GREEN COVER DEMONSTRATION PROJECT

LIVERPOOL CITY CENTRE AND PENRITH

Prepared for the Office of Environment and Heritage
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NSW GOVERNMENT | Public Works
Government Architect's Office

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GREENCOVER DEMONSTRATION PROJECT
LIVERPOOL CITY CENTRE AND PENRITH

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INTRODUCTION

Scientific research and assessment indicates that urban environments experience increased temperatures due to infrastructure development, hard paved and dark coloured surfaces, car engines, air conditioners, reduced green cover, soil sealing and global and local climate change.

Increased density and heat contributors in cities are creating an urban heat island effect that is increasingly affecting the economy and quality of life of those in our cities (Hopkins and Goodwin, 2011). Consideration of projected climate scenarios will enable urban planners and designers to create urban environments that can best mitigate the impacts of climate change. By integrating green cover and green spaces into the urban environment, there is potential to moderate the effects of increased heat.

Climate change is likely to have significant impacts on NSW – it is the most populous state in Australia, accounting for 32 per cent of the national population (ABS 2011). Sydney's daily summer temperatures are now 0.5°C to 0.9°C hotter than the long-term average (DECCW, 2010 in DP&I, 2010) and the *NSW Climate Impact Profile* (DECCW, 2010b) projects that by 2050 the mean daily maximum and minimum temperatures are virtually certain to increase by 1.5°C -3°C in all seasons. Research on the impacts of climate change on temperatures in Sydney also indicates that by mid century there is likely to be a larger degree of warming in Western Sydney than in coastal areas (CSIRO 2008).

Strategies for mitigating temperature increases will enhance a community's resilience and local government capacity to respond to heat effects of climate change. Climate change adaptation, particularly for Western Sydney, is a priority for the NSW Government, as set out in the *Metropolitan Plan for Sydney 2036 (The Metro Plan)*. *The Metro Plan* sets a target for Sydney to become a leader in urban adaptation to climate change in the Asia-Pacific region.

Urban green cover can include bushland, private and community gardens, parks, greenways and corridors, street trees, canopy trees, green roofs, green walls and green infrastructure. Green cover is an effective way to mitigate heat impacts in urban areas with a multitude of co-benefits, such as reducing energy demands, storing carbon, filtering airborne particles, providing aesthetic, social and health benefits, managing stormwater and providing habitat for local fauna.

The Metro Plan prioritises addressing climate change and protecting Sydney's natural environment as critical to maintaining Sydney's quality of life, its economic productivity and its competitive status as a global city.

The Department of Planning and Infrastructure has prepared *Draft Centres Design Guidelines*, which are under exhibition in 2011. The Draft Guidelines provide design principles to guide the urban renewal of existing centres and the design of new centres throughout New South Wales.

The Draft Guidelines have been developed to ensure centres are well designed, functional and liveable and can meet the need to accommodate additional population and activities within walking catchments. The Draft Guidelines are a tool to assist in the design

2010 was the 18th consecutive year with above average maximum temperatures in Sydney, with an average maximum of 22.6°C, which was 0.9°C above the historical average. Minimum temperatures were also above average, at 15.0°C during 2010 compared to a historical average of 13.9°C.

(Source: BoM 2011)

(Source: Department of Planning and Infrastructure, *Draft Centres Design Guidelines*, 2011)

of urban centres and to help accommodate growth and change. The Draft Guidelines include good practice planning and urban design principles which will standardise planning and design information to create a common understanding and language in adapting centres for growth.

The Draft Guidelines are not a policy document but support the directions of existing NSW Government planning policies.

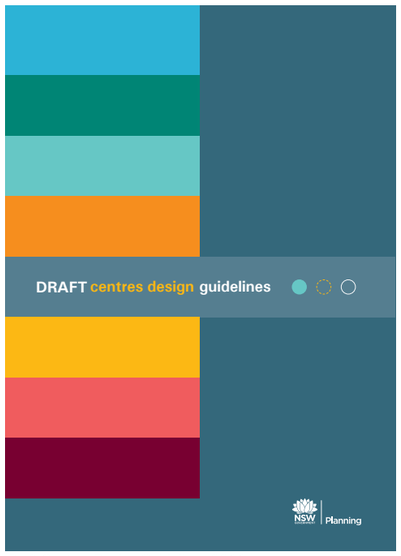
The Draft Guidelines establishes the following principles for urban renewal relevant to this Green Cover Demonstration Project:

- Green cover
- Integrating water
- Street trees
- Water sensitive urban design
- Preserve nature and natural corridors
- Adapting to climate change
- Walkable centres
- Parks and squares
- Community gardens

The purpose of this Green Cover Demonstration Design study is to demonstrate ways in which green cover can be employed by NSW local governments to mitigate heat impacts in typical urban situations.

