

## Report Information

<b>Reference</b>	Living Infrastructure_Final Report
<b>Prepared by</b>	Tait Network
<b>On behalf of</b>	EPSDD

## Revision History

Revision Number	Revision Date	Details	Authorised
A	23.08.2018	Draft for Client review	OT

## Table of Contents

<b>1.0</b>	<b>Executive Summary</b> .....	<b>4</b>
<b>2.0</b>	<b>Background</b> .....	<b>5</b>
<b>3.0</b>	<b>Literature Review</b> .....	<b>7</b>
3.1	Documents Reviewed .....	7
3.1.1	Policy approach .....	7
3.1.2	Terminology.....	8
3.1.3	Mechanisms .....	10
<b>4.0</b>	<b>Existing Statutory Provisions in the ACT</b> .....	<b>17</b>
4.1	Territory Plan.....	17
4.1.1	Terms and Definitions .....	17
4.1.2	References.....	17
4.2	Summary of Existing TCCS Standards.....	18
4.2.1	MIS 01: Street Planning And Design .....	19
4.2.2	MIS 06: Verges.....	19
4.2.3	MIS 08: Stormwater .....	19
4.2.4	MIS 15: Urban Edges Management Zone.....	19
4.2.5	DS 14: Urban Open Space.....	19
4.2.6	MIS 24: Soft Landscape Design.....	20
4.2.7	MIS 25: Plant Species for Urban Landscape Projects.....	20
<b>5.0</b>	<b>Spatial Analysis</b> .....	<b>21</b>
5.1	Data Sets .....	21
5.2	Scenarios 1, 2 and 3 .....	21
5.3	Methodology.....	22
5.3.1	General assumptions: .....	22
5.3.2	Exclusions .....	22
5.3.3	Terminology.....	22
5.4	Existing Conditions.....	22
5.5	Facts and Figures behind the data.....	22
5.5.1	Suburb.....	22
5.5.2	Street.....	23
5.5.3	Block – Study Blocks.....	23
5.5.4	Block – All Blocks .....	24
5.5.5	Planting (POS & PPOS) .....	25
5.6	Canopy / Permeability.....	26

5.6.1	Suburb.....	26
5.6.2	Street.....	27
5.6.3	Block – Study Blocks.....	27
5.6.4	Block – All Blocks .....	28
5.7	Possible Future Conditions.....	28
5.8	Scenario 2.....	28
5.9	Scenario 3.....	28
<b>6.0</b>	<b>Findings from Data Analysis .....</b>	<b>29</b>
6.1	Existing Living Infrastructure .....	29
6.1.1	Where it is? .....	29
6.1.2	Where is it missing? .....	29
6.2	Expected Impact .....	30
<b>7.0</b>	<b>Recommendations .....</b>	<b>32</b>
7.1	Overview .....	32
7.2	Block Level.....	32
7.3	Street Level.....	35
7.4	Suburb Level.....	36
7.5	Living Infrastructure in the Statutory Framework .....	36
7.6	Resources and maintenance .....	37
7.7	Education.....	37
<b>8.0</b>	<b>Further Studies.....</b>	<b>38</b>
<b>10.0</b>	<b>Conclusion.....</b>	<b>40</b>
<b>11.0</b>	<b>Attachments.....</b>	<b>41</b>

## 1.0 Executive Summary

- Synopsis – we are engaged by x to do x and deliver x
- The definitions may vary across jurisdictions but are only nominally different. The main difference is the variations of percentage applied to the terms. This is where our focus lies, on creating stronger minimum standards
- An integrated planning, or ‘whole of Government’, approach is considered to be a key factor in the success of green infrastructure strategies and should include the public, professionals, relevant peak bodies, associations or institutions.. (Lit Review)
- Living infrastructure should be identified as an asset as essential as roads and storm water pipes and funded accordingly (GANSW) in order to initiate institutional and political commitment that will ensure the appropriate institutional arrangements needed for long term success (Alexandra). (lit Review)
- X number of issues identified and x number of mechanisms are proposed to address said issues. The mechanisms are across three scales to assist in delivery of overcoming these issues
- Its through rating tools, design guides and statutory controls that the topic must be approached in addition to funding and education.
- The preference would be to do wholesale revision and implement this as a suite, but even minor adjustments and strengthening of existing rules where the criteria fails the intent of the rule will make significant differences
- A range of further studies is required to implement the recommendations in this report.

**Commented [A1]:** Katherine can you comment on this approach – is this what you would like the exec summary to say?

## 2.0 Background

As Canberra evolves to become a more compact city with more intensively developed urban areas, the need for making living infrastructure an integral part of the city's form and function increases. A balance must be achieved between urban intensification and amenity provided by living infrastructure. Living infrastructure refers to all interconnected ecosystems within urban areas and integrates and builds upon 'green infrastructure' and 'blue infrastructure' within the urban landscape.

*Canberra's Living Infrastructure Information Paper* (February 2018) outlines the ACT's commitment to developing a living infrastructure strategy, including targets for urban tree canopy cover as part its integrated approach to climate change. The strategy will sit within the Land Use Sector of the *ACT Climate Strategy to a Net Zero Emissions Territory* policy being developed in 2018.

Environment Planning Sustainable Development Directorate (EPSDD) is considering the policy principles, strategies and mechanisms for establishing living infrastructure requirements as part of urban intensification in future urban renewal and greenfield development in the ACT. In particular, EPSDD is interested in how living infrastructure can be supported through the mechanisms in the Territory Plan, Government policies, design and technical guidelines.

Tait Network were engaged in 2018 by the Planning Policy Division of EPSDD to provide advice and recommendations on policy principle and mechanisms to support the implementation of living infrastructure as part of residential development in urban renewal and greenfield development areas. The strategies and mechanisms provided will inform changes within the Territory Plan and ACT Planning policing including changes to street subdivision design, verge widths, zoning, plot ratio, building height, private open space and vegetated cover with the objective to provide optimum living infrastructure outcomes.

A project steering group was established by EPSDD comprised of representatives across ACT Government. The steering group took part in 2 workshops, one to review early findings from the literature review and data analysis phases, and another to review the draft recommendations. Feedback was captured through meeting minutes, and each comment addressed in response to comments.

This report is the culmination of the project, capturing the outcomes of a literature review process (undertaken in Stage 1 of the project) and analysis of data provided by EPSDD (undertaken in Stage 2 of the project). It sets down our key findings and recommendations for improving urban infrastructure outcomes in the ACT.

### Project Focus

A key focus of the project is the application of living infrastructure under the Territory Plan and an assessment of the effectiveness of existing terminology and mechanisms for supporting living infrastructure, including requirements for site open space, private open space, principle private open space, and private planting area. Consideration is to be given to the need for additional or replacement terminology and mechanisms (eg vegetated cover) in the Territory Plan. This report makes recommendations for inclusion of effective provisions in the relevant ACT Government policies, design and technical guidelines and the Territory Plan.

### Living Infrastructure Definition

In this project, living infrastructure refers to all interconnected ecosystems within an urban catchment. Living Infrastructure integrates and builds upon the concepts of 'green infrastructure' (which focuses on vegetation) and 'blue infrastructure' (which focuses on water management) within urban landscapes. In the literature definitions of 'green infrastructure' vary and can be almost indistinguishable from living Infrastructure. They include, for example, vegetation and urban forests

as well as water sensitive urban design and the environmental, social and economic benefits that accrue from these elements.

The full definition and benefits of living infrastructure provided by the client are set out in **Attachment 1**.

## 3.0 Literature Review

The desktop literature review concerns approaches to establishing requirements for living infrastructure (however named) under existing planning and development and sustainability frameworks in selected Australian jurisdictions as well as one international jurisdiction. The primary focus is on planning policy and mechanisms designed to enhance green infrastructure drawing on various government documents, policies and legislation and academic papers.

### 3.1 Documents Reviewed

The list of documents reviewed covers statutory instruments, policy documents, design guidelines, design manuals/standards, other government documents (including those relating to good examples of living or green infrastructure) and academic papers. State and Territory statutory instruments for living infrastructure often defer to Local Environmental Plans (LEPs) and as such selective statutory instruments have been reviewed as examples of progressive living infrastructure outcomes.

The literature will be discussed in terms of policy, terminology, mechanisms and methods used to foster and deliver living or green infrastructure. While the focus is Australia, overseas programs, notably the Seattle Green Factor, is included as an example of successful implementation, now with ten years' experience of implementing green infrastructure in the private realm. Another international context (Rotterdam, The Netherlands) is referenced as it provides valuable policy insights about residents' views on green infrastructure adaption measures, and their willingness to pay for it.

The literature shows it is important to recognise that while 'Integrating Green Infrastructure into ... Strategic and Statutory frameworks is considered essential ... this alone will not ensure delivery of outcomes. A collaborative and appropriately funded approach is needed' (GANSW).

A full list of reviewed titles is available at Attachment 2.

Summaries of select documents is available at Attachment 3.

#### 3.1.1 Policy approach

A best practice policy approach identified in the literature is for evidence-based policy (Arundel) that includes measurable spatial policy standards that could be mapped to benchmark and monitor implementation and performance. Ambitious policies appear to produce better livability outcomes for residents, even if those targets are not met, than less ambitious ones.

The literature points to Living Infrastructure policy having the best prospects for success if it:

- is based on a whole-of-government approach and integrated with other urban policies and infrastructure
- is evidenced based
- treats Living Infrastructure as an essential asset and combined with urban development and 'grey' infrastructure to create a multi-purpose infrastructure that mimics nature to deliver critical ecosystem services, health benefits and promote active lifestyles
- promotes a network of open spaces connected to 'blue infrastructure', residential and employment areas.
- takes every opportunity to insert living infrastructure in development projects and upgrades of traditional infrastructure
- embeds consultation and participation in its processes
- focuses, at least initially, on key demonstration projects (eg maintaining and developing the urban forest) that will engage the public and demonstrate the benefits of living infrastructure
- is supported by clear design principles and guidelines and
- is appropriately funded, including for program maintenance and monitoring.

An integrated planning, or ‘whole of Government’ approach is considered to be a key factor in the success of green infrastructure strategies and should include the public, professionals, relevant peak bodies, associations or institutions.. Effective synergies occur through integration of urban and conservation planning to deliver social, economic and environmental benefits (Alexandra, Meyers). Integration of green infrastructure with the more traditional grey infrastructure and urban development to move from a single purpose to a more multi-purpose infrastructure that mimics nature would provide valuable ecosystem services. Living infrastructure should be identified as an asset as essential as roads and storm water pipes and funded accordingly (GANSW) in order to initiate institutional and political commitment that will ensure the appropriate institutional arrangements needed for long term success (Alexandra). Literature concerning urban trees also highlights integration – that of urban forest policies with other urban policies (land use, planning, transport, health, ecology and open space management) as a factor in the success of transitions in urban forest policy (Kendal).

A commitment to continuing consultation and participatory planning methods is seen as central to successful urban strategies (Alexandra, Kendal, Melbourne Metro Rail).

A best practice policy approach identified in the literature is for evidence-based policy (Arundel) that includes measurable spatial policy standards that could be mapped to benchmark and monitor implementation and performance. Ambitious policies appear to produce better livability outcomes for residents, even if those targets are not met, than less ambitious ones.

A policy focus on maintaining and developing the urban forest will contribute greatly to the quality of living infrastructure including social and cultural services and equity. Key success factors are an integrated approach within government agencies and a commitment to engagement processes with the public and relevant industries (Kendal). It also needs to be supported by adequate funding and informed by research and improvements in practice (Kendal). The available evidence on urban heat island in the ACT, for example, shows that trees provide extensive cooling benefits (Meyers). Research also points to the importance of establishing and maintaining reliable inventories (Kendal).

Both the City of Melbourne Council and the City of Sydney Council have prioritised development of their urban forests and provide valuable precedents to draw upon for a similar policy in Canberra. Both Councils have adopted a ‘whole-of-forest’ approach to include trees in the public, institutional and private realms and their definitions of ‘urban forest’ include trees and vegetation. Both have a strong focus on soil.

### 3.1.2 Terminology

#### Statutory instruments

A review of relevant terminology in statutory instruments in NSW and Victoria revealed a considerable overlap with terminology in the Territory Plan. The meaningful differences comes in refer to implementation of these terms through use of minimum percentages for each given mechanism. such as Perhaps Mmost relevant in the context of the proposed term ‘vegetated cover (permeable area)’ are the terms ‘minimum landscaped area’ (NSW) and ‘garden area’ (Victoria). It should be noted that ‘garden area’ as defined in this context may include elements such as paving or swimming pools and therefore does not equate to the permeable area.

‘Minimum Landscaped Area’ is an established term in the NSW documents. ‘Garden area’ is a new requirement for a mandatory minimum ‘Garden area’ introduced in 2017 into the Neighbourhood Residential Zone and the General Residential Zone in the Victoria Planning Provisions. Its purpose is to protect the open garden character of the state’s suburbs, towns and cities in the context of demand for different housing typology to meet future needs of the community. It is not restricted to ground level. ‘.

Consideration should also be given to developing a more multipurpose infrastructure that integrates green and grey infrastructure to mimic more natural systems, and how this might be expressed in the Territory Plan. This represents a radical shift in thinking that may be needed (GANSW) to ensure a viable living infrastructure.

## Design manuals and design standards

### ACT

The ACT's Municipal Infrastructure and Standards contain comparable provisions for green infrastructure but could benefit from illustrations and images to clarify the intended outcomes. The ACT Statutory provisions and design standards have limited impact on green space in the private realm because landscape plans, or their equivalent, are not necessarily required for all developments or renovations in the private realm.

