Planning controls for living infrastructure and urban heat in estates and commercial development

Final Report

Prepared for ACT Government Environment, Planning and Sustainable Development Directorate, Sustainability Policy Section

27 June 2022

This report has been prepared in collaboration by Civille, Tait Network, Edge Environment and UNSW.

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Planning controls for living infrastructure and urban heat in estates and commercial development

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DISCLAIMER

CONTENTS

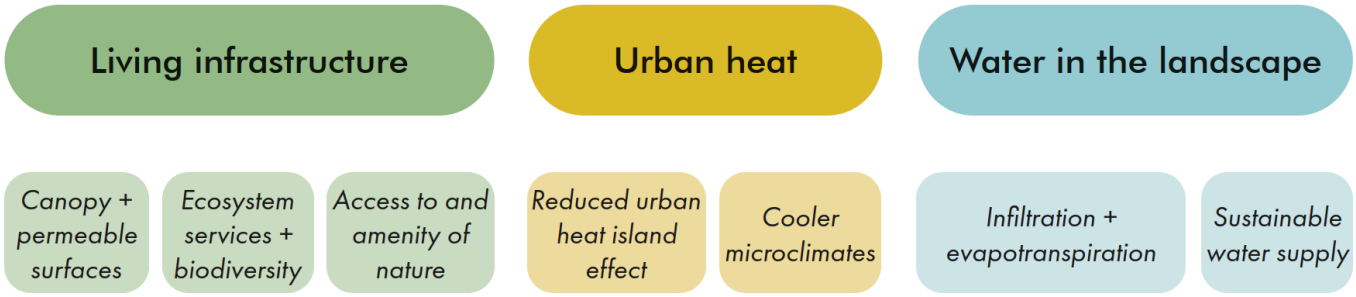
EXECUTIVE SUMMARY

HIGH LEVEL OBJECTIVES

Canberra's Living Infrastructure Plan aims to:

- Reduce urban heat island effects and increase access to shade
- Retain water in the landscape and use rainfall better
- Improve water penetration to sustain vegetation and allow ground water recharge
- Improve access to and amenity of nature in the city
- Maintain ecosystem services and biodiversity in the city's landscape.

In response to these broad aims, this report (Section 4) has recommended a set of goals and objectives relevant to planning and design of development. These are organised into three groups:



Living infrastructure goals:	Urban heat goals:	Water in the landscape goals:
L1. Increasing tree canopy cover and total quantity of green infrastructure	H1. Reduce the urban heat island effect	W1. Encourage infiltration and evapotranspiration
L2. Improving access to and amenity of nature in the city	H2. Enable people to adapt and thrive by creating cooler microclimates within the city	W2. Provide sustainable water supplies for irrigation and cooling
L3. Maintaining ecosystem services and biodiversity in the city's landscape		

A set of objectives has been developed under each of these goals, as listed below. These goals and objectives are not intended as development controls, however, they have provided a framework and structure for the planning provisions that are presented in this report. They are potentially useful for incorporation into the Territory Plan as high-level policy objectives.

Planning objectives

Goals	Objectives
L1. Increasing tree canopy cover and total quantity of green infrastructure	1. Contribute to the ACT's tree canopy cover target of 30% by 2045 2. Maximise total green cover and vegetation density in the urban environment.
L2. Improving access to and amenity of nature in the city	1. Provide green infrastructure where it is easily accessible to people in their everyday activities. 2. Improve equity of access to green infrastructure by considering the needs, values, motivations, uses, and barriers to engagement with various cultures and user groups. 3. Provide quality green infrastructure that encourages positive engagement with nature in the urban environment.
L3. Maintaining ecosystem services and biodiversity in the city's landscape*	1. Plant a diverse range of locally native species, considering species likely to thrive in a changing climate. 2. Create habitat for a range of locally native wildlife, including habitat that is well-connected via urban green corridors. 3. Link blue and green infrastructure, enhancing green infrastructure where there is water in the landscape and using vegetation to help encourage infiltration and evapotranspiration.
H1. Reduce the urban heat island effect	1. Across the urban area as a whole, maximise green cover and minimise impervious areas. 2. Where hard surfaces are required (e.g. roofs and paved areas), use 'cool materials' which reduce heat absorption. 3. Where green cover is provided, maximise its cooling effect by maximising soil volume, maximising vegetation density, and ensuring that vegetation has access to water.
H2. Enable people to adapt and thrive by creating cooler microclimates within the city	1. Orient site features to minimise exposure to hot summer sun, buffer exposure to hot winds and maximise access to cooling breezes. 2. Maximise shade, particularly where people are likely to be active in hot weather. 3. Use water in the landscape to provide evaporative cooling.
W1. Encourage infiltration and evapotranspiration	1. Contribute to the ACT's permeable surfaces target of 30% by 2045. 2. Minimise 'directly connected' impervious areas by directing runoff from hard surfaces into planted areas, where it can soak into soils. 3. Retain water in features like ponds and wetlands, from where it can evaporate.
W2. Provide sustainable water supplies for irrigation and cooling	1. Capture rainwater or treated stormwater and store for reuse, to enable flexible, unrestricted water use for irrigation and cooling purposes.

* Goal L3 and the associated objectives are largely beyond the scope of this project. However, we understand that the ACT Government is undertaking separate projects on ecosystem services, habitat connectivity and tree protection. This separate work could be integrated in the Territory Plan with the recommendations of this consultancy through a high-level policy statement based on goal L3.

PROPOSED PLANNING PROVISIONS

This report (Section 7) recommends a set of planning provisions that address each of the high-level goals and objectives in the three areas of living infrastructure, urban heat and water in the landscape. Proposed planning provisions include:

- Design criteria that describe the intended outcomes. These include both performance-based outcomes and guiding principles.
- Performance-based criteria are accompanied by benchmarks, which set the expected level of performance.
- Definitions of important terms.

These elements are recommended for inclusion in the revised Territory Plan.

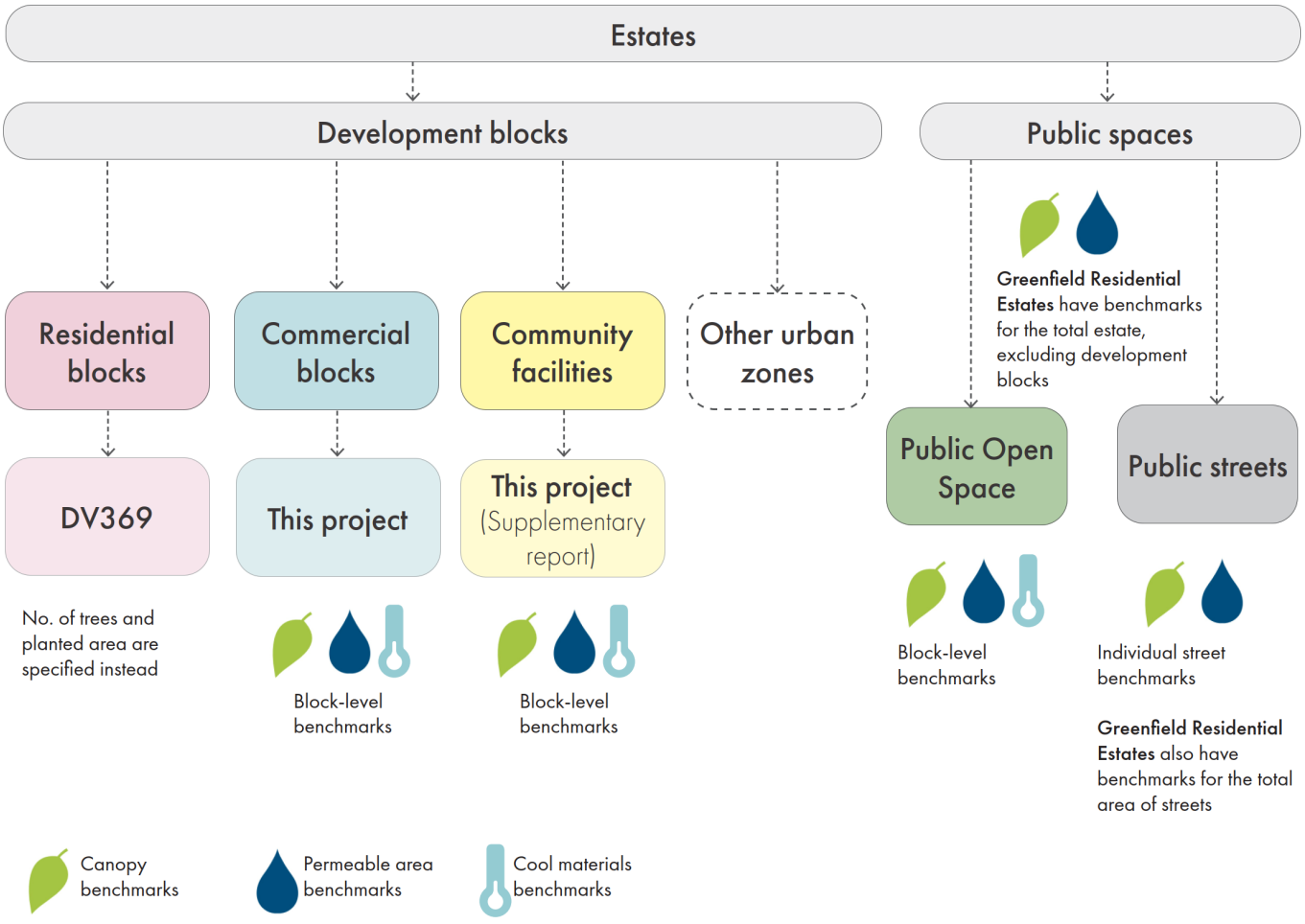
Note that a separate Technical Guidance document has been prepared to support the proposed planning provisions. This supports all the proposed planning provisions. Its contents should be incorporated into guidance materials to support the revised Territory Plan.

There are three main benchmarks proposed to apply widely:

- Canopy cover
- Permeable surface area
- Cool materials (roofs and paving).

Some other benchmarks (e.g. shade, cool façades) are proposed for specific situations where these measures are relevant.

The following diagram summarises where benchmarks have been recommended. Note that the focus of this report is estates and commercial development. A separate supplement to this report covers community facilities.



CANOPY AND PERMEABILITY BENCHMARKS

Canopy and permeability benchmarks are a special case where specific targets have been set for the ACT as a whole, and there are important questions about how much different development types should contribute to these targets, and the details of how benchmarks should be applied to development.

Therefore, canopy and permeability benchmarks have been given special consideration and detailed analysis, which is summarised in Section 8 of this report. This recommends a framework of benchmarks listed in the following tables.

Summary of the recommended framework for Greenfield residential estates

Elements	Residential zones	Other land uses (e.g. commercial, community and industrial)
Development blocks	Covered by DV369, no need for further benchmarks	See Table 28
Public Streets	Current project: Individual streets Streets total	
Public Open Space	Current project: Minimum public open space blocks	
Estate	Current project: Estates total excluding development blocks	

Summary of the recommended framework for all other development including other estates

Location	Residential Zones	Commercial Zones	Community Facility Zone	Industrial Zones	Other Urban Zones
Development block (E.g. "private land". Covers a large majority of standard development)	Covered by DV369, no need for further benchmarks	Current project: Surface carparks Surface Open Space/ Movement Networks	Current project – separate workstream	Future work	Future work
Public streets (Urban 'public street' DAs are rare outside of estates)	Recommended future work: Public streets permeability benchmarks by land use zone, minimum canopy benchmark for all public streets				
Public open space ('Public open space' DAs are rare outside of estates)	Recommended future work: Interim recommendation - canopy and permeability benchmark common to all public open space Ultimate recommendation - canopy and permeability benchmarks by open space typology				

OPTIONS FOR POTENTIAL FUTURE CONSIDERATION

This report has examined a range of potential options for planning provisions, benchmarks and assessment methods including varying levels of complexity. The recommended approach at this stage is to rely on simple measures to quantify living infrastructure, urban heat and permeability outcomes in development, as listed in the following table:

Items	Simple measures proposed now
Tree canopy cover	Total canopy cover, with future canopy estimated via expected canopy diameter for small, medium and large trees planted into an appropriate minimum soil volume.
Permeable surfaces	Total permeable area (with planted area preferred)
Urban heat	Simple benchmarks to define cool roof, cool paving, cool façade and shade requirements

In the future, more sophisticated methods could be contemplated to measure living infrastructure, urban heat and permeability outcomes in development. These are summarised in Section 9.4 of this report as, with three types of methods explained: rules of thumb, rating tools and simulation tools.

This report also recommends future work to fill gaps in the framework of canopy and permeability benchmarks (see Section 9.1), and to investigate how urban heat provisions should be applied to residential development (see Section 9.3).

1 INTRODUCTION

This report explores the options for planning controls to address living infrastructure and urban heat in estates and commercial development

As Canberra grows, including both greenfield development on its fringes and infill development in established areas, there are concerns about the status of green infrastructure. The estimated tree canopy cover in 2020 was 22.5% (ACT Government 2021b). It is lower in new suburbs and infill development could reduce canopy cover in established areas.

As Canberra grows, and in the context of a changing climate, it is also increasingly exposed to the negative effects of urban heat. The ACT's Climate Change Strategy (ACT Government 2019a, p.30) states that "heatwaves will become hotter (day and night), longer and more frequent... We have already seen more hot days (above 35°C) and fewer cold nights in the ACT region. Projections are for up to an additional five hot days per year in the near future (2030). The number of hot days could increase to 20 more per year by 2070."

The Climate Change Strategy also notes that hot days and heatwaves will be exacerbated in some parts of the city by the urban heat island (UHI) effect. The UHI effect means that the average ambient temperature in cities tends to be hotter than surrounding non-urban areas. Urban heat islands occur because buildings and paved surfaces absorb, store and re-radiate heat from the sun back to the environment. In an urban environment, less vegetation cover and less water retained in the landscape also reduces evapotranspiration, which is a key process for removing heat from the environment. Evapotranspiration includes evaporation of water from surfaces, as well as transpiration of water by plants. Waste heat from transport and (paradoxically) air conditioning also contributes to additional heat in urban areas.

Canberra's Living Infrastructure Plan outlines actions to respond to these challenges, including targets for the city's canopy cover and pervious area, and action to introduce requirement(s) for microclimate assessments of significant developments.

ACT's Environment, Planning and Sustainable Development Directorate (EPSDD) is working on various actions in the Living Infrastructure Plan. The current project, the subject of this report, is focused on planning controls for living infrastructure and urban heat in estates and commercial development.

This Final Report is the final stage of reporting for the project. It includes the following:

- Section 2 provides background information on the existing context in ACT, including the climate, exposure to heat, the nature of existing development and the policy drivers for this project.
- Section 3 summarises the key contents of existing policies relevant to this project, distilling important principles established and intentions conveyed in the documents.
- Section 4 distils these principles and intentions into more specific planning objectives for living infrastructure, urban heat and water in the landscape, recommending a framework that is based on the ACT's policy position and clarifies what development should be aiming to achieve.
- Section 5 looks at policy options in terms of existing and proposed examples around Australia. It then recommends an approach for ACT, considering both the science and practicality of what can be required or encouraged as an outcome of development.
- Section 7 recommends a set of planning provisions, including design criteria and measures. These address the objectives from Section 4 and follow the approach recommended in Section 5.
- Section 8 focuses on benchmarks and minimum standards for living infrastructure, tree canopy and permeable areas in particular.
- Section 5 considers urban heat assessment options which could be applied in the development planning and design process, including simulation tools, rating tools and semi-quantitative methods.
- Section 9 summarises future work recommended beyond this project, including work to fill gaps in the framework of canopy and permeability benchmarks, to investigate how urban heat provisions should be applied to residential development, and to introduce more sophisticated assessment methods for living infrastructure, urban heat and water in the landscape.

2 BACKGROUND

Canberra's physical conditions and the nature of past development mean that in a changing climate, urban heat is an increasing risk. Recent policies make commitments to reduce this risk.

2.1 PHYSICAL CONTEXT

Canberra's climate (based on data analysis at Weatherspark) includes cold winters and hot dry summers, with a monthly mean maximum temperature of 28.5°C, and 9 hours of sunshine. Temperatures regularly reach over 32°C and can be >40°C in heatwaves. Rainfall is relatively evenly spread throughout the year and averages 625 mm/year. Canberra experiences prevailing westerly and northwesterly winds, which tend to be hot in summer. However, in summer, easterly winds are also significant, and these tend to be cooler.

Meyers *et al* (2017) mapped surface heat in Canberra and found that Canberra's built-up areas had a surface urban heat island at night that was around 8 °C warmer in summer and 6 °C warmer in winter than surrounding rural areas. During the daytime, on a hot morning, land surface temperatures varied by as much as 22 °C in urban Districts and by up to 10°C in suburban areas.

Figure 1 from Meyer *et al* (2017) shows land surface temperature differences on a hot morning (9 February 2017), highlighting places with temperatures significantly above the mean: these include new housing developments, large shopping centres and industrial areas. These land uses have a high proportion of impervious surfaces and relatively little vegetation. An area of grasslands is also highlighted in Figure 1. Dry grass can reach similar surface temperatures to impervious areas.

Figure 2 shows ACT's tree canopy cover in 2020 at Division level. The total canopy cover across the ACT has been estimated at 22.5% in 2020 (ACT City Services), however it varies from suburb to suburb, with some older established suburbs having close to 40% canopy cover while some newer suburbs have below 10%. Figure 3 lists the canopy coverage and permeability of each division in Canberra.

There is an observable correlation between the areas of high surface temperature in Figure 1 and low canopy cover in Figure 2.

Meyer *et al* (2017) show how surface temperatures vary between different parts of the urban area, showing that the following areas have high surface temperatures:

- Both large and small shopping centres, with their extensive areas of roofing and car parks, and little shade
- Industrial areas, with their large expanses of roofing and paving, and few trees
- Dry grass where it is unirrigated
- Newer residential areas with high density housing and little canopy cover provided by immature trees

Meanwhile, water bodies, irrigated areas and older residential areas with more canopy cover and larger gardens (also potentially irrigated) are cooler.

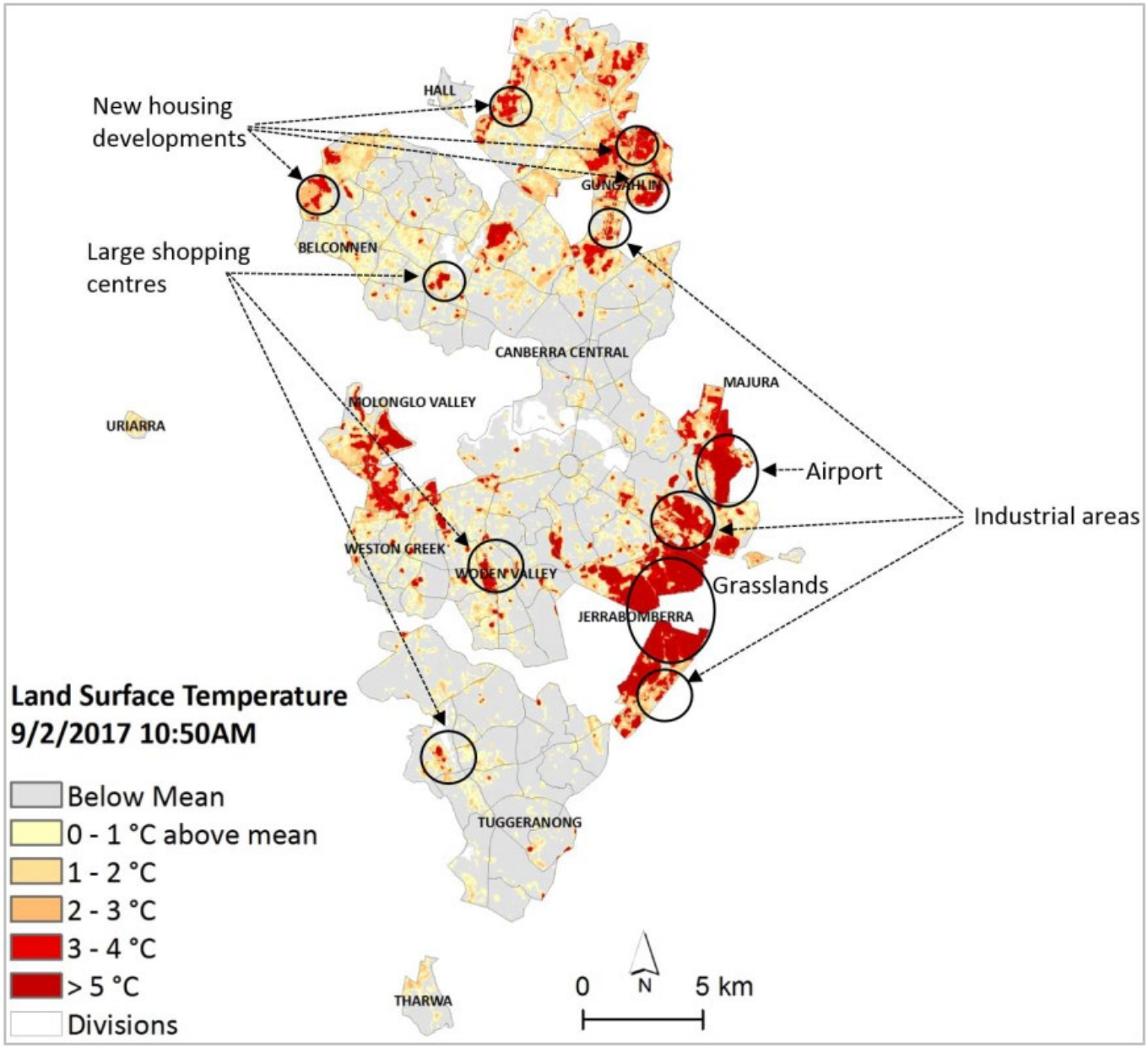


Figure 1: Hot spots defined as departures from 35 °C, which is the mean land surface temperature for the area shown. Temperature is derived from Landsat 8 thermal imagery on 9 February 2017 (10.50 AM DST). (Meyer et al 2017)

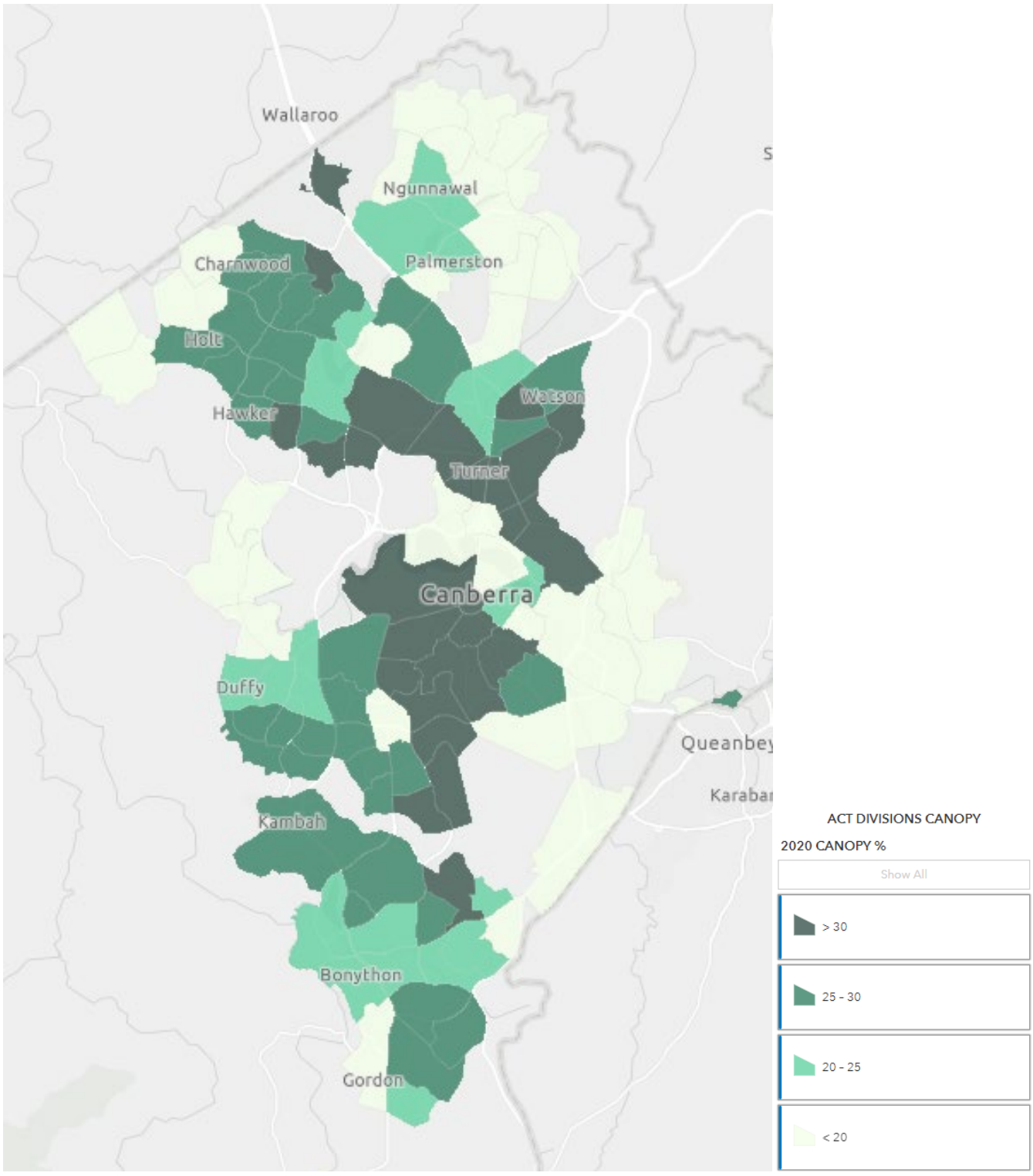


Figure 2: 2020 canopy cover in ACT Divisions (%) (source: ACT Government)

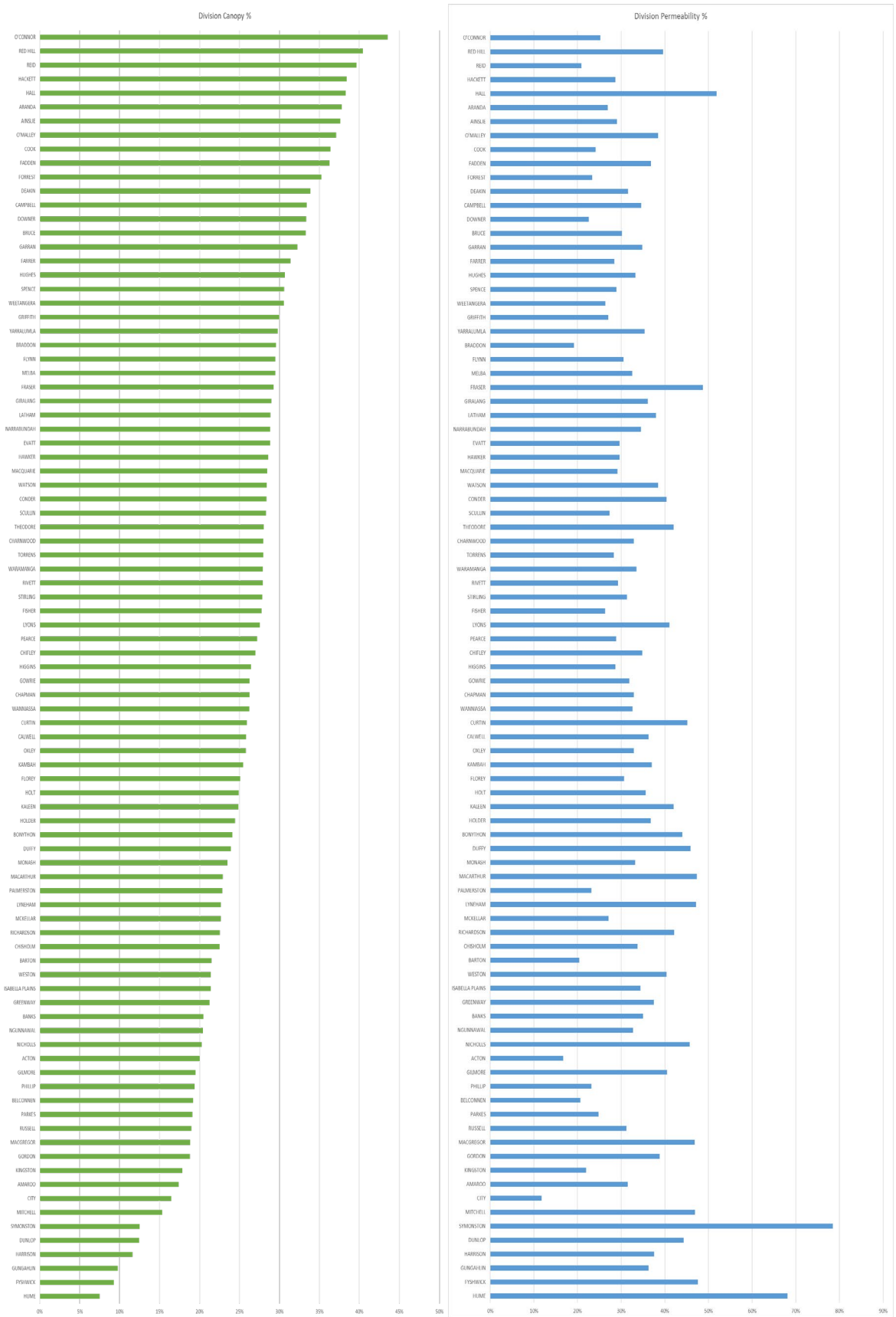


Figure 3: Canopy coverage and permeability of each division in Canberra. Both charts are ordered by canopy coverage percentage. *Note that some suburbs are excluded from the data as they are still being developed, the trees are yet to establish, and the hardstand area has yet to be constructed. Others have been removed as the Canberra Airport and Capital Hill as they are atypical.*

2.2 DEVELOPMENT CONTEXT

This project is focused on estates and commercial development. The following sections examine the nature of existing development in commercial zones and estates, providing important context about what is currently being achieved in terms of canopy, pervious area, and other green infrastructure/urban heat outcomes.

COMMERCIAL DEVELOPMENT

Commercial development in ACT includes development in six different commercial zones:

- CZ1 major centres core zone
- CZ2 major centres business zone
- CZ3 major centres services zone
- CZ4 local centres zone
- CZ5 mixed use zone
- CZ6 leisure and accommodation zone

Examples of existing development in each of these zones are included in Appendix A. Most include very little canopy cover or pervious area. Most are dominated by impervious areas including roofs, roads, car parks and other paved areas.

Using data available from ACT Government on canopy cover and pervious area, we have analysed each of the examples.

We have also looked at canopy cover and pervious area across the whole area of each zone in the ACT. Results are listed in Table 1.

In Table 1, the first row shows the total canopy coverage and permeability across CZ1 zones in the ACT, first as a total then also separating data into roads and blocks. The following two rows show how the study sites compare with total figures for that land use zone. The same is repeated in the following rows for other commercial zones.

Canopy and permeability data is also plotted in Figure 4 to Figure 7:

- Figure 4 and Figure 5 show the total canopy cover and permeability across commercial, industrial, residential and urban open space zones in the ACT – both on the blocks (Figure 4) and in the streets (Figure 5).
- Figure 6 and Figure 7 show the canopy cover and permeability for the examples included in Appendix A. Again, data is presented separately for blocks (Figure 6) and streets (Figure 7).

This analysis shows how large a gap there currently is between canopy cover and pervious area outcomes in commercial zones and the targets set in the Living Infrastructure Plan.

Table 1: Canopy cover and pervious area

Site	Combined		Street		Block	
	Canopy %	Permeability %	Canopy %	Permeability %	Canopy %	Permeability %
CZ1 Average	8.8	11	20	5	5	7
CZ1-WANNIASSA	17	3	20	4	12	2
CZ1-BELCONNEN	1	1	2	0	1	1
CZ2 Average	13.7	24	20	16	12	13
CZ2-BELCONNEN	2	0	0	0	2	0
CZ2-DICKSON	13	2	31	2	10	2
CZ3 Average	7.9	12	11	7	7	5
CZ3-BRADDON	11	1	26	2	2	1
CZ3-WESTON	9	6	12	9	4	2
CZ4 Average	17.8	26	24	10	15	13
CZ4-FORDE	7	2	0	0	7	2
CZ4-FADDEN	18	11	18	13	6	6
CZ5 Average	12.1	26	16	31	21	43
CZ5-BARTON	15	14	19	31	13	5
CZ5-FRANKLIN	5	11	12	4	4	12
CZ6 Average	21.1	64	16	31	21	43
CZ6-NICHOLLS	19	48	0	0	20	41
CZ6-CITY	23	20	0	0	20	5
IZ1 Average	8.2	43	8	31	8	34
IZ1-MITCHELL	16	25	0	0	14	24
IZ1-SYMONSTON	9	21	17	32	6	16
IZ2 Average	6	21	10	18	5	16
IZ2-MITCHELL	9	7	36	9	9	6
IZ2-FYSHWICK	8	11	51	28	8	8

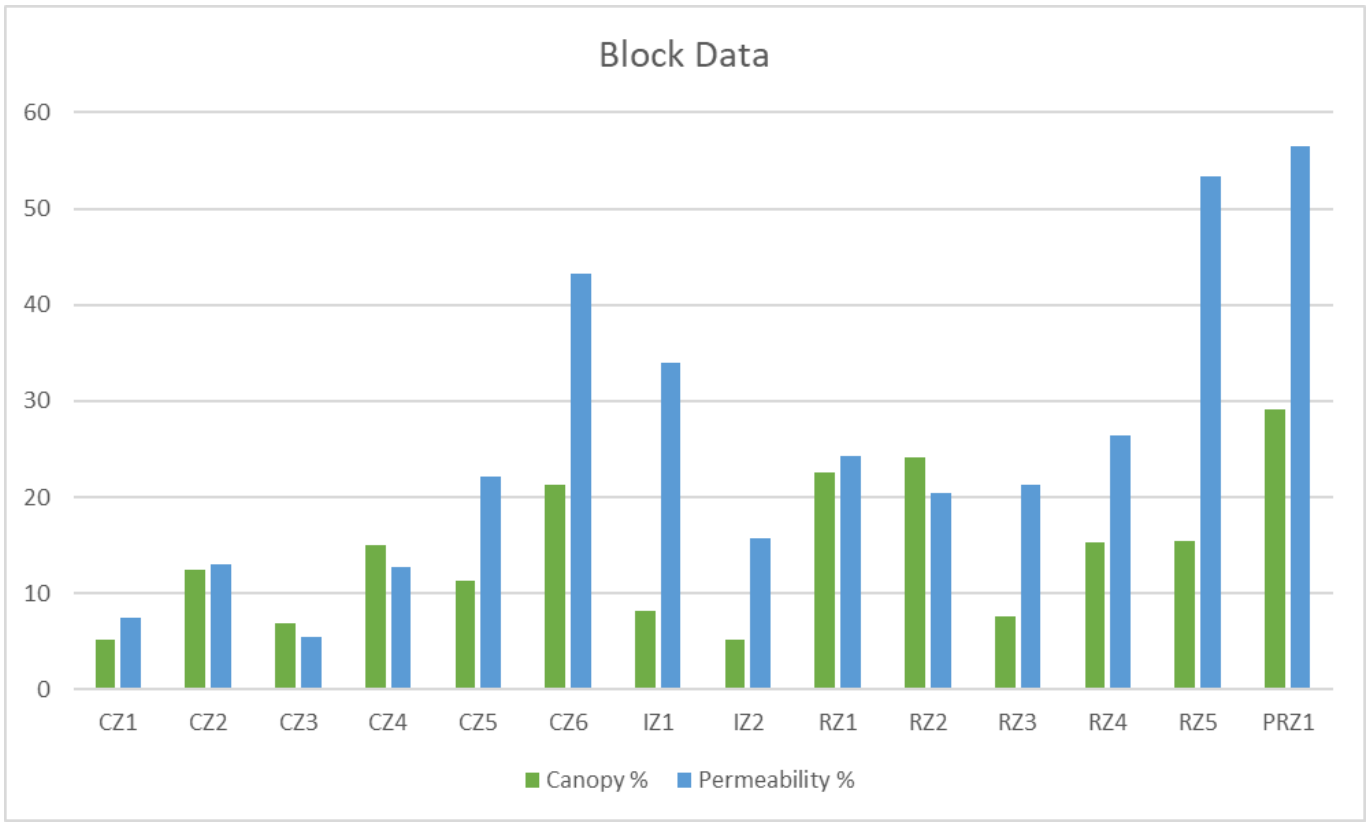


Figure 4: Canopy cover and permeability on blocks across various zones in ACT

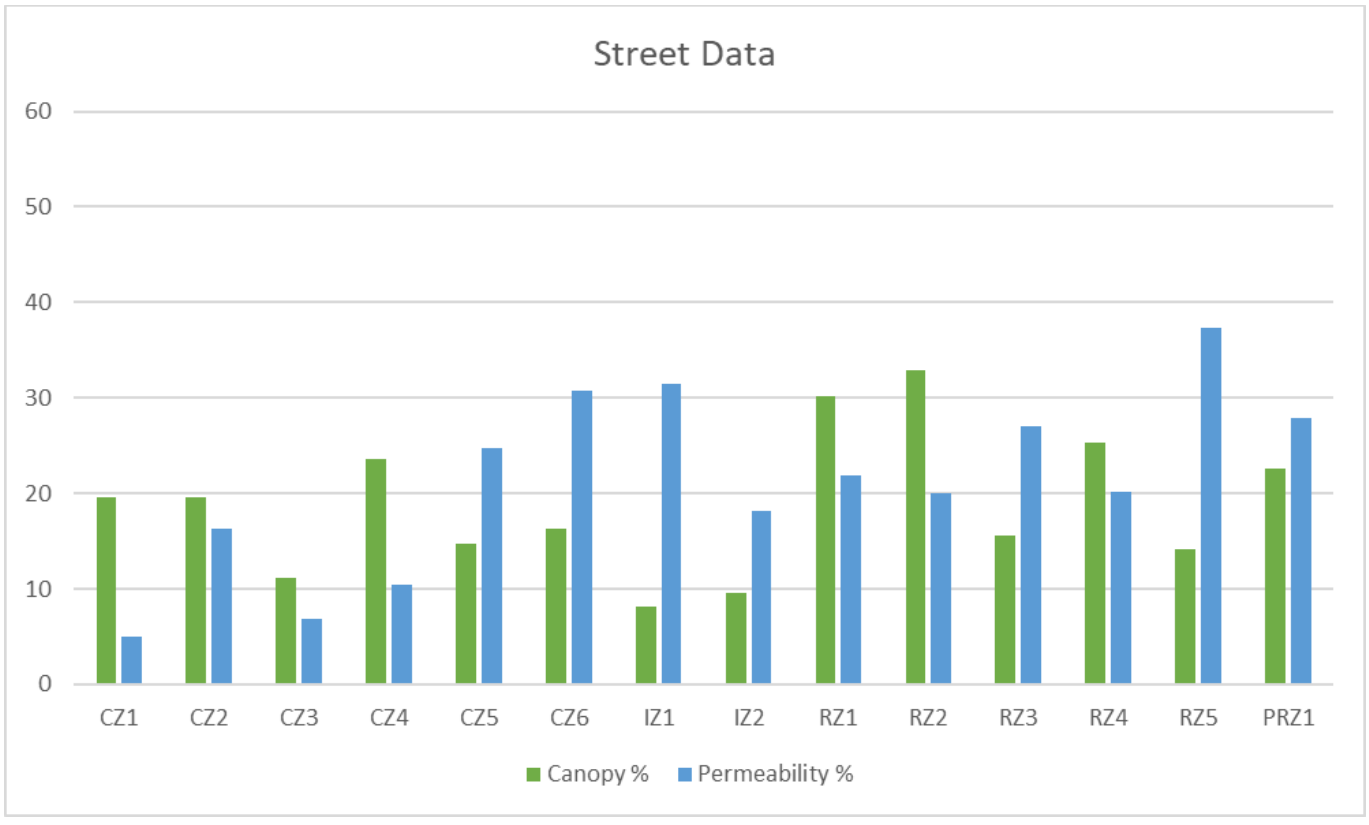


Figure 5: Canopy cover and permeability in streets across various zones in ACT

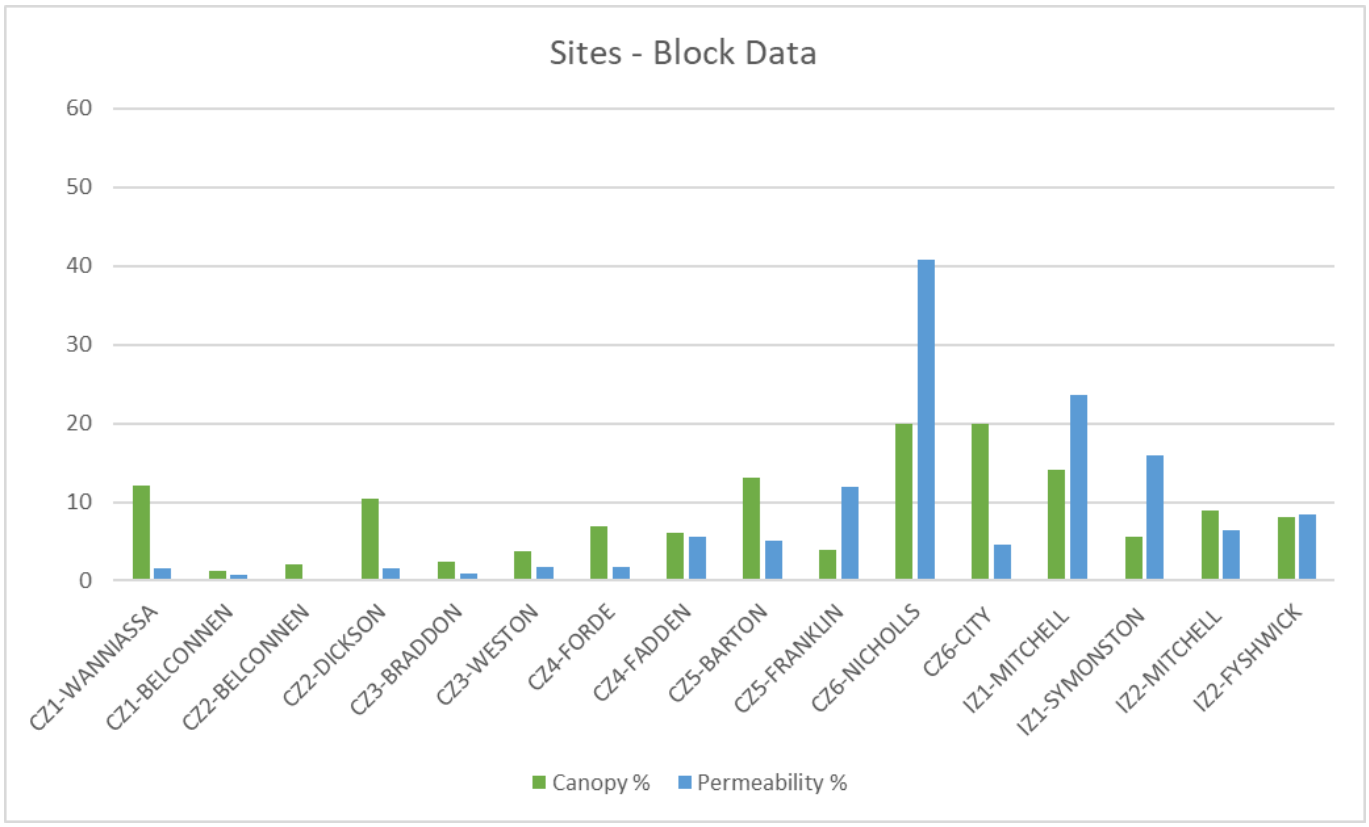


Figure 6: Canopy cover and permeability on blocks in the examples in Appendix A

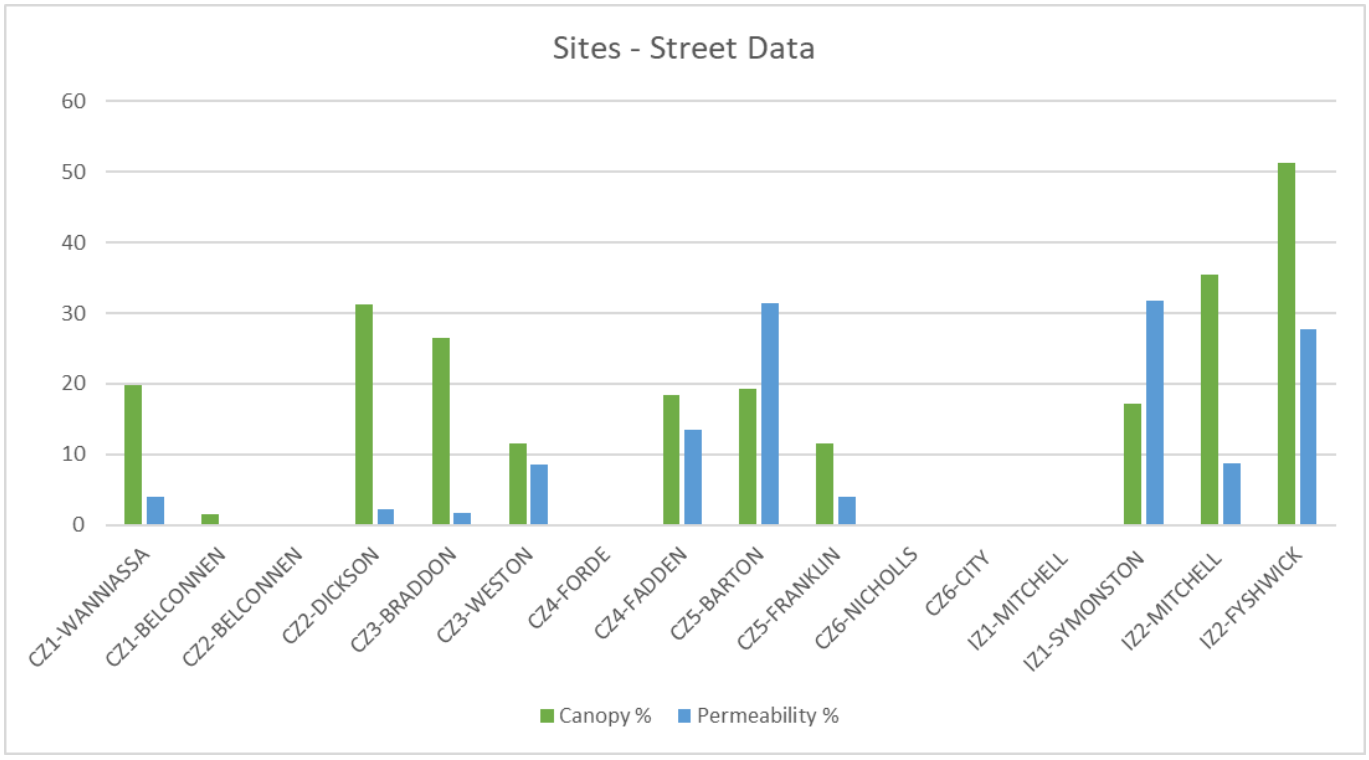


Figure 7: Canopy cover and permeability in streets in the examples in Appendix A

ESTATES

Estates cover a broad range of development types, from small redevelopments to whole new suburbs. Typically, estates include some public land (e.g. public streets and public open space) as part of the development. One of the triggers for an Estate Development Plan is when there is infrastructure to be handed back to the Territory on the development's completion.

