Report for Landcom

Cherrybrook Station SSP
Ecologically Sustainable Development Plan

5 April 2022

EDGE

Project Delivered for:

Samantha Mitchell - Development Manager

Landcom

Level 14, 60 Station St

Parramatta NSW 2150

0436 946 786 – smitchell@landcom.nsw.gov.au

Project Delivered by:

Kevin Anderson – Senior Consultant

Edge Environment

Level 5, 39 East Esplanade, Manly, NSW 2095, AUSTRALIA

kevin.anderson@edgeenvironment.com

Dr Jenni Garden - Senior Consultant

Edge Environment

60 Halifax Street, Adelaide SA 5000

jenni.garden@edgeenvironment.com

Dr Prae Wongthong – Sustainability Consultant

Edge Environment

60 Halifax Street, Adelaide SA 5000

prae.wongthong@edgeenvironment.com

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Executive Summary

This study relates to a proposal to develop land called the ‘Cherrybrook Station Government Land State Significant Precinct’ (Cherrybrook Station SSP) by Landcom on behalf of the landowner, Sydney Metro. The State Significant Precinct is centred around Cherrybrook Station on the Metro North West Line.

This Ecologically Sustainable Development (ESD) Plan sets the framework for sustainable outcomes for the Cherrybrook Station SSP by quantifying its environmental footprint, setting ESD targets and identifying potential initiatives to minimise the environmental footprint. It responds to the ESD Key Study Requirement in the *Study Requirements for Cherrybrook Station Government Land (2020)*.

The Cherrybrook Station SSP will include a retail space, pedestrian and bicycle links, residential, community facilities, improved landscaping, and new public areas. The design, construction and ongoing operation of this precinct is aimed to be undertaken in a sustainable manner, implementing a range of sustainability initiatives that will minimise the impact of the local environment, help mitigate and adapt to climate change impacts, and improve the liveability of the area for residents, commuters, visitors, and biodiversity.

To inform sustainable outcomes for the SSP, the ESD Plan:

1. Establishes a quantitative baseline environmental footprint based on GHG, water and waste indicators
2. Presents a suite of design initiatives that can be adopted at the detailed design (and later stages) to reduce the environmental footprint across one or multiple indicators
3. Proposes a set of measurable and achievable targets to ensure that the environmental footprint of development within the SSP performs better than the baseline.

The ESD Plan has set appropriate ESD targets aligned to the Landcom Sustainability Strategy and the Plan’s assessment of the key environmental footprint impacts of the SSP (Table 1).

Table 1. Summary of proposed ESD Targets

Indicator	#	Metric	Minimum Target
Waste	1	Diversion of residential waste from landfill during operations	50%
	2	Diversion of construction and demolition waste from landfill during construction and decommissioning	95%
Energy & GHG emissions	3	Reduction in Scope 1 and 2 emissions in the as built Precinct compared to a business-as-usual baseline	50%
	4	Reduction in Scope 1, 2 and 3 greenhouse gas emissions in the as built Precinct compared to a business-as-usual baseline. Scope 3 emissions must include construction materials (embodied carbon), waste disposal & processing, and employee & resident commuting.	20%
	5	Reduction in Scope 1 and 2 greenhouse gas emissions by 2050 compared to a business-as-usual baseline	100%
	6	Tree canopy cover 30 years after the end of construction	A minimum 25% tree canopy (current 10% cover), subject to addressing bushfire protection measures which may limit

Indicator	#	Metric	Minimum Target
			tree canopy coverage to 15%
	7	% of predicted project energy demand supplied from onsite renewable energy	5%
	8	All residential dwellings to achieve the following minimum energy ratings: Detached and semi-detached: 60 | Low Rise BASIX 45 | Mid-Rise BASIX 45 | High Rise BASIX 40	N/A
Water	9	% reduction in mains potable water use in the built Precinct compared to a business-as-usual baseline	40% - 50%
	10	Residential dwellings to achieve BASIX 60 water rating	N/A

The ESD Plan also identifies a suite of potential sustainability initiatives that may be adopted to reduce the environmental footprint of the Precinct and meet the ESD targets.

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1 Introduction

1.1 Overview

This study relates to a proposal to develop land called the 'Cherrybrook Station Government Land State Significant Precinct' (the State Significant Precinct) by Landcom on behalf of the landowner, Sydney Metro. The State Significant Precinct is centred around Cherrybrook Station on the Metro North West Line. The Metro North West Line delivers a direct connection with the strategic centres of Castle Hill, Norwest, Macquarie Park and Chatswood. It covers 7.7 hectares of government-owned land that comprises the Cherrybrook Station, commuter carpark and station access road (Bradfield Parade) and vacant land to the east of the station (referred to as the Developable Government Land) (DGL). It is bound by Castle Hill Road (south), Franklin Road (south east) and Robert Road (north west).

As a State Significant Precinct, the Minister for Planning and Public Spaces (the Minister) has determined that it is of State planning significance and should be investigated for rezoning. This investigation will be carried out in accordance with study requirements issued by the NSW Department of Planning, Industry and Environment (now Department of Planning and Environment (DPE)) in May 2020. These study requirements were prepared in collaboration with Hornsby Shire Council and The Hills Shire Council.

The outcome of the State Significant Precinct process will be new planning controls. This will enable the making of development applications to create a new mixed-use local centre to support Cherrybrook Station and the needs of the local community.

At the same time, DPE is also working with Hornsby Shire and The Hills Shire Councils, as well as other agencies such as Transport for NSW, to undertake a separate planning process for a broader area called the Cherrybrook Precinct. Unlike the State Significant Precinct, the outcome of this process will not be a rezoning. Instead, it will create a Place Strategy that will help set the longer-term future for this broader area. Landcom will be consulted as part of this process.

Figure 1 illustrates the site boundaries of the State Significant Precinct and the Cherrybrook Precinct.

Figure 1: Cherrybrook Precinct and Cherrybrook Station State Significant Precinct (subject of this proposal)

Source: NSW Department of Planning, Industry & Environment

1.2 Purpose

The purpose of this study is to address the relevant study requirements for the State Significant Precinct, as issued by DPE. It is part of a larger, overall State Significant Precinct Study. This State Significant Precinct Study undertakes planning investigations for the precinct in order to achieve a number of objectives that are summarised as follows (refer to the State Significant Precinct Study Planning Report for a full list of the study requirements):

- facilitate a mixed-use local centre at Cherrybrook Station that supports the function of the station and the needs of the local community
- deliver public benefit through a mixed use local centre
- deliver transport and movement initiatives and benefits
- demonstrate the suitability of the site for the proposed land uses
- prepare a new planning framework for the site to achieve the above objectives.

1.3 Proposal

The proposed new planning controls for the State Significant Precinct are based on the investigations undertaken as part of the State Significant Precinct Study process. A Reference Scheme has also been prepared to illustrate one way in which the State Significant Precinct may be developed in the future under the proposed new planning controls.

The proposed planning controls comprise amendments to the Hornsby LEP 2013 to accommodate:

- Rezoning of the site for a combination of R4 High Density Residential, B4 Mixed Use and RE1 Public Recreation zoned land;
- Heights of between 18.5m - 22m;
- FSR controls of 1:1 – 1.25:1;
- Inclusion of residential flat buildings as an additional permitted use on the site in the B4 Mixed Use zone;
- Site specific LEP provisions requiring the delivery of a minimum quantity of public open space and a maximum amount of commercial floor space; and
- New site-specific Design Guide addressing matters such as open space, landscaping, land use, built form, sustainability, and heritage.

The Reference Scheme (refer to **Figure 2**) seeks to create a vibrant, transit-oriented local centre, which will improve housing choice and affordability and seeks to integrate with Hornsby's bushland character. The Reference Scheme includes the following key components:

- Approximately 33,350m^2 of residential GFA, with a yield of approximately 390 dwellings across 12 buildings ranging in height from 2 to 5 storeys (when viewed from Bradfield Parade).
- A multi-purpose community hub with a GFA of approximately 1,300m^2.
- Approximately 3,200m^2 of retail GFA.
- Over 1 hectare of public open space, comprising:
    - A village square with an area of approximately 1,250m^2, flanked by active retail and community uses.
    - A community gathering space with an area of approximately 3,250m^2.
    - An environmental space around the pond and Blue Gum High Forest with an area of approximately 8,450m^2.
- Green corridors and pedestrian through site links, providing opportunities for potential future precinct-wide integration and linkages to the north.

Parcel	*Area	Res GFA	Units	Non-Res GFA	Community	Portion FSR*
A	8,597	12,031	141	749		1.49
B	9,610	11,924	140	2,452	1,300	1.68
C	2,574	2,736	32			1.06
D	6,715	6,621	78			0.98
	27,272	**33,312**	**391**	**3,201**	**1,300**	

Figure 2 Reference Scheme

Source: SJB

1.4 Relevant study requirements

This Ecologically Sustainable Development (ESD) Plan responds to the ESD (10.1) Key Study Requirement in the Study Requirements for Cherrybrook Station Government Land (2020):

> *Provide a Sustainability Plan that identifies the key sustainable design opportunities for the design, construction and ongoing operation phases of the proposal and establishes a baseline and target for environmental footprint for waste, water, and greenhouse gas emissions in addition to renewable energy targets. This should include reference to the Green Star Communities tool, climate change adaptation and a methodology for implementation. It should also include the impacts of climate change including the increase in wind/storm events in the future.*

As such, this ESD Plan sets the framework for sustainable outcomes for the Cherrybrook Station SSP by quantifying its environmental footprint, setting ESD targets and identifying potential initiatives to minimise the environmental footprint.

This plan also addresses the following Climate Change Mitigation and Adaptation (11.1) Key Study Requirement:

> *Undertake a sustainability assessment of the proposal, reflecting the directions outlined in the 'NSW Climate Change Policy Framework', October 2016, and Northern District Plan 2018 and Hornsby Councils target to achieve a net-zero carbon emissions by 2050. Options for achieving both net zero buildings and a net zero SSP site should be considered.*

Table 2 provides a checklist of compliance to the SSP Study Requirements for items 10.1 and 11.1.

Table 2: Compliance checklist for SSP Study Requirements

Ref.	SSP Study Requirement	Report section
10.1	*Provide a Sustainability Plan that identifies the key sustainable design opportunities for the design, construction, and ongoing operation phases of the proposal…*	Section 3
	establishes a baseline and target for environmental footprint for waste, water, and greenhouse gas emissions…	Baseline: Section 2 Target: Section 7
	In addition to renewable energy targets.	Section 7
	This should include reference to the Green Star Communities tool,	Section 5
	climate change adaptation…	Section 6
	methodology for implementation.	Section 7.1
	It should also include the impacts of climate change including the increase in wind/storm events in the future.	Section 6
11.1	*Undertake a sustainability assessment of the proposal, reflecting the directions outlined in the 'NSW Climate Change Policy Framework', October 2016, and Northern District Plan 2018 and Hornsby Councils target to achieve a net-zero carbon emissions by 2050. Options for achieving both net zero buildings and a net zero SSP site should be considered.*	Section 4

1.5 Sustainability context and literature review

The Cherrybrook Station SPP is set within an extensive sustainability context comprising of state level to precinct-level sustainability commitments, priorities and aims (**Figure 3**). A key commitment running through the documents is the commitment to net zero emissions by 2050 and greenhouse gas (GHG) reduction which is identified at each level of policy and strategic documentation. The following section presents an overview of the key documents and draws a direct connection between these supporting documents and the Cherrybrook Station SSP.

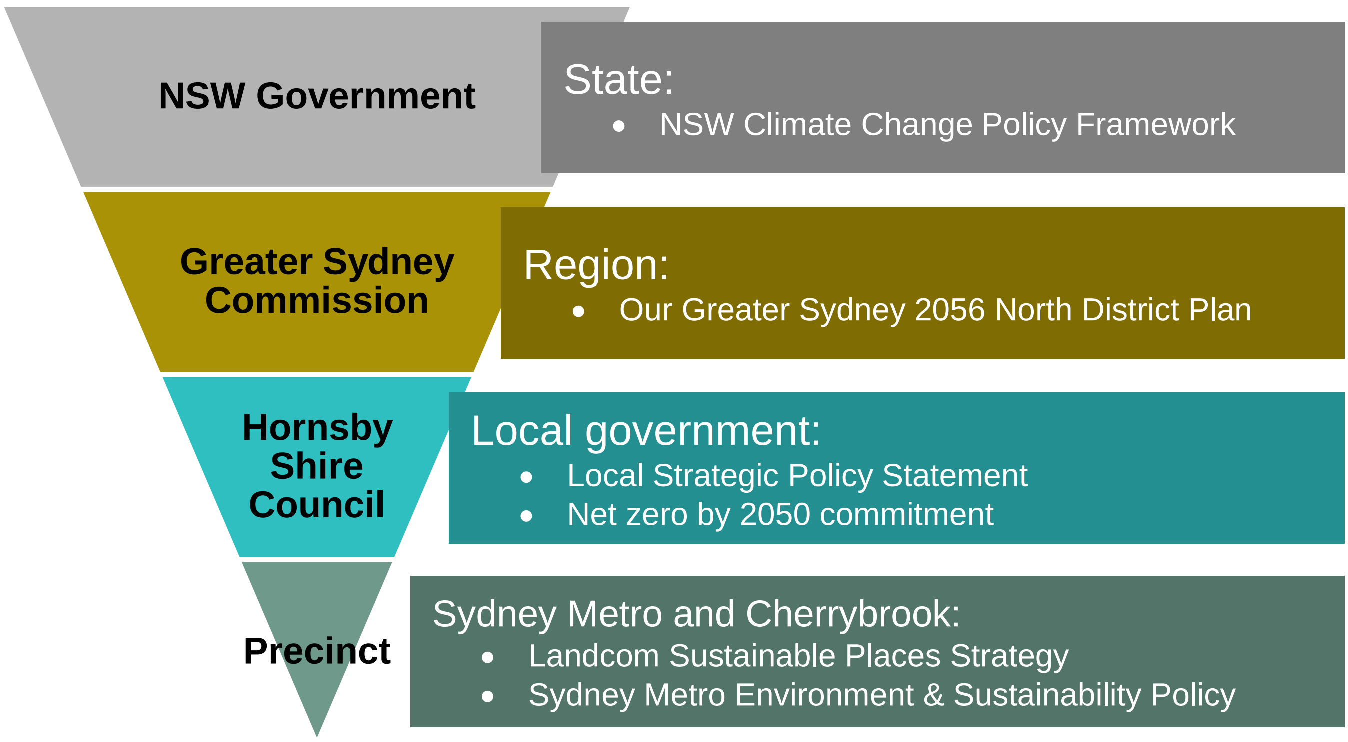
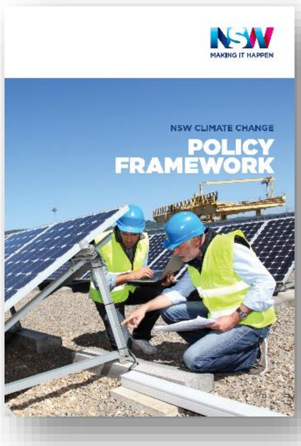


Figure 3. Sustainability context and literature review summary



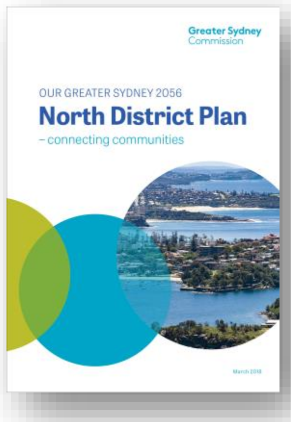
1.5.1 NSW Climate Change Policy Framework

The NSW Climate Change Policy Framework ("the Framework") responds to the challenges of climate change through both greenhouse gas (GHG) mitigation and climate resilience and adaptation. Importantly, it outlines aspirational long-term objectives for the state of NSW to:

- *"Achieve net-zero emissions by 2050"*
- [Ensure] *"NSW is more resilient to a changing climate"*

The Framework sets out the role of the NSW government in achieving these objectives in the areas of government policy, operations, and advocacy. The Cherrybrook Precinct can adopt the following actions listed in the Framework:

- *"Create a certain investment environment"* – by setting clear minimum targets for GHG performance
- *"Reduce risks and damage to public and private assets in NSW arising from Climate Change"* – by assessing and monitoring future climate change risks and implementing adaptations appropriate to the timescale and cost.
- *"Reduce climate change impacts on health and wellbeing*" – by identifying initiatives and targets that promote health and wellbeing in a changing climate
- *"Manage impacts on natural resources, ecosystems and communities"* – by conserving and responsibly managing water, materials, energy, and waste.



1.5.2 Greater Sydney Commission – North District Plan

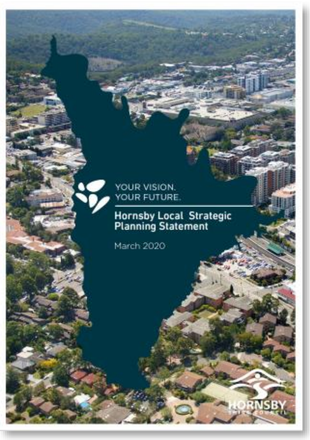
The North District Plan (“the Plan”) presents a vision and set of planning priorities for the future of the North District of Greater Sydney as a 30-minute city with improved lifestyle and environmental assets. The Metro Northwest Line is noted in the Plan as part of the enabling infrastructure to provide faster transport links for growth areas in the North District, including Cherrybrook, to the Harbour CBD and its associated business and jobs opportunities.

The Sustainability directions of the Plan focus on:

- *“Valuing green spaces and landscape”* – Open space and urban tree canopy
- *“Using resources wisely”* – Reduced transport emissions and energy use
- *“Adapting to a changing world”* – providing and acting on natural hazard and climate change data and associated risks

The following solutions and pathways listed under ‘Planning Priority N21 Reducing carbon emissions and managing energy, water and waste efficiently’ can be delivered through the Cherrybrook precinct:

- *“Precinct-wide energy, water and waste efficiency systems”*
- *“Transport demand management initiatives, including work from home, improved walking and cycling, improved access to car sharing, carpooling and on-demand transport”*
- Efficient building standards
- *“Building and precinct-scale renewable energy generation”*
- *“Waste diversion from landfill”*



1.5.3 Hornsby Shire Council – Local Strategic Planning Statement

The Local Strategic Planning Statement (“LSPS”) provides a local government area-level breakdown of how the three sustainability directions in the North District Plan will be delivered at a local level.

Importantly, Council has a commitment to net zero emissions by 2050. It will seek to meet this through initiatives similar to those identified in the North District Plan, such as: increased use of renewable energy for both buildings and precincts, public transport and efficient car use (e.g. through carpooling, electric vehicles and autonomous vehicles, and waste diversion.

Additional relevant Council documents include:

- Hornsby Local Environmental Plan (HLEP 2013)
- Hornsby Development Control Plan (HDCP 2013)

A suite of additional strategies and plans are forthcoming in the Future Hornsby set of studies and documents.

1.5.4 Sydney Metro – Environment & Sustainability Statement of Commitment

The Sydney Metro program of works incorporates both the Northwest section, which includes the Cherrybrook Station, and the City & Southwest section, which connects Cherrybrook to the CBD and southwest Sydney.

The program Environment & Sustainability Statement of Commitment ("the Statement") aims to deliver services, places and transport infrastructure for our customers while protecting the environment, contributing to economic prosperity, and delivering social benefits for the communities we serve. The commitments relevant to the Cherrybrook Precinct include:

- *"Create liveable places that are well integrated and promote active and sustainable transport."*
- *"Conserve and enhance the natural environment and our built and cultural heritage."*
- *"Work collaboratively with delivery partners to provide social benefits to the communities in which we work."*
- *"Tackle climate change and contribute to the NSW Government target of net zero emissions."*
- *"Promote the greening of our cities to help combat the 'urban heat island' effect."*
- *"Establish robust objectives and targets that are measurable and take into account whole-of-life considerations."*

1.5.5 Landcom – Sustainable Places Strategy

Landcom is developing the Cherrybrook Precinct in partnership with Sydney Metro. Landcom's Sustainable Places Strategy ("the Strategy") encapsulates the aim of creating places that "deliver social environmental and economic shared value". Strategy establishes four goals relevant to the Cherrybrook Precinct:

1. Climate Resilient Places – achieve high environmental performance in terms of building energy and water use, reduced demand on potable water, reduced greenhouse gas emissions, use of renewable energy, minimise urban heat island effect, use sustainable products, divert waste from landfill.
2. Healthy & Inclusive Places – encourage active and healthy lifestyles and provide public and active transport
3. Productive Places – provide electric vehicle charge stations
4. Accountable & Collaborative Places – collaborate with the supply chain and publicly report on sustainability performance

1.6 Focus of this ESD plan

This Ecologically Sustainable Development (ESD) Plan quantifies the environmental baseline footprint of Cherrybrook Station SSP and propose targets which are informed with potential initiatives. For the purposes of this study, the environmental footprint consists of the following indicators of environmental impact and resource consumption (Figure 4):

1. Energy and greenhouse gas emissions:
    - Energy is required to both construct and power the Precinct. Electricity, gas, and fuels typically involve the extraction and burning of fossil fuels, a finite resource that is also a leading cause of anthropogenic climate change.

- The use and operation of the Precinct when built will also lead to indirect greenhouse gas (GHG) emissions through the motorised commuting of residents and workers, the treatment and processing of waste generated, and materials consumed in its maintenance and repair.

2. Water:
    - Freshwater and potable water is a precious resource in Australia and across the globe. Using our tap water efficiently is key to managing this precious resource and creating resilience against drought.
    - Heavy rain can lead to flooding in urban areas with high proportions of hard, impermeable surfaces such as asphalt and concrete. This issue can be aggravated by the impacts of climate change. Capturing rainwater and installing permeable surfaces that water can sink through and reduce runoff volumes.
3. Waste and materials:
    - Materials are essential for building and maintaining a Precinct. Materials like concrete and steel are typically made from finite raw materials (like metals and rocks) that are heavily processed with high amounts of energy to make the finished product. This results in both the depleting of finite resources and the emission of greenhouse gasses.
    - When materials and goods finish their useful life, they are deposited into our waste management systems. Often this leads to landfilling, which can mean the wastage of finite and valuable goods that could still be put to good use elsewhere in our economy. In addition, when organic materials are landfilled, a process called anaerobic digestion leads to the emission of methane, a highly potent greenhouse gas.

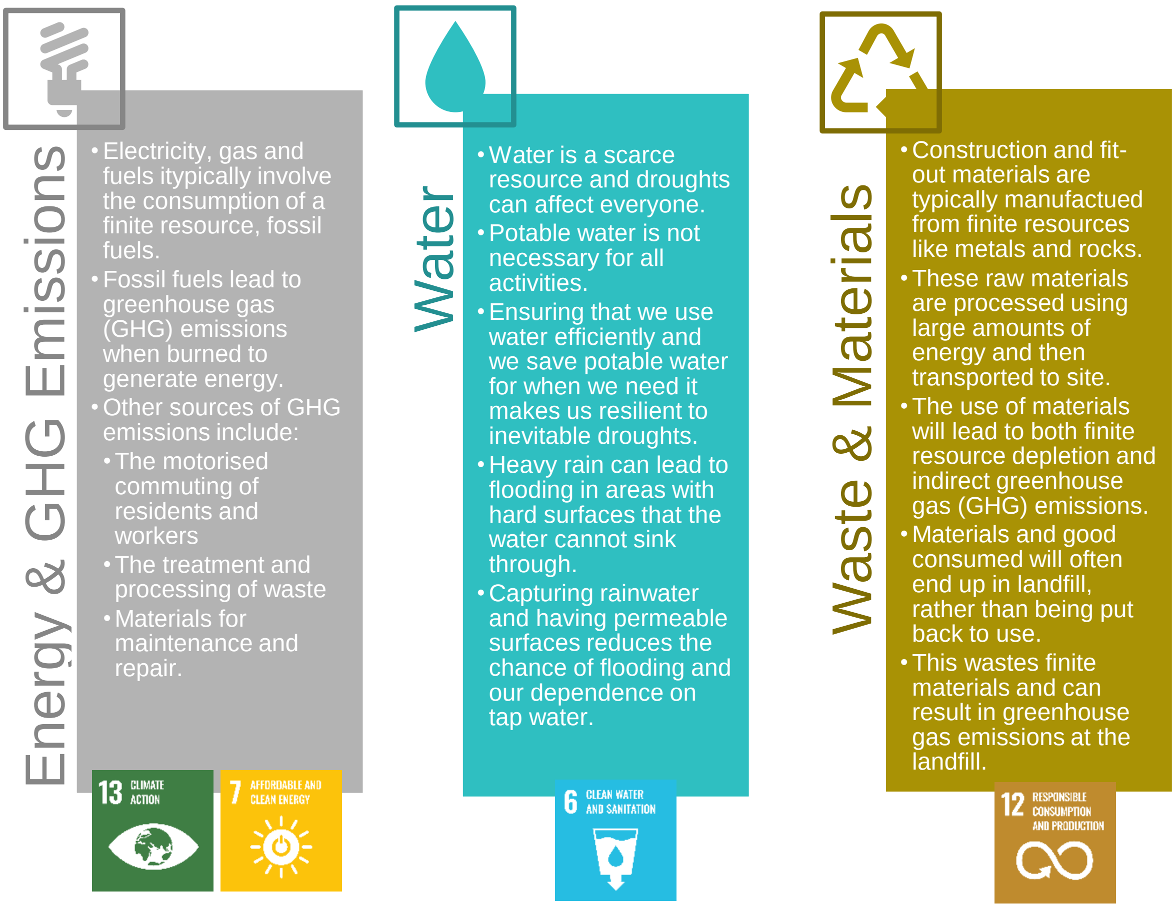


Figure 4. Overview of the Precinct's environmental footprint and relevant UN SDGs

These three indicators reflect the key environmental sustainability impacts of the built environment and are aligned with the United Nations Sustainable Development Goals (UN SDGs):

- SDG 6: Ensure access to water and sanitation for all
- SDG 7: Ensure access to affordable, reliable, sustainable, and modern energy
- SDG 12: Ensure sustainable consumption and production patterns
- SDG 13: Take urgent action to combat climate change and its impacts

The UN SDGs were published in 2015 and provide a framework and definition for sustainability at a global level. Reducing the Precinct's negative impacts and increasing the Precinct's positive impacts in these areas will lead to more sustainable outcomes and contribute to sustainable development.