### Adelaide

The *Adelaide Design Manual: Greening* emphasises the value of creating a web of interrelated natural systems across a range of scales and applications in the city with the intent of building a city that is sustainable, economically prosperous and resilient. This manual and the companion *Green Infrastructure Guidelines* are examples of best practice in support of green elements of living infrastructure. The *Guidelines* provide guidance for the public and private realms; the Manual focuses on the public realm. The *Guidelines* and the *Greening Manual* include excellent drawings and photographs.

Key concepts:

- living architecture: the integration of plants with the built form eg green roofs, roof terraces, green walls and facades
- green streets: focuses on the pedestrian experience, a solid presence of trees, low plantings and rain gardens to maximise pedestrian amenity and activation of commercial spaces
- urban forest: the combined collection of trees in the urban area, including city streets, parks, reserves and individual properties within private gardens and public institutions
- urban food: provision for growing food in urban areas, communal spaces of institutions or apartment complexes. It ranges from edible plants in garden beds to organized community gardens

Principles:

- create a connected network of greening
- reinforce urban character
- harness multiple functions of greening
- create conditions for success and longevity of greening
- create value with welcoming spaces
- integrate tree planting strategies
- maximise the seasonal benefits of greening
- create continuous tree canopies across the city
- use greening to improve the human scale of streets
- harness storm water for healthier streets
- apply best practice

Water sensitive urban design is also included in the Adelaide Design Manual. It is not discussed here because it is established practice in the ACT and is being further developed by EPSDD.

### NSW and Sydney

NSW's *Low Rise Medium Density Design Guide 2017* is a toolkit 'for improving the design of low rise medium density residential development ...' is another example of best practice. It contains the design

criteria that must be met in order to obtain a complying development certificate under the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008*. NSW. (Note: an amended Code comes into force July 2018.). It includes clear links to development standards in the enabling legislation, strategic context, clear objectives and design criteria supported by excellent drawings and images. Terminology in this guide relevant to living infrastructure that is not covered in the Territory Plan includes:

- green roof
- green wall
- landscaped area
- public open space

Another best practice example is the City of Sydney *Landscape Code* adopted in 2016 for the creation of high quality, sustainable landscape surfaces in the private realm. Volume 1 applies to single dwellings and volume 2 to all other development. The Code is part of the development approval process and clearly outlines what documentation is required for submission. Volume 1 outlines mandatory requirements for new or modifications to existing trees, front fences, front yards and green roofs/walls and provides design guidance for each type of space. Clear links are given to enabling legislation, planning documents and relevant guides. Volume 2 in particular provides a clear section on the relationship between this Code and other plans and policies. The Code includes excellent drawings and images to guide the user. The landscape requirements section is an excellent precedent for urban forest policy on trees, soils, green walls and roofs. The landscape guidance section ranges from best practice landscape design to utilities and maintenance. Terminology in this Code relevant to living infrastructure that is not covered in the Territory Plan includes:

- green roof
- local species
- public domain
- soft landscape
- urban canopy
- urban ecology

Water sensitive urban design is also included in the Code. It is not discussed here because it is established practice in the ACT and is being further developed by EPSDD.

### 3.1.3 Mechanisms

High quality design guidelines, manuals or standards are critical to the delivery of living or green infrastructure. The literature indicates a range of mechanisms to be used to support successful implementation of living or green infrastructure in urban development. Initiated through policy development, much of this implementation occurs within the various statutory frameworks, these are summarised below in Table 1.

Table 2 sets out the various mechanisms used, their definition and application in NSW, Victoria and the ACT. Though beyond the scope of this project, it will be essential to embed regular maintenance into the program and identify adequate and continuing funding for it. International research in the Netherlands indicates that the public may be willing to contribute (Verburg).

Table 1

Mechanism	Framework		
	Statutory	Guideline	Education

plot ratios, site cover, verge widths, private open space, principle private open space, site open space, pervious surfaces, garden or planting areas, communal open space	✓		
Planning objectives	✓		✓
Rating schemes	✓	✓	
Design Standards	✓		✓
Design guidelines/best practice advice		✓	✓
Design Factsheets (can include statement about what is mandatory and what is not)		✓	✓

### Rating Schemes

The use of rating schemes or score cards is supported by the literature (AILA, Seattle Green Factor, Yarra Council) and merit consideration where mandatory requirements exist. Such schemes can provide clarity and facilitate the design approval process and have built-in incentives (eg bonus points for use of local plants and materials); see Sustainable Sites Initiative (SITES) <http://www.sustainablesites.org/>, the Seattle Green Factor <http://www.seattle.gov/dpd/codesrules/codes/greenfactor/default.htm>, or the Built Environment Sustainability Scorecard (BESS), as assessment tool created by local governments in Victoria <http://www.bess.net.au/>.

### Statutory Mechanisms

Table 2

Mechanisms supporting implementation of green infrastructure in urban development

Jurisdiction	Mechanism	Definition	Application	Scale	Minimum % of Mechanism
ACT	'Planting Area' within Private Open Space	an area of land within a block that is not covered by buildings, vehicle parking and maneuvering areas or any other form of impermeable surface and that is available for landscape planting (ACT	3.3 Residential Zones Single Dwelling Housing Development Code: R38	Large Block (with an area greater than 500m <sup>2</sup> )	50% minimum area in (minimum private open space area equal to 60% of the block area, less 50m <sup>2</sup> ) is planting area

		Planning and Land Authority Part B Definition of Terms)			
			: R39	Mid Sized Block (with an area greater than 250m <sup>2</sup> but less than or equal to 500m <sup>2</sup> )	50% minimum area in (minimum private open space area equal to 40% of the block area, less 50m <sup>2</sup> ) is planting area
			: R40	Compact Block (with an area less than or equal to 250m <sup>2</sup> )	50% minimum area in (minimum private open space area equal to 20% of the block area, less 50m <sup>2</sup> ) is planting area
			3.4 Residential Zones Multi Unit Housing Development Code: R38	RZ1 (Suburban Zone), RZ2 (Suburban Core Zone)	Not less than 20% of the total site area is planting area
			: R39	RZ3 (Urban Residential Zone), RZ4 (Medium Density Residential Zone), RZ5 (High Density Residential Zone), Commercial Zones	Not less than 10% of the total site area is planting area

NSW <sup>1</sup>	Landscape Area	a part of a site used for growing plants, grasses and trees, but does not include any building, structure or hard paved area (Sydney Local Environment Plan 2012)	SEPP <sup>2</sup> Part 3C > Division 3 > Subdivision 3: for dwelling houses and attached development  Part 3C > Division 4 > Subdivision 3: for detached development	Lot Area 200m <sup>2</sup> - 300m <sup>2</sup>	10% of lot area
				Lot Area >300m <sup>2</sup> - 450m <sup>2</sup>	15% of lot area
				Lot Area >450m <sup>2</sup> - 600m <sup>2</sup>	20% of lot area
				Lot Area >600m <sup>2</sup> - 900m <sup>2</sup>	30% of lot area
				Lot Area >900m <sup>2</sup> - 1,500m <sup>2</sup>	40% of lot area
				Lot Area >1,500m <sup>2</sup>	45% of lot area
			Part 3B > Division 3 > Subdivision 3	Manor House	50% of lot area minus 100m <sup>2</sup>  Minimum dimension of any area included in the landscaped area calculation is 1.5m  At least 50% of the area forward of the

<sup>1</sup> Definition and parameters are from the State Environment Planning Policy (Exempt and Complying Development Codes) 2008 (NSW) that informs the Design Criteria in the Low Rise Medium Density Design Guide for development applications 2018.

<sup>2</sup> State Environment Planning Policy (Exempt and Complying Development Codes) 2008 (NSW)

					building line is to be landscape area
			Part 3B > Division 2 > Subdivision 3	Dual Occupancy	50% of lot area minus 100m <sup>2</sup>  Minimum dimension of any area included in the landscaped area calculation is 1.5m  At least 25% of the area forward of the building line is to be landscape area
			Part 3B > Division 4 > Subdivision 3	Multi Dwelling (Terraces)	R1, R2 or RU5 zoned land 30% of lot area  R3 zoned land 20% of lot area  Minimum dimension of any area included in the landscaped area calculation is 1.5m  At least 25% of the area forward of the building line is to be landscape area
			Additional control from NSW Low Rise Medium Density Design Guide: 2.4C-1	Multi Dwelling Housing	R1, R2 or RU5 zoned land 30% of lot area  R3 zoned land 20% of lot area  Minimum dimension of any area included in the landscaped area calculation is 1.5m  At least 50% of the area forward of the building line is to be landscape area
<b>VIC: Yarra Planning Scheme</b>	Garden Area	An area on a lot with a minimum dimension of 1m	General Residential	Lot Size 400-500m <sup>2</sup>	25%

		<p>that does not include:</p> <p>a). a dwelling or residential building, except for:</p> <ul style="list-style-type: none"> <li>- an eave, fascia or gutter that does not exceed a total width of 600mm;</li> <li>- a pergola;</li> <li>- unroofed terraces, patios, decks, steps or landings less than 800mm in height;</li> <li>- a basement that does not project above ground level;</li> <li>- any outbuilding that does not exceed a gross floor area of 10m<sup>2</sup>; and</li> <li>- domestic services normal to a dwelling or residential building;</li> </ul> <p>b) a driveway; or</p> <p>c) an area set aside for car parking</p>	<p>Zone: 32.08-4</p> <p>Neighbourhood Residential Zone: 32.09-4</p>		
				Lot Size 501-650m <sup>2</sup>	30%
				Lot Size above 650m <sup>2</sup>	35%

'The minimum garden area requirement specifies the percentage of a lot that must be set aside to ensure the open garden character of suburbs is protected' Source; Victoria Environment, Land, Water and Planning, Planning Practice Note 84.

## 4.0 Existing Statutory Provisions in the ACT

### 4.1 Territory Plan

#### 4.1.1 Terms and Definitions

Existing statutory provisions for principle private open space, private open space, site open space and private planting area, communal open space and site cover in the ACT Territory Plan.

Term	Definition	Function
<b>Principal Private Open Space</b>	private open space that is directly accessible from a habitable room other than a bedroom.	provides minimum dimensions for an area of open space.
<b>Communal Open Space</b>	common outdoor open space for recreation and relaxation of residents of a housing development.	provides adequate open space for dwellings that have a shared open space.
<b>Planting Area</b>	an area of land within a block that is not covered by buildings, vehicle parking and manoeuvring areas or any other form of impermeable surface and that is available for landscape planting.	provides adequate on-site space for landscape planting.
<b>Plot Ratio</b>	the gross floor area in a building divided by the area of the site.	provides limitation in build footprint for a dwelling.
<b>Private Open Space</b>	an outdoor area within a block useable for outdoor living activities, and may include balconies, terraces or decks but does not include any area required to be provided for the parking of motor vehicles and any common driveways and common vehicle manoeuvring areas. Up to 25 per cent of any part of private open space may be roofed over, except that a balcony may be entirely roofed over.	provides adequate outdoor area.
<b>Site Coverage</b>	the proportion of the actual site covered by dwellings and all other buildings.	controls building footprint.

Commented [A2]: Provides?

#### 4.1.2 References

A summary of the term and location where it is used in the Territory Plan.

Territory Plan Part	Terms Used	Location
<b>Precinct Codes</b>	Principal Private Open Space	

	Communal Open Space Private Open Space Plot Ratio Urban Open Space	
<b>Residential Zones Development Code</b>	Plot Ratio	R5, R10, Element 13.2 C54
<b>Single Dwelling Housing Development Code</b>	Principal Private Open Space Planting area Plot Ratio Private Open Space Site Coverage	R41, C41, Table 8 R38, R39, R40 R1, R22 R22, R38, C38, R39, C39, R40, C40 C38, C39, C40
<b>Multi-Unit Housing Development Code</b>	Principal Private Open Space Communal Open Space Plot Ratio Private Open Space	R61,C61, Table A9 R39, R38 R4, R6, R7, R8, R9, R16, R4, R38, C38, R39, C39,
<b>Estate Development Code</b>	Street Tree Street Verge Street Medians Public Realm	R22, R24, C24, R25, C25, C60, C65, R92, R116, Element 17 Table 2A & 2B C15, R60, C60, R92, R125, Element 17 Table 4 Element 17 Table 4 C23, Element 17 Table 4

#### 4.2 Summary of Existing TCCS Standards

TCCS Design Standards are currently in the process of being updated from the Design Standards (DS) to the Municipal Infrastructure Standards (MIS) documents. The following eight standards have been reviewed for relevance to the Planning and Design for Living Infrastructure as Part of Residential Intensification in a Changing Climate project:

- MIS 01: Street Planning And Design (Draft)
- MIS 06: Verges (Draft)
- MIS 08: Stormwater (Draft)
- MIS 15: Urban Edges Management Zone (Draft)
- DS 14: Urban Open Space
- DS 16: Urban Wetlands Lakes And Ponds
- MIS 24: Soft Landscape Design (Draft)
- MIS 25: Plant Species For Urban Landscape Projects (Draft)

The above documents were reviewed to present a summary of existing elements within the Standard which have relevance to Living Infrastructure policy.

#### 4.2.1 MIS 01: Street Planning And Design

- Environmental considerations
  - WSUD design standards
  - Street design for energy and water conservation
- Climate change considerations
  - Landscaped areas are designed to provide amenity and biodiversity, protect buildings and spaces from the elements and incorporate sustainable urban drainage systems.
  - Species selection that is appropriate to the Canberra climate and will require minimal watering or maintenance activities.