Two important types of estates are:

- Greenfield residential estates where the land has not been previously developed for residential or other use and will require an Estate Development Plan
- Other estates i.e. developments that require an Estate Development Plan in locations that have previously been residential or other development

It is difficult to make generalisations or meaningful comparisons between greenfield residential estates and other estates, as they vary widely in scale, and can include a range of development types within them.

One element that can be more easily compared across different estates is the streetscape. Figure 8 compares road typologies across the extent of Canberra. It shows that the lower order roads in the hierarchy tend to include greater canopy cover.

Figure 9 shows how the urban lower order roads compare under different land use zoning. These were selected as areas of interest in urban development and there are very few Distributor and Arterial roads within commercial zones.

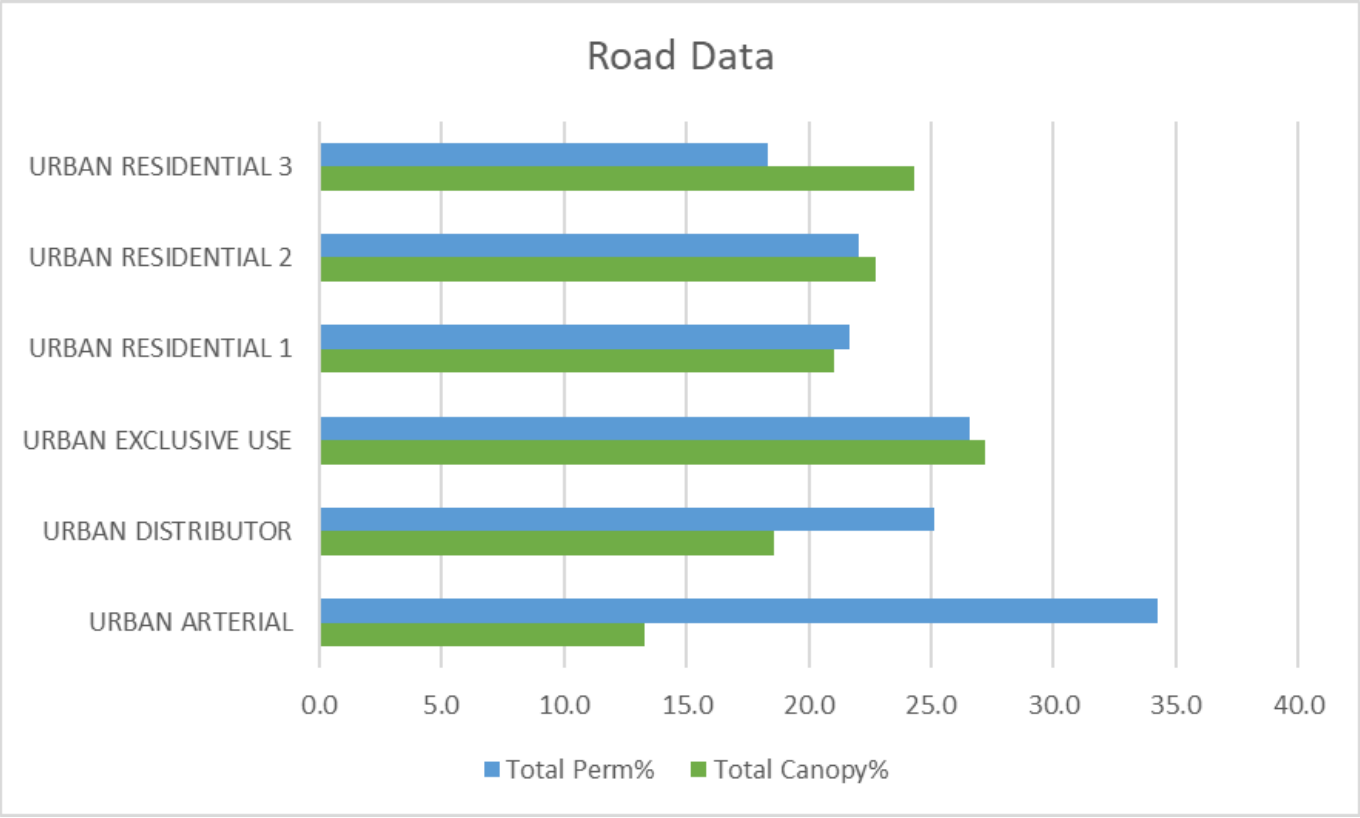


Figure 8: Canopy cover and permeability of different road types across ACT. Permeability is measured as a proportion of the total road reserve and would include verges, medians, etc.

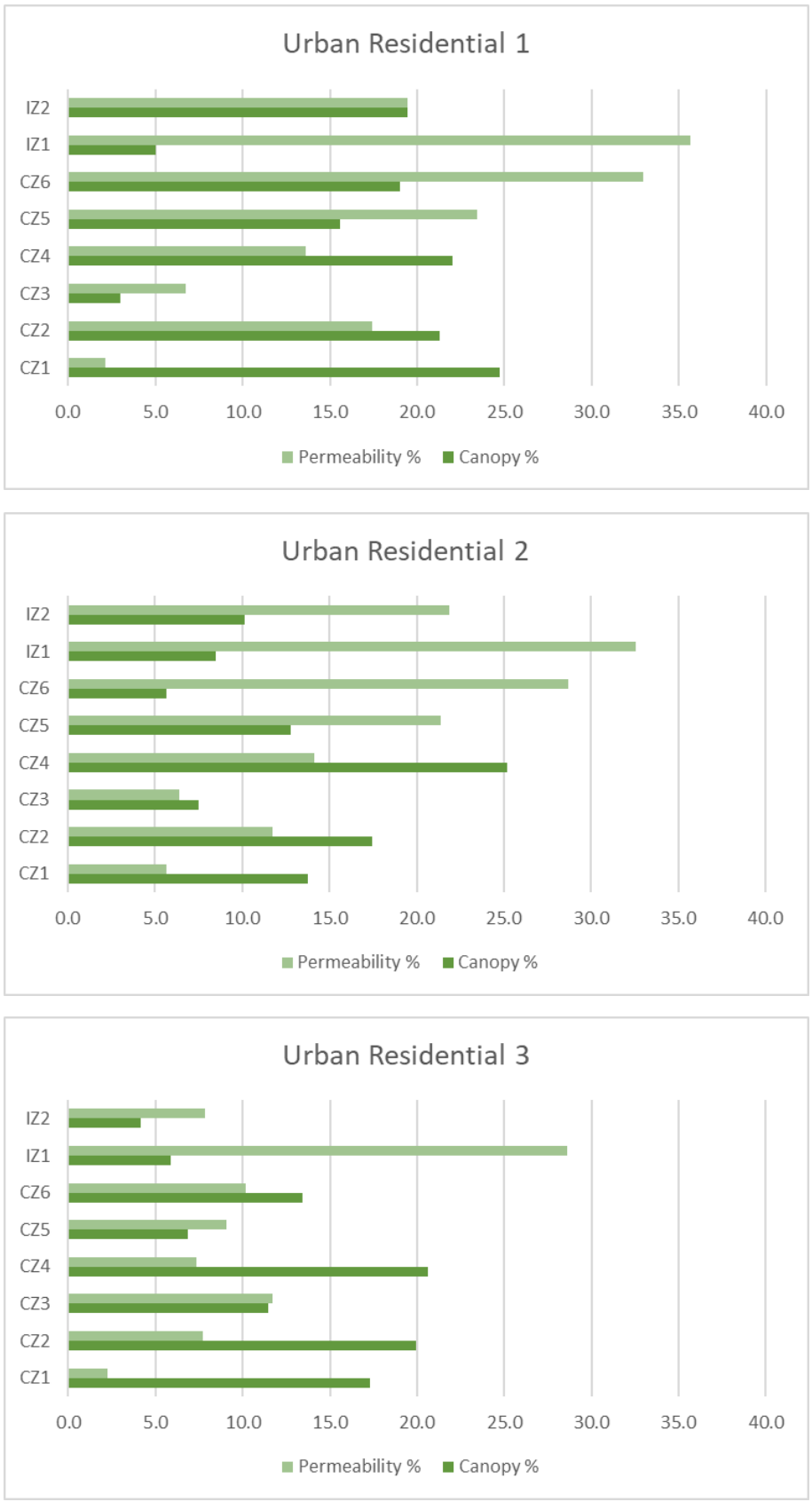


Figure 9: Canopy cover and permeability of urban lower order roads in commercial land use zones

2.3 POLICY CONTEXT

ACT PLANNING STRATEGY 2018

The ACT's 2018 Planning Strategy underpins this project. It establishes a Sustainable and Resilient Territory as one of five main themes in the strategy. This theme includes adapting to a changing climate and establishing resilience in built forms, infrastructure and natural assets. There is a commitment in the ACT Planning Strategy to review planning and development codes, guidelines and standards to incorporate living infrastructure objectives.

ACT CLIMATE CHANGE STRATEGY AND THE LIVING INFRASTRUCTURE PLAN

The ACT government has adopted a Climate Change Strategy (ACT Government 2019a), which is supported by the Living Infrastructure Plan (ACT Government 2019b). The Living Infrastructure Plan is the main plan setting out actions to reduce heat and its impacts. It also encompasses other benefits from living infrastructure, beyond heat mitigation. Its scope includes:

- Reducing urban heat island effects and increasing access to shade
- Retaining water in the landscape and using rainfall better
- Improving water penetration to sustain vegetation and allow groundwater recharge
- Improving access to and amenity of nature in the city
- Maintaining ecosystem services and biodiversity in the city's landscape

The Living Infrastructure Plan sets two important targets for living infrastructure: 30% tree canopy cover (or equivalent) and 30% permeable surfaces in Canberra's urban footprint by 2045. It also includes an action (Action 4, p.5) to "Introduce requirement(s) for microclimate assessments of significant developments located in centres, urban renewal projects and urban intensification precincts, to assist with development assessment".

Therefore, the current project is focused on the living infrastructure targets and the microclimate assessment requirement, both in centres (with its focus on the commercial development zones) and in urban renewal and intensification precincts (with its focus on estates).

TERRITORY PLAN REVIEW

With evolving long-term aspirations for Canberra, and to address community and industry concerns about the planning system, the quality of recent development and its impacts on landscape character, ACT is reviewing the Territory Plan (ACT Government 2020). Proposed reforms will deliver a more 'spatially-led' and 'outcomes focused' planning system. The intention is that the structure and processes within the planning system should be simpler, more flexible, and provide greater certainty.

The proposed reforms will include a shift away from the 'rules and criteria' format of planning provisions. The December 2021 Project Update (ACT Government 2021a) flags the following five key principles for the planning system:

- Easy to use – having information that is easy to find about important matters.
- Certainty – including certainty of the considerations when deciding an application and what statutory documents need to contain.
- Flexibility – at the development level, there will be flexibility in how developments can be proposed to be delivered within the parameters of the performance provisions.
- Transparency – in processes and decision-making.
- Outcomes focussed – for developments, the focus will be on how the development performs from a range of considerations rather than a limited focus on whether it meets individual prescriptive planning rules.

ACT Government (2021) notes that while the focus is on performance-based outcomes and flexibility at the development level, the plan will still include mandatory provisions where it is considered relevant, for example to limit impacts on neighbours and public spaces and control unsuitable development.

We expect that new planning provisions, including provisions for urban heat, living infrastructure and microclimate assessment, will take a form similar to planning codes in other jurisdictions around Australia, which are all evolving in a similar direction. This typically includes:

- Inclusion of planning and design criteria, which clearly describe the desired outcomes.
- Performance criteria, against which outcomes can be evaluated quantitatively or semi- quantitatively.
- In some cases, a set of measures deemed to satisfy the performance criteria.
- Flexibility in the measures applied to specific developments, providing that it can be demonstrated that the performance criteria are satisfied.
- Minimum standards are often still included to avoid negative outcomes.

EXISTING CODES IN THE TERRITORY PLAN

The Territory Plan defines land use zones applicable in ACT, and includes a set of Codes. The codes include:

- Codes for specific development types (e.g. the Estate Development Code and Commercial Development Code, relevant to this project)
- General Codes on specific topics including Water Sensitive Urban Design (WSUD), bushfire risk mitigation, etc.
- Precinct Codes for specific places. It is understood that the updated Territory Plan will include District Codes

Living infrastructure and urban heat could be addressed in a new General Code on the topic. New/amended provisions could also be included within Development Codes and Precinct/District Codes.

It is worth understanding the contents of existing codes, to understand what is already required in new development in the ACT, including requirements that contribute to or compete with living infrastructure and urban heat outcomes.

Existing codes relevant to this project are listed below, along with a summary of their content relevant to living infrastructure and urban heat.

Estate Development Code

The Estate Development Code is focused on topics relevant at estate scale (e.g. block layout and orientation, street and path network, servicing) and the design of streets. Blocks within the estate are all covered by other Codes.

Provisions in the Estate Development Code relevant to living infrastructure and urban heat include those related to:

- Block layout and orientation – there are requirements to consider a wide range of factors including solar access in residential zones.
- Size and location of parks – there are requirements in residential estates.
- Street trees – including a requirement to include street trees in most street types, a requirement to shade 30% of footpaths and shared paths and a requirement that the selection and location of street trees is to comply with TAMS DS23.
- Street verges – including a requirement that no more than 50% of the verge is impervious.
- Tree protection requirements.
- Water sensitive urban design – including rules for stormwater drainage, peak flows and stormwater quality, which apply to estates larger than 2,000 or 5,000 m^2.

Commercial Zones Development Code

The Commercial Zones Development Code includes some provisions relevant to living infrastructure and urban heat:

- It includes a set of landscaping criteria. There are no applicable rules, but there are a set of general design criteria for landscaping and a criterion for tree planting in and around car parks to provide shade and soften the visual impact of parking areas.
- A set of criteria for building design and materials, including "a contribution to the amenity and character of adjacent public spaces"; "interesting, functional and attractive facades that contribute positively to the streetscape, pedestrian and cycling experience"; and "minimal reflected sunlight".
- Tree protection requirements.
- Rules for WSUD that are similar to those for estates, with the same thresholds at 2,000 and 5,000 m^2. For commercial development there is also a requirement for 40% reduction in mains water consumption.

WSUD Code

The Waterways: Water Sensitive Urban Design General Code (WSUD Code) includes requirements for stormwater retention, as well as a requirement that certain developments (sites greater than 2000 m^2 involving works that have potential to alter the stormwater regime, or developments that increase the impervious area of the site by 100 m^2 or more) achieve "a minimum of 20% of the site area to be permeable."

Stormwater quality criteria in the WSUD Code are often met with specific types of green infrastructure designed for stormwater treatment, including ponds, wetlands and rain gardens.

The WSUD Code also includes a mandatory 40% mains water use reduction target for certain types of development. This may discourage irrigation of landscaped areas.

Precinct Codes

Newer Precinct Codes have started to reflect the move towards living infrastructure with Rules expanding on issues such as heat island mitigation, canopy coverage, microclimate, and open space areas. The provisions within the new Precinct Codes typically put the onus on the proponent to demonstrate options considered and outcomes agreed by suitably qualified professionals. The methodology and targets are not mandated. An example is provided in Section 3.4.

MUNICIPAL INFRASTRUCTURE STANDARDS

The following seven standards have been reviewed from TCCS's Municipal Infrastructure Standards (MIS) documents to present a summary of existing elements which have relevance to Living Infrastructure policy:

- MIS 01: Street Planning And Design
- MIS 06: Verges
- MIS 08: Stormwater
- MIS 15: Urban Edges Management Zone
- MIS 16: Urban Open Space
- MIS 24: Soft Landscape Design
- MIS 25: Plant Species For Urban Landscape Projects

These documents were reviewed to present a summary of existing elements within the Standard which have relevance to Living Infrastructure policy. This is presented in Table 2.

Table 2: Contents in the Municipal Infrastructure Standards relevant to living infrastructure and urban heat

Reference	Title	Relevant contents
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.
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
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
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
MIS 16	Urban Open Space	• Provisions for open space • Provision of urban wildlife and nature conservation
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

Reference	Title	Relevant contents
		• 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
MIS 25	Plant Species for Urban Landscape Projects	• Provision of suitable plant species for Canberra and specific site conditions • Consideration of the suitability of the species in specific situations • Set back requirements: o Path o Kerb o Building o Driveways (Refer MIS 07) o Services (Refer MIS 06) • Target Soil Volume requirements • Site restrictions (Available Soil Volume)

VARIATION TO THE TERRITORY PLAN NO 369

The variation to the Territory Plan No 369 (DV369) for Living Infrastructure in Residential Zones is due to come into force for established suburbs during the second half of 2022, and for new and recent estates as part of the Planning System Reform process, most likely in 2023.

DV369 includes changes to make sure standards for soft landscaping area in all residential areas (RZ1 to RZ5) are met. The variation responds to Direction 3.3 of the ACT Planning Strategy 2018, which seeks to "Integrate living infrastructure and sustainable design to make Canberra a resilient city within the landscape". Action 3.3.1 is to: "Support the implementation of a living infrastructure plan for the ACT through the review of planning policy and planning mechanisms to support the maintenance and enhancement of the urban forest in precinct, estate and district level planning processes, and relevant development and design guidelines." DV369 responds to Action 2 of Canberra's Living Infrastructure Plan, which seeks to achieve 30% tree canopy cover (or equivalent) and 30% permeable surfaces in urban areas by 2045. DV369 will assist in working towards achieving these targets for urban areas by making changes related to site coverage and planting area requirements on private land in all residential zones (RZ1 to RZ5).

DV369 includes the following for residential zones:

- Introduces provisions for how much 'site coverage' a block may have; that is, the amount of land that is covered by non-permeable surfaces, including house, terraces, pergolas, patios, decks and balconies. For example, large blocks will be allowed 40% site coverage and mid-size blocks 50%.
- Expands the definition of 'planting area' and its requirements. For example, large blocks will be required to have 50% of their private open space allocated for planting and compact blocks 30%. Planting area must have a minimum dimension of 2.5 metres.
- Introduces a minimum level of tree planting, with associated requirements for canopy trees; for example, large blocks up to 800 m^2 will be required to have one small and one large canopy tree and mid-sized blocks at least one small canopy tree. The variation defines canopy trees and their size.
- Reinforces the Territory Plan's criteria and guidelines so developers and architects consider planting area, site coverage, water infiltration, landscape quality, deep root planting, tree canopy, green roofs, green walls and the like.

A summary of changes to be adopted as part of DV369 is provided in Table 3 to Table 6.

Table 3: Proposed changes to Single Dwelling Housing Development Code

Block size	Private Open Space (% of block)	Planting area (% of Private Open Space(SOP))	Private Open Space (% of block)	Planting area + minimum dimension	Site coverage (new provision)	Number of trees (see size requirements in table below) (new provision)
	Current requirements		Proposed Changes			
Large blocks (up to 800m^2)	60% - 50m^2	50% of min POS	60%	50% of min POS, min dimension 2.5m	40%	At least one small and one large canopy tree
Large blocks (over 800m^2)	60% - 50m^2	50% of min POS	60%	50% of min POS, min dimension 2.5m	40%	One medium and one large canopy tree plus one additional large or two additional medium canopy trees for each 800m^2
Mid-size blocks	40% - 50m^2	50% of min POS	50%	50% of min POS, min dimension 2.5m	50%	At least 2 small canopy tree
Compact blocks (front loading)	20%	50% of min POS (10% of block)	50%	30% of block, min dimension 2.5m	50%	At least 1 small canopy tree
Compact blocks (rear loading)	20%	50% of min POS (10% of block)	30%	30% of block, min dimension 2.5m	70%	At least 1 small canopy tree

* planting area definition amended to clarify that terraces, pergolas, patios, decks and pools are not included

Table 4: Single dwellings – planting area

Block size	Current	Proposed
600m^2	155m^2	180m^2
400m^2	55m^2	100m^2

Table 5: Proposed changes to Multi-Unit Housing Development Code

Zone	Site open space	Planting area	Site open space	Site coverage (new provision)	Planting area	Trees (new criterion)	Number of trees (see size req. in table above) – (new provision)
	Current requirements		Proposed Changes				
RZ1 and RZ2	40% of site, min dimension 2.5m	20% of site area	40% of site, min dimension 2.5m	40% of block	35% of the block, min dimension 2.5m	Existing and new trees to provide at least 15% canopy cover	Blocks less than 800m^2 At least one small and one large canopy tree Blocks over 800m^2 One medium and one large canopy tree plus one additional large or two additional medium canopy trees for each 800 m^2
RZ3, RZ4, RZ5	20% of site, min dimension 2.5m	10% of site area	20% of site, min dimension 2.5m (though incorrectly labelled in DV)	45% of block	25% of the block, min dimension 2.5m	Existing and new trees to provide at least 15% canopy cover	
Residential in commercial zones	20% of site, min dimension 2.5m	10% of site area	20% of site, min dimension 2.5m	N/A	10% of site area		

* planting area definition amended to clarify that terraces, pergolas, patios, decks and pools are not included

Table 6: Multi-unit development – planting area

Block size	800m² block (m²)		1200m² block (m²)	
	Current	Proposed	Current	Proposed
RZ1 and RZ2	160	280	240	420
RZ3, RZ4, RZ5	80	200	120	300
Residential in commercial zones	80	80	120	120

3 POLICY OBJECTIVES

Existing policy documents, particularly the Living Infrastructure Plan, provide the core principles that planning provisions should follow.

3.1 ENHANCING LIVING INFRASTRUCTURE

The goals of the Living Infrastructure Plan (ACT Government 2019b, p.16) are broad:

> "To reduce the risks from the key climate change impacts of heatwaves, droughts, storms and bushfires, and build resilience to a changing climate.
>
> "To conserve and enhance Canberra's landscape and urban ecosystems, for quality of life and sustainability, which rely on the health and functionality of our trees and other vegetation, open spaces, soils, wildlife (biodiversity) and water systems."
>
> "To promote community-wide health and wellbeing through access to nature which provides recreational, fitness and relaxation opportunities, and improves mental health.
>
> "To recognise that our landscapes, with living infrastructure asset components, are an essential part of our economic prosperity, and provide wide-ranging and vital benefits and revenue."

Five principles define the scope and purpose of the plan (ACT Government 2019b):

- Reducing urban heat island effects and increasing access to shade
- Retaining water in the landscape and using rainfall better
- Improving water penetration to sustain vegetation and allow ground water recharge
- Improving access to and amenity of nature in the city
- Maintaining ecosystem services and biodiversity in the city's landscape.

These indicate the following three important points about what should be included in planning provisions for green infrastructure.

1) WATER IS A KEY FACTOR ENHANCING THE BENEFITS OF LIVING INFRASTRUCTURE

All living things need water, and access to water can help living infrastructure thrive. However, urban areas are typically designed to retain little rainfall and ensure efficient drainage of runoff. This can leave urban green infrastructure deprived of water. Irrigation can play a role, however the concepts of 'retaining water in the landscape', 'improving water penetration' and 'allowing ground water recharge' imply simpler methods to capture rainfall before it runs off and encourage infiltration. This would also reduce runoff and stormwater pollutant loads.

2) COOLING THE CITY IS ONE OF MANY BENEFITS OF LIVING INFRASTRUCTURE

Although living infrastructure and urban cooling are closely related, living infrastructure is associated with a range of different benefits beyond cooling. To meet the Territory Plan review objectives, the planning system should be clear about the full range of benefits (i.e. it should be outcomes-focused), it should be clear about the objectives to be met (providing certainty) and it should be organised to make it easy to find information about each of the important matters connected with different aspects of living infrastructure (for ease of use).

3) OTHER BENEFITS ENCOMPASS BOTH HUMAN HEALTH AND ECOSYSTEM HEALTH

Figure 10 organises the objectives of living infrastructure to illustrate themes and linkages between them. On the left, there are benefits to people (access to shade, access to nature in the city); in the centre and on the right, there are ecosystem services (reducing the heat island, improving biodiversity and recharging groundwater).

To cover this range of topics effectively, this report therefore recommends that the planning system should include separate intent statements and separate sets of planning controls dealing with:

- Green infrastructure, including tree canopy and other permeable areas (see Section 3.2)
- Cooling the city, including microclimate assessment (see Sections 3.4 and 5)
- Water in the landscape – water is already covered in a separate water sensitive urban design code (see Section 3.5).

Section 4 follows this structure and fills it out with more specific objectives suitable to guide planning and design.

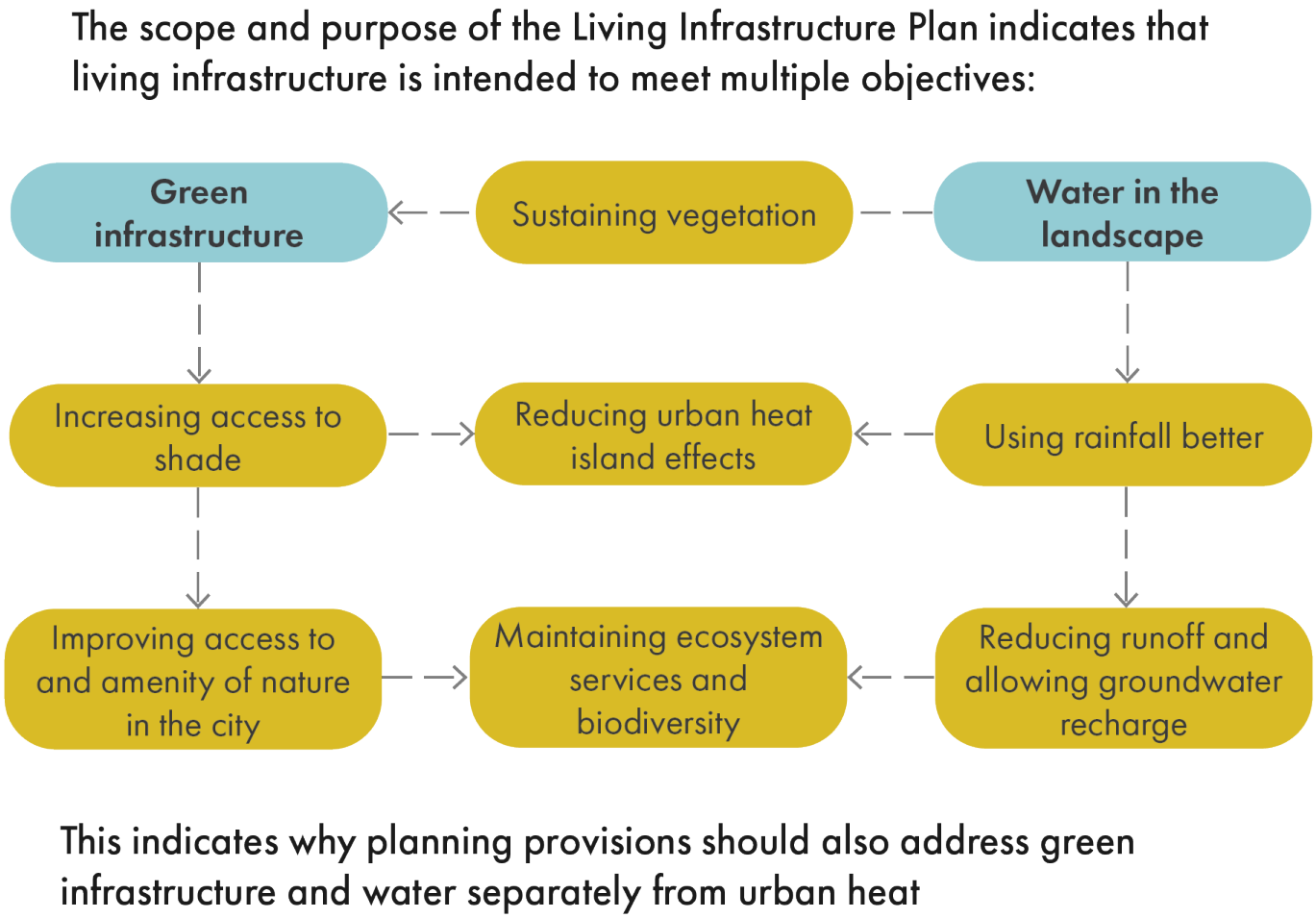


Figure 10: Important benefits of living infrastructure

3.2 CANOPY AND PERMEABLE AREA TARGETS

Canberra's Living Infrastructure Plan has established specific targets for 30% canopy cover and 30% permeable area by 2045. There are some important aspects about how these targets are intended to be applied.

BOTH PUBLIC AND PRIVATE LAND SHOULD CONTRIBUTE TO ACHIEVING TARGETS

The targets apply to Canberra's 'urban footprint', which is defined in the Living Infrastructure Plan (ACT Government 2019b, p.33) as "the geographic extent of the existing urban area", which is mapped in the plan but will expand in the future as the city continues to grow and expand. The urban footprint includes some non-urban land, for example in the Hills, Ridges and Buffers zone.

The Living Infrastructure Plan indicates (ACT Government 2019b, p.19) that the targets "will encompass both public and private land" and (p.22) "are to be achieved on both public and private land".

To date, reporting has been at suburb/division level rather than smaller precincts, land use types or individual blocks. While all land uses and types of development can make some contribution to reducing the impacts of urban heat, not all will be able to accommodate 30% canopy and 30% permeable area, particularly when considered at individual block scale. However, some land use types will be able to accommodate greater canopy cover. This report includes some consideration of what a reasonable contribution by each land use type would be.

WHERE THE TARGETS CANNOT BE ACHIEVED, 'EQUIVALENT BENEFITS' ARE TO BE CONSIDERED

Where 30% canopy cover cannot be achieved, the Living Infrastructure Plan introduces the notion of 'equivalent benefits' (ACT Government 2019b, p.22): "there are multiple methods and measures to achieve equivalent benefits, and not every area will be suited to the same methods. Where 30% canopy cover cannot be easily achieved through tree and vegetation plantings, alternative locality-specific solutions will be used based on assessment of microclimate and built environment conditions. In assessing the most effective and appropriate living infrastructure options, the focus will be on achieving the suite of benefits, city cooling plus environmental services, equivalent to the 30% target."

The Living Infrastructure Plan (ACT Government 2019b, p.22) goes on to suggest that "Alternative treatments to meet the equivalence of the tree canopy cover and permeable surfaces targets may include green roofs and walls, wetlands and rain gardens, water features and fountains, watered grass, shrub beds, and climbers on structures."

Note that in some places, the Living Infrastructure Plan mentions equivalence only in connection with canopy cover, while in others it is clearly linked to both canopy cover and permeable area, therefore it is assumed the intention is that it would apply to both.

How equivalence would be determined is a key question. This is not yet clear, however there are some indications in the Living Infrastructure Plan about the current thinking:

- It mentions a "suite of benefits" including city cooling and environmental services. Therefore, it seems the intention is not to simply substitute trees with any other green cover, but to ensure a wide range of benefits are considered. Elsewhere in the document when environmental/ecosystem services are mentioned, they are described in very broad terms, including creating oxygen, removing air and water pollutants, capturing and storing carbon. Accounting for all these services would require a well-developed method.
- There is the clear intention that alternative treatments should also be living infrastructure, however some of the suggested options (e.g. green roofs and green walls, water features and fountains) are expensive to implement and won't be appropriate for all development types. Typical development scenarios require some consideration to understand what may be appropriate in different built environment conditions.

It is understood that the ACT Government has undertaken two research projects into equivalence between different types of living infrastructure and that further research is underway.

The ACT Government has indicated that for this reason, substitution between types of living infrastructure for the purposes of achieving the targets is not a focus of the current project.

3.3 COOLING THE CITY

'Cooling the city' features in the title of the Living Infrastructure Plan, highlighting the importance of this objective. Among the goals of the Living Infrastructure Plan (ACT Government 2019b, p.16) is "To reduce the risks from the key climate change impacts of heatwaves, droughts, storms and bushfires, and build resilience to a changing climate."

As shown in Figure 11, there are five principles which are listed as the scope and purpose of Canberra's Living Infrastructure Plan (ACT Government 2019b). These indicate the following three important points about what should be included in urban heat planning provisions.

1) URBAN HEAT SHOULD BE ADDRESSED BOTH AT 'MACRO' SCALE AND 'MICRO' SCALE

The UHI effect is relevant at 'macro' or urban level – on the scale of the city, suburb or precinct. It can be measured in terms of an increased ambient temperature in the urban environment.

Shade is relevant at 'micro' or human level – on the scale of urban infrastructure such as individual trees, structures, water features and other elements of the built environment. Microclimate is often expressed in terms of thermal comfort or the 'feels like' temperature, which is influenced by a number of factors including ambient temperature, radiant heat from surfaces, shade, air movement and evaporation.

2) GREEN INFRASTRUCTURE SHOULD BE PART OF THE SUITE OF MEASURES APPLIED

Green infrastructure can help address urban heat both at macro scale (increased green cover will help reduce the UHI effect) and micro scale (for example, trees provide shade and any vegetation with access to water cools its immediate surrounds via evapotranspiration).

Green infrastructure also provides other important benefits in urban areas, providing ecosystem services, supporting biodiversity, improving amenity and access to nature for people living in the city.

3) WATER IN THE LANDSCAPE SHOULD BE PART OF THE SUITE OF MEASURES APPLIED:

Evapotranspiration cools at both macro and micro scales.

Retaining more water in the landscape also has other important benefits – for example, it can help improve vegetation growth, health and canopy cover, reduce runoff and stormwater pollutant loads.

This report therefore considers how the planning system could encourage better use of green infrastructure and water in the landscape to reduce urban heat and its impacts.

It also considers what other measures should be applied to address urban heat at macro and micro scales. The Living Infrastructure Plan (ACT Government 2019b) acknowledges that there are measures beyond living infrastructure that could help cool the city, including alternative materials for building surfaces and pavements and measures to encourage air flow. These ideas are mentioned in the Climate Change Strategy (ACT Government 2019a, p.67): "In addition to implementing Canberra's Living Infrastructure Plan, Government will continue exploring opportunities to reduce heat absorption of building surfaces and pavements and encourage air flow throughout the city."

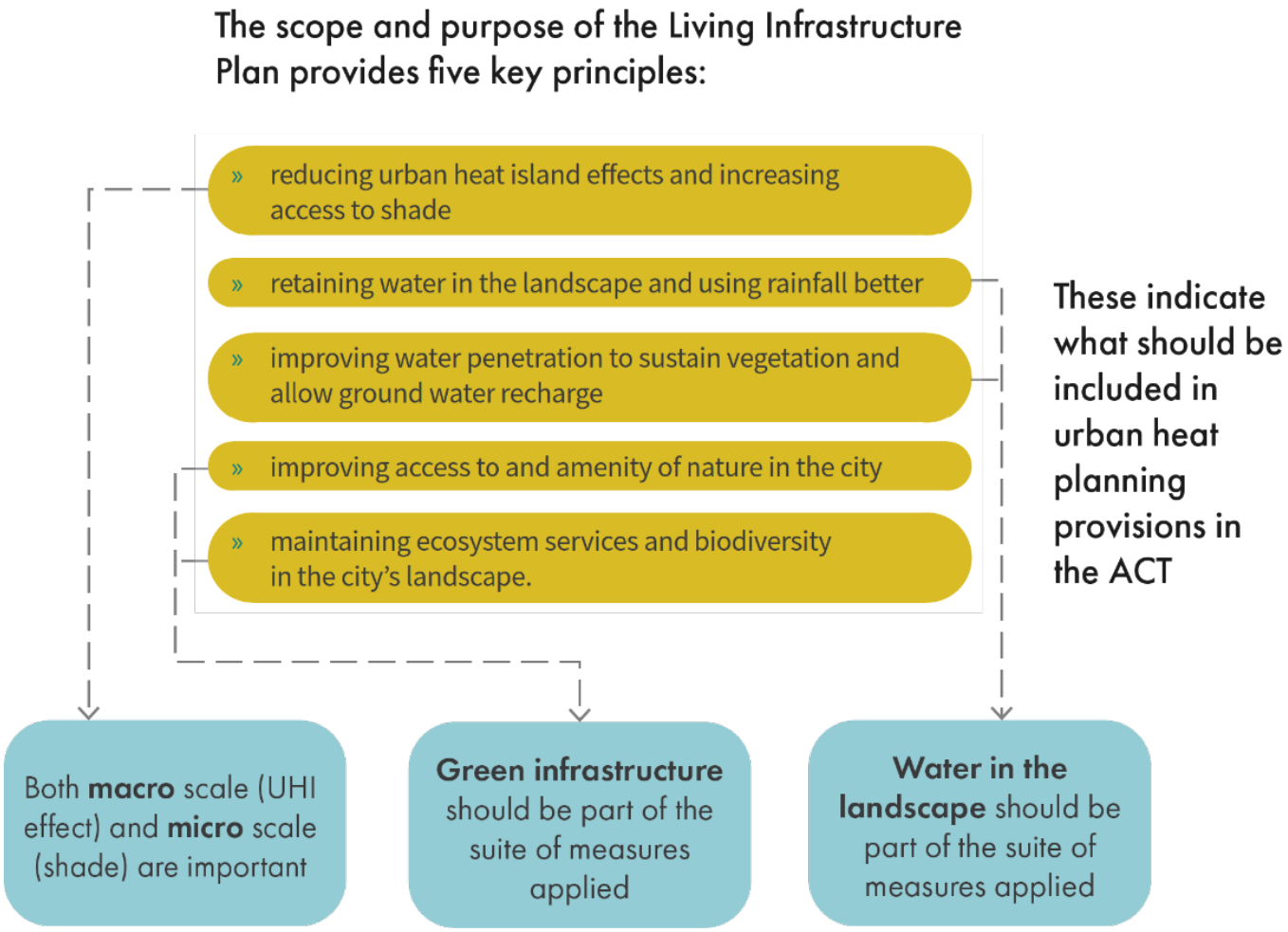


Figure 11: Principles for addressing urban heat in the ACT

3.4 MICROCLIMATE ASSESSMENT

The concept of microclimate assessment is introduced in the Living Infrastructure Plan (ACT Government 2019b, p.25).

This identifies some features indicating what microclimate assessment is expected to include:

- Microclimate assessments are "necessary to better inform decisions on how and where best to intervene."
- Microclimate assessment should help with "understanding of natural systems and design options at different scales."
- Assessment should account for "local factors including quantity of impermeable surfaces, surfaces contributing to urban heat, and wind flow or blockage and turbulence."

It also makes some important points about how microclimate assessment is expected to work:

- There is the intention to mandate the use of microclimate assessment "to inform policy and forward planning studies for centres, urban renewal projects and urban intensification precincts" suggesting its use for early stages of planning and in larger (precinct) scale assessments.
- There is the intention to "introduce requirement(s) for microclimate assessments of significant developments located in centres, urban renewal projects and urban intensification precincts, to assist with development assessment." This suggests some threshold for 'significant' developments and seems to suggest that microclimate assessment for specific developments would typically be completed after forward planning for these same centres/precincts.

The Living Infrastructure Plan (ACT Government 2019b, p.25) makes commitments to:

- "Prepare a Microclimate Assessment Guide and mandate its use to inform policy and forward planning studies for centres, urban renewal projects and urban intensification precincts..." (Action 3); and
- "Introduce requirement(s) for microclimate assessments of significant developments located in centres, urban renewal projects and urban intensification precincts, to assist with development assessment" (Action 4).

A requirement for microclimate assessment has been written into some of ACT's recent Precinct Codes including those for Holt, Lyneham and Bruce. These controls have no mandatory rule but they include criteria describing key principles of urban heat mitigation. There is also a requirement for a microclimate assessment to be undertaken by a suitably qualified professional. An example is shown below. This is not specific on the method to be used for microclimate assessment, but does list some of the measures to be included, which do include green, blue and grey infrastructure options. Each of the Precinct Codes is slightly different. Note that some define the suitably qualified professional as "a person with qualifications, experience and/or skills, relevant to urban climate science, urban modelling and microclimate assessment" suggesting an expectation for modelling methods to be used.

C24

Development demonstrates that there is no net gain of urban heat.

Compliance with this criterion is demonstrated in a microclimate assessment report by a qualified professional which details building and place design and use of mitigating measures including:

a) low thermal mass, high albedo and or high emissivity building materials and/or finishes
b) inclusion of canopy trees to achieve an overall minimum of 30% shade across the precinct.
c) use of permeable surfaces.
d) use of water features
e) appropriate location of open space and buildings
f) other types of cooling measures such as green roofs, vertical gardens and shade structures.

This criterion does not apply to a development application for the change of use of an existing building or structure.

Extract from the Fyshwick Precinct Code, 30 April 2021

3.5 RETAINING WATER IN THE LANDSCAPE AND THE PERMEABLE AREA TARGET

Figure 10 shows the role of water in sustaining green infrastructure, and Figure 11 shows how water plays a role in cooling. However, Figure 10 also shows how retaining more water in the landscape is connected with other benefits, including reducing runoff and increasing groundwater recharge. These go beyond green infrastructure and cooling, and are more connected with the objectives of water sensitive urban design (WSUD).

The ACT already has a WSUD Code, and this already includes rules and criteria for on-site stormwater retention. The rules (for certain development types) state:

a) "stormwater retention management measures are provided and achieve all of the following:
   i) "Stormwater storage capacity of 1.4kL per 100m² of the total impervious area of the site is provided specifically to retain and reuse stormwater generated on site as a whole
   ii) "Retained stormwater is used on site

b) "development captures, stores and uses the first 15mm of rainfall falling on the site."

The permeable area target is also connected with WSUD, and the WSUD Code already includes a rule (for certain development types): "a minimum of 20% of the site area to be permeable". The associated criteria make connections with green infrastructure and cooling.