Current or 'business as usual' practices in the built environment are considered unsustainable and necessitate interventions to implement and integrate sustainable outcomes throughout the development process. The type of intervention and the scale of opportunities diminish as a development progresses along the development pathway (

Figure 5). This Plan has been developed at the 'Planning' step in

Figure 5, and recognises the strong opportunity for shaping sustainable outcomes at this stage.

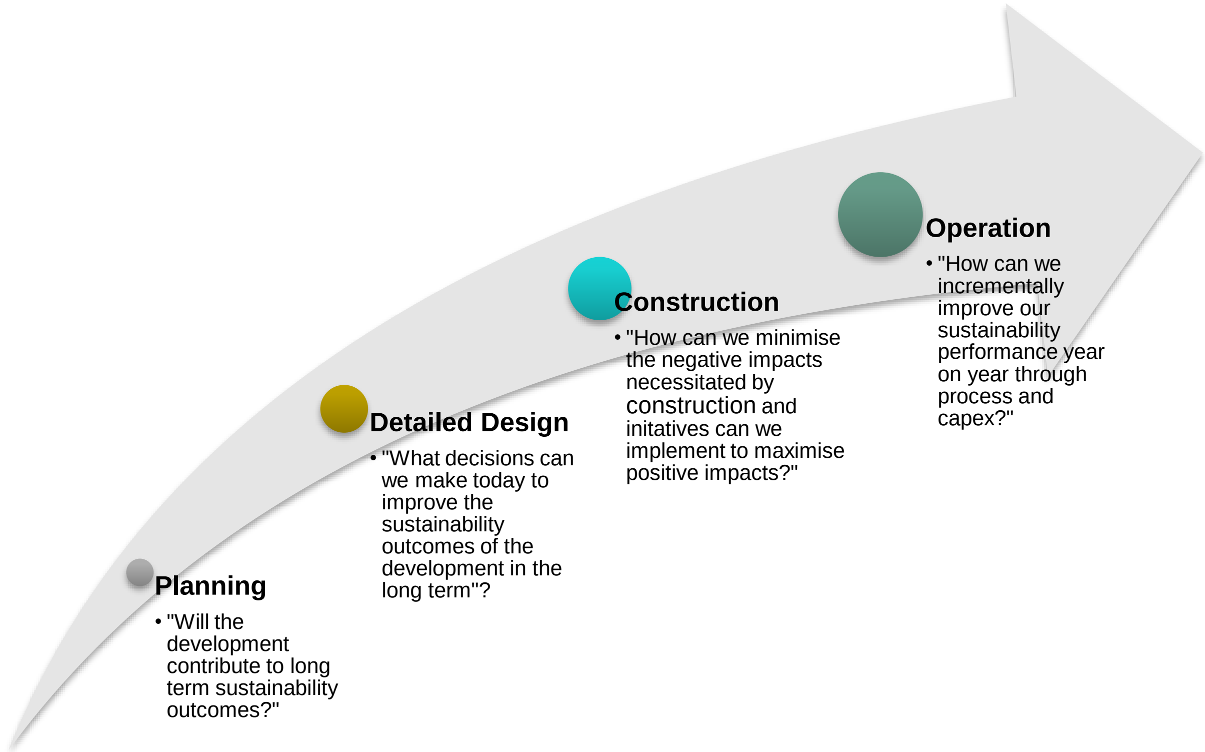


Figure 5. Sustainability approach throughout the development process

1.7 Methodology

To inform sustainable outcomes for the Precinct, this Plan (**Figure 6**):

1. Establishes a quantitative baseline environmental footprint based on GHG, water and waste indicators
2. Presents a suite of design initiatives that can be adopted at the detailed design (and later stages) to reduce the environmental footprint across one or multiple indicators
3. Proposes a set of measurable and achievable targets to ensure the Precinct performs better than the baseline in both construction and operation.

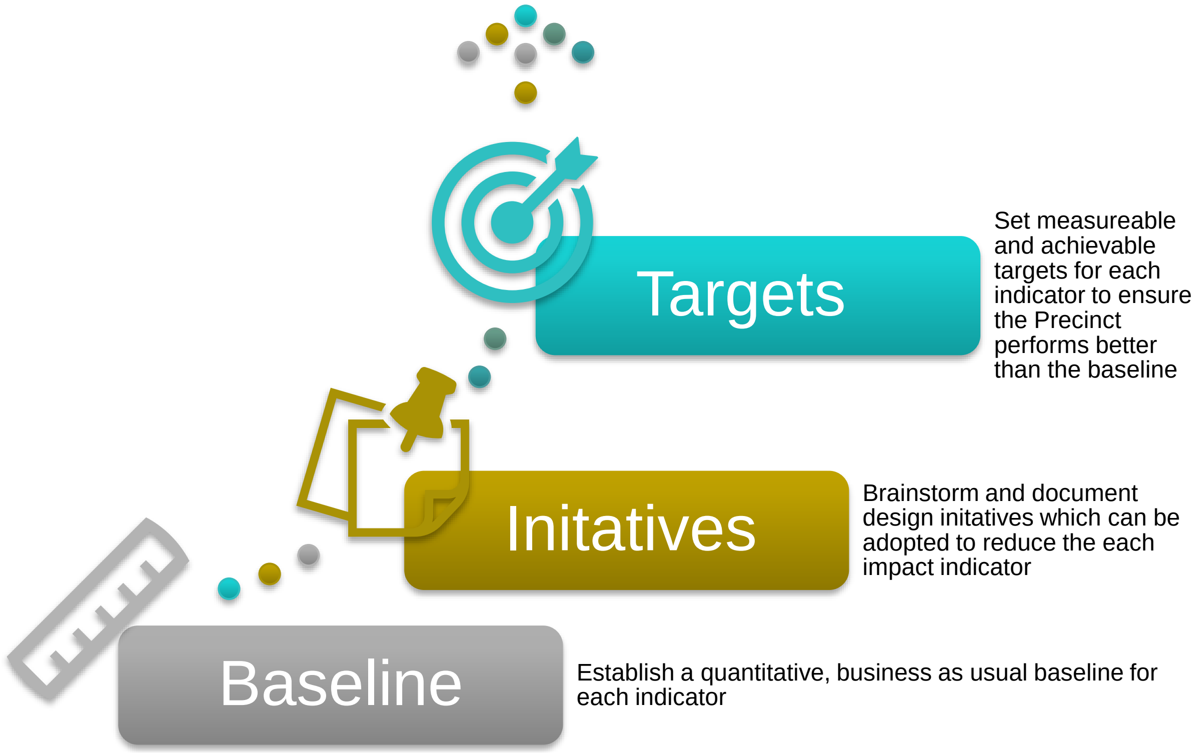


Figure 6. ESD Plan approach

2 Baseline

Establishing baselines are important for understanding the current situation/conditions, informing, and establishing realistic and useful targets, and assessing progress in achieving targets. The baseline modelled for Cherrybrook Station SSP is the projected "business-as-usual" proposed planning controls and envisaged future development. It models the planned precinct design using business as usual technologies, and activities to determine GHG emissions, potable water demand, waste generation and diversion from landfill, and GHG emissions embodied in materials. The baseline does NOT include the impacts of sustainability initiatives outlined in this ESD Plan. Rather, it sets the context for comparing the potential benefits of the initiatives.

As we are modelling a baseline based on proposed business-as-usual design and use, our baseline includes a number of assumptions as outlined in this section. Some of these key assumptions are intrinsically associated with the dimension and conceptual design of the precinct. The assumptions embedded in the baseline modelling are as follows:

- Precinct lifespan and occupation:
  - 50-year lifespan
  - 900 residents
  - 120 employees

- The reference scheme prepared by SJB considers the following spaces:
  - Total precinct land area: 53,343 m2
  - Developable land area: 33,405.00 m2
  - Residential spaces total area: 33,350.00 m2
  - Commercial / retail spaces area: 3,200.00 m2
  - Indoor public amenities: 1,300.00 m2
  - Green open spaces: 23,052.00 m2

- Precinct infrastructure dimensions:
  - Cycleways 2m wide: 500 m
  - Footpaths 2m wide: 500 m
  - Drainage: 500 m
  - Sewage: 500 m
  - Other services: 500 m

2.1 Energy and greenhouse gas emissions

Greenhouse gases (GHGs) are chemical compounds that, when emitted, contribute to the greenhouse effect of warming the earth's atmosphere. There are six GHGs identified under the Kyoto Protocol and formally adopted in GHG measurement and accounting practices (refer to the six presented at the top of Figure 6). They include well known compounds such as carbon dioxide (CO_2) and methane (CH_4) and lesser-known compounds such as dinitrogen monoxide (N_2O).

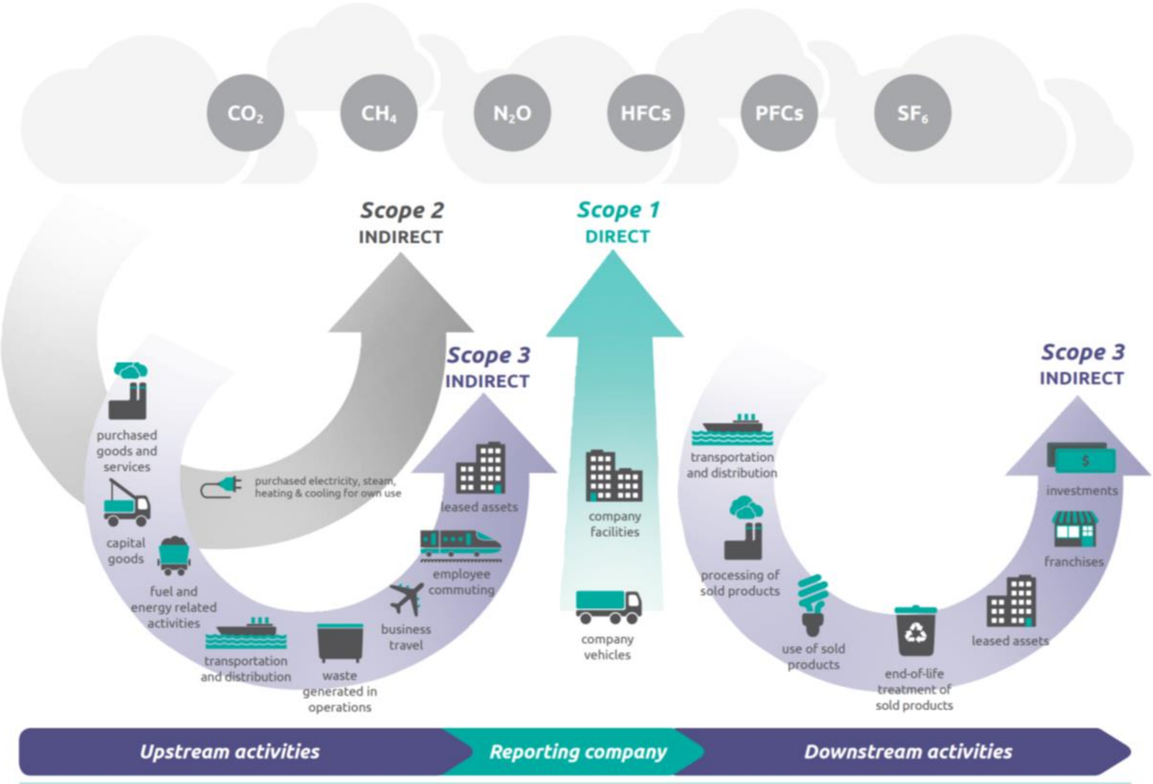


Figure 7. Sources of greenhouse gas emissions. Source: World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD), 2011, Corporate Value Chain (Scope 3) Accounting and Reporting Standard

There are many activities and processes that can lead to GHG emissions, such as burning fossil fuels in vehicles, planes or electricity generation plants or the anaerobic digestion of organic matter in landfills. It is also acknowledged that individuals, organisations, and precincts can indirectly cause the emission of GHGs through our purchasing or spend on goods and services as well as our investments and other financial activities. Therefore, even if we do not directly release GHG emissions from our activities, we depend on services and goods that do. The full spectrum of activities that contribute to GHG emissions, both direct and indirect, are captured in Figure 7.

The sub-model of energy and GHGs for Cherrybrook Station SSP accounts for scope 1, 2 and relevant categories of scope 3. These categories include embodied emissions in materials, waste management and those related to the location of the precinct including such as residents and employees commuting.

Modelling results indicate that most of the emissions are located within scope 3, accounting for 63% of the total, while scope 1 and scope 2 accounts for 6% and 31%, respectively. These figures represent a total whole-of-life emissions of 337,062 tonnes of CO_2-eq (**Figure 8**).

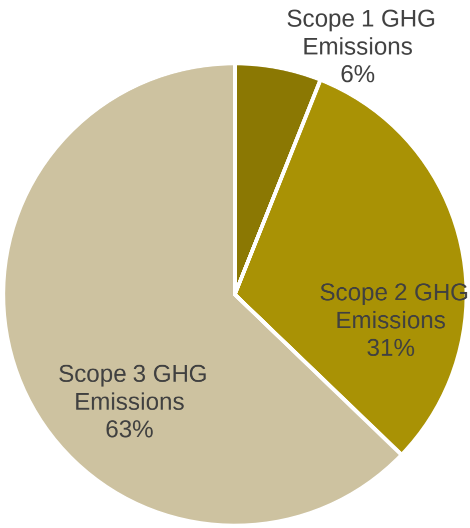


Figure 8. Whole-of-life GHG emissions by scope

To investigate key drivers of GHG emissions in each Scope, we have analysed the proportion of GHG emitted by emitter source and by project component, as shown below.

When grouped by primary GHG emitters, 42% of emissions are associated with operational and maintenance energy use, and 34% with car use by residents and workers (**Figure 9**,

Table 3). Construction and end-of-life emissions are considered negligible, accounting for less than 1% each, though 13% of emissions are embodied in construction materials.

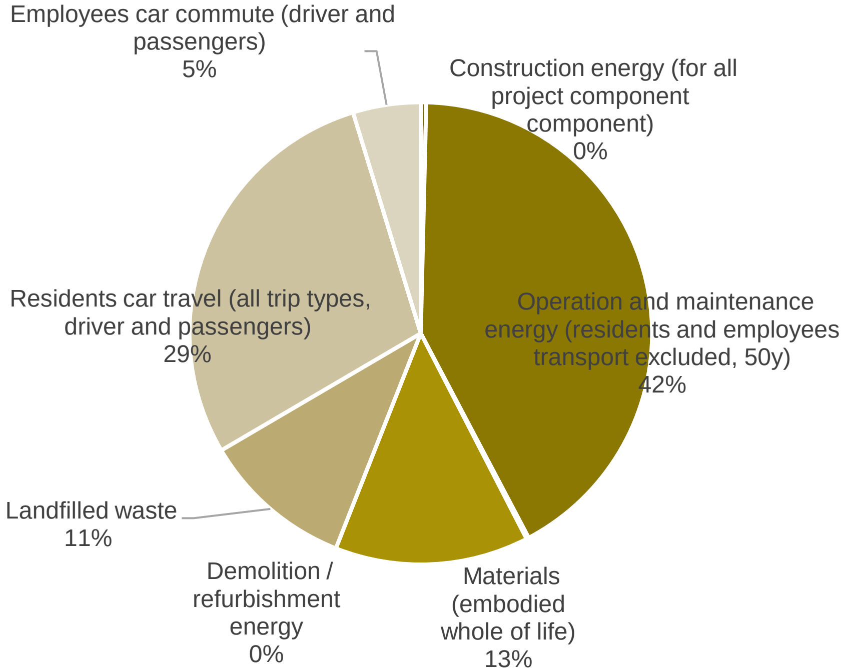


Figure 9. Whole-of-life main GHG emitters

Table 3 GHG Emissions by emission source

Emissions source	Scope 1 (t CO_2-eq)	Scope 2 (t CO_2-eq)	Scope 3 (t CO_2-eq)	Scope 1,2&3 (t CO_2-eq)
Construction energy (for all project component component)	610	563	100	1,274
Operation and maintenance energy (residents and employees transport excluded, 50y)	19,189	104,519	17,513	141,220
Demolition / refurbishment energy	525	-	27	552
Materials (embodied whole of life)	-	-	45,657	45,657
Landfilled waste	-	-	35,628	35,628
Residents car travel (all trip types, driver, and passengers)			96,783	96,783
Employees car commute (driver and passengers)			15,948	15,948
Total	**20,324**	**105,082**	**211,656**	**337,062**

When GHG emissions are grouped by project component, 76% of emissions from all 3 scopes are associated with dwellings, 12% with commercial spaces, 8% with infrastructure, 3% with offices, and 1% with public amenities (**Figure 10**,

Table 4). This pattern of emissions correlates with the area of the Precinct comprised by each project component (e.g. dwelling comprise the greatest Precinct area, and public amenities the least), irrespective of the emissions intensity of each of the components.

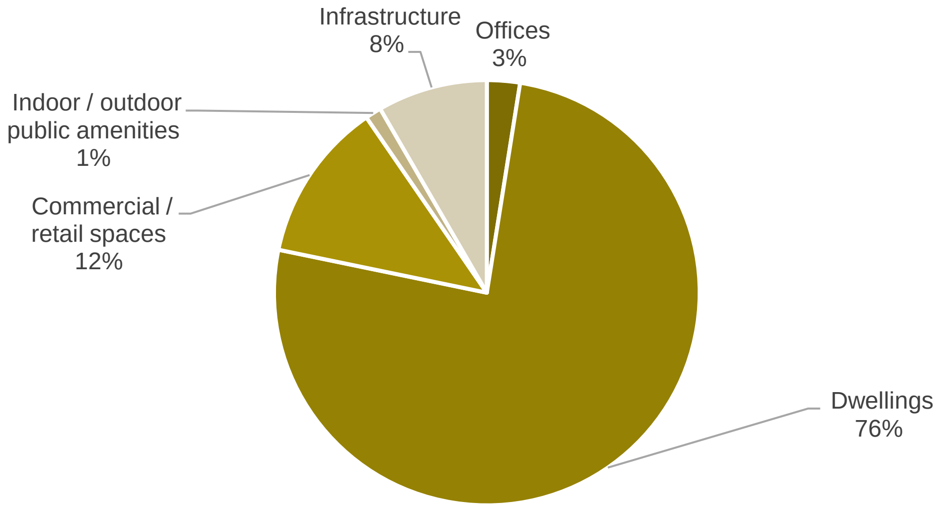


Figure 10. Whole-of-life emissions by project component

Table 4. GHG emissions by project component

Project component	Scope 1 GHG Emissions (t CO_2-eq)	Scope 2 GHG Emissions (t CO_2-eq)	Scope 3 GHG Emissions (t CO_2-eq)	Scope 1,2&3 GHG Emissions (t CO_2-eq)
Offices	177	6,595	1,676	8,448
Dwellings	19,636	66,861	168,778	255,275
Commercial / retail spaces	199	4,958	35,914	41,071
Indoor / outdoor public amenities	156	2,068	1,889	4,110
Infrastructure	156	24,600	3,403	28,159
Total	**20,324**	**105,082**	**211,656**	**337,062**

These findings indicate that efforts to reduce emissions should focus on resident's travel and worker commutes, and on-site energy consumption during the operation of the precinct. Further details regarding assumptions and estimations for energy and GHG modelling are provided in **Appendix A**.

2.2 Water

This sub-model estimates total water demand and potable water use. The baseline assumes 100% of the demand is sourced from mains water, making potable water use and total water demand equal. The model estimates a whole-of-life consumption of 3,656 ML. The findings show that water use for construction and end-of-life stage platforms are negligible when compared with the operational and maintenance consumption (**Table 5**, **Figure 11a**).

From a project component perspective, 72% of water consumption is associated with dwellings, 24% with public amenities, 3% with commercial spaces, and less than 1% with precinct infrastructure (**Table 6**, **Figure 11b**). Based on these findings, construction and demolition water use is considered negligible from a lifecycle perspective.

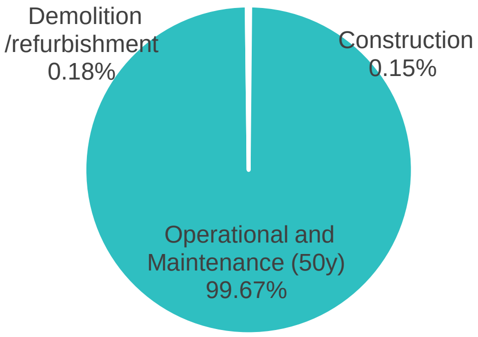
Table 5. Whole-of-life water consumption by project life stage

Stage of life	Total consumption (kL)
Construction	5,473
Operational and Maintenance (50y)	3,644,848
Demolition /refurbishment	6,657
Total	**3,656,978**

Table 6. Whole-of-life water consumption by project component

Project component	Total consumption (kL)
Offices	25,613
Dwellings	2,642,070
Commercial / retail spaces	113,840
Indoor / outdoor public amenities	870,131
Infrastructure	5,324
Total	**3,656,978**

(a) (b)



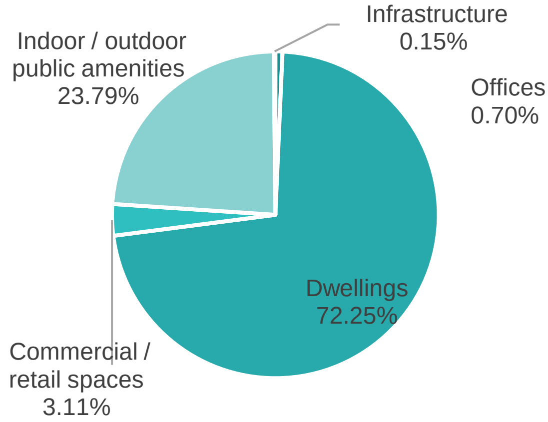


Figure 11. Whole of life water consumption by: (a) life stage, and (b) project component

A significant portion of the annual operational and maintenance consumption is related to domestic water use and irrigation for green spaces (**Table 7**). Domestic water consumption is estimated according to Sydney Water averages for all seasons, and irrigation is estimated as per the Green Star calculator and recommended assumptions. Further details regarding assumptions and estimations for water modelling are provided in **Appendix B**.

Table 7. Operational and maintenance water consumption

Description	Annual consumption (kL)
Office spaces	511
Residential spaces	52,758
Commercial spaces (retail)	2,269
Indoor public amenities	922
Green areas	16,344
Streets 6m wide cleaning	-
Cycleways 2m wide (m) cleaning	42
Footpaths 2m wide (m) cleaning	42
Drainage cleaning	10
Total (annual)	**72,897**
Total (50 years)	**3,644,848**

2.3 Waste

Waste generation is estimated based on data provided in official local government and industry reports. The available reports indicate 44% of municipal waste in Hornsby Shire Council is diverted from landfill, with a desired diversion target of 70%. Diversion of commercial and industry waste is estimated at 62%, though also with a target of 70%.

Construction and demolition waste are not included for the purposes of this study and so the following outputs relate only to operational and maintenance waste generation. Based on our assumptions, an estimated 60,005 tonnes of waste will be generated over the Precinct's lifespan, with just under half of this (27,338 tonnes) going to landfill (**Table 8**). This landfill disposal amount represents 35,628 tonnes of CO_2-eq due to waste management (landfill waste only).

Table 8. Operational and maintenance waste generation

Project component	Total Generation (tonnes)	Total disposed to landfill (tonnes)	GHG Emissions (ton CO_2-eq)
Offices	525	200	239
Dwellings	25,200	14,112	19,757
Commercial / retail spaces	34,100	12,958	15,550
Indoor / outdoor public amenities	180	68	82
Total	60,005	27,338	35,628

Over the Precinct's lifespan, 57% of waste is projected to be generated by commercial areas, 42% by residents, and the balance by public amenities (0.29%) and offices (0.87%) (**Figure 12**).

Contrary to results for GHG emissions and water consumption (see Sections 2.1 and 2.2), generated waste is strongly correlated to user intensity. For example, commerce and retail is the most intense waste generator (3.1 tonnes/ full-time employee equivalent) and is responsible for more than half of the waste generated, but accounts for only 9.6% of the precinct area.

Interestingly, the proportion of GHG emissions due to waste management is higher for dwellings, compared to commercial areas (**Figure 13**). One explanation is that diversion rates are currently lower for residents than commerce and the emissions per ton of waste are higher for residents: 1.4 ton CO_2-eq/ ton compared with 1.2 ton CO_2-eq/ ton according to EPA (2019) data. Further details regarding assumptions and estimations for waste modelling are provided in **Appendix C**.

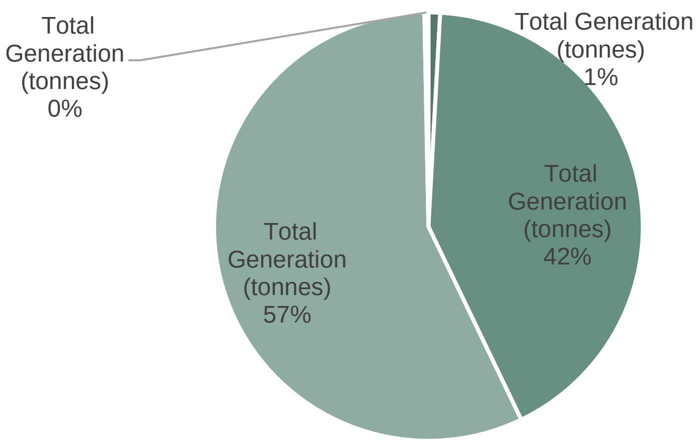


Figure 12. Operational and maintenance waste generation

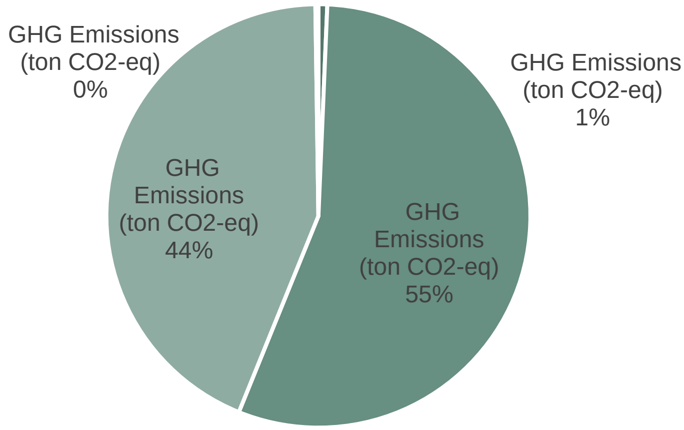


Figure 13. GHG emissions from landfilled waste management

2.4 Materials

Only construction materials were considered for the purposes of this modelling. Since there is currently no detailed design available, material estimations are based on previous research undertaken by Edge Environment, internal data, and LCIA databases. These rates include cradle-to-gate emissions and accounts for construction and maintenance materials. They do not include construction energy since it is already accounted for under the construction stage in the energy and GHG emissions sub-model.