#### 4.2.2 MIS 06: Verges

- Provision for appropriate and adequate landscaping
- Provision for buffer space for reduction in traffic noise level at dwellings
- The verge should be of sufficient width to allow space for all relevant services, landscaping, indented parking, future carriageway widening, paths and swale drains
- Provision of trees to the verge, consideration of the root zone, species selection of appropriate size
- Consideration of the surface treatment of verges
- Planting module requirements

#### 4.2.3 MIS 08: Stormwater

- Provision of stormwater infrastructure which will enhance the urban environment by providing assets of social, environmental and economic value.
- Provision of stormwater infrastructure which will protect and maximise the value of aquatic and terrestrial ecosystems within the stormwater system.
- Consideration of WSUD
- Consideration to maximise natural habitat for fauna via indigenous riparian, floodplain, and foreshore vegetation.
- Consideration of Ecology and Landscaping
- Consideration of impervious and pervious surface treatments.
- Treatment of buffer strips and tree pits

#### 4.2.4 MIS 15: Urban Edges Management Zone

- Provision of an appropriate interface between the urban area and surrounding public and unleased land.
- Consideration of the retention of existing trees and native vegetation while allowing for bushfire regulation requirements.
- Consideration of provision of appropriate canopy coverage for native fauna
- Provision of an adequate buffer between development and environmentally sensitive areas
- Consideration of vegetation coverage to allow for wildlife movement

#### 4.2.5 DS 14: Urban Open Space

- Provisions for parks and open space
- Provision of urban wildlife and nature conservation

#### DS 16: Urban Wetlands Lakes And Ponds

- Provision of pollutant reduction in SW
- Provision of enhanced environmental amenity
- Consideration of appropriate species selection

#### 4.2.6 MIS 24: Soft Landscape Design

- Consideration of appropriate species selection
- Consideration of maintenance requirements
- Consideration of appropriate soil provision
- Provision of structural soil and cells
- Provision of permeable paving
- Protection of existing trees
- Consideration of the retention of existing trees in the planning of residential estates
- Provision of urban tree planting including street trees and car parks
- Provision of appropriate shrub planting
- Provision of appropriate grassing including dryland and native species
- Consideration of the relationship between trees and infrastructure
- Specification of trees
- Provision of landscape within carparks
- Consideration of planting within medians

#### 4.2.7 MIS 25: Plant Species for Urban Landscape Projects

- Provision of suitable plant species for Canberra and specific site conditions
- Provision of suitable plant species for Canberra and specific site conditions
- Consideration of the suitability of the species in specific situations
- Set back requirements:
  - Path
  - Kerb
  - Building
  - Driveways (Refer MIS 07)
  - Services (Refer MIS 06)
- Target Soil Volume requirements and site restrictions (Available Soil Volume)

## 5.0 Spatial Analysis

(overview of section)

### 5.1 Data Sets

The data provided by EPSDD is a combination of LiDAR data sets as well as data collected from ACTmapi, through the use of GIS mapping software. The data was supplied as excel spreadsheets, shape files, and aerial PDFs visually mapping the study areas, inclusive of relevant areas and percentages of various ground treatments, building footprints and canopy areas.

The data sets are of various scales collected within Canberra pertaining to the suburb, street and block level of the following six study case suburbs, facilitating the comparison between a range of suburbs within the ACT:

- Dickson;
- Franklin;
- Mawson;
- Page;
- Turner;
- Wright.

### 5.2 Scenarios 1, 2 and 3

The spatial analysis was divided into three stages and the data was supplied under the following scenarios:

- Scenario 1 – assessment of existing living infrastructure and built form;
- Scenario 2 – assessment of built form coverage under maximum development yield within the existing zoning and its impact on living infrastructure;
- Scenario 3 – assessment of built form coverage under projected high development yield for future scenarios and its impact on living infrastructure.

*Maximum Yield* data sets provided for Scenario 2 & 3 was collected from a range of suburbs where blocks reflect what is provided in the current market in terms of dwelling types and building footprint and is allowable under the existing Territory Plan Zoning. This data set was extracted from ACTMapi and Development Application data to assess the impact of urban intensification on living infrastructure. *Maximum Yield* data was collected from the following suburbs:

- O'Malley;
- Hughes;
- Campbell;
- Ainslie;
- Jacka;
- Pearce;
- O'Connor;
- Mawson;
- Braddon;
- Casey;
- Forde;
- Phillip.

## 5.3 Methodology

This section will expand on the methodology underpinning the data. Specific methodology applied to the various sections of this report are mentioned in their respective sections.

### 5.3.1 General assumptions:

All calculations have been processed from the largest spread of data available, the absolute findings are limited to their respective study areas where an absolute figure has been provided. Where the data is calculated from averages in the absence of absolute figures, it has been assumed that the respective study areas provided reflect a reliable spread of data.

For example, absolute data has been provided for permeability of study blocks, not for every block within the study suburb. It has been assumed that the study blocks represent a reliable spread of data and that the average permeability of these study blocks can be applied to all blocks within the study area to calculate suburb permeability. This assumption has been made across all calculations where necessary. Further detail on assumptions can be found in their respective sections within this report.

### 5.3.2 Exclusions

Some exclusions have been made to data sets where the omission of particular study sites improves the reliability of the calculation. Specific exclusions are mentioned in their respective sections within this report.

### 5.3.3 Terminology

Terminology referred to throughout this section is defined below.

- Total Street Area is the area of the street that includes carriageway and verges.
- Road is the carriageway.
- Verge is edge of carriageway to block boundary.
- Building footprint over block area is the percentage of site coverage.
- Older (or old) suburbs refers to the following suburbs: Dickson, Mawson, Page, Turner.
- Newer (or new) suburbs refers to the following suburbs: Franklin and Wright.
- Permeable area refers to an area without building footprint, paving, hardstand and other impermeable surfaces.
- Hardstand area refers to any area of impermeable paving including footpaths. Hardstand area includes driveways in study blocks and does not include driveways in study streets.

## 5.4 Existing Conditions

Existing conditions have been generated from data sets identified in 1.0 Data Sets section of this document. Detailed methods to specific sections of data is described in each section where relevant. The calculations and further information be found in a corresponding spreadsheet:

*TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

## 5.5 Facts and Figures behind the data

### 5.5.1 Suburb

### Data Spread

The data gathered at suburb level is made up of study areas for study suburbs. Included is the dwelling numbers, and breakdown of land use areas within the total study area. Averages have been calculated for all data where relevant.

*Data from Suburb Level: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

### Suburb Data

The graphs below demonstrate the spread of area across the study suburbs. It shows that total area is predominantly made up by block area in all study suburbs, except in Franklin where block area is the same as street area. Wright, similarly to Franklin, block area only represents 4% more than street area to total study area.

*Data from Table 3.1.1: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

*Dickson Study Area Graph*

*Franklin Study Area Graph*

*Mawson Study Area Graph*

*Page Study Area Graph*

*Turner Study Area Graph*

*Wright Study Area Graph*

## 5.5.2 Street

### Data Spread

The data for streets is made up of 5 to 6 study streets for each study suburb with 33 study streets in total. The 5 to 6 study streets collected for each suburb represents a spread of street types and street classifications. Data collected includes dimensions for road and verge widths, and square metre area for roads, verges, hardstands, driveways, canopies, permeable area, and impermeable area.

*Data from Street Level: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

Averages of street data for each suburb have been calculated by street type and street classification. Comparisons between suburb streets such as “Driveway Area to Verge Area”, “Verge Area to Total Street Area”, and “Verge Area over Total Street Area” others can be found in the spreadsheet. For consistency of comparisons, all streets calculations have been separated by street classification or street type.

*Data from Tables 3.1.2a-b: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

The investigation / comparison of streets was narrowed down to only streets classified Access Street. Modified access streets investigates only areas interfacing residential blocks, removing areas of intersection and other anomalies from the calculation. As access streets interface predominantly Single Residential housing typologies, modified data reflects a more consistent comparison of streets.

*Data from Table 3.1.2c: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

*Major Collector Graph*

*Minor Collector Graph*

*Modified Access Street Graph*

## 5.5.3 Block – Study Blocks

### Data Spread

A comprehensive set of data was collected for each study block including block type, Land Use Zone, number of dwellings, block area, block width, building area, hardstand area, easement area, total permeable area, total impermeable area, TP Private Open Space area, TP Planting area, and canopy area. Averages per block and per suburb have been calculated from the data where relevant.

Data from Block Level\_Footprint: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx

### Block Spread

The data for blocks is made up of 11 to 20 study blocks for each study suburb with 91 study blocks in total. The 11 to 20 study blocks collected for each suburb represents a spread of dwelling types and residential land use zones. Table 3.1.3 below shows the spread of dwelling types per suburb.

STUDY BLOCKS							
3.1.3	SINGLE DWELLING	TOWN HOUSE	TERRACE	MULTI UNIT	DUPLEX	DUAL OCCUPANCY	TOTAL SAMPLES
DICKSON	12	-	-	5	3	-	20
FRANKLIN	5	1	2	2	1	-	11
MAWSON	6	3	1	4	3	-	17
PAGE	8	1	2	-	-	1	12
TURNER	8	3	-	6	-	3	20
WRIGHT	5	2	1	3	-	-	11

The single dwelling typology had the largest range of sample sizes across all six suburbs and provides a consistent comparison for study blocks between suburbs. Single dwellings will form the focus of the building footprint analysis of study blocks.

### Increasing Site Cover

Building footprint to block area calculated for all study suburbs and have been sorted by both dwelling types and land use zones. These calculations found that the newer suburbs of Franklin and Wright have a greater percentage of building footprint to block area in contrast to the older suburbs. This finding is consistent across all calculations including all dwelling types and all land use zones.

Data from Tables 3.1.3a-b, d: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx

Average SR Dwelling Site Coverage Graph

## 5.5.4 Block – All Blocks

### Data Spread

The data for all block is made up of all blocks for each study suburb with some exceptions. Blocks that were removed from this data set include empty or near empty blocks, and multi-unit sites from RZ1

and RZ3 zoned blocks. Block data collected includes Land Use Zone, block area, building area, and canopy area but not dwelling numbers. While dwelling numbers have not been identified in this data set and there is no differentiation between single residential blocks and other blocks, multiunit blocks identified by comparatively large block sizes have been excluded from RZ1 & RZ3 blocks for a more reliable comparison between what is predominately Single Residential blocks.

*Data from Block Level\_ : TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

### Block Spread

Calculation for the spread of block typologies across Land Use Zones was generated for comparison between suburbs. These calculations found that Large Blocks are far more prevalent in older suburbs and Compact Blocks are only found in newer suburbs with the exception of Page where compact blocks represent 2% of total blocks.

- Compact block means a block with an area of 250m<sup>2</sup> or less;
- Mid sized block means a block with an area greater than 250m<sup>2</sup> but less than or equal to 500m<sup>2</sup>;
- Large block means a block with an area greater than 500m<sup>2</sup>.

*Data from Tables 3.1.4: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

### Increasing Site Cover

Building footprint to block area calculated for all study suburbs and have been sorted by block types and land use zones. These calculations found that the newer suburbs of Franklin and Wright have a greater percentage of building footprint to block area in contrast to the older suburbs. This finding is consistent across all calculations including all block types and all land use zones. As illustrated below, even the comparison of large blocks demonstrates a significant increase in site cover.

*Data from Table 3.1.4e: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

*All Blocks Site Coverage Graph*

## 5.5.5 Planting (POS & PPOS)

All suburbs average:

<b>Single Dwelling</b>	87.5% of large blocks meet the Territory Plan planting requirements. All mid-size block examples meet the planting requirements. No compact block examples were given.
<b>Dual Occupancy</b>	All Dual occupancy examples meet the planting requirements
<b>Townhouses</b>	30% of townhouses meet the planting requirements
<b>Terrace Houses / compact blocks</b>	30% of terrace houses on compact blocks meet the planting requirements
<b>Multi Unit</b>	All multi-unit examples meet the planting requirements

## 5.6 Canopy / Permeability

### Canopy Data Spread

The data gathered for canopy area is a comprehensive set of data which contains canopy area mapped using LiDAR at suburb, street, and block level. At suburb level, the canopy area data is sorted by suburb, land use zone, and between open space, streets, and blocks. At street and block level, the canopy data is provided for each study site and can be sorted correspondingly; street canopy can be sorted by street classification and street type; block canopy can be sorted by land use zone, block area, and dwelling type. Canopy data has additionally be supplied for all blocks individually. Averages have been calculated for all data where relevant.

*Data from Suburb Level, Street Level, & Block Level\_ : TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

### Mature Canopy Data

Canopies in the newer suburbs of Franklin & Wright have not reached their mature size and thus may not accurately reflect the mature canopy areas found in other study suburbs. To increase accuracy, mature canopy areas for open space & street trees was gathered from .DWG landscape drawings for Wright and these areas were added to existing LiDAR data. The investigation on study blocks for Wright and Franklin also found areas of tree canopy not picked up by the LiDAR data and have mapped these areas on top of the shape files and used as supplementary data. The investigation on study blocks for other suburbs found discrepancy between LiDAR data and actual canopy area found within the aerial.

For all canopy readings in Scenario 1 and all further scenarios, these blocks have been omitted from analysis and calculations to enhance reliability of information:

- Dickson S19 B22;
- Dickson S4 B79;
- Mawson S27 B24;
- Mawson S28 B38;
- Page S15 B15;
- Page S7 B20;
- Turner S62 B33&34.