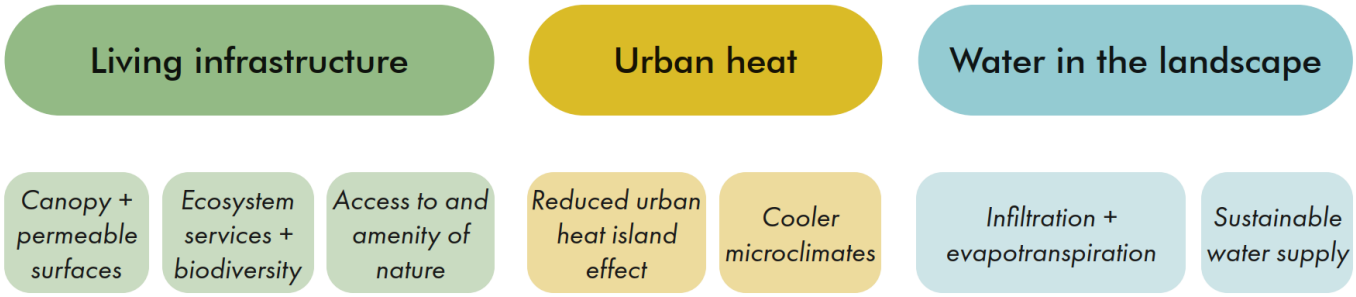
A full review of the WSUD Code is beyond the scope of this project, but this report considers how WSUD provisions could better support green infrastructure and urban cooling objectives. While the existing WSUD provisions do encourage stormwater retention to reduce runoff, they are not particularly concerned with where that water is used. To support green infrastructure, water should be directed to passive irrigation or used for irrigation. For cooling, evapotranspiration is beneficial and so is direct evaporation from open water bodies and other water features.

4 PLANNING OBJECTIVES

Urban greening, cooling and managing water are interrelated, but are also worthy of individual consideration, to cover the full scope of each.

Based on the review in Section 3 of the policy position established by Canberra's Living Infrastructure Plan, a set of goals and objectives have been developed, which provide a link between this high-level policy and the planning system. These include goals and objectives for living infrastructure, urban heat and water in the landscape. There are 7 goals, as shown in Figure 12. Objectives are proposed in the following sections, 4.1 to 4.3.

These goals and objectives are not intended as development controls, however, they have provided a framework and structure for the planning provisions that are presented in Section 7. They are potentially useful for incorporation into the Territory Plan as high-level policy objectives.



Living infrastructure goals:	Urban heat goals:	Water in the landscape goals:
L1. Increasing tree canopy cover and total quantity of green infrastructure	H1. Reduce the urban heat island effect	W1. Encourage infiltration and evapotranspiration
L2. Improving access to and amenity of nature in the city	H2. Enable people to adapt and thrive by creating cooler microclimates within the city	W2. Provide sustainable water supplies for irrigation and cooling
L3. Maintaining ecosystem services and biodiversity in the city's landscape		

Figure 12: Framework of high-level goals

4.1 INCREASING LIVING INFRASTRUCTURE

Living infrastructure has a wide range of benefits, as shown in Figure 13. This picture includes ecosystem services, benefits to human health and economic benefits. To achieve this full range of services and benefits it is important to consider what type of green infrastructure is integrated into urban areas, and where it is located.

The Living Infrastructure Plan makes it clear that tree canopy is important, but that all forms of green infrastructure can play a role. The total permeable area target encourages all kinds of green cover, and the idea of equivalence has the potential to acknowledge how different types of green infrastructure contribute in their own way towards green infrastructure objectives.

Table 7 lists a suggested set of green infrastructure objectives. which translates the intentions of the Living Infrastructure Plan into a framework focused on opportunities in development and able to inform planning provisions.

Table 7: A suggested set of green infrastructure objectives for development

Goals	Objectives
L1. Increasing tree canopy cover and total quantity of green infrastructure	1. Contribute to the ACT's tree canopy cover target of 30% by 2045 2. Maximise total green cover and vegetation density in the urban environment.
L2. Improving access to and amenity of nature in the city	1. Provide green infrastructure where it is easily accessible to people in their everyday activities. 2. Improve equity of access to green infrastructure by considering the needs, values, motivations, uses, and barriers to engagement with various cultures and user groups. 3. Provide quality green infrastructure that encourages positive engagement with nature in the urban environment.
L3. Maintaining ecosystem services and biodiversity in the city's landscape*	1. Plant a diverse range of locally native species, considering species likely to thrive in a changing climate. 2. Create habitat for a range of locally native wildlife, including habitat that is well-connected via urban green corridors. 3. Link blue and green infrastructure, enhancing green infrastructure where there is water in the landscape and using vegetation to help encourage infiltration and evapotranspiration.

* Goal L3 and the associated objectives are largely beyond the scope of this project. However, we understand that the ACT Government is undertaking separate projects on ecosystem services, habitat connectivity and tree protection. This separate work could be integrated in the Territory Plan with the recommendations of this consultancy through a high-level policy statement based on goal L3.

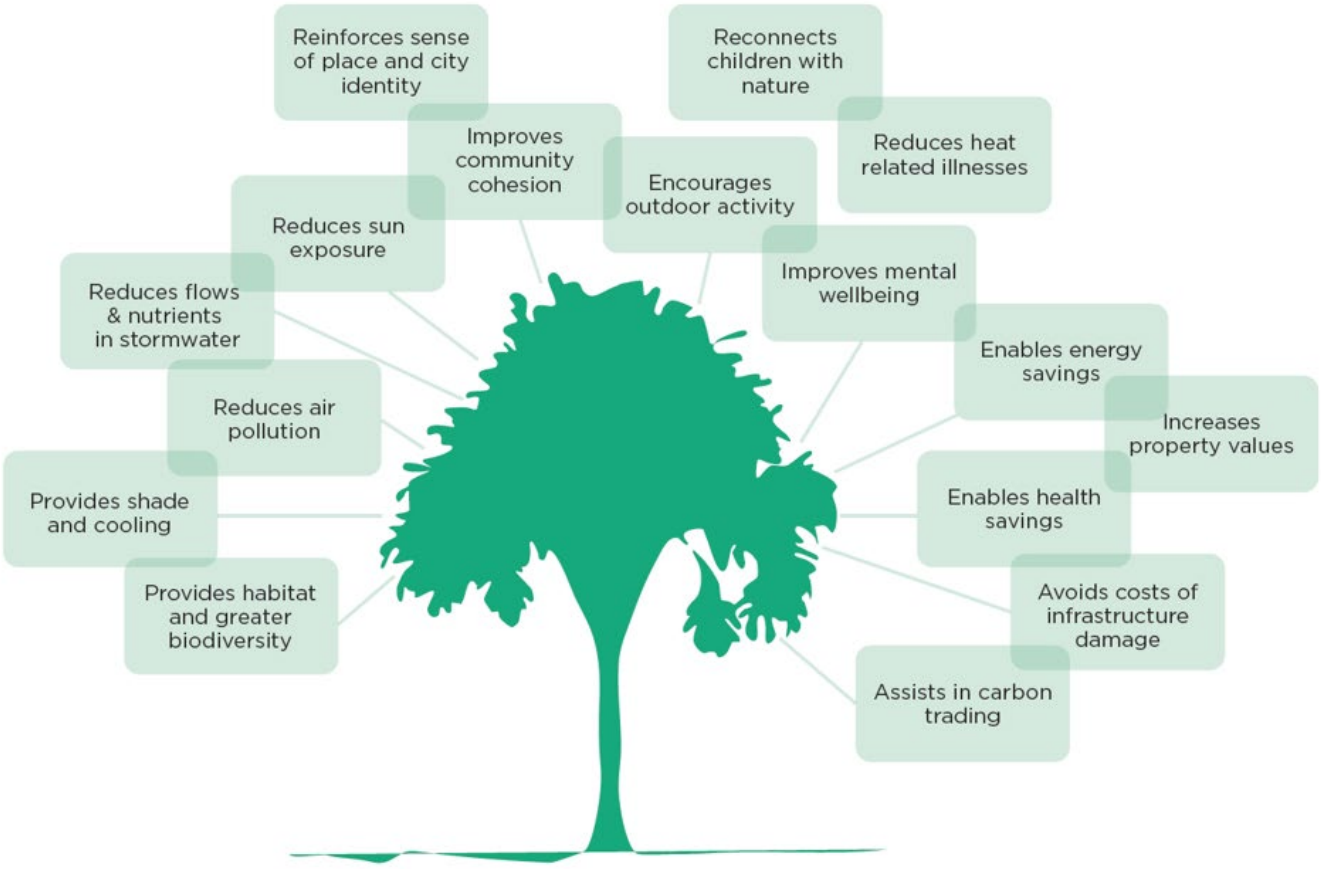


Figure 13: Benefits of trees (based on City of Melbourne 2014)

4.2 REDUCING THE IMPACTS OF HEAT

To understand the impacts of urban heat on people living in Canberra, and to plan and design effective mitigation measures, we consider heat at two scales, as discussed in Section 3.3:

- The 'macro' or 'urban' scale
- The 'micro' or 'human' scale

To help break down all the ways in which planning and design can help improve resilience to urban heat, WSROC's Urban Heat Planning Toolkit established a framework, shown in Figure 14, showing how we should plan and design both to reduce urban heat (at macro scale) and mitigate its impacts (at micro scale) so that people can adapt, survive heatwaves and thrive in a hotter climate. WSROC's framework is broad and we expect that several aspects included within it (namely, low carbon cities, sustainable water supplies, cool buildings, cool home and robust energy systems) will be addressed in other parts of the ACT's planning system. The ACT's Climate Change Strategy (ACT Government 2019a) has separate goals related to renewable energy, reducing emissions from gas, climate wise, zero emissions homes and other buildings. The focus for this project should be on reducing the urban heat island effect (i.e., macro scale) and creating cool outdoor spaces (i.e., micro scale).

WSROC's Urban Heat Planning Toolkit (McAuley *et al* 2021) goes on to organise potential design measures in terms of where they are most effective at reducing urban heat and its impacts. This is shown in Figure 15.

Table 9 compares the cooling effects of different measures in quantitative terms. It lists potential effects on surface temperatures, air temperatures and thermal comfort (expressed as a 'feels like' temperature) for a range of cooling strategies. Each of these temperature effects helps to indicate where each design measure is most effective:

- The most effective strategies for improving 'feels like' temperatures are those that create shade (noting that the cooling influence is only felt within the shaded area).
- Green open spaces are also moderately effective for improving 'feels like' temperatures, however green roofs and walls are not.
- Cool pavements, roofs and walls are all effective for reducing surface temperatures. However, they have a limited effect on air temperatures or 'feels like' temperatures.
- Evaporative cooling, particularly misting fans, can create significant reductions in air temperatures, although only within a relatively small zone of influence.

To reduce the UHI effect at city scale, relevant measures include increasing green cover and ensuring vegetation has access to water for evapotranspiration. Cool materials for roofs and paved surfaces are also effective at this scale, as they reflect solar radiation back up towards space.

The micro scale is more complex – people's experience of heat is influenced by air and surface temperatures as well as access to shade, water and cooling breezes, which can help maintain human thermal comfort during hot conditions. There are many aspects of urban design that influence the microclimate, including:

- Orientation of streets and other public spaces, which influences exposure to sun, shade and air flow.
- 'Sky view factor', or the proportion of sky visible from the ground. Wide streets with low buildings either side are more open to the sky and exposed to solar radiation, while narrow streets with tall buildings either side are more often shaded.
- Canopy cover and other shade – as shade is very effective at reducing 'feels like' temperatures.
- WSUD, irrigation and evaporative cooling, which all have the potential to cool via evaporation or evapotranspiration.

WSROC's Urban Heat Toolkit prioritises measures for cooling at city-scale and human scale. These measures and the order in which they are prioritised are equally relevant in Canberra's climate. They have been consolidated into a suggested set of urban cooling objectives in Table 8.

Table 8: A suggested set of urban cooling objectives for development (based on McAuley et al 2021)

Goals	Objectives
H1. Reduce the urban heat island effect	1. Across the urban area as a whole, maximise green cover and minimise impervious areas. 2. Where hard surfaces are required (e.g. roofs and paved areas), use 'cool materials' which reduce heat absorption. 3. Where green cover is provided, maximise its cooling effect by maximising soil volume, maximising vegetation density, and ensuring that vegetation has access to water.
H2. Enable people to adapt and thrive by creating cooler microclimates within the city	1. Orient site features to minimise exposure to hot summer sun, buffer exposure to hot winds and maximise access to cooling breezes. 2. Maximise shade, particularly where people are likely to be active in hot weather. 3. Use water in the landscape to provide evaporative cooling.

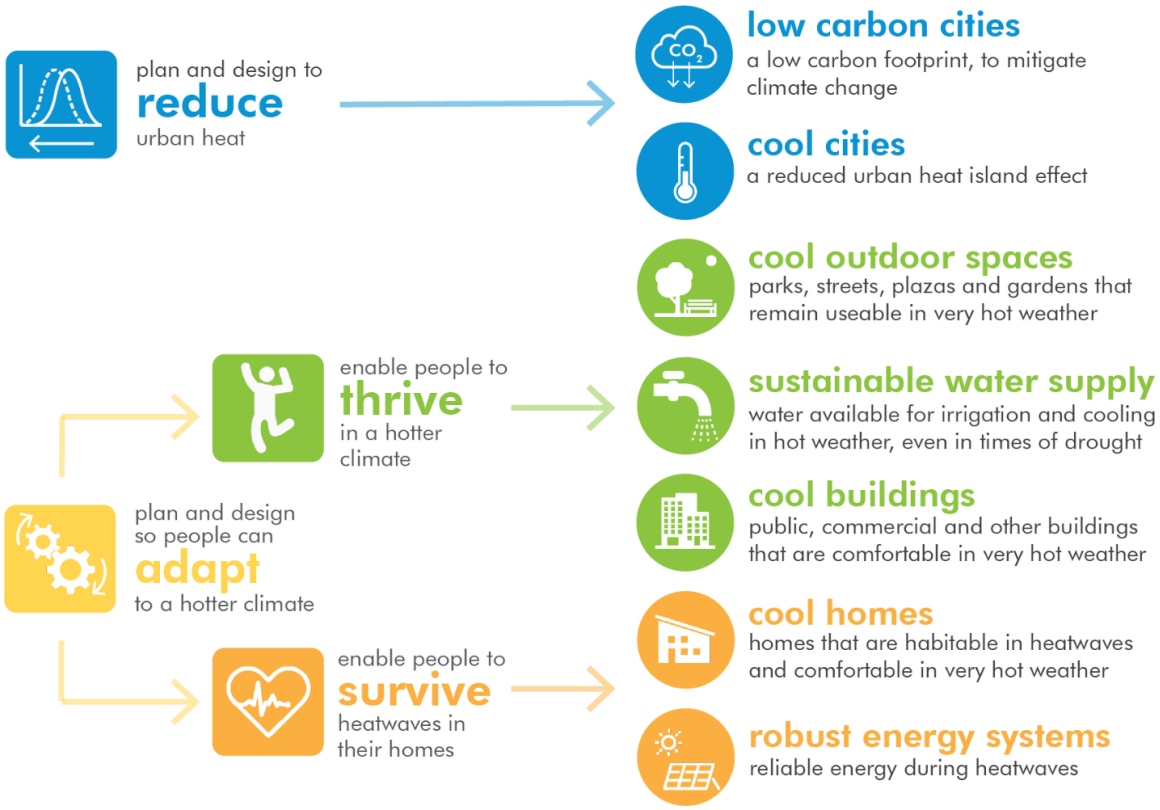


Figure 14: Urban planning and design approaches to reduce urban heat and help people adapt (McAuley et al 2021)

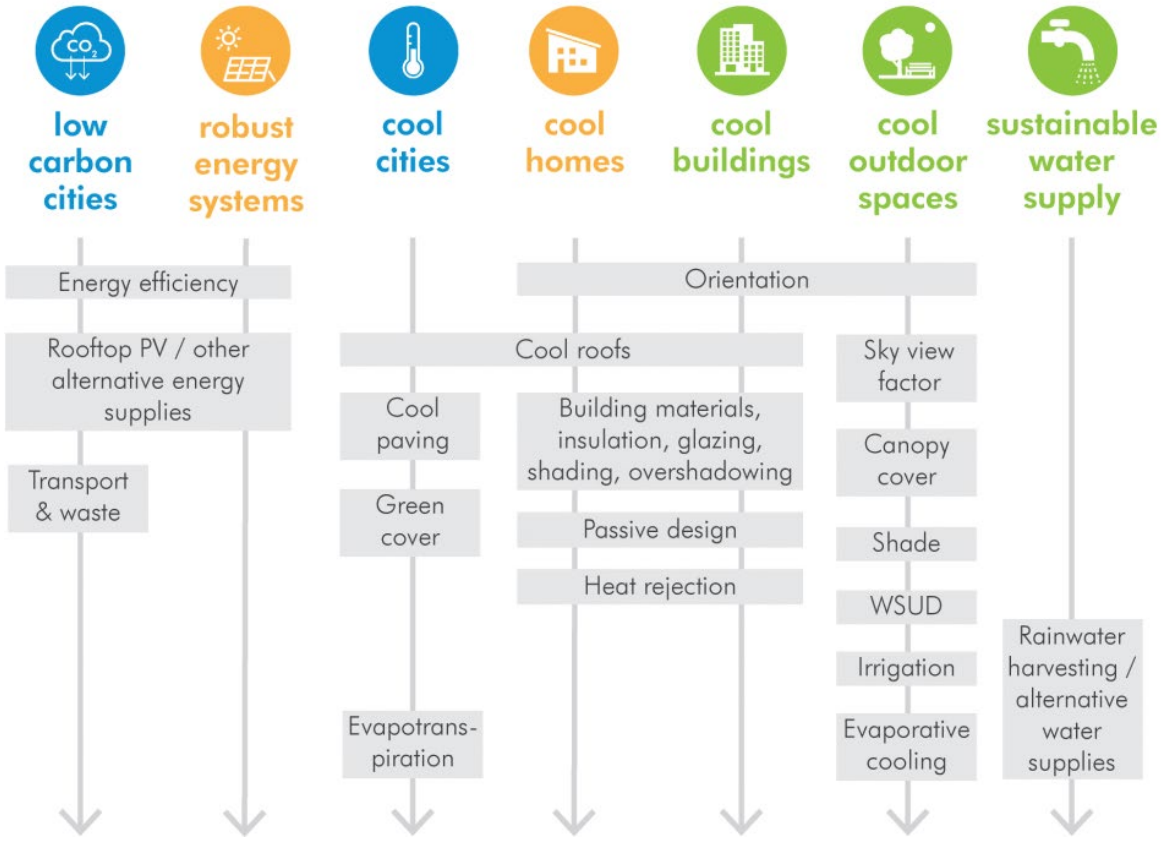


Figure 15: Potential design measures for reducing the impacts of urban heat (McAuley et al 2021)

Table 9: Cooling capacity of different strategies (as presented in McAuley et al 2021, based on Osmond and Sharifi 2017)

Heat mitigation strategy	Maximum air temperature reduction within the zone of influence[a]	Thermal comfort improvement (Feels-like temperature)[b]	Maximum surface temperature reduction[c]	Key constraints
Mature street trees	4.0 °C	8.0 °C	15 °C	Space/conflict with grey infrastructure
Solar control systems (shading)	0.8 °C	8.0 °C	15 °C	Installation cost
Cool pavements	2.5 °C	0.5 °C	33 °C	Reflectance changes over time Undesirable glare
Permeable pavements	2.0 °C	2 °C (after sprinkling with water)	20 °C	Less suitable for heavy traffic Evaporation is less effective in humid weather and only effective when there is moisture present Maintenance
Cool roofs / walls and facades	2.5 °C (indoors)	0.5 °C	33 °C	Undesirable glare Complex reflectance in street canyon
Green roofs and walls	4.0 °C	0.1 °C	20 °C	High cost to install and maintain Water supply for walls Heat- and water- stress
Green open spaces	4.0 °C	4.0 °C	15 °C	Need to accommodate multiple needs
Evaporative cooling[d]	8.0 °C	1.0 °C	N/A	High cost to install and maintain Water supply required
Misting fans[e]	15 °C	1.0 °C	N/A	Less effective in humid weather Small zone of influence

Effectiveness[f]	Very high	High	Medium	Low	Negligible

Notes:

a. This indicator is best used when evaluating the overall temperature outcome along a street canyon, across an urban precinct, neighbourhood or development site. The zone of influence may vary depending on the type and size of intervention from few meters to several dozens of meters; as well as height of the intervention (i.e. cool/green roofs may have a stronger influence several meters above the ground).

b. Outdoor thermal comfort is best used to assess the capacity of an intervention to improve people's thermal perception (feeling), or levels of heat stress in open spaces. This is typically assessed by thermal comfort indices such as the Universal Thermal Climate Index (UTCI) or Physiological Equivalent Temperature (PET) using a scale that ranges from very hot (extreme heat stress) to very cold (extreme cold stress) thermal perception.

c. Surface temperature drops are best used to determine the potential impact of interventions on ameliorating urban overheating across large areas. It is also a relevant indicator on the potential outdoor thermal improvement that may be achieved as surface temperatures influence on the amount of heat directly emitted by surfaces towards pedestrians.

d. Generally, it refers to water bodies like ponds that are passive technologies.

e. Generally, it refers to active technologies such as sprinklers or misting fan systems.

f. Effectiveness may vary depending on context (i.e. industrial versus residential site), macroclimatic conditions (i.e. during heatwave compared to a typical summer day), location and extent of the mitigation technology.

4.3 RETAINING WATER IN THE LANDSCAPE

In a typical urban area, hard surfaces (including roofs and paved areas) are directly connected to efficient drainage systems. Most rainfall is converted to runoff, which leaves the urban landscape quickly.

In a natural water balance, more rainfall is able to infiltrate into the ground, more is taken up by vegetation and lost to evapotranspiration, and less runs off.

If a more natural water balance can be restored in urban areas, it is associated with:

- More water available in the landscape to support green infrastructure.
- Lower stormwater pollutant loads.
- Cooling associated with evaporation and evapotranspiration.

Table 10 provides a suggested set of 'water in the landscape' objectives. These complement existing WSUD objectives, but do not cover every aspect of WSUD. A WSUD approach also typically aims to reduce mains water consumption, reduce wastewater discharge, reduce stormwater runoff, and improve the quality of stormwater runoff. These complementary objectives should also be considered in a more holistic review of WSUD objectives and planning provisions.

Table 10: A suggested set of 'water in the landscape' objectives for development

Goals	Objectives
W1. Encourage infiltration and evapotranspiration	1. Contribute to the ACT's permeable surfaces target of 30% by 2045. 2. Minimise 'directly connected' impervious areas by directing runoff from hard surfaces into planted areas, where it can soak into soils. 3. Retain water in features like ponds and wetlands, from where it can evaporate.
W2. Provide sustainable water supplies for irrigation and cooling	1. Capture rainwater or treated stormwater and store for reuse, to enable flexible, unrestricted water use for irrigation and cooling purposes.

*

5 URBAN HEAT ASSESSMENT

A range of assessment methods are likely to prove useful in the long-term; simple options are needed in the short-term.

In an effort to better manage the impacts of urban heat, a range of urban heat mitigation tools have been developed and applied to select urban settings across Australia. The increasing diversity of options available to quantify urban heat and to plan for urban heat mitigation has resulted in a lack of standardisation across Australian jurisdictions and a poor understanding of the benefits and limitations of urban heat assessment methods and tools.

In addition to the established simulation tools that have been available since the 1990s, a range of alternative simulation and ratings tools have recently emerged. A variety of rating and other tools are available as a method of assessing urban heat mitigation options, both in Australia (for example, the WSROC Cool Suburbs Tool currently under development) and in parts of the United States (Earth Resources Observation and Science Center, 2021).

In this report, the authors seek to make a distinction between simulation tools, rating tools and simple comparative assessment merhods, as shown in Table 11. Sections 5.1 and 5.2 provide an overview of select simulation and rating tools, based on the authors' experience of using and applying these tools to different scenarios across South Australia, Victoria, NSW and the ACT. The aims of doing so are to provide a holistic overview of simulation tools in comparison to rating tools. Our focus here is how these tools would be applied as part of a development assessment process. Section 5.3 briefly explores the idea of simple comparative assessment, using simple indicators and rules of thumb.

Table 11: Options for urban heat assessment

Options	Simulation tools	Rating tools	Simple comparative assessment
Description	Computer models that represent urban areas and their temperature characteristics in detail	Simplified models or scoring systems that weigh up different measures	Simple metrics and rules of thumb to help compare different options
Examples	ENVI-met SOLWEIG TARGET	WSROC Cool Suburbs Tool UNSW UHI Decision Support Tool and Performance Index	Metrics such as canopy cover, pervious area Rules of thumb provided in guideline documents
Features	Specialist expertise required to set up and interpret outputs Significant data inputs and computation time required	Simpler to use by non-experts Less intensive input data and quicker to use	Simplest option No need for ongoing support of a tool

5.1 SIMULATION TOOLS

Simulation tools are computer-based programs that allow for the modelling of urban heat scenarios. Models are created in the chosen simulation tool, based on either existing information pre-loaded to the tool or created from development concepts and

designs produced in a language recognised and used by the simulation tool.

Simulation tools seek to quantify heat within complex urban settings, usually through comparing a baseline scenario to at least one urban heat mitigation scenario. The urban heat mitigation scenario will typically include a variety of urban heat mitigation measures, such as:

- Tree canopy cover
- Irrigated turf
- Albedo and emissivity of horizontal surfaces
- Albedo and emissivity of vertical surfaces
- Water bodies
- Shade structures, etc

BENEFITS OF SIMULATION TOOLS

As cities have become increasingly densified, the prevalence of impermeable and heat-absorbing materials has increased, often at the detriment of living infrastructure and the loss of impermeable surfaces.

Simulation tools have been utilised as an evidence-based approach to assessing current and future heat scenarios. Simulation tools provide generalised heat outputs based on the scenario modelled. The model creator can model multiple scenarios to determine the impact of different urban heat mitigation measures.

Despite temperature outputs from different tools having minor variances, the benefit of conducting a microclimate assessment is that the tools will provide information that when adopted by the developer during the planning stage of development can be used to justify alterations to the development. These alterations have been proven to reduce urban heat and increase the thermal comfort for users of the modelled development.

Simulation tool can be used at multiple scales and applied to any type of development. The larger the development, the greater likelihood of changes to urban heat resulting from the development. A simulation tool can allow a designer and developer to better understand the heat impact of developments, including the selection of materials, and to incorporate learnings into future developments.

KEY CONSIDERATIONS AND LIMITATIONS

Due to the variety of urban heat outputs provided by different simulation tools, there is a need to determine the most appropriate use of simulation tools as a planning requirement in a development assessment setting. Key factors influencing the suitability of simulation tools at various scales and development types include:

- The costs and time of utilising different simulation tools.
- The computing requirements to operate complex scenarios at large scale.
- The value of the information provided by the simulation tool.
- The ability of the information outputs to be easily interpreted and to influence planning and development decisions at an appropriate planning and development timeframe, in order to mitigate urban heat.

Other factors that need to be considered when determining how to operate and interpret simulation tool outputs are described below.

In order to accurately model urban heat, the designs of the proposed development must reflect the completed development. Many of the simulation tools on the market require specific input data and are not capable of modelling generic benchmarks, such as 30% tree canopy cover within a defined area (Sharifi, Bartesaghi Koc, Vanderburg, Marchant, & Soebarto, 2021). The specific location of the chosen urban heat mitigation measures (for example, a tree) in relation to other urban cooling measures and the built environment will influence the urban heat mitigation outputs. For example, a collection of trees, planted closely together will influence urban heat in a different manner to the same number and species of trees dispersed evenly across the proposed area for development.

It is not feasible to model multiple urban heat mitigation initiatives within the same model and to isolate the influence of one urban heat mitigation initiative, i.e., modelling both irrigated turf and high albedo roofs is likely to reduce the impact of urban heat of a particular development (Sharifi, Bartesaghi Koc, Vanderburg, Marchant, & Soebarto, 2021). However, determining the degree that the high albedo surface aided in the mitigation of urban heat in relation to the irrigated turf is not feasible within the same model. In order to determine which urban heat mitigation factor created a greater cooling effect, would require the running of two separate models. One model to calculate the urban heat mitigation outputs of high albedo roofs and the other to calculate urban heat mitigation outputs of irrigated turf.

For this reason, the use of simulation tools to model urban heat scenarios requires a contractor who has a sound understanding of both urban heat modelling and the influence of particular urban heat mitigation measures applied to certain climatic zones. In addition to this, a set of guidelines or urban heat principles are required to better understand the extent to which each urban heat mitigation mechanism can assist in reducing urban heat and the interrelationship between different urban heat mitigation measures.

Each of the different simulation tools are capable of producing outputs based on the capabilities of the tool. For example, the simulation tool ENVI-met is capable of modelling the influence of

vertical surfaces on urban heat, whereas many other simulation tools are not capable of modelling the influence of vertical surfaces. It can be seen that the use of different simulation tools creates different temperature outputs. It is important that the tool utilised for an urban heat assessment produces outputs that are accurate and are reflective of real life conditions.

A microclimate assessment utilising a simulation tool typically operates within the boundaries established within the microclimate assessment and unless the surrounding environment is modelled, this is not incorporated into the simulation outputs. This has implications for modelling of sites located in areas already prone to urban heat as opposed to developments in areas located in suburbs within existing urban heat mitigation measures. Heat radiating from surrounding environments outside of the simulation boundaries will not be accurately captured through an urban heat mitigation simulation.

However, tools such as ENVI-Met use a 'nested' approach whereby the site being modelled is 'nested' in a larger domain which is assumed to have the averaged urban geometry and meteorological parameters of the site being modelled.

UTILISING SIMULATION TOOLS AT SCALE

There are a range of urban heat mitigation simulation tools available on the market. The need for a variety of tools has primarily arisen due to the increasing complexity of modelling urban heat scenarios across different landscape scales (Sharifi, Bartesaghi Koc, Vanderburg, Marchant, & Soebarto, 2021). As such, tools that are capable of simulating large areas tend to do so by limiting the detail of both the inputs and outputs and providing information that is more generalized in nature. Mesoscale models such as the Weather Research and Forecasting (WRF) model can model (for example) gross greenery %, proportion of hard surfaces etc at city-wide scale, but this is not particularly useful for planning.

The tools that are best applied to smaller scale scenarios can provide highly detailed information related to urban heat. However, some high input simulation tools, such as ENVI-met, can require a network of computers to run models for complex or multiple scenarios and skilled operators to create and operate the simulation models. As such, there is a higher cost and time requirement to access and use these tools (Sharifi, Bartesaghi Koc, Vanderburg, Marchant, & Soebarto, 2021). The high detail input and output simulation tools are not well suited to modelling large scale areas (Greater than 25 ha), due to the time required to both create and then run the model.

Whilst modelling urban heat mitigation measures at the lot scale is feasible, in order to minimise heat in urban environments, a large-scale approach is required. For example, the ability of a single allotment to reduce the impact of urban heat, is highly influenced by the surrounding landscape. However, a large area, such as a suburb that has considered urban heat in the planning stages of development and implemented a range of urban heat mitigation measures will have a greater influence on urban heat.

When considering the most appropriate tool to apply to a particular scale, it is important to note the 2021 report commissioned by the ACT Government recommending the following three scales (Alluvium 2021):

- Block or single building scale (4000 m2 or less)
- Precinct or estate scale (4000 m2 to 100 ha)
- District to city-wide scale (> 100 ha)

The categorization of these scales requires alteration in order to ensure simulation tools, such as ENVI-met, SOLWEIG and TARGET are applied to an appropriate landscape scale. One recommendation outlined by Sharifi, Bartesaghi Koc, Vanderburg, Marchant, & Soebarto (2021) is to simplify the scales to two categories:

- Less than 250,000 m2 (25 ha)
- Greater than 250,000 m2 (25 ha)

This will allow for better understanding of the applicability of a tool requiring detailed inputs and outputs, compared to a tool requiring reduced inputs, that is best applied to large scale developments.

OUTPUTS

When running the same model across different simulation tools, the outputs will differ. This is due to different tools presenting temperature in different formats. For example, the simulation tool ENVI-met presents temperature data as Universal Thermal Comfort Index (UTCI). UTCI is considered the most accurate numeric representation of the way humans feel temperature and the most advanced outdoor thermal comfort indicator. UTCI considers:

- Air movement/wind speed.
- Relative humidity
- Radiant heat.
- Air temperature.

The simulation tool SOLWEIG provides temperature output data in the form of Mean Radiant Temperature (MRT). Mean Radiant Temperature does not consider the other essential determinants of thermal comfort (relative humidity, wind speed or air temperature). However, a study by Renouf et al. (2020) as part of a case study of the suburb of Salisbury, South Australia demonstrated that MRT can be converted to UTCI (Renouf, et al., 2020).

The Water Sensitive Cities tool TARGET produces outputs in the form of average maximum air temperature and average maximum land surface temperature. Again, UTCI can be extracted from the TARGET tool through applying assumptions

and analysis to the data outputs, but the primary outputs are not UTCI. As such, both TARGET and SOLWEIG require highly skilled operators to interpret findings and outputs from these tools and to standardise the outputs of the tools.

SIMULATION TIME FRAME

Data-demanding models can only simulate relatively short periods of time. Typically 24 or 48 hours are selected, often representing heatwave conditions.

TIMING

The timing of a microclimate assessment is key. As previously discussed a microclimate assessment is only valuable if the simulated model is representative of the on-ground conditions. Modelling of sites in the pre-development phase, regardless of the tool used, may not provide accurate data outputs if the completed development does not accurately reflect the microclimate assessment modelling (Sharifi, Bartesaghi Koc, Vanderburg, Marchant, & Soebarto, 2021). It is recognised that a microclimate assessment will provide valuable information related to the site and may assist in creating a cooler urban environment. When determining the most applicable timing of an assessment, there are both pros and cons to all stages of development.

Assessments conducted early in the pre-design and design stages can assist in building capacity and understanding of urban heat and may result in designs that assist decision makers to reduce urban heat. However, there may also be considerable flow-on financial impacts to the developer as a result of a microclimate assessment at this stage due to the need to significantly alter designs.

Simulation modelling assessments conducted during construction or post construction are not desirable as any suggested or required changes to the design will have severe impacts on project completion dates and finances.

As such, multiple assessments may be required throughout the pre-design, design and construction phases. Furthermore, the complexity of urban heat mitigation and the relationship between heat, green infrastructure, water and the built environment will typically mean that multiple assessments are required for most developments. This is particularly so if heat mitigation is not considered early in the planning and design phase (Sharifi, Bartesaghi Koc, Vanderburg, Marchant, & Soebarto, 2021).

More than one assessment may be required (Sharifi, Bartesaghi Koc, Vanderburg, Marchant, & Soebarto, 2021):

- To assess and inform decisions making at the pre-design stage; and
- To correctly model whether the heat mitigation parameters have provided the required level of heat mitigation once detailed site plans and building designs have been finalised.

Recommendations related to the specific use of simulation tools and the timing of microclimate assessments will be provided in the feasibility assessment phase of this project.

CONSIDERATIONS

All simulation tools have limitations and no one tool is best applied to all scenarios to produce the required outputs. As such, the use of simulation tools to model urban heat, requires a nuanced and tailored approach, based on the scale of the area and the complexity of the design that is to be modelled.

The outputs provided by the simulation tools have a considerable influence on the urban heat mitigation measures that are selected to buffer the impacts of urban heat. It is important to contextualise the results and outputs of the simulation tools and to consider the outputs in relation to the current and future planning provisions. Simulation tools can be utilised to great effect but utilised in isolation of the surrounding environment can provide inaccurate outputs. As such, it is important that guidelines provide evidence-based information to key decision makers and allow for an easily understood knowledge of when and how to conduct a microclimate simulation assessment.

5.2 RATING TOOLS

Rating tools are emerging as an urban heat assessment option that are more readily applicable to the planning and development assessment process.

In contrast to simulation tools, ratings tools aim to assess urban heat outcomes through utilising a points-based framework for urban heat mitigation measures at different scales and development scenarios. Rating tools can be easily understood and incorporated into urban planning systems, without the need to accurately quantify current heat impacts.

There are a range of rating tools that have been developed. All of which are utilising an urban heat peer-review evidence base to provide a platform for city-wide cooling.

The most publicised and well-known use of a rating tool has been designed by the Western Sydney Regional Organisation of Councils (WSROC) as part of a collaborative partnership to ensure future development in Sydney's west considers and plans for urban heat mitigation. The development of a rating tool has allowed for a standardised approach to managing urban heat across Western Sydney that is compatible with the NSW urban planning system.

WSROC's tool provides an assessment of the performance of an actual or potential project by generating a rating. The rating is produced by combining scores against a range of criteria that have been developed based on urban heat mitigation measures that relate to the different elements of WSROC's resilience framework.

WSROC's tool is described in detail in the following sections.

CONTEXT AND PURPOSE

The urban heat tool aims to inform and guide planning and development decisions by providing a synthesis of urban heat science and practices in an easy-to-use platform.

Recognising that to successfully address the complex issue of urban heat, the tool provides an integrated approach that considers a range of factors contributing to heat exacerbation including:

- The local climate context (including the effects of climate change).
- Development site condition (e.g., greenfield or brownfield sites).
- Development scale (e.g., masterplan, lot scale).
- Development typology (e.g., building, residential home or park).

The purpose of the tool is to:

- Set out a broad range of urban heat resilience measures (represented by credits) that contribute to and guide improved place-based urban heat resilience.
- Identify the specific urban heat resilience measures that should be considered for different development types and scales, supporting its use in early stages of planning and design.
- Scoring (via a rating system) the urban heat resilience performance of a development from a precinct to lot scale.
- Provide guidance and assessment of planning by government and developers, for existing, transforming and new suburbs.

RATING TOOL CREDITS

The rating tool assigns Credits to implemented urban heat measures. The Credits aim to ensure that all scales and types of development are considered, with the broader aim of ensuring a landscape scale reduction in urban heat. The Credits are grouped under six categories:

1. Urban design.
2. Cool streets.
3. Cool parks.
4. Cool homes.
5. Cool buildings (non-residential).
6. Innovative new technologies.

Each Credit is individually structured in the tool as follows:

- Outcome of a Credit: Outlines the desired outcomes of the credit.
- Credit criteria: Explains requirements that must be met.
- Guidance: Provides general guidance to support development/design of compliant solutions.
- Science Rationale: Provides relevant references drawn from the scientific literature to support the Credit criteria.
- Related Credits: Lists other Credits in the tool that are complementary.

The tool includes some "mandatory" Credits that must be satisfied to qualify for a "cool suburbs" rating. The mandatory Credits are listed in Table 12.

Table 12: Summary of credit categories and mandatory credits

Credit Category	Mandatory Credits
Urban Design	Retention of existing tree canopy
	Water Sensitive Urban Design
Cool Parks	Shade
	Irrigation
Cool Streets	Shade
	Irrigation
Cool Homes	Passive Cooling
	Cool Roofs
	Alternative Energy Supply
Cool Buildings	Passive Design
	Cool Roofs, Green roofs and Green Walls
	Alternative Energy Supply

SCORECARD

The Credit system is supported by a scorecard. The Scorecard identifies the specific details of a particular development scenario. This includes using the following framework to contextualise the development in question:

- Step 1 – Provide the details of the development
- Step 2 – Define the development context, including climatic zone, development site conditions, development scale and the planning zones/typologies.
- Step 3 – Assess the compliance of each of the Credit criteria relevant to the development type.
- Step 4 – Undertake the response checklist

After completing the above steps, the rating tool generates a cool suburbs rating for the development.

BENEFITS OF THE WSROC RATING TOOL

The rating tool is designed to reduce heat across all scales and types of development, regardless of the development proponent, location or intention of the development. The tool has been developed using peer-reviewed research as a basis for reducing urban heat and the understanding that a range of urban heat mitigation measures are required to successfully reduce urban heat. Points are applied to particular urban heat mitigation measures, categorised across six categories (described further below).

MANAGEMENT OF RATING TOOLS

There are two parts to the tool framework. The science translation piece, which can be used independent of the tool (which is captured in the rationale document), and then the Excel based tool itself.

There are multiple potential users for the tool. Developers could be required to use the tool in order to receive development approval. The onus would be on them to provide the evidence base and complete the process, with a report being provided to relevant government agencies. However, they could also use the tool very early to guide their design process to identify development options that give the best chance of a cool suburb/lot.

The tool can also be used by government agencies to:

(a) check proposed developments for their ability to meet cool suburb requirements and hence inform the DA process and

(b) inform planning controls.

HOW TO DETERMINE SUCCESS

A rating tool provides an overall rating for a development (from a master planned community to a single lot development) on a points basis. In the case of the ACT, the government would determine how many points are required to achieve the level required for a "cool suburb". This removes the ambiguity of whether a 1.5'C cooling is materially better than a 1.3'C cooling, which is the perennial challenge with simulation models.

Credits for development at different scales:

When developing at large scales, there are a range of measures that if incorporated into the design can assist in the reduction of urban heat. For example, the street orientation and broader urban morphology has a significant impact on whether buildings can take advantage of prevailing cool winds and the broader exposure of northern and western surfaces to the summer sun. The Urban Design Credit is designed to take advantage of passive ventilation and a reduction in radiant heat resulting from building and street orientation and aspect.

At the street level, there is recognition that the role of particular urban heat mitigation measures are more applicable than others. This includes street trees and associated shade and canopy cover and pavement types, including the colouration, albedo, emissivity and permeability of pavement type. All which can and do influence urban heat.

Urban parks can represent important oases from heat. The use of shade from trees and artificial structures with the use of localised water bodies, such as fountains, lakes and creeks can assist to

create a cooler environment. Irrigated living turf is particularly important in the context of urban parks to buffer the effects of urban heat.

The design of the urban home and garden can significantly either increase or decrease the impacts of heat and the reliance on air-conditioning systems (for those who can afford it) to manage the effects of heat. The Cool Homes credit promotes passive design criteria and rewards the developments considering the impacts of design on urban heat.

The Cool Buildings (non-residential) Credits are designed to target predominantly commercial precincts and places where the community work and regularly attend. Similar to the Cool Homes Credit, the focus of the credits is to ensure passive design criteria are incorporated into planning and development.

The final Credit category for Innovative New Technologies seeks to reward those who are utilising novel and newly developed technologies to reduce the impact of urban heat. Credits associated with this category are only applied once other Credit categories have been considered. The Credit system is designed as an incentive for those seeking to collaborate in new partnerships to increase the understanding and adoption of new credits.

Applicability to other Australian and overseas climate scenarios:

The majority of the inputs factored into the tool are applicable to other jurisdictions within Australia, including the ACT. There are some inputs that can and must be tailored, if the tool is to be applied to other jurisdictions. This could be easily altered and made relevant to the ACT by creating a framework for the ACT climate and the urban planning system, including zones currently defined in the ACT planning regulations.

LIMITATIONS OF RATING TOOLS:

Rating Tools do not allow for a granular before and after assessment of a particular development. Rating tools utilise commonly accepted findings from peer-reviewed literature to support the evidence base, based on the interrelationship of a range of urban cooling measures.

Rating tools do not specifically factor in the before and after assessment of sites, to determine if the development has increased or decreased heat in a particular location. However, when applied to a district or city-wide scale it is likely to be of much greater use.

Until a microclimate assessment is conducted, the impact of the range of implemented urban heat mitigation measures is not known.

The practice of using a points-based system has not been broadly applied over a number of years tested to determine the efficacy of the tool in relation to its goals of reducing urban heat.

Rating tools need to be tailored to the climatic and environmental conditions of the area they are applied to, i.e., the ACT. In the case of the WSROC rating tool, the data that supports the function of the tool could be tailored to the conditions of the ACT, without the need to redesign the functionality or alter the supporting evidence base of the tool. Whilst there are not any off-the-shelf tools currently available on the market, the design of many rating tools is such that the functionalities would only need to be tweaked, rather than creating wholesale changes to the tool.

5.3 SIMPLE COMPARATIVE ASSESSMENT

If a framework is provided, alternative options could be compared using simple 'rules of thumb'.

Rules of thumb could state (in simple, transparent terms) what will be considered equivalent, allowing straightforward comparison between options.