Furthermore, only materials accounting for up to 90% of a typical building's global warming potential were included in the baseline. This selection includes:

- Aluminium Façade
- Aluminium Other (e.g. window and door frames, railings, mechanical and electrical systems)
- Concrete Other
- Concrete Structural
- Steel Other (e.g. railings, secondary structures, ornaments)
- Steel Reinforcement
- Asphalt for infrastructure components
- Aggregates for infrastructure components

76% of materials use (weight/weight) are used in the construction of dwellings, and 74% of all Precinct materials correspond to different types of concrete, assuming the physical nature of materials in the Precinct is based on the dimensions of the components. Hence, the largest components of the Precinct – dwellings – account for most of the materials, followed by retail, and infrastructure (Figure **14**). Therefore, high emitting materials such as steel and aluminium account for a more prominent portion of total embodied emissions. The model estimates that reinforcement steel (28%), aluminium (28%), and structural concrete (25%) account for most of the embodied emissions (Figure 15).

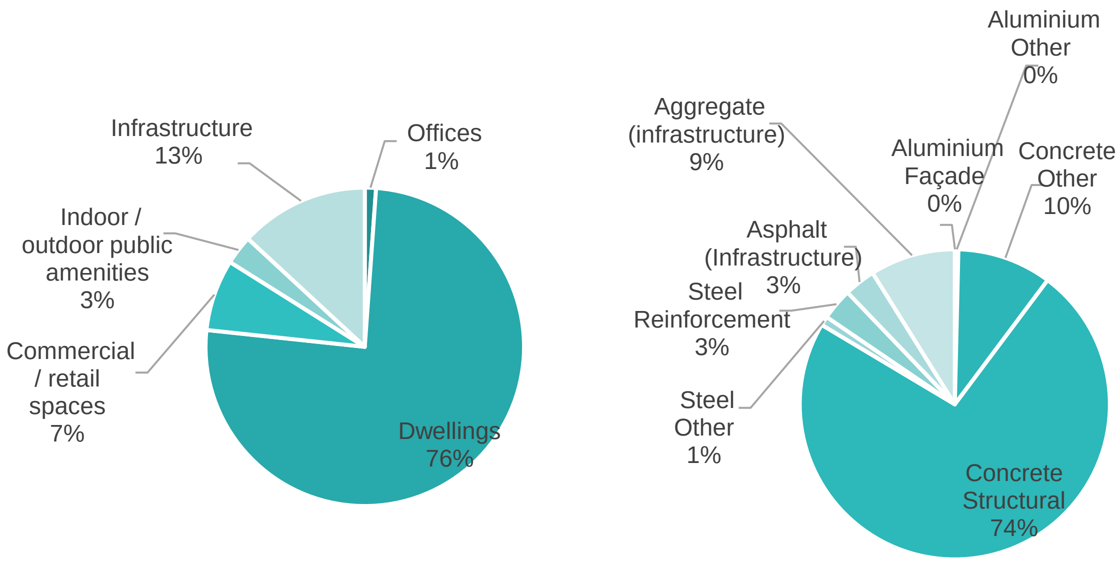


Figure 14. Materials use in the precinct (weight/weight)

Dwellings accounts for 76% of the materials whilst it accounts by 86% of the materials embedded emissions. On the other hand, infrastructure consumes 13% of the materials by weight, but it only account for less than 1% of emissions (See Figure **14** vs Figure 15). Given the high intensity of metals, it is expected that the proportion contributed to the Precinct embodied emissions will be higher for dwellings than by weight of materials alone. Further details regarding assumptions and estimations for materials modelling are provided in **Appendix D**.

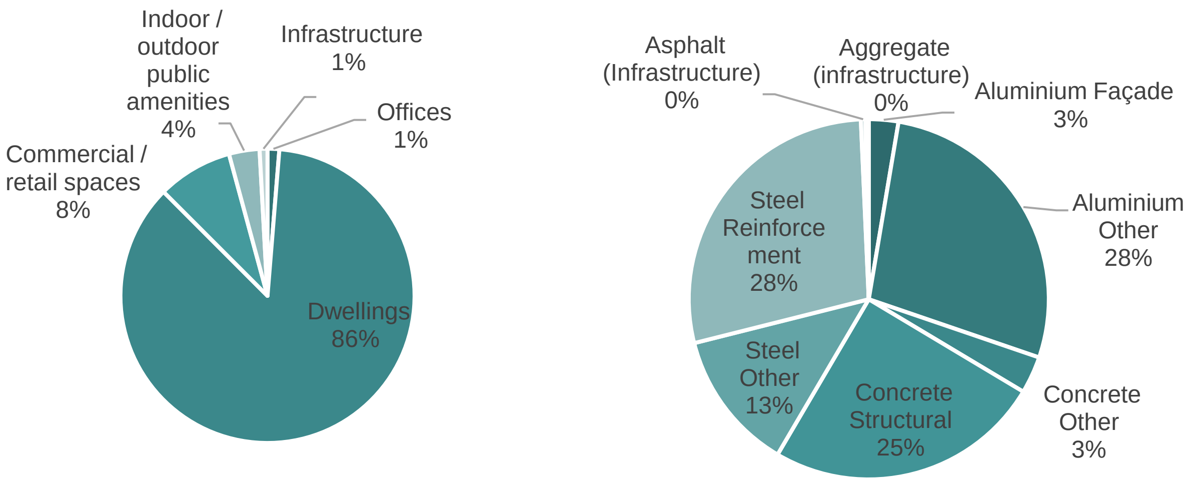


Figure 15. Materials embodied GHG emissions

3 Potential initiatives

This study suggests 10 sustainable initiatives for the design, construction and ongoing operation phases of the project. The purpose of these initiatives is to model their impacts on the baseline estimated in the previous section. The results of this excersise will assit on setting achivable targets for the SSP.

Each initiative is allocated a primary sustainability indicator code: energy and GHG emissions (E), water (W), or waste and materials (M). For each initiative, we also present sub-initiatives, which represent the potential range of approach options. We recognise that many sub-initiatives will impact, to varying degrees, more than one indicator.

Figure 16 summarises the initiatives. For details and example of each of the initiatives, please refer to **Appendix F**.

Energy & GHG emissions

E1. Greening

- E101. Green roofs & rooftop gardens
- E102. Green walls & vertical gardens
- E103. Increased canopy cover

E2. Renewable Energy

- E201. Solar panels on buildings
- E202. Solar panels on public access spaces

E3. Cool surfaces

- E301. Cool seal products on rooftops
- E302. Cool seal products on pavements

E4. Natural and low energy lighting

- E401. Self-emitting pavements for cycleways and footpaths
- E402. Smart lighting

E5. Active and public transport incentives

- E501. Infrastructure & facilities for cyclists
- E502. Walkable distance to diverse services of public transport
- E503. Mixed land use including diversity of amenities
- E504. Reduced parking, car pool parking, & car-share exclusive parking

Water

W1. WSUD – stormwater management

- W101. Stormwater/rainwater diversions & capture, including rainwater gardens
- W102. Permeable paving
- W103. Domestic rainwater reuse
- W104. Rainwater for fire system top up

W2. Water efficient fixtures & appliances

- W201. Water saving fixtures & appliances
- W202. Dry appliances (composting toilets)

Waste & materials

M1. Mass timber buildings

- M101. Mass timber buildings

M2. Low carbon materials & dematerialisation

- M201. Low carbon concrete
- M202. Dematerialisation
- M203. Reused materials
- M204. Environmental Product Disclosures (EPDs)

M3. Circular economy

- M301. Commingled materials
- M302. Food waste

Figure 16. Summary of initiatives

Indicators will likely have benefits that extend beyond the three main indicators considered here. Additional likely benefits include, for example: improved biodiversity and ecosystem functioning, improve human physical and mental health and well-being, increased local economic prosperity, increased local property values, decreased crime rates, and increased infrastructure lifespans.

Each initiative may have a variety of ways to interpret and implement them within the project phases, ranging from business-as-usual approaches to novel, innovative, and at times experimental approaches. Whilst minimum sustainability targets may be achieved through a business-as-usual approach only, Landcom strive to be leaders in the sustainability space, and so favour consideration of a combination of buisness-as-usual and more innovative approaches.

Implementation examples from within Australia or internationally are also provided, showing where possible, examples of business-as-usual through the innovative and experimental options in **Appedix F**.

3.1 Modelling

The following section provides the modelled estimates of the impacts of implementing initiatives outlined in **Figure 16**. The modelling of initiatives aims to reduce GHG emissions, landfilled waste, and potable water consumption from the baseline. The purpose of including this modelling based on potential initiative implementation is to demonstrate achievable, sustainability improvements, and so provide confidence in setting targets. It should be noted that the following initiatives modelling is considered conservative, and increased benefits are considered possible with careful consideration and innovative design.

Although each of the initiatives is classified into a key sustainability category, their implementation can impact multiple categories. Therefore, each of the initiatives is modelled for all three sustainability impacts to assess their trade-offs. Outputs have also been presented per sub-initiative to avoid overlapping and double counting between similar initiatives.

3.1.1 Reduction of GHGs

These initiatives try to reduce scope 1, 2 and 3 emissions at different stages of the Precinct's lifespan.

E1. Greening

This first group includes green roofs, rooftops gardens, green walls, and increase of canopy (see Box A). These initiatives are naturally grouped because they have the similar objectives of reducing temperatures and sequestering CO_2. These reductions represent less energy consumption for cooling and hence, less GHG emissions.

According to Edge's research and internal modelling, this reduction is estimated at 31% (59,574 annual kWh) less electricity used for rooms under green roofs, 12% (46,122 annual kWh) less electricity for rooms behind green walls and 42 tonnes of CO_2-eq sequestration per year. However, greening initiatives have a counter-productive impact on water consumption since plantings require irrigation. However, this impact on water consumption could be offset with appropriate design and the combined installation of water harvesting infrastructure.

E2. Renewable Energy

Solar panels offer the most important opportunity for the precinct. The modelling assumes an installation of 4,476 m2 (716 kW) of solar panels with an efficiency of 16%. The results show a production of 984,332 kW/year for Sydney climatic conditions, which represents a reduction of 906 CO_2-eq tonnes/ year.

E3. Cool surfaces

Like greening, cool surfaces seeks to reduce temperature outdoors and indoors. The model assumes 10,000m2 rooftops with cool surfaces. Research indicates that 15 % of energy reduction of rooms under this cool surfaces. This accounts for 119,148 kWh/year or a saving of 110 tonnes of CO_2-eq.

E4. Natural and low energy lighting

These initiatives include motion sensors and the use of natural lightening. It is important to mention that LED technology is considered BAU in this study, so it is not considered in this model. It is estimate that 30% of electricity could be saved with these initiatives, reducing 25,719 kWh/year or 24 tonnes of CO_2-eq every year.

E5. Active and public transport incentives

Findings in the baseline discovered that scope 3 emissions associated with travel offers a significant opportunity to reduce emissions. This group of initiatives include land use diversity, cycling facilities, reduced parking spots, and pedestrian, cyclists, and electric vehicles prioritisation. Since there is a critical overlap between these initiatives, a sustainable transport assessment may be necessary to determine each of the benefits and trade-offs. However, it is possible to set a target for a shift in car use for residents and employees of the precinct.

Transport studies would be required to determine the impacts of active and public transport in Cherrybrook Station SSP. However, there are some good examples of the impacts of transport strategies to reduce car trips such as Parramatta LGA which can be used as reference.

Transport surveys from Parramatta LGA demonstrates that the combination of facilities, access to public transport, and land use makes it possible to reduce car trips to just 20% of all trips. This rate of car use in Cherrybrook Station SSP could save 462 tonnes of CO_2-eq per year.

M1. Mass timber buildings

Conservatively, use of mass timber could reduce 9% of the embodied emissions of a traditional concrete and steel building. For this study, it is assumed that only one of the residential buildings will be built with mass timber. The GHG emission savings of this action is estimated to be 354 tonnes for the whole-of-life of the building.

A more ambitious goal such as using mass timber in all buildings represents a reduction of 4,008 tonnes of CO_2-eq throughout the SSP life cycle.

M2. Low carbon concrete

Low carbon concrete could be used as a replacement for concrete for the rest of the buildings if business-as-usual concrete does not already include supplementary cementitious materials (as per the baseline). The replacement with a low carbon mix could reduce 46% of the emissions embodied in concrete, equivalent to a savings of 5,717 tonnes CO-2e throughout its life cycle.

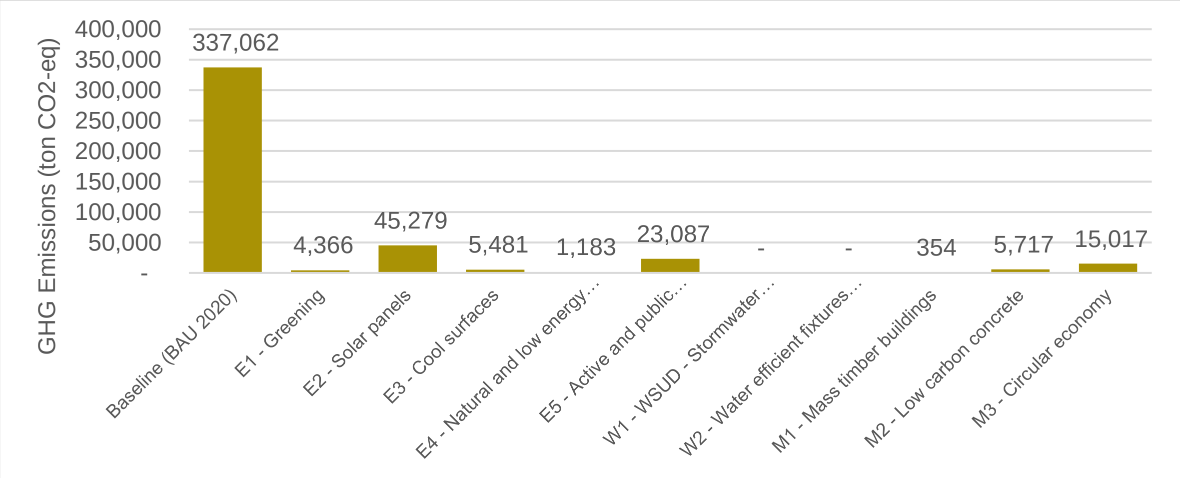


Figure 17. GHG emissions reduction by initiatives group (whole-of- life, 50 years)

Figure 17 summarises the impacts of these initiatives throughout the lifecycle of the precinct. Note that E2 (solar panels) are a significant contributor to the reduction efforts of this sustainability proposal.

E2 is followed by E5 (active and public transport incentives), and M3 (circular economy) which has a significant impact in scope 3 emissions thanks to waste diverted from landfill and subsequently, a reduction in waste management emissions (see Section 3.11.3).

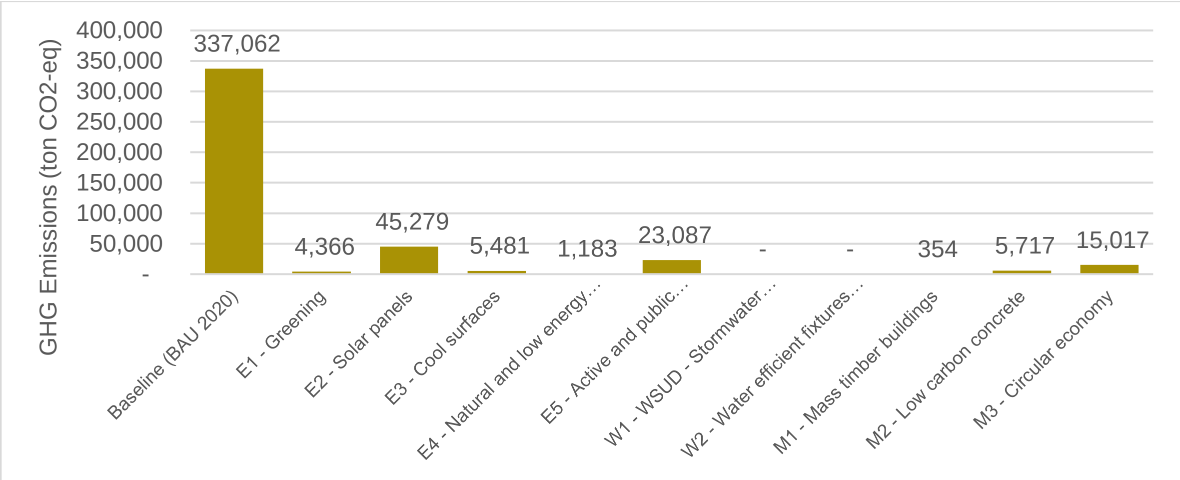


Figure 17. GHG emissions reduction by initiatives group (whole-of- life, 50 years)

Figure 18 below summarises the percent reduction for the combination of all initiatives. Initiatives E1 (greening) and E3 (cool surfaces) were excluded from this modelling to avoid double counting due to the overlap and mutually exclusive nature of this initiatives with E2 (solar panels). The findings show a total reduction in emissions of 26% due to the combination of all initiatives.

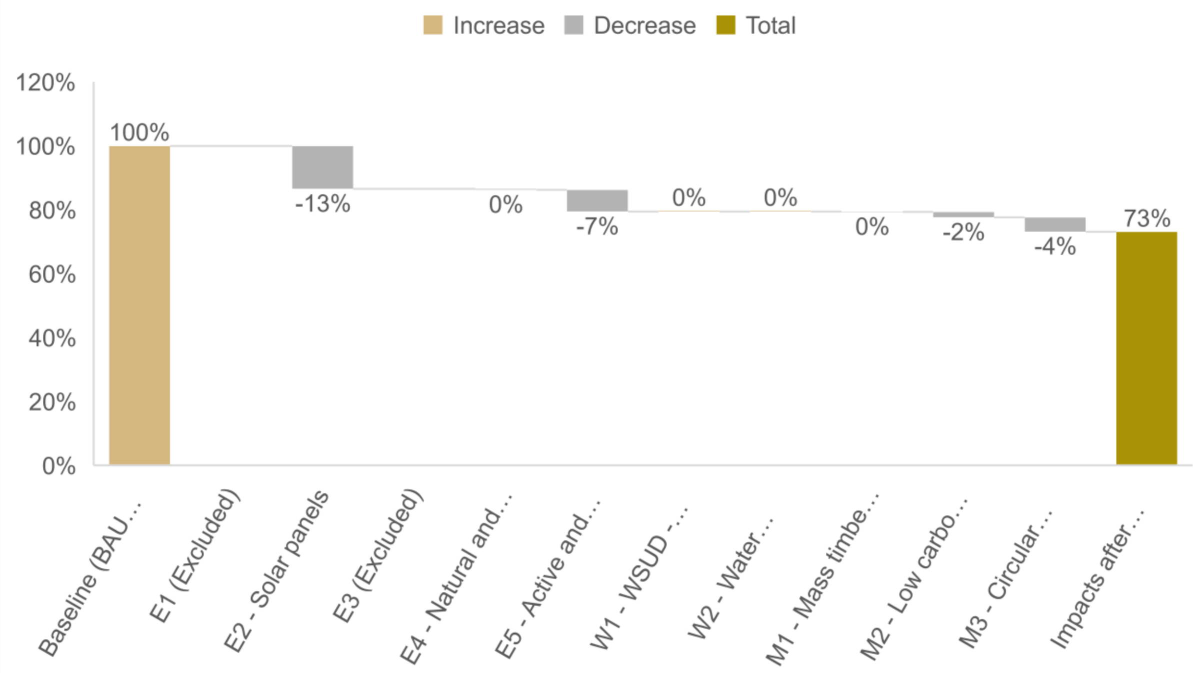


Figure 18. Percentage GHG reduction by initiatives group (whole-of-life, 50 years)

3.1.2 Potable water reduction

As mentioned previously, all water demands are assumed to be on potable water. Therefore, initiatives in this section seek to reduce the use of potable water.

W1. WSUD - Stormwater management

This first initiative includes the collection of stormwaters and its treatment with WSUD methods. According to Cherrybrook SSP WSUD advisor, an average 5kL of stormwater could be collected per building per day. This represents 18,250 kL per year or 912,500 kL for all the modelled operational stage (**Figure 19**).

<u>W2. Water efficient fixtures and appliances</u>

The baseline assumes that all fixtures and appliances in buildings are rated as at least 3-star water saving as per 2020 benchmarks. Water efficient equipment is assumed to be rated 5-star. According to estimations of common appliances in households, the difference of changing all fixtures and appliances represents a reduction of 33% of water use, or 931 ML of water during the precinct operational stage (**Figure 19**).

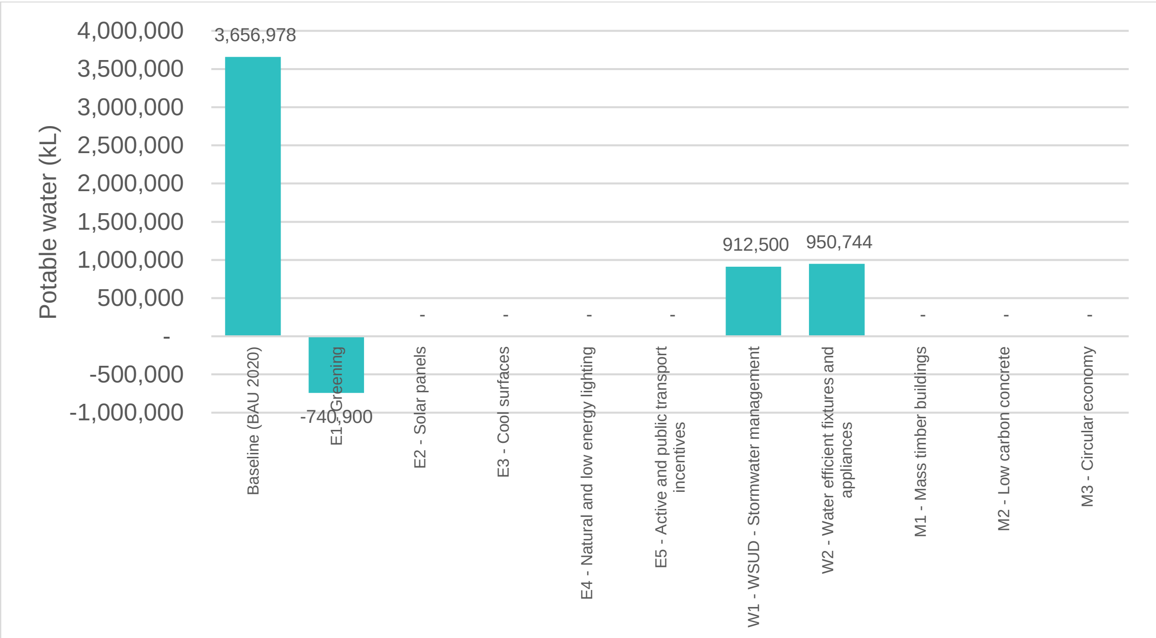


Figure 19. Reduction of potable water by initiative (operational 50 year)

Figure 20 below demonstrates that all initiatives could reduce potable water by 51%. W2 (water efficient fixtures and appliance) presents the largest chance of improvement (26%) while WSUD could reduce 25% of original potable water demand.

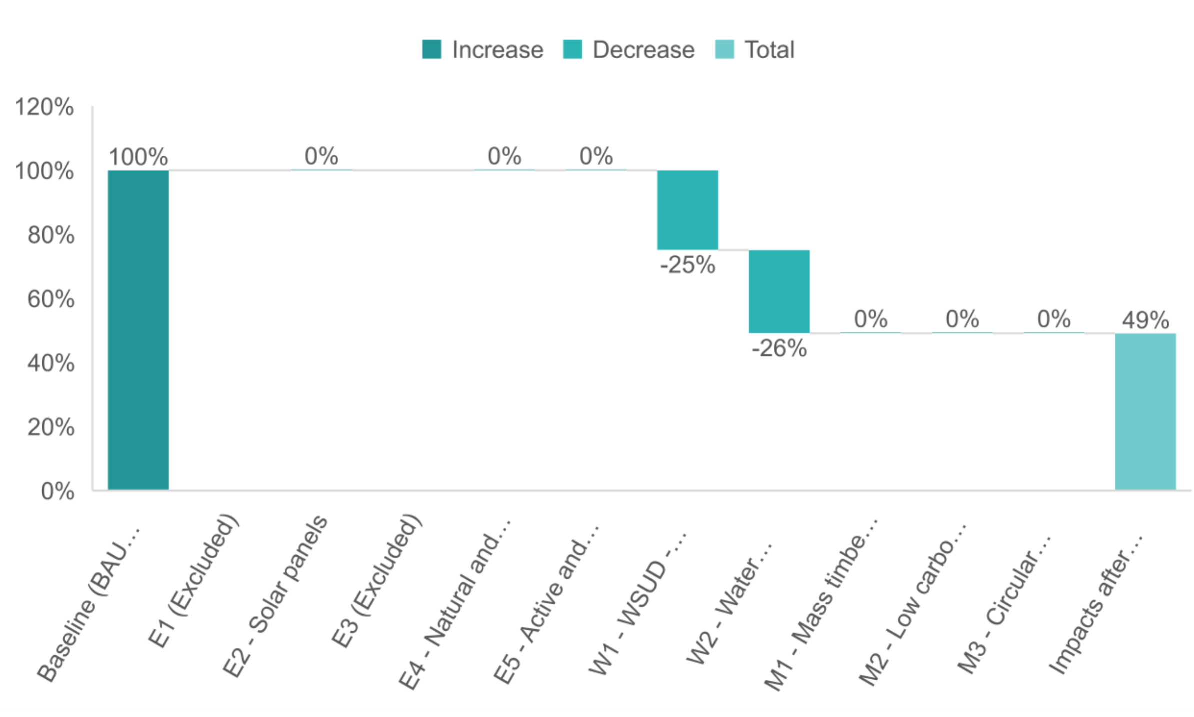


Figure 20. Percentage reduction of potable water (operational 50 year)

3.1.3 Waste diversion from landfill

There are many metrics that could be analysed from waste diversion, with the most prominent being the diversion of waste from landfill. This target has been modelled to represent the greatest and most comprehensive environmental impacts of waste produce in landfill, since it is associated with a significant amount of emissions due to waste management processes in landfills.