### Permeability Data Spread

The data for permeability was gathered from an investigation of study sites. The permeability data is provided for each study site at street and block level and can be sorted correspondingly; street permeability can be sorted by street classification and street type; block permeability can be sorted by land use zone, block area, and dwelling type. Permeability at street takes into consideration hardstand area such as paths and driveway area but does not identify details such as permeable paving. Permeability at block level considers hardstand area such as driveways, paths, and other paving, as well as building footprint areas. Averages have been calculated for all data where relevant.

*Data from Suburb Level\_Permeability: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

### 5.6.1 Suburb

#### Suburb Level Permeability

The permeability data at suburb level is calculated using a combination of existing permeability data that exists for street and block level, and other suburb level data. To find suburb permeability, the calculation is separated into three main parts: open space permeability, street permeability, on block

permeability. Firstly, all open space areas were assumed to be 100% permeable. Secondly, the street permeability was calculated by taking the average percentage of permeability for all study streets and applying the percentage to the total street area for the suburb to find the permeable street area per suburb. Finally, the block permeability was calculated by taking the average percentage of permeability for blocks by land use zone and applying the percentage to the total block area by land use zone. The sum of permeable areas for each land use zone provides the total permeable area for blocks. The suburb level permeability can be projected by adding open space, street, and block permeable areas together.

*Data from Suburb Level\_Permeability: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

### **Suburb Level Canopy / Permeability Data**

The data calculated for canopy at suburb level reveals that Turner has the most canopy coverage of all study suburbs at 30% coverage. The spread of canopy coverage over different areas largely varies between suburbs, the main commonality being that canopy is predominately found on blocks and streets. These canopy areas combined make up over 70% of all canopy cover in older suburbs. Turner is also identified as the suburb that has the most permeable area. Some consistencies have been identified in the spread of permeability over different areas. Open space area contributes the most to the permeability of a suburb in all study suburbs except Mawson, Page, and Wright. Blocks contribute more to the permeability of a suburb than streets in all study suburbs except Franklin and Wright.

*Data from Tables 3.2.1a-d: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

*Suburb Level Canopy and Permeability Graphs*

## **5.6.2 Street**

### **Street Level Canopy & Permeability**

The data calculated for canopy at street level reveals that Access Streets contribute the most to canopy coverage in all study suburbs except for Franklin & Turner. Access Streets are also identified as the street classification which has the most percentage of permeable area in all study suburbs except for Turner. Average percentages of canopy and permeability of streets per suburb have also been sorted by Street Type. Modified Access Streets offers the most reliable insight on canopy and permeability data, it can also be expected that Access Streets account for majority of the streets found in a typical suburb. Modified Access Street data identifies Turner as the most canopy covered, and Mawson as the most permeable.

*Data from Tables 3.2.2a-d: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

*Modified Access Street Canopy and Permeability Graphs*

## **5.6.3 Block – Study Blocks**

### **Block Level Canopy & Permeability**

The canopy data calculated for Single Residential dwelling typologies shows consistency between canopy to block coverage and the era of the suburb. The oldest suburbs, Turner and Mawson have a canopy to block coverage of 31% and 32% respectively. Dickson and Page have a canopy to block coverage of 15% and 19%. While Franklin and Wright both have 0% canopy on their Single Residential blocks. The permeability data calculated for Single Residential dwelling typologies again shows a relatively consistent percentage to the era of the suburb. Turner and Mawson have 62% and 66% permeable area respectively, Dickson and Page both have 52% permeable area, Franklin and Wright have 23% and 32% permeable area for Single Residential blocks.

*Data from Tables 3.2.3a-b: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*

#### 5.6.4 Block – All Blocks

##### Block Level Canopy

The data was calculated from residential land use zones in lieu of dwelling typology information for this data set. The focus on single residential dwellings lead to comparisons between RZ1 & RZ3 zoned blocks. The canopy data for all blocks closely corresponds with the SR block findings for 3.2.3 Study Blocks. The canopy data here still shows consistency between canopy to block coverage and the era of the suburb. For RZ1 blocks, the oldest suburbs, Turner and Mawson have a canopy to block coverage of 28% and 24% respectively. Dickson and Page have a canopy to block coverage of 19% and 17%. While Franklin (RZ3) and Wright have a canopy to block coverage of 1% and 0%.

*Data from Block Level\_ALL BLOCKS\_Transpose: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*  
*All Blocks Canopy Graph*

#### 5.7 Possible Future Conditions

##### 5.8 Scenario 2

Potential development Yield Existing Zoning. Following EPSDD Proposed Methodology, Scenario 2 measures the effect of an increased yield within existing zoning. Building from the existing data of Scenario 1, Scenario 2 uses “max yield” case study blocks to calculate the change to canopy and permeability of study suburbs at block level. The change in canopy and permeability on block level was then combined with existing data for streets and open space to measure the impact at suburb level.

Scenario 2 does not measure impact to street trees, or permeability of streets which could be affected by an increased yield.

*Data from Scenario 2: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*  
*Insert Treemap here*

##### 5.9 Scenario 3

High Development Yield. Following EPSDD Proposed Methodology, Scenario 3 measures the effect of maximum development yield through higher possible zoning for blocks in proximity to commercial centers (600m), frequent rapid transit corridors (600m), and light rail transit corridors (800m). Building from the existing data of Scenario 1, Scenario 3 uses “max yield” case study blocks to calculate the change to yield and canopy of study suburbs within the higher zoned blocks. Only areas within the maximum development yield radii are affected by the change, the calculation retains the existing data for areas outside the max yield catchment radii. This method applies to all Scenario 3 calculations including dwelling yields, canopy areas and permeable areas. Changes to canopy have been calculated on block level and do not account for increase in driveways affecting street tree coverage.

Scenario 3 does not measure impact to street trees which could be affected by an increased yield.

*Data from Scenario 3: TN\_Living Infrastructure Study Scenario 1, 2 & 3.xlsx*  
*Insert Treemap here*

## 6.0 Findings from Data Analysis

### 6.1 Existing Living Infrastructure

#### 6.1.1 Where it is?

##### Blocks

Existing canopy coverage is predominately found on blocks and streets. These canopy areas combined make up over 70% of all canopy cover in older suburbs. The larger spread of data for on block canopy in land use zones indicates that canopy cover is largely found in RZ1 & RZ3 blocks which suggests that single dwelling blocks contains most canopy area. Study blocks indicate this to be correct in suburbs Mawson and Turner.

##### Streets & Open Space

When considering block and street canopy in the older suburbs, it should be noted that the coverage of block canopy is consistently provided by street trees. From an assessment of the aerial photography and LiDAR information provided, it is clear that street trees provide a considerable area of canopy coverage on block. Open space canopy cover is found to be variable between study suburbs, ranging from 16% cover in Dickson, to 33% cover in Turner.

#### 6.1.2 Where is it missing?

##### Streets

While canopy area for newer suburbs, Wright and Franklin, is largely unreliable as trees have not reached their mature sizes, it can be expected that trees in these suburbs provide far less canopy coverage over blocks and streets due to various factors impacting newer suburbs. Trees within streets have a comparable verge area to old suburbs but could have less soil volume for growth due to increase in services within the verge. The increased area of hardstand due to increase in size and frequency of paths, and increased area of driveway due to increasing block density and standard driveway sizes, greatly decreases street permeability. The decrease of street permeability could detrimentally impact the health of street trees affecting their canopy sizes.

##### Trees over Blocks

Street trees in newer suburbs are subject to more clearances than those of older suburbs. Projected mature street tree canopies in newer suburbs typically not overlap as they do on older suburbs and will not overlap block boundaries to provide on block cover. As found in older suburbs, street trees provide a consistent network of canopy coverage within a suburb, over streets and over blocks. Street trees which do not provide on block cover will account for the potentially significant disparity between suburb canopy cover for older and newer suburbs.

##### Diminishing Block Sizes

In addition to losing on block canopy cover offered by street trees, on block canopy cover could be adversely affected further by larger driveways, decreasing block sizes and increasing building areas. The decreasing block sizes are demonstrated in the shifting spread of block typologies found in each study suburb. This change is demonstrated in the considerable increase of compact blocks in newer suburbs. Apart from the 2% of compact blocks in Page, there are no compact blocks in older suburbs. Whereas in Franklin and Wright, compact blocks make up 13% and 6% of blocks, respectively. An example comparing average RZ1 blocks in Turner and Wright demonstrates the shift toward smaller

blocks and a significant increase in block coverage by building footprints. The average RZ1 block in Turner is 1154m<sup>2</sup> whereas the average RZ1 block in Wright is less than half of this, at 499m<sup>2</sup>. The difference in building sizes within these blocks are less dissimilar. The average building footprint of an RZ1 dwelling in Turner is 334.66m<sup>2</sup>. Comparably, the same building footprint in Wright is 274.45m<sup>2</sup>. As a result, it can be observed that building areas are not reducing in size proportionally to the reduction in block size, and rather the buildings footprint is not considerably affected by the reduction of block size. It is the space for canopy area and permeable area on block that is reduced drastically from the dwindling block size and the proportionally increasing building footprint. Further, when comparing block typologies, large blocks, which are a more direct comparison sharing similar block areas, it is clear that buildings in newer suburbs are covering more block area than in older suburbs. Large blocks follow the trend of smaller, compact and mid-sized blocks in the same suburbs, where the percentage of building footprint to block area is much higher than older suburbs. The average percentage of building footprint to block area in large blocks within RZ1 is over 50%, whereas in all older suburbs the same percentage does not exceed 33%.

The effects of these various factors impacting canopy coverage cannot be accurately projected at the moment, however, it can be expected that newer suburbs will have substantially less canopy coverage than older suburbs.

## 6.2 Expected Impact

### Projections

The impact of increasing density is a significant consideration for older suburbs where the canopy cover may be integral the character of the suburb. General impacts of an increasing density can be observed in the existing conditions of the newer suburbs. It can be anticipated that the same impacts will affect older suburbs as density increases. These general impacts include a trend toward an increase in building footprint area over block and an increase impermeable area as paths and driveways increase in size and frequency. The effect of these conditions to canopy area will become apparent as trees in newer suburbs reach their mature sizes.

### Block Canopy

Scenario 2 & 3 investigates change to on block canopy bought on by increasing density. The output of calculations measured from block level data indicates a considerable loss of on block canopy. For Scenario 2, Mawson and Turner will lose over half of the existing on block canopy. For Scenario 3, Dickson and Turner lose over 40% of the existing on block canopy. When analysed at suburb level, looking at the difference in percentage of canopy cover over suburb, the impact appears far lesser. Older suburbs in Scenario 2 lose 3% - 7% canopy cover over suburb area, and older suburbs in Scenario 3 lose 2% - 4% canopy cover over suburb area. The reason for this is that the impact has been mitigated greatly by the unchanged canopy area of open space and street trees.

### Street Canopy

While it can be assumed that there will be no change to the open space canopy cover from increasing density of these Scenarios, it is the impact to street trees which becomes the critical determining factor when measuring the impact of increasing density on canopy. In understanding that street trees contribute to a larger proportion of canopy cover than open space streets, and also that street trees provide a significant portion of on block canopy, then the impact of increasing density can be largely determined by the impact on street trees. A percentage of on block canopy could potentially be protected by safeguarding the health of existing street trees. Factors concerning the health of street trees include the permeability of street area, the permeability of block area, space on block for canopy area, and soil volume among many others. An example of detrimental impact could be the

increase in services within the verge area to service the increase in yield that may decrease the available soil volume for street trees or affect the existing root zone of established street trees. Should the impact on street trees be detrimental, then the impact will reflect at suburb level canopy correspondingly.

### **Open Space Canopy**

Open space canopy provides a significant portion of canopy to the overall canopy area of a suburb. The data does not indicate that open space area provides consistent canopy coverage over study area. However, it can be expected that existing canopy coverage would be undisturbed by increased density and will represent a larger portion of the overall canopy cover of the suburb as on block canopy cover is lost to increased density. Open space canopy cover has potential for further planting to increase canopy coverage. Additionally, the area of open space provided contributes greatly to the overall permeability of a suburb.

### **Shifting of Roles**

The role of the street tree has shifted between older and newer suburbs, from a network of canopy covering street area and offering on block coverage to a more scattered network of canopy between parking bays, paths and driveways that generally only covers the verge width. This shift should inform the approach taken when addressing living infrastructure in older as opposed to newer suburbs. To newer suburbs the approach taken should be a reparative one, to supplement canopy coverage to meet satisfactory standards or a standard similar to other suburbs in Canberra. The implementation of this repair, whether to open space, streets, or blocks, can contribute significant improvement to the suburb as a whole. However it should be recognised that the primary constraint facing living infrastructure is the increase in building footprint to block density and the consequent effects of this. For older suburbs, the approach taken should be one which prioritises street tree canopy retention.

## 7.0 Recommendations

Recommendations below have been drawn from findings during the Literature Review and Spatial Analysis phase of works.

### 7.1 Overview

Living Infrastructure lacks priority within existing planning and development provisions. These recommendations support embedding Living Infrastructure across statutory frameworks.

The recommendations are presented as:

- Issue: defines what the issue is / what is it we are trying to achieve
- Principle: defines the principle or the policy
- Mechanisms Employed: nominates the mechanism or other planning instrument utilised.

This structure provides an outline of the issues, the guiding principles for addressing issues, and outlines proposed mechanisms.

defines the higher outcomes with recommendations for finer grain planning policy and mechanism. It also assists government if not all the recommendations or mechanism are supported, that we still have agreement on the broader principle.

The recommendations are grouped at the block, street and suburb level and then looks at the broader policy context, resourcing and education.

### 7.2 Block Level

#### Issue

Block sizes are decreasing and dwelling sizes are increasing in their footprint on the site, leaving less available permeable planting area.