As mentioned earlier in this report, ACT Government is undertaking research into equivalence between different types of living infrastructure, and therefore a framework of alternative living infrastructure measures is not a focus of the current project. However, urban heat assessment is within the scope of the project, and here there are good reasons to set up a framework to weigh up alternative measures for addressing urban heat objectives:

- This approach would provide a framework that is readily understood by a range of disciplines who need to engage with urban heat planning provisions. Rather than leaving urban heat assessment to technical experts, this could encourage all disciplines involved in urban design to engage with the principles and integrate appropriate measures into each part of the design.
- There is a need for a simple assessment pathway for those developments where urban heat simulation is not a realistic option.
- A framework for comparative assessment would provide greater clarity to industry about specific policy objectives and benchmarks, priorities and acceptable solutions.
- A framework for weighing up alternative measures would be a starting point to build a rating tool later.

As part of this project, information available in existing guidelines was examined to see whether 'rules of thumb' could be established for alternative measures to address urban heat, either at city or microclimate scale.

Existing guidelines do provide some guidance that enables different cooling options to be compared in semi-quantitative terms (e.g. refer to Table 9). However, this is not clear enough to translate into a reliable method to weigh up alternatives in the planning system.

5.4 RECOMMENDED APPROACH

It is recommended that all three options explored above (simulation, rating tools and simple comparative assessment) have a potential future role in ACT's planning system, but none are yet ready to be adopted immediately. Therefore, urban heat assessment is not recommended as part of the current set of planning provisions. A developer could still choose to undertake an assessment, but it is not proposed as an essential requirement.

What is recommended instead is a basic set of requirements for living infrastructure, cool materials, shade and other simple measures that have clear urban heat mitigation benefits. Section 7 takes this approach.

A framework or method for weighing up alternative urban heat measures could be contemplated as a future project – refer to Section 9.4.

6 OPTIONS FOR PLANNING PROVISIONS

Many Australian jurisdictions are working to improve planning provisions for green infrastructure and urban heat.

6.1 AUSTRALIAN EXAMPLES

Around Australia, many jurisdictions are overhauling planning provisions. Generally, there is a shift away from minimum standards towards performance-based outcomes, with an emphasis on providing flexibility rather than prescriptive approaches. However, there is also tension with providing more clarity and certainty in planning systems.

Against this backdrop, many jurisdictions are also working to improve green infrastructure and urban heat provisions in their planning systems. This also presents challenges and tensions – it is not easy to measure the performance outcomes of green infrastructure (which are varied and complex), and current planning provisions tend to be simply minimum standards (e.g., site coverage and deep soil area requirements). Everywhere, there is tension over increasing minimum standards, hopes that performance-based provisions could encourage better outcomes, and few examples of such an approach applied in practice. Most of the examples discussed here are based on minimum standards, however in some cases, minimum standards are presented as a 'benchmark' or 'deemed to satisfy' solution, with the option left open for alternatives to be proposed.

Several state-based approaches are under development but with little detail yet released for comment. For example, in Victoria, the Plan Melbourne Implementation Plan (Victoria State Government 2019) includes an action (#91) calling for a "Whole-of-government approach to cooling and greening Melbourne" including "preparing new guidelines and regulations that support greening new subdivisions and developments via landscaping, green walls, green roofs and increase the percentage of permeable site areas in developments." Some guidelines have been released but as yet, no new regulations.

NSW has released their Draft Design and Place SEPP (NSW Government 2021a), which includes proposed new provisions for green infrastructure and urban heat, however it is now clear the proposed SEPP will not proceed in its current form.

ESTATES

Estate development goes through varied planning processes from place to place, and often planning provisions are site-specific. We have located some examples with canopy cover targets. Victoria currently has the most systematic approach, having introduced a commitment, in their 30-year Infrastructure Strategy (2021), targeting 30% tree canopy coverage in new growth areas: "Over the next 30 years, achieve 30% tree canopy coverage in new growth areas by mandating coverage during precinct development, funding relevant Victorian Government agencies and local government to plant, replace and maintain canopy trees, and work with utility providers to remove barriers to tree planting."

In NSW, new subdivisions have site-specific development controls. So far:

- The Wilton DCP (NSW Government 2021b) includes a requirement "Development is to demonstrate alignment with the Neighbourhood Plan strategy to deliver 40% tree canopy."
- The Aerotropolis Precinct Plan (NSW Government 2022) includes an objective (BGO2) "Achieve the targets in the Region Plan of 40% tree canopy cover across the Aerotropolis by 2036."

NSW has other planning provisions in draft, for example the Aerotropolis Phase 2 DCP (NSW Government 2021c) includes deep soil, canopy cover and permeable area requirements for a range of specific land uses including public open space (45% canopy cover except where there are sports court and fields). The benchmarks for commercial development are listed below.

The Draft Aerotropolis Phase 2 DCP also includes broader urban heat provisions. The relevant provisions are PO1 and PO2. PO1 is shown in Table 13. PO2 is focused on building design to minimise heat gain and cooling demands indoors.

STREETS

Specific requirements for street trees are relatively common in planning provisions, as street trees are typically provided by subdivision developers. Some planning provisions simply define on which street types trees are required, while others are specific on how many are required (e.g. one per block). Lists of acceptable species are common, and planting specifications (e.g. pot sizes, other installation details) are sometimes defined.

Some planning provisions currently in draft are proposing more specific street requirements that are intended to reduce the impacts of urban heat.

The Draft Aerotropolis Phase 2 DCP includes requirements that:

- Street trees are to be planted at 15 m intervals on all local streets
- Tree pits are to be designed in accordance with a specification showing passive irrigation
- "Continuous tree canopy cover is achieved along both sides of the street"
- "Provide 50% of north-south oriented streets with shade for active transit users during the hottest times of the day."
- "Provide 80% of east-west oriented streets with shade for active transit users during the hottest times of the day."

Also in NSW, Penrith City Council's draft DCP amendment for Urban Heat Management (Penrith City Council 2021) includes a proposed provision "Street trees are to be provided at a rate of one tree for every 10m of site frontage, rounded down to the nearest 10m. At least one tree must be provided. Where possible, trees should be of a scale sufficient to produce interlocking canopies, unless specific requirements are provided elsewhere in this DCP."

RESIDENTIAL DEVELOPMENT

Requirements for trees and landscaping in residential development are becoming more common. The following examples are in force:

- NSW's Apartment Design Guide (supporting SEPP65) includes minimum requirements for deep soil zones in apartment development.
- Victoria's Apartment Design Guidelines (2017) and the Victorian Planning Provisions (Clauses 55.03-8, 55.07-4 and 58.03-5) include minimum landscaping, deep soil and tree requirements for apartment developments of various sizes.
- South Australia has recently updated its Planning and Design Code with new requirements for tree planting and landscaping in residential infill areas.
- Western Australia's Residential Design Codes include minimum requirements for trees on residential lots of varying sizes.
- Within NSW, the Wilton Growth Area Development Control Plan 2021 includes requirements for trees at the front and rear of residential properties.

Penrith City Council's draft DCP amendment C14 for Urban Heat Management also includes specific tree planting requirements for residential land, including trees in the front, rear and side setbacks.

COMMERCIAL DEVELOPMENT

There are fewer examples of planning provisions with specific green infrastructure or urban heat requirements for commercial development.

The Draft Aerotropolis Phase 2 DCP is one example, which has some requirements for some specific types of development Canopy cover and deep soil requirements are listed in Table 14. Requirements for permeable surfaces are listed in Table 15.

Penrith City Council's draft DCP amendment C14 for Urban Heat Management includes some tree canopy requirements for commercial development, these are listed in Table 16. These focus solely on at-grade car parks (discussed further below) and setbacks – where setbacks are required.

Penrith City Council's draft DCP amendment C14 for Urban Heat Management also requires some other measures to address urban heat in commercial development, including:

- A requirement for drip irrigation or passive irrigation of private landscaped areas
- Cool roofs (a specific standard is defined)
- A requirement for certain walls to be shaded
- A requirement to provide cool refuges, including indoor and outdoor staff break areas that act as cool refuges

Penrith City Council's draft DCP amendment C14 for Urban Heat Management includes a section that defines specific requirements for cool refuges.

The City of Parramatta has proposed a planning control for cool façades in their CBD (City of Parramatta 2021), this also requires shade to be provided over certain building façades.

CAR PARKS

At-grade car parks are one specific land use which is often part of commercial development and where there are often requirements to provide trees. As with tree requirements in streets, older provisions are simply focused on amenity, while some recent examples are focused on mitigating urban heat with these provisions.

In the Draft Aerotropolis Phase 2 DCP, the proposed provision states: "Provide 1 medium tree for every 5 at grade car spaces, and maximise shading (as shown below) by:

a. Orienting the tree parallel to the parking space;
b. Staggering the configuration rather than linear;
c. Selecting a tree with a Leaf Area Index of >4; and
d. Using structurally engineered pits or vaults and WSUD design criteria to provide appropriate space for tree root development."

Penrith City Council's draft DCP amendment C14 for Urban Heat Management includes the proposed provision listed in Table 16.

Table 13: Proposed provisions for UHI mitigation in the public domain, in the draft Aerotropolis Phase 2 DCP (NSW Government 2021)

9.2.2	Performance Outcome	Benchmark Solution
PO1	Site layout of development and public domain mitigates urban heat island effect.	1. Evaporative cooling is enabled through implementation of design initiatives and features, including: a. Water Sensitive Urban Design; b. Misting infrastructure in public places during high and extreme heat days; c. Irrigation of all public and private open spaces (using harvested stormwater) with 50% of grassed areas and 100% trees irrigated; b. Use of dips and concave spaces to trap water and reduce run off; and c. Use of fountains, water features and other water-based infrastructure to cool the environment. 2. Provide shade for the protection of summer sun through: a. Trees; b. Awnings, eaves, and overhangs; and c. Building design. 3. Use pavements which are permeable and have high albedo, resulting in less solar absorption. When using permeable pavers, it must be demonstrated there is no impact on the salinity or sodicity of underlying soils. 4. Provide public drinking taps in public areas every 500m. 5. Provide tree canopy cover in parks as follows: • for open spaces without sports courts and fields, a minimum tree canopy of 45%; • for open spaces with sports courts and fields, a minimum tree canopy of 45% applies to areas outside the courts and fields. Where possible, the remaining area should exceed the 45% minimum to compensate for the lack of canopy on the courts and fields. 6. Provide a microclimate impacts assessment report that integrates heat preparedness and outlines the planning and design for a cooler community. 7. Public seating has adequate shading.

Table 14: Minimum deep soil and canopy cover proposed in the draft Aerotropolis Phase 2 DCP for commercial sites (NSW Government 2021)-

Recommended Guidance	Minimum tree Canopy Target (% of site area)	Minimum deep soil (% of site area)	Minimum Tree Planting Rates*
Business Parks			
All lots	35% site area	25% site area	For every 300m^2 of site area, at least two medium trees or one large tree is to be planted in the deep soil area
Industrial sites			
All lots	25% site area	15% site area	For every 400m^2 of site area or part thereof, at least two medium trees or one large tree is to be planted in the deep soil area
Bulky goods			
All lots	25% site area	15% site area. Minimum 6m dimension	For every 400m^2 of site area or part thereof, at least two medium trees or one large tree is to be planted in the deep soil area

Notes*:

- Small trees are trees with a canopy spread of 6 metres or greater
- Medium trees are trees with a canopy spread of 8 metres or greater
- Large trees are defined as trees with a canopy spread of 12 metres or greater.

Table 15: Minimum permeable area proposed in the draft Aerotropolis Phase 2 DCP for centres and employment lands (NSW Government 2021)

Urban typology	Lot requirements			Typology elements					
	Site cover	Perviousness		Lot area		Streets (including plazas and urban public spaces adjacent to a street)		Open space (including parks, gardens, playgrounds, playing fields, and alike)	
				% of Overall Area	Perviousness	% of Overall Area	Perviousness	% of Overall Area	Perviousness
High-density mixed-use centre	60%	40%	**Base scenario**	50%	35%	35%	35%	15%	90%
			Alternative/ Parkland solution	58%	30%	32%	35%	20%	90%
Medium density mixed use centre	50%	50%	**Base scenario**	55%	50%	30%	35%	15%	90%
			Alternative/ Parkland solution	58%	35%	32%	38%	20%	90%
Employment – business, commercial and light industrial	60%	40%	**Base scenario**	55%	40%	30%	30%	15%	90%
			Alternative/ Parkland solution	55%	30%	30%	30%	20%	90%
Employment – Large format industrial	70%	30%	**Base scenario**	60%	30%	25%	35%	15%	90%
			Alternative/ Parkland solution	65%	15%	20%	35%	15%	90%

** The perviousness of a lot may be subsidised by other on-site detention and landscaping measures where it is not deemed acceptable or it is seen to be too onerous by a delegated authority for the site coverage to be reduced to meet the perviousness requirements. An example of this would be in a zero lot line opportunity (for a podium or attached built forms) in a centre, employment area or for an integrated development*

Table 16: Penrith City Council's proposed tree canopy provisions for commercial development

Industrial, Business, Tourism and Commercial development	Open car parks on private land a) A minimum of 40% tree canopy cover must be provided over the total combined area of all car parking spaces, where car parking is to be provided on the development site. b) Canopy cover is to be calculated by finding: The percentage of the specified area covered by the anticipated canopy at 2/3 of the selected species total maximum width, when fully grown. Figure 2 provides an example of how canopy cover should be calculated. c) Trees should be provided across the car park area and can be located within landscaped setbacks and deep soil zones. d) Where tree roots are expected to grow beneath car parking spaces, engineered tree pits or vaults and aeration infrastructure must be provided and designed in accordance with design guidance provided in engineering design guidelines, the Penrith Street and Park Tree Management Plan and this DCP. e) Wherever possible, canopy trees are to be orientated to the north, east or west of parking spaces to maximize shade during the day. f) Trees and woody plants above 200mm high should be planted a minimum of 600mm back from the wheel stop, measured from their trunks. Low planting should be provided in this space.
Additional controls for Industrial, Business, Commercial and Tourism development where landscaped setbacks are required.	a) Landscape setbacks must provide adequate soil area for tree planting and be filled with as many large trees as possible. Canopy from large trees should be supported with medium and small trees and vegetation to provide a collective cooling effect, where they will not obstruct views, signage, or impact safety.

6.2 EXAMPLES IN ACT

'NO NET GAIN IN URBAN HEAT'

As seen in Section 3.4, some existing Precinct Codes call for "no net gain in urban heat". However, it is not entirely clear what this means, or how it should be demonstrated that this outcome is met. Therefore, it is recommended that future provisions are more specific on their objectives, relevant indicators and required outcomes, and appropriate methods to demonstrate compliance.

SPECIFIC REQUIREMENTS IN DV369

The variation to the Territory Plan DV369 aims to increase canopy cover and pervious area on residential blocks with provisions for:

- Maximum site coverage
- More specific requirements for planted areas
- Minimum requirements for tree planting, defined in terms of the number of large and small trees

Similar requirements could be imposed on commercial development, however commercial development is currently subject to very few requirements for setbacks, planted areas or trees.

Further analysis of commercial developments in each zone in ACT could indicate where commercial developments are already providing some landscaped area and how this could be enhanced without significant competition for space.

OTHER OPTIONS PREVIOUSLY RECOMMENDED

A previous report to ACT Government (Tait Network 2018) was focused on residential development but also made recommendations relevant to estates and to streetscapes. These are summarised below.

Suburb Level

A significant proportion of trees at the suburb level are located in the public realm within public open space. The current Estate Development Code specifies areas per population for district parks and areas for neighbourhood parks but not for town parks or public open space, which tend to be defined by adjacent development areas or existing topography. Functions for Town parks may have shrub or flower beds but no mention is made of trees. Similarly, trees are not specifically listed as a feature of public open space which may include remnant and planted native vegetation.

Therefore, Tait Network (2018) made the following recommendations:

- Open Space Control - Open space provision needs to be added by implementing a new rule that allocates minimum percentage of neighbourhood to open space. This rule is to be applied to developments greater than or equal to twenty hectares. Where specific site conditions such as creek lines, areas of environmental significance etc. exist, protection would be afforded through the Precinct Code.
    - Proposed Rule: A minimum of 30% of development boundary is zoned PRZ1 or NUZ3 for developments 20ha or greater
- Public Realm Canopy Cover Control - Implementation of additional rule that allows for an assertive approach towards creating a minimum canopy cover for public open space.
    - Proposed Rule: A minimum 40% of canopy cover is provided in the public realm with exception to street verges, street medians, access ways & pedestrian lanes.
- Remnant Trees - Implementation of provisions regarding retention of remnant trees to give instant shade while landscaping matures and provide habitat.
- Shading of Footpaths - Revision of Rule 25 of the Estate Development Code to make the rule mandatory, ensuring the comfort and liveability of the public realm is addressed.

Street Level

Currently there is no requirement for a minimum provision of canopy cover for streets. Allocating a minimum canopy coverage based on street type can help reduce the urban heat felt in suburbs. Recommended targets (Tait Network 2018) were:

- No more than 30% of the finished street verge surface is impervious
- Need to increase available planting area in street verges
- Shared use Access Street 'woonerf' Style to provide more than 40% street trees
- Access street A to provide 40% street trees
- Access street B to provide 40% street trees
- Minor Collector to provide 25% street trees
- Major Collector to provide 30% street trees

Tait Network (2018) also made recommendations about what would need to change about the design of streetscapes to achieve these outcomes:

- Location of services - there is a need for more efficient location of services that result in an increase of soil volume. Measures may include location of services in shared corridors and under footpaths.

- Permeable verge control - review the Estate Development Code to improve permeability in the verge with a maximum impermeable area (30% recommended as listed above)
- Tree clearances - by modifying the current approach towards tree clearance, it can better support the specification of large trees in street planting.
- Verge parking - implement community education programs on the negative impact to living infrastructure of parking on verges.
- Trees in median - better street configuration in larger streets can create opportunities for large trees to be planted in a median and to enable WSUD treatment.
- Permeable materials - implement incentives to use permeable materials in construction, including the use of permeable pavers, permeable concrete, and permeable asphalt.

6.3 RECOMMENDED APPROACH TO PLANNING PROVISIONS

The recommended approach to planning provisions draws on previous recommendations and the approaches in place elsewhere, noting that planning provisions around Australia are gradually emerging to better address green infrastructure, urban heat and water in the landscape, therefore approaches are evolving. Around Australia, other jurisdictions are also seeking approaches that are practical, and that strike a reasonable balance between various goals.

The Statement of Requirements for this project asked for "an assessment of the impact of each recommended approach on the financial and practical feasibility of development" (ACT Government 2021c).

The following sections describe how financial and practical feasibility has been considered in the approach to planning provisions.

A PRAGMATIC APPROACH

Many planning provisions elsewhere include a mix of quantitative performance-based provisions and non-quantitative principles of good design. This is also recommended for ACT. This approach suits topics like green infrastructure, urban heat and water sensitive urban design (as well as urban design more generally), where planning provisions aim to encourage good design with clear principles and a few measurable benchmarks, without being overly prescriptive on topics where the design process needs to balance multiple objectives at a site-specific level.

Therefore, in this report two types of provisions have been recommended:

1. Performance-based outcomes, each of which is associated with a quantitative performance 'benchmark'.
2. Guiding principles, which are qualitative in nature.

Benchmarks provide certainty and a simple assessment pathway for most developments. Guiding principles provide clear direction without being overly prescriptive.

Table 17 outlines the considerations that have been examined in working out what type of benchmarks should apply and in recommending appropriate benchmark values. There is more explanation following the table, and it also points to more detailed information elsewhere in this report.

One of the features of the canopy cover and permeable surface area benchmarks recommended in this report, mentioned in Table 17, is that they do not attempt to act as 'pseudo site coverage controls'. ACT's planning system already includes requirements for maximum site coverage and setbacks where this is considered important. However, in commercial (and some other) zones, there are limited requirements for setbacks, and up to 100% site coverage is allowed. This helps create street-focused, walkable centres.

For this reason, when it comes to commercial blocks, the preferred approach is to apply canopy cover and permeable surface area benchmarks only to those parts of the block beyond the building footprint, and to allow planting on structures (e.g. over a basement) to count as permeable area. Deep soil requirements are not recommended for commercial zones, as deep soils are usually defined to exclude any soil on top of a structure, therefore they act as a site coverage control.

Of course, some living infrastructure can be incorporated onto buildings – for example, green roofs and walls. However, these are expensive to install and maintain. Planning provisions should encourage this type of infrastructure, but it should not be essential to meet living infrastructure provisions in any development.

Table 17: Financial and practical considerations in setting benchmarks for living infrastructure, urban heat and water in the landscape

	What is typical elsewhere	Financial and practical considerations	What has been explored in more detail
Living infrastructure benchmarks	Planning provisions have always included some controls pertaining to living infrastructure, however the approach is evolving to provide greater emphasis on canopy cover as a key measure. Therefore, tree canopy cover requirements are becoming more common. One of their common features is that requirements are typically expressed as a percentage canopy cover for the site.	• Tree canopy should be provided in all parts of a development (i.e. on blocks, in streets and in public open space). • Commercial blocks and small estates have limited flexibility and a range of constraints. Living infrastructure requirements should not act as a pseudo site coverage control (see below). • Green roofs, walls and other vegetation on structures should be encouraged, but as these are expensive options, they should not be essential to meet living infrastructure provisions. • Living infrastructure provisions need to work with existing requirements (under review) for significant trees and other protected vegetation.	A range of options were considered for canopy benchmarks. Consideration was given to both: • Where benchmarks should apply (i.e. to estates, streets, public open space, development blocks, parts of the block). • At what level they should be set. The analysis of options is covered in Section 8 of this report.
Urban heat benchmarks	Planning provisions for urban heat are less common, though are gradually emerging. Where they do exist (or are in draft), they typically focus on specific elements of the development, which may include cool roofs, cool paving, shade and irrigation. There are modelling tools available for urban heat, and rating tools are emerging, but they are not yet adopted in planning provisions.	If proponents are asked to perform a microclimate or urban heat assessment: • It needs to be clear what measurable outcomes it is trying to achieve. • Suitable guidance also needs to be available to make sure that proponents are taking a consistent approach and that development assessment staff can review the outputs. • The complexity of the approach needs to suit the scale of development. Even if urban heat assessment is suitable for some developments, a simpler approach may be required for others.	This report (Section 5) includes a review of the practicality of existing available urban heat assessment approaches including simulation tools, rating tools and semi-quantitative assessment.
Water in the landscape	Planning provisions for water sensitive urban design are common, but existing provisions do not usually emphasise retaining water in the landscape – the focus is typically on treating stormwater runoff to reduce pollutant loads. There are some recent examples of requirements for permeable surface area, expressed as a percentage of the site. Runoff reduction targets are another (potentially complementary) option.	• ACT already has a control within the WSUD Code for "a minimum of 20% of the site area to be permeable". However, this could act as a pseudo site coverage control, which is not recommended for small estates or commercial blocks (see below). • There is likely to be a natural preference to meet permeable surface area requirements with planting on grade wherever possible, as this is a relatively low-cost option. Planting on structures and permeable paving are alternative options but are more expensive, therefore should not be essential to meet the benchmarks. • Other measures could also be encouraged to retain water in the landscape, such as passive irrigation and WSUD features that retain water for infiltration/evapotranspiration.	A range of options were considered for permeable surface area benchmarks in Section 8 of this report, alongside the canopy cover assessment. A runoff reduction target is discussed as a potential future option in Section 9 of this report.

REALISTIC BENCHMARKS

The recommended canopy and permeability benchmarks are set for various different parts of the development:

- Commercial blocks are broken into the building footprint, surface carpark (if there is one) and the surface open space and movement network, with different benchmarks applicable to each.
- Estates are made up of different components, each of which would have its own benchmark:
    - Development blocks
    - Public streets
    - Public open space

This approach allows a realistic benchmark to be set for each part of a development. The approach can accommodate any type of estate, as the benchmark for the estate would be determined based on its individual components.

It means that in most commercial developments and some estates (e.g., estates in denser infill areas), the canopy and permeability benchmarks would be less than the Territory-wide 30% by 2045 targets. This is considered reasonable for a range of reasons:

- Commercial zones and high-density development also needs to meet other objectives (e.g. vibrant streetscapes and walkable centres) and it is not considered appropriate to limit site coverage beyond existing controls.
- It is also not appropriate to make expensive infrastructure like green roofs essential.
- Other zones and lower-density areas will be able to incorporate higher canopy cover and permeability, balancing the outcome for the ACT's urban area as a whole.

It is also worth noting that the urban heat outcomes would still be strong:

- When considering the UHI at a city scale, the combination of cool roof, cool paving, canopy and permeable surface controls would have an impact across most parts of the development footprint.
- When considering microclimate at a human scale, canopy cover (as well as other urban heat controls) would be required in the places people are most likely to be present – surface carparks, surface open space and movement networks, public streets and public open space.

TRANSPARENT BENCHMARKS

In Section 8, canopy cover and permeable surface area has been analysed in existing development. This provides a point of reference as to where proposed benchmarks sit in relation to existing development. Stakeholders who have reviewed this analysis have been able to see how realistic or ambitious the proposed benchmarks are, and they have provided informed input on what they would consider appropriate. Their input has been taken into account in the recommendations.

The transparency of the approach also means that if ACT Government wishes to strengthen the benchmarks in the future, this analysis remains a relevant point of reference. For example, in the future when the Municipal Infrastructure Standards are updated, higher canopy cover and permeable area may appear more achievable in public streets.

COST-EFFECTIVE MEASURES

It has been mentioned above that green roofs and green walls are deliberately included only as an optional measure, as they are expensive to install and maintain. This has also been a consideration in leaving other items as recommended but not essential to meet the benchmarks, including irrigation systems and water features.

There are cost-neutral alternative materials available to meet cool roof and cool paving benchmarks.

ALTERNATIVE OPTIONS

It should be noted that when a development cannot meet the benchmarks, the intention is that the developer should have the option to propose a different approach that also aims to meet the same objectives.

It is noted that flexibility is necessary for all development, regardless of size, particularly those with challenges such as contamination constraints.

At this stage, there is not much guidance available to proponents about how they would demonstrate an equivalent outcome. In Section 9.4 of this report, there are several recommendations focused on addressing this gap in the future.

7 PROPOSED PLANNING PROVISIONS

A set of planning provisions, including design criteria and measures, is recommended to address the planning objectives.

7.1 SCOPE: ESTATES AND COMMERCIAL ZONES

The scope of this project includes estates and commercial zones. Within each of these broad categories, there are many different types of development.

Commercial zones include six different types. Within these zones, there are both development blocks and streets. When considering planning provisions for commercial development, the main focus has been on commercial blocks.

Types of estates were discussed in Section 2.2. Estates cover a broad range of development types, from small redevelopments to whole new suburbs. They may include any or all of the 23 different land use zones defined in the Territory Plan. A common feature of estates is that they typically include some public land (e.g. public streets and public open space) as part of the development.

Therefore, when considering planning provisions for estates, the focus has been on provisions that are either applicable to the estate as a whole, or to the public land within the estate. Development blocks within the estate will be subject to their own planning provisions. These will include the following:

- Residential blocks are covered by living infrastructure provisions in DV369
- Commercial blocks will be covered by the living infrastructure, urban heat and water in the landscape provisions recommended in this report.
- Community Facility Zone blocks are the subject of a separate supplement to this report.

Two important types of estates are identified in this report:

1. Greenfield residential estates where the land has not been previously developed for residential or other use and will require an Estate Development Plan
2. Other estates i.e. developments that require an Estate Development Plan in locations that have previously been residential or other development

There are different opportunities to address living infrastructure, urban heat and water in the landscape in these two different types of estates, due to their different scales. Therefore, some additional provisions have been proposed for greenfield residential estates.

Note that this project, being focused on estates and commercial development, has not proposed planning provisions and benchmarks for every type of development block, public street or public open space. The Community Facilities Zone is covered by a separate supplement to this report. Remaining gaps are identified in Section 9, and include:

- Urban heat provisions for residential blocks (DV369 does cover living infrastructure).
- Provisions for industrial development and other land use zones.
- Additional detail addressing all types of public streets and public open spaces.

7.2 DESIGN CRITERIA

The following sections recommend a set of design criteria and measures which address the objectives in Section 4 for enhancing living infrastructure, reducing urban heat, and retaining water in the landscape.

The design criteria are intended for consideration for incorporation into the Territory Plan as development controls. Higher-level goals and objectives (from Section 4, and included below to provide a structure within which the design criteria are organised) are potentially useful for incorporation into the Territory Plan as high-level policy objectives, however these are not intended as development controls.

These design criteria and measures are organised into three groups:

- Living infrastructure (Table 18)
- Urban heat (Table 19)
- Water in the landscape (Table 20)

Design criteria are further organised into existing rules, performance-based criteria and principles for consideration. Where a criterion is performance-based, then a quantifiable benchmark is recommended against which performance can be measured. These benchmarks are not intended to be mandatory, as flexibility will be required for sites that cannot achieve them. For example, at some sites, it may not be possible to achieve tree canopy benchmarks due to constraints such as biodiversity or contamination that limit tree planting. In these cases, alternative measures should be proposed to meet the same objectives.

Note that there is also a third type of design criteria, which is covered by existing rules. These are included for a complete picture of all the relevant planning provisions related to each objective.

The final column of each table include key points about how each criterion is to be applied, and refers to further information available in the separate technical guidance document.

Figure 16 illustrates the structure of the provisions. Figure 17 shows where benchmarks have been proposed for greenfield residential estates, and Figure 18 shows where benchmarks have been proposed for other estates.

This format, organised into design criteria supported by quantifiable measures where appropriate, and more detailed technical guidance material provided separately, is intended to suit the ACT Government's current Planning System Review and Reform Project, however drafting and format will need to be adapted by the ACT Government prior to adoption.

Two key new measures recommended in this report are canopy and permeability benchmarks for different parts of development. These are explored further in Section 8.

Other new measures recommended include cool roofs, cool paving and cool façades. These are defined in the technical guidance.

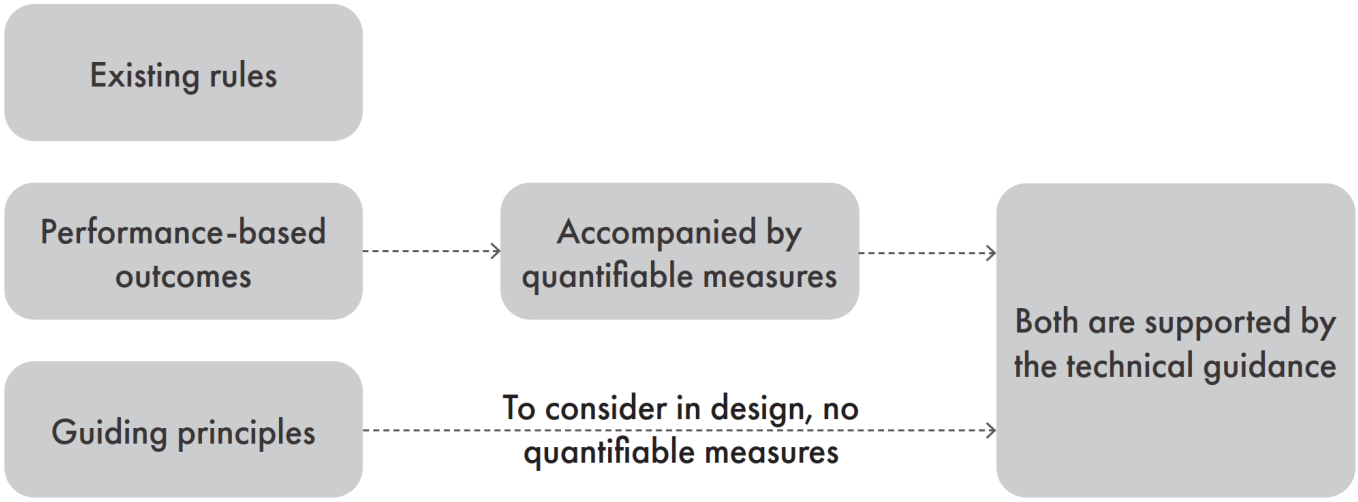


Figure 16: Types of design criteria included in the proposed planning provisions

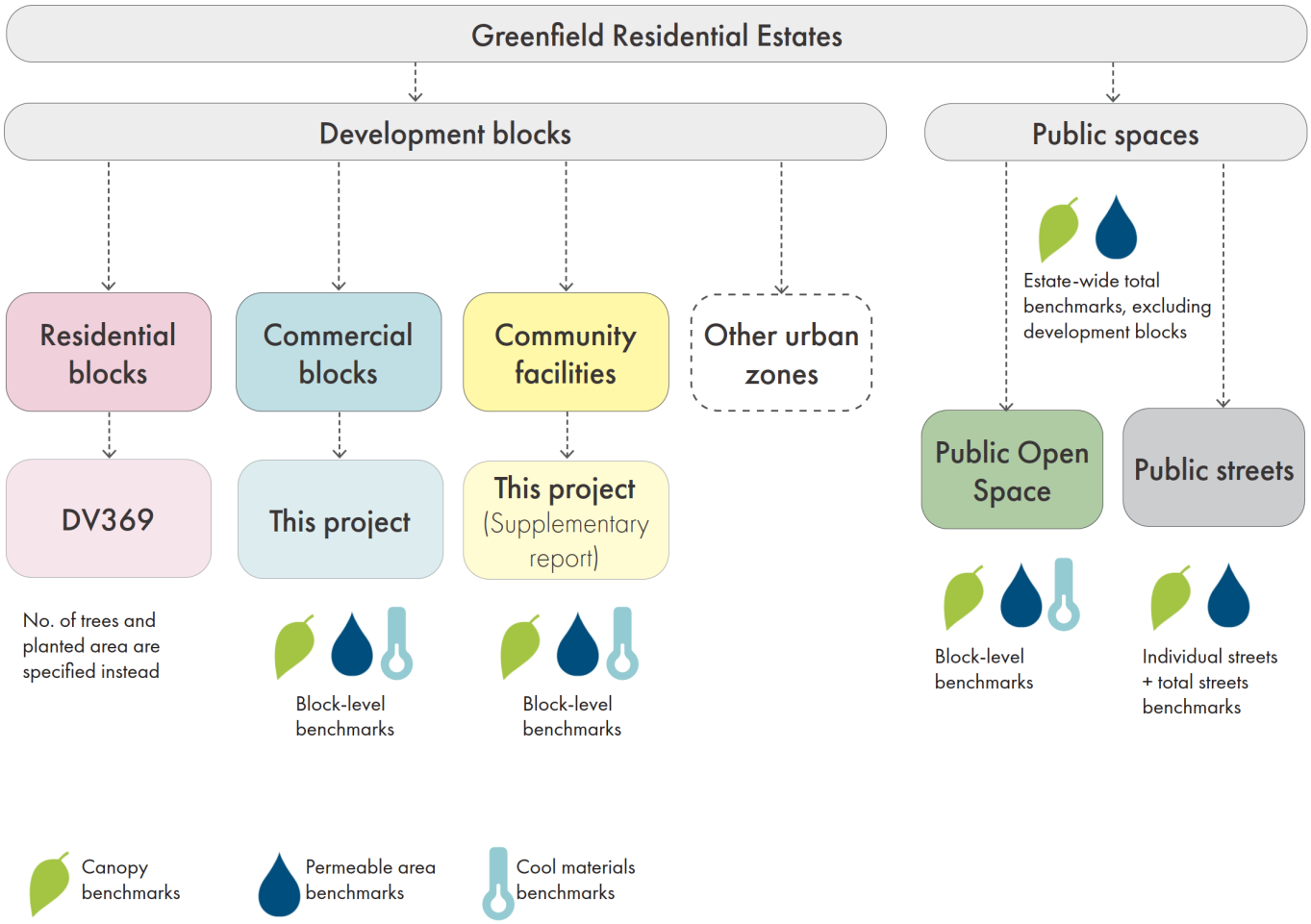


Figure 17: Main benchmarks proposed for greenfield residential estates

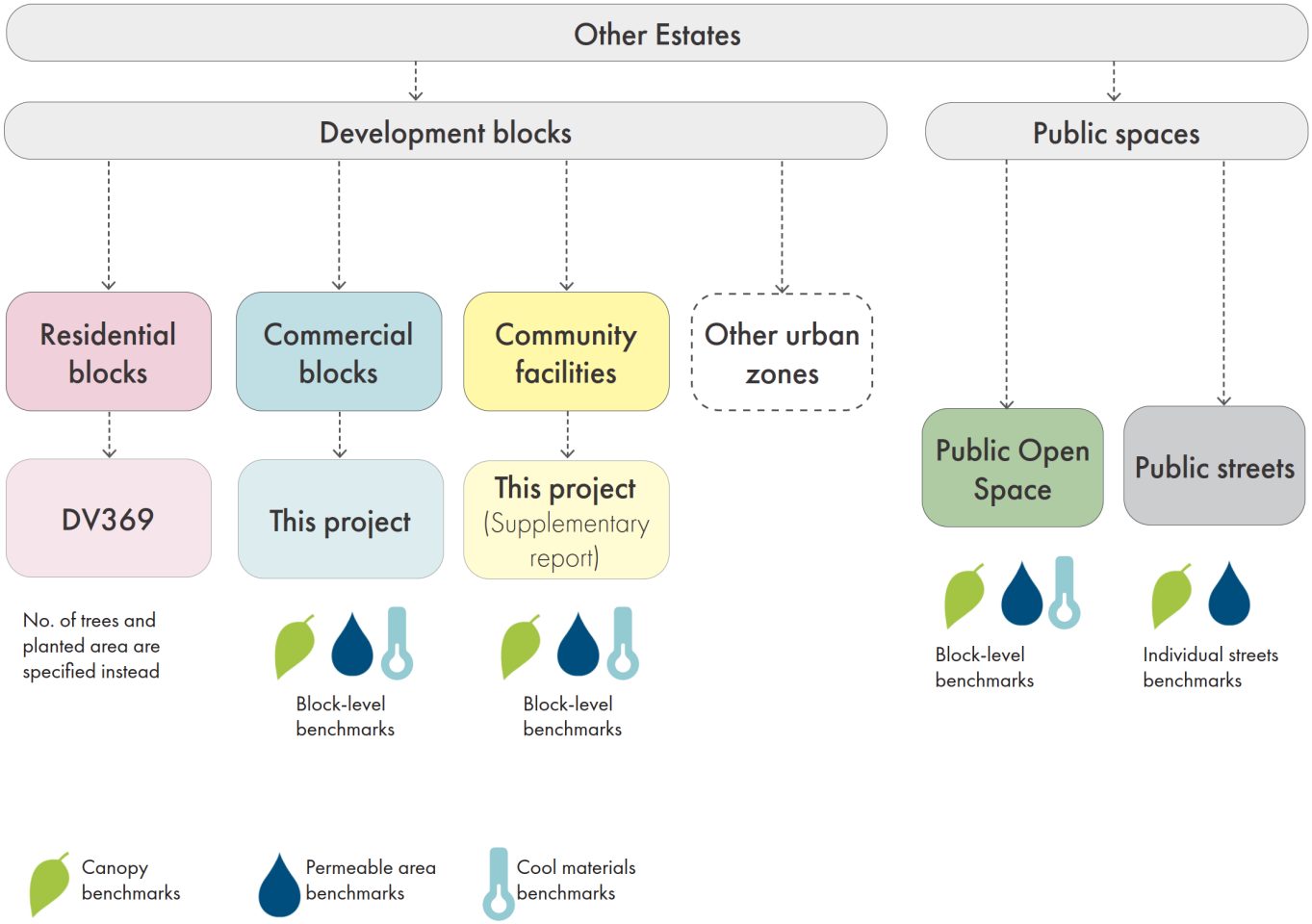


Figure 18: Main benchmarks proposed for other estates

7.3 LIVING INFRASTRUCTURE

There are some relevant existing rules that direct this planning – for example, requirements to retain high value vegetation and provide access to open space from residential blocks.

To meet Goal L1, proposed new provisions focus on canopy cover and other planting, as well as measures such as soil volume and access to water, that will support trees and other vegetation. There are several performance-based measures proposed, these are discussed below and listed in Table 18.

To meet Goal L2, proposed new provisions emphasise provision of green infrastructure in the urban environment where people are most likely to benefit. There are existing relevant provisions relating public realm access in the Estate Development Code. Proposed guiding principles emphasise access to green infrastructure.

As noted above, Goal L3 and the associated objectives are largely beyond the scope of this project. There are some relevant existing provisions identified and some additional guiding principles are proposed, to capture ideas at the intersection of living infrastructure, urban heat and water in the landscape.

CANOPY

Section 8 recommends benchmarks for canopy cover in greenfield residential estates, other estates and commercial blocks.

Street trees make an important contribution to overall canopy cover in the city, but streets are also complex spaces which need to meet multiple competing needs. Section 8 only includes basic canopy cover benchmarks for public streets. Section 9 recommends future work to develop more specific benchmarks for different street types and to update the Municipal Infrastructure Standards where they relate to street trees (e.g. the requirements for species selection and soil volume in streets).

Note that future canopy cover should be estimated based on the tree dimensions given in R39 in DV369 (refer to Table 32).

OTHER VEGETATION

DV369 includes a definition of ***planted area.*** This could also be useful to clarify the planning provisions for estates and commercial development, however the definition could be updated to refer to features more commonly seen in higher density commercial and mixed use development, such as podium planting.

In this report the emphasis is on ***permeable area***, which should be largely made up of ***planted area*** but can also include ***permeable paving*** – see below.

Note that the definition of permeable area should include:

- Any planted area with some capacity to absorb water, whether it be in deep soils or shallow soils on structures.
- Permeable paving.

Permeable area should be measured in plan, so vertical planting (e.g. green walls) should not be considered to make a contribution to the permeable area (if vegetation is planted into a planter bed or box visible in a plan view, this small area could be counted). Permeable area covered by a roof should also be discounted.

Section 8 recommends benchmarks for permeable area in greenfield residential estates, other estates and commercial blocks. Guiding principles emphasise a preference for planted area over permeable paving wherever possible (which is also likely to be lower cost).

Note that the definition of permeable area, as suggested above, would include green roofs and podium planting, however in Section 8, the benchmarks for commercial blocks exclude the building footprint, therefore planting on the building itself (i.e. green roofs, podium planting) would not count towards the benchmark. Podium planting, green roofs and green walls are encouraged via guiding principles but as they are high-cost options, the recommended benchmarks have been structured in a way that these features are not essential.

SOIL VOLUME

Soil volume requirements follow those established in R39 in DV369 (refer to Table 32). Rather than requiring deep soils (which act as a site coverage control), these requirements relate to the soil area and volume.

This approach puts the focus on canopy coverage as the key outcome, while soil plays a supporting role.