M3. Circular economy

This group includes a variety of sub-initiatives to reduce landfilled waste, or even waste generation. Instead of modelling several waste streams and making a myriad of assumptions the modelling of this initiative assumes the achievement of NSW State waste diversion from landfill target (70%). Actual data from Hornsby Shire Council estimates a diversion rate of 44% from residential and 62% from commerce and industry waste. Achieving 70% of waste diversion in both streams represents 12,514 tonnes of waste diverted from landfill for the 50-year lifespan of the Precinct operation (Figure 21). The diversion of all this waste represents a reduction of 15,017 tonnes of CO_2-eq (as seen above in **Figure 17**).

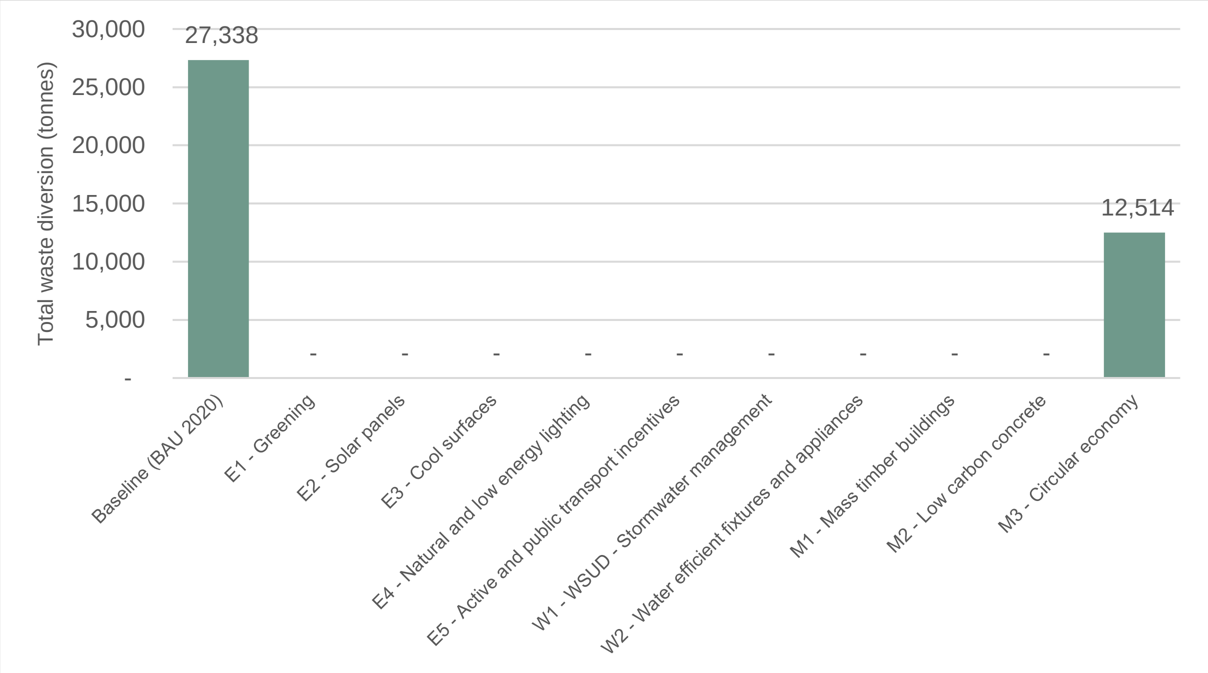


Figure 21. Reduction of landfilled waste by initiative (operational 50 year)

M3 (circular economy) initiative represents 100% of the reduction of materials in this study. It includes sub-initiatives such as increased recycling rates through the implementation of commingled recycling stream (M301) and increased recycling food waste (M302). Assuming these initiatives increase the diversion of waste to 70%, it would divert 46% of landfilled waste estimated in the baseline (**Figure 22**).

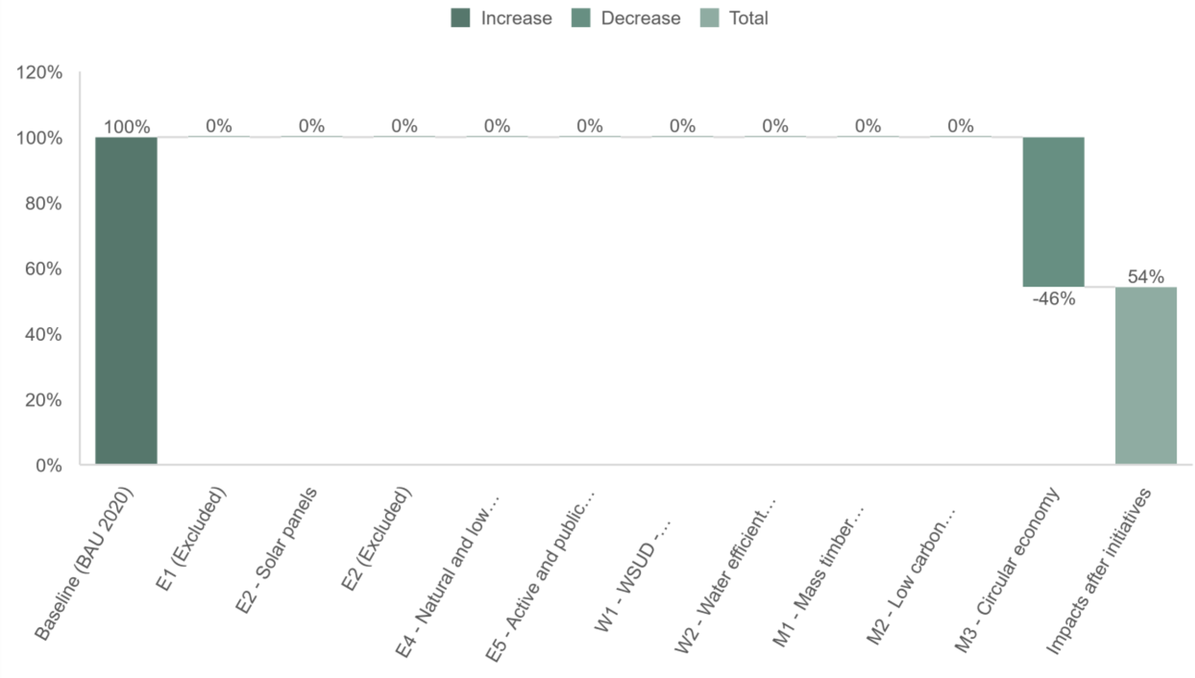


Figure 22 Percentage reduction of landfilled waste

4 Net zero assessment

4.1 Greenhouse gas emissions and climate change

The excessive release of GHGs as a result of man-made industrial activities and processes has led to the enhanced greenhouse effect, or climate change. Peer-reviewed scientific studies collated and published by the Intergovernmental Panel on Climate Change (IPCC) in 2015 found that:

"*Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels…*"[1]

In addition, it found that the earth is on track for 1.5°C global average warming (given current rates of activity) between 2030 and 2052 and this will significantly affect: "*health, livelihoods, food security, water supply, human security and economic growth*". The Intergovernmental Panel on Climate Change (IPCC) therefore recommends a global target to limit warming to 1.5°C.

4.2 Net zero emission targets

To limit warming to 1.5°C a GHG reduction pathway that achieves net zero emissions by 2050 is recommended by the IPCC (**Figure 23**).

Net zero emissions refers to a state of net neutral or balanced GHG emissions through both man-made and natural actions. An equilibrium is reached between activities that emit GHGs and activities that absorb or capture GHG emissions from the earth's atmosphere.

A target to achieve net zero emissions by 2050 has been set at a Council, regional and State level through:

- The NSW government's NSW Climate Change Policy Framework
- The Greater Sydney Commission's Northern District Plan
- Hornsby Shire Council's net zero emissions resolution

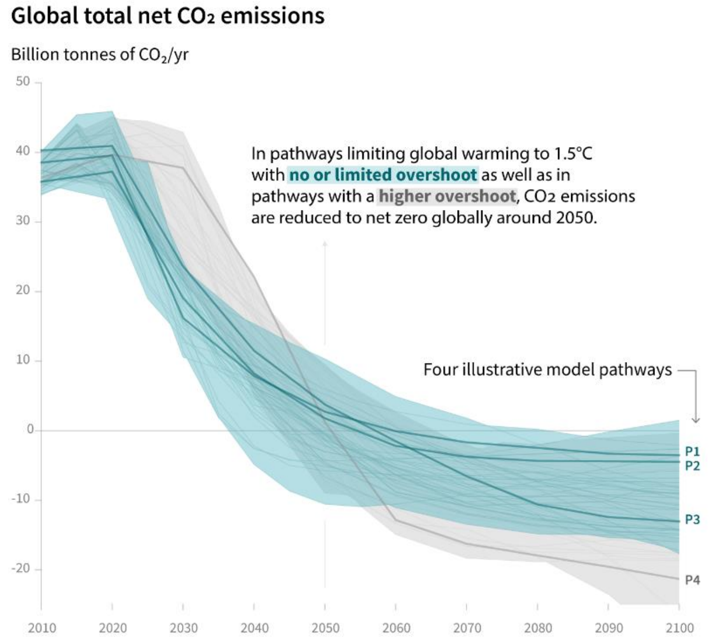


Figure 23. Emissions reduction pathway to limit global warming to 1.5 degrees Celsius. Source: Intergovernmental Panel on Climate Change, 2018, The Special Report on Global Warming of 1.5 °C

The federal government is also bound by a similar commitment under its ratification of the Paris Agreement.

It should be noted that an interim target of ~50% reduction by 2030 is as essential to achieving the 1.5 degree warming target as net zero by 2050 (Figure 23). The need for strong decarbonisation in the short term is reflected in the NSW Government's target of a 35% reduction by 2030 and its Net Zero Plan Stage 1: 2020-2030.

This Plan therefore assesses the potential for the Precinct to support net zero emissions by 2050 in both the buildings and the site.

[1] Source: Intergovernmental Panel on Climate Change, 2018, The Special Report on Global Warming of 1.5 °C

4.3 Net Zero Assessment

The baseline chapter of this Plan (refer to Chapter 2) presents a high-level, 'business as usual' assessment of the Precinct's cradle to grave Scope 1, 2 and 3 GHG emissions for major emissions sources[2]. The following initiatives presented in earlier chapters were selected for the net zero assessment to understand how the Precinct can support a transition to net zero emissions by implementing solutions available today:

- E2 – solar panels: Photovoltaic solar panels on all rooftops (assumes 50% of rooftop space is available for solar panels)
- E4 – natural and low energy lighting: 50% energy reduction through smart lighting control and natural light provision.
- E5 – active and public transport incentives: 20% reduction in resident and worker commuting car trips through access to public transport options and local job creation
- M3 – circular economy: 70% diversion from landfill of waste generated by both residents and offices, in line with the NSW Waste Avoidance and Resource Recovery Strategy 2014-21

Comparing these initiatives with the business as usual baseline carbon footprint suggests that approximately 30% of the Precinct's major emissions sources can be mitigated through the implementation of these initiatives (**Figure 24**).

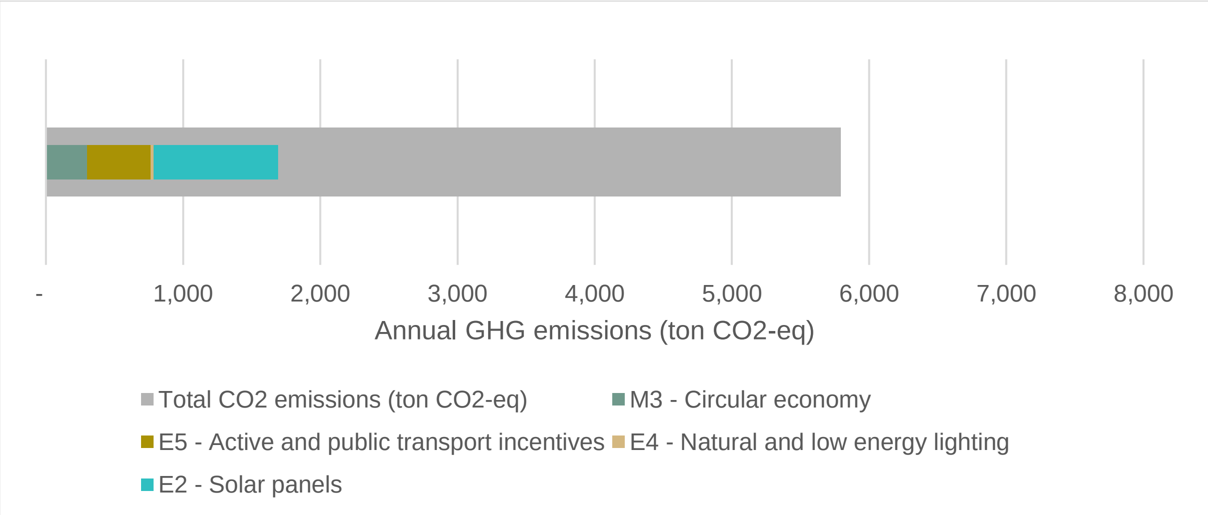


Figure 24. Contribution of GHG reduction initiatives vs total GHG emissions, all operational sources (assumes net positive energy generation through E2 solar panels)

[2] It is important to note that not all emissions sources were modelled for this high-level study. Major emissions sources based on Edge's past building Life Cycle Assessments were identified for the purposes of this study.

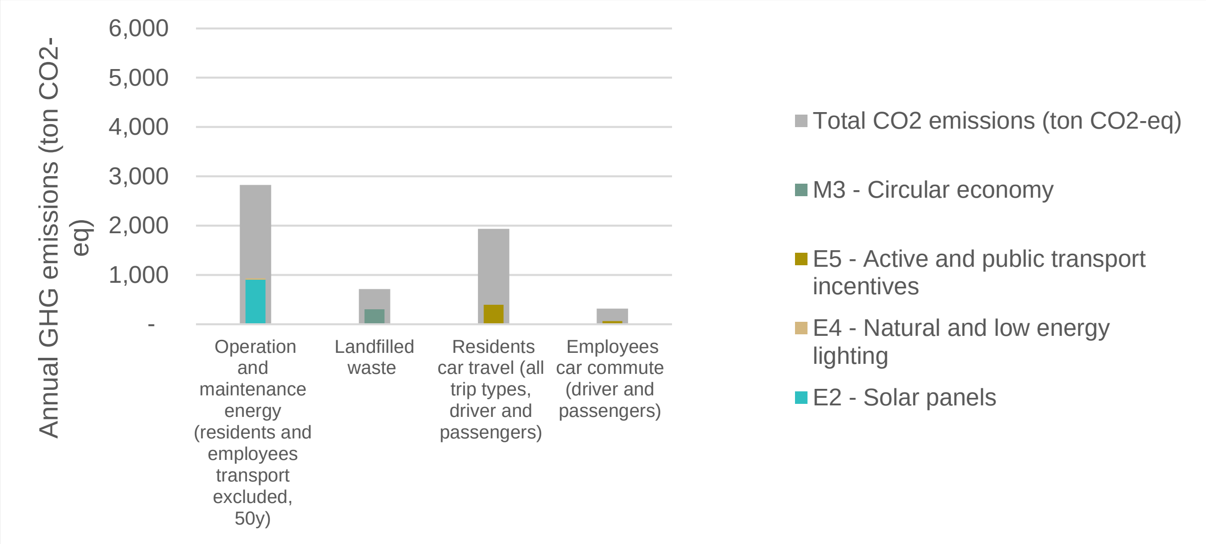


Figure 25. Contribution of GHG reduction initiatives vs total GHG emissions, by operational emissions source (assumes net positive energy generation through E2 solar panels)

4.4 Approach to net zero emissions

To make up the approximately 70% shortfall in reduction of major emissions sources required to achieve net zero emissions, additional initiatives and actions are required. The approach to identifying and implementing such initiatives and actions should consider the appropriate action type and timescale for implementation.

A range of action types are available to reduce GHG emissions (**Figure 26**). Adopting new technologies can eliminate GHG emissions associated with existing technologies (for example the generation of energy from solar panels rather than coal fired power stations). Compared to soft actions such as behaviour and process change, technological solutions are often more costly but low effort. Emissions reduction initiatives should consider the appropriate action type for the emissions source, target population and the perceived or real cost versus benefit.

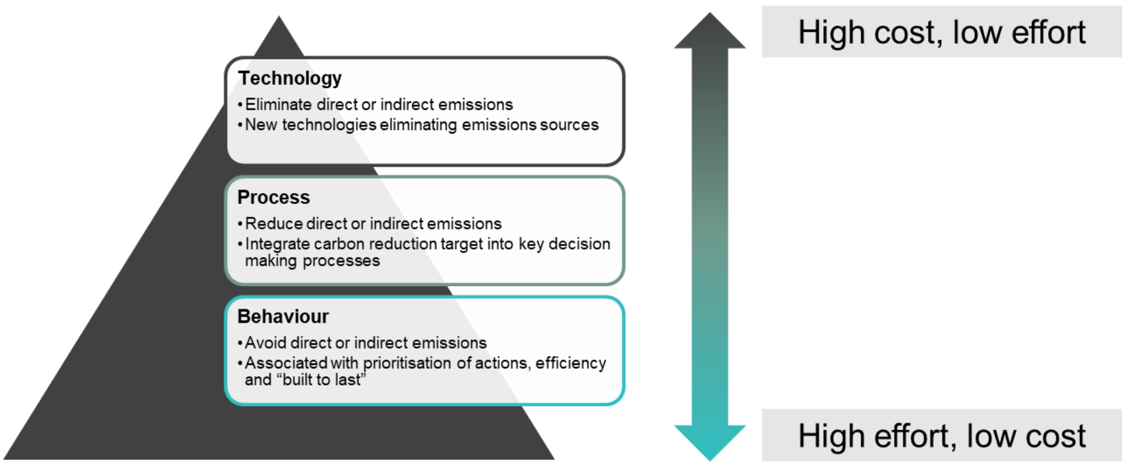


Figure 26. Consideration of the pyramid of action types to reduce GHG emissions

The long timescales of net zero commitments (both 2030 and 2050) mean that priorities and contexts will inevitably shift as time progresses (**Figure 27**). In the short term, 'no regrets' solutions with positive or neutral net present value (NPV) should be implemented, alongside systems or processes to accurately account for GHG emissions. As time progresses, solutions with the lowest negative NPV should be priorities, while still seeking out new solutions or revised solutions with positive or neutral NPVs. While 2050 remains in the distant future, planning can begin now by:

- Identifying shortfalls that require research and investment today
- Advocating for industry action or collaboration on difficult emissions sources
- Communicating net zero ambitions to suppliers in a commercial context to send a clear market signal
- Identifying and monitoring key decision points or triggers for the adoption of different plans and actions, adjusting to the social, political, economic, and environmental context.

No regrets

2025

Implement solutions with positive or neutral NPV

Establish systems and processes for carbon accounting and mitigation

Reduction pathway

2030

Implement priority solutions with lowest negative NPV

Continue to seek positive or neutral NPV projects

Advocacy and trigger points

2050

Support the identification and development of long term solutions (technology or process)

Advocate for industry action on priority, persistent carbon impacts

Communicate ambition to supply chain in a commercial context

Monitor trigger or decision points and act

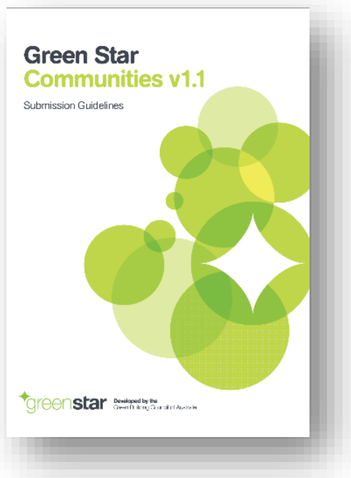
Figure 27. Consideration of appropriate timescales for the implementation of GHG reduction initiatives

Alongside the additional initiatives listed in Chapter 3, the following initiatives can be considered for implementation during the Precinct's development process to meet the modelled shortfall (**Table 9**). These initiatives should be considered for implementation with consideration of the appropriate timescale and action type to maximise both cost-effectiveness and success in implementation.

Table 9. List of potential additional initiatives

Emissions source	Additional initiatives
Energy	• Upgrade or install electric appliances in lieu of gas • Upgrade or procure cooling appliances with no GHG-based refrigerants • Upgrade or install high energy star ratings for energy efficient appliances • Design or upgrade rooms and buildings to minimise air-leakage and therefore cooling and heating requirements
Landfilled waste	• Advocate for the ban or minimisation of 'hard-to-recycle' goods to avoid the need for landfilling in the first place • Advocate for the increased recyclability of packaging materials • Advocate for circular economy solutions for textile and clothing waste • Implement soft plastic and food and garden waste collection (including on-site composting)
Commuting of residents and workers	• Install or upgrade electric vehicle charging stations coupled with renewable generation • Implement carpooling or car share arrangements • Increase the safety of cycling and walking paths

5 Green Star Communities and Green Star Homes Alignment



The Green Building Council of Australia (GBCA) is a member-based organisation serving as the peak building sustainability organisation in Australia. The Green Star Communities Rating Tool provides a third party assured standard or benchmark of the sustainability performance of precincts across Australia that can be easily interpreted by the general public.

The Rating defines communities in the broadest sense, capturing not just a physical location but the associated economy, culture, social setting, and other socio-economic layers to place. The sustainability categories assessed under the Rating include:

- Governance
- Liveability
- Economic Prosperity
- Environment

All the ESD initiatives are aligned to some of Green Star Communities Credits and the recently presented Green Star Home categories. Therefore, they could contribute on reaching a high-level rating in both frameworks if executed. The table below summarises the relationship of initiatives with these rating tools.

Table 10. List of potential additional initiatives

Initiative	Sub-initiative	Green Star Communities v1.1 Categories	Green Star Communities v1.1 Credits	Green Star Homes Categories
Greening	Green roofs and rooftop gardens (public and private access)	Environment	Greenhouse Gas Strategy, Heat Island Effect	Healthy, Resilient, Positive
	Green walls (vertical gardens)	Environment	Greenhouse Gas Strategy, Heat Island Effect	Healthy, Resilient, Positive
	Increased canopy	Environment	Greenhouse Gas Strategy, Heat Island Effect, Ecological Value, Sustainable Sites	Healthy, Resilient, Positive
Solar panels	Solar panels on buildings	Environment, Economic prosperity	Greenhouse Gas Strategy, Peak Electricity Demand Reduction	Positive
	Solar panels on public access spaces	Environment, Economic prosperity	Greenhouse Gas Strategy, Peak Electricity Demand Reduction	Positive
Cool surfaces	Use cool seal products on rooftops	Environment	Greenhouse Gas Strategy, Heat Island Effect	Resilient, Positive
	Use cool seal products on pavements	Environment, Economic prosperity, Innovation	Greenhouse Gas Strategy, Heat Island Effect, Innovation	Resilient, Positive

Initiative	Sub-initiative	Green Star Communities v1.1 Categories	Green Star Communities v1.1 Credits	Green Star Homes Categories
Natural and low energy lighting	Self-emitting pavements for cycleways and footpaths	Environment, Economic prosperity, Innovation	Greenhouse Gas Strategy, Light Pollution, Innovation	Positive
	Motion detectors	Environment, Economic prosperity	Greenhouse Gas Strategy	Positive
Active and public transport incentives	Infrastructure and facilities for cyclists	Environment	Greenhouse Gas Strategy, Sustainable Transport and Movement, Sustainable Sites	Healthy, Positive
	Walkable distance to diverse services of public transport	Environment	Greenhouse Gas Strategy, Sustainable Transport and Movement, Sustainable Sites	Healthy, Positive
	Mixed land use including diversity of amenities	Environment	Greenhouse Gas Strategy, Sustainable Transport and Movement, Sustainable Sites	Healthy, Positive
	Reduced parking, parking pooling, and car-share exclusive parking spots	Environment	Greenhouse Gas Strategy, Sustainable Transport and Movement, Sustainable Sites	Healthy, Positive
WSUD - Stormwater management	Stormwater/rainwater diversion and capture, including rainwater gardens	Environment	Integrated Water Cycle	Resilient, Positive
	Permeable paving	Environment	Integrated Water Cycle	Resilient, Positive
	Rainwater as replacement for toilets	Environment	Integrated Water Cycle	Resilient, Positive
	Rainwater as replacement fire sprinklers	Environment	Integrated Water Cycle	Resilient, Positive
Water efficient fixtures and appliances	Water saving fixtures and appliances	Environment	Integrated Water Cycle	Positive
	Dry appliances (composting toilets)	Environment	Integrated Water Cycle	Positive
Mass timber buildings	Mass timber buildings	Environment	Green House Gas Strategy, Materials	Healthy, Resilient, Positive
Low carbon materials and dematerialisation	Low carbon concrete	Environment	Green House Gas Strategy, Materials	Positive
	Dematerialisation	Environment	Green House Gas Strategy, Materials, Waste Management	Positive
	Re-used materials	Environment	Green House Gas Strategy, Materials, Waste Management	Positive
	EPDs	Environment	Green House Gas Strategy, Materials	Positive
Circular economy	Comingled materials	Environment	Waste management	Positive
	Food waste	Environment	Waste management	Positive

6 Climate adaptation alignment

Globally, and locally, we are locked into a certain amount of climate change, with impacts already being experienced. The climate changes projected for the coming years (to 2070) in the Greater Sydney region include[3]:

- Increased annual average temperatures (up to 1.9°C), particularly in summer and spring
- Increased annual rainfall (~8.9%), particularly in summer and autumn
- Increased risk of severe fire events, particularly in summer and spring
- Increased number of hot days (additional 10-20 days >35°C), particularly in summer and spring
- Decreased number of cold nights (average of 12 fewer nights per year less than 2°C), particularly during winter

Climate change impacts of key concern for the Cherrybrook Station precinct were assessed by AECOM[4] to relate to extreme heat and severe storms. Specific considerations included:

- "…the selection of building materials (e.g. façades, roofing) that are resistant to hail and can withstand strong winds…"
- "…materials and design interventions that will reduce the impact of extreme heat events and urban heat impacts…"
- "Opportunities to reduce the precinct's reliance on grid supplied energy…"
- "…capacity building… to ensure that the community is prepared and know what to do during these events"

The sustainability initiatives outlined in this ESD Plan will help to mitigate climate change and adapt to changing conditions, including addressing resilience recommendations outlined in the AECOM Climate and Community Resilience Assessment report[5]. Some ways in which the initiatives can contribute to climate change adaptation are identified in

[3] Source: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW

[4] *Climate and Community Resilience Assessment: Cherrybrook Station Precinct* (2019). A report prepared by AECOM for Landcom.