#### Principle

Control the footprint of the dwelling on the site, and ensure permeable area for planting is provided.

#### Mechanisms employed:

- Site Cover controls
  - Planting area minimums
  - Rating tool
  - Landscape design controls
1. Amend planting area definition to “an area of land within a block that is not covered by buildings, vehicle parking and maneuvering areas or any other form of impermeable surface and that is available for landscape planting. The minimum dimension of any area included in the planting area calculation is 1.5m”.
  2. Amend Site Coverage Definition to, “the proportion of the site covered by dwellings and all other buildings except for:
    - a pergola;

- unroofed terraces, patios, decks,

- In Single Dwelling Housing Development Code replace section 5.2 Private Open Space in with Living Infrastructure controls;

Rule 38 - For Large Blocks	Criteria 38
Site Coverage maximum of 40% + 50m <sup>2</sup> of block area	Planting area is achieved through use of Rating Tool with minimum standard score
Planting Area minimum of 30% of block area	
Trees on block minimum of one tree at the front of the block with mature height of five metres, and one tree at the rear of the block with mature height of eight metres	

Rule 39 - For Medium Blocks	Criteria 39
Site Coverage maximum of 60% + 50m <sup>2</sup> of block area	Planting area is achieved through use of Rating Tool with minimum standard score
Planting Area minimum of 20% of block area	
Trees on block minimum of one tree at the front of the block with mature height of five metres, and one tree at the rear of the block with mature height of eight metres	

Rule 40 - For Compact Blocks	Criteria 40
Site Coverage maximum of 80% of block area	Planting area is achieved through use of Rating Tool with minimum standard score
Planting Area minimum of 10% of block area	
Trees on block minimum of one tree at the front of the block with mature height of five metres	

- Review effectiveness of Plot Ratio mechanism in the Single Dwelling Housing Development Code

5. In the Multi Unit Housing Development Code replace section 4.2 and 4.3 Site Open Space with Living Infrastructure Controls.
- a. Relocate content pertaining to amenity, current content R38 a), b) and R39 a), b)., to Element 6 Amenity;

Rule 38 – RZ1 and RZ2	Criteria 38
Site Coverage maximum of 60% of block area	Planting area is achieved through use of Rating Tool with minimum standard score
Planting Area minimum of 30% of block area	

Rule 39 – RZ3, RZ4, RZ5 and commercial zone	Criteria 39
Site Coverage maximum of 70% of block area	Planting area is achieved through use of Rating Tool with minimum standard score
Planting Area minimum of 20% of block area	

6. In the Multi Unit Housing Development Code introduce R40 to section 4.4 Landscape Design to;

Rule 40 – Landscape Design	Criteria 40
The landscape design is to provide for a combination of tree planting – for shade, mid height shrubs, lawn and ground covers	Planting area is achieved through use of Rating Tool with minimum standard score
The landscape design indicates that at least 50% of the overall number of trees and shrubs are species native to the region	
Planting of trees of semi-mature stock	
Planting of trees with a minimum mature height of 4m	

7. Single Dwelling and Multi Unit developments should require:
- a. Landscape plans to be submitted as a requirement for Development Application
  - b. implementation of approved landscape plans prior to certificate of occupancy

- 8. For Multi Unit developments landscape plans must be prepared and signed off by a registered Landscape Architect.

### 7.3 Street Level

#### Issue

Verge design, in particular location of services, is impacting negatively on the ability to achieve sufficient street tree canopy cover.

#### Principle

Ensure that the tree asset is prioritised in street configurations to increase shade and cooling effects on streets and neighbouring blocks.

#### Mechanisms

- Verge design
  - Street level recommendations
  - Verge permeability
  - Education (parking on verge)
  - Review standards for driveways
1. Review controls to:
    - a. Allow for tree overhang on block
    - b. Ensure deep root plant zones for trees in the verge through relocation or reconfiguration of other assets
    - c. Revise clearance requirements between infrastructure and tree assets

These controls are contained across a myriad of documents, such as the Estate Development Code, Design Standards for Urban Infrastructure and Utility Provider controls. These documents should be reviewed to ensure living infrastructure and tree assets are given equal consideration alongside other assets.

2. Review Estate Development Code section 9.2 Street Verge to:

R60	C60
<b>No more than 30% of the finished street verge surface is impervious</b>	<i>unchanged</i>

3. Review street configurations allowing medians in large streets and creating opportunities for large trees to be planted in the median strip.
4. Implement community education program about the impact of parking on the verge
5. Review design standards for driveways. For dual occupancy proposals within the established suburbs, where subdivision (including Unit Title subdivision) is permissible, a single verge crossing for both dwellings should be encouraged. The width requirement for verge crossings could be reduced for single dwelling verge crossings, consider Standard B14, 55.03-9 of the Yarra Council Planning Scheme.

6. Implement incentives to use permeable materials in construction including permeability in streets and footpaths

## 7.4 Suburb Level

### Issue

A significant proportion of trees at the suburb level are located in Open Space. Within the Estate Development Code, however, there is no current requirement for a minimum provision of broad scale open space for greenfield suburbs and no provision of a minimum canopy cover for greenfield suburbs.

### Principle

Increase tree numbers for shading and cooling and to enhance urban habitat

### Mechanisms

- Minimum open space in new estates
  - Trees in the public realm / open space
  - Minimum coverage of 50% for Greenfield suburbs
1. Implement a new rule in the Estate Development Code to allocate a minimum percentage of the suburb area to broad scale open space
  2. Implement provision in the Estate Development Code regarding the retention of remnant trees to give instant shade while landscaping matures
  3. Allocate a minimum tree coverage of approximately 50% for greenfield suburbs to be achieved through street trees and open space control
  4. Revise rule 25 of the Estate Development Code to make the rule mandatory

## 7.5 Living Infrastructure in the Statutory Framework

### Issue

Living Infrastructure lacks priority within existing planning and development provisions.

### Principle

Consider green infrastructure as essential infrastructure

### Mechanisms

1. Implement statutory Living Infrastructure Design Guidelines.
2. Include green infrastructure in:
  - a. Territory Plan strategic direction, structure plans, concept plans, precinct codes and development codes
  - b. Infrastructure and landscape design standards

## 7.6 Resources and maintenance

### Issue

Current level of funding does not support the implementation or maintenance of high quality Living Infrastructure

### Principle

Identify funding to embed Living Infrastructure as essential infrastructure in the planning framework

### Mechanisms

1. Identify funding streams in collaboration with relevant departments
  - a. Identify key existing government funding programs which may support Living Infrastructure – eg. Land Development Contribution Scheme

## 7.7 Education

### Issue

There is a lack of public awareness regarding the importance and impact of living infrastructure on wellbeing, comfort and as a community asset

### Principle

Normalise conversation about the positive impact of living infrastructure in the community and among practitioners and officials.

### Mechanisms

1. Implement public education programs which emphasise the value of Living Infrastructure on:
  - a. Healthy cities
  - b. Biodiversity
  - c. Urban heat island effect
  - d. Mental health and wellbeing

## 8.0 Further Studies

The scope of this project is limited and has identified a range of further studies that could be undertaken to support the ongoing development of living infrastructure in the ACT. Many of the recommendations in Section xx will require additional research and development.

### Improving and building the data set

The Scenario 1 data gathered for this analysis facilitated valuable insight into how living infrastructure exists in Canberra. Scenario 2 & 3 built on this existing data to understand how living infrastructure will look in tomorrow's Canberra. From all of these data sets provided, reliable findings about living infrastructure have been established. To further the understanding of living infrastructure, data sets for future studies can build on and refine these data sets.

The continual observation of the blocks experiencing increasing density and measuring impact to living infrastructure on these blocks will allow us to better understand how our older suburbs will look going into the future. The continual observation of living infrastructure in newer suburbs is also important to understand how canopy is affected by the many factors impacting newer suburbs. For relevant suburbs, the mature canopy should be measured against projected mature canopy of landscape plans to understand how accurate these projections are. Some other suggestions on improvements to data:

- As with any data set, a larger spread of data will yield a more reliable result. A larger spread of data could involve:
  - More study suburbs
  - More study streets
  - More study blocks
- The mature canopy data could be sourced for newer suburbs, this will give a more reliable comparison between suburbs
- For street level data, the study suburbs could include data about how much of each street classification accounts for the total street area. This will allow for study street data to be projected up to suburb level with much greater accuracy, rather than needing to take an average of all street classifications at suburb level.

### Rating tools

One of the key recommendations is the development of a rating tool to take the place of key criteria in the Territory Plan. More study is required of rating tools to understand their complexity and success in driving the desired outcomes. An ACT specific tool should be developed based on this additional research. Discussions should be held with jurisdictions using rating tools such as Seattle to gain an understanding of the impact the Seattle Green Factor has had on tree canopy and vegetation after ten years.

### Understanding the interdependencies in the territory plan at the block level

The proposed introduction of a site coverage and planting area control to replace the private open space control also overlaps with the plot ratio controls. Further study is required to model the interdependencies between these controls and better understand their effect on each other. It is likely that the plot ratio controls could be removed all together from the Territory Plan.

### Comprehensive review of controls affecting street trees

The controls affecting the delivery of street trees that provide shade and cooling are spread across a range of documents. A study mapping the impact of these controls in section and plan for different

street types and adjacent block typologies is required to identify how controls need to be modified. Service providers must be part of this discussion.

#### **Percentage of open space in new estates**

A study of the wider Canberra urban form beyond the 6 studied for this project, plus additional research into this topic are required to inform this proposed rule. The control could be based around area per hectare, area per head of population or area per district.

#### **Design standards for driveways**

A study of alternatives configurations for reduced driveway widths and configurations is required.

Living Infrastructure Design Guidelines

The preparation of Living Infrastructure Design Guidelines as a best practice design guide for practitioners, government and citizens across all scales of development.

#### **Inclusion of living infrastructure across all levels of documents**

Further work around how and where living infrastructure can be embedded across documents.

#### **Funding mechanisms**

Strategic policy on how the current economic model in the ACT can be augmented to allow for the ongoing maintenance of living infrastructure.

#### **Education Campaign**

Development of an education campaign on living infrastructure.

10.0 **Conclusion**

**Commented [A3]:** Katharine,  
Probably not required?

## 11.0 Attachments

1. Definition and Benefits of Living Infrastructure, Excerpt from Brief;
2. Literature Review References
3. Literature Review Summaries

## **Attachment 1**

**Definition and Benefits of Living Infrastructure  
Excerpt from Brief**



## STATEMENT OF REQUIREMENTS (CONSULTANCY SERVICES)

Planning and Design for Living Infrastructure as Part of Residential Intensification in a Changing Climate.

### Definition of Living Infrastructure

At a broad scale, Living Infrastructure refers to all interconnected ecosystems within an urban catchment. Living Infrastructure integrates and builds upon the concepts of 'green infrastructure' (which focusses on vegetation) and 'blue infrastructure' (which focuses on water management) within urban landscapes.

Within the ACT policy context, four basic components of living infrastructure have been identified as:

- plants (native and exotic vegetation)
- open spaces (parks, pathways, verges)
- lakes, ponds, and waterways (stormwater treatments)
- soils and surfaces.

Living infrastructure is an essential component of the urban environment that occurs on and applies to:

- Public land: parks open spaces and reserves, waterways and wetlands, streets and transport corridors, squares and plazas, sports and playing fields
- Private land: front gardens and backyards, building roofs and building facades and walls

Living infrastructure is supported by:

- stormwater management, capture and reuse
- ground water recharge
- urban runoff quality and quantity
- capacity of stormwater systems.

### Benefits of Living Infrastructure

Living infrastructure provides a range of beneficial ecosystem services in the urban environment, including:

- reducing urban heat and improving resilience to climate change
- reducing urban stormwater run-off, improving water quality and groundwater infiltration
- increasing urban biodiversity and habitat connectivity
- reducing urban air pollution
- reducing energy usage in the built environment
- increasing property values
- increasing urban amenity, community health and wellbeing.

## **Attachment 2**

**Literature Review References**

Adelaide City Council (2014). *Adelaide Design Manual: Green Infrastructure Guidelines*: Adelaide City Council, Adelaide.

<http://www.adelaidedesignmanual.com.au/design-toolkit>

Adelaide City Council (2016). *Adelaide Design Manual: Greening*: Adelaide City Council, Adelaide (A companion document, *Greening: Technical Specifications*, is currently under development.)

<http://www.adelaidedesignmanual.com.au/design-toolkit/greening>

Alexandra J, Norman B, Steffen W and Maher W (2017) *Planning and Implementing Living Infrastructure in the Australian Capital Territory – Final Report*, Canberra Urban and Regional Futures, University of Canberra, Canberra.

<https://junglefy.com.au/wp-content/uploads/2017/08/Living-Infrastructure.pdf>

Arundel, J. Lowe, M, Hooper, P, Roberts, R. Rozek, J. Higgs, C., Giles-Corti, B. (2017). *Creating Liveable Cities in Australia*. RMIT, Melbourne.

<http://cur.org.au/project/national-liveability-report/>

Australian Institute of Landscape Architects (2016). *Smart Cities Plan*. ACT: Australian Institute of Landscape Architects, Canberra.

<https://cities.infrastructure.gov.au/23822/documents/47915>

City of Melbourne (2012). *Urban Forest Strategy, Making a great city greener 2012-2032*, Victorian Government, Melbourne.

<https://www.melbourne.vic.gov.au/SiteCollectionDocuments/urban-forest-strategy.pdf>

City of Perth (2016). *Urban Forest Plan 2016-2036*, City of Perth Council, Perth.

