the ongoing development of the public realm is considered holistically with regard to utilities infrastructure upgrades, urban development and integration of greening as a complimentary development strategy across the city.

Other objectives

- Create a document which is educational both within council and for the wider community
- Create a shared resource to be utilised across council departments and by external organisations
- Support state government objectives and align with related State and City Policy guidelines
- That the guidelines will form part of the City of Adelaide Development Review documents
- Include clear guidelines for implementation of Green Infrastructure elements including performance measures
- Promote triple bottom line approach to budget / provide long term valuation of cost/benefit
- Communicate long term Green Infrastructure goals

Themes

The following themes were recurrent in the workshop and follow up discussion with the working group.

- Integration
- Value
- Education
- Alignment
- Communication

Notes from the ACC Green Infrastructure Workshop

Appendix 4: Example Maintenance Strategies

Green Roofs, Walls and Facades

Extract from '*Growing Green Guide: A Guide to Green Roofs, Walls and Facades in Melbourne and Victoria, Australia*'

(Department of Environment and Primary Industries Vic, 2014, pp 93-95)

"For some green roofs, walls or facades, particularly those located on commercial premises, maintenance will be undertaken by someone other than the building owner. A maintenance agreement with the installation company or with a recommended third party may be the most economical way to ensure the best long-term performance of a green roof, wall or facade. If a maintenance contract is used, it is important to be clear about the duration of the maintenance agreement, the scope of maintenance responsibility, and the need for hand over at changeover to either new contractors or back to the building owner....

Common Maintenance Tasks:

Maintain planting design

Plant replacement, infill plantings

Maintain plant growth

Remove waste plant material (leaf litter, prunings, weeds), inspect for signs of pests or disease and treat as needed, make seasonal adjustments to irrigation volume and frequency as needed, ensure adequate nutrition levels for plants; inspect after severe weather events (e.g. wind or heat) to look for signs of stress

Minimise weeds

Mulching, weed control

Manage lawns

Regular mowing, annual renovation

Maintain trees

Regular pruning, annual tree inspection, brace and support as needed

Maintain climbing plants

Annual or biannual pruning to maintain density and cover and to remove growth from fixtures (windows, drains). Rejuvenate to renovate habit and growth

Rejuvenate climbing plants

Vigorous pruning to renew stems and encourage new basal growth (every 5-7 years)

Monitor plant performance

Maintain records of plant health, vigour and coverage, pest and disease impact

Maintain substrate

Top-up of growing substrate may be required due to wind, rain or animal activity (check the depth of the growing substrate before any additions are made to ensure weight loadings are not exceeded)

Maintain irrigation (and fertigation) systems

Manually test and inspect the irrigation system regularly and monitor any automated systems (check volume of irrigation delivered, its frequency, substrate moisture content, and, for hydroponic green walls, nutrient levels in the water supply)

Monitor plant nutrition

Maintain a log of fertiliser additions and records of pH and electrical conductivity values before and after addition of fertiliser

Maintain drainage

Ensure roof drains are clear and functioning, remove dirt, litter and other deposits from drain inspection chambers, check plumbing hardware, check condition of filter sheet and deeper layers if necessary

Maintain non-vegetated zones

Remove vegetation from perimeter zones and around other equipment and fixtures

Maintain wind protection features

Check the condition and fit of protection systems

Maintain safety systems

Check safety anchor points for fall arrest systems, check access points, e.g. ladders and stairways, check electrical safety of power points, lighting and irrigation control system

Passively Irrigated Street Trees and Planting

Example Maintenance Activities

Component	Key Activities	Typical Frequency
Filter Media	Remove leaf litter and gross pollutants Check for biofilms (algal biofilms may develop on the surface of the filter media leading to clogging issues) Monitor the ponding of water following rainfall events	3 months & following storm events
	Remove accumulated sediment(or scarify filter media surface if required)	Annually
Mulch	Check depth and even distribution of mulch layer Check mulch is not touching the tree trunk Replace mulch (if required) Check for sediment/silt accumulation within mulch layer	3 months
Vegetation	Inspect plant health (signs of disease, pests, poor growth) Check plant stability (tree supports) Remove weeds (avoid use of herbicides) Prune plants (where applicable) Water plants (if required during establishment phase)	3 months
Civil components	Inspect for physical damage, concrete cracking and subsidence (sinking) Ensure inlet and outlet points are clear of sediment, litter and debris	3 months & following storm events
	Inspection opening: Check the underdrain (slotted drainage pipe) system for standing water or sediment accumulation Flush the underdrain system (if required	Annually

Raingardens

Example Maintenance Activities

Component	Key Activities	Typical Frequency
Filter Media	Remove leaf litter and gross pollutants Check for biofilms (algal biofilms may develop on the surface of the filter media leading to clogging issues) Monitor ponding of water following rainfall events Check for permanently boggy/pooled areas	3 months & following storm events
Erosion	Check for erosion/scouring Check for evidence of preferential flow paths Replace filter media in eroded areas Add rock protection around inlets (if required)	3 months
Mulch	Check depth and even distribution of mulch Check mulch is not touching plant stems Check for sediment/silt accumulation in mulch layer Replace mulch (if required) Retain mulch using jute mats or nets (if required)	3 months
Vegetation	Inspect plant health and cover Replace dead plants (maintain a consistent vegetation density of 6–10 plants per square metre across the raingarden filter media) Remove weeds (avoid use of herbicides) Prune plants (where applicable) Water plants (if required during establishment phase)	3 months
Civil components	Check infrastructure for damage and repair as required Ensure inlet and outlet points are clear of sediment, litter and debris	3 months & following storm events
	Inspection opening for underdrain (slotted drainage pipe): Check water level Check for sediment accumulation Flush the underdrain system (if required)	Annually

Permeable Pavements

Example Maintenance Activities

Component	Key Activities	Typical Frequency
Paving Surface	Check for accumulated sediment Sweep, wet vacuum or pressure hose the surface of the pavers to remove clogging material Check infill material is present between pavers Monitor ponding of water following rainfall events	3 months & following storm events
Bedding material	Check level of the pavement surface	Annually
Underdrain	Check inspection openings for sediment accumulation	3 months