Table 11. Potential impacts of climate change on initiatives and example mitigation considerations

Key Initiative	Potential contribution of the initiative to adapting to climate change	Potential impacts of climate change on the initiative
E1. Greening	• Canopy cover and vertical or roof plantings can create a localised cooling effect that reduces the severity of heatwaves and hot days. • Planting arrays can be designed to provide wind breaks for susceptible infrastructure (e.g. solar panels) during storms and extreme wind events. • Species selections can consider heat tolerance and fire resilience.	• Increased plant mortality due to extreme heat • Storm damaged plants • Bushfire risk
E2. Renewable Energy	• Solar panels increase self-sufficiency in energy supply, mitigating the effects of blackouts and brownouts caused by damage to electricity generation or distribution infrastructure during extreme weather events. • Solar panels provide independent energy generation infrastructure, which can power critical air conditioning during droughts and hot days.	• Storm damage • Extreme heat reducing efficiency
E3. Cool surfaces	• Contributes to lowering the urban heat island effect, which will be exacerbated during heatwaves and hot days.	• Extreme heat impact on integrity of surfaces and cool seal material (e.g. the melting tarmac)
E4. Natural and low energy lighting	• Natural or low energy lighting reduces the strain on the grid during heatwaves and hot days, where the energy demand typically peaks due to air conditioning and cooling demand.	• Mains power blackouts • Storm damage
E5. Active and public transport incentives	• Public transport provides climate controlled transportation for vulnerable populations during droughts, hot days, and other extreme weather events.	• Extreme heat risk for users • Public transport breakdowns
W1. WSUD – stormwater management	• WSUD features can be designed to help minimise potential flooding impacts (location, capacity) • Plantings and permeable paving can help minimise flooding impacts • WSUD initiatives can be designed to capture and store rainfall on site for use in irrigation, to provide self-sufficiency during drought.	• Infrastructure damage from extreme storm events and potential localised flooding
W2. Water efficient fixtures and appliances	• Water efficiency measures reduce the demand on the water supply, which creates resilience to drought.	• Mains power blackouts
M1. Mass timber buildings	• Timber buildings can withstand gusty winds, i.e. very strong loads for short durations.	• Fire risk for materials under extreme heat conditions
M2. Low carbon materials and dematerialisation	• Materials with resilience properties and features can be specified to withstand extreme heat and storm conditions	• Extreme heat/storms may impact material integrity
M3. Circular economy	• N/A	• N/A

7 Targets

Measurable and achievable targets (**Table 12**) are proposed for at least each environmental footprint indicator to ensure the Precinct performs better than the footprint baseline calculated in Section 2. The proposed targets are derived from the analysis and research presented throughout this ESD Plan:

- **Section 1.5: Sustainability context and literature review** – the targets consider the overarching policy, planning and strategic context of the Cherrybrook Station SSP, including the NSW Climate Change Framework and Landcom Sustainable Places Strategy.
- **Section 2: Baseline** – several targets refer to a 'business as usual' baseline. A high*level baseline was established in Section 2 of this ESD Plan.
- **Section 3: Initiatives** – potential initiatives to minimise the environmental footprint are identified and their impact on reducing the environmental footprint modelled at a high level to inform the level of ambition of the targets. These initiatives set out a range of options and pathways for designers and construction contractors to achieve the targets.
- **Section 4: Net Zero Assessment** – the findings and drivers of the net zero assessment inform specific emissions reduction targets.

A minimum mandatory target is presented in the table below.

Table 12. Proposed environmental footprint targets for the Precinct

Indicator	#	Metric	Minimum Target	Justification
Waste	1	Diversion of residential waste from landfill during operations	50%	A 70% target for municipal solid waste (MSW) and commercial and industrial waste (C&I) is set by the NSW Waste Avoidance and Resource Recovery Strategy for 2021-22.
	2	Diversion of construction and demolition waste from landfill during construction and decommissioning	95%	Minimum target is derived from the Landcom Sustainable Places Strategy (Section 1.5.5)
Energy & GHG emissions	3	Reduction in Scope 1 and 2 emissions in the as built Precinct compared to a business-as-usual baseline	50%	Minimum target is derived from the Landcom Sustainable Places Strategy (Section 1.5.5).
	4	Reduction in Scope 1, 2 and 3 greenhouse gas emissions in the as built Precinct compared to a business-as-usual baseline. Scope 3 emissions must include construction materials (embodied carbon), waste disposal & processing, and employee & resident commuting.	20%	The net zero assessment conducted for this study (Section 4) identified the potential for a 29% reduction based on feasible initiatives. This target is different from target 3 as it includes scope 3 emissions. Scope 3 emissions represent most of the emissions from of the Precinct as estimated on the modelling (63%).
	5	Reduction in Scope 1 and 2 greenhouse gas emissions	100%	This target is aligned to the NSW Climate Change Policy Framework and NSW's net

Indicator	#	Metric	Minimum Target	Justification
		by 2050 compared to a business-as-usual baseline		zero by 2050 target (Section 1.5)
	6	Tree canopy cover 30 years after the end of construction	A minimum 25% tree canopy (current 10% cover), subject to addressing bushfire protection measures which may limit tree canopy coverage to 15%	Tree canopy cover was considered among the initiatives identified and modelled in Section 3. The draft Greener Places Design Guide (Government Architect NSW) identifies an indicative place-based target of greater than 25 per cent tree canopy cover in urban residential (medium- to high-density)
	7	% of predicted project energy demand supplied from onsite renewable energy	5%	Minimum target is derived from the Landcom Sustainable Places Strategy (Section 1.5.5)
	8	All residential dwellings to achieve the following minimum energy ratings: Detached and semi-detached: 60 | Low Rise BASIX 45 | Mid-Rise BASIX 45 | High Rise BASIX 40	N/A	Target is derived from the Landcom Sustainable Places Strategy (Section 1.5.5)
Water	9	% reduction in mains potable water use in the built Precinct compared to a business-as-usual baseline	40% - 50%	50% target is derived from the Landcom Sustainable Places Strategy (Section 1.5.5). The water-related initiatives modelled in this study demonstrate the potential to achieve a 31% in potable water (Section 3). Achieving higher saving rates is possible as these initiatives does not include all state-of-art initiatives such as some WSUD initiatives, and it does not consider future technology improvements.
	10	Residential dwellings to achieve BASIX 60 water rating	N/A	Target is derived from the Landcom Sustainable Places Strategy (Section 1.5.5)

Developers can propose frameworks or methodologies to meet the above targets, including but not limited to:

- Green Star rating
- Environmental Product Declaration
- 3rd party verified Life Cycle Assessment

7.1 Implementation methodology

To ensure that the environmental footprint of the Precinct is reduced throughout its life cycle, sustainability will continue to be considered at each step of the project planning and development process (**Figure 28**). The future planning process will be key to ensuring appropriate sustainability targets are embedded into requirements and integrated as the design progresses. Reviews of sustainability performance and initiatives will be undertaken at relevant intervals, such as:

- Detailed DA Stage
- Tender responses
- Final Green Star rating (if relevant).

Landcom/Sydney Metro may seek to utilise existing sustainability programs, such as BASIX, Green Star and NABERS to provide third-party assurance and industry benchmarking on performance. This ESD Plan is expected to form the foundation for reducing the environmental footprint of the Precinct throughout its life cycle by establishing a baseline and potential initiatives and targets.

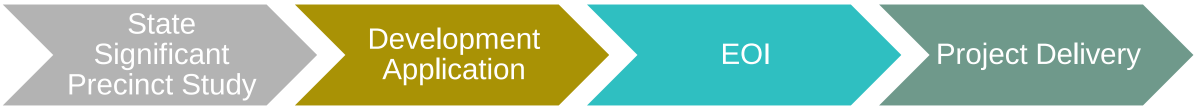


Figure 28: Key stages in the planning and development process

8 Conclusion

This study addresses the *Study Requirements for Cherrybrook Station Government Land (2020)* items 10.1 and 11.1. This ESD Plan:

- Establishes a baseline environmental footprint for the Cherrybrook Station SSP for water, energy & carbon, and waste & materials.
- Identifies potential initiatives to minimise the Cherrybrook Station SSP's environmental footprint and presents the modelled results of their contribution to reducing the baseline environmental footprint.
- Presents the results of a net zero assessment regarding the pathway and potential for a net zero precinct. Principles and initiatives to address the residual emissions are also outlined in the ESD Plan.
- Outlines the potential interface of the ESD targets and initiatives with the Green Star Communities and Homes Rating and climate change adaptation goals.
- Presents ESD targets to minimise the environmental footprint of the Cherrybrook Station SSP throughout design, construction, and operation.

The key findings of the ESD Plan include:

- **Baseline environmental footprint**:
    - **Energy & Carbon**: most of the emissions are located within scope 3, accounting for 63% of the total, while scope 1 and scope 2 (direct emissions) accounts for 6% and 31%, respectively.
    - **Water:** 72% of life cycle water consumption is associated with dwellings, 24% with public amenities, 3% with commercial spaces, and less than 1% with precinct infrastructure.
    - **Materials:** Reinforcing steel (28%), aluminium (28%), and structural concrete (25%) account for most of the embodied emissions.
    - **Waste:** Over the Precinct's lifespan, 57% of waste is projected to be generated by commercial areas, 42% by residents, and the balance by public amenities and offices approximately 1%).
- **Initiatives**: 10 initiatives (with several sub-initiatives) to reduce the whole of life environmental footprint were identified. These initiatives were modelled to reduce life cycle scope 1 2 and 3 emissions by 30% and potable water use by 31%.
- **Net zero assessment:** approximately 30% of the Cherrybrook Station SSP scope 1, 2 and 3 emissions can be mitigated through feasible initiatives modelled at a high level for this study.

The ESD Plan establishes 10 targets to reduce the environmental footprint of the Cherrybrook Station SSP throughout design, construction, and operation (refer to **Table 12**). It is recommended that these targets are considered in the proceeding steps of the planning and development process. The future planning process will be key to ensuring appropriate sustainability targets are embedded into requirements and integrated as the design progresses.

Appendix A. Energy and GHG Model

Construction

Description	Project component	Electricity			Diesel			Gas			Total Energy Use (MJ)	Scope 1 GHG (ton CO2-eq)	Scope 2 GHG (ton CO2-eq)	Scope 3 GHG (ton CO2-eq)	Scope 1, 2 & 3 GHG (ton CO2-eq)	Assumptions	Reference
		Rate	Rate Unit	Total consumption (kW)	Rate	Unit	Total consumption (kL)	Rate	Unit	Total consumption (MJ)							
Office spaces	Offices	64.50	MJ/m2	8,958	150.50	MJ/m2	2	-	na	-	32,325	5	7	1	14	70% diesel, 30% electricity	Cole R J (1999)
Residential spaces	Dwellings	64.50	MJ/m2	597,521	150.50	MJ/m2	130	-	na	-	2,156,094	352	490	78	920	70% diesel, 30% electricity	Cole R J (1999)
Commercial spaces (retail)	Commercial / retail spaces	64.50	MJ/m2	57,333	150.50	MJ/m2	12	-	na	-	206,882	34	47	7	88	70% diesel, 30% electricity	Cole R J (1999)
Indoor public amenities	Indoor / outdoor public amenities	64.50	MJ/m2	23,292	150.50	MJ/m2	5	-	na	-	84,046	14	19	3	36	70% diesel, 30% electricity (assumed as a commercial space)	Cole R J (1999)
Green areas	Indoor / outdoor public amenities	-	na	-	1.20	L/m3	28	-	na	-	1,068	75	-	4	79	Only earthworks - strip and respread topsoil (1m depth)	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Streets 6m wide	Infrastructure	-	na	-	1.69	L/m2	-	-	na	-	-	-	-	-	-	Only pavement - Full depth asphalt	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Cycleways 2m wide (m)	Infrastructure	-	na	-	0.73	L/m2	1	-	na	-	28	2	-	0	2	Bike path - asphalt	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Footpaths 2m wide (m)	Infrastructure	-	na	-	2.00	L/m2	2	-	na	-	77	5	-	0	6	Block paved footpaths	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Drainage	Infrastructure	-	na	-	45.60	L/m	23	-	na	-	880	62	-	3	65	Medium 450-750 RCP + Semi-mountable kerb	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Sewage	Infrastructure	-	na	-	45.00	L/m	23	-	na	-	869	61	-	3	64	As drainage -Medium 450-750 RCP	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Total				**687,104**			**225**			**-**	**2,482,268**	**610**	**563**	**100**	**1,274**		

Operation and Maintenance

Activity	Project component	Electricity			Diesel / Petrol			Gas			Total Energy Use (MJ)	Scope 1 GHG (ton CO2-eq)	Scope 2 GHG (ton CO2-eq)	Scope 3 GHG (ton CO2-eq)	Scope 1, 2 & 3 GHG (ton CO2-eq)	Assumptions	Reference
		Rate	Rate Unit	Total consumption (kW)	Rate	Unit	Total consumption (kL)	Rate	Unit	Total consumption (MJ)							
Offices consumption	Offices	321.35	kWh/m2	160,675	na	na	-	128.54	MJ/m2	64,270	642,698	3	132	17	152	3 Stars Nabers Energy rating for 50h/week of occupancy, 10 computers/ 100 sqm, 10% electricity, 10% gas	NABERS Energy for offices Reverse Calculator v12
Residents consumption	Dwellings	1,798.67	kWh/person	1,618,800	na	na	-	8,129.00	MJ/person	7,316,100	13,143,780	377	1,327	256	1,960	3 person household, with gas heater, no pool	https://www.energymadeeasy.gov.au/benchmark (retrieved on 11/08/2020)
Commercial consumption (retail)	Commercial / retail spaces	37.44	kWh/m2	119,792	na	na	-	14.97	MJ/m2	47,917	479,168	2	98	13	113	3 Stars Nabers Energy rating for 61h/week of service. Single storey, 360 trading days, no parking, no other amenities, 1000m2, 90% electricity, 10% gas	NABERS Energy and Water for shopping centres Reverse Calculator v6.0
Indoor public amenities	Indoor / outdoor public amenities	38.44	kWh/m2	49,866	na	na	-	14.97	MJ/m3	19,466	199,342	1	41	5	47	(Assumed as a commercial space) 3 Stars Nabers Energy rating for 61h/week of service. Single storey, 360 trading days, no parking, no other amenities, 1000m2, 90% electricity, 10% gas	NABERS Energy and Water for shopping centres Reverse Calculator v6.0
Street lighting	Infrastructure	600.00	kWh/m	-	na	na	-	na	na	-	-	-	-	-	-	Underpasses (municipal road)	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Cycleways and footpaths lightening	Infrastructure	600.00	kWh/m	600,000	na	na	-	na	na	-	2,160,000	-	492	60	552	Underpasses (municipal road), double street lights	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Streets 6m wide maintenance	Infrastructure	-	na	-	0.43	L/m2	-	-	na	-	-	-	-	-	-	Full Depth Asphalt	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Residents car travel (all types of travel, driver and passenger)	Dwellings	-	na	-	0.13	L petrol/km	776	-	na	-	26,552	-	-	1,936	1,936	2.075 car trips (driver)/resident-day, 8.5km average distance, only residents, Scope 3	TfNSW, Household Travel Survey - Data by LGA 2018/2019 (Hornsby) / Budget Direct, Average fuel consumption in Australia 2020
Employees car commute (driver and passenger)	Commercial / retail spaces	-	na	-	0.13	L petrol/km	128	-	na	-	4,375	-	-	319	319	15.3km average distance each way, 260 days a year, only employees, Scope 3	TfNSW, Household Travel Survey - Data by LGA 2018/2019 (Sydney Region) / Budget Direct, Average fuel consumption in Australia 2021
Total (annual)				**2,549,232**			**904**			**7,447,753**	**16,655,915**	**384**	**2,090**	**2,605**	**5,079**		
Total (50 years)				**127,461,600**			**45,216**			**372,387,625**	**832,795,768**	**19,189**	**104,519**	**130,244**	**253,952**		

Demolition /refurbishment

9 6

Description	Project component	Electricity			Diesel			Gas			Total Energy Use (MJ)	Scope 1 GHG (ton CO2-eq)	Scope 2 GHG (ton CO2-eq)	Scope 3 GHG (ton CO2-eq)	Scope 1, 2 & 3 GHG (ton CO2-eq)	Assumptions	Reference
		Rate	Rate Unit	Total consumption (kW)	Rate	Unit	Total consumption (kL)	Rate	Unit	Total consumption (MJ)							
Office spaces	Offices	na	na	-	4.80	L/m2	2	na	na	-	93	7	-	0	7	Only diesel - Assuming that 4.8L of diesel is required per m2 GFA	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Residential spaces	Dwellings	na	na	-	4.80	L/m2	160	na	na	-	6,179	434	-	22	456	Only diesel - Assuming that 4.8L of diesel is required per m2 GFA	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Commercial spaces	Commercial / retail spaces	na	na	-	4.80	L/m2	15	na	na	-	593	42	-	2	44	Only diesel - Assuming that 4.8L of diesel is required per m2 GFA	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Indoor public amenities	Indoor / outdoor public amenities	na	na	-	4.80	L/m3	6	na	na	1	241	17	-	1	18	Only diesel - Assuming that 4.8L of diesel is required per m2 GFA	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Infrastructure	Infrastructure	na	na	-	4.80	L/m2	10	na	na	-	371	26	-	1	27	Only diesel - Assuming that 4.8L of diesel is required per m2 GFA	TAGG 2013, Greenhouse Gas Assessment Workbook for Road Projects
Total				**-**			**194**			**-**	**7,476**	**525**	**-**	**27**	**552**		

Construction

Description	Project component	Rate	Rate unit	Total consumption (kL)	Potable water (%)	Non-potable water (%)	Potable water (kL)	Non-potable water (kL)	Assumptions	Reference
Office spaces	Offices	0.26	L/m2/week	10	100%	0%	10	-	18 months construction (78 weeks)	WRAP (2011) / Victoria Roads - Integrated Water Management Guidelines June 2013
Residential spaces	Dwellings	0.26	L/m2/week	669	100%	0%	669	-	18 months construction (78 weeks)	WRAP (2011) / Victoria Roads - Integrated Water Management Guidelines June 2013
Commercial spaces (retail)	Commercial / retail spaces	0.26	L/m2/week	64	100%	0%	64	-	18 months construction (78 weeks)	WRAP (2011) / Victoria Roads - Integrated Water Management Guidelines June 2013
Indoor public amenities	Indoor / outdoor public amenities	0.26	L/m2/week	26	100%	0%	26	-	18 months construction (78 weeks)	WRAP (2011) / Victoria Roads - Integrated Water Management Guidelines June 2013
Green areas	Indoor / outdoor public amenities	0.74	kL-year/m2	4,270	100%	0%	4,270	-	(1 year consumption for establishment watering) 20% undercover, evapotranspiration from BoM, and other Green Start standard practice assumptions: application efficiency (75%), monthly rainfall, crop coefficient (0.6) + earthworks (100L/m2)	Green Star, Potable Water Calculator 14102015 / Australian Bureau of Meteorology (BoM)
Streets 6m wide	Infrastructure	216.00	L/m2	-	100%	0%	-		Pavement layer compaction and sub-grade compaction	Victoria Roads - Integrated Water Management Guidelines June 2013
Cycleways 2m wide (m)	Infrastructure	216.00	L/m2	216	100%	0%	216		Pavement layer compaction and sub-grade compaction	Victoria Roads - Integrated Water Management Guidelines June 2013
Footpaths 2m wide (m)	Infrastructure	216.00	L/m2	216	100%	0%	216		Pavement layer compaction and sub-grade compaction	Victoria Roads - Integrated Water Management Guidelines June 2013
Drainage	Infrastructure	1.60	L/m	1	100%	0%	1		Drainage cleaning	Victoria Roads - Integrated Water Management Guidelines June 2013
Sewage	Infrastructure	2.60	L/m	1	100%	0%	1		Sewage cleaning (Drainage cleaning)	Victoria Roads - Integrated Water Management Guidelines June 2013
Total				**5,473**			**5,473**	-		

Operation and Maintenance

Description	Project component	Rate	Rate unit	Annual consumption (kL)	Potable water (%)	Non-potable water (%)	Potable water (kL)	Non-potable water (kL)	Assumptions	Reference
Office spaces	Offices	1.02	kL-year/m2	511	100%	0%	511	-	3 Stars Nabers Water rating for 50h/week of occupancy	NABERS Water for Offices Reverse Calculator v1.0
Residential spaces	Dwellings	58.62	kl-year/person	52,758	100%	0%	52,758	-	Average according to Sydney Water (all seasons)	https://www.sydneywater.com.au/SW/your-home/using-water-wisely/water-efficiency-targets/index.htm (retrieved on 11/09/2020)
Commercial spaces (retail)	Commercial / retail spaces	0.71	kL-year/m2	2,269	100%	0%	2,269	-	3 Stars Nabers Water rating for 61h/week of service. Single storey, 360 trading days, no parking, no other amenities, 1000m2	NABERS Energy and Water for shopping centres Reverse Calculator v6.0
Indoor public amenities	Indoor / outdoor public amenities	0.71	kL-year/m2	922	100%	0%	922	-	Considered a commercial spaces - 3 Stars Nabers Water rating for 61h/week of service. Single storey, 360 trading days, no parking, no other amenities, 1000m2	NABERS Energy and Water for shopping centres Reverse Calculator v6.0
Green areas	Indoor / outdoor public amenities	0.64	kL-year/m2	16,344	100%	0%	16,344	-	20% undercover, evapotranspiration from BoM, and other Green Start standard practice assumptions: application efficiency (75%), monthly rainfall, crop coefficient (0.6)	Green Star, Potable Water Calculator 14102015 / Australian Bureau of Meteorology (BoM)
Streets 6m wide cleaning	Infrastructure	7.00	L/m2	-	100%	0%	-		Pavement cleaning (6 times per year)	Victoria Roads - Integrated Water Management Guidelines June 2013
Cycleways 2m wide (m) cleaning	Infrastructure	7.00	L/m2	42	100%	0%	42		Pavement cleaning (6 times per year)	Victoria Roads - Integrated Water Management Guidelines June 2013
Footpaths 2m wide (m) cleaning	Infrastructure	7.00	L/m2	42	100%	0%	42		Pavement cleaning (6 times per year)	Victoria Roads - Integrated Water Management Guidelines June 2013
Drainage cleaning	Infrastructure	1.60	L/m	10	100%	0%	10		Drainage cleaning (12 times per year)	Victoria Roads - Integrated Water Management Guidelines June 2013
Total (annual)				**72,897**		**0%**	**72,897**	-		
Total (50 years)				**3,644,848**			**3,644,848**	-		

40,657

Demolition /refurbishment

Description	Component	Rate	Rate unit	Total consumption (kL)	Potable water (%)	Non-potable water (%)	Potable water (kL)	Non-potable water (kL)	Assumptions	Reference
Office spaces	Offices	105.00	L/m2	53	100%	0%	53	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Residential spaces	Dwellings	105.00	L/m2	3,502	100%	0%	3,502	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Commercial spaces (retail)	Commercial / retail spaces	105.00	L/m2	336	100%	0%	336	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Indoor public amenities	Indoor / outdoor public amenities	105.00	L/m2	137	100%	0%	137	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Green areas	Indoor / outdoor public amenities	105.00	L/m2	2,420	100%	0%	2,420	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Streets 6m wide	Infrastructure	105.00	L/m2	-	100%	0%	-	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Cycleways 2m wide (m)	Infrastructure	105.00	L/m2	105	100%	0%	105	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Footpaths 2m wide (m)	Infrastructure	105.00	L/m2	105	100%	0%	105	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Total				**6,657**			**6,657**	-		

Appendix B. Water Model

Construction

Description	Project component	Rate	Rate unit	Total consumption (kL)	Potable water (%)	Non-potable water (%)	Potable water (kL)	Non-potable water (kL)	Assumptions	Reference
Office spaces	Offices	0.26	L/m2/week	10	100%	0%	10	-	18 months construction (78 weeks)	WRAP (2011) / Victoria Roads - Integrated Water Management Guidelines June 2013
Residential spaces	Dwellings	0.26	L/m2/week	756	100%	0%	756	-	18 months construction (78 weeks)	WRAP (2011) / Victoria Roads - Integrated Water Management Guidelines June 2013
Commercial spaces (retail)	Commercial / retail spaces	0.26	L/m2/week	58	100%	0%	58	-	18 months construction (78 weeks)	WRAP (2011) / Victoria Roads - Integrated Water Management Guidelines June 2013
Indoor public amenities	Indoor / outdoor public amenities	0.26	L/m2/week	26	100%	0%	26	-	18 months construction (78 weeks)	WRAP (2011) / Victoria Roads - Integrated Water Management Guidelines June 2013
Green areas	Indoor / outdoor public amenities	0.74	kL-year/m2	7,287	100%	0%	7,287	-	(1 year consumption for establishment watering) 20% undercover, evapotranspiration from BoM, and other Green Start standard practice assumptions: application efficiency (75%), monthly rainfall, crop coefficient (0.6) + earthworks (100L/m2)	Green Star, Potable Water Calculator 14102015 / Australian Bureau of Meteorology (BoM)
Streets 6m wide	Infrastructure	216.00	L/m2	648	100%	0%	648		Pavement layer compaction and sub-grade compaction	Victoria Roads - Integrated Water Management Guidelines June 2013
Cycleways 2m wide (m)	Infrastructure	216.00	L/m2	216	100%	0%	216		Pavement layer compaction and sub-grade compaction	Victoria Roads - Integrated Water Management Guidelines June 2013
Footpaths 2m wide (m)	Infrastructure	216.00	L/m2	216	100%	0%	216		Pavement layer compaction and sub-grade compaction	Victoria Roads - Integrated Water Management Guidelines June 2013
Drainage	Infrastructure	1.60	L/m	1	100%	0%	1		Drainage cleaning	Victoria Roads - Integrated Water Management Guidelines June 2013
Sewage	Infrastructure	2.60	L/m	1	100%	0%	1		Sewage cleaning (Drainage cleaning)	Victoria Roads - Integrated Water Management Guidelines June 2013
Total				**9,220**			**9,220**	**-**		