Table 18: Living infrastructure design criteria

Objectives	Design criteria	Where applicable	Type of criteria	Benchmarks against which performance-based criteria should be measured	Notes and further information
L1.1 Contribute to the ACT's tree canopy cover target of 30% by 2045	Include sufficient trees in the development to meet the relevant canopy cover benchmark for the development type when trees reach maturity.	Greenfield residential estates Other estates Commercial blocks	Performance-based outcome	Canopy benchmarks for different development types – refer to Section 8	Estimate future canopy cover using the tree dimensions given in R39 in DV369 (refer to Table 32). Refer to Technical Guidance Section 2.2 for further information.
	Protect existing high value trees	Anywhere existing vegetation is present	Existing/revised legislation	The *Tree Protection Act 2005* includes relevant requirements.	Note that this legislation is under review as part of a separate project.
	Plant trees into sufficient soil volume and soil quality for good growth and long-term health, including soils of sufficient depth and room for roots to spread laterally. Where there are constraints: • Consider providing extended soil zones under paved areas to enable larger trees • On structures, consider large planter beds sufficient to support trees	Anywhere new trees are planted to meet canopy benchmarks	Performance-based outcome	Soil volume requirements as per R39 in DV369 (refer to Table 32).	Refer to Technical Guidance Section 2.4 for further information.
	Place trees where they can grow to a large size while minimising conflict with other infrastructure, both underground and overhead.	Anywhere new trees are planted	Guiding principle		

Objectives	Design criteria	Where applicable	Type of criteria	Benchmarks against which performance-based criteria should be measured	Notes and further information
	In general, select tree species which will provide dense, contiguous summer canopy coverage. In selecting trees, also consider: • Retaining existing trees that provide immediate canopy cover • Planting some fast-growing species and advanced stock to provide greater canopy cover sooner • Planting some species which may be slower growing but will provide greater canopy cover in the long term.	Anywhere new trees are planted	Guiding principle		Refer to the Technical Guidance Section 2.5 for further information.
L1.2 Maximise total green cover and vegetation density in the urban environment.	Maximise ***planted area.*** Aim to meet as much as possible of the relevant ***permeable area*** benchmark for the development type with planted area. Where opportunities for planted area are limited, permeable paving The remainder can be made up of permeable paving.	Greenfield residential estates Other estates Commercial blocks	Performance-based outcome	Permeable area benchmarks for different development types – refer to Section 8	Refer to the Technical Guidance Section 2.3 for further information. As noted in the proposed definition above, all planted areas should be counted in the total permeable area, even when the vegetation density and soil volume are relatively low – i.e. shallow planter beds on structures should be counted in the total permeable area.
	Maximise vegetation cover by considering every possible opportunity to provide planted areas, including: • Planter beds on structures • Green roofs However, also consider maintenance of planted areas to ensure their long-term sustainability. Design for simpler maintenance and avoid features unlikely to be maintained.	Commercial blocks	Guiding principle		Refer to the Technical Guidance Section 2.3 for further information.
	Maximise vegetation density by prioritising planting where there is access to sufficient soil volume, soil quality and water to support dense growth of trees, shrubs and understorey vegetation.	Anywhere new vegetation is planted	Guiding principle		

Objectives	Design criteria	Where applicable	Type of criteria	Benchmarks against which performance-based criteria should be measured	Notes and further information
L2.1 Provide green infrastructure where it is easily accessible to people in their everyday activities.	Prioritise canopy cover and other planting in places where people are more likely to be present – for example, around play areas, picnic areas, seating, amenities, along paths. Where space is limited, consider features such as green walls and planter boxes to increase access to green infrastructure.	Greenfield residential estates Other estates Commercial blocks	Guiding principle		
	Create a network of green spaces along walking and cycling routes, to support active transport and outdoor recreation.	Greenfield residential estates	Guiding principle		Refer to the Technical Guidance Section 2.1 for further information.
	Prioritise green infrastructure in streets with high place value and those likely to have higher pedestrian and active transport use.	Greenfield residential estates Other estates	Guiding principle		
L2.2 Improve equity of access to green infrastructure by considering the needs, values, motivations, uses, and barriers to engagement with various cultures and user groups.	Locate public open space within walking distance from all residents.	Greenfield residential estates	Existing rule	R67, Estate Development Code.	
	In locating public open space, consider residents with greater needs to access open space, for example those in higher-density housing.	Any development that includes a residential component	Guiding principle		
	Design green infrastructure that is accessible and appealing to the specific residents, visitors and user groups expected to inhabit the site, including people with limited mobility and other special needs. In commercial zone development, consider places where people spend a lot of time, particularly places where people live. Mixed use development needs quality green infrastructure on site, where it is accessible to all.	Commercial blocks, particularly in CZ5	Guiding principle		

Objectives	Design criteria	Where applicable	Type of criteria	Benchmarks against which performance-based criteria should be measured	Notes and further information
L2.3 Provide quality green infrastructure that encourages positive engagement with nature in the urban environment.	Public open space has a role to play in providing opportunities for engagement with nature. Provide opportunities for interaction with the natural environment (e.g. nature play, wildlife observation, community gardens).	Public open space	Guiding principle		
L3.1 Plant a diverse range of locally native species, considering species likely to thrive in a changing climate.	Select species likely to thrive in the local site context (e.g., soil conditions, moisture, solar exposure, frost exposure, room for roots and canopy to spread). For trees and other vegetation expected to have a long lifespan, select species that are tolerant of heat and other stresses.	Anywhere new trees or other vegetation is planted	Guiding principle		Refer to the Technical Guidance Section 2.5 for further information.
L3.2 Create habitat for a range of locally native wildlife	Protect existing high value vegetation	Anywhere existing vegetation is present	Existing/revised legislation	The *Tree Protection Act 2005* and the *Nature Conservation Act 2014* include relevant requirements.	Note that tree protection legislation is under review as part of a separate project.
	Wherever possible, include shrubs and understorey planting to support trees and to cover areas where trees can't be provided.	Anywhere new trees or other vegetation is planted	Guiding principle		Refer to the Technical Guidance Section 2.3 for further information.
L3.3 Link blue and green infrastructure.	Preserve natural waterways and co-locate green corridors	Greenfield residential estates	Guiding principle		Refer to the Technical Guidance Section 2.1 for further information.
	Where stormwater treatment is required, use vegetated stormwater treatment systems that combine the benefits of stormwater treatment with green infrastructure and water in the landscape. Smaller developments that do not trigger the WSUD Code requirements should still consider where they can use vegetation that would filter stormwater and reduce pollutant loads.	Any development that triggers WSUD Code requirements	Existing rule + guidelines on how to meet it.	WSUD Code Rule R6	ACT Practice Guidelines for Water Sensitive Urban Design.

7.4 URBAN HEAT

The proposed planning provisions for urban heat pick up those elements that are not covered by living infrastructure. These include:

- Layout and orientation of development for protection from summer sun, buffering from hot winds and access to cooling breezes.
- Shade
- Cool materials for roofs and paved surfaces.
- Water used for cooling purposes.

Each of these is discussed below and proposed provisions are listed in Table 19.

LAYOUT AND ORIENTATION

Layout and orientation are relevant at all scales of development, to provide protection from summer sun, buffering from hot winds and access to cooling breezes.

However, different opportunities apply at different scales and in different parts of a development.

Greenfield residential estates have more scope to consider layout and orientation of major features:

- The orientation of streets and location of open space will affect the ways in which air flows through the development.
- Within individual streets, the configuration of the street (including basic dimensions of key elements including roadway, verges, medians, paths and trees, as well as space allocated to underground/overhead services) will affect solar exposure, but trees can be strategically located to reduce exposure. There are several design considerations including the street orientation, width and depth of the street 'canyon'.

At block scale, the orientation of buildings and location of landscape features are relevant to solar exposure and air movement.

Layout and orientation are best addressed with guiding principles rather than strict requirements, as there are multiple considerations and existing rules that developers must comply with. For example, ACT's Residential Solar Access Provisions, which ensure minimum levels of solar access for residential dwellings in winter. There is potential for alignment between solar access provisions and design criteria for urban heat, and there is more information in the Technical Guidance.

SUMMER SHADE

Summer shade is important in urban development, to provide relief from solar exposure in summer (solar access is likely to be more desirable in winter). Canopy benchmarks will ensure a reasonable quantity of total shade, however, summer shade should be prioritised where people are more likely to be active outdoors.

The only place where a quantitative benchmark is recommended is for public open space, to ensure that summer shade is provided over key areas such as play equipment, picnic tables and seating. Shade structures are already commonly included in parks, and this requirement would formalise the practice. What is recommended is that summer shade cover can simply be measured when viewed directly overhead, as shadow diagrams for particular dates and times are not typically produced in landscape design, and are not likely to add significant value.

COOL ROOFS

Roofs often dominate commercial blocks, and therefore cool roofs are highly relevant here. Most roofs can use cool materials with no impact on building costs or performance (in fact they are likely to improve thermal performance of the building in warm weather). Many commercial buildings already use light-coloured roofs and a cool roof standard may lead to relatively little change, simply ensuring that these roofs do actually meet cool roof standards, and that they are used wherever possible. Areas of green roof, rooftop gardens, solar panels and service areas may be excluded from cool roof requirements.

Note that public open space typically includes relatively little roof area, however public buildings in these settings can set a strong example. Therefore it is recommended that the cool roof requirement be applied to public open space.

Proposed cool roof standard

At least 75% of the roof area is to meet nominated Solar Reflectance Index (SRI) values

Nominated SRI minimums:

- for roof pitch < 15°, 3-year SRI minimum of 64
- for roof pitch > 15°, 3-year SRI minimum of 34
- for terrace areas, 3-year SRI minimum of 28.

This standard should apply to all proposed roof areas, with the following specific exceptions:

- Heritage requirements preclude the use of cool roofing materials
- It can be demonstrated that glare would be a problem for particular locations above the building's roof
- Parts of the roof designed as a green roof and covered with vegetation are exempt from the calculation
- Parts of the roof where PV is mounted flat on the roof are exempt from the calculation(all other roof areas with PV count toward the Cool Roof calculation)

COOL PAVING

Anywhere paving is installed, it can potentially be designed as cool paving. Although with paving, reflected solar radiation, including reflected thermal radiation and light, can be an issue at microclimate scale. Therefore, some site-specific consideration is required to minimise these negative effects in places where people could be affected.

Therefore the proposed cool paving standard includes a range of materials which could be suitable in different situations.

In Table 19, it has been recommended that cool paving provisions should apply to commercial blocks and public open space.

In streets, paved surfaces dominate, and cool paving is a relevant consideration. However, road pavements need to meet strict standards and therefore rather than applying a general cool paving provision, it is recommended that cool materials be considered in a future update of the Municipal Infrastructure Standards – refer to Section 1.1.

Proposed cool paving standard

At least 75% of paved surfaces (other than public roads) should meet the following cool paving standard:

- The following types of paving will be considered 'cool paving':
- Paving with light-coloured aggregates, pigments and binders (e.g. fly ash, slag, chip, sand seals and reflective synthetic binders).
- High emittance and high albedo cement and asphalt (e.g. slag, white cement).
- Resin-based concrete (using natural clear coloured tree resins in place of cement to bind the aggregate).
- Light-coloured coatings (e.g. cementitious coating, elastomeric coating) including infrared reflective coatings, high white coatings, colour changing coatings.
- Thermochromic materials (intelligent coatings developed with nanotechnology that can applied to enhance the thermal and optical properties of pavements and reduced glare effect on pedestrians).
- Permeable paving (including porous asphalt cement, pervious Portland cement concrete, block pavements, reinforced grass pavements, vegetated pavements), providing it is installed on a subgrade with the capacity for infiltration or temporary storage of water below the pavement.

This standard should be applied to all other paving, except where:

- Heritage requirements preclude the use of cool paving materials
- It can be demonstrated that undesirable glare or reflected heat would cause unavoidable negative impacts in the particular context
- It can be demonstrated that paving is well covered by shade during summer

COOL FAÇADES

Cool façades are a particular measure recommended to combat the impact of reflective glazing by simply incorporating shade into the façade design. Extensive glazed façades may be relatively infrequent, but cool façade requirements can be a straightforward measure that adds a modest additional cost to buildings that are already adopting an expensive façade treatment.

Proposed cool façade standard

These standards are to be applied to a calculation of shade cover on 21 December on the east facing façade at 10am, northeast and southeast facing façade at 11.30am, north facing façade at 1pm, northwest and southwest facing façade at 2.30pm and the west facing faced at 4pm.

The extent of the vertical façade that comprise Reflective Surfaces must demonstrate the following minimum percentage shading of the façade:

Reflective Surface Ratio (RSR)	RSR <30%	RSR = 30%-70%,	RSR >70%
Minimum percentage shading for the first 12 m from the street wall or ground plane	No shading is required	1.5*RSR-45%	75%
Minimum percentage shading for the remaining extent of the building above the first 12 metres from the ground plane		0.8*RSR-24%	40%
Where it is demonstrated that shading cannot be achieved, maximum external solar reflectance	No maximum	62.5-0.75*RSR	10

Shading may be provided by:

- External feature shading with non-reflective surfaces;
- Intrinsic features of the building form such as reveals and returns; and
- Vegetation such as green walls

COOL ZONES

'Cool zones' captures the idea of places where it is possible to enjoy time outdoors, even when temperatures are very high.

Cool zones would be difficult to capture in a strict definition, however they are recommended with a guiding principle. A broad definition is proposed below.

Greenfield residential estates often include ponds or wetlands, and cool zones could be co-located with these.

Cool zones should also be considered in central public open spaces and in private open space where there is high use and it is considered appropriate to invest in elements such as water features.

A cool zone should include:

- Orientation for protection from summer sun and hot winds, and for access to cooling breezes.
- Shade in summer.
- Water that people can get close to (this could be an 'active' water feature such as a fountain, or simply a 'passive' feature such as a pond).
- Planting to reduce the impact of hard surfaces and encourage evapotranspiration.

Table 19: Urban heat design criteria

Objectives	Design criteria	Where applicable	Type of criteria	Benchmarks against which performance-based criteria should be measured	Notes and further information
H1.1 Across the urban area as a whole, maximise green cover and minimise impervious areas.	Refer to: *L1.2 Maximise total green cover and vegetation density in the urban environment.* *W1.1 Contribute to the ACT's permeable surfaces target of 30% by 2045.*				
H1.2 Where hard surfaces are required (e.g. roofs and paved areas), use 'cool materials' which reduce heat absorption.	Where paving is required and particularly where it cannot be shaded, use ***cool paving***	Commercial blocks, Public open space	Performance-based outcome	At least 75% of paved surfaces (other than public roadways) should be ***cool paving***	Refer to the Technical Guidance Section 3.7 for more information
	Provide ***cool roofs*** to all buildings	Commercial blocks, Public open space	Performance-based outcome	At least 75% of the roof area is to meet nominated Solar Reflectance Index (SRI) values	Refer to the Technical Guidance Section 3.5 for more information
	Consider light coloured materials for walls/vertical surfaces. However, also consider their potential negative effects and preferably use light coloured materials only where heat can be absorbed by surrounding vegetation	Commercial blocks, Public open space	Guiding principle		Refer to the Technical Guidance Section 3.6 for more information.
H1.3 Where green cover is provided, maximise its cooling effect by maximising soil volume, maximising vegetation density, and ensuring that vegetation has access to water.	Refer to: *L1.2 Maximise total green cover and vegetation density in the urban environment.*				
	Where practical, provide an irrigation system. However, note that irrigation systems require a long-term investment in operation and maintenance therefore are not suitable everywhere.	Anywhere new vegetation is planted	Guiding principle		
	Design for passive irrigation, where runoff from hard surfaces is directed into vegetated areas and allowed to soak into soils.	Anywhere new vegetation is planted	Guiding principle		Refer to the Technical Guidance Section 4.1 for more information.
H2.1 Orient site features to minimise exposure to hot summer sun, buffer	Where space allows, buffer hot westerly/north-westerly winds with urban forest and/or waterbodies (e.g., ponds or wetlands) on the upwind side of the site to reduce local air temperatures.	Greenfield residential estates	Guiding principle		Refer to the Technical Guidance Section 3.3 for more information.

Objectives	Design criteria	Where applicable	Type of criteria	Benchmarks against which performance-based criteria should be measured	Notes and further information
exposure to hot winds and maximise access to cooling breezes.	Where practicable, locate open space upwind of heat sensitive land uses such as schools, community centres, public transport hubs, hospitals, and child / aged-care facilities.	Greenfield residential estates	Guiding principle		Refer to the Technical Guidance Section 3.3 for more information.
	Where possible, orient streets to the cool easterly evening breezes, to help remove stagnant, heated air.	Greenfield residential estates	Guiding principle		Refer to the Technical Guidance Section 3.1 for more information.
	Street canyons should be configured to promote shade and ventilation to reduce local air and surface temperatures and improve outdoor thermal comfort.	Greenfield residential estates Other estates	Guiding principle		
	Prioritise canopy trees and shade structures on the northern and western sides of buildings.	Commercial blocks	Guiding principle		Refer to the Technical Guidance Section 3.2 for more information.
	Orient site features to make the most of cool easterly evening breezes, to help remove stagnant, heated air.	Commercial blocks	Guiding principle		
	Block or redirect hot summer winds using vegetation and/or built form features such as fences and walls.	Commercial blocks	Guiding principle		
H2.2 Maximise shade, particularly where people are likely to be active in hot weather.	Provide summer shade over outdoor spaces people will actively use. For example, this should include features such as: • In public open space: play areas, seating areas, paths • In commercial blocks: loading docks, outdoor work areas and outdoor break areas. • In streets: footpaths and bike lanes. Also provide adequate solar access to ensure comfort in winter.	Greenfield residential estates Other estates Commercial blocks	Performance-based outcome for public open space Guiding principle elsewhere	In public open space, 50% of play areas and 50% of seating should be shaded, as measured at solar noon on the summer solstice or when the sun is directly overhead.	Refer to the Technical Guidance Section 3.4 for more information.
	Where the site caters to those more vulnerable to heat stress (i.e. older adults and infants), also consider providing shade to areas such as: • Accessible car parking spaces • Main/accessible building entrance • Walkway between parking area and building entrance	Commercial blocks	Guiding principle		Refer to the Technical Guidance Section 3.4 for more information.

Objectives	Design criteria	Where applicable	Type of criteria	Benchmarks against which performance-based criteria should be measured	Notes and further information
	In general, prioritise shade over hard surfaces, to reduce their heating effect.	Greenfield residential estates Other estates Commercial blocks	Guiding principle		
	Integrate structures into building design to shade north and west facing walls	Commercial blocks	Guiding principle		Refer to the Technical Guidance Section 3.6 for more information.
	Provide shade over reflective façades	Commercial blocks	Performance-based outcome	Reflective façades need to meet a cool façade standard	Refer to the Technical Guidance Section 3.6 for more information.
H2.3 Use water in the landscape to provide evaporative cooling.	Create outdoor 'cool zones', which provides an opportunity to access the outdoors during hot weather while avoiding heat stress. A cool zone should include: • Orientation for protection from hot winds and access to cool breezes • Comprehensive shade cover in summer. • At least one water feature where people can get close to the water, preferably including some water movement.	Greenfield residential estates	Guiding principle		Refer to the Technical Guidance Section 3.8 for more information.
	Consider fountains, water play features and/or misters to provide active cooling in cool zones. However, active water features require a long-term investment in operation and maintenance, therefore are not suitable everywhere.	Commercial blocks	Guiding principle		Refer to the Technical Guidance Section 4.3 for more information.

7.5 WATER IN THE LANDSCAPE

Water can play an important role in supporting green infrastructure – trees and other vegetation needs access to water to grow and thrive. A reliable supply of water is also important for evapotranspirative cooling.

The design criteria in Table 20 are focused on these two roles of water – supporting green infrastructure and supporting cooling. An important concept underpinning these design criteria is that of retaining water in the landscape. Note that this generally complements existing WSUD provisions – this is discussed further below.

PERMEABLE AREA

Permeable area is the key performance-based outcome proposed in Table 20. Note that this provision, and the associated permeable area benchmarks, are intended to replace the existing rule in the WSUD Code (R9) which stipulates (for certain developments) a minimum of 20% of the site area to be permeable. The reasons why were discussed in Section 6.3 – refer to Table 17.

IRRIGATION AND PASSIVE IRRIGATION

The proposed planning provisions encourage irrigation but recognise that irrigation systems are not always appropriate. Irrigation is only recommended as an option to consider where there is a strong likelihood of irrigation systems being maintained in the long-term.

What is encouraged wherever possible is 'passive irrigation', whereby runoff from hard surfaces is directed via gravity into planted areas and encouraged to soak into the soil before excess runs off.

Urban trees and other vegetation often has minimal access to water, and passive irrigation could potentially make an important contribution to support canopy cover and other vegetation.

SUSTAINABLE WATER SUPPLIES

Using more water for irrigation and cooling purposes could potentially be at odds with water conservation objectives, however, access to sustainable water supplies could help overcome barriers to increased water use.

There are existing requirements for stormwater retention and reuse in the WSUD Code (Rule R2), and at this stage it is not proposed to change these.

OTHER WSUD PROVISIONS

Note that the WSUD Code includes other provisions that are beyond the scope of this project (including stormwater quality, hydrology, water conservation and wastewater management). Other than the permeable area provision, it is not proposed to change other WSUD provisions, as they are generally complementary.

Table 20: Water in the landscape design criteria

Objectives	Design criteria	Where applicable	Type of criteria	Benchmarks against which performance-based criteria should be measured	Notes and further information
W1.1 Contribute to the ACT's permeable surfaces target of 30% by 2045.	Include sufficient ***permeable area*** to meet the relevant ***permeable area*** benchmark for the development type.	Greenfield residential estates Other estates Commercial blocks	Performance-based outcome	Permeable area benchmarks for different development types– refer to Section 8.	Permeable area can include planted area and permeable paving. Refer to the Technical Guidance Section 2.5 for more information.
	Planted areas are the preferred type of permeable area, as plants naturally maintain the permeability of soils. Wherever possible, maximise planting density, as planting density is generally correlated with greater capacity to intercept rainfall and reduce runoff.	Anywhere a permeable area benchmark applies	Guiding principle		
	Permeable paving can be used to contribute to the total permeable surface area. Where permeable paving is proposed, there needs to be a viable plan for its long-term maintenance, to ensure that its permeability can be maintained.	Anywhere a permeable area benchmark applies	Guiding principle		Refer to the Technical Guidance Section 4.1 for more information.
W1.2 Minimise 'directly connected' impervious areas by directing runoff from hard surfaces into planted areas, where it can soak into soils.	Wherever possible, provide a vegetated buffer between impervious areas and drainage systems, so that runoff has an opportunity to soak into soils before overflowing into the drainage system. • For small impervious areas (e.g. paths), this could simply involve directing runoff into adjacent planted areas • For larger impervious areas, use a buffer strip, swale, or rain garden.	Greenfield residential estates Other estates Commercial blocks	Guiding principle		Refer to the Technical Guidance Section 4.1 for more information.
	Improve infiltration with soil improvements, deep rooted plants and capacity for water detention.	Anywhere new vegetation is planted	Guiding principle		Refer to the Technical Guidance Section 4.1 for more information.

Objectives	Design criteria	Where applicable	Type of criteria	Benchmarks against which performance-based criteria should be measured	Notes and further information
	In urban environments, there is a need to address the potential negative impacts of infiltration on surrounding infrastructure. Allow a sufficient buffer or use a physical barrier between infiltration zones and underground structures.	Anywhere passive irrigation or infiltration is proposed	Guiding principle		Refer to the Technical Guidance Section 4.1 for more information.
W1.3 Retain water in features like ponds and wetlands, from where it can evaporate.	Consider WSUD features such as ponds and wetlands, which retain water for evaporation. Size these features appropriately for the site, considering how much water will be captured from the catchment area, how much will be lost to evaporation, and the potential to provide top up from a sustainable water supply.	Greenfield residential estates	Guiding principle		Not all stormwater treatment systems retain water. Refer to ACT Practice Guidelines for Water Sensitive Urban Design for more information.
W2.1 Capture rainwater or treated stormwater and store for reuse, to enable flexible, unrestricted water use for irrigation and cooling purposes.	Harvest either rainwater or treated stormwater for reuse.	Greenfield residential estates Other estates Commercial blocks	Existing rules	Existing requirements for stormwater retention in the WSUD Code (Rule R2).	ACT Practice Guidelines for Water Sensitive Urban Design
	Connect rainwater/treated stormwater to irrigation systems, to top up water features and other outdoor water use.	Greenfield residential estates Other estates Commercial blocks	Guiding principle		Refer to the Technical Guidance Section 4.2 for more information.

7.6 APPLYING THE PROVISIONS

Most of the planning provisions in Table 18, Table 19 and Table 20 could be applied to a wide range of different estates and commercial developments. However, there will be some small-scale developments (e.g. alterations and additions, development applications for signage or only for change of use) where it does not make sense to apply the provisions.

Table 21 recommends specific situations when and how proposed planning provisions should apply. Note that existing rules mentioned in the tables above (e.g. WSUD Code rules) already have defined thresholds where they apply, and no changes to these are recommended.

Table 21: Development to which proposed planning provisions should apply

Development types to which provisions should apply	Applicable planning provisions	Specific situations when and how provisions should apply
Large residential and other estates.	All provisions relevant to estates	The trigger to apply the planning provisions could simply be whenever an Estate Development Plan is required.
Commercial blocks.	Canopy and permeable area benchmarks and soil volume requirements	When development includes building/landscaping works which will change the site's canopy cover and/or permeability: • If the new development maintains block-level canopy and permeability at or above the relevant benchmarks, then it should be considered to comply with the benchmarks. • If the new development would reduce the block-level canopy area or permeable surface area below the benchmarks, then it will need to include measures elsewhere on the block, that bring the block up to the benchmarks. • If the existing block is below the benchmarks, then the new development should rectify this in proportion to the area being developed. i.e., the benchmarks should be applied to the part of the block being developed Development Applications not involving building or landscaping works (e.g. signage) should be excluded.
	Cool materials benchmarks	These should apply whenever a substantial area of new roofing or new paving is constructed. This could be defined with its own specific threshold, however there are already a range of thresholds to define when a new building or area of paving would trigger the need for a development application, and therefore the best approach may simply be to say that any time a new roof or new paved area is part of a development application, then it needs to meet the cool roof or cool paving standard.
	Cool façade benchmark	The proposed cool façade standard is written in such a way that it defines within it that it needs to be applied when the Reflective Surface Ratio (RSR) of the proposed façade is greater than 30%.
	Other provisions (guiding principles) relevant to commercial blocks	Whenever either of the above are triggered, then the relevant guiding principles should be applied as well.

7.7 ASSESSMENT

When a development application needs to respond to the proposed planning provisions for living infrastructure, urban heat and water in the landscape, then the following should be submitted:

- As part of the Landscape Master Plan, show proposed canopy cover, planted area, total pervious area, and include schedules that show how future canopy cover has been estimated and appropriate soil area and volume have been allowed. Where shade provisions apply, this should also show shaded areas.
- A cool materials plan that shows roof and paved areas and identifies the materials proposed for these areas. For roof products, include manufacturer's information confirming SRI values.
- Where a reflective façade is proposed, submit drawings showing how it would be designed to meet the cool façade standard.
- A brief response to each of the design criteria should be included to explain how each has been considered.

If a development will deviate from the benchmarks, then evidence should be provided how it will meet the intent of the objectives. It will be up to each developer to demonstrate how their proposed approach would achieve equivalent outcomes. Currently, available guidance and tools provide relatively little information to support the assessment of alternative approaches – this is a future need that is discussed in more detail in Section 9.

8 CANOPY AND PERMEABILITY ASSESSMENT

A set of canopy and permeability benchmarks are recommended based on assessment of existing development and test cases

8.1 FRAMEWORKS INVESTIGATED

A variety of potential canopy and permeability benchmarks have been investigated. The options investigated were sourced from Australian precedents, stakeholder feedback and the test sites investigation included in Appendix B.

The following sections outline the options investigated for commercial development, greenfield residential estates and other estates.

These have led to a set of recommendations (Section 8.2). the implications of these recommendations are explored in Section 8.3.

In order to set benchmarks the urban form of cities was considered. As illustrated in Figure 16 cities are comprised of public streets, public open space and development blocks. It was established that all zones can be separated into the following parts – public streets, public open space, and development blocks. This framework allows benchmarks to focus on similar elements across all zones while accounting for a variety of development types.

With the exception of greenfield residential estates establishing benchmarks for public streets and public open space is outside the scope of this project. However, due to the important of these elements in improving living infrastructure and permeability outcomes across the city we have explored possible frameworks for establishing benchmarks and recommended an approach for future projects – see also Section 9.1 Additional benchmarks.

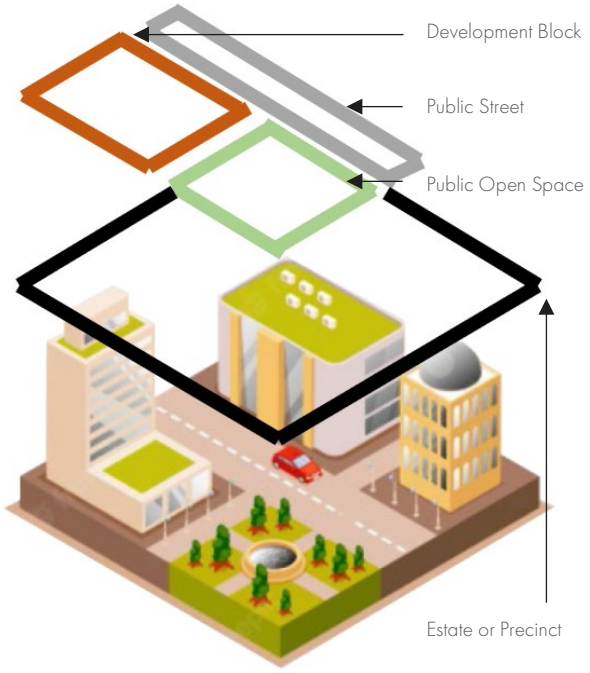


Figure 19: Showing diagram of public open space, public street and development blocks within an estate or precinct source: https://www.freepik.com/

COMMERCIAL DEVELOPMENT

The analysis undertaken in Section 2.2 and Appendix A investigates commercial precincts based on land-use zoning. It was noted that development within commercial zones have high variation in building footprint, building typologies, building heights, canopy coverage and permeability. Land ownership (public or privately leased) was also noted as a critical factor when exploring possible assessment options.

A series of frameworks were considered for establishing benchmarks within commercial zones. Options considered for each element of commercial zones are listed below - Table 22 (development blocks), Table 23 (public streets) and Table 24 (public open space).

GREENFIELD RESIDENTIAL ESTATES

Table 25 lists frameworks investigated for to establish benchmarks for greenfield residential estates, that is greenfield development that has not been previously developed for residential purposes.

OTHER ESTATES

Table 26 lists options investigated for other estates, including urban renewal estates as well as commercial and industrial estates.

Table 22: Frameworks considered for development blocks within commercial zoning.

	Benefits	Risks	Action	Reference Image
Benchmarks by Precinct	Allows individual blocks within a precinct to have different requirements while achieving a precinct wide benchmark	Difficult to implement a block benchmark without knowing the other typologies and benchmarks within the precinct. Possibility of each development block passing delivery on to next block	Not recommended	
Benchmarks by Place and Movement Framework	Opportunity to prioritise canopy coverage in areas with higher movement and place metrics	Requires the classification of streets and civic spaces based on place and movement, not currently within the ACT system	Not recommended	
Benchmarks by Land Use Zone	Uses an existing land use category within the Territory Plan	Many developments typologies can be built within the same zone across a range of public and privately held land, complex to apply a one size fits all set of benchmarks	Not recommended	 Land Use

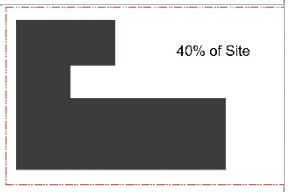
	Benefits	Risks	Action	Reference Image
Benchmarks by Development Typology	Controls can vary based on a particular built form typology on block	Typologies found within commercial zones are difficult to classify as many buildings contain multiple types (office, retail etc.)	Not recommended	
Benchmarks by Block	Benchmarks could be applied on a block by block basis	Will likely become a pseudo site coverage control which will impact commercial building footprint, not considered appropriate for this type of typology	Not recommended	
Benchmarks by on Block Elements (Surface Movement & Open Space, Surface Carpark)	Allows for a simple set of controls for similar elements across a variety of land use zones	Will require definitions that don't currently exist in the Territory Plan	Recommended	

Table 23: Frameworks considered for public streets within commercial zoning.

	Benefits	Risks	Action
Benchmarks by Land Use	Uses an existing land use category within the Territory Plan	May apply different benchmarks to the same or similar street typologies solely because they are in different land use zones	Recommended for permeability benchmark only
Benchmarks Based on Hierarchy	Groups streets using an existing classification	Streets typologies in commercial zones are largely Access Roads which have a similar typology	Not recommended
Benchmarks by Place and Movement Framework	Prioritises areas with higher movement and place	Requires the classification of streets and civic spaces based on place and movement	Not recommended
Benchmarks Based on Hierarchy + Land Use	Controls would vary depending on hierarchy and urban context	This would result in a large number of combinations many of which do not currently exist in ACT	Not recommended
Minimum Public Streets Benchmarks	Provides a simple minimum across all public street types regardless of classification or land use zone	May cause issues for particularly constrained streets	Recommended for canopy benchmark only

Table 24: Frameworks considered for public open space within commercial zoning.

	Benefits	Risks	Action
Benchmarks by Land Use	Uses an existing land use category within the Territory Plan	May apply different benchmarks to the same or similar public open space typologies solely because they are in different land use zones	Not recommended
Benchmarks by Place and Movement Framework	Prioritises areas with higher movement and place	Requires the classification of open spaces based on place and movement	Not recommended
Benchmarks by Public Open Space Typology (Parks, Laneways, Buffers etc)	Controls would vary depending on the typology	Would require new definitions and classifications	Recommended
Minimum Open Space Benchmarks	Provides a simple minimum for each public open space type regardless of typology or land use zone	Unable to mandate higher benchmarks where appropriate to that typology	Recommended intermediate solution

Table 25: Frameworks investigated for greenfield residential estates

	Benefits	Risks	Action
Benchmarks for Development Blocks	Residential development blocks covered in DV369 Commercial development blocks covered by proposed commercial zones benchmarks above Community facilities development blocks covered by proposed benchmarks in separate work stream Industrial development blocks subject to future project		
Individual Street Benchmarks	Prevents streets from having extremely low canopy and permeability	Minimum may have to be set by the lowest-performing typology	Recommended
Total Streets Benchmark	Would allow the estate developers to balance benchmarks for less constrained streets	This may result in the uneven spread of street trees	Recommended
Individual Public Open Space Block Benchmarks	This would result in each public open space having a minimum benchmark	Unable to mandate higher benchmarks where appropriate	Recommended
Total Public Open Space Benchmark	Would allow the estate developer to fit public open space trees where appropriate	May cause tree grouping in areas of low amenity to meet the benchmark	Not recommended
Total Estate Benchmark	Will allow developers to balance benchmarks in all areas of the estate	May incentivise public open space trees, as they are the cheaper and easier but have a lower amenity/cooling value than that of street trees	Recommended

Table 26: Framework investigated for other estates including urban renewal, commercial and industrial estates

	Benefits	Risks	Action
Benchmarks for Development Blocks		Residential development blocks covered in DV369 Commercial development blocks covered by proposed commercial zones benchmarks above Community facilities development blocks covered by proposed benchmarks in separate work stream Industrial development blocks subject to future project	
Estate wide benchmark	Provides a simple minimum to all estates	Smaller estates are less flexible and more variable	Not recommended
Benchmarks by zone	Would adjust for industrial, commercial, and industrial zoning	Many estates contain multiple land use zones	Not recommended
No additional benchmarks	Takes advantage of the benchmarks for the elements that make up an estate, leveraging off the benchmarks discussed above	Will not allow developer flexibility to balance canopy and permeability across a precinct	Recommended

8.2 RECOMMENDED FRAMEWORK

Having established the preferred approach through the assessment of the framework options above the following is recommended framework for further exploration.

It is noted that flexibility is necessary for all estate development, regardless of size, particularly those with challenges such as contamination constraints.

Recommendation

> Maintain flexibility for developers as benchmarks are translated into planning framework, to recognise the challenges that will face certain developments, for examples estates with contamination constraints.

Establish permeability benchmarks for surface open space & movement networks on development blocks

Exploration of recommended future work is included at Section 9.1 Additional benchmarks.

Exploration of recommendations for current project are included below at Section 8.3 Exploration of Recommended Framework.

Table 27: Summary of the recommended framework for Greenfield residential estates

Elements	Residential zones	Other land uses (e.g. commercial, community and industrial)
Development blocks	Covered by DV369, no need for further benchmarks	See Table 28
Public Streets	Current project: Individual streets Streets total	
Public Open Space	Current project: Minimum public open space blocks	
Estate	Current project: Estates total excluding development blocks	

Table 28: Summary of the recommended framework for all other development including other estates

Location	Residential Zones	Commercial Zones	Community Facility Zone	Industrial Zones	Other Urban Zones
Development block (E.g. "private land". Covers a large majority of standard development)	Covered by DV369, no need for further benchmarks	Current project: Surface carparks Surface Open Space/ Movement Networks	Current project – separate workstream	Future work	Future work
Public streets (Urban 'public street' DAs are rare outside of estates)	Recommended future work: Public streets permeability benchmarks by land use zone, minimum canopy benchmark for all public streets				
Public open space ('Public open space' DAs are rare outside of estates)	Recommended future work: Interim recommendation - canopy and permeability benchmark common to all public open space Ultimate recommendation - canopy and permeability benchmarks by open space typology				

8.3 EXPLORATION OF RECOMMENDED FRAMEWORK

Having established the recommended framework for benchmarks across commercial, greenfield residential estates and other estate categories a detailed exploration of precedents was undertaken to understand what is currently being delivered in terms of canopy coverage and permeability for each of these categories. This exploration is presented below with datasets established from precedents. See also illustrations at Appendix B. Having established the current range of canopy coverage and permeability a series of recommendations are made.

COMMERCIAL ZONES

As outlined above the recommended framework for commercial zones is:

- Development Blocks
    - Surface open space & movement networks
    - Surface carparks
- Public Open Spaces
- Public Streets

Exploration of public open spaces and public streets is included at Section 9.1 The discussion below pertains to development blocks only which are within the scope of this project.

Development Blocks

As commercial building footprint controls are likely to act as a pseudo site coverage control limiting gross floor area, we are proposing to focus on surface elements within commercial blocks where they are provided by the proponent. These have been separated into canopy coverage benchmarks for surface carparks and surface open space & movement networks.

For carparks, we have investigated only surface car parking, as that is where permeability and canopy coverage can realistically be incorporated.

Surface open space and movement networks refer to any area that is outside the building footprint and not within a surface carpark. These areas consist of a variety of spaces that are predominately used for pedestrian movement and open space – see Appendix B for examples of areas.

Figure 20 and Figure 21 below are generated from the test sites at Appendix B and demonstrate the levels of canopy coverage and permeability are currently being achieved in these areas. They have been organised into land-use zoning and division. These values have been used to better understand what benchmarks may be achievable moving forward.

Surface Car Park Summary

The tree canopy data within surface car park areas shows that many have low canopy coverage the majority having less than 10%. While in contrast, the CZ2 Deakin example shows that 45% canopy coverage is an achievable outcome. Given there are very few servicing constraints in these areas combined with the high urban cooling impact of carpark shading, an ambitious canopy coverage of 30% has been recommended. Trees planted within the carpark will need to meet the planting requirements of DV369 in terms of planting area and soil volumes. These areas can contribute to permeability, as can additional planting areas and permeable paving.

Open Space / Movement Summary

The open space and movement areas refer to any area of a development block that is outside of the building's footprint. The data shows that open space and movement areas have a wide variety of canopy coverage and permeability. Many of which require large areas of hardstand for vehicle and pedestrian movement. However, as sites like the CZ1 City site manage to achieve 45% canopy coverage despite having a large amount of hardstand, a 35% minimum benchmark is considered be achievable. As there is a high variety of typologies and constraints in these areas a more aggressive benchmark may prove difficult to achieve in highly constrained areas.

Based on this analysis the following benchmarks are recommended for development blocks in commercial zones.

Development Block Recommendation

Establish canopy coverage benchmarks for surface elements on development blocks

Establish permeability benchmarks for surface open space & movement networks on development blocks

Table 29: Recommended benchmarks for development blocks in commercial zones

	Recommended Canopy Coverage Benchmark	Recommended Permeability Benchmark
Surface Open Space/ Movement Networks	35%	15%
Surface Carpark	30%	10%
Building Footprint	0%	0%

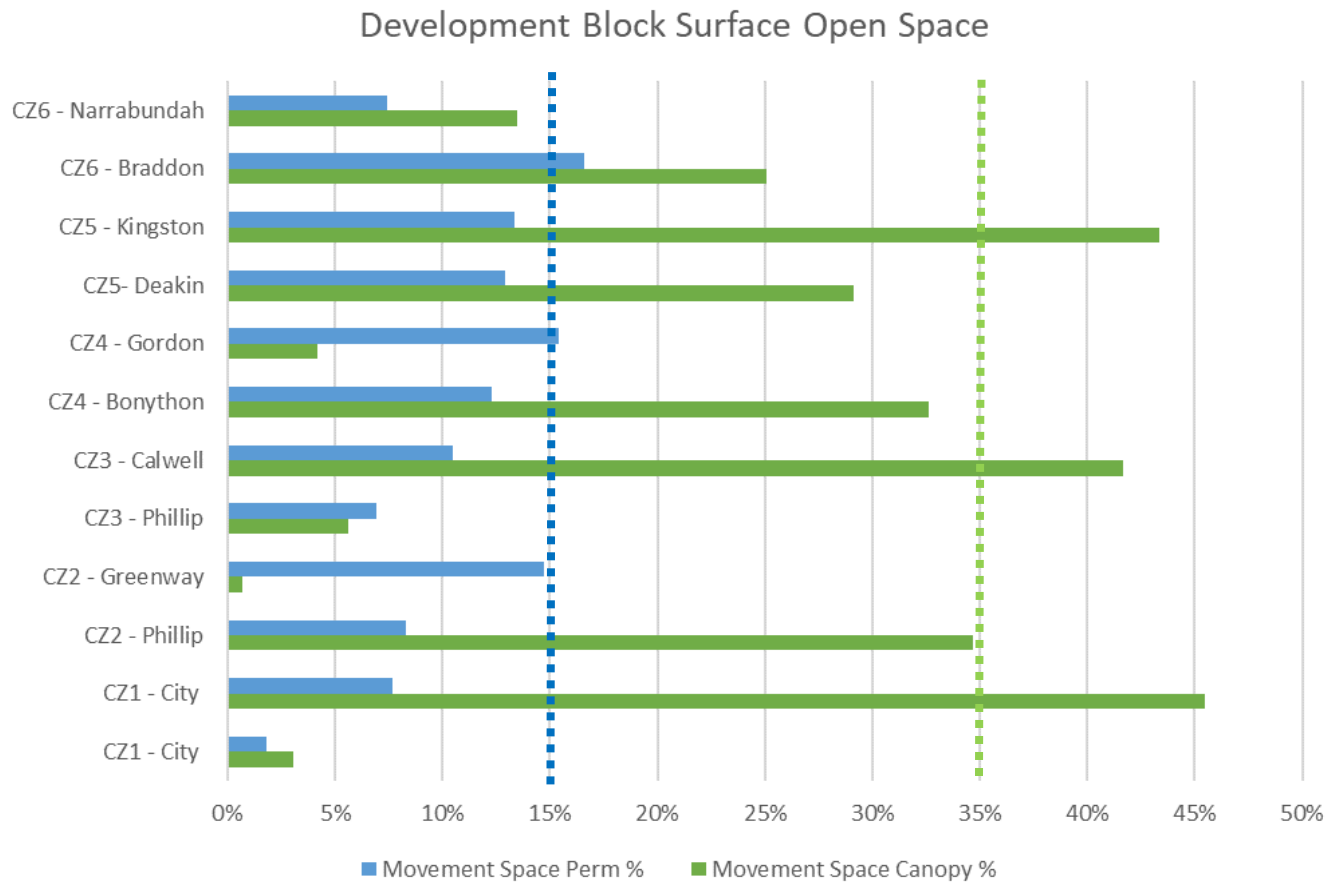


Figure 20: Canopy cover and permeability in development block surface open space and movement areas of test sites shown in Appendix B

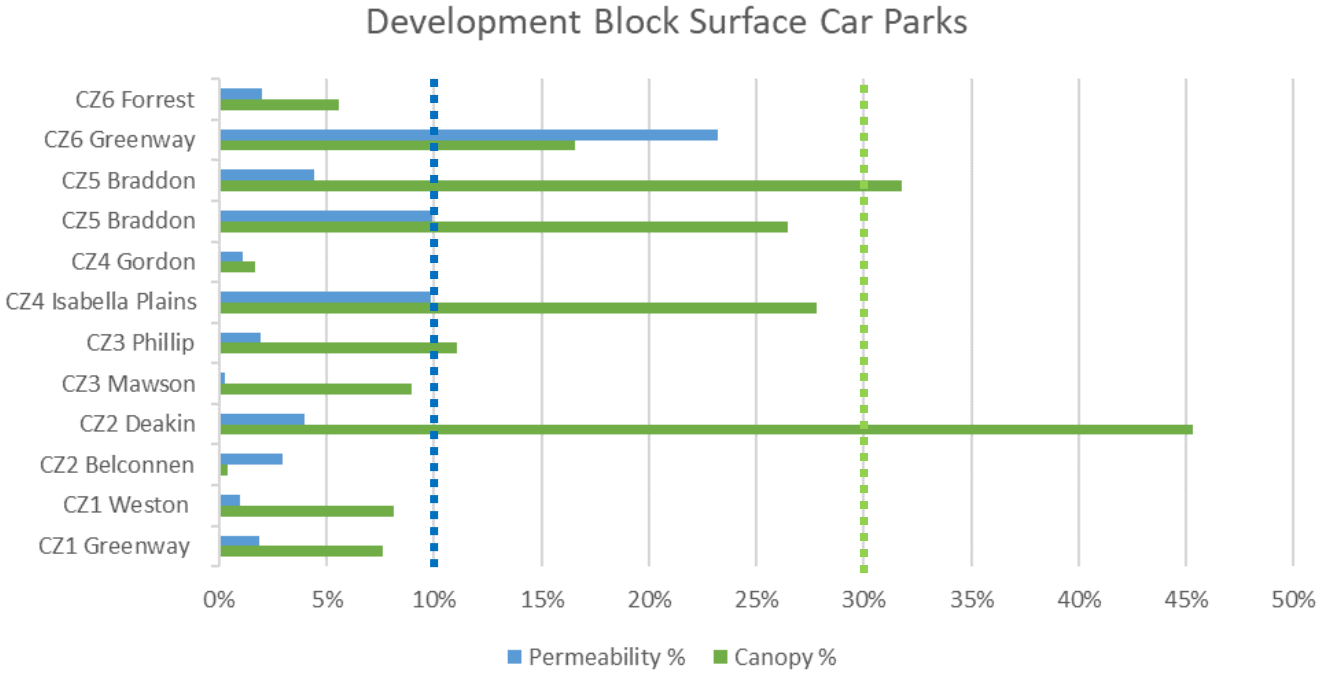


Figure 21: Canopy cover and permeability in development block surface car park areas of test sites shown in Appendix B

Interaction with DV369

Variation 369 currently includes provisions around living infrastructure for residential development within commercial zones. This includes requirements for the number and size of trees and well as a minimum planting area. The proposed updated planting area definition states that planting area is required to be permeable at ground surface. This would act as a pseudo site coverage control rule preventing built form in these areas. The requirements for tree planting are based on soil depth and surface area which would allow trees to be delivered on roof/podiums and not impact the building's footprint. See recommended rules and definitions in Table 30 to Table 32 below.