[https://www.perth.wa.gov.au/sites/default/files/City%20of%20Perth%20Urban%20Forest%20Plan\\_0.pdf](https://www.perth.wa.gov.au/sites/default/files/City%20of%20Perth%20Urban%20Forest%20Plan_0.pdf)

City of Perth (2017). *Urban Forest Plan 2016-2036, Addendum*. City of Perth Council, Perth.

[https://www.perth.wa.gov.au/sites/default/files/documents/Urban%20Forest%20Report\\_Addendum\\_2017.pdf](https://www.perth.wa.gov.au/sites/default/files/documents/Urban%20Forest%20Report_Addendum_2017.pdf)

City of Seattle, Department of Construction and Inspections (2016). *Seattle Low rise Zoning summary*, viewed on 16<sup>th</sup> June 2018.

[http://www.seattle.gov/dpd/cs/groups/pan/@pan/documents/web\\_informational/dpds021571.pdf](http://www.seattle.gov/dpd/cs/groups/pan/@pan/documents/web_informational/dpds021571.pdf)

City of Sydney Council (2016) *Sydney Landscape Code Volume 1: Single dwellings*. Sydney.

[http://www.cityofsydney.nsw.gov.au/\\_data/assets/pdf\\_file/0008/277847/Landscape-Code-Volume-1-Single-Dwellings\\_Web.pdf](http://www.cityofsydney.nsw.gov.au/_data/assets/pdf_file/0008/277847/Landscape-Code-Volume-1-Single-Dwellings_Web.pdf)

City of Sydney Council (2016) *Sydney Landscape Code Volume 2: All Development Except for Single dwellings*. Sydney.

[http://www.cityofsydney.nsw.gov.au/\\_data/assets/pdf\\_file/0009/277848/Landscape-Code-Volume-2\\_Web.pdf](http://www.cityofsydney.nsw.gov.au/_data/assets/pdf_file/0009/277848/Landscape-Code-Volume-2_Web.pdf)

City of Sydney Council (2013) *Urban Forest Strategy 2013*. Sydney.

[http://www.cityofsydney.nsw.gov.au/\\_data/assets/pdf\\_file/0003/132249/Urban-Forest-Strategy-Adopted-Feb-2013.pdf](http://www.cityofsydney.nsw.gov.au/_data/assets/pdf_file/0003/132249/Urban-Forest-Strategy-Adopted-Feb-2013.pdf)

Government Architect NSW (GANSW) (2017). *Greener Places*, Establishing an urban green infrastructure policy for New South Wales. NSW Government, Sydney.

<http://www.governmentarchitect.nsw.gov.au/policies/greener-places>

Jacobs, B., Mikhailovich, N., and Delaney, C. (2014) *Benchmarking Australia's Urban Tree Canopy: An i-Tree Assessment*, prepared for Horticulture Australia Limited by the Institute for Sustainable Futures, University of Technology Sydney.

<https://opus.lib.uts.edu.au/handle/10453/37506>

Kendal D, Farrar A, Plant L, Threlfall C G, Bush J, Baumann J (2017). *Risks to Australia's urban forest from climate change and urban heat*. Clean Air and Urban Landscapes Hub. Australia.  
<[http://www.nesurban.edu.au/publications-resources/research-reports/CAULRR07\\_RisksAustralianUrbanForest\\_Nov2017.pdf](http://www.nesurban.edu.au/publications-resources/research-reports/CAULRR07_RisksAustralianUrbanForest_Nov2017.pdf)>

Melbourne Metro Rail Authority (2017). *Living Infrastructure Plan*; Victoria State Government, Victoria.  
[https://metrotunnel.vic.gov.au/\\_data/assets/pdf\\_file/0016/111832/Metro-Tunnel-Living-Infrastructure-Plan.pdf](https://metrotunnel.vic.gov.au/_data/assets/pdf_file/0016/111832/Metro-Tunnel-Living-Infrastructure-Plan.pdf)

Meyers J, Devereux D, Van Niel T and Barnett G (2017) *Mapping surface urban heat in Canberra*. CSIRO, Australia.  
[http://www.environment.act.gov.au/\\_data/assets/pdf\\_file/0005/1170968/CSIRO-Mapping-Surface-Urban-Heat-In-Canberra.pdf](http://www.environment.act.gov.au/_data/assets/pdf_file/0005/1170968/CSIRO-Mapping-Surface-Urban-Heat-In-Canberra.pdf)

NSW Department of Planning and Environment (2018). *State Environmental Planning Policy (Exempt and Complying Development Codes) Amendment (Low Rise Medium Density Housing) 2017*. NSW Government, Sydney  
<https://www.legislation.nsw.gov.au/EPs/2018-132.pdf>

NSW Department of Planning and Environment (2017). *Low rise medium density design guide*. NSW Government, Sydney  
<https://www.planning.nsw.gov.au/policy-and-legislation/housing/~media/56B9F795CFD44E71812332AFD30799E1.ashx>

NSW government (2018). *Sydney Landscape code; Volume1: single Dwellings*. Sydney: NSW government  
[http://www.cityofsydney.nsw.gov.au/\\_data/assets/pdf\\_file/0008/277847/Landscape-Code-Volume-1-Single-Dwellings\\_Web.pdf](http://www.cityofsydney.nsw.gov.au/_data/assets/pdf_file/0008/277847/Landscape-Code-Volume-1-Single-Dwellings_Web.pdf)

NSW government (2018). *Sydney Landscape code; Volume 2: All development except single Dwellings*. Sydney: NSW government.  
[http://www.cityofsydney.nsw.gov.au/\\_data/assets/pdf\\_file/0009/277848/Landscape-Code-Volume-2\\_Web.pdf](http://www.cityofsydney.nsw.gov.au/_data/assets/pdf_file/0009/277848/Landscape-Code-Volume-2_Web.pdf)

Green Business Certification Inc (2014) *SITES v2 Rating System for sustainable land design and development*  
<http://www.sustainablesites.org/>

Verburg, P., van Teeffelen, A. and Derksen, M. (2018). *Green infrastructure for urban climate adaptation: How do residents' views on climate impacts and green infrastructure shape adaptation preferences?* *Landscape and urban planning*, 157, pp.106-130.  
<https://www.sciencedirect.com/science/article/pii/S0169204616300949#!>

Victoria Institute of Strategic Economic studies (VISES). (2015). *Green Infrastructure Economic Framework*. Victoria University, Melbourne.  
<https://www.vu.edu.au/sites/default/files/cs/es/pdfs/green-infrastructure-economic-framework-summary-report-fin.pdf>

Yarra City Council (2018). *Yarra planning scheme*. Yarra: Victorian Government, Melbourne. (Note: various related Planning Advisory Notes and Practice Notes were also consulted – too numerous to list)  
<http://planningschemes.dpcd.vic.gov.au/schemes/yarra>

Yarra City Council (2018) *Sustainable Design Assessment in the Planning Process*, Victorian Government, Melbourne.

<https://www.yarracity.vic.gov.au/services/planning-and-development/planning-applications/environmentally-sustainable-design-in-planning>

Yarra City Council (2018) *Medium Developments Sustainable Design Assessment (SDA)*, Victorian Government, Melbourne.

<https://www.yarracity.vic.gov.au/services/planning-and-development/planning-applications/environmentally-sustainable-design-in-planning/sustainable-design-assessment-sda>

Yarra City Council (2018) *The 10 key sustainable building categories*, Victorian Government, viewed on 16 June 2018.

<https://www.yarracity.vic.gov.au/services/planning-and-development/planning-applications/environmentally-sustainable-design-in-planning/the-10-key-sustainable-building-categories>

**Attachment 3**  
Literature Review Summaries

**Australian Institute of Landscape Architects. *Smart Cities Plan*. ACT: Australian Institute of Landscape Architects; 2016.**

This paper is a submission in response to the Commonwealth Government's Smart Cities Plan (March 2016). It emphasises the value of living infrastructure as being able to enhance and regenerate natural resources rather than simply minimise damage to environmental systems. This regenerative capacity is increased through strategic connectivity of landscape assets. AILA proposes living infrastructure be recognised as an asset class thus enabling broader economic objectives to be realised.

**Terminology:** Living infrastructure, green infrastructure assets

**Mechanisms:** recognition of living infrastructure as an asset class; embracing living infrastructure metrics, creative living infrastructure funding and implementation strategies. Sustainable Sites Initiative (SITES) <http://www.sustainablesites.org> rating system via Commonwealth funded City Deals <https://cities.infrastructure.gov.au/city-deals> delivered via local government.

**Adelaide City Council. *Adelaide Design Manual: Green Infrastructure Guidelines*: Adelaide City Council, Adelaide; 2014.**

Green infrastructure is defined in this document as the web of interrelated natural systems that underpin and are integrated with the urban fabric. These include living architecture, the urban forest, green streets and water sensitive urban design. Eight guiding principles provide a high level framework for the implementation of Green Infrastructure initiatives to achieve real and lasting benefit.

These guidelines, prepared by Aspect Studios, are set out in four sections: Context, Applications, elements, and Implementation with four appendices including Best Practice Examples, Policy and Background Research, Workshop Summary and Examples of Maintenance strategies. It covers both public and private realms. This structure ensures guidelines which draw on a wide body of knowledge and focused on Adelaide and the issues it faces to become a healthy, resilient city. Further details are attached at Attachment 2. The document is supported by excellent photographs and technical illustrations.

The importance of embedding green infrastructure in the city's urban design framework and of working across a range of scales and a range of levels is emphasised. Scales include regional, city, and individual; levels include policy and planning, city design and city assets. Benefits of green infrastructure, its design and maintenance are key elements in the guidelines.

Successful implementation green infrastructure depends on (1) an integrated design approach requiring prioritisation of greening equal to, or more important than, other infrastructure; (2) collaboration with a diverse group of professionals such as landscape architects, engineers, policy makers, asset managers, architects, ecologists, soil scientists, horticulturalists and authorities; and (3) collaboration between Council, developers, building owners, private residents, design consultants, contractors, operations and maintenance personnel and utility providers responsible for a range of city assets.

**Terminology:** Green infrastructure, Urban Design Framework, Improved water management, Human Health and Wellbeing, Increased Livability, Climate modification Economic Prosperity, Improved Urban Ecology, whole-of-life-cycle-cost analysis, Living Architecture, Green Streets, Water Sensitive Urban Design, Urban Forest, Urban Food, Soft Engineering, Hard Engineering.

**Mechanisms:** recognition of green infrastructure as an asset, policy that includes incentives and contributions (from Council and or developers), use of a rating tool. Green Infrastructure Rating Tool (GIRT), evidenced passed design, staged implementation, capacity building, and illustration of opportunities via example.

**Adelaide City Council. *Adelaide Design Manual: Greening*: Adelaide City Council, Adelaide; 2016. A companion document, *Greening: Technical Specifications*, is currently under development.**

This document is part five or seven in the Adelaide Design Manual and emphasises the value of creating a web of interrelated natural systems across a range of scales and applications in the city with the intent of building a city that is sustainable, economically prosperous and resilient. It refers to and draws heavily upon the Green Infrastructure Guidelines above. This 'greening' approach stresses the benefits, doing more with less money, looking beyond the public realm, educating (seen as critical) users, developers, designers engineers contractors and maintenance staff about sustainable urban design approaches and their implementation. Its focus is the public realm.

Eleven greening principles 'outline the implementation of green infrastructure initiatives to achieve real and lasting benefits for the City of Adelaide'. The Greening Approaches set out are intended to be used as a toolkit for green infrastructure approaches in conjunction with the Green Infrastructure Guidelines. The approaches are organised under five headings: 1. Living Architecture; 2. Green Streets; 3. The Urban Forest; 4. Water sensitive Urban Design; and 5. Urban Food. The five approaches are elaborated as to their purpose, elements and significance for the city.

A significant part of the document is devoted to Street trees and planting, both seen as important in moderating the city's climate, helping to meet future climate challenges and creating a more climate resilient city. The approach adopted seeks to achieve planting that is environmentally and contextually appropriate for the character and heritage of Adelaide. Five themed planting palettes, including related street tree and planting groups, provide design intent for themes and desirable physical characteristics (should be referenced to the Street Types section in the Adelaide Design Manual). Each palette theme and approach is further elaborated (precinct use and approaches intended to achieve design, environmental and social outcomes) and located on a map. Minimum Design Standards to be adhered to for all projects set out street tree and planting palettes. These palettes and the Green Infrastructure Guidelines must be used when implementing greening approaches throughout the city's public realm. Species for planting palettes (as opposed to tree palettes) are not provided and are determined on a case by case basis with Adelaide City Council. Greening of Squares is determined by individual Master Plans.

The document provides a coherent approach to greening the City's streets, supported by excellent images, maps and illustrations.

Terminology: Green Infrastructure, Water Sensitive Urban Design, Greening Principles, Living Architecture, Green Streets, Urban Forest, Urban Food, Planting Palettes, Design Standards.

Mechanisms: Planting palettes; plant selection that is environmentally and contextually appropriate, principles designed to enhance ecological, social and economic values, design manual defines parameters, Design intent approach, precinct based planting design, creation of connected network of greening. Foster best practice.