Operation and Maintenance

Description	Project component	Rate	Rate unit	Annual consumption (kL)	Potable water (%)	Non-potable water (%)	Potable water (kL)	Non-potable water (kL)	Assumptions	Reference
Office spaces	Offices	1.02	kL-year/m2	511	100%	0%	511	-	3 Stars Nabers Water rating for 50h/week of occupancy	NABERS Water for Offices Reverse Calculator v1.0
Residential spaces	Dwellings	58.62	kl-year/person	59,851	100%	0%	59,851	-	Average according to Sydney Water (all seasons)	https://www.sydneywater.com.au/SW/your-home/using-water-wisely/water-efficiency-targets/index.htm (retrieved on 11/09/2020)
Commercial spaces (retail)	Commercial / retail spaces	0.71	kL-year/m2	2,057	100%	0%	2,057	-	3 Stars Nabers Water rating for 61h/week of service. Single storey, 360 trading days, no parking, no other amenities, 1000m2	NABERS Energy and Water for shopping centres Reverse Calculator v6.0
Indoor public amenities	Indoor / outdoor public amenities	0.71	kL-year/m2	922	100%	0%	922	-	Considered a commercial spaces - 3 Stars Nabers Water rating for 61h/week of service. Single storey, 360 trading days, no parking, no other amenities, 1000m2	NABERS Energy and Water for shopping centres Reverse Calculator v6.0
Green areas	Indoor / outdoor public amenities	0.64	kL-year/m2	27,895	100%	0%	27,895	-	20% undercover, evapotranspiration from BoM, and other Green Start standard practice assumptions: application efficiency (75%), monthly rainfall, crop coefficient (0.6)	Green Star, Potable Water Calculator 14102015 / Australian Bureau of Meteorology (BoM)
Streets 6m wide cleaning	Infrastructure	7.00	L/m2	126	100%	0%	126		Pavement cleaning (6 times per year)	Victoria Roads - Integrated Water Management Guidelines June 2013
Cycleways 2m wide (m) cleaning	Infrastructure	7.00	L/m2	42	100%	0%	42		Pavement cleaning (6 times per year)	Victoria Roads - Integrated Water Management Guidelines June 2013
Footpaths 2m wide (m) cleaning	Infrastructure	7.00	L/m2	42	100%	0%	42		Pavement cleaning (6 times per year)	Victoria Roads - Integrated Water Management Guidelines June 2013
Drainage cleaning	Infrastructure	1.60	L/m	10	100%	0%	10		Drainage cleaning (12 times per year)	Victoria Roads - Integrated Water Management Guidelines June 2013
Total (annual)				**91,455**		**0%**	**91,455**	**-**		
Total (50 years)				**4,572,751**			**4,572,751**	**-**		

45,994

Demolition /refurbishment

Description	Component	Rate	Rate unit	Total consumption (kL)	Potable water (%)	Non-potable water (%)	Potable water (kL)	Non-potable water (kL)	Assumptions	Reference
Office spaces	Offices	105.00	L/m2	53	100%	0%	53	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Residential spaces	Dwellings	105.00	L/m2	3,961	100%	0%	3,961	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Commercial spaces (retail)	Commercial / retail spaces	105.00	L/m2	305	100%	0%	305	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Indoor public amenities	Indoor / outdoor public amenities	105.00	L/m2	137	100%	0%	137	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Green areas	Indoor / outdoor public amenities	105.00	L/m2	4,131	100%	0%	4,131	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Streets 6m wide	Infrastructure	105.00	L/m2	315	100%	0%	315	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Cycleways 2m wide (m)	Infrastructure	105.00	L/m2	105	100%	0%	105	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Footpaths 2m wide (m)	Infrastructure	105.00	L/m2	105	100%	0%	105	-	Cleaning and dust suppression	Victoria Roads - Integrated Water Management Guidelines June 2013
Total				**9,111**			**9,111**	**-**		

Appendix C. Waste Model

Municipal Solid Waste

Description	Project component	Residents	Generation Rate (ton/resident)	Annual generation (tonnes)	Diversion rate	Waste disposed to landfill (tonnes)	Emission factors (ton CO2-eq/ton waste)	GHG Emissions (ton CO2-eq)	Assumptions	Reference
Residential spaces	Dwellings	900.00	0.56	504	44%	282	1.4	395.1	Generation rate from the National Waste Report and diversion rate from Resource Recovery Survey Data	Department of the Environment and Energy. National Waste Report 2018/ NSW EPA. 2018-19 Local Government Waste and Resource Recovery Data Report/ Department of the Environment and Energy. National Greenhouse Accounts Factors 2019
Total (annual)				**504**		**282**		**395**		
Total (50 years)				**25,200**		**14,112**		**19,757**		

Commercial and Industry

Description	Project component	EFTE	Generation Rate (ton/EFTE)	Annual generation (tonnes)	Diversion rate	Waste disposed to landfill (tonnes)	Emission factors (ton CO2-eq/ton waste)	GHG Emissions (ton CO2-eq)	Assumptions	Reference
Office spaces	Offices	35	0.3	11	62%	4	1.2	4.8	Retail Trade (Other Store- Based Retailing)/ Diversion rate as per target (NSW Waste Avoidance and Resource Recovery Strategy 2014-21)	Department of the Environment and Energy. National Waste Report 2018 / Department of the Environment and Energy. National Greenhouse Accounts Factors 2019
Commercial spaces (retail)	Commercial / retail spaces	220	3.1	682	62%	259	1.2	311.0	Professional, Scientific and Technical Services/ Diversion rate as per target (NSW Waste Avoidance and Resource Recovery Strategy 2014-21)	Department of the Environment and Energy. National Waste Report 2018 / Department of the Environment and Energy. National Greenhouse Accounts Factors 2019
Indoor public amenities	Indoor / outdoor public amenities	12	0.3	4	62%	1	1.2	1.6	Public Administration and Safety (Other Store- Based Retailing/ Diversion rate as per target (NSW Waste Avoidance and Resource Recovery Strategy 2014-21)	Department of the Environment and Energy. National Waste Report 2018 / Department of the Environment and Energy. National Greenhouse Accounts Factors 2019
Total (annual)				**696**		**265**		**317**		
Total (50 years)				**34,805**		**13,226**		**15,871**		

Municipal Solid Waste

Description	Project component	Residents	Generation Rate (ton/resident)	Annual generation (tonnes)	Diversion rate	Waste disposed to landfill (tonnes)	Emission factors (ton CO2-eq/ton waste)	GHG Emissions (ton CO2-eq)	Assumptions	Reference
Residential spaces	Dwellings	1,021.00	0.56	572	44%	320	1.4	448.3	Generation rate from the National Waste Report and diversion rate from Resource Recovery Survey Data	Department of the Environment and Energy. National Waste Report 2018/ NSW EPA. 2018-19 Local Government Waste and Resource Recovery Data Report/ Department of the Environment and Energy. National Greenhouse Accounts Factors 2019
Total (annual)				**572**		**320**		**448**		
Total (50 years)				**28,588**		**16,009**		**22,413**		

Commercial and Industry

Description	Project component	EFTE	Generation Rate (ton/EFTE)	Annual generation (tonnes)	Diversion rate	Waste disposed to landfill (tonnes)	Emission factors (ton CO2-eq/ton waste)	GHG Emissions (ton CO2-eq)	Assumptions	Reference
Office spaces	Offices	35	0.3	11	62%	4	1.2	4.8	Retail Trade (Other Store- Based Retailing)/ Diversion rate as per target (NSW Waste Avoidance and Resource Recovery Strategy 2014–21)	Department of the Environment and Energy. National Waste Report 2018 / Department of the Environment and Energy. National Greenhouse Accounts Factors 2019
Commercial spaces (retail)	Commercial / retail spaces	220	3.1	682	62%	259	1.2	311.0	Professional, Scientific and Technical Services/ Diversion rate as per target (NSW Waste Avoidance and Resource Recovery Strategy 2014–21)	Department of the Environment and Energy. National Waste Report 2018 / Department of the Environment and Energy. National Greenhouse Accounts Factors 2019
Indoor public amenities	Indoor / outdoor public amenities	12	0.3	4	62%	1	1.2	1.6	Public Administration and Safety (Other Store- Based Retailing/ Diversion rate as per target (NSW Waste Avoidance and Resource Recovery Strategy 2014–21)	Department of the Environment and Energy. National Waste Report 2018 / Department of the Environment and Energy. National Greenhouse Accounts Factors 2019
Total (annual)				**696**		**265**		**317**		
Total (50 years)				**34,805**		**13,226**		**15,871**		

Appendix D. Materials Model

LCIA Assumptions

Material	Material use per GFA (m2)		Life Cycle Impacts per unit of material		LCIA Material Selection	Other assumptions	Reference
	Factor	Unit / m2	Global warming potential (kg CO2-eq/unit)	Density (kg/m3)			
Aluminium Façade	0.76	kg	41.63	2,710.00	Aluminium, primary, at plant/RER U/AusSD U	EDGE's data	
Aluminium Other	8.10	kg	40.50	2,710.00	Aluminium, primary, at plant/RER U/AusSD U	EDGE's data	
Concrete Other	0.10	m3	405.00	2,406.00		Non supplementary cementitious materials	Holcim Virodecs EPD https://epd-australasia.com/wp-content/uploads/2019/07/Holcim-ViroDecs-EPD.pdf
Concrete Structural	0.73	m3	405.00	2,406.00		Non supplementary cementitious materials	Holcim Virodecs EPD https://epd-australasia.com/wp-content/uploads/2019/07/Holcim-ViroDecs-EPD.pdf
Steel Other	22.84	kg	6.57	7,850	Steel, converter, low-alloyed, at plant/RER U/AusSD U	EDGE's data	
Steel Reinforcement	79.30	kg	4.23	7,850	Reinforcing steel, at plant/RER U/AusSD U	EDGE's data	
Steel Structural	7.21	kg	6.20	7,850	Rolled steel, structural, at regional store /AU U	EDGE's data	
Asphalt	na	na	na	na	na	Estimated in a case by case basis for infrastructure components	ISCA Materials Tool v 1.2 /TAAG Workbook 2013
Aggregate	na	na	na	na	na	Estimated in a case by case basis for infrastructure components	ISCA Materials Tool v 1.2 /TAAG Workbook 2013

Materials impacts

Description	Project component	Material	Quantity	Unit	Global warming potential (kg CO2-eq)	Tonnage	Assumptions
Office spaces	Offices	Concrete Structural	365.09	m3	147,862	878	
Office spaces	Offices	Aluminium Other	4,048.03	kg	163,958	4	
Office spaces	Offices	Concrete Other	49.01	m3	19,847	118	
Office spaces	Offices	Steel Reinforcement	39,652.04	kg	167,653	40	
Office spaces	Offices	Steel Other	11,418.19	kg	75,059	11	
Office spaces	Offices	Aluminium Façade	378.23	kg	15,747	0	
Residential spaces	Dwellings	Concrete Structural	24,351.57	m3	9,862,387	58,590	
Residential spaces	Dwellings	Aluminium Other	270,003.63	kg	10,935,974	270	
Residential spaces	Dwellings	Concrete Other	3,268.63	m3	1,323,797	7,864	
Residential spaces	Dwellings	Steel Reinforcement	2,644,791.36	kg	11,182,450	2,645	
Residential spaces	Dwellings	Steel Other	761,593.22	kg	5,006,405	762	
Residential spaces	Dwellings	Aluminium Façade	25,228.07	kg	1,050,357	25	
Commercial spaces (retail)	Commercial / retail spaces	Concrete Structural	2,336.58	m3	946,316	5,622	
Commercial spaces (retail)	Commercial / retail spaces	Aluminium Other	25,907.39	kg	1,049,329	26	
Commercial spaces (retail)	Commercial / retail spaces	Concrete Other	313.63	m3	127,021	755	
Commercial spaces (retail)	Commercial / retail spaces	Steel Reinforcement	253,773.08	kg	1,072,979	254	
Commercial spaces (retail)	Commercial / retail spaces	Steel Other	73,076.41	kg	480,375	73	
Commercial spaces (retail)	Commercial / retail spaces	Aluminium Façade	2,420.68	kg	100,784	2	
Indoor public amenities	Indoor / outdoor public amenities	Concrete Structural	949.24	m3	384,441	2,284	
Indoor public amenities	Indoor / outdoor public amenities	Aluminium Other	10,524.88	kg	426,290	11	
Indoor public amenities	Indoor / outdoor public amenities	Concrete Other	127.41	m3	51,602	307	
Indoor public amenities	Indoor / outdoor public amenities	Steel Reinforcement	103,095.32	kg	435,898	103	
Indoor public amenities	Indoor / outdoor public amenities	Steel Other	29,687.29	kg	195,152	30	
Indoor public amenities	Indoor / outdoor public amenities	Aluminium Façade	983.40	kg	40,943	1	
Streets 6m wide	Infrastructure	Asphalt (Infrastructure)	840.00	m3	128,700	2,016	Quantities from TAAG: full depth pavement
Streets 6m wide	Infrastructure	Cement	16.74	tonnes	16,600	17	Quantities from TAAG: full depth pavement
Streets 6m wide	Infrastructure	Aggregate (infrastructure)	3,780.00	tonnes	62,600	3,780	Quantities from TAAG: full depth pavement
Cycleways 2m wide (m)	Infrastructure	Asphalt (Infrastructure)	412.00	m3	57,100	989	Quantities from TAAG: asphalt cycleway
Cycleways 2m wide (m)	Infrastructure	Aggregate (infrastructure)	2,195.00	tonnes	36,200	2,195	Quantities from TAAG: asphalt cycleway
Footpaths 2m wide (m)	Infrastructure	Asphalt	412.00	m3	57,100	989	Quantities from TAAG: asphalt cycleway
Footpaths 2m wide (m)	Infrastructure	Aggregate (infrastructure)	2,195.00	tonnes	36,200	2,195	Quantities from TAAG: asphalt cycleway

LCIA Assumptions

Material	Material use per GFA (m2)		Life Cycle Impacts per unit of material		LCIA Material Selection	Other assumptions	Reference
	Factor	Unit / m2	Global warming potential (kg CO2-eq/unit)	Density (kg/m3)			
Aluminium Façade	0.76	kg	41.63	2,710.00	Aluminium, primary, at plant/RER U/AusSD U	EDGE's data	
Aluminium Other	8.10	kg	40.50	2,710.00	Aluminium, primary, at plant/RER U/AusSD U	EDGE's data	
Concrete Other	0.10	m3	405.00	2,406.00		Non supplementary cementitious materials	Holcim Virodecs EPD https://epd-australasia.com/wp-content/uplo
Concrete Structural	0.73	m3	405.00	2,406.00		Non supplementary cementitious materials	Holcim Virodecs EPD https://epd-australasia.com/wp-content/uplo
Steel Other	22.84	kg	6.57	7,850	Steel, converter, low-alloyed, at plant/RER U/AusSD U	EDGE's data	
Steel Reinforcement	79.30	kg	4.23	7,850	Reinforcing steel, at plant/RER U/AusSD U	EDGE's data	
Steel Structural	7.21	kg	6.20	7,850	Rolled steel, structural, at regional store /AU U	EDGE's data	
Asphalt	na	na	na	na	na	Estimated in a case by case basis for infrastructure components	ISCA Materials Tool v 1.2 /TAAG Workbook 2013
Aggregate	na	na	na	na	na	Estimated in a case by case basis for infrastructure components	ISCA Materials Tool v 1.2 /TAAG Workbook 2013

Materials impacts

Description	Project component	Material	Quantity	Unit	Global warming potential (kg CO2-eq)	Tonnage	Assumptions
Office spaces	Offices	Concrete Structural	365.09	m3	147,862	878	
Office spaces	Offices	Aluminium Other	4,048.03	kg	163,958	4	
Office spaces	Offices	Concrete Other	49.01	m3	19,847	118	
Office spaces	Offices	Steel Reinforcement	39,652.04	kg	167,653	40	
Office spaces	Offices	Steel Other	11,418.19	kg	75,059	11	
Office spaces	Offices	Aluminium Façade	378.23	kg	15,747	0	
Residential spaces	Dwellings	Concrete Structural	27,548.31	m3	11,157,065	66,281	
Residential spaces	Dwellings	Aluminium Other	305,448.18	kg	12,371,587	305	
Residential spaces	Dwellings	Concrete Other	3,697.72	m3	1,497,578	8,897	
Residential spaces	Dwellings	Steel Reinforcement	2,991,984.66	kg	12,650,419	2,992	
Residential spaces	Dwellings	Steel Other	861,570.88	kg	5,663,618	862	
Residential spaces	Dwellings	Aluminium Façade	28,539.87	kg	1,188,242	29	
Commercial spaces (retail)	Commercial / retail spaces	Concrete Structural	2,118.26	m3	857,895	5,097	
Commercial spaces (retail)	Commercial / retail spaces	Aluminium Other	23,486.67	kg	951,282	23	
Commercial spaces (retail)	Commercial / retail spaces	Concrete Other	284.33	m3	115,152	684	
Commercial spaces (retail)	Commercial / retail spaces	Steel Reinforcement	230,061.16	kg	972,722	230	
Commercial spaces (retail)	Commercial / retail spaces	Steel Other	66,248.33	kg	435,490	66	
Commercial spaces (retail)	Commercial / retail spaces	Aluminium Façade	2,194.50	kg	91,367	2	
Indoor public amenities	Indoor / outdoor public amenities	Concrete Structural	949.24	m3	384,441	2,284	
Indoor public amenities	Indoor / outdoor public amenities	Aluminium Other	10,524.88	kg	426,290	11	
Indoor public amenities	Indoor / outdoor public amenities	Concrete Other	127.41	m3	51,602	307	
Indoor public amenities	Indoor / outdoor public amenities	Steel Reinforcement	103,095.32	kg	435,898	103	
Indoor public amenities	Indoor / outdoor public amenities	Steel Other	29,687.29	kg	195,152	30	
Indoor public amenities	Indoor / outdoor public amenities	Aluminium Façade	983.40	kg	40,943	1	
Streets 6m wide	Infrastructure	Asphalt (Infrastructure)	840.00	m3	128,700	2,016	Quantities from TAAG: full depth pavement
Streets 6m wide	Infrastructure	Cement	16.74	tonnes	16,600	17	Quantities from TAAG: full depth pavement
Streets 6m wide	Infrastructure	Aggregate (infrastructure)	3,780.00	tonnes	62,600	3,780	Quantities from TAAG: full depth pavement
Cycleways 2m wide (m)	Infrastructure	Asphalt (Infrastructure)	412.00	m3	57,100	989	Quantities from TAAG: asphalt cycleway
Cycleways 2m wide (m)	Infrastructure	Aggregate (infrastructure)	2,195.00	tonnes	36,200	2,195	Quantities from TAAG: asphalt cycleway
Footpaths 2m wide (m)	Infrastructure	Asphalt	412.00	m3	57,100	989	Quantities from TAAG: asphalt cycleway
Footpaths 2m wide (m)	Infrastructure	Aggregate (infrastructure)	2,195.00	tonnes	36,200	2,195	Quantities from TAAG: asphalt cycleway

Appendix E. Initiatives Model

Initiatives summary

Code	Initiatives	Total reduction (ton CO2-	Total potable water reduction (kL)	Total waste to landfill (ton)
E1	Greening	4,366	- 740,900	-
E2	Solar panels	45,279	-	-
E3	Cool surfaces	5,481	-	-
E4	Natural and low energy lighting	1,183	-	-
E5	Active and public transport incentives	23,087	-	-
W1	WSUD - Stormwater management	-	912,500	-
W2	Water efficient fixtures and appliances	-	950,744	-
M1	Mass timber buildings	354	-	-
M2	Low carbon concrete	5,717	-	-
M3	Circular economy	15,017	-	12,514

Sub initiatives detail

Initiative	Sub-Initiatives	Description	Energy: Rate	Energy: Unit	Energy: Annual saving (kW)	Energy: Annual reduction (ton CO2-eq)	Energy: Total reduction (ton CO2-eq)
E1	E101	Green roofs and rooftop gardens (public and private acc	31%	% energy reduction (kW)	59,574	55	2,740
E1	E102	Green walls (vertical gardens)	12%	% energy reduction (kW)	46,122	42	2,122
E1	E103	Increase canopy cover	11.43%	Increment of canopy cover	na	- 10	- 496
E3	E301, E302	Cool surfaces	15%	% energy reduction (kW)	119,148.50	110	5,481
E4	E402	Natural and low energy lightening	30%	% energy reduction due to lighting control and natural light (kW)	25719.375	24	1,183
E5	E501, E502, E503	Active and public transport incentives	20%	% car trips reduction (MJ)		462	23,087
W2	W202	Dry appliances (composting toilets)					-
E4	E401	Self emitting pavements for cycleways and footpaths	50%	% energy reduction (kw)	-	-	-
W2	W201	Water saving fixtures and appliances					-
M3	M301, M302	Circular Economy	1.2	ton CO2-eq / ton waste to lanfill		300	15,017
E2	E201, E202	Solar power	na	na	984,332	906	45,279
W1	W101, W102, W10	WSUD - Stormwater management (all)					-
M1	M101	Mass timber buildings * total savings	9%	na	na	354	354
M2	M201	Low carbon concrete	46%	Reduction of CO2 emissions from nonstructural		5,717	5,717
Total						7,959	100,484

Initiative	Sub-Initiatives	Water: Rate	Water: Unit	Water: Annual saving (kL)	Water: Total reduction (kL)	Waste: Rate	Waste: unit	Waste: diverted from landfill (ton)	Waste: Total diverted from landfill (ton)
E1	E101	0.7409	kL-year/m2	-7409	- 370,450				
E1	E102	0.7409	kL-year/m2	-7409	- 370,450				
E1	E103				-				
E3	E301, E302				-				
E4	E402				-				
E5	E501, E502, E503				-				
W2	W202	3.5	L/average flush	383.25	19,163				
E4	E401				-				
W2	W201	33	% demand reduction	18,632	931,582				
M3	M301, M302				-	70%	diversion from landfill target (%)	250.28	12,514
E2	E201, E202				-				
W1	W101, W102, W10	50	kL/day	18,250	912,500				
M1	M101				-				
M2	M201				-				
Total					1,122,344				12,514

Initiative	Sub-Initiatives	Assumptions	Reference
E1	E101	31% of electricity reduction for room under green roof (average), 5000m2 of green roof (50% of rooftops), BAU annual electricity use - 37.44 kW/m2	State of Victoria (2014), Growing Green Guide: A guide to green roofs, walls and facades in Melbourne and Victoria, Australia, ISBN 978-1-74326-715-8
E1	E102	12% of electricity reduction for room behind wall (minimum for green roofs), 10000m2 of green walls, BAU annual electricity use - 37.44 kW/m2	State of Victoria (2014), Growing Green Guide: A guide to green roofs, walls and facades in Melbourne and Victoria, Australia, ISBN 978-1-74326-715-8
E1	E103	All current trees survive and reach full spread by 2050, no other trees are planted, and no trees are lost.	Internal iTree modelling
E3	E301, E302	Applied to 10000 m2 of rooftops as per scheme buildings	US Department of Energy. Factsheet: Cool roofs are ready to save energy, cool urban heat islands, and helps slow global warming
E4	E402	Lighting accounting for 10% of energy use in households and 29% in commercial premises (average)	https://www.wbdg.org/resources/daylighting https://www.energyrating.gov.au/products/lighting
E5	E501, E502, E503	Reduction of car trips to Parramatta-like rates 1.65 car trips (driver)/resident-day - 20.48%	TfNSW, Household Travel Survey - Data by LGA 2018/2019 (Parramatta)
W2	W202	6 public toilets, 50 uses per day per toilet	http://www.westernwater.com.au/files/assets/public/documents/fact-sheets-and-brochures/saving-water/business-amenities-fact-
E4	E401	Replacing 50% of current cycling and cycleways	
W2	W201	All 5 stars (2020) water rating appliances (BAU - 3 star 2020). This change represents 33% of water reduction according to internal estimations (see other	Sydney Water
M3	M301, M302	Diversion rate as per target (NSW Waste Avoidance and Resource Recovery Strategy 2014–21)	Department of the Environment and Energy. National Waste Report 2018 / Department of the Environment and Energy. National Greenhouse Accounts Factors 2019
E2	E201, E202	16% efficiency at 4,476m2 (50% of rooftops) - 716.16kW installed power in Sydney (Mascot weather station)	National Renewable Energy Laboratory. PVWatts Calculator. https://pvwatts.nrel.gov/pvwatts.php
W1	W101, W102, W10	5kL demand for each of the 10 tanks	From Landcom
M1	M101	Applies for public building only, Lifecycle CLT Building, using the same MEP systems as the reference and including carbon sequestration (9% reduction)	B. Durlinger et all. 2013. Life Cycle Assessment of a cross laminated timber building. ISBN: 978-1-921763-63-2
M2	M201	219 kg CO2/ m3	Holcim Virodecs EPD https://epd-australasia.com/wp-content/uploads/2019/07/Holcim-ViroDecs-EPD.pdf
Total			

Appendix F. Initiatives details and examples

Each initiative is allocated a primary sustainability indicator code: energy and GHG emissions (E), water (W), or waste and materials (M). For each initiative, sub-initiatives are presented to represent the potential range of approach options. It is recognised that many sub-initiatives will impact, to varying degrees, more than one indicator. Symbols are used to indicate the potential range of sustainability indicators that each initiative may impact, as follows:

Energy & GHG emissions

Water

Waste & materials

It is noted that the idicators will likely have benefits that extend beyond the three main indictors considered here. Additional likely benefits include, for example: improved biodiversity and ecosystem functioning, improved human physical and mental health and well-being, increased local economic prosperity, increased local property values, decreased crime rates, and increased infrastructure lifespans.

Each initiative may have a variety of ways to interpret and implement them within the project phases, ranging from business-as-usual approaches to novel, innovative, and at times experimental approaches. Implementation examples from within Australia or internationally are also provided, showing where possible, examples of business-as-usual through tho innovative and experimental options.

E1. Greening

E101. Green roofs & rooftop gardens

- Also called 'living roofs', these can be public, private, or restricted access.
- Green roofs refer to permanent rooftop planting systems that cover a significant portion of a roof space and may be extensive (shallow soiled, 20-150mm) or intensive (deep soiled, >150mm)
- Rooftop gardens refer to roofs with less planted areas than green roofs and plantings usually in containers.
- Green roofs especially can contribute positively to: reducing and cleaning stormwater runoff, energy savings in buildings, thermal insulation in building, solar panel functioning when used in combination, cleaning the air of pollutants, cooling the air and reducing urban heat island effects, and biodiversity.
- Cooling effects of green roofs occur through the day and night, so help to reduce urban heat island effects during the day and night (compared to cool seal roofs, see E301).
- If accessible by people, can also contribute positively to physical and mental health and wellbeing through nature exposure

Examples.

Melbourne Sky Park

Edible rooftop garden on the STEM Kitchen + Garden building in San Francisco produces 9-14kg produce each week

Solar combined with green roof on top of the US Federal Building in San Francisco

E102. Green walls & vertical gardens

- Also called ‘living walls’, ‘eco walls, or ‘live walls’, they are now regularly installed, particularly at the small scale, though larger scale examples, and innovative design, are increasing as developments aim to become more sustainable.
- Numerous examples of use in residential and commercial settings, at small and large scales, indoors and outdoors, and taking many forms, including building facades, walls, balcony gardens, internal wall features, and other vertical infrastructure.
- Benefits include: cleaning and cooling the air, stormwater management, biodiversity, reducing carbon emissions, energy savings in buildings, aesthetics, and public health and wellbeing.