As per Section 7.1 it was recommended that commercial building footprint not be impacted by proposed living infrastructure provisions. This is to allow for development types that require a large building footprint. However, it would be appropriate for residents within commercial zones to have access to a minimum level of amenity through living infrastructure. In this way these dwellings will be more comparable to their residential zone equivalent.

The block level benchmarks that are recommended in DV369 would not conflict with the proposed commercial benchmarks, as the proposed benchmarks are for surface open space and movement networks and surface carparking. This means that if a development has a small building footprint the surface open space/movement network and surface carparking benchmarks will exceed the canopy and permeability requirements of DV369. However, if the building footprint is large, the block requirements from DV369 will become relevant and ensure a level of living infrastructure for residents similar to residential zones.

DV369 Recommendation

Maintain the requirements for residential development in commercial zones in DV369. These will work in concert with the proposed commercial zone benchmarks ensuring that residents living in commercial zones enjoy a similar level of living infrastructure as residents living in residential zones.

Table 30: R40 from DV369 proposed tree requirements

R40	C40
Development provides a minimum level of tree planting, with associated planting requirements as described in table A7b, consistent with the following: a) for *large blocks* less than or equal to 800m^2, one small tree and one medium tree b) for *large blocks* more than 800m^2: i) one medium tree and one large tree, and ii) one additional large tree or two additional medium trees for each additional 800m2 block area.	Tree planting provided in the development ensures: a) planting in deep soil zones, including minimum dimensions for deep soil zones, to support healthy canopy tree growth, and provide adequate room for canopy trees b) planting of canopy trees with appropriate species and with a semi-advanced stock and minimum heights at maturity c) landscaping to provide substantial shade in summer and admit winter sunlight to outdoor and indoor living areas.

Extract from DV369

"Planting area means an area of land within a block that is available for landscape planting and that is not covered by buildings, structures, vehicle parking and manoeuvring areas or any other form of impermeable element that impacts permeability of the ground surface (i.e. terraces, pergolas, patios, decks or pools)"

Table 31: R39 from DV369 proposed planting area requirements

R39	C39
This rule applies to all development in commercial zones. Not less than 20% of the total site area is allocated to the following: a) for developments with fewer than 20 *dwellings*, none of which are *apartments*, one or more of the following: i) *communal open space* that complies with the following: a) a minimum dimension of 2.5m b) is directly accessible from common entries and pathways; and/or ii) *private open space* that complies with the following: a) a minimum dimension of 2.5m; and b) is associated with *dwellings* at the *lower floor level*; and/or b) in all other cases, *communal open space* that complies with the following: i) a minimum dimension of 2.5m; and ii) is directly accessible from common entries and pathways. **For development in commercial zones, not less than 10% of the total site area is planting area.**	To reduce urban heat island effects, retain water and maintain ecosystem services, open space on the site achieves the following: a) adequate useable space for a range of recreational activities for residents to support active living b) adequate space for planting, particularly trees with deep root systems c) a contribution to on-site infiltration of stormwater run-off d) reasonable accessibility that is designed to be inclusive for all residents e) reasonable connectivity for pedestrians and cyclists to key local destinations and community uses f) if the minimum required planting area can't be provided on site, an equivalent area should be achieved through planting on structures. One or more of the following matters may be considered when determining compliance with this criterion: i) whether the total area of *upper floor level private open space* contributes to the function of other open space on the site; and/or ii) whether any adjoining or adjacent public open space is readily available for the use of residents.

Table 32: R39 from DV369 proposed planting area requirements

Tree size	Mature height	Minimum canopy diameter	Minimum soil depth (deep soil zone)	Minimum soil surface area dimension	Minimum pot size (litres)	Minimum soil volume
Small Tree	5-8m	4m	0.8m	3m	45**	18m^3
Medium Tree	8-12m	6m	1m	5m	75**	42m^3
Large Tree	>12m	8m	1.2m	7m	75**	85m^3
	Notes: For the purposes of this table, a tree is defined as a woody perennial plant suitable for the Canberra climate. It does not include any plant described in schedule 1 of the Pest Plants and Animals (Pest Plants) Declaration 2015 (No 1) or any subsequent declaration made under section 7 of the Pest Plants and Animals Act 2005, unless the tree is included on the ACT tree register. *This table applies to new trees only, not existing trees that are to be retained as part of the development. ** The maximum pot size for small, medium and large *eucalyptus sp*. trees if selected is 45 litres, with maximum height at planting of 2.5m and maximum trunk caliper of 3cm.					

Site 1

Site 2

Table 33: Showing how DV369 and CZ controls compare on different developments

	DV369		CZ Controls	
	Canopy Coverage	Planting Area	Canopy Coverage	Planting Area
Site 1	5 Large trees – 7.5% of Site	10%	35% of Movement Network – 8.4% of site	15% of Movement Network – 3.6% of Site
Site 2	13 Large trees – 6.5% of Site	10%	35% of Movement Network & 30% of Carparks – 27% of site	15% of Movement Network & 10% of Carparks – 10.3% of site

GREENFIELD RESIDENTIAL ESTATES

Greenfield residential estates refer to developments where the land has not been previously developed for residential or other uses and will require an Estate Development Plan. Greenfield residential estates provide an opportunity for a developer to incorporate canopy coverage and permeability with a holistic view of the whole estate. For this reason, an estate wide benchmark is recommended as it allows an estate developer the flexibility to balance benchmarks in different areas to suit their site/design.

As outlined above the recommended framework for greenfield residential estates is:

- Development Blocks
- Public Open Spaces
- Public Streets
- Estate Wide

Public Streets within Greenfield residential estates

The estate wide benchmark on its own has the potential to encourage trees to be primarily located in open space, where they are cheapest and most easily placed. However, it is important that street trees be prioritised, to ensure a reasonable distribution of canopy cover in the places people are most likely to benefit from it. As local residential streets also contribute to pedestrian movement throughout an estate the amenity and walkability of these areas are improved by the shading provided by trees. Factors exist that may encourage developers to provide canopy coverage to the open space instead of the streets. This is primarily due to street tree conflicts with services, lighting, and driveways. Streets are also typically planted at a more mature age than open space trees and can potentially add to development costs.

Given the importance of street canopy coverage, it is recommended that there be a benchmark for each street to ensure a minimum canopy coverage in these areas. This minimum would have to be somewhat conservative for the most constrained streets to meet this benchmark. For this reason, a total street benchmark is also recommended. This would allow the balance of the canopy coverage using streets that are less constrained.

It is recommended that rear lanes be excluded from these benchmarks as they typically have low potential to incorporate canopy and permeability.

Public Open Space within Greenfield residential estates

We recommend a benchmark for each public open space block within the estate. This would ensure that each public open space area is provided with a minimum canopy coverage to avoid low amenity open space with few trees. It is recommended that this is not applied to non-urban zoning (NUZ) to ensure canopy coverage is prioritised in areas of pedestrian movement. Some open space areas such as narrow pedestrian walkways and playing fields may need to be excluded from this benchmark.

Residential Blocks within Greenfield Residential Estates

Benchmarks for residential blocks are recommended to be as per Variation 369 (DV369) or future equivalent. An alternative would be that the estate developer could use these benchmarks to contribute to their estate wide benchmark. This would mean that a developer's block mix would affect the amount of canopy coverage required from the public streets and public open space in their estate. However, this may cause unforeseen issues due to its complicated nature. We have tested calculating these DV369 assumptions in the suburbs of Strathnairn, Macnamara and Taylor. It can be seen in Table 34 that in all 3 estates despite having different block mixes their assumed block canopy coverage only varied between 10-12%. As residential block canopy coverage based on DV369 is complicated and doesn't impact heavily on the total estate wide benchmark it is recommended that they be excluded from the estate wide benchmark.

Other Development Blocks within Greenfield residential estates

Blocks with commercial, industrial or community facilities zoning will be required to meet on block benchmarks specific to their zoning (community facility zoned development blocks are part of a separate workstream, commercial development blocks as above, and industrial development blocks subject to future project). This will not contribute to any estate wide canopy and permeability benchmarks.

Table 34 shows the canopy coverage and permeability across public streets, public open space, and development blocks in 8 suburbs in the ACT. Dickson, Turner, Mawson and Page were calculated using GIS data and the other estates were calculated based on their approved design, assuming trees successfully mature to their full canopy size.

These 8 test estates have been investigated to understand what is achievable in the components of an estate and have been used to inform the benchmarks shown in the table below. In more constrained areas such as individual streets a minimum below the average of each test estate. These benchmarks increase in accordance with the benchmark's flexibility. The highest benchmarks being the flexible, which is the estate wide benchmark that excluded development blocks.

From Table 34 it can be seen that all suburbs assessed currently meet the proposed permeability benchmarks for all elements. Only Macnamara is achieving the estate wide canopy benchmark. It is achieving this primarily though street and open space as the on-block canopy coverage is only 12%. No suburb in more that 10% off achieving the estate wide benchmark which is the most ambitious benchmark. It is thought that this benchmark

could be readily achieved by planting more trees within public open space, particularly for suburbs like Dickson that have an open space coverage of only 16%. Mawson, Page and Wright are the only suburbs that don't meet the total street canopy coverage. The other suburbs demonstrate that this benchmark is achievable.

Greenfield residential estates Recommendations Summary

It is recommended that greenfield residential estate developers are given the flexibility to meet impactful estate wide benchmarks while still ensuring that each element of an estates is considered and meets minimum canopy and permeability.

Table 34: Greenfield residential estate Analysis

Division	Canopy					Permeability				
	Total	Open Space	Street	Block	Total Excluding Block	Total	Open Space	Street	Block	Total Excluding Block
Inner Suburbs										
DICKSON	26%	16%	44%	19%	32%	55%	100%	45%	41%	69%
TURNER	30%	33%	34%	25%	34%	61%	100%	44%	49%	70%
Middle Suburbs										
MAWSON	23%	29%	21%	21%	25%	58%	100%	40%	48%	73%
PAGE	19%	28%	24%	16%	25%	47%	100%	40%	44%	55%
Outer Suburbs										
WRIGHT	13%	21%	25%	1%	24%	39%	100%	40%	25%	51%
MACNAMARA	27%	29%	47%	12%	38%	56%	87%	34%	50%	60%
STRATHNAIRN	19%	15%	32%	10%	24%	55%	87%	41%	44%	61%
TAYLOR	25%	32%	31%	11%	31%	68%	93%	48%	46%	73%

Table 35: Recommended Benchmarks for Greenfield residential estates

	Canopy Coverage %	Permeability Coverage %
Urban Open Space Blocks	25%	50%
Individual Streets	20%	20%
Streets Total	30%	30%
Estate Total Excluding Development Blocks	35%	40%
Development Blocks	Residential development blocks covered in DV369 Commercial development blocks covered by proposed commercial zones benchmarks Community facilities development blocks covered by proposed benchmarks in separate work stream Industrial development blocks subject to future project	

OTHER ESTATES

Other estates include urban renewal sites, residential, mixed use precincts as well as commercial and industrial precincts. These areas do not have the same opportunity that greenfield residential estates have to meet on overall canopy coverage and permeability benchmarks. It is not recommended that an estate total be applied. Instead, their benchmarks will depend on the zoning and elements that comprise the estate. It is recommended that further investigation be undertaken to attain appropriate industrial zoning benchmarks. See the example below showing which benchmark each element smaller estate would have to meet if it were developed with these conditions.

Examples of how these smaller infill estates would be broken up into elements can be found in Appendix B. Infill estates are required work within the existing block and road network. As they do not have the same flexibility that comes from a greenfield estate is recommended that estate wide benchmarks not be applied

Other Estates Recommendations Summary

Other estates do not have the consistency in land use to set reasonable benchmarks for other estates as a group. Nor do they have the flexibility to balance estate wide benchmarks across a large area. Therefore, is recommended that their benchmarks be determined based on the elements and zoning within the estate.

Table 36: Summary of the recommended framework for all other development including other estates

Location	Residential Zones	Commercial Zones	Community Facility Zone	Industrial Zones	Other Urban Zones
Development blocks	Covered by DV369, no need for further benchmarks	Current project: Surface carparks Surface Open Space/ Movement Networks	Current project – separate workstream	Future work	Future work
Public streets	Recommended future work: Public streets permeability benchmarks by land use zone, minimum canopy benchmark for all public streets				
Public open space	Recommended future work: Interim recommendation - canopy and permeability benchmark common to all public open space Ultimate recommendation - canopy and permeability benchmarks by open space typology				

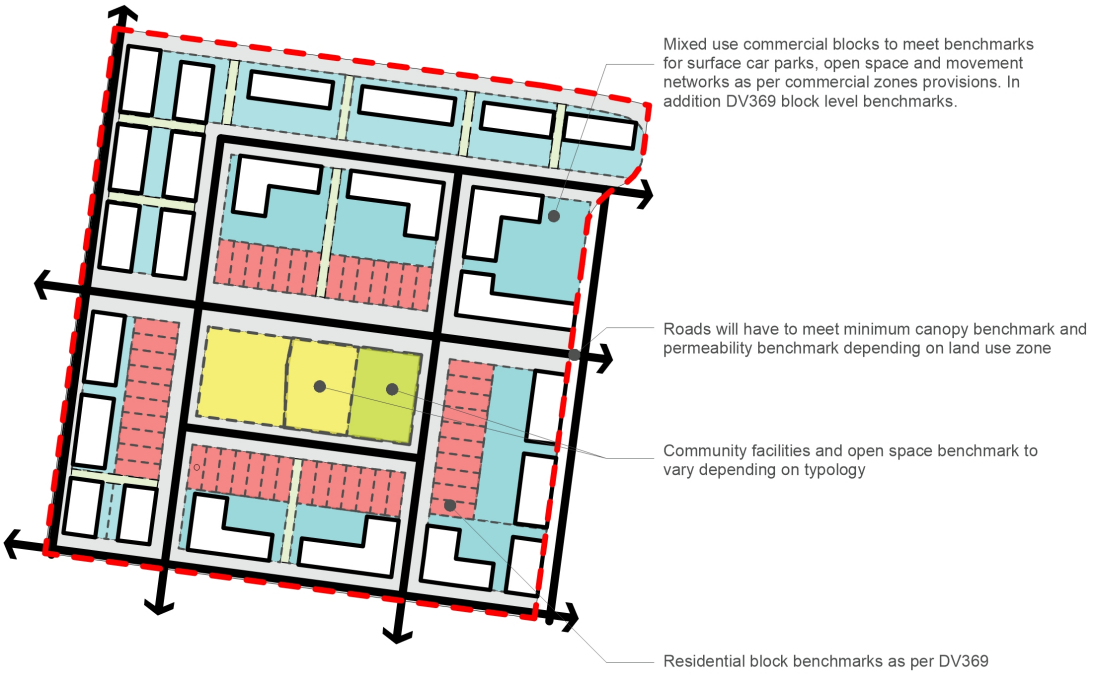


Figure 22: Recommended requirements per element for other estates

Data from other estate test sites in Appendix C have been included in the tables below. It makes assumption about the canopy and permeability outcomes that will be decided in future projects for Public Street and Public Open Space. As well as an assumption about the typology delivered on CFZ sites. The table demonstrates that these estates will deliver a nominal estate outcome.

Table 37: Summary of the nominal canopy coverage outcomes in other estates using proposed methodology

Test Locations	Development Zones			Public Streets	Public Open Space	Nominal Estate Outcome
	Residential Zones	Commercial Zones	Community Facility Zone			
East Lake	4%	20%	35%	30%	35%	22%
Watson s76	15%	-	-	30%	35%	26%
Founders Lane	15%	18%	-	30%	35%	19%

Table 38: Summary of the nominal permeability coverage outcomes in other estates using proposed methodology

Test Locations	Development Zones			Public Streets	Public Open Space	Nominal Estate Outcome
	Residential Zones	Commercial Zones	Community Facility Zone			
East Lake	20%	10%	30%	30%	50%	19%
Watson s76	25%		-	30%	50%	39%
Founders Lane	25%	10%	-	30%	50%	19%

9 RECOMMENDATIONS FOR FUTURE WORK

A range of recommendations are made for potential future projects, which could fill gaps and complement the approach proposed in this report.

9.1 ADDITIONAL BENCHMARKS

Having established the recommended framework for benchmarks across commercial, greenfield residential estates and other estates at Section 7.2 Recommended Framework, a number of areas identified for future projects.

This section explores the recommended framework for those future projects, particularly public open space, public streets and industrial zone development blocks.

Public Streets in Commercial Zones

Public streets and public open spaces make up approximately 20% of the sites tested in commercial zones. Whilst these elements are outside the scope of this project, due to their significance they have been included in the options investigation and is recommended that they be investigated further as part of a future project.

From the datasets provided approximately 90% of the streets in commercial zones are classified within the 3 urban residential categories. For this reason, our investigation has focused on these 3 categories. As is shown in Figure 23 there is no significant difference in the canopy coverage and permeability of the urban residential streets when looking at the hierarchy.

Figure 24 combines the 3 urban residential street categories and compares their canopy and permeability percentage according to their zoning. The data shows there is a significant difference in performance particularly regarding permeability. The data shows that as the density of the zoning increases the permeability decreases. This is appropriate from an urban form perspective as more hardscape is typical of areas with high pedestrian traffic.

Based on the options investigation a minimum canopy benchmark for all streets is recommended as the most appropriate provision, as the data suggests there are no significant obstacles that prevent canopy coverage across zones and hierarchy. It is expected that higher density areas will have more constraints such as services that will make canopy benchmarks more difficult to achieve. The data illustrates that highly constrained zones (C1 and C2) are achieving some of the highest canopy coverage, see Figure 24. Trees provide higher cooling and amenity benefits in high density paved areas and as such canopy coverage should be prioritised in these areas.

It is recommended that permeability benchmarks vary depending on land use zone. Zones with a high amount of pedestrian movement should have lower permeability benchmarks as hardscape enhances movement and amenity.

Public Streets in Commercial Zones Recommendation

The recommended approach for public commercial streets is to apply a minimum canopy benchmark to all streets within all commercial streets and vary permeability benchmarks based on zoning. As it is appropriate for roads with higher pedestrian and cycling traffic to have larger amounts of hardscape. Specific percentage benchmarks have not been recommended as they are outside of this investigation's scope. It is recommended that this be completed as part of a separate assessment.

Table 39: Recommended assessment framework for public streets in commercial zones

	Recommended Canopy Benchmark	Recommended Permeability Benchmark
CZ1	X%	x%
CZ2		x%
CZ3		x%
CZ4		x%
CZ5		x%
CZ6		x%

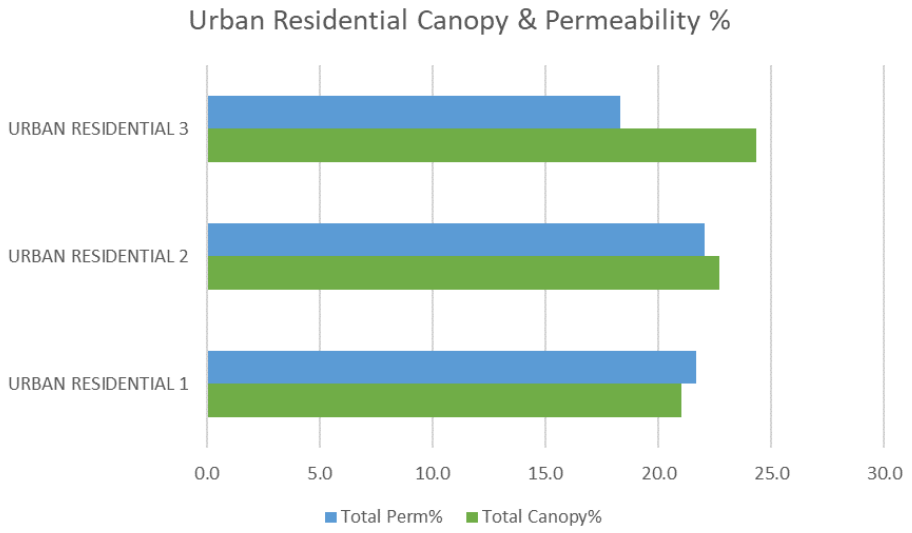


Figure 23: Canopy cover and permeability of urban residential roads in commercial zones

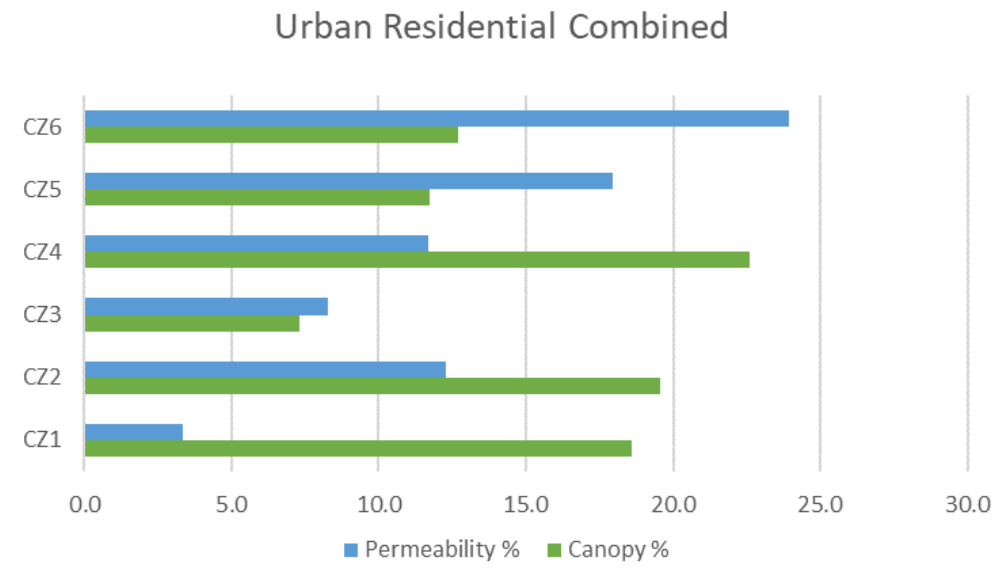


Figure 24: Canopy and permeability percentage of urban residential roads according to their zoning

Public Open Space in Commercial Zones

The provided data sets have limited information regarding public open space in commercial zones as there is no data field indicating open space areas within commercial zoning. By examining the initial test sites in Appendix B it can be seen that where a commercial precinct has an area of dedicated open space the canopy coverage is greatly increased. These areas provide an opportunity to greatly increase amenity and urban cooling and should be prioritised. See the list below showing types of open space found in the Estate Development Code and Municipal Infrastructure Standards,

- Ngunnawal, Aboriginal and Torres Strait Islander culturally significant sites
- Town parks
- District parks
- Neighbourhood parks (central, local and pocket)
- Micro parks
- Community Recreation Parks (CRP)
- Sportsgrounds
- Pedestrian parklands
- Laneways
- Informal use ovals
- Natural open space (Grasslands or woodland sites)
- Semi-natural open space
- Heritage Parks
- Special purpose areas; (skate parks, exercise parks, dog parks, community garden and urban orchards, BMX tracks, learn to ride centres, equestrian areas, water skiing areas, showgrounds
- Broadacre open space.

Public Open Space in Commercial Zones Recommendation

It is recommended that comprehensive benchmarks could be created depending on the type of open space being developed. The appropriateness of this method will be dependent on the typologies having a significant difference in canopy coverage and permeability. It is recommended that this be investigated as a future project.

In the interim, it is recommended that a conservative benchmark for all open space blocks be implemented as a future project. This simple approach will ensure canopy and permeability be given some consideration during the design of these areas even if many open space typologies will easily meet these benchmarks.

Table 40: Recommended intermediate recommended assessment framework

	Recommended Canopy Benchmark	Recommended Permeability Benchmark
Public Open Space	x%	x%

Table 41: Recommended assessment framework which groups similar types public open space in all zoning

Typology*	Recommended Canopy Benchmark	Recommended Permeability Benchmark
Laneways	x%	x%
Natural	x%	x%
Special Purpose Areas	x%	x%
Community Recreation Parks	x%	x%
Micro parks	x%	x%
Sportsgrounds	x%	x%
Civic	x%	x%

* Typologies to be determined by future project.

All Public Streets and Public Open Spaces – except those within 'greenfield residential estates'

Building on the recommendation to consider public streets and public open spaces as critical parts of the city to contribute canopy coverage and permeability across the ACT. The framework outlined for public streets and public open spaces in commercial zones above should be considered for public streets and public open spaces in other zones to provide a comprehensive framework that covers all parts of 'other estates' and potentially capital works projects being undertaken in streets and open spaces.

Recommendation for Public Streets and Public Open Spaces

It is recommended that benchmarks for public streets and public open spaces in other zones also be investigated in a future project.

Development Blocks in Industrial Zones and Other Urban Zones

Development blocks in residential zones, community zones and commercial zones now all attract some form of canopy and permeability requirements through DV369, this project or concurrent workstream. Development blocks in industrial zones require equivalent exploration to ensure a comprehensive framework for 'other estates' and standard development applications.

Recommendation for Development Blocks in Industrial Zones and Other Urban Zones

It is recommended that benchmarks for development blocks in industrial zones be investigated in a future project.

Surface car parks in other zones

Across many development types, surface car parks are often a notable component of the land use and an important contributor to paved area, yet there are opportunities to include more trees and increase permeability, as is recommended for commercial zones.

Surface car parks are similar across most zones, therefore similar (or the same) benchmarks could potentially be adopted in other zones. This could be a simple addition to the planning system, which requires relatively little further analysis.

Recommendation for surface car parks in other zones

It is recommended that canopy and permeability benchmarks proposed for surface car parks in commercial zones should also be considered for surface car parks in other zones.

9.2 TERRITORY-WIDE ANALYSIS

To provide more confidence around the approach of individual benchmarks for different zones and land uses, ACT Government could consider a future Territory-wide analysis to better understand the capability of each different land use zone to contribute towards the 2045 targets. This would give more certainty about what needs to be achieved in different land use zones, as well as how it should be achieved – via the planning system and new development, via public initiatives, or via incentives for existing development to add more green infrastructure. Some of this work has begun, as documented in the Urban Tree Canopy Coverage Report (ACT Government 2021b). This covers both a range of public initiatives and support for community-led contributions towards the canopy target. Similar attention should be devoted to the permeable surfaces target and to urban heat outcomes in the future.

9.3 URBAN HEAT PROVISIONS FOR RESIDENTIAL BLOCKS

DV369 applies living infrastructure provisions to residential blocks, however other urban heat provisions are a gap that should be addressed in the future. Residential dwellings are a significant land use across the urban area as a whole, and they play a crucial role as places of refuge during heatwaves.

The thermal performance of the building itself is therefore a more important consideration in residential development. McAuley et al (2021) discuss how Australian building standards lack standards for 'passive thermal performance' of homes, which is a key gap.

There are also opportunities for additional measures to improve urban heat island and microclimate outcomes in residential development. Most of the planning provisions in Section 7 are just as relevant to residential development as they are to commercial development.

A few specific areas where residential development potentially presents greater opportunities than commercial development are as follows:

- Cool roofs: unlike commercial and industrial development where lighter-coloured roofs are common, dark-coloured roofs are popular in residential development. Cool roofs are recommended for Canberra's climate (Osmond and Sharifi 2017).
- Passive irrigation and infiltration: in lower density development, opportunities to disconnect drainage systems and increase infiltration are generally greater.
- Layout and orientation: could also be more flexible in lower-density residential development.

The application of additional urban heat measures to residential development should be considered in a future project.

9.4 UPDATED ASSESSMENT METHODS

The set of planning provisions proposed in Section 7 of this report includes certain quantitative indicators (e.g. canopy cover, permeable area, cool materials and shade) as 'benchmarks'. There will be the option for developers to put forward alternative solutions that deviate from these benchmarks, with supporting evidence to show how the alternative solution would still meet the objectives.

At this time there is little direction available as to how an alternative solution would be assessed. Therefore, this project has identified several potential urban heat assessment methods that could be contemplated in the future.

A summary is provided in Table 42. This organises assessment methods into three types. In Section 5 of this report, urban heat assessment methods were organised into three types (simulation tools, rating tools and simple comparative methods). The same broad types of options exist for assessment of living infrastructure and water in the landscape. This provides a useful framework to contemplate the features of different options and examine which might be suitable in the future. All these methods would allow alternative measures to be weighed up, accounting for different levels of complexity.

The following text provides more information on what to consider in the potential future development of new assessment methods for tree canopy and permeable surfaces. Urban heat assessment methods were covered thoroughly in Section 5.

Table 42: Potential future assessment methods for tree canopy, permeable surfaces and urban heat

Items	Simple measures proposed now	Potential future assessment methods that enable comparisons to weigh up alternatives		
		Type 1: Rule of thumb methods	Type 2: Rating tools	Type 3: Simulation tools
Tree canopy cover	Total canopy cover, with future canopy estimated via expected canopy diameter for small, medium and large trees planted into an appropriate minimum soil volume.	Variables such as soil volume and access to water could be accounted for using simple rules of thumb, when estimating future canopy cover. See City of Sydney example below.	ACT could develop a 'tree canopy calculator', which factors in tree species, soil volume, access to water, etc. into future canopy cover	Existing tools designed for urban forest management. For example the Tree Planting Predictor
Permeable surfaces	Total permeable area (with planted area preferred)	Different types of permeable area could be defined and weighted differently in the estimation of total permeable area.	ACT Government could develop a tool (or adapt an existing tool) similar to the City of Melbourne's Green Factor Tool, which accounts for different types of green infrastructure in a site-wide score.	A runoff reduction target could be defined and a tool such as MUSIC[1] could be used to model the rainfall-runoff relationship including infiltration and evapotranspiration (this would account for the water cycle benefits of permeable surfaces, but would not account for the other benefits of plants).
Urban heat	Simple benchmarks to define cool roof, cool paving, cool façade and shade requirements	Information available on the performance of different cooling methods could potentially be translated into simple rules of thumb defining how alternative measures should be compared. Refer to Section 5.3.	ACT Government could develop a tool (or adapt an existing tool) similar to the WSROC Cool Suburbs Tool. Refer to Section 5.2.	Various urban heat simulation tools are available, refer to Section 5.1.

[1] Model for Urban Stormwater Improvement Conceptualisation

CANOPY COVER

In an ideal method estimate future canopy cover, the following factors should be considered:

- Local climatic conditions, including the changing climate
- Tree species – tree size and leaf area index are both important factors in future canopy cover
- Available space and soil volume – within a certain range, greater soil volume should contribute to greater canopy cover
- Access to water, including passive and active irrigation – this should also contribute to greater canopy cover as well as faster-growing canopy cover
- Establishment and long-term maintenance success – an attrition factor should be included
- Timing – consider including a short-term benchmark (e.g. for 2030) as well as the 2045 benchmark, to encourage:
    - Retention of canopy trees that are already established or will be established earlier
    - A mix of trees, including some faster-growing species
    - A method to estimate future canopy cover is recommended to ensure that there is a clear and consistent approach to estimating future canopy cover based on trees planted today (accounting for the tree species, soil volume and other local conditions).

If this range of factors are built into the canopy estimation method, then there are incentives to select species likely to perform well, and include features like adequate soil volume and access to water within the landscape design.

SOIL VOLUME

The spatial extent, depth of soil and total volume should be a consideration in selecting appropriate vegetation and in estimating how large canopy trees are expected to grow.

Existing soil volume requirements are simply set as a minimum volume required per tree. While there is a clear logic to this approach, it can also place too strict a limit on tree planting, minimising the number and size of trees that can be included in development. To help meet the 2045 canopy targets, ACT Government should also consider how the planning system can encourage more tree planting, by encouraging appropriate planting even when conditions are somewhat less than ideal.

If soil volume is built into the estimation of canopy cover as a variable, this could allow soil volume requirements to be less prescriptive, while still accounting for its importance.

Soil volume requirements could also be varied with some simple rules of thumb, independently of a canopy cover estimation method. For example, the City of Sydney (2015) has variable soil volume requirements:

- Approx. 30% less soil is required for 'favourable' planting sites (shaded and protected from winds, with limited hard / paved surfaces, low reflection, moderate soil depth (600mm+) that is free draining and where organic mulch is applied regularly)
- When the tree is irrigated regularly, soil volume can be reduced by 10%
- Where the trees have shared root systems, soil volume can be reduced by 10%

Soil volume requirements could also be reviewed for individual tree species, and potentially the minimum volume could be set lower. This should be framed as a true minimum, and if considered appropriate, an 'ideal' volume could also be indicated.

PERMEABLE AREA

Permeable areas aim to meet multiple objectives, from retaining more water in the landscape and reducing runoff to supporting various forms of green infrastructure.

Weighing up the benefits of alternative permeable areas is therefore complicated by the fact that different options may perform differently against each objective.

Important factors to be considered include:

- Soil depth and soil qualities such as porosity, permeability and water-holding capacity.
- Vegetation types and planting density.
- Access to water, including irrigation and passive irrigation.
- Stormwater flows through features such as ponds, wetlands and rain gardens specifically designed for stormwater treatment.

Note that ACT Government is working on a green infrastructure equivalence tool which, in the future, will allow different options to be compared and could facilitate more ambitious green infrastructure benchmarks that better account for the quality as well as the quantity of various permeable areas.

9.5 UPDATING THE MUNICIPAL INFRASTRUCTURE STANDARDS

Wherever features are proposed in the public domain, ACT's Municipal Infrastructure Standards (MIS) are relevant. In Section 2.3 of this report, Table 2 identified sections of the MIS relevant to living infrastructure.

It is apparent that certain requirements in the MIS currently constrain the potential for higher canopy cover and permeable surface area in development. Stakeholders have made several comments about where these standards need to be revised, including:

- Verge widths
- Paved areas including paths
- Soil standards
- Tree species selection
- Soft landscape design
- Vehicle access requirements
- Maintenance standards

Some specific issues and considerations are listed in the following sections. However, given that living infrastructure, urban heat and water management raise complex, interconnected issues that cut across many aspects of urban planning and design, a *comprehensive* review of the MIS is recommended. Rather than revising individual requirements in isolation, there is a need for integrated thinking on how the MIS can support the desired outcomes of the Living Infrastructure Plan.

STREETSCAPE ELEMENTS

There is a need for improved design templates to show how more green infrastructure can be included in various different types of streetscapes, while still meeting other requirements for traffic and pedestrian movement, vehicle access and location of services.

Tait Network (2018) made some recommendations about what would need to change about the design of streetscapes to achieve higher canopy cover, including:

- Location of services - there is a need for more efficient location of services that result in an increase of soil volume. Measures may include location of services in shared corridors and under footpaths.
- Tree clearances - by modifying the current approach towards tree clearance, it can better support the specification of large trees in street planting.
- Trees in median - better street configuration in larger streets can create opportunities for large trees to be planted in a median and to enable WSUD treatment.

MATERIALS

The MIS defines materials that can be used for various types of pavements in the public domain and there is a need to include options for cool paving and permeable paving.

SPECIES SELECTION

The MIS includes a species list for planting in public spaces. There is also the Canberra Plant Selector tool – it is understood that this includes the same species as the MIS.

With a new emphasis on the role of living infrastructure in urban cooling, the species list and plant selector tool should be reviewed to add information about factors relevant to cooling. A relevant metric is leaf area index (LAI), defined as the one-sided green leaf area per unit ground surface area (LAI = leaf area / ground area, m^2 / m^2) in broadleaf canopies. Species with LAI ≥3 are preferred for cooling purposes.

With the climate changing, and with more information becoming available on species more likely to thrive in future climatic conditions, this information should also be added to the species list and plant selector tool. In principle, aim to plant species with an upper temperature range limit for maximum tree growth 2°C higher than current average maximum of 20°C. There is relevant information available in a local research paper (Australian National University, 2019) and in the new Which Plant Where tool.

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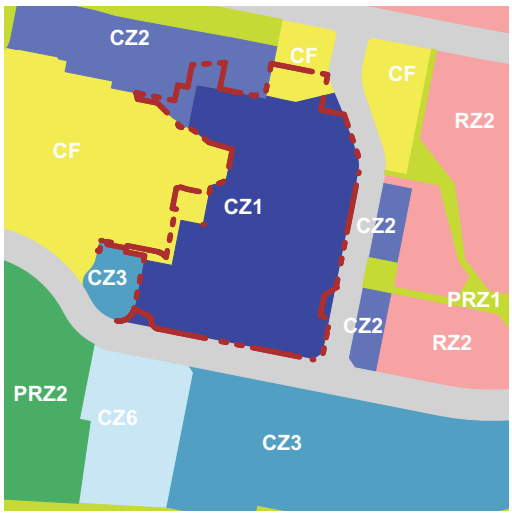
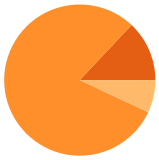
APPENDIX A EXAMPLES OF EXISTING DEVELOPMENT IN EACH COMMERCIAL ZONE

The following examples are studies of a variety of commercial precincts within ACT to understand what elements they are comprised of and how these elements perform regarding canopy coverage and permeability. The terms street, developed, and pocket park have been updated to public street, public open space and development block respectively for purposes of the report.