**Kendal D, Farrar A, Plant L, Threlfall C G, Bush J, Baumann J (2017). *Risks to Australia's urban forest from climate change and urban heat*. Clean Air and Urban Landscapes Hub. Australia.**

This paper documents a study of public trees in Australia's cities and provides analysis of risk under two scenarios: limited climate change and 'business as usual'. Several strategies are offered for urban forest managers to adapt to increasing temperatures including building resistance (irrigation, pest control, mulching, improving abiotic conditions) resilience (irrigation, soil improvement, improved stock selection, planting techniques, longer establishment maintenance) and selection of species better able to adapt to future climates (consult with Nursery industry about better lead times etc and diversity of selection). Meaningful engagement with the community and industry will help to create successful urban forests of the future. The report provides useful data for planning and policy development and illustrates the importance of establishing and maintaining reliable tree inventories. Key factors for success with urban forest policy and governance include building a shared vision of the

urban forest and broad based partnerships across government departments and non-government stakeholders as well as sharing information across jurisdictional boundaries and between Australian cities. Integration of urban forest policies with other urban policies (land use, planning, transport, health, ecology and open space management) is also a factor in the success of transitions in urban forest policy. Adequate funding, resources, availability of technical expertise together with monitoring and evaluation to support adaptations to species composition and to governance, management and engagement processes is another key success factor. The importance of the urban forest to social and cultural services and equity is emphasised as is the need to engage with the community.

Terminology: Urban forest diversity, ecosystem services, biodiversity, social and cultural services, resistance, resilience.

Mechanisms: build resistance, resilience, improved tree planting and selection techniques, continuing consultation/engagement with industry and community, fostering urban forest 'champions, whole of government approach including policy integration, adequate funding for resources, maintenance and technical expertise, monitoring, sharing information across jurisdictions (State and National).

**Alexandra J, Norman B, Steffen W and Maher W (2017) *Planning and Implementing Living Infrastructure in the Australian Capital Territory – Final Report, Canberra Urban and Regional Futures, University of Canberra, Canberra.***

This document is a literature review to support delivery of innovative, high quality living infrastructure as part of Canberra's urban renewal and development processes. A number of key themes and issues relevant to Canberra are identified. Of these the following are relevant to Stage 1 of this project: an integrated government approach, institutional and political commitment, capacity for integrated planning across all levels and functions of government and active community involvement, an emphasis on cultural aspects of innovation, and research and development. Consultation and participatory planning methods are central to successful urban strategies – a wider process that mobilises citizens, civic institutions, communities and practitioners. Techniques such as scenario planning help to build capacity and build support. Good practice in water sensitive design should be integrated into living infrastructure planning and policy and risk reduction should be a key design element. Urban forests and biodiversity conservation are integral to living infrastructure. Good use should be made of outcome-focused guidelines and design principles to enhance the quality of planning decisions. It is also important to be able to broadly quantify ecosystem service benefits for options under consideration.

Well-designed living infrastructure is an essential component of effective climate mitigation and adaptation strategies for cities. There is a strong rationale for integrated planning focused on achieving multiple benefits. Living infrastructure needs to be understood in terms of transitions towards meeting societal needs for sustainability as well technical and material aspects and it is important to distinguish between incremental and transformational adaptation. Cities face a range of constraints to transformative change, including institutional complexity and incremental planning. Responsiveness to new challenges, circumstances, knowledge and climate change is critical to adaptive and transformative capacity.

Strong case is made for green infrastructure in urban renewal projects in Canberra especially along the transit corridors. Several types of living infrastructure are commonly used in urban development: tree plantings, WUSD, green roofs and walls, community gardens and green connectors. Living infrastructure is best implemented not as individual elements but as a broad, interconnected green infrastructure network that provides multiple ecosystem services to urban populations. Two other important strategies contribute to successful living infrastructure: enhancing sense of place and providing financial incentives for installation of living infrastructure, for example Vancouver requires five percent of the value of development be directed into social infrastructure. Several examples of implementation of this type of infrastructure are provided.

The paper proposes five ideas for Canberra – a design competition along light rail corridor; integrated planning across several scales from pocket parks and walking corridors between light rail stops, to larger scale connectivity between the transit corridor and nature reserves and existing parks (Haig Park a good example); blue infrastructure - Sullivan’s Creek offers opportunities); challenge to private sector developers along the corridor to give high priority to living infrastructure and a climate scorecard for three main metrics to be achieved - storing carbon, heat adaptation and managing WSUD.

Waste water in Canberra, especially stormwater, needs to be treated as a resource to be managed and reused. Transformation of water systems includes both technological innovation and the broader challenges of governance and institutional reform. There is the possibility of creating of micro-pockets of urban ‘floodplain forest’ where run-off is concentrated to mimic say, River Oak forests.

The literature is split on usefulness of defining living infrastructure as an asset which may obfuscate wider role of government as protector of the public’s long term interests. Rather than focus on assets it may be better to focus on understanding how policy decisions are made and effect change that way. Also, having guiding design principles focused on outcomes may be more effective than investing in valuation studies.

**Seattle Green Factor** <http://www.seattle.gov/dpd/codesrules/codes/greenfactor/default.htm>

Adopted in 2007, the Seattle Green Factor (SGF) is a weighted, score-based code requirement for specified developments in Seattle. It was based on the Berlin Biotope Area Factor [https://www.berlin.de/senuvk/umwelt/landschaftsplanung/bff/index\\_en.shtml](https://www.berlin.de/senuvk/umwelt/landschaftsplanung/bff/index_en.shtml) and modified to suit the Seattle context. Currently SGF does not apply to single residential development. SGF is a response to concerns about balancing urban density with liveability and the need to support ecosystem function especially in relation to stormwater and the heat island effect. It was also a response to LEED provisions at the time which focussed on buildings rather than landscape. SGF does not apply to all development in Seattle and currently does not apply to single residential zones.

GSF aims to increase the amount and quality of landscaping in urban areas while allowing flexibility for developers and designers to use property efficiently. As a mandated system it provides flexibility for developer to meet the code and rewards:

- low water use
- layered planting with site appropriate plants
- tree preservation
- large canopy street trees
- permeable paving
- green roofs and walls
- bioretention areas

Bonuses points are achievable by including drought tolerant or native plant species, irrigation with harvested rainwater, landscape features that are visible to passers-by and Food cultivation.

SGF scores required are typically tied to zones: The city of Seattle requires the equivalent of 30% of a block in commercial zones to be vegetated using the SGF

Zone	Minimum Score
Commercial and neighbourhood commercial	0.30
Industrial Commercial (in urban villages)	0.30
Midrise and highrise residential	0.50
Lowrise multifamily residential	0.60
South Downtown	0.30

Lots of unusual configuration may be assessed based on project impact area rather than total area, giving developers flexibility to use the site efficiently. A worksheet and score sheet are attached.

A completed green factor scoresheet and landscape plans must be included as part of the plan set submitted for development/building approval. Minimum designer qualifications apply to preparation of the landscape plans, depending on the size of the development together with detailed requirements for information and standards to be provided on the landscape plan. Maintenance is given high priority and a Landscape Management Plan is also required as part of the project. It is not submitted with the development application, instead the designer certifies one has been prepared and handed to building owner.

A Landscape Improvement Checklist must be signed by the project's landscape professional and submitted to the building inspector and landscaping must be installed in accordance with the approved plans *prior* to issue for final Certificate of Occupancy. except in special circumstances – for example, severe drought. Critically, because SGF is embedded in the statutory framework, building owners may be subject to legal action if the landscape elements are not installed as per the approved plans.

		Planting Area					TOTAL**
		1	2	3	<i>keep adding columns as needed</i>		
A1	<i>square feet</i>						0
A2	<i>square feet</i>						0
A3	<i>square feet</i>						0
B1	<i>square feet</i>						0
B2	<i># of plants</i>						0
B3	<i># of trees</i>						0
B4	<i># of trees</i>						0
B5	<i># of trees</i>						0
B6	<i># of trees</i>						0
B7	<i># of trees</i>						0
C1	<i>square feet</i>						0
C2	<i>square feet</i>						0
D	<i>square feet</i>						0
E	<i>square feet</i>						0
F1	<i>square feet</i>						0
F2	<i>square feet</i>						0
G	<i>square feet</i>						0
H1	<i>square feet</i>						0
H2	<i>square feet</i>						0
H3	<i>square feet</i>						0
H4	<i>square feet</i>						0

\* See Green Factor score sheet for category definitions

\*\* Enter totals on the Green Factor score sheet

The interactive Excel version of this worksheet is available at [www.seattle.gov/dpd/greenfactor](http://www.seattle.gov/dpd/greenfactor).

Green Factor Score Sheet		SEATTLE <i>green factor</i>	
Project title:		enter sq ft of parcel	
Parcel size (enter this value first)	5,000	SCORE	-
<b>Landscape Elements**</b>	Totals from GF worksheet	Factor	Total
<b>A Landscaped areas (select one of the following for each area)</b>			
1	Landscaped areas with a soil depth of less than 24" <i>enter sq ft</i> 0	0.1	-
2	Landscaped areas with a soil depth of 24" or greater <i>enter sq ft</i> 0	0.6	-
3	Bioretention facilities <i>enter sq ft</i> 0	1.0	-
<b>B Plantings (credit for plants in landscaped areas from Section A)</b>			
1	Mulch, ground covers, or other plants less than 2' tall at maturity <i>enter sq ft</i> 0	0.1	-
2	Shrubs or perennials 2'+ at maturity - calculated at 12 sq ft per plant (typically planted no closer than 18" on center) <i>enter number of plants</i> 0	0.3	-
3	Tree canopy for "small trees" or equivalent (canopy spread 8' to 15') - calculated at 75 sq ft per tree <i>enter number of plants</i> 0	0.3	-
4	Tree canopy for "small/medium trees" or equivalent (canopy spread 16' to 20') - calculated at 150 sq ft per tree <i>enter number of plants</i> 0	0.3	-
5	Tree canopy for "medium/large trees" or equivalent (canopy spread of 21' to 25') - calculated at 250 sq ft per tree <i>enter number of plants</i> 0	0.4	-
6	Tree canopy for "large trees" or equivalent (canopy spread of 26' to 30') - calculated at 350 sq ft per tree <i>enter number of plants</i> 0	0.4	-
7	Tree canopy for preservation of large existing trees with trunks 6"+ in diameter - calculated at 20 sq ft per inch diameter <i>enter inches DBH</i> 0	0.8	-
<b>C Green roofs</b>			
1	Over at least 2" and less than 4" of growth medium <i>enter sq ft</i> 0	0.4	-
2	Over at least 4" of growth medium <i>enter sq ft</i> 0	0.7	-
<b>D Vegetated walls</b>			
	<i>enter sq ft</i> 0	0.7	-
<b>E Approved water features</b>			
	<i>enter sq ft</i> 0	0.7	-
<b>F Permeable paving</b>			
1	Permeable paving over at least 6" and less than 24" of soil or gravel <i>enter sq ft</i> 0	0.2	-
2	Permeable paving over at least 24" of soil or gravel <i>enter sq ft</i> 0	0.5	-
<b>G Structural soil systems</b>			
	<i>enter sq ft</i> 0	0.2	-
<i>sub-total of sq ft = 0</i>			
<b>H Bonuses</b>			
1	Drought-tolerant or native plant species <i>enter sq ft</i> 0	0.1	-
2	Landscaped areas where at least 50% of annual irrigation needs are met through the use of harvested rainwater <i>enter sq ft</i> 0	0.2	-
3	Landscaping visible to passersby from adjacent public right of way or public open spaces <i>enter sq ft</i> 0	0.1	-
4	Landscaping in food cultivation <i>enter sq ft</i> 0	0.1	-
<i>Green Factor numerator =</i>			

\* Do not count public rights-of-way in parcel size calculation.

\*\* You may count landscape improvements in rights-of-way contiguous with the parcel. All landscaping on private and public property must comply with the Landscape Standards Director's Rule (DR 6-2009)

The interactive Excel version of this score sheet is available at [www.seattle.gov/dpd/greenfactor](http://www.seattle.gov/dpd/greenfactor).

Green Business Certification Inc (2014) *SITES v2 Rating System for sustainable land design and development* - The SITES v2 Rating System is owned by Green Business Certification Inc. The material on which the SITES v.2 Rating System is based was developed through a collaborative, interdisciplinary effort of the American Society of Landscape Architects Fund, The Lady Bird Johnson Wildflower Center at The University of Texas at Austin, and the United States Botanic Garden  
<http://www.sustainablesites.org/>

SITES is a US based, independent landscape-focussed rating system applicable to projects across the scales from single blocks to a large subdivisions, brownfield and greenfield sites. It is a system that can be used world-wide. SITES is administered by the Green Business Certification Inc (GNCI) and is not tied to a specific development approval process. There is a fee for registration and a separate fee for certification of a project. Because SITES provides performance benchmarks rather than prescriptive practices, it can support the unique conditions of a site, encouraging flexibility and creativity appropriate to site context and intended use.

Central to SITES is the idea that ecosystem services through sustainable landscapes create resilient communities better able to recover from catastrophic events (eg floods, drought, wildfire s) and benefit property owners, local and regional communities and economies. Since its inception in 2007, SITES has been extensively field tested in a two year pilot program involving more than 160 projects. As at March 20187, some 120 projects across 35 US States and eight countries have registered or certified with SITES.

By aligning design and development practices with the functions of healthy ecosystems, ... SITES offers several significant benefits and values: 1) it advances best practices in landscape architecture and other environmental design professions, 2) it may help design professionals fulfil their health, safety, and welfare responsibilities for licensure, 3) clients can be assured that their project has achieved rigorous, field-tested standards for sustainability, 4) clients can market the SITES certification of their projects (as many do for the LEED® green building program), and 5) it is ethically responsible, protects natural systems for present-day use and appreciation, and preserves ecosystems and their essential services for future generations. (GBCI, SITES v2 Rating System for sustainable land design and development 2014)

The site-specific benchmarks are organised by development phases:

- Site context
- Predesign assessment and planning
- Site design – water
- Construction
- Operations and Maintenance
- Education and performance monitoring
- Innovation and exemplary performance

Each phase includes prerequisites, which must be achieved and are not scored, and potential credits which are scored and count towards the final rating and level of certification. For example, under Site Context the prerequisites include conservation of aquatic ecosystems, and habitats for threatened and endangered species while credits can be achieved for redevelopment of degraded site, location of projects within existing developed areas and connection to multi-modal transit networks. A sample summary scorecard is attached.