Seven of the ten warmest years on record (151 years) for Sydney have occurred in the ten years between 2001 and 2010, with this decade the warmest on record for minimum temperatures.

(Source: BoM 2011)



Draft Centres Design Guidelines 2011,
Department of Planning
& Infrastructure

EXECUTIVE SUMMARY

The Green Cover Demonstration Design Project has been undertaken by the NSW Government Architect's Office in partnership with the Office of Environment and Heritage and the Department of Planning and Infrastructure.

The objectives of the project are:

• To develop potential site specific demonstration designs for urban green cover;

• To provide opportunities to demonstrate best practice landscape design of green cover for mitigating the heat island effect;

• To meet objectives of *The Metro Plan* actions, to enhance local government capacity and resilience to climate change, particularly in Western Sydney; and

• To assist NSW local governments to integrate green cover design into the planning process.

Two local government areas, Liverpool City Council and Penrith City Council were selected as study areas. The focus of the study for Liverpool was the city centre and at Penrith, Jameson Park and the adjacent industrial precinct.

The study areas were selected for their urban development patterns typical in Western Sydney, and the contrasting characteristics of city centre and regional park and industrial area, providing a broad canvas for exhibiting green cover principles. The focus sites are also recognised as regional cities in *The Metro Plan* under the Department of Planning and Infrastructure's 'City of Cities' approach.

The extent of heat island effect contributors were mapped and quantified for each study area by the NSW Government Architect's Office. This was completed by identifying and measuring the extent of the contributors using aerial photos and by undertaking site visits. The mapping showed that heat island effect contributors cover approximately 95 per cent of the Liverpool City Centre study area and 42 per cent of this area is within the public domain. The Penrith study found that 72 per cent of the study area potentially contributes to the heat island effect, with 53 per cent of this area within the public domain.

These findings illustrate the significant opportunity that local councils can have to implement green cover strategies in the public domain and reduce the urban heat island effect.

Key strategies for increasing green cover in urban areas were identified as:

• Cool Roofs - green roofs and light coloured and reflective roof surfaces;

• Cool Walls - green walls and shaded walls;

• Cool Pavements - reduced hard surface area, permeable pavements and light coloured, high albedo (highly reflective) pavements;

• Cool Streets - opportunistic street tree planting with shade providing canopy, mass planting understorey, bio-swales and median planting;

•.Cool Carparks - canopy tree plantings, median planting and bio-swales, permeable pavement;

• Cool Canopies - increased canopy trees and shade provision to parks, cycleways, footpaths, amenities and forecourts and shade structures, including structures covered with climbing plants; and

• Green Infrastructure - bio-swales, raingardens, soft-landscaped detention basins, de-channelisation of hard engineering (concrete culverts).

Within the Liverpool and Penrith study areas, site-specific opportunities were identified as demonstration design projects for implementing the key strategies and increasing green cover. These sites were selected following the site analysis and workshops with Liverpool and Penrith Councils. These sites were chosen for being achievable projects within the public domain and for their relevance and application to other local government areas.

Demonstration sites selected within the Liverpool City Centre include the Council Building Rooftop, Liverpool Library Forecourt, Bathurst Street surface carpark, George Street, Crawford service-way and laneways.

Demonstration sites selected within Penrith include Jameson Park, drainage corridors, Jameson Park carpark and netball court precinct, Batt Street and the industrial precinct.

This study demonstrated that there is a wide range of potential strategies that can be readily employed as part of regular Council maintenance programs and are within Councils resources and capabilities.

A variety of opportunities can be realised incrementally depending on resources through:

- Pilot projects
- Capital works projects
- Maintenance programs
- Public domain plans
- Local Government and private partnerships
- Development Controls and incentives
- Community programs.

CONTENTS

GREENCOVER DEMONSTRATION PROJECT

APPENDICES -

1.0 PURPOSE

The Office of Environment and Heritage (OEH), in consultation with the Department of Planning and Infrastructure (DP&I) engaged the Government Architect's Office (GAO) to develop a demonstration design project that identifies achievable strategies for mitigating heat impacts in Western Sydney by increasing urban green cover. The studies focused on two areas in Western Sydney, the Liverpool City Centre and the Penrith Local Government Area.

The strategies have potential to be implemented by NSW local councils and will demonstrate leading practice landscape design of green cover strategies to reduce heat. The project will assist councils to initiate and implement green cover