Land Use

Site Components



13% Street

80% Developed

7% Pocket Park

Aerial

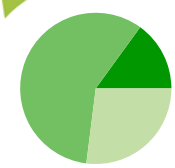
Land Ownership

Public

Private

Canopy Coverage

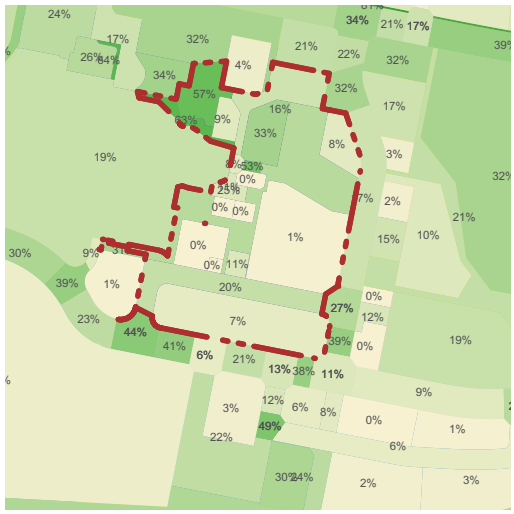
17%



15% Street

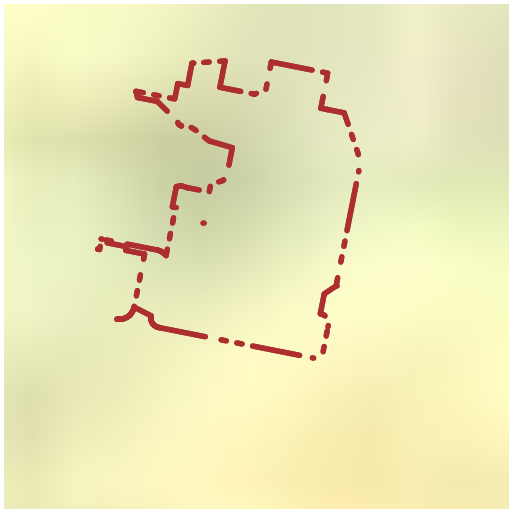
58% Developed

27% Pocket Park



Canopy Coverage

0 100

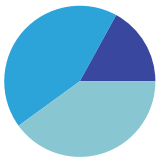


Surface Land Temperature

23°C 45°C

Permeability

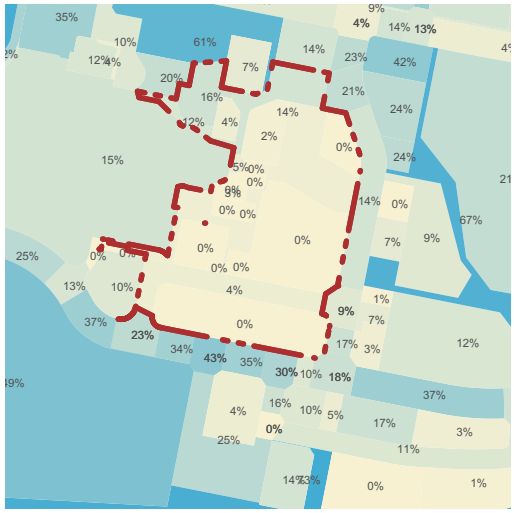
3%



17% Street

43% Developed

40% Pocket Park



Permeability

0 100

CZ1 Average

8.8%

11%

Living Infrastructure

Wanniassa - Tuggernong

CZ1 Site A

Tait Network

SCALE AT A4
1:7500

REVISION

DATE

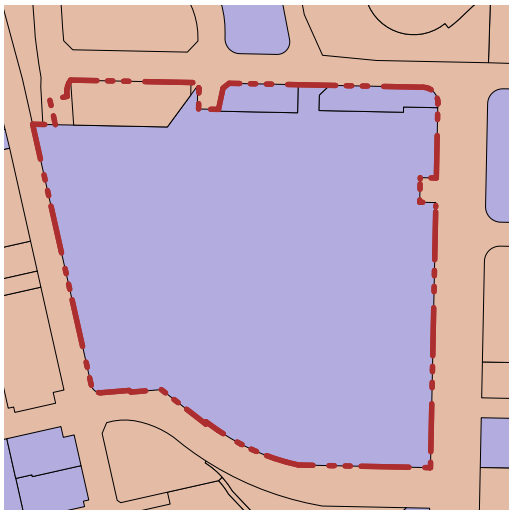
DRAWING NUMBER
SK-001

Land Use

Site Components

0%	Street
100%	Developed
0%	Pocket Park

Aerial

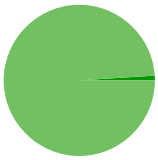


Land Ownership

Public | Private

Canopy Coverage

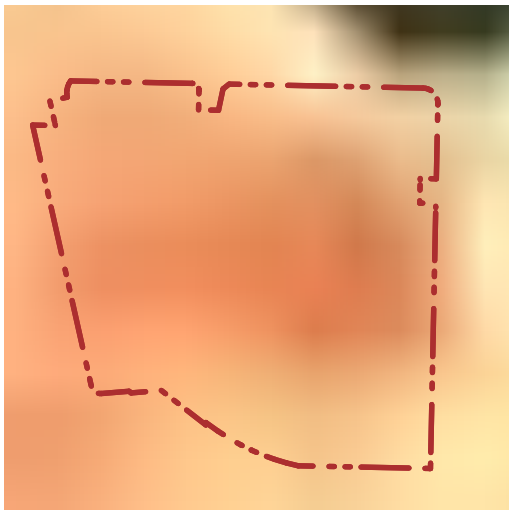
1%



1%	Street
99%	Developed
0%	Pocket Park

Canopy Coverage

100

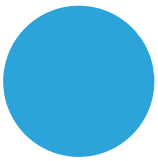


Surface Land Temperature

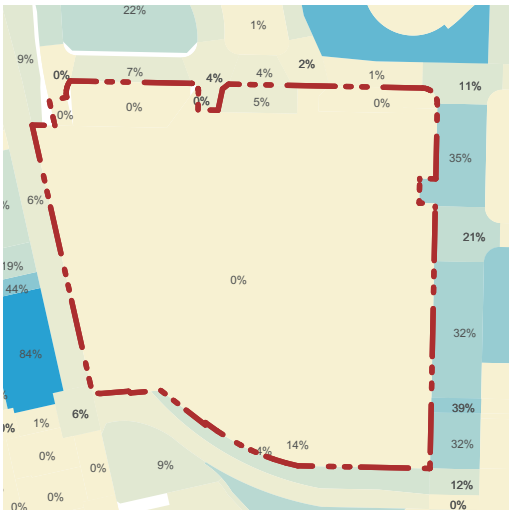
23°C | 45°C

Permeability

1%



0%	Street
100%	Developed
0%	Pocket Park



Permeability

0 | 100

CZ1 Average

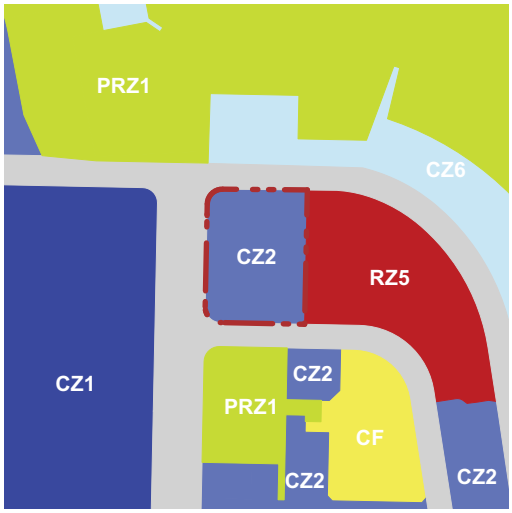
8.8%

11%

Living Infrastructure
Belconnen
CZ1 Site B

Tait Network

SCALE AT A4
1:7500
REVISION
DATE
DRAWING NUMBER
SK-002

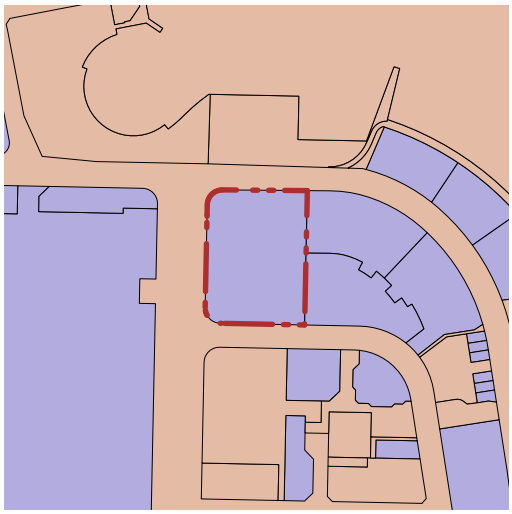


Land Use

Site Components

0%	Street
100%	Developed
0%	Pocket Park

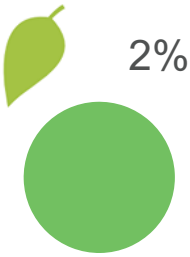
Aerial



Land Ownership

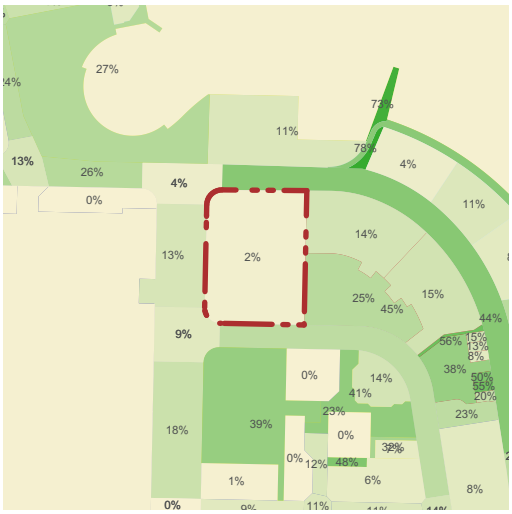
Public | Private

Canopy Coverage



2%

0%	Street
100%	Developed
0%	Pocket Park



Canopy Coverage

0 | 100

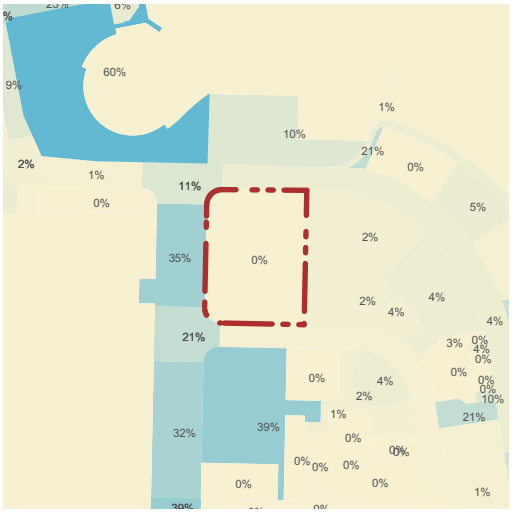
Surface Land Temperature

23°C | 45°C

Permeability

0%

0%	Street
100%	Developed
0%	Pocket Park



Permeability

0 | 100

CZ2 Average

13.7%

24%

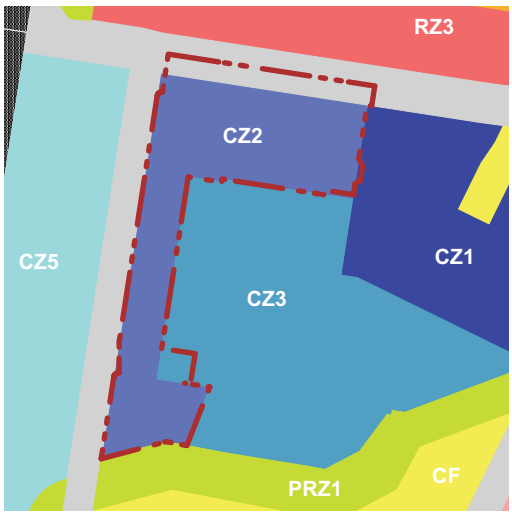
Living Infrastructure
Belconnen
CZ2 Site A