SITES offers professional accreditation on successful completion of an exam appropriate training and experience. [http://www.sustainablesites.org/education-listing?field\\_education\\_type\\_value\\_1=SITES+rating+system+specific+courses](http://www.sustainablesites.org/education-listing?field_education_type_value_1=SITES+rating+system+specific+courses) . There is also a free webinar series about sustainable landscape design and development.

Project Name: \_\_\_\_\_ Date: \_\_\_\_\_

Project ID#: \_\_\_\_\_

**SITES v2 Scorecard Summary**

YES		7		NO		Possible Points:	
0	0	0	0	0	0	0	0
<b>1: SITE CONTEXT</b>							
Y							13
<b>1: SITE CONTEXT</b>							
Y							Possible Points: 13
Y							2 to 3
Y							2
Y							2
Y							3 to 6
Y							4
Y							2 to 3
<b>2: PRE-DESIGN ASSESSMENT + PLANNING</b>							
Y							Possible Points: 3
Y							4
Y							3
Y							3
<b>3: SITE DESIGN - WATER</b>							
Y							Possible Points: 23
Y							4 to 6
Y							4 to 6
Y							4 to 6
Y							4 to 6
Y							4 to 6
<b>4: SITE DESIGN - SOIL + VEGETATION</b>							
Y							Possible Points: 40
Y							4 to 6
Y							4 to 6
Y							4
Y							3 to 6
Y							4 to 6
Y							4
Y							1 to 4
Y							4
<b>5: SITE DESIGN - MATERIALS SELECTION</b>							
Y							Possible Points: 41
Y							2 to 4
Y							3 to 4
Y							3 to 4
Y							3 to 4
Y							3 to 5
Y							1 to 5
Y							1 to 5
Y							5
Y							1 to 5
<b>6: SITE DESIGN - HUMAN HEALTH + WELL-BEING</b>							
Y							Possible Points: 30
Y							2 to 3
Y							2
Y							2
Y							3 to 6
Y							2
Y							3 to 4
Y							4
Y							4
Y							1 to 2
Y							3
<b>7: CONSTRUCTION</b>							
Y							Possible Points: 17
Y							3 to 5
Y							3 to 4
Y							3 to 4
Y							3 to 4
Y							2 to 4
<b>8: OPERATIONS + MAINTENANCE</b>							
Y							Possible Points: 22
Y							3 to 5
Y							4 to 5
Y							2 to 4
Y							3 to 4
Y							2 to 4
<b>9: EDUCATION + PERFORMANCE MONITORING</b>							
Y							Possible Points: 11
Y							3 to 4
Y							3
Y							4
<b>10: INNOVATION OR EXEMPLARY PERFORMANCE</b>							
Y							Bonus Points: 9
Y							3 to 9
<b>TOTAL ESTIMATED POINTS</b>							
Y							200
<b>SITES Certification levels</b>							
Y							CERTIFIED 70
Y							SILVER 85
Y							GOLD 100
Y							PLATINUM 135

**Jacobs, B., Mikhailovich, N., and Delaney, C. (2014) *Benchmarking Australia's Urban Tree Canopy: An i-Tree Assessment*, prepared for Horticulture Australia Limited by the Institute for Sustainable Futures, University of Technology Sydney.**

This paper provides, at a high level, an estimate of land surface cover for 139 Local Governments across Australia. Metrics (i-Tree <https://www.itreetools.org/>) used in the report offer an opportunity to benchmark green cover to inform green infrastructure development at low cost. The report is presented as a first step in 'strengthening and understanding of the composition of land cover and how urban greening strategies can be maximised in urban areas of Australia [and act as a catalyst] for 'a process of social change through benchmarking.'

Land cover is categorised to enable analysis of ecological function and identification of opportunities for creating green cover:

- Tree cover
- Shrub cover
- Grass and /or bare ground
- Hard surfaces

Distinguishing between tree and shrub cover provides information about laying of existing green cover. Distinguishing between hard surfaces and grass/bare ground potentially reveals what is potentially plantable and area that may offer innovative solutions such as green roofs on 'hard surfaces'. I-Tree in this project draws on Google Earth imagery overlaid with shape file boundaries. The data reveals the ACT to have the highest proportion of tree cover (56%) in the local government areas studied. This provides a useful benchmark of combined private and public green cover when setting future green cover targets across a range of scales in the ACT.

This report may have been overtaken by more recent and detailed data for the ACT, and its high level nature limits its use, nevertheless the categorization of land cover provides valuable insights for policy and project development. A three-stage research process is recommended:

- quantitative analysis: high level land surface mapping of land cover by area, percentages of cover by category
- quantitative analysis: refinement of land surface mapping - essentially to distinguish between public and private ownership, how is bare grass used, where are the areas of opportunity (bare grass and hard surfaces) located etc, overlap with socioeconomic indexes ( most useful when overlaid with mapped urban heat island effects)
- qualitative analysis: understanding quality: building on the quantitative data, undertake qualitative analysis to maximise human and environmental benefits of urban greening (targeted intervention).  
Questions to ask include:
  - which plant species would best suit
  - what are human engagement patterns with new or existing vegetation
  - where are priority areas for native vegetation
  - what are broader social impacts of urban greening

The report recommends undertaking a Social Return on Investment (SROI) analysis to attribute a dollar value to and long and short term outcomes for further urban greening.

Terminology: Tree cover, shrub cover, grass/bare ground, hard surfaces, potentially plantable, currently non-plantable, urban greening,

Mechanisms: strategic policy based research.

**Government Architect NSW (GANSW) (2017). *Greener Places, Establishing an urban green infrastructure policy for New South Wales*. NSW Government, Sydney.**

<http://www.governmentarchitect.nsw.gov.au/policies/greener-places>

GANSW sets out a draft policy guide for design, planning, design and delivery of green infrastructure in urban NSW. Green infrastructure is defined as

The network of green spaces, natural systems and semi-natural systems including parks, rivers, bushland and private gardens that are strategically planned, designed and managed to support a good quality of life in an urban environment.

This concept of landscape as green infrastructure creates a collaborative framework of designers, planners, developers and policy makers seeking to achieve local and state goals related to liveability, quality of life and wellbeing. In this context green infrastructure is seen as crucial to a city as transport, cultural and communications infrastructure, complementing other types of infrastructure projects. Its elements range from 'residential gardens to local parks and housing estates, streetscapes and highway verges, services and communications corridors, waterways and regional recreation areas'. Page 13 of this document includes a diagram illustrating how these elements can be utilised in a green infrastructure network.

Well-designed green infrastructure should respond to the following key principles:

- Integration – combine with urban development and grey infrastructure
- Connectivity – create an interconnected network of open space
- Multifunctionality – deliver multiple ecosystem services simultaneously
- Participation – involve stakeholders in development and implementation

A strong case is made for green infrastructure as an essential asset, promoting multifunctional design delivering a range of benefits to a single area. 'Well-designed and planned green infrastructure will help absorb flood water, cool the urban environment, clean the air, provide space for local food production and ensure the survival of Sydney's fauna and flora as well as providing space for recreation, sport and leisure.' Green infrastructure is seen to deliver key environmental, economic and social benefits.

The document offers a vision of what an integrated, connected and multifunctional green infrastructure network would look like. It would provide for:

- Conservation of the natural environment
- Increased access to open space
- Improved connectivity to promote active living
- Increased urban greening to ameliorate climate extremes

Effective implementation of green infrastructure requires:

- appropriate **statutory measures** at state and local government levels – inclusion of green infrastructure as essential infrastructure in strategic planning outcomes and requirements in regional and district plans; inclusion of green infrastructure in land use and infrastructure plans, priority precincts etc; issue of manuals, toolkits, practice notes about open space strategies, urban bushland and waterway strategies and urban canopy cover strategies; monitoring and reporting of outcomes; development of model council Development Control Plan clauses to provide guidance to councils.
- **collaborative action** between the government, stakeholders and local communities through a series of workshops to finalise key actions for implementation; assign measurable outcomes for each action; assign lead agencies to instigate policy ; identify partners to work lead agencies.
- **enacting key principles** of integration, connectivity, multifunctionality and participation.
- **funding** at a level required to deliver the desired outcomes. Identifying the funding will require an audit of all existing funding programs, embedding green infrastructure as essential infrastructure in the planning framework; identifying new funding streams; in collaboration with relevant departments

undertake pilot urban canopy and greenspace linkage projects; identifying funding stakeholders (eg State government agencies, councils, industry peak bodies and private sector); and identifying key existing government funding programs.

Importantly, *'Greener Places'* is not a one-size-fits-all approach and publically available mandatory monitoring and reporting on policy outcomes is essential. Data should be made available to the community: examples could include live green grid mapping, known urban canopy coverage, information on priority projects and monitoring and reporting on grant allocations from the various green infrastructure funding programs.

Key elements in the delivery of green infrastructure include:

- Establishing a green infrastructure design policy
- Establishing design standards, design guidance and design manuals to support good practice and outcomes for green infrastructure
- Working across government to embed policy principles in all relevant areas
- Consult with a range of stakeholders prior to finalising policy.

Key mechanism: policy and design guidance (manuals, standards etc) embedded in statutory framework.

**Verburg, P., van Teeffelen, A. and Derksen, M. (2018). Green infrastructure for urban climate adaptation: How do residents' views on climate impacts and green infrastructure shape adaptation preferences? *Landscape and urban planning*, 157, pp.106-130.**

<https://www.sciencedirect.com/science/article/pii/S0169204616300949#!>

Abstract

Cities are particularly prone to the effects of climate change. One way for cities to adapt is by enhancing their green infrastructure (GI) to mitigate the impacts of heat waves and flooding. While alternative GI design options exist, there are many unknowns regarding public support for the various options. This study aims to fill this gap by performing a socio-cultural valuation of urban GI for climate adaptation that encompasses multiple dimensions: people's notion of and concerns about climate impacts, the degree to which people acknowledge the benefits of GI to alleviate such impacts, and people's preferences for different GI measures, including their willingness to pay (WTP). Data were collected through photo-assisted face-to-face surveys (n = 200) with residents in Rotterdam, the Netherlands, and linked to GI GIS data. Respondents had a notion of and concerns about climate impacts, but did not necessarily acknowledge that GI may help tackle these issues. Yet, when residents were informed about the adaptation capacity of different GI measures, their preferences shifted towards the most effective options. There was no information effect, however, on people's WTP for GI, which was mostly related to income and ethnicity. Our study shows that economic valuation alone would miss nuances that socio-cultural valuation as applied in this paper can reveal. The method revealed preferences for particular adaptation designs, and assists in detecting why policy for climate adaptation may be hampered. Understanding people's views on climate impacts and adaptation options is crucial for prioritizing effective policy responses in the face of climate change.

This statistically rigorous study addressed:

- Notions of and concerns about climate impacts – concerns about urban heat were significantly more frequent among respondents who noticed temperature differences within the city and concerns about future heat impacts were more common among people who currently experienced it as a problem. Concerns about flooding were similar except that concerns about urban flooding were more common among respondents living in streets with little green infrastructure.
- Rating of green infrastructure benefits – respondents did not fully acknowledge the capacity of green infrastructure to mitigate local climate change effects. Overall, respondents acknowledged green

infrastructure's capacity to mitigate local flooding but its ability to regulate temperature was less acknowledged.

- Preferences for green infrastructure measures - respondents showed a preference for green infrastructure that is diverse, aesthetically attractive and familiar over the simple and unfamiliar.  
**Home level:** preference for gardens followed by green roofs (especially for those with children)  
**Neighborhood level:** most preferred streets with shrubs or trees over grass strips. Local squares were preferably turned in to pocket parks with grass, shrubs and trees.  
**City level:** people preferred canals and trees over grass strips along main roads. Wooded parks were preferred as city parks, possibly because of their suitability for a combination of uses – sport, play, rest and enjoying nature. Spatial analysis revealed that people living in an area with greater green infrastructure cover more often preferred water rich parks over wooded parks.

At all levels, preferences shifted to more effective green infrastructure measures after respondents had been provided with more information about climate (impacts). Measures were primarily chosen because of their attractiveness and usefulness. There was a preference for large-scale green infrastructure over small-scale.

- Willingness to pay for green infrastructure measures – about two thirds of respondents were willing to pay for green infrastructure measures, mostly via an annual household tax.

#### Discussion

In general people were aware of the impact of urban heat and flooding and considered these to be serious future challenges. The study shows that providing information about the benefits of green infrastructure can increase support for adaptation measures indicating that environmental education has the potential to create public support for adaptation measures. 'Acceptability can increase when green infrastructure designs are promoted on a neighbourhood level to influence neighborhood norms so the residents do not feel like an outsider when they install a rain garden or green roof.'

Residents in green infrastructure poor areas preferred new trees being planted over shrubbery suggesting that urban planning should prioritise tree planting in new suburbs.

#### Conclusions

- People's awareness of climate impacts and understanding of green infrastructure benefits shapes their preferences for green infrastructure measures. Understanding this helps planners to identify more effective policy responses.
- In general, people are willing to support climate adaptation through green infrastructure as long as it is multifunctional.
- It is advisable to create public support for green infrastructure by making people aware of climate change impacts and by providing information about the multiple benefits of green infrastructure and tailor the choice to local preferences.