Examples.

Green wall at Adelaide Zoo entrance, SA.

Vertical gardens on transport flyover supports in Mexico City

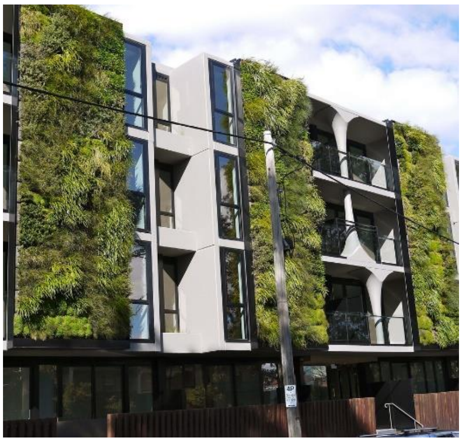
Bosco vertical, in Milan, Italy supports mature trees and plantings on residential balconies

Green wall in an SEB office meeting room in Singapore

Park Royal on Pickering in Singapore, features solar-powered “sky gardens” and was awarded the highest rating for green buildings in Singapore

Curved vertical garden installed along a residential staircase in London, UK

National Grid HQ in Warwick, England installed native and wildlife-friendly living walls on their new multistorey car park



Illura Apartments in West Melbourne, VIC has 4 green walls

E103. Increased canopy cover

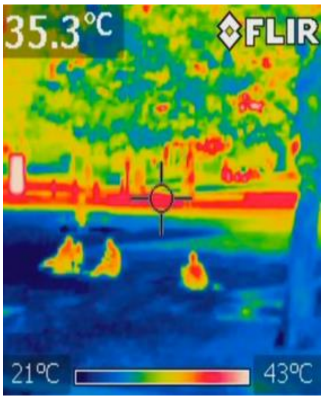
- A now globally accepted critical mechanism for creating liveable cities.
- Can contribute significantly to cooling urban areas
- Can contribute positively to environmental and social health and wellbeing, climate change mitigation and adaptation, local economy prosperity, and infrastructure lifespans (see Appendix H for further examples of the myriad benefits provided by trees).
- With careful species selection can also positively influence water sensitive urban design (WSUD) and biodiversity sensitive urban design (BSUD) outcomes.

Examples.

Example of urban tree plantings before and after (Portland, Oregon)

5 MILLION TREES
for Greater Sydney

NSW government commits to planting 5M trees across Greater Sydney by 2030



Thermal imagery showing cooling effect of trees

E101, E102, E103. Wider environmental benefits

Of all the potential greening initiatives, increasing tree canopy cover has been shown to provide the greatest range of benefits. Whilst the benefits provided by trees increases over time as the tree matures, the specific amount of benefits provided varies by tree species, age, and condition.

For the purposes of this project, benefits of increased canopy cover have been based on very high-level estimates averaged across tree species, ages, and conditions. The following though provides an example of how ecosystem service benefits can vary depending on tree species and tree age. In this case, we have modelled a newly planted and a mature Sydney blue gum (*Eucalyptus saligna*), the cumulative benefits over the growth of the newly planted gum over a 50-year period, and a mature tuckeroo (*Cupaniopsis anacardioides*). This modelling assumes healthy and natural growth of the trees.

	1. Sydney blue gum (immature)*	***2. Sydney blue gum growth over 50 yrs****	**3. Sydney blue gum (mature)*****	**4. Tuckeroo (mature)******
				
Carbon stored	0.6 kg	*7.9 tonnes*	9.03 tonnes	0.23 tonnes
Carbon sequestered	0.5 kg/yr	*478.3 kg*	0.02 t/yr	0.01 t/yr
Potential evapotranspiration	0.1 m^3/yr	*330.7 m^3 (total over 50 years)*	1,389.2 m^3/yr	21 m^3/yr
Oxygen produced	1.3 kg/yr	*1.3 tonnes (total over 50 years)*	40 kg/yr	35.9 kg/yr
Air pollution removed^	0.001 kg/yr	*3.65 kg*	0.01 t/yr	0.22 kg/yr
Total benefits value	$0.02/yr	*$28*	$68.45/yr	$1.38/yr
Structural/replacement value	$73.41	*n/a*	$72,489.84	$2,835.26

* *Assumed to be 2m tall and have a 2.5cm diameter at breast height (DBH)*
** *Provides modelled total benefits over 50 years' worth of growth from immature*
*** *Assumed to be 40m tall and have a 2.5m DBH*
**** *Assumed to be 7m tall and have a 30cm DBH*
^ *Includes: CO, O3, SO2, N2, PM2.5*

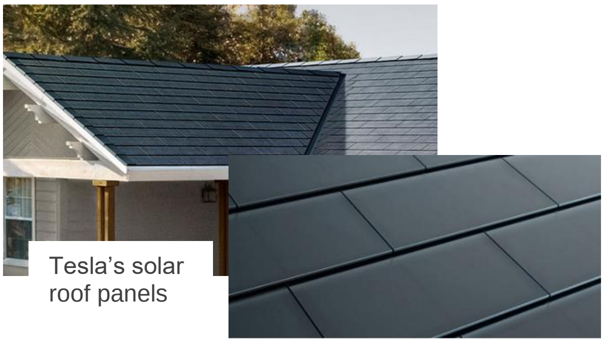
E2. Renewable Energy

E201. Solar panels on buildings

- Refers to traditional roof-top solar panels (now a common addition to residential and commercial buildings to help save energy costs) as well as more innovative photovoltaic technology (e.g. coloured solar panels) that can replace conventional building materials for active building materials.
- Can provide operational cost reductions
- It can contribute to meet the Basix target for GHG emissions reduction (35%-45% for Cherrybrook)
- In some cities, installing traditional roof-top solar panels is now a requirement for new builds.
- Performance of traditional roof top solar panels can be improved by combining with green roofs which cool the local environment around the solar panels (refer to example image for E101)
- Innovative evolutions in solar panel design mean that solar panels can now be installed in an artistic manner, and that may not look like traditional solar panels, which may be an architectural/aesthetic preference, particularly for some commercial buildings.

Examples.

Examples of different building integrated photovoltaic panels on display in 2018 at the Solar Energy Research Institute of Singapore (SERIS)



Tesla's solar roof panels

Swiss company, Solaxess, produces coloured and white-finish nanotechnology films to fit to traditional solar panels which alter their appearance without inhibiting function.

E202. Solar panels on public access spaces

- Refers to more modern applications of solar panels in public use spaces
- This application of solar panels in more novel than traditional roof top applications, and are often intentionally designed to be multi-purpose, such as being part of art instalments, or aesthetic functional applications (e.g. lighting bike/cycle paths, lighting public spaces).
- Combining solar panels in an innovative, interesting and functional ways in public spaces can help activate spaces, combine technology, design, art, nature, and culture, and build community awareness and support for sustainable design.
- Can provide operational costs reductions and can have educational and aesthetic benefits for the community.
- May also have benefits for water and waste and materials if designed as such (e.g. Singapore's Supertrees)

Examples.

'The Silicone Forest' at a light rail station in Portland, Oregon (USA). Solar panels power the lights in these art installments.

Ross Lovegrove's 'Solar Trees of Vienna', was designed for the MAK in Vienna and debuted in 2007 as a nature/art/design installation. It also acted as public lighting and meeting points .

'La Monarca', the world's first solar mural installation. Unveiled in San Antonio, Texas (USA) in 2017.

'Supertree Grove' at Gardens by the Bay, Singapore. These structures combine technology, nature, and functionallity. The trunks are covered with vertical gardens, incorporated solar panels store energy to light the Gardens at night, their canopies provide shade during the day, and they collect rainwater for use in irrigation in the Gardens.

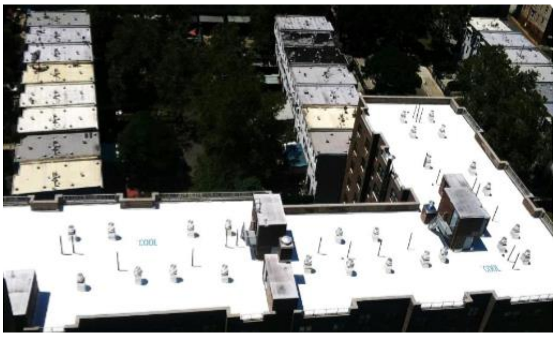
'Solaroad', the world's first solar panel bike path installed in 2014 in Amsterdam, The Netherlands.

E3. Cool surfaces

E301. Cool seal products on rooftops

- Lighter surfaces reflect more heat than darker ones which lowers external air and surface temperatures.
- Cool seal products are applied to existing dark rooftops to make them white (or paler) and so less heat enters buildings resulting in energy savings from cooling requirements.
- Compared to cooling provided by green roofs (see E101), cool sealed roofs provide greater cooling during the day, though the effects last less time than green roofs which continue to cool through the night.
- Easy to implement and has relatively low cost.

Examples.



Since 2009, New York City has painted more than 2 million square meters of rooftops white. Estimating urban cooling effects of up to 1.5°C, and internal building energy savings of up to 30%.

E302. Cool seal products on pavements

- Cool seal products are being increasingly applied to city's existing dark road surfaces to make them white (or paler) and so provide cooling by decreasing heat absorbed during the day, and decreasing heat released at night.
- Studies from the USA indicate that paler road surfaces may cool road surface temperatures by up to 8°C. Recent trials in Adelaide of different cool surface products (see image below right) indicate diurnal cooling effects of between 2.6°C and 8.65°C, and night cooling effects of between 1.5°C and 4.2°C.
- Easy to implement and relatively low cost.

Examples.

Los Angeles, USA, is painting its streets pale grey to help mitigate urban heat.

Adelaide, SA, cool roads trial found differences in cooling effects of different products

Western Sydney, NSW, cool roads trials

City of Charles Sturt, SA, cool roads program

E4. Natural and low energy lighting

E401. Self-emitting pavements for cycleways and footpaths

- An emerging and increasingly popular approach to public space lighting that is self-sufficient, environmentally friendly, and practical. The technology uses self-illuminating material, called luminophores or photo-luminescent pebbles, that charge in the sun and can glow for up to 10 hours after dark.
- Some available products use recycled materials in the construction of paths, and other products can be sprayed on to surfaces retrospectively.
- The implementation of this type of pavement could reduce the need for streetlights. This represents a potential reduction of energy use and GHG emissions.

Examples.

Glow-in-the-dark bike and pedestrian path in Prusków, Poland, opened in 2016.

Van Gogh-Roosegaarde cycle path in Eindhoven, The Netherlands opened in 2014. It's glow-in-the-dark design is inspired by van Gogh's Starry Night.

Glow-in-the-dark footpaths being trialled in Singapore, 2017.

Spray-on 'Starpath' glow-in-the-dark product being trialled in Cambridge, UK in 2013.

The 'Gosford Glow Path', Australia's first glow-in-the-dark footpath installed in 2014 on a walkway under the railway line at Wyoming, NSW. Similar paths have since been trialled in Brisbane and Canbera.

E402. Smart lighting

- Also referred to as 'intelligent' lighting uses systems that allow for light on demand (e.g. motion-sensor, light-sensor, voice command, timer).
- Lighting integrates energetically efficient LEDs and can be either fully activated from non-lit, or simply brightened from being previously low light when motion/activity is detected/controlled. This can be applied in the home setting (e.g. security lights, room activity sensors, smart home systems such as Google Home) or in public spaces such as pedestrian paths and even streetlights.
- Benefits include significant energy savings and decreased CO_2 emissions (up to 80% less electricity used), extended lifetime of LED lights so lower maintenance costs, environmentally friendly, decreased light pollution, and increased safety.
- Easily installed, monitored, and controlled.

Examples.

Smart Home devices (e.g. Google Home) allow home features such as lighting to be controlled from apps enabling greater and more efficient control of home energy systems.

Motion-controlled outdoor campus lighting at the Univeristy of London, England.

64 streetlights were installed along Pirie Street, in Adelaide, SA, as part of Australia's first intelligent streetlight system trial.

Jaipur, India's largest sensor-based smart lighting project.

E5. Active and public transport incentives

E501. Infrastructure & facilities for cyclists

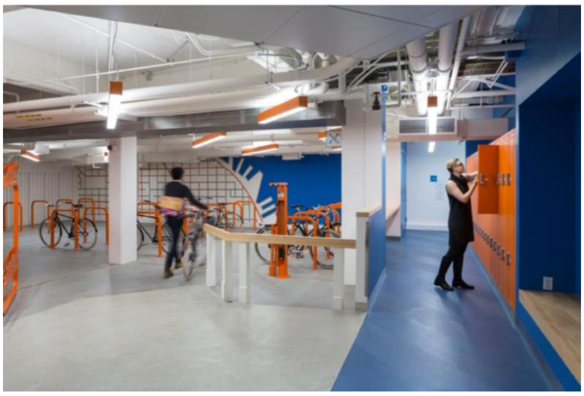
- Promoting increased cycling, over personal car use, provides cost savings, helps reduce GHG emissions, and supports health and well-being benefits for users of the precinct.
- Clear Australia standards are widely available regarding the design of safe cycle paths and infrastructure.
- Extends beyond providing safe cycle paths, to also include bike facilities that support cycling as a regular commuting option, such as secure bike storage sheds or lockers, bike maintenance stations, and end-of-trip facilities (i.e. storage, shower, changing facilities).
- Additional learnings to be had from globally leading bike-friendly cities in the EU (e.g. Copenhagen, Denmark, Amsterdam, The Netherlands, Strasbourg, France, and Malmo, Sweden)

Examples.

Protected or segregated bike lanes (example shown from Victoria) are preferred by cyclists and many drivers.

The ‘Hovenring’ in Eindhoven, The Netherlands, is an elevated roundabout for cyclists so they can safely cross the busy road intersection.

Free, covered ad secure bike storage sheds and lockers at NSW public transport hubs.



End of trip facilities at 100 California, San Francisco, USA, include bike maintenance stands, personal lockers, attractive murals and wayfinding, good lighting, and shower and toilets.

E502. Walkable distance to diverse services of public transport

- Creating walkable cities and precincts is an increasing priority world-wide.
- Creating areas and services that encourage walking, over personal car use, provides cost savings, helps reduce GHG emissions, and supports health and well-being benefits for users.
- Trees and other plants and green space have been shown, world-wide, to encourage walking
- Common characteristics of walkable cities/precincts include:
    - Design coherence: clear and easily navigated paths linking areas of interest/activity in close proximity
    - Safety: walkways segregated from traffic, ample time given at traffic crosswalks, and adequate lighting for night use
    - Comfort: consider both the paving materials used, design to allow for easy flow by pedestrians and cyclists, and the environmental comfort provided through tree shading
    - Accessibility: opportunity for all individuals to use the pedestrian environment
    - Attractiveness and interest: clean and well-maintained surroundings, increased green space and tree plantings, art installation and interesting architecture, mixed-use buildings easily accessible, and activities that provide pedestrian interest

Examples.

Times Square, New York, USA was converted into pedestrian plazas in 2010 following a trial year which showed an increase in pedestrian use and safety, when cars were removed and walkability of the precinct improved.

Amsterdam, The Netherlands is one of the world's most walkable cities, with limited car traffic in the centre, attractive tree and flower plantings, and a network of walkways and bikeways that connect multiple residential, cultural, green space, commercial, and transport hubs,

The High Line in New York is a disused elevated freight rail line that was re-activated in 2009 as a public park and walkway. It connects over 2.3km of Manhattan and includes public meeting places, a diversity of plantings, artistic installations, and cultural events.

E503. Mixed land use including diversity of amenities

- Providing a diversity of amenities and mixed land uses, particularly when integrated with walkability (see E502), can increase the value of local residential buildings and improves the liveability of the zone.
- Encouraging local pedestrian access to stores, restaurants and other businesses, transport hubs, schools and medical centres, green spaces and sport/recreation centres reduces the need to own cars and encourages social connections
- Creates benefits for reducing GHG emissions and improving physical and mental health and well-being in people.
- Land use planning should be based on “transit-oriented development”, a new approach to sustainable land use planning which specifically integrates transport systems with land use

Examples.

Figure taken from Liang *et al.* (2020) depicting a common traditional urban land use matrix (left), compared to the same land use matrix if planned based on transit-oriented development (right).

E504. Reduced parking, parking pooling, and car-share exclusive parking

- An increasing global trend is minimising vehicle traffic in cities and urban centres, particularly private vehicles.
- When coupled with improving cycling infrastructure, walkability and amenity diversity (see E501-E503), doing so frees land and spaces on building for other purposes, reduces traffic and associated negative impacts such as smoke, noise, and hazards for pedestrians, and improves the liveability of urban centres.
- Large scale examples of restricted vehicle access, or car-free zones can be seen in global cities such as: New York, London, Madrid, Oslo, Chengdu, Hamburg, Copenhagen, Paris, Athens, Brussels, Mexico City, and Vancouver.
- Other examples seen more commonly include car-pooling, parking pooling, and car-share exclusive car parks.

Examples.

A car-free day trialled in Paris in 2015 saw an increase in space for other activities, a cleaner environment, and a drop in noise levels by 3 decibels. The City now holds a car-free day on the first Sunday of each month.

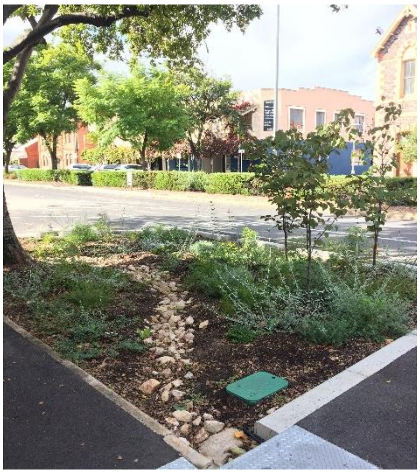
Since 2008, Sydney has installed over 800 dedicated on-street car-share parking, resulting in cost savings for residents, fewer cars on City streets, and reducing competition for parking and polluting emissions.

W1. WSUD – stormwater management

W101. Stormwater/rainwater diversion and capture, including rainwater gardens

- WSUD is now a widely accepted and implemented aspect of urban design. Capturing, storing, and using rainwater where it falls provides filtration and runoff slowing functions as well as a number of other benefits including improving water quality of natural systems, supporting health of on-site plantings, cooling urban environments, supporting biodiversity conservation, improving urban aesthetics, and reducing stormwater infrastructure and management costs.
- Implementation of such diversion and capture features can take many forms and is dependent on the local context and environmental conditions.

Examples.



A street verge rainwater garden in Adelaide, SA (image by Edge Environment)

A rain garden in the City of Unley, SA, installed as part of the a street verge upgrade program and in alignment with their Development and Stormwater Management Design Guide.

A section of Port Road, City of Charles Sturt, SA, in 2008 (left) and 2018 (right) showing the outcome of part of a large-scale water retention and storage Aquifer Recharge project which converted a cement drainage line and grassy swale into a thriving and biodiveristy rich wetland whislt also managing stormwater, minimising flooding, and cooling the local environment (images from Google Earth).

W102. Permeable paving

- Permeable paving allows infiltration of stormwater runoff, rather than it being diverted into stormwater channels. This can help water nearby plantings and reduce pollution of waterways due to run-off from non-permeable surfaces.
- Other benefits include reducing the dimensions and costs of stormwater infrastructure.
- Permeable paving is commonly applied to pedestrian footpaths and driveways and can take many forms.

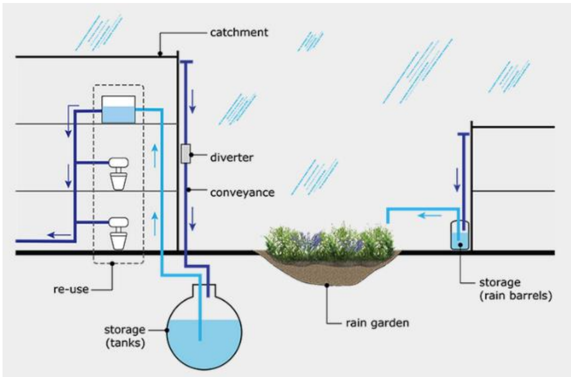
Examples.

Examples of permeable paving applied in private and public driveways, footpaths and open spaces.

W103. Domestic rainwater reuse

- Rainwater harvesting can help to decrease stormwater runoff but can also help to substantially reduce costs associated with water consumption by reducing the use of mains water for uses such as toilets and fire sprinklers, as well as washing machines, swimming pool replenishment, and garden irrigation.
- Rainwater also tends to contain lower calcium levels than mains water, providing further such as: increased lifespan of componentry (e.g. toilet valves won't calcify), less detergent used, and healthier plants.
- Some cities have specific requirements for rainwater harvesting in new private or commercial developments. For example, in 2011, Tucson, Arizona, USA became the first US city to require rainwater harvesting as part of all new commercial developments.

Examples.



Examples of residential and commercial rainwater harvesting systems for toilets, fire sprinklers etc.

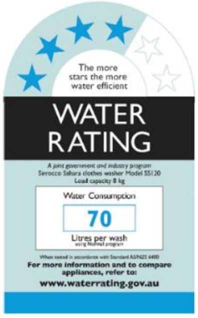
W2. Water efficient fixtures and appliances

W201. Water saving fixtures and appliances

- A range of water saving fixtures and appliances are available, targeting the biggest water using fixtures and appliances in Australian households: showers, taps, washing machines, and toilets, with toilets generally being the largest water user.
- Installing water saving fixtures and appliances could provide significant water use savings, and Australian households could save an average of $175 per year due to reduced costs associated with heating water, and reduced water consumption.
- BASIX targets for water use indicate that new properties in Cherrybrook should reduce consumption by 40% respect the benchmark. This initiative can help go beyond this target

Examples.

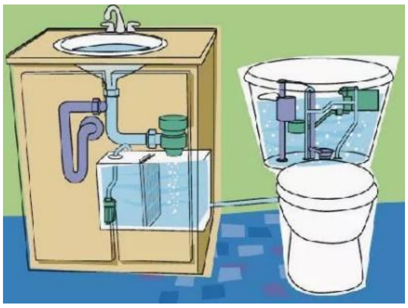
Water efficient washing machines and dishwashers can save up to 60% in water use. In Australia, the Water efficiency Labelling and Standards (WELS) scheme helps identify and compare water-efficiency in appliances



Sensor taps can save up to 60% in water use

Standard toilet installs in Australia now include dual flush options to help save up to 70% of water use

Installing rain shower heads or flow restrictors can help reduce water use by up to 30%



More innovative water-saving toilet designs use grey water stored from the sink to flush the toilet and can eliminate mains water use for flushing (L-R): Caroma's Profile Smart 305 (Australia); Roca's W+W design (Spain); and Sloan's AQUS system (USA), which can be retrofitted to existing toilets.

W202. Dry appliances (composting toilets)

- Also referred to as 'waterless' or 'dry sanitation' toilets, the installation of composting toilets can have significantly lower environmental impacts than water-efficient toilets (See W201).
- They negate the need for water which can save up to 35,000L of water per year per average family household in Australia. This reduces household costs associated with water consumption and reduces demand on water treatment on and off-site.
- Composting toilets are available in 3 main types: continuous composting, batch composting, and self-contained composting. The first 3 types require underground infrastructure, whereas the self-contained unit may be retrofitted to existing concrete slabs.
- Although dry appliances are still subject to public debate for private applications. There is an important opportunity for public use, where appliances such as toilets are used more than 50 times a day.

Examples.

A self-contained composting toilet by Natire-Loo that can be fitted to existing concrete slabs.

A waterless toilet by Clivus Multrum installed in a family home near Brisbane, Qld.

The Eco-restroom at New York's Bronx Zoo uses Clivus Multrum composting toilet systems.

New York's Prospect Park installed the City's first pubic park composting toilets in 2017.

UK's annual Glastonbury festival has replaced traditional water-flushing port-a-loos with organic composting toilets.

M1. Mass timber buildings

M101. Mass timber buildings

- Mass timber constructions can store large amounts of carbon and so may provide environmental benefits assuming combined with a fully sustainable life cycle.
- Compared to steel and concrete structures, using timber in buildings provides carbon savings in the manufacture, transport and installation phases.
- Installation of mass timber buildings drives innovation and upskills developers and contractors for the delivery of mass timber buildings.
- Examples of mass timber buildings are increasing globally, with existing structures in locations such as: Portland, London, Atlanta, Norway, Vancouver, Minneapolis, and Australia

Examples.

Carbon 12, located in Portland, Oregon, is the largest mass timber building in the USA

Mjøsa Tower, is a mixed-used, 18-story building in Norway. Opened in 2019, it is the World's tallest mass timber building.

The first and largest commercial mass timber building in Australia is International House in Sydney.

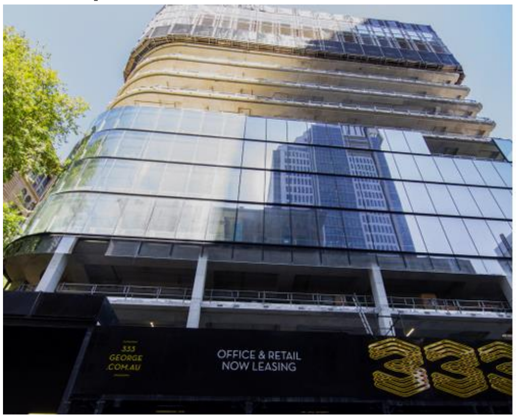
24 King opened in Brisbane in 2018 and is currently the tallest mass timber building in Australia.

M2. Low carbon materials and dematerialisation

M201. Low carbon materials & dematerialization

- Traditional concrete is one of the highest-emitting building materials used in construction. Low carbon concrete can reduce embodied carbon emissions by up to 75% and so provides a low carbon alternative.
- Use of low carbon concrete also drives innovation and upskills developers and contractors for the delivery of low carbon concrete buildings.
- Low carbon concrete may also perform better than traditional concrete in some areas, such as: improved durability, lower shrinkage, earlier strength gain, higher flexural tensile strength and increased fire resistance
- Various current and emerging low carbon concrete options depending on the application, including: grasscrete, Hempcrete, Ferrock, Ashcrete, and Timbercrete.

Examples.



333 George St in Sydney is a mixed-use 18-storey building which used low carbon concrete to help achieve a 5 star Green Star rating.