Tait Network

SCALE AT A4
1:7500
REVISION

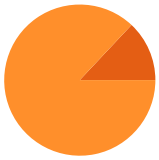
DATE

DRAWING NUMBER
SK-003



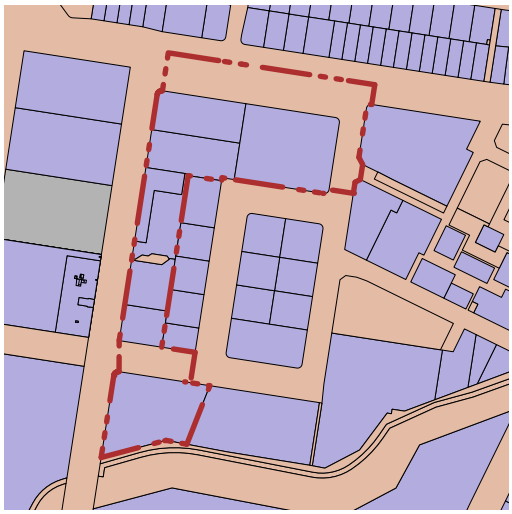
Land Use

Site Components



13%	Street
87%	Developed
0%	Pocket Park

Aerial

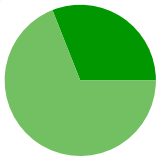


Land Ownership

Public | Private

Canopy Coverage

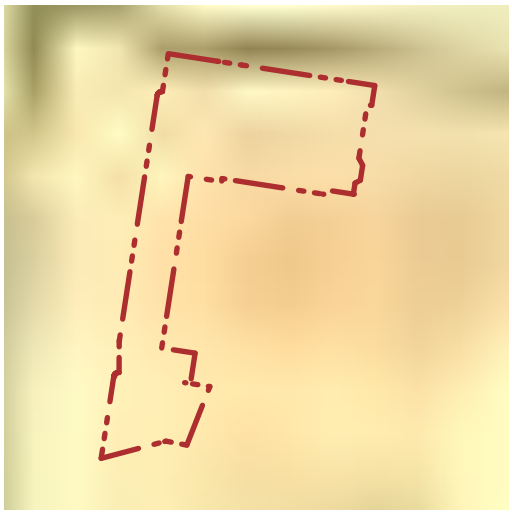
13%



31%	Street
69%	Developed
0%	Pocket Park

Canopy Coverage

0 | 100

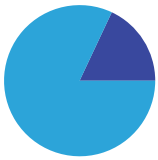


Surface Land Temperature

23°C | 45°C

Permeability

2%



18%	Street
82%	Developed
0%	Pocket Park

Permeability

0 | 100

CZ2 Average

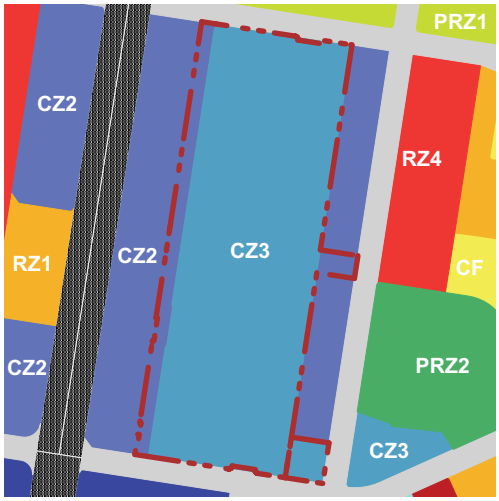
13.7%

24%

Living Infrastructure
Dickson - Inner North
CZ2 Site B

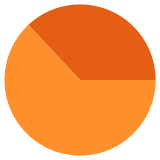
Tait Network

SCALE AT A4
1:7500
REVISION
DATE
DRAWING NUMBER
SK-004



Land Use

Site Components



37% Street

63% Developed

0% Pocket Park

Aerial

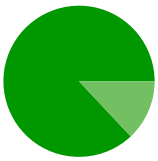
Land Ownership

Public

Private

Canopy Coverage

11%



87% Street

13% Developed

0% Pocket Park

Canopy Coverage

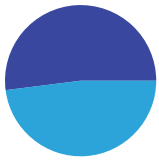
0 100

Surface Land Temperature

23°C 45°C

Permeability

1%



52% Street

48% Developed

0% Pocket Park

Permeability

0 100

CZ3 Average

7.9%

12%

Living Infrastructure

Braddon - City

CZ3 Site A

Tait Network

SCALE AT A4
1:10000

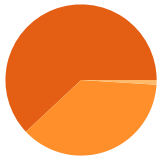
REVISION

DATE

DRAWING NUMBER
SK-005

Land Use

Site Components

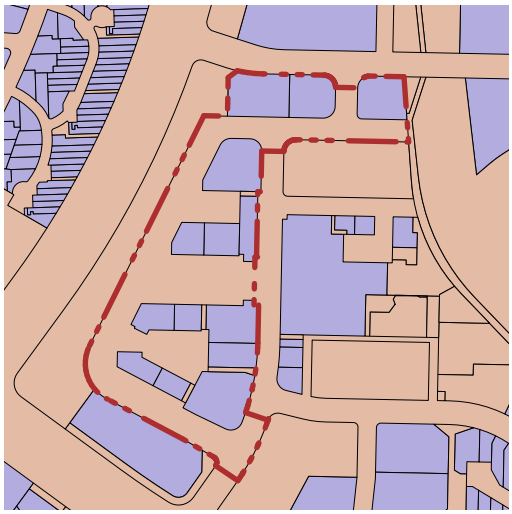


62% Street

37% Developed

1% Pocket Park

Aerial

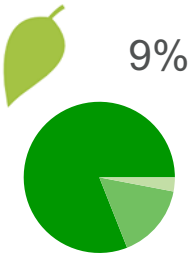


Land Ownership

Public

Private

Canopy Coverage

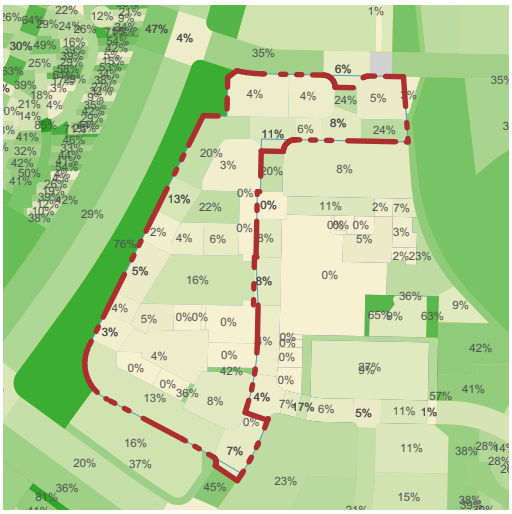


9%

81% Street

16% Developed

3% Pocket Park



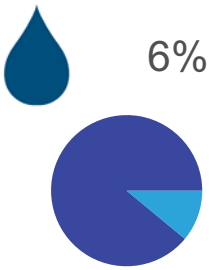
Canopy Coverage

0 100

Surface Land Temperature

23°C 45°C

Permeability

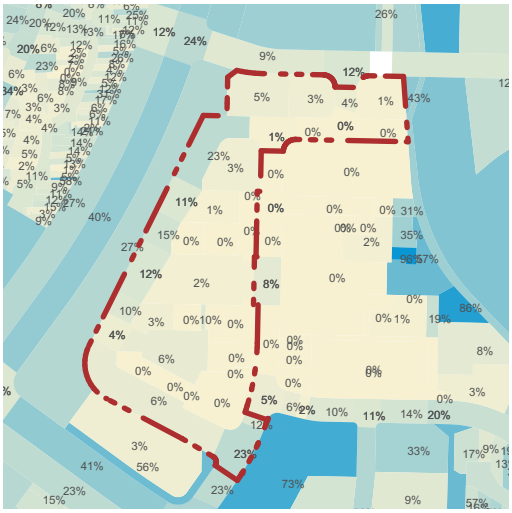


6%

89% Street

11% Developed

0% Pocket Park



Permeability

0 100

CZ3 Average

7.9%

12%

Living Infrastructure

Weston - Weston Creek

CZ3 Site B

Tait Network

SCALE AT A4
1:7500

REVISION

DATE

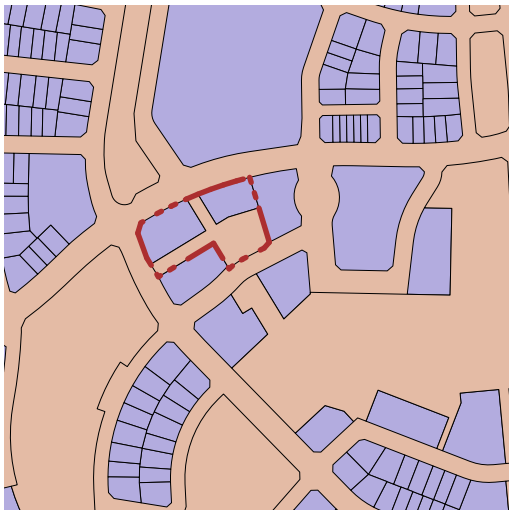
DRAWING NUMBER
SK-006

Land Use

Site Components

0%	Street
100%	Developed
0%	Pocket Park

Aerial

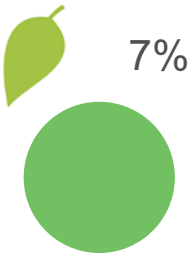


Land Ownership

Public

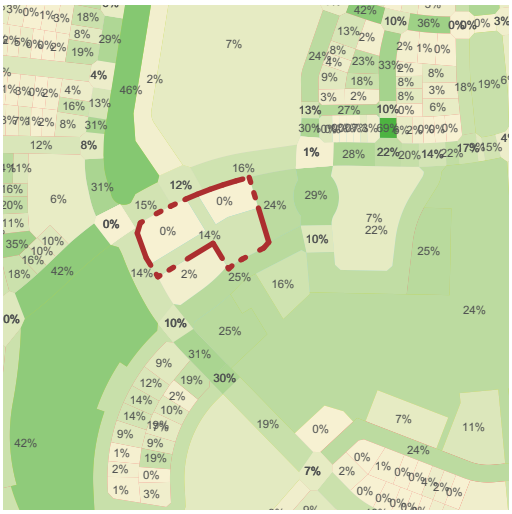
Private

Canopy Coverage



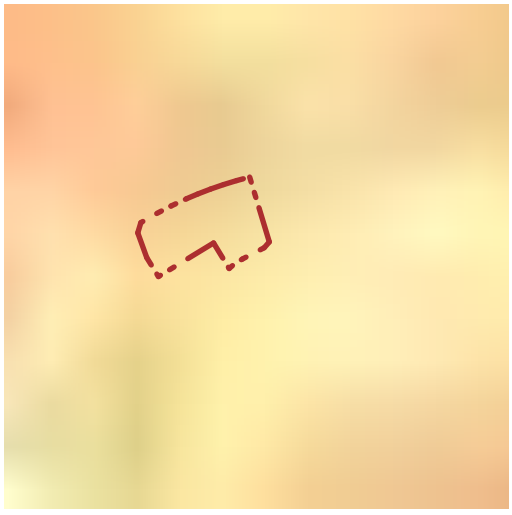
7%

0%	Street
16%	Developed
0%	Pocket Park



Canopy Coverage

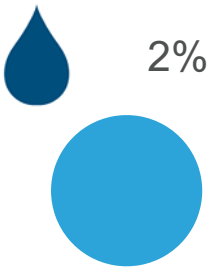
0 100



Surface Land Temperature

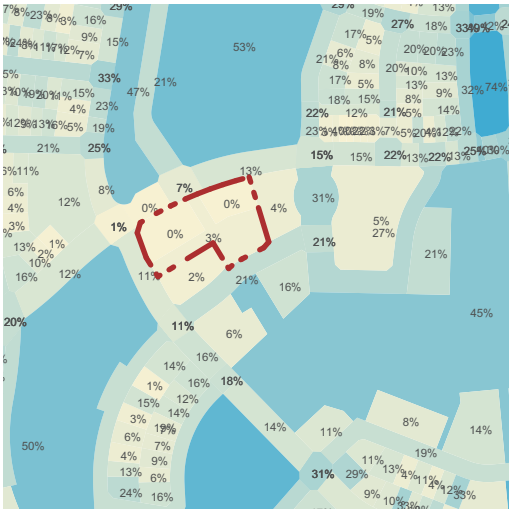
23°C 45°C

Permeability



2%

0%	Street
100%	Developed
0%	Pocket Park



Permeability

0 100

CZ4 Average

17.8%

26%

Living Infrastructure

Forde - Gungahlin

CZ4 Site A

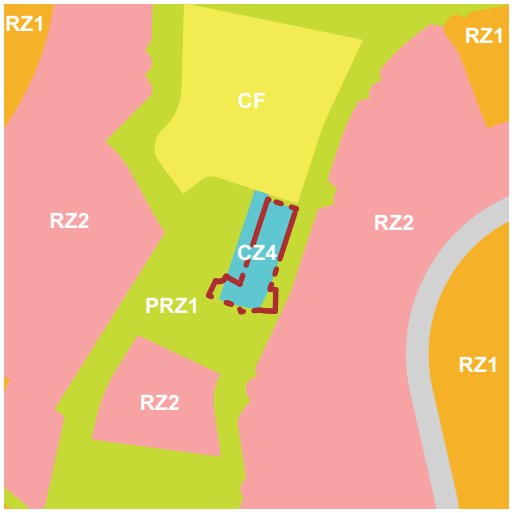
Tait Network

SCALE AT A4
1:7500

REVISION

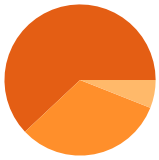
DATE

DRAWING NUMBER
SK-007



Land Use

Site Components

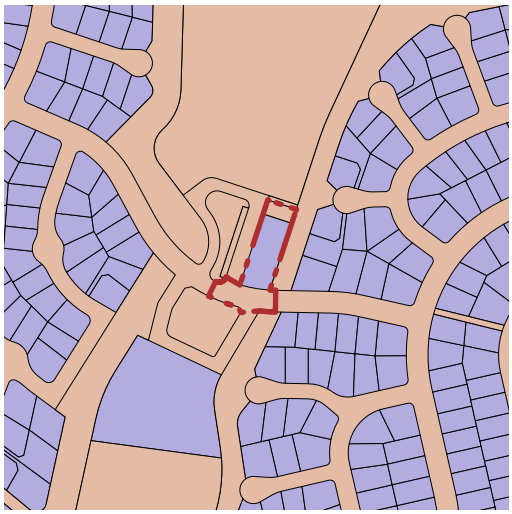


62% Street

32% Developed

6% Pocket Park

Aerial



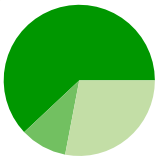
Land Ownership

Public

Private

Canopy Coverage

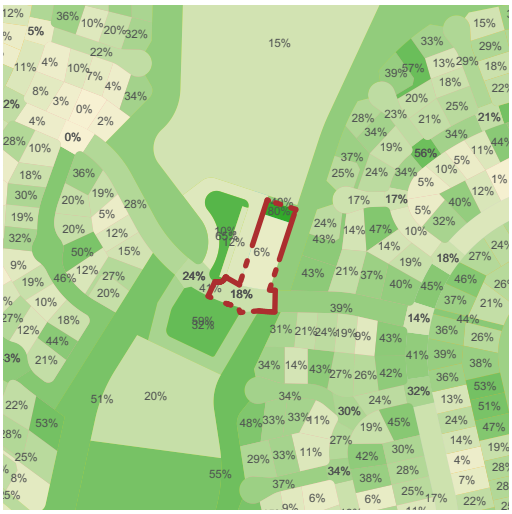
18%



62% Street

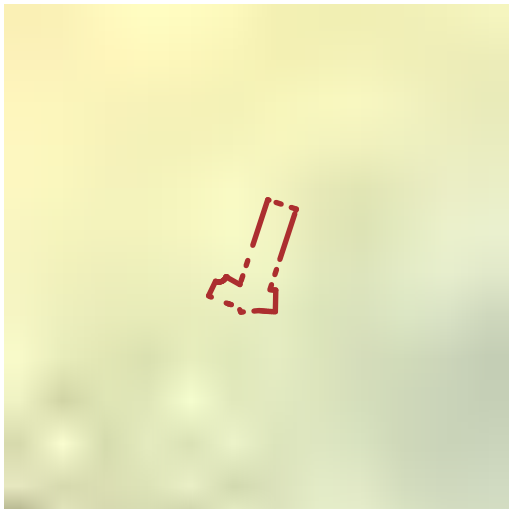
10% Developed

28% Pocket Park



Canopy Coverage

0 100

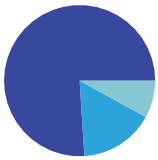


Surface Land Temperature

23°C 45°C

Permeability

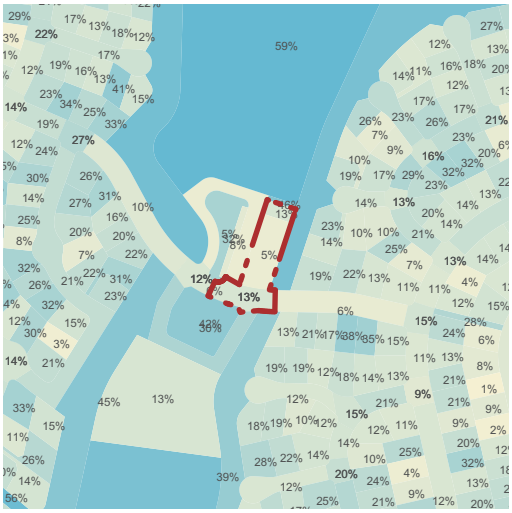
11%



76% Street

16% Developed

8% Pocket Park



Permeability

0 100

CZ4 Average

17.8%

26%

Living Infrastructure

Fadden - Tuggeranong

CZ4 Site B

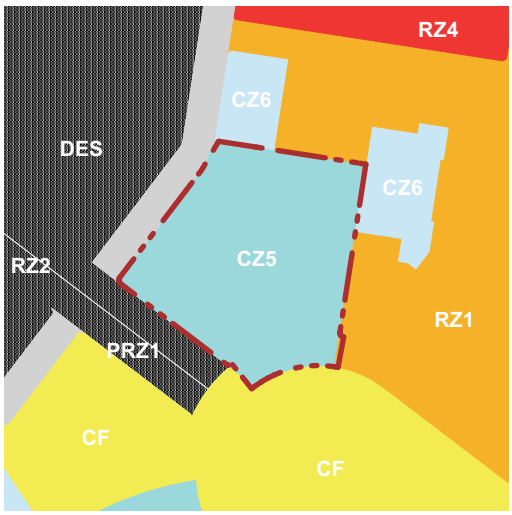
Tait Network

SCALE AT A4
1:7500

REVISION

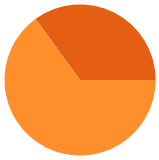
DATE

DRAWING NUMBER
SK-008



Land Use

Site Components

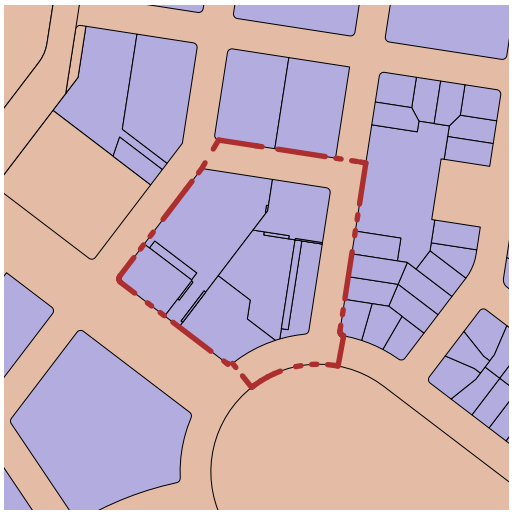


35% Street

65% Developed

0% Pocket Park

Aerial



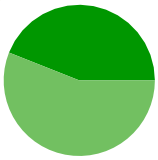
Land Ownership

Public

Private

Canopy Coverage

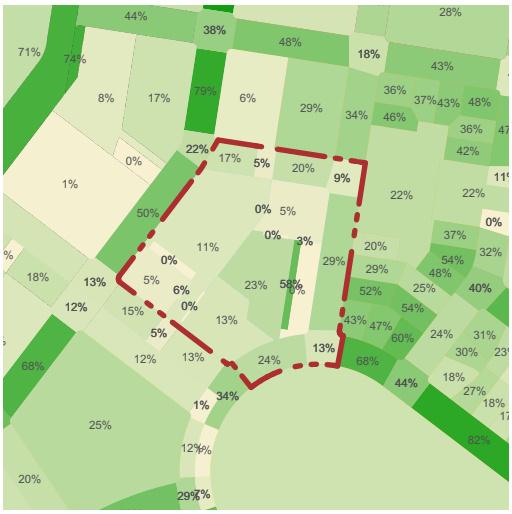
15%



44% Street

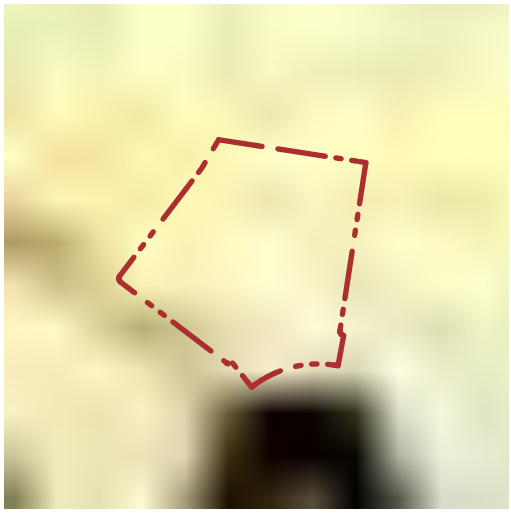
56% Developed

0% Pocket Park



Canopy Coverage

0 100

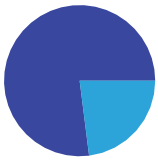


Surface Land Temperature

23°C 45°C

Permeability

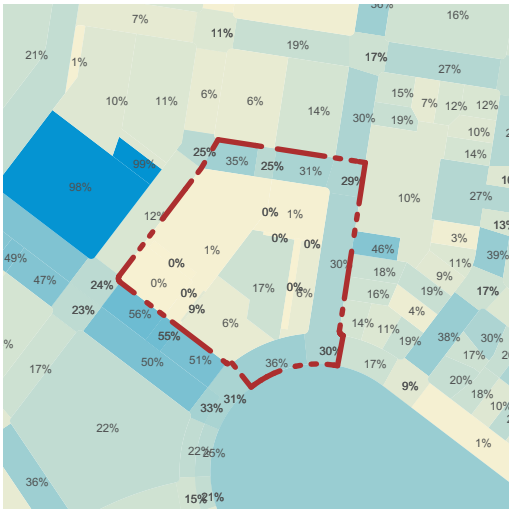
14%



77% Street

23% Developed

0% Pocket Park



Permeability

0 100

CZ5 Average

12.1%

26%

Living Infrastructure

Barton

CZ5 Site A

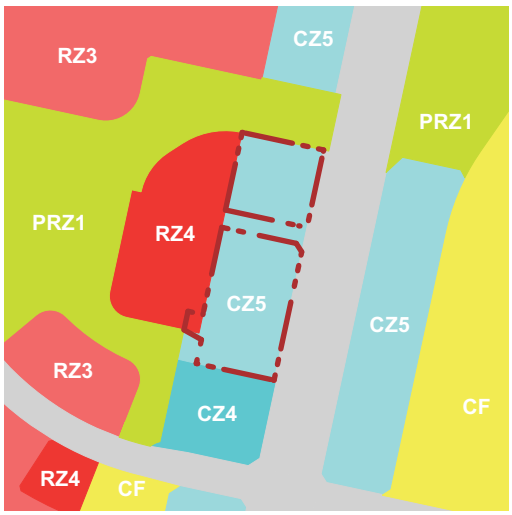
Tait Network

SCALE AT A4
1:7500

REVISION

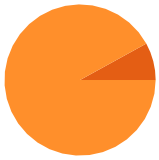
DATE

DRAWING NUMBER
SK-009



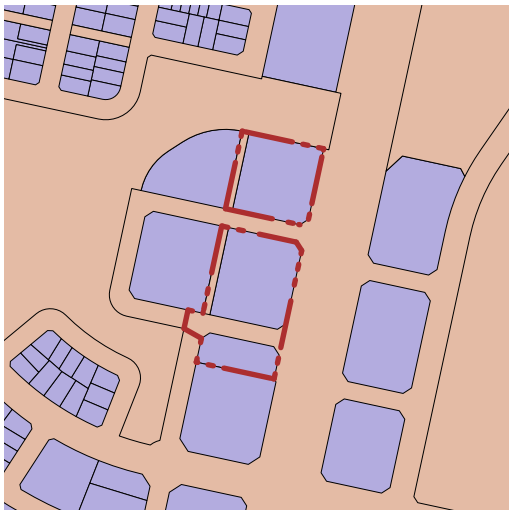
Land Use

Site Components



8%	Street
92%	Developed
0%	Pocket Park

Aerial

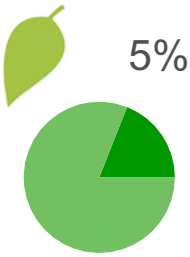


Land Ownership

Public

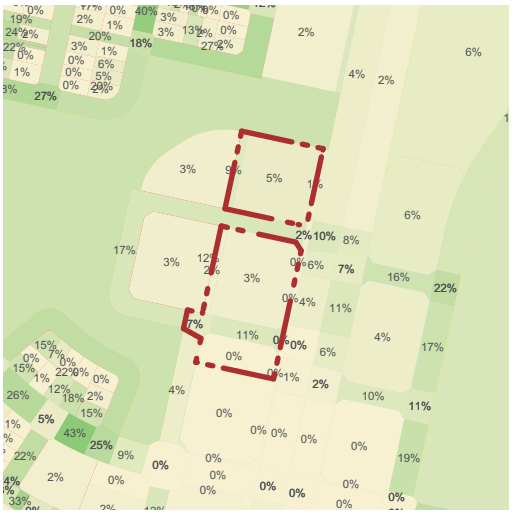
Private

Canopy Coverage



5%

19%	Street
81%	Developed
0%	Pocket Park



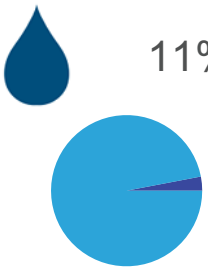
Canopy Coverage

0 100

Surface Land Temperature

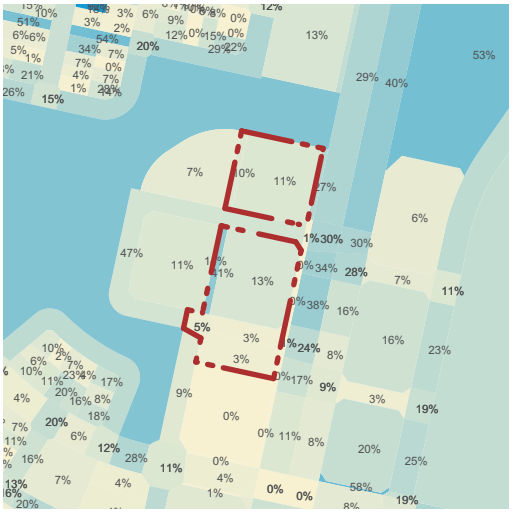
23°C 45°C

Permeability



11%

3%	Street
97%	Developed
0%	Pocket Park



Permeability

0 100

CZ5 Average

12.1%

26%

Living Infrastructure

Franklin - Gungahlin

CZ5 Site A

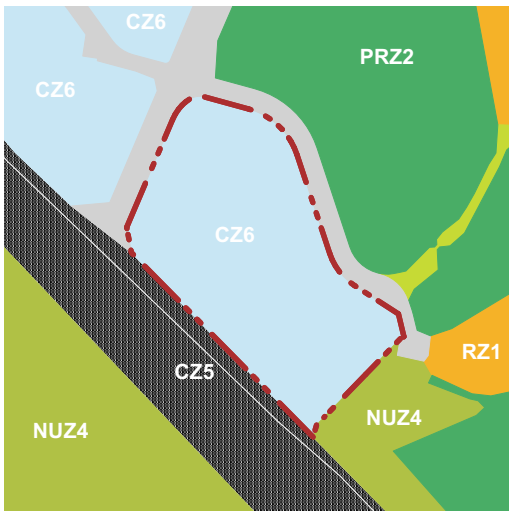
Tait Network

SCALE AT A4
1:7500

REVISION

DATE

DRAWING NUMBER
SK-010

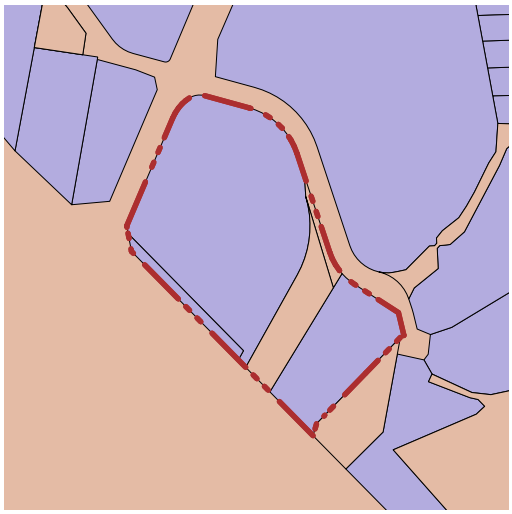


Land Use

Site Components

0%	Street
85%	Developed
15%	Pocket Park

Aerial



Land Ownership

Public | Private

Canopy Coverage

19%

0%	Street
90%	Developed
10%	Pocket Park

Canopy Coverage

0 | 100

Surface Land Temperature

23°C | 45°C

Permeability

48%

0%	Street
72%	Developed
28%	Pocket Park

Permeability

0 | 100

CZ6 Average

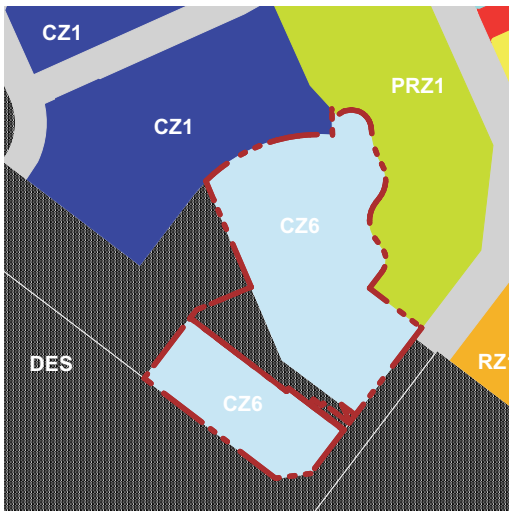
21.1%

64%

Living Infrastructure
Nicholls - Gungahlin
CZ6 Site A

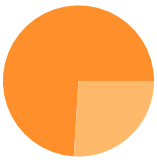
Tait Network

SCALE AT A4
1:7500
REVISION
DATE
DRAWING NUMBER
SK-011



Land Use

Site Components



0%	Street
74%	Developed
26%	Pocket Park

Aerial

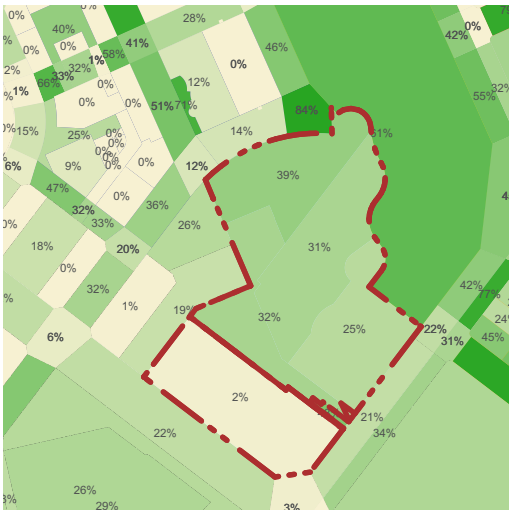
Land Ownership

Public | Private

Canopy Coverage

23%

0%	Street
64%	Developed
36%	Pocket Park



Canopy Coverage

0 | 100

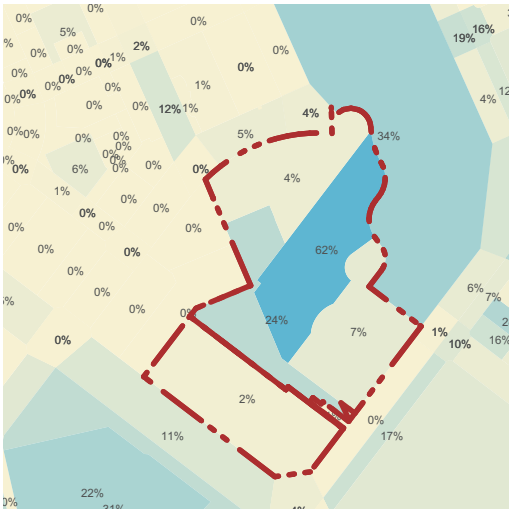
Surface Land Temperature

23°C | 45°C

Permeability

20%

0%	Street
17%	Developed
83%	Pocket Park



Permeability

0 | 100

CZ6 Average

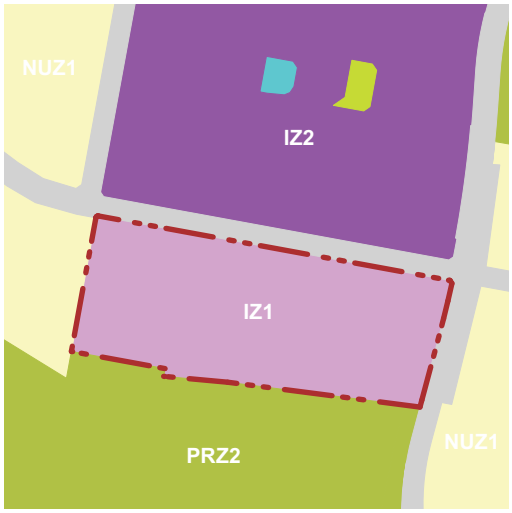
21.1%

64%

Living Infrastructure
City
CZ6 Site B

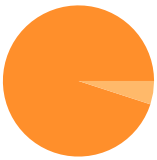
Tait Network

SCALE AT A4
1:7500
REVISION
DATE
DRAWING NUMBER
SK-012



Land Use

Site Components



0%	Street
95%	Developed
5%	Pocket Park

Aerial

Land Ownership

Public | Private

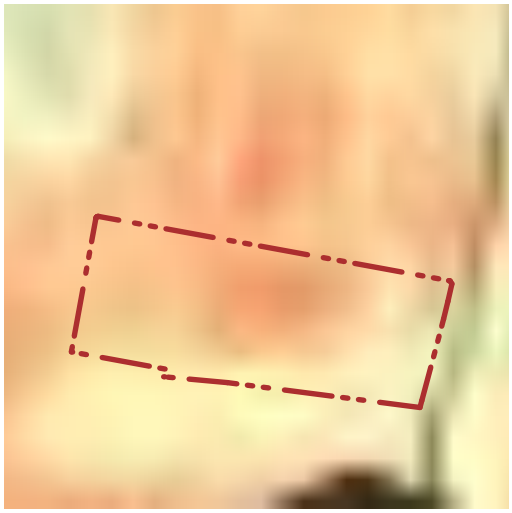
Canopy Coverage

16%

0%	Street
85%	Developed
15%	Pocket Park

Canopy Coverage

0 — 100

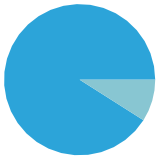


Surface Land Temperature

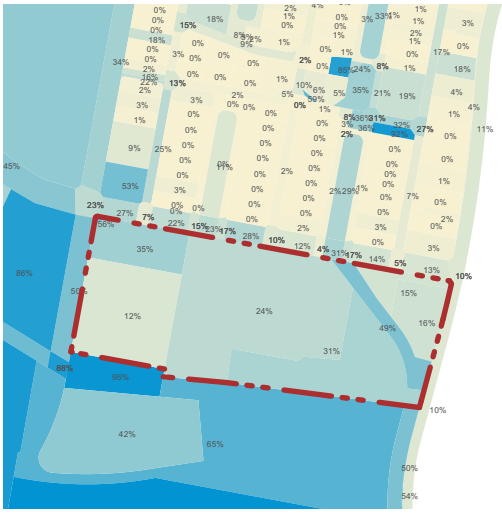
23°C — 45°C

Permeability

25%



0%	Street
91%	Developed
9%	Pocket Park



Permeability

0 — 100

IZ1 Average

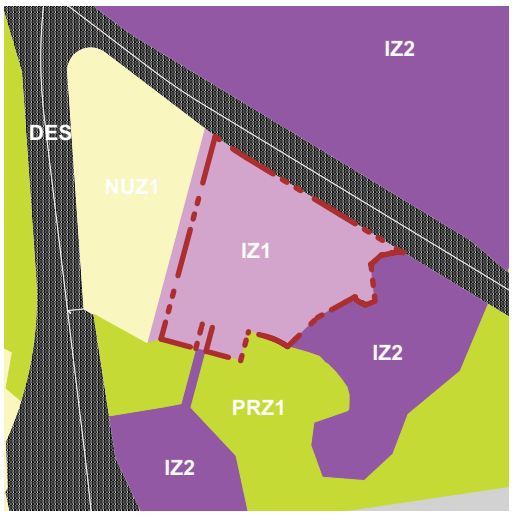
8.2%

43%

Living Infrastructure
Mitchell - Gungahlin
IZ1 Site A

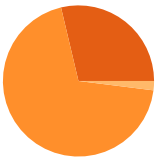
Tait Network

SCALE AT A4
1:15000
REVISION
DATE
DRAWING NUMBER
SK-013



Land Use

Site Components

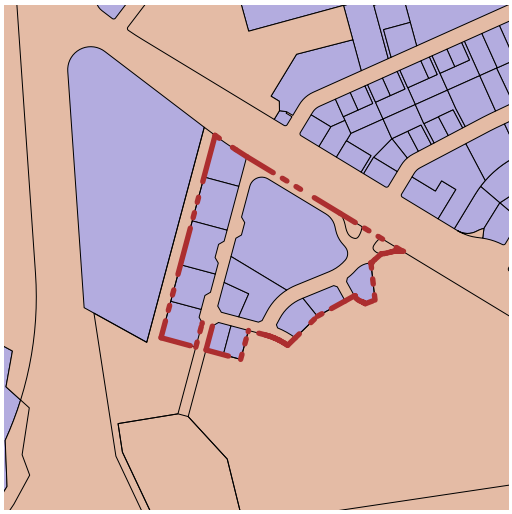


29% Street

70% Developed

2% Pocket Park

Aerial



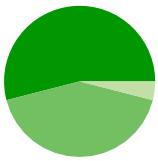
Land Ownership

Public

Private

Canopy Coverage

9%



54% Street

42% Developed

4% Pocket Park

Canopy Coverage

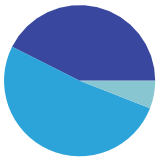
0 100

Surface Land Temperature

23°C 45°C

Permeability

21%



43% Street

52% Developed

6% Pocket Park

Permeability

0 100

IZ1 Average

8.2%

43%

Living Infrastructure

Symonston

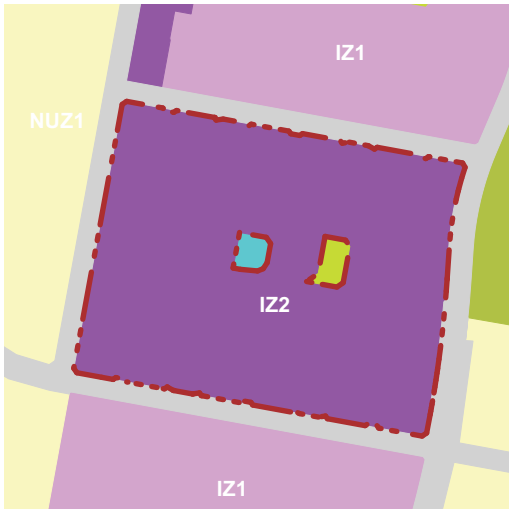
IZ1 Site B

Tait Network

SCALE AT A4
1:15000
REVISION

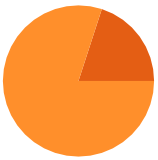
DATE

DRAWING NUMBER
SK-014



Land Use

Site Components



20%	Street
80%	Developed
0%	Pocket Park

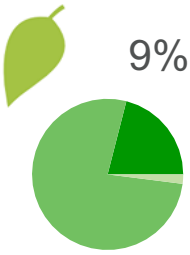
Aerial

Land Ownership

Public

Private

Canopy Coverage

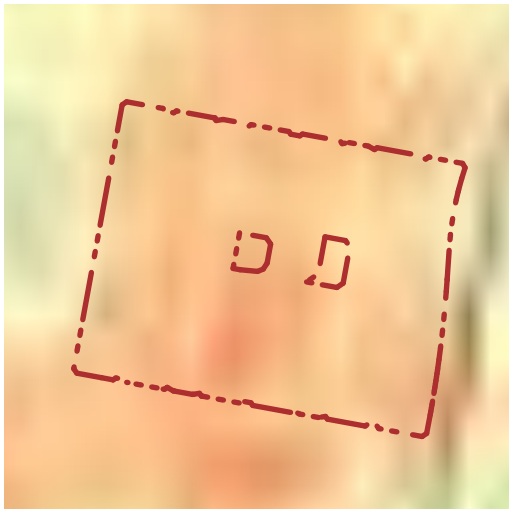


9%

21%	Street
77%	Developed
2%	Pocket Park

Canopy Coverage

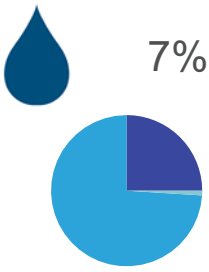
0 100



Surface Land Temperature

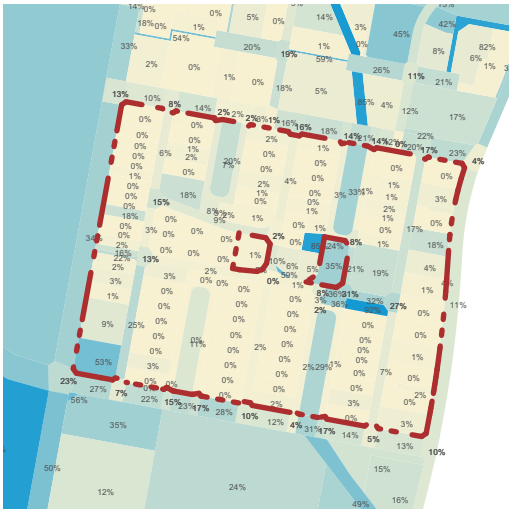
23°C 45°C

Permeability



7%

25%	Street
74%	Developed
1%	Pocket Park



Permeability

0 100

IZ2 Average

6%

21%

Living Infrastructure

Mitchell - Gungahlin

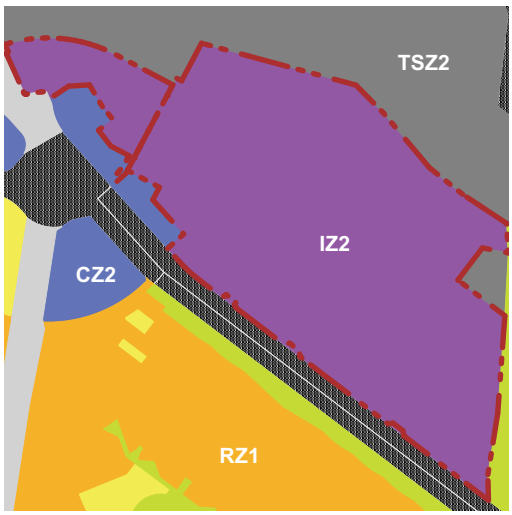
IZ2 Site A

Tait Network

SCALE AT A4
1:15000
REVISION

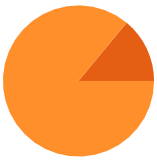
DATE

DRAWING NUMBER
SK-015



Land Use

Site Components



14% Street

86% Developed

0% Pocket Park

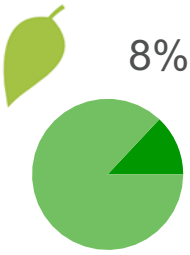
Aerial

Land Ownership

Public

Private

Canopy Coverage

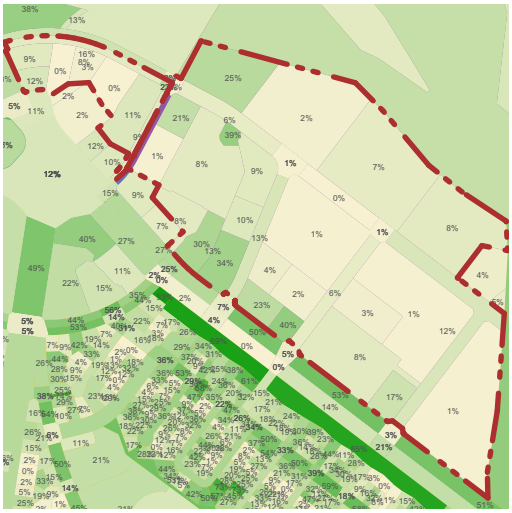


8%

13% Street

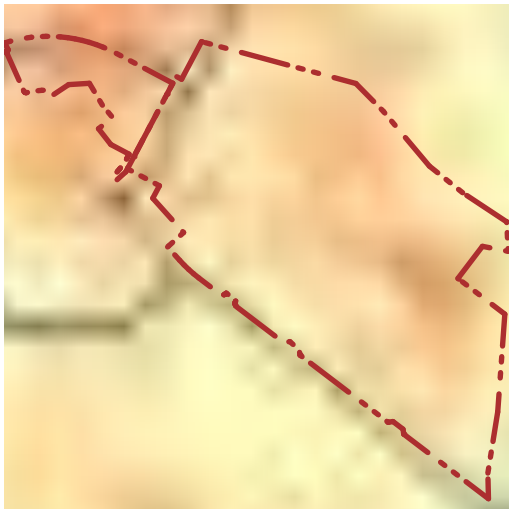
87% Developed

0% Pocket Park



Canopy Coverage

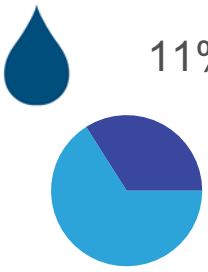
0 100



Surface Land Temperature

23°C 45°C

Permeability



11%

34% Street

66% Developed

0% Pocket Park

Permeability

0 100

IZ2 Average

6%

21%

Living Infrastructure

Fyshwick - Inner South

IZ2 Site B

Tait Network

SCALE AT A4
1:15000

REVISION

DATE

DRAWING NUMBER
SK-016

APPENDIX B COMMERCIAL ZONES TEST SITES INVESTIGATION

The following examples separate commercial blocks into elements in order to understand what living infrastructure is currently being achieved in the surface carparking and movement networks / open space.

CZ1: City

Canopy : 45% Permeability : 8%

CZ1: City

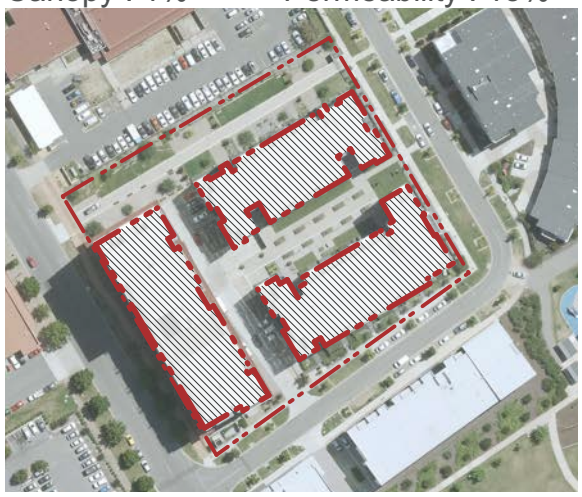
Canopy : 3% Permeability : 2%

CZ2: Phillip

Canopy : 35% Permeability : 8%

CZ2: Tuggeranong

Canopy : 1% Permeability : 15%



CZ3: Calwell, Tuggeranong

Canopy : 42% Permeability : 10%

CZ3: Phillip, Woden Valley

Canopy : 6% Permeability : 7%

NORTH

Living Infrastructure
Movement Network

Tait Network

SCALE AT A4
1:2500
REVISION
A
DATE
22/04/22
DRAWING NUMBER
SK-101

CZ4: Bonython, Tuggeranong

Canopy : 33% Permeability : 12%

CZ4: Gordon, Tuggeranong

Canopy : 4% Permeability : 15%

CZ5: Kingston, Canberra Central

Canopy : 43% Permeability : 13%

CZ5: Deakin, Canberra Central

Canopy : 29% Permeability : 13%

CZ6: Braddon, Canberra Cental

Canopy : 25% Permeability : 17%

CZ6: Narrabundah, Canberra Central

Canopy : 13% Permeability : 7%

Living Infrastructure
Movement Network

Tait Network

SCALE AT A4
1:2500
REVISION
A
DATE
22/04/22
DRAWING NUMBER
SK-102

CZ1 : Greenway, Tuggeranong

Canopy : 7.62% Permeability : 1.87%

CZ1 : Weston, Weston Creek

Canopy : 8.09% Permeability : 0.97%

CZ2 : Belconnen

Canopy : 0.41% Permeability : 2.94%

CZ2 : Deakin, Canberra Central

Canopy : 45.32% Permeability : 3.96%

CZ3 : Mawson, Woden Valley

Canopy : 8.96% Permeability : 0.75%

CZ3 : Phillip, Woden Valley

Canopy : 11.04% Permeability : 1.91%

Living Infrastructure

Commercial Zones

Car Parks

Tait Network

SCALE AT A4
1:2500

REVISION
A

DATE
22/04/22

DRAWING NUMBER
SK-103

CZ4 : Isabella Plains, Tuggeranong

Canopy : 27.82% Permeability : 9.87%

CZ4 : Gordon, Tuggeranong

Canopy : 1.69% Permeability : 1.09%

CZ5 : Braddon, City Central

Canopy: 26.47% Permeability: 9.90%

CZ5: Braddon, City Central

Canopy: 31.76% Permeability: 4.43%

CZ6 : Forrest, Canberra Central

Canopy: 6% Permeability: 2%

CZ6: Greenway, Tuggeranong

Canopy: 16.53% Permeability: 23.19%

Living Infrastructure
Commercial Zones
Car Parks

Tait Network

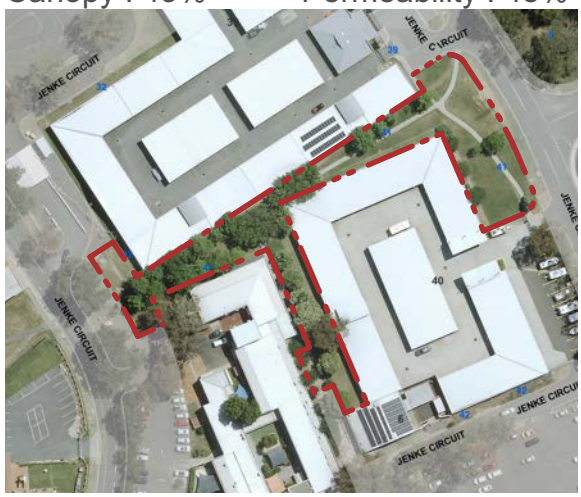
SCALE AT A4
1:2500
REVISION
A
DATE
22/04/22
DRAWING NUMBER
SK-104

CZ1 : Gungahlin

Canopy : 25% Permeability : 20%

CZ2: Kambah, Tuggeranong

Canopy : 43% Permeability : 48%



CZ3 : Belconnen

Canopy : 52% Permeability : 42%

CZ4 : Red Hill, Canberra Central

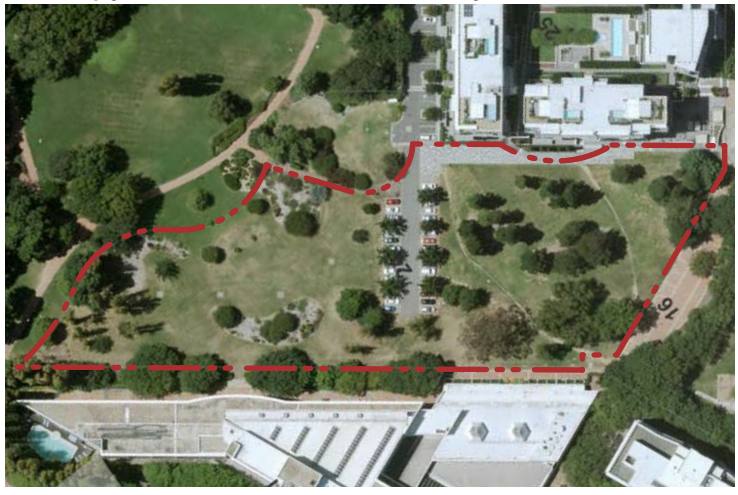
Canopy : 70% Permeability : 20%

CZ5 : Barton, Canberra Central

Canopy : 39% Permeability : 30%

CZ6 : City, Canberra Central

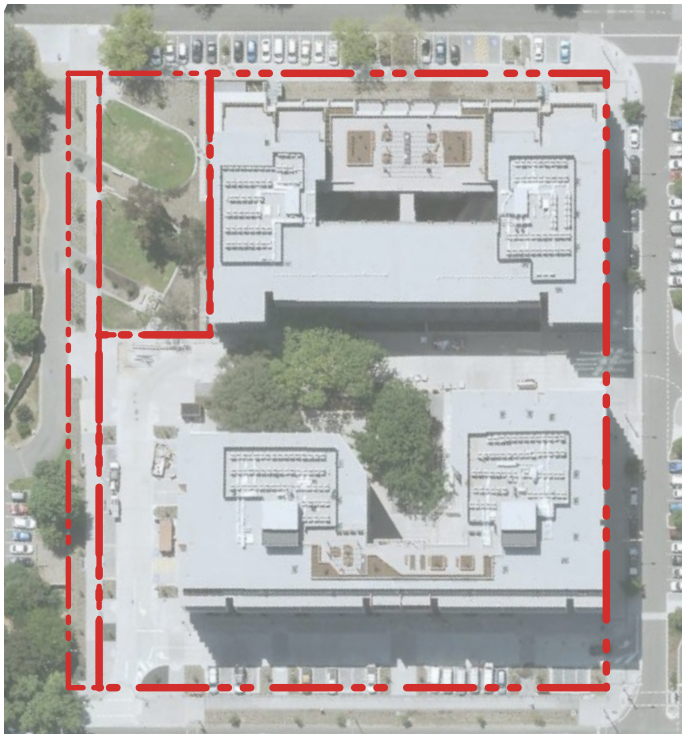
Canopy : 32% Permeability : 62%



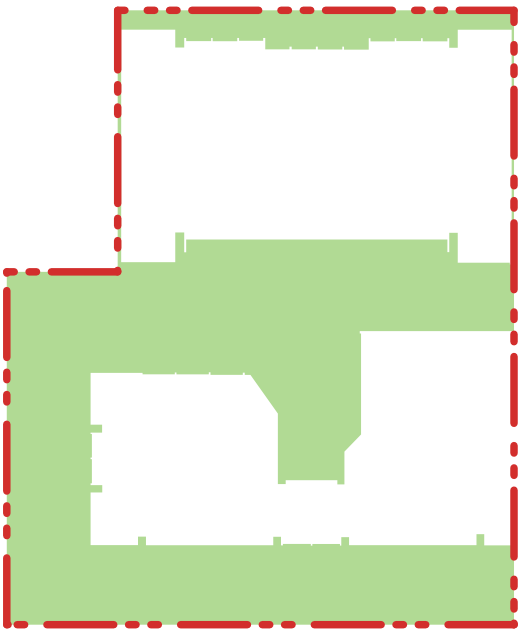
Living Infrastructure
Commercial Zones
Public Open Spaces

Tait Network

SCALE AT A4
1:2500
REVISION
A
DATE
22/04/22
DRAWING NUMBER
SK-105



Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	5898
Surface Open Space	5226
Surface Carpark	0
Overall Block	11124

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	728	6.5	1829	16.4
POS	2225	20	N/A	N/A
Planting Area	1112	10	783	7

Founders Lane, Currong St Braddon

Existing Conditions

10.4%

3.6%

Living Infrastructure

Commerical Controls Comparison

Founders Lane

Tait Network

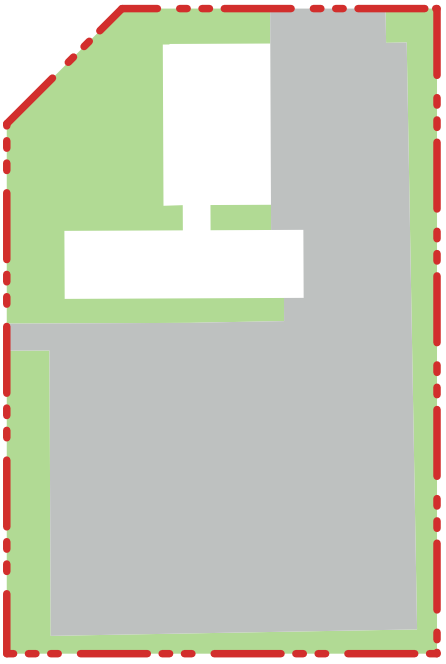
SCALE AT A4
1:1500

REVISION
A

DATE
6/06/22

DRAWING NUMBER
SK-120

Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	1349
Surface Open Space	3241
Surface Carpark	6072
Overall Block	10663

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	728	6.8	2956	27.7
POS	2133	20	N/A	N/A
Planting Area	1066	10	1093	1.5

220 Northbourne Ave, Braddon

Existing Conditions

27.4%

3.8%

Living Infrastructure

Commerical Controls Comparison

220 Northbourne

Tait Network

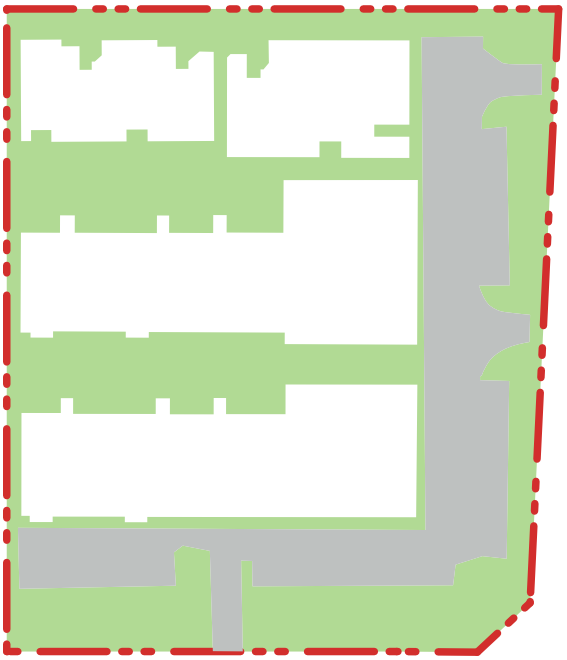
SCALE AT A4
1:1500

REVISION
A

DATE
6/06/22

DRAWING NUMBER
SK-121

Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	5183
Surface Open Space	5666
Surface Carpark	2673
Overall Block	13522

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	878	6.4	2785	20.5
POS	2704	20	N/A	N/A
Planting Area	1352	10	1117	8.2

1 Braybrooke Street, Bruce

Existing Conditions

16.6%

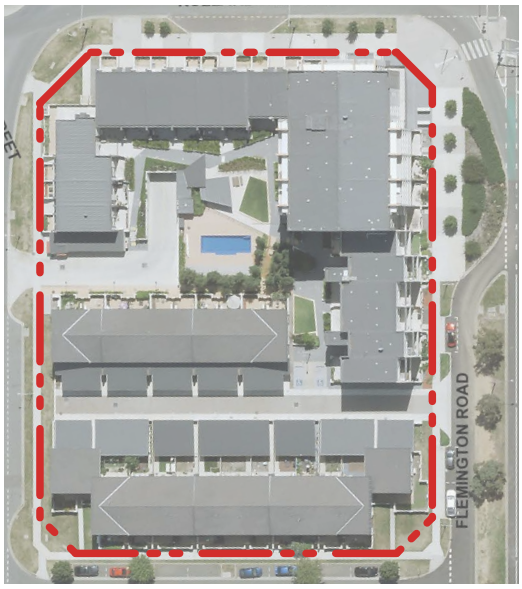
16.8%

Living Infrastructure

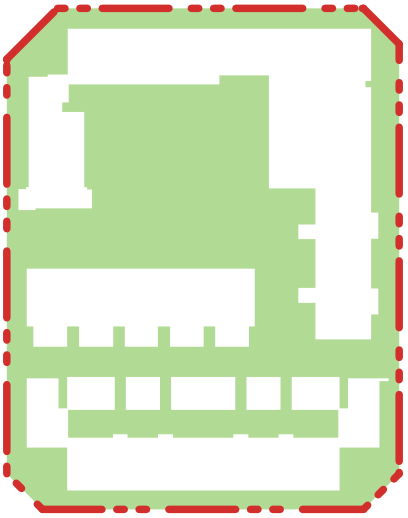
Commerical Controls Comparison
1 Braybrooke Street

Tait Network

SCALE AT A4
1:1500
REVISION
A
DATE
6/06/22
DRAWING NUMBER
SK-122



Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	3437
Surface Open Space	4175
Surface Carpark	0
Overall Block	7612

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	528	7	1461	19.1
POS	1522.4	20	N/A	N/A
Planting Area	761.2	10	626	2.7

235 Flemington Road, Gungahlin
Existing Conditions

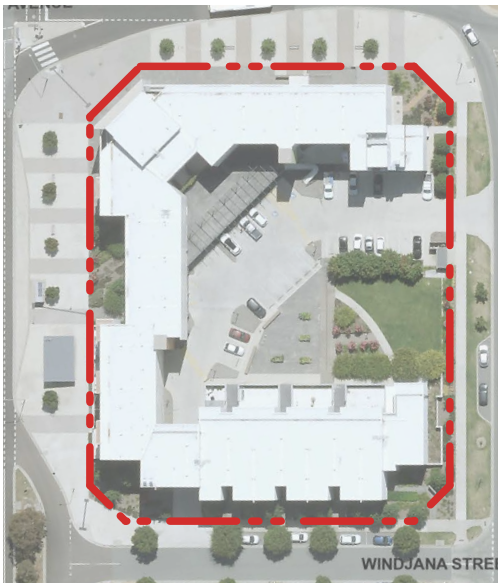
1.5%

9.8%

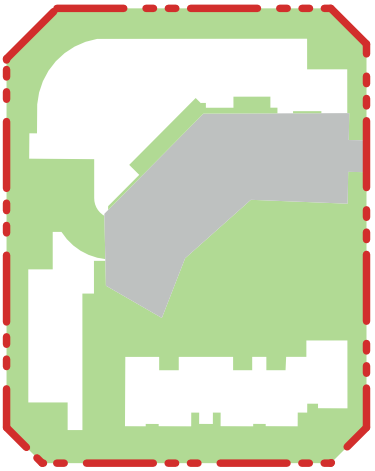
Living Infrastructure
Commerical Controls Comparison
235 Flemington Road

Tait Network

SCALE AT A4
1:1500
REVISION
A
DATE
6/06/22
DRAWING NUMBER
SK-123



Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	1975
Surface Open Space	3195
Surface Carpark	1048
Overall Block	6319

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	428	6.7	1432	22.6
POS	1263.8	20	N/A	N/A
Planting Area	631.9	10	384	2.5

162 Flemington Road, Harrison
Existing Conditions

2.2%

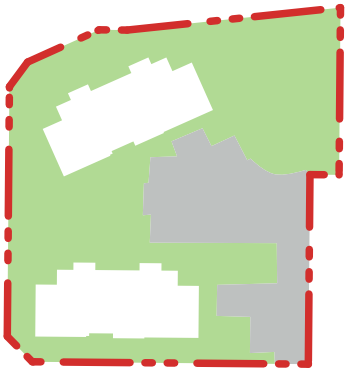
12.3%

Living Infrastructure
Commerical Controls Comparison
162 Flemington Road

Tait Network

SCALE AT A4
1:1500
REVISION
A
DATE
6/06/22
DRAWING NUMBER
SK-124

Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	832
Surface Open Space	2451
Surface Carpark	835
Overall Block	4118

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	328	7.9	1108	27
POS	823.6	20	N/A	N/A
Planting Area	411.8	10	451	11

91 Ernest Cavanagh Street, Gungahlin
Existing Conditions

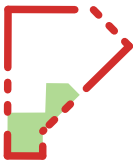
11.5% 31.6%

Living Infrastructure
Commerical Controls Comparison
91 Ernest Cavanagh Street

Tait Network

SCALE AT A4
1:1500
REVISION
A
DATE
6/06/22
DRAWING NUMBER
SK-125

Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	348
Surface Open Space	98
Surface Carpark	0
Overall Block	445

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	78	17.5	34	7.7
POS	89	20	N/A	N/A
Planting Area	44.5	10	14.7	3.3

92 Phyllis Ashton Circuit, Gungahlin
Existing Conditions

2.5%

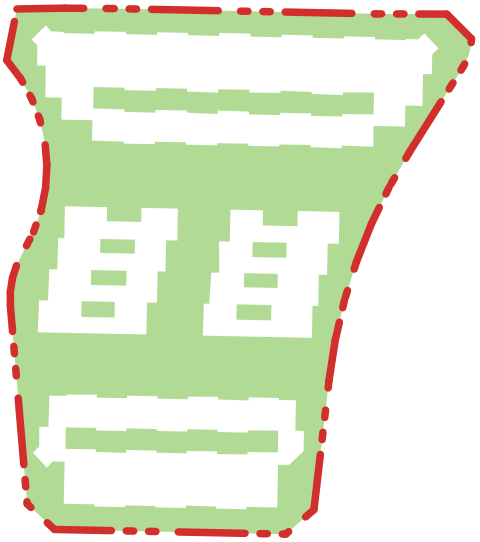
0.0%

Living Infrastructure
Commerical Controls Comparison
92 Phyllis Ashton Circuit

Tait Network

SCALE AT A4
1:1500
REVISION
A
DATE
6/06/22
DRAWING NUMBER
SK-126

Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	3076
Surface Open Space	3479
Surface Carpark	0
Overall Block	7091

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	478	6.7	1217	17.1
POS	1418.2	20	N/A	N/A
Planting Area	709.1	10	522	2.5

1 Tom Nicholas Crescent, Forde
Existing Conditions

7.6%

5.6%

Living Infrastructure
Commerical Controls Comparison
1 Tom Nicholas Crescent

Tait Network

SCALE AT A4
1:1500
REVISION
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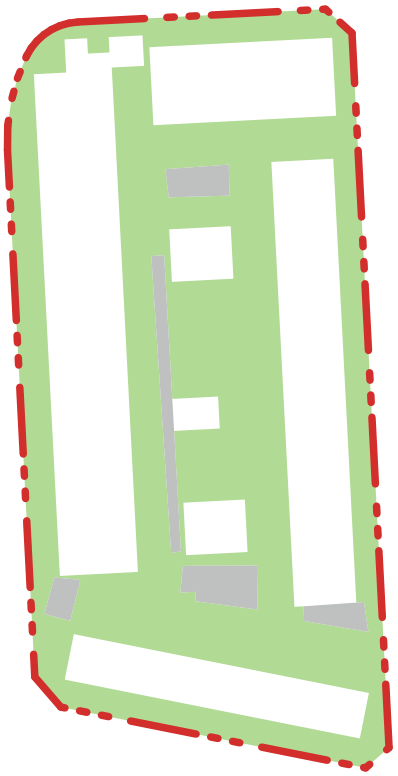
DRAWING NUMBER
SK-127

Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	4145
Surface Open Space	5275
Surface Carpark	413
Overall Block	9828

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	678	6.9	1970	20
POS	1965.6	20	N/A	N/A
Planting Area	982.8	10	832	8.5

562 Cotter Road, Coombs

Existing Conditions

0%

4.0%

Living Infrastructure

Commerical Controls Comparison
562 Cotter Road

Tait Network

SCALE AT A4
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REVISION
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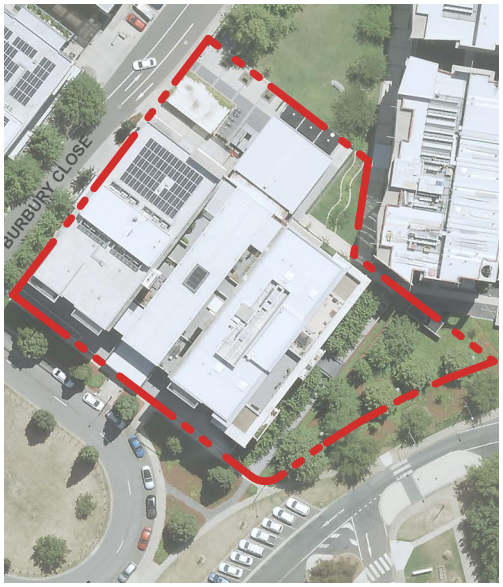
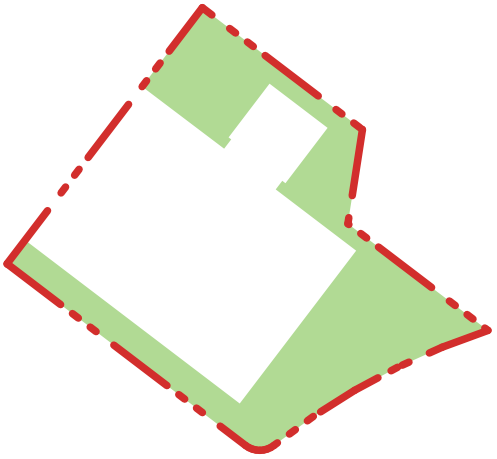
DATE
6/06/22

DRAWING NUMBER
SK-128



Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	982
Surface Open Space	442
Surface Carpark	0
Overall Block	1424

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	128	8.9	154.7	10.9
POS	284.8	20	N/A	N/A
Planting Area	142.4	10	66	4.7

9 Fitzroy Street, Forrest
Existing Conditions

5.1%

3.1%

Living Infrastructure
Commerical Controls Comparison
9 Fitzroy Street

Tait Network

SCALE AT A4
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REVISION
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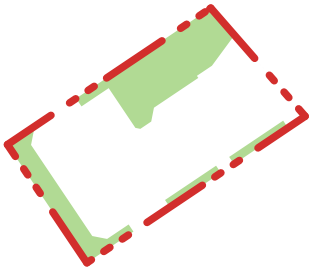
DATE
6/06/22
DRAWING NUMBER
SK-129

Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	2272
Surface Open Space	1858
Surface Carpark	0
Overall Block	4127

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	228	7.9	650	15.8
POS	825.4	20	N/A	N/A
Planting Area	412.7	10	279	6.8

5 Sydney Avenue, Barton
Existing Conditions

13.7%

6.7%

Living Infrastructure
Commerical Controls Comparison
5 Sydney Avenue

Tait Network

SCALE AT A4
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REVISION
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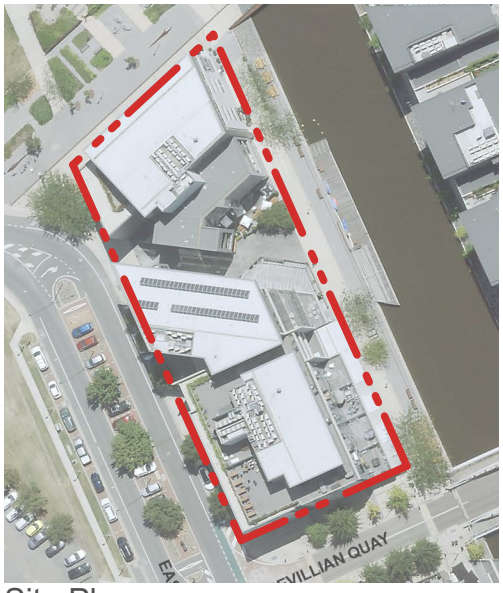
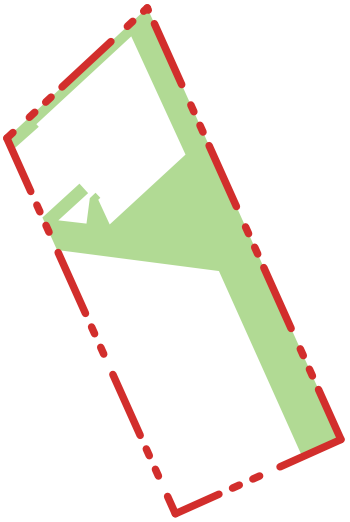
DRAWING NUMBER
SK-130



Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	2045
Surface Open Space	1115
Surface Carpark	0
Overall Block	3160

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	228	7.2	390	12.3
POS	632	20	N/A	N/A
Planting Area	316	10	167	5.3

21 Eastlake Parade, Kingston
Existing Conditions

2.1%

0.0%

Living Infrastructure
Commerical Controls Comparison
21 Eastlake Parade

Tait Network

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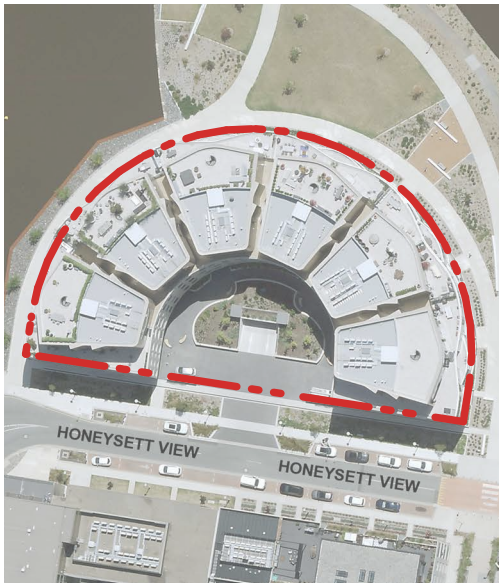
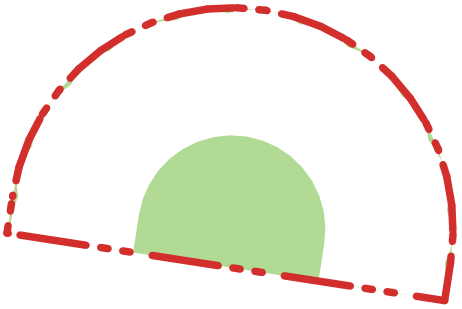


Site Plan



Surface Condition

Legend

- Subject Site Block Boundary
- Surface Open Space
- Surface Car Park

Area	m2
Building Footprint	2803
Surface Open Space	885
Surface Carpark	0
Overall Block	3688

Category	DV369		Draft Commercial Controls	
	m2	% of Block	m2	% of Block
Canopy	279	8.4	310	8.4
POS	737.6	20	N/A	N/A
Planting Area	368.8	10	133	3.6

45 Honeysett View, Kingston
Existing Conditions

0%

0%

Living Infrastructure
Commerical Controls Comparison
45 Honeysett View

Tait Network

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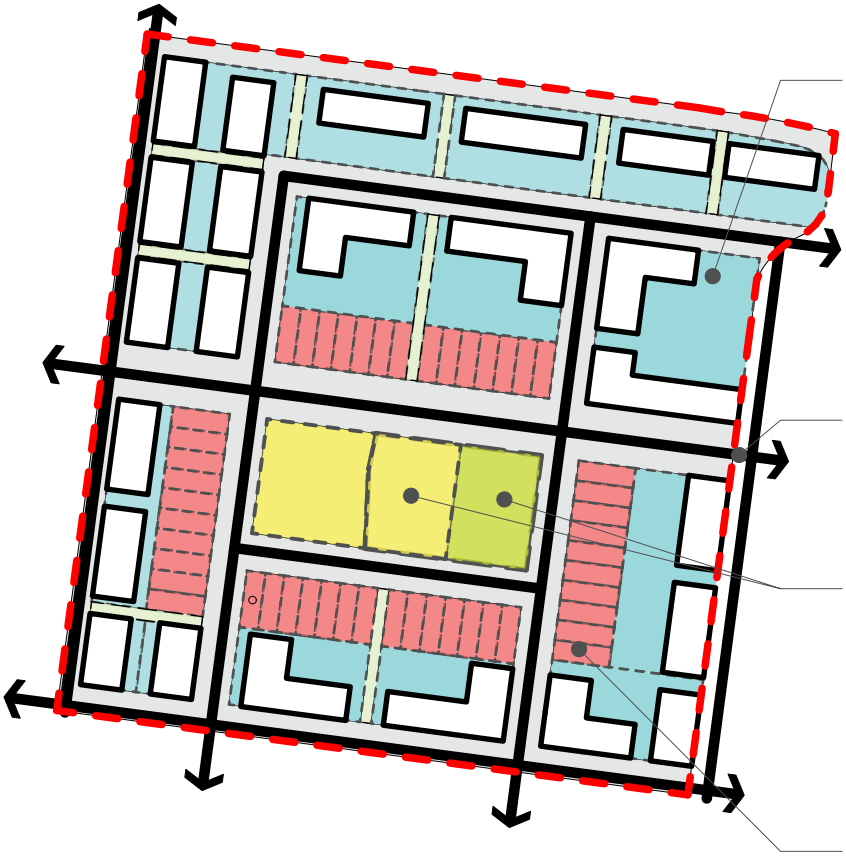
SK-132

APPENDIX C OTHER ESTATES TEST SITES INVESTIGATION

The following examples show how the recommended framework would apply controls to infill estates.



Mixed use commercial blocks to meet benchmarks for surface car parks, open space and movement networks as per commercial zones provisions. In addition DV369 block level benchmarks.

Roads will have to meet minimum canopy benchmark and permeability benchmark depending on land use zone

Community facilities and open space benchmark to vary depending on typology

Residential block benchmarks as per DV369

	Residential Zones		Commercial Zones		Community Facilities Zone		Public Streets		Public Open Space		Nominal Estate Outcome	
	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%
East Lake	4%	20%	20%	10%	35%	30%	30%	30%	35%	50%	**22%**	**19%**

East Lake, Kingston

Living Infrastructure
Other Estates

Tait Network

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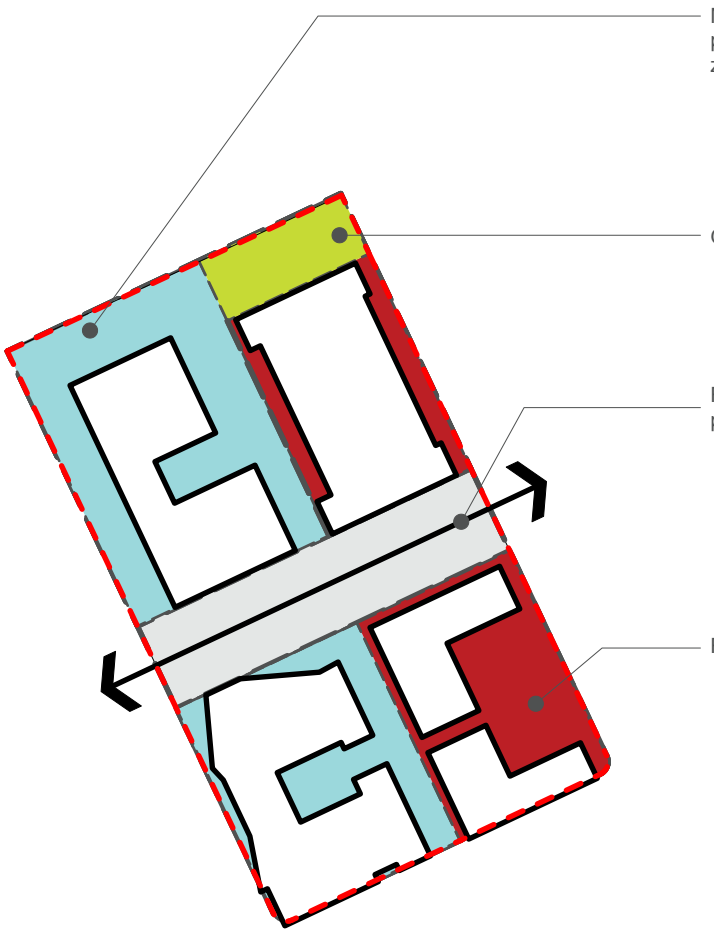
SK-200



	Residential Zones		Commercial Zones		Community Facilities Zone		Public Streets		Public Open Space		Nominal Estate Outcome	
	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%
Founders lane	7%	25%	18%	10%	-	-	30%	30%	35%	50%	**17%**	**19%**

Founder Lane, Canberra City

Living Infrastructure
Other Estates

Tait Network

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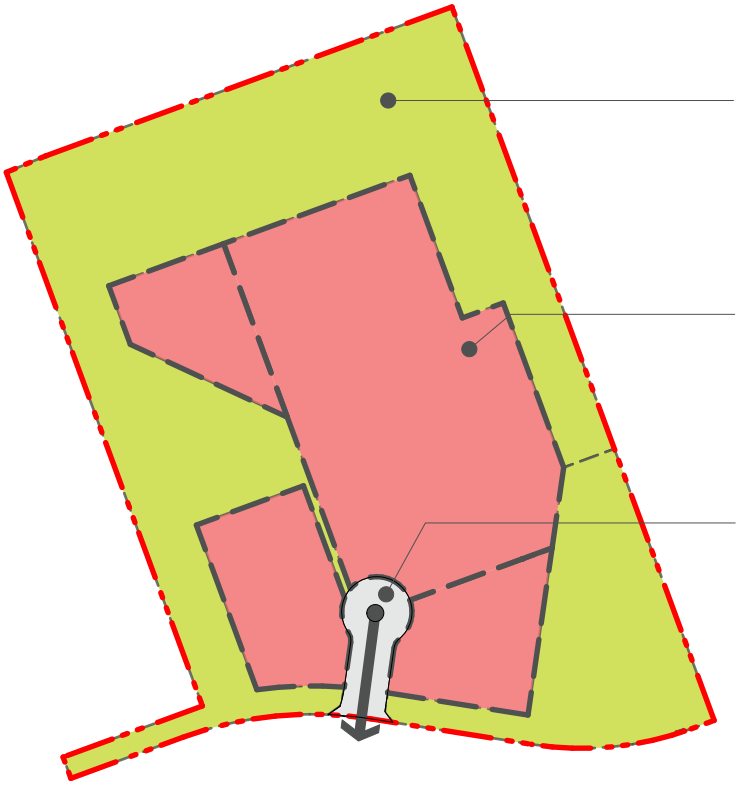

	Residential Zones		Commercial Zones		Community Facilities Zone		Public Streets		Public Open Space		Nominal Estate Outcome	
	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%	Canopy%	Permeability%
Watson s76	15%	25%	-	-	-	-	30%	30%	35%	50%	**26%**	**39%**

Section 76, Watson

Living Infrastructure
Other Estates

Tait Network

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SK-202