Wellcamp Airport at Toowoomba, QLD, comprises Australia's first low carbon concrete pavement.

Hempcrete incorporates woody fibres of the hemp plant, a fast-growing and renewable resource. It is also lightweight which helps to reduce transport emissions

Timbercrete combines sawdust and concrete to create a lightweight product that helps to reuse the sawdust waste product and reduces GHG emissions through reduced transport emissions and replacement of some energy-intensive components of traditional concrete

M202. Reduced direct and indirect use of raw materials (dematerialization)

- Dematerialisation is a critical aspect of sustainable development entailing action at every stage of construction and operation, including links to improving product efficiency, and saving, reusing, or recycling materials
- Through basic decisions in the design phase of architectural projects material consumption can be reduced over many years.
- Dematerialisation strategies include: minimising use of materials, reduction of secondary finishes, consideration of life cycle costs and embodied energy (see M1, and M201), and consideration of passive energy systems and low energy services (e.g. solar (See E2), intelligent lighting (see E4), rainwater harvesting and low water use (see W1 and W2), low energy heating and cooling systems (See E1 and E3))

Examples.

Bowden, a suburb in the City of Charles Sturt, SA, is inspiring excellence in sustainable development. It mandates all buildings achieve at least a 5 Star Green Star rating, and includes Australia's first 5 Star Green Star rated townhouse development as well as the country's first residential project to receive a 6 Star Green Star rating ('world leadership'). It has also committed to achieving a precinct-wide Green Star – Communities rating.

West Village in Brisbane's West End has achieved a 6 Star Green Star Community rating. The project incorporated several sustainability initiatives from the building materials used through to facilities provided for residents and community.

Dockside Green in British Columbia, Canada, is potentially the world's Greenest Neighbourhood. It has achieved globally significant sustainability ratings for the phases already completed. Strategies include: extensive greening, rainwater harvesting, biomass gasificiation plant, on-site sewerage and water treatment, high-efficiency (Water and enegery) appliances and fixtures, alternative transport options, solar panels, and careful materials selection and design.

M203. Reused materials

- Material recycling is a major ecological principle of ecological engineering which aims to minimise waste production and also utilise generated wastes as inputs for other processes
- Examples include using wetlands to treat wastewater, phytoremediation (i.e. the use of plants to manage water, soil, and air wastes), and using recycled materials in innovative ways (e.g. see M201)
- Benefits of materials recycling include reduced pollution from transport emissions, reduce overall build costs, reduced impact on landfill sites, reduced demand for other products that rely on natural resources.

Examples.

City of Paramatta, Sydney, is trialling the resurfacing of some roads with reconophalt, a product that contains recycled plastics and glass.

"Upcycle Studios" in Copenhagen, Denmark, is a townhouse development that uses substantial amounts of reused materials, including reclaimed wood, upcycled windows, and 850 tonnes of concrete with recycled materials content from Copenhagen Metro Construction.

The project team are now planning to build the world's most sustainable building project, "UN17 Village", on the outskirts fo Copenhagen.

The 35,000 m2 eco village will implement each of the UN's 17 sustainable development goals. Due for completion in 2023.

Developed in 2017, a new innovation, "Pretty Plastic" tiles is considered the world's first 100% recycled cladding material. Dutch studios Overtreders W and Bureau SLA, developed the product using recycled PVC construction products (e.g. downpipes, roof gutters). The tiles were first installed on a permanent building at the Sint-Oelbert Gymnasium school in the Netherlands.

Repurpose It, located in Epping VIC, is an innovative waste-to-resource plant that converts contaminated hard waste materials (e.g. rail ballast, soil, C&D waste) into high-value sand, clay and aggregates for use in commercial construction projects. The company has recently registered an EN15804 compliant EPD for its recovered mineral aggregates (see M204).

M204. Environmental Product Declarations (EPDs)

- Environmental Product Declarations are increasing in popularity in Australia and New Zealand, with new aspects such as textiles and social impact being added to more usual construction materials.
- Benefits of EPDs include: demonstrating leadership in a commitment to environmental responsibility and transparency, providing transparency in communication of life cycle environmental performance of goods and services, improving corporate image, and the potential to improve products.
- EPDs could be used to make better informed decisions on selection of products and services. Therefore, it facilitates the reduction of embodied environmental impacts.

Examples.

Spanish company, Acciona, became the first construction company in the world to register an EPD for civil infrastructures.

Bombardier, a world leading manufacturer of planes and trains, published its second airraft EPD in 2017. It is the only aircraft manufacturer to disclose the full environmental impact of its products

AUSTRALASIA EPD®
ENVIRONMENTAL PRODUCT DECLARATION

EPD®
THE INTERNATIONAL EPD® SYSTEM

All EPDs registered through the Australasian EPD® Programme are published on the International EPD® System website.

M3. Circular economy

M301. Commingled materials

- Commingled materials, also known as 'single-stream' or 'single-sort' recycling reduces the cost on waste management costs/levies, contributes to government targets and requirements, and may simplify and so increase the amount of recycling by residents.
- Commingled materials are separated and decontaminated at high-tech waste management facilities operated by private service providers and councils. Sorting systems in these facilities use a combination of different strategies to separate waste streams including:
    - Blowers to separate lightweight materials such as paper and carboard
    - Magnets
    - Optical scanners
    - Shredders and screens
    - Manual separation
- It requires the provision of bin infrastructure, appropriate signage, and collection services.

Examples.

Co-mingled recycling negates the need to separate different materials, with a single collection bin being used to collect materials such as: paper, plastic, glass, steel, aluminium, and cardboard. Different regions and companies will have different limitations on which materials can be combined.

M302. Food waste

- Recycling and reusing food waste reduce emissions associated to waste management and reduces the cost on waste management cost/levies and contributes to government target and requirements.
- Strategies may include residential and commercial food waste recycling options, with composted soil and fertiliser able to be reused on site in landscaping, gardens (including rooftop and vertical gardens, see E1), and community produce gardens.
- Collective commercial food waste recycling solutions can be co-located to support residential users. For example, the Pulpmaster technology, currently used in food courts and commercial businesses, macerate food waste into pulp that then is collected by the product provider. This pulp is then used in to produce biogas for renewable energy generation and organic fertilisers.

Other examples

During construction of Dockside Green, organic waste such as paper towels and lunch leftovers were composted. During the current occupation of the development, compost from commercial and residential buildings is used to build healthy soil in landscapes across the site.

The “compost revolution” is an approach expanding across Australian councils encouraging and supporting residents to convert food scraps into soil and fertilizer, thereby reducing landfill and GHG emissions. Includes a variety of small to large compost bins and worm farms.

The images used as examples for the initiatives were taken from various online sources, as listed below.

INITIATIVE	SUB-INITIATIVE	IMAGE SOURCES
E1. Greening	E101. Green roofs & rooftop gardens	https://landscapeaustralia.com/articles/an-elevated-exchange-sky-park-one-melbourne-quarter/ http://www.stemkitchensf.com/garden http://www.stemkitchensf.com/garden
	E102. Green walls & vertical gardens	https://fytogreen.com.au/adelaide-zoo-curved-green-wall/ https://www.theguardian.com/cities/2018/oct/30/mexico-city-via-verde-vertical-gardens-pollution-climate-change https://unsplash.com/photos/0NJ9urGXrIg https://www.verticalgreen.com.sg/products/greenwallsystem/ https://inhabitat.com/park-royal-tower-wohas-stunning-vertical-urban-park-opens-in-singapore/ https://www.ansgroupglobal.com/living-wall/case-studies/linksway https://www.sminational.com.au/living-wall-projects/national-grid-uk http://www.growinggreenguide.org/wp-content/uploads/2014/02/growing_green_guide_ebook_130214.pdf
	E103. Increase canopy cover	https://www.portlandoregon.gov/bes/article/574025 https://www.planning.nsw.gov.au/Policy-and-Legislation/Open-space-and-parklands/5-million-trees https://theconversation.com/can-trees-really-cool-our-cities-down-44099
E2. Solar panels	E201. Solar panels on buildings	https://landartgenerator.org/blagi/archives/75833 https://www.solaxess.ch/en/home/ https://www.tesla.com/en_AU/solarroof
	E202. Solar panels on public access spaces	https://trimet.org/publicart/yellowline.htm https://www.designrulz.com/solar-energy-trees/ https://monarcas.org/ https://unsplash.com/photos/UoovvM6CMoQ https://en.solaroad.nl/

INITIATIVE	SUB-INITIATIVE	IMAGE SOURCES
E3. Cool surfaces	E301. Cool seal products on rooftops	https://cooperator.com/article/how-cool-roofs-help-your-property-and-the-environment/full https://coolroofs.org/documents/NYC_CoolRoofs_6-14-17_Presentation.pdf
	E302. Cool seal products on pavements	https://e360.yale.edu/features/urban-heat-can-white-roofs-help-cool-the-worlds-warming-cities https://yoursay.cityofadelaide.com.au/cool-road?tool=news_feed#tool_tab https://www.cityofparramatta.nsw.gov.au/western-sydney-cool-roads-trial https://www.charlessturt.sa.gov.au/environment/climate-change/coolseal
E4. Natural and low energy lighting	E401. Self-emitting pavements for cycleways and footpaths	https://www.ecowatch.com/solar-powered-bike-path-poland-2031343702.html https://www.dezeen.com/2014/11/12/daan-roosegaarde-van-gogh-bicycle-path-glowing-patterns-nuenen-netherlands/ https://www.boredpanda.com/glow-in-the-dark-rail-corridor-singapore/?utm_source=google&utm_medium=organic&utm_campaign=organic https://slate.com/human-interest/2013/12/pro-teq-starpath-uses-solar-power-to-light-christ-s-pieces-park-in-cambridge-england.html https://www.dailytelegraph.com.au/newslocal/central-coast/australias-first-glowinthedark-footpath-installed-at-wyoming/news-story/74eb60c889ccb4a7cca36405214f2f56
	E402. Smart lighting	https://robots.net/tech-reviews/best-smart-home-devices-you-dont-want-to-miss/ https://www.linkedin.com/pulse/how-motion-detectors-work-public-space-using-example-university/ https://www.abc.net.au/news/2016-05-26/intelligent-led-street-light-trial-australian-first-for-adelaide/7445362 https://www.tvilight.com/wp-content/uploads/2019/06/Jaipur-Smart-City-Lighting-Tvilight-Case-Study.pdf
E5. Active and public transport incentives	E501. Infrastructure and facilities for cyclists	https://www.vicroads.vic.gov.au/traffic-and-road-use/cycling/bicycle-infrastructure-design https://ipvdelft.com/projects/hovenring/ https://appln.transport.nsw.gov.au/bikelockers/faces/jsp/public/home.xhtml

INITIATIVE	SUB-INITIATIVE	IMAGE SOURCES
		https://bikesmakelifebetter.com/bike-parking-for-employers-developers-a-guide-to-end-of-trip-facilities/
	E502. Walkable distance to diverse services of public transport	https://www.thefifthestate.com.au/wp-content/uploads/2014/12/Precincts_ebook_final-double-page.pdf https://www.tripstodiscover.com/travel-by-foot-most-walkable-cities-around-the-world/ https://www.thehighline.org/
	E503. Mixed land use including diversity of amenities	https://www.sciencedirect.com/science/article/abs/pii/S0149718919302381
	E504. Reduced parking, parking pooling, and car-share exclusive parking	https://www.elitereaders.com/oslo-city-to-ban-cars-by-2019/
W1. WSUD – stormwater management	W101. Stormwater/rainwater diversion and capture, including rainwater gardens	https://www.unley.sa.gov.au/files/assets/public/development-amp-major-projects/building-and-renovating/development-guidelines/city-of-unley-stormwater-guidelines.pdf https://greenhillaustralia.com.au/project/leader-street_forestville/
	W102. Permeable paving	https://www.unley.sa.gov.au/files/assets/public/development-amp-major-projects/building-and-renovating/development-guidelines/city-of-unley-stormwater-guidelines.pdf https://www.premierpavers.com.au/permeable-pavers/ https://www.buildings.com/article-details/articleid/18830/title/permeable-pavement-battles-stormwater-runoff
	W103. Domestic rainwater reuse W104. Rainwater for fire system top up	https://www.rainfilltanks.com.au/invest-rainwater-harvesting-systems-water-filters-perth/ https://www.next.cc/journey/design/rain-water-harvesting https://www.constructionmagnet.com/gutter-opportunities/gutter-contractors-find-rainwater-harvesting-systems-help-turn-a-profit https://www.ny-engineers.com/blog/automatic-fire-sprinklers-a-lucrative-investment
W2. Water efficient fixtures & appliances	W201. Water saving fixtures & appliances	https://www.energy.gov.au/households/water-efficiency https://www.intelligenthanddryers.com/blog/benefits-sensor-taps-problems https://www.oyster.com/articles/could-dual-flush-toilets-become-2010s-must-have-amenity/

INITIATIVE	SUB-INITIATIVE	IMAGE SOURCES
		https://www.zdnet.com/article/the-toilet-re-imagined-four-water-saving-designs/ https://specify.caroma.com.au/products/toilet-suites/profile/profile-5-toilet-suite-deluxe-with-integrated-hand-basin-2 https://www.treehugger.com/watersaver-technologies-aqus-uses-sink-greywater-for-toilet-4856382 https://www.waterwisetech.net/specs/sloan_aqus_information_brochure.pdf
	W202. Dry appliances (composting toilets)	https://www.yourhome.gov.au/water/waterless-toilets https://www.nature-loo.com.au/products/composting-toilets https://www.spec-net.com.au/press/0415/cli_290415/Odourless-Waterless-Toilets-Clivus-Multrum https://www.theguardian.com/music/2016/jun/18/glastonbury-new-organic-toilets https://clivusmultrum.com/green-building-bronx.php https://www.dnainfo.com/new-york/20170619/windsor-terrace/composting-toilet-prospect-park-wellhouse-public-restroom
M1. Mass timber buildings	M101. Mass timber buildings	https://e360.yale.edu/features/as-mass-timber-takes-off-how-green-is-this-new-building-material https://www.puitmajaliit.ee/news/norway-to-build-world-s-tallest-timber-building https://www.woodsolutions.com.au/inspiration-case-study/2017-atda-winner-international-house-sydney https://architectureau.com/articles/australias-tallest-engineered-timber-office-building-opens/
M2. Low carbon materials & dematerialisation	M201. Low carbon concrete	https://www.boral.com.au/projects/333-george-street https://www.wagner.com.au/main/what-we-do/earth-friendly-concrete/efc-home/ https://inhabitat.com/11-green-building-materials-that-are-way-better-than-concrete/
	M202. Dematerialisation	https://new.gbca.org.au/showcase/communities-and-precincts/bowden-development/ https://www.westvillage.com.au/sustainability/ http://www.solaripedia.com/files/571.pdf

INITIATIVE	SUB-INITIATIVE	IMAGE SOURCES
	M203. Reused materials	https://www.roadsonline.com.au/city-of-parramatta-trials-reconophalt-roads/ https://www.dezeen.com/2020/03/03/pretty-plastic-overtreders-w-bureau-sla-upcycled-products/ https://www.dezeen.com/2019/04/16/upcycle-studios-townhouses-lendager-group-copenhagen-recycled-materials/ https://www.unenvironment.org/news-and-stories/story/skys-limit-architects-design-un17-eco-village-copenhagen
	M204. EPDs	https://www.environdec.com/Articles/EPD/EPD-as-part-of-a-sustainable-strategy/ https://www.bombardier.com/en/media/newsList/details.bca_20171003_bombardierreceivescs300epd.bombardiercom.html https://edgeenvironment.com/uptake-of-epds-in-australia/
M3. Circular economy	M301. Comingled materials	https://www.regenwaste.com/what-is-commingled-waste-and-why-do-you-need-to-know-about-it https://www.cleanaway.com.au/waste/commingled-recycling/
	M302. Food waste	http://www.solaripedia.com/files/571.pdf https://compostrevolution.com.au/products/

Appendix G The Benefits of Trees

G.1 The following summary of urban tree benefits is taken from Planet Ark.

The Benefits of Trees

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1 TREES ARE GOOD FOR THE ENVIRONMENT

- Trees promote biodiversity [1]
- Trees produce oxygen [1]
- Trees combat the greenhouse effect through carbon sequestration [1]
- Trees reduce storm-water run-off [1]
- Trees help control temperature [1]
- Trees reduce salinity and soil erosion [2]
- Trees reduce noise and air pollution [1]
- Trees act as water filters and improve water quality [1]
- Trees help conserve energy with their shading and evapotranspiration effect [1]
- Trees provide nucleii for rain and help increase rainfall [2]
- Trees improve air quality by absorbing polluting gases and odours and filtering air particles [1]
- Trees save water as shade from trees slows water evaporation [1]

2 TREES ARE GOOD FOR BUSINESSES

- The presence of trees translates into increased financial returns [4]
- Trees attract customers [4]
- Trees provide a good impression for customers [4]
- Shoppers linger longer in the shade [4]
- Trees help businesses achieve greater market identity [4]
- Trees provide attractive commercial settings [4]
- Trees allow businesses to differentiate themselves from competitors [4]
- Trees give businesses a competitive edge [4]
- Trees help create a sense of security for customers [4]

3 TREES ARE GOOD FOR OUR CITIES

- Trees cool cities by shading homes and streets, and by releasing water vapour into the air through their leaves [1]
- Trees break up urban "heat islands" [5]
- Shade from trees helps to prolong the life of city pavements and roads, and reduces the need for resurfacing [4]
- Trees beautify cityscapes
- Trees aid in traffic control by separating pedestrians from vehicles [7]
- Tree canopy cools parking lots and reduces the evaporative hydrocarbon emissions from parked vehicles that are released from fuel tanks and hoses as gasoline evaporates [4]

4 TREES ARE GOOD FOR THE ECONOMY

- Fruit harvested from community orchards can be sold, thus providing income
- Trees can be utilised for fuel, building materials and craft wood
- Trees increase property values. The beauty of a well-planted property and its surrounding street and neighbourhood can raise property values by as much as 15 percent [8]
- Trees attract businesses and customers to communities [9]
- For a planting cost of US $250 - $600, a single street tree returns over US $90 000 of direct benefits [10]
- Trees enhance tourism by adding beauty and shade to a location [11]

5 TREES MAKE CARING, SHARING COMMUNITIES

- Tree plantings provide an opportunity for community involvement and engage all cultures, ages and genders in the important role of tree planting or tree care
- Trees beautify communities and improve the views
- Trees make great landmarks that can give communities a new identity and encourage community spirit
- Shared green spaces, particularly those having trees, help strengthen social ties among neighbours. A US series of studies of inner-city neighbourhoods shows green spaces with trees contribute to healthier, more supportive patterns of interaction among residents, including greater sharing of resources [12]
- Individuals living in 'greener' buildings reported more social activities, more visitors, knew more of their neighbours and had stronger feelings of belonging [12]

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6 TREES MAKE HAPPY, HEALTHY CHILDREN

- Tree shade helps reduce exposure to harmful ultraviolet rays, thus providing protection to children at schools and playgrounds - where children spend hours outdoors
- Trees provide fun play opportunities for children through activities like climbing, swinging or creating a tree house
- Children living in tree-lined streets have a lower risk of developing asthma and its symptoms [13]
- Attention Deficit Disorder symptoms are relieved in children after spending prescribed amounts of time in green spaces - the greener the setting, the more the relief [14]
- Girls with home views of nature score higher on tests of concentration and self-discipline and score lower on tests of impulsivity [15]
- Planting trees encourages environmental custodianship amongst children
- Kindergarten children playing in forest-type environments improved significantly in 8 out of 9 tasks on a physical fitness test whereas children playing in less natural outdoor play environments only improved in 3 out of 9 tasks [16]
- In two Swedish nurseries with similar conditions and similar teaching staff, children with the green outdoor play settings reported less than half the number of sick days than the children at a city day care centre with no green play setting [17]

7 TREES HEAL AND HELP YOU LIVE LONGER!

- A study of senior citizens in Japan found that the presence of parks and tree-lined streets near senior citizen residences were significant predictors of higher survival over the following five years. Living in areas with walkable green spaces positively influenced the longevity of urban senior citizens independent of their age, sex, marital status, baseline functional status and socioeconomic status [18]
- Planting trees and gardening is a physical activity that helps you burn kilojoules
- Many trees have significant medicinal properties [19]
- Hospital patients have been shown to recover from surgery more quickly when their hospital room offered a view of trees [20]

8 TREES MAKE SOCIETY A BETTER PLACE

- The presence of trees can be associated with lower crime rates as it helps people to relax thereby reducing aggression [21]
- The presence of trees increases surveillance and discourages criminals, as the 'green and groomed' appearance of a property is a cue that the owners and residents care about a property and watch over it and each other [21]
- Trees ease poverty's burden in inner city neighbourhoods [22]
- Trees act as privacy screens and muffle sound
- Inner city families with trees and greenery in their immediate outdoor surroundings have safer domestic environments than families who live in areas that are barren of street trees and nature [21]

9 TREES ADD VALUE TO THE WORLD AS IT IS

- Trees mark the seasons, telling us when it's Spring, Summer, Autumn or Winter
- Trees feed people, animals and birds
- Trees can be utilised symbolically. Christmas just wouldn't be the same without a Christmas Tree!
- Trees shelter plants, crops and livestock, protecting them from the elements
- Trees have historic value. Old trees represent a link with the past that can extend through hundreds of years
- The trunk of a tree can tell its own story and help us to learn about the kind of environment and climactic conditions that the tree has lived through in a certain area
- Trees are valuable as commemoratives of deceased loved ones and for passing on something of value to future generations

10 TREES MAKE THE WORLD A BEAUTIFUL PLACE

- Trees provide canopy and habitat for wildlife
- Trees can mask unsightly views. They muffle sound from nearby streets and freeways, and create an eye-soothing canopy of green
- Trees absorb dust and wind and reduce glare
- Trees creatively inspire the artists, writers and musicians that influence our culture. Think Flame Trees by Cold chisel, Tall Trees by Crowded House, Home Among the Gum Trees by John Williamson, or of poet Joyce Kilmers's Trees or artist Paul Cezanne's Poplar Trees
- Trees are a work of nature's art, with leaves changing colour, and trees growing, changing shape, becoming mobile in the wind, casting brilliant shadows, filtering rays of sun and moonlight, and yielding flowers and fruit of many colours.

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The Benefits of Trees

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G.2 Wider environmental benefits of trees (modelled)

Of all the potential greening initiatives, increasing tree canopy cover has been shown to provide the greatest range of benefits. Whilst the benefits provided by trees increases over time as the tree matures, the specific amount of benefits provided varies by tree species, age, and condition.

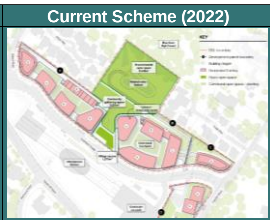
For the purposes of this project, benefits of increased canopy cover have been based on very high-level estimates averaged across tree species, ages, and conditions. The following provides an example of how ecosystem service benefits can vary depending on tree species and tree age. In this case, EDGE modelled a newly planted and a mature Sydney blue gum (*Eucalyptus saligna*), the cumulative benefits over the growth of the newly planted gum over a 50-year period, and a mature tuckeroo (*Cupaniopsis anacardioides*). This modelling assumes healthy and natural growth of the trees.

	1. Sydney blue gum (immature)*	***2. Sydney blue gum growth over 50 yrs****	**3. Sydney blue gum (mature)*****	**4. Tuckeroo (mature)******
				
Carbon stored	0.6 kg	*7.9 tonnes*	9.03 tonnes	0.23 tonnes
Carbon sequestered	0.5 kg/yr	*478.3 kg*	0.02 t/yr	0.01 t/yr
Potential evapotranspiration	0.1 m^3/yr	*330.7 m^3 (total over 50 years)*	1,389.2 m^3/yr	21 m^3/yr
Oxygen produced	1.3 kg/yr	*1.3 tonnes (total over 50 years)*	40 kg/yr	35.9 kg/yr
Air pollution removed^	0.001 kg/yr	*3.65 kg*	0.01 t/yr	0.22 kg/yr
Total benefits value	$0.02/yr	*$28*	$68.45/yr	$1.38/yr
Structural/replacement value	$73.41	*n/a*	$72,489.84	$2,835.26

* *Assumed to be 2m tall and have a 2.5cm diameter at breast height (DBH)*
** *Provides modelled total benefits over 50 years' worth of growth from immature*
*** *Assumed to be 40m tall and have a 2.5m DBH*
**** *Assumed to be 7m tall and have a 30cm DBH*
^ *Includes: CO, O3, SO2, N2, PM2.5*

Appendix H Sustainability Impacts of Scheme Changes

The initial scheme proposed for Cherrybrook SSP in early 2021 was updated in February 2022. This new scheme, as modelled and presented in this report, has different sustainability impacts respect to the previous design. The table below summarises and compares the sustainability impacts estimated for both schemes.

Lifecycle sustainability impact	Units	Previous Scheme (2021) 	Current Scheme (2022) 	Difference	%	
Baseline Impacts						
Energy Use	GJ	975,857	835,285	- 140,572	14%	Improved
Scope 1 Emissions	ton CO^{2}-eq	23,736	20,324	- 3,412	14%	Improved
Scope 2 Emissions	ton CO^{2}-eq	125,906	105,082	- 20,824	17%	Improved
Scope 3 Emissions	ton CO^{2}-eq	235,350	211,656	- 23,694	10%	Improved
Total Emissions	ton CO^{2}-eq	384,992	337,062	- 47,930	12%	Improved
Potable water use	ML	4,591	3,657	- 934	20%	Improved
Non-potable water use	ML	-	-	- 0	0%	Improved
Total water use	ML	4,591	3,657	- 934	20%	Improved
Materials use	tons	101,435	92,854	- 8,581	8%	Improved
Materials embodied GHG emissions	ton CO^{2}-eq	50,471	45,657	- 4,814	10%	Improved
Waste generation	tons	63,393	60,005	- 3,388	5%	Improved
Waste to landfill	tons	29,235	27,338	- 1,897	6%	Improved
GHG emissions from waste management	ton CO^{2}-eq	38,284	35,628	- 2,656	7%	Improved
Initiatives impacts (reductions)						
GHG emissions reduction	ton CO^{2}-eq	108,490	90,637	- 17,853	16%	
Potable water savings	ML	1,977	1,863	- 114	6%	
Waste diversion from landfill	ton	13,747	12,514	- 1,233	9%	
GHG emissions reduction as % of baseline	%	28%	27%			Technically same
Potable water savings as % of baseline	%	43%	51%			Improved
Waste diversion from landfill as % of baseline	%	47%	46%			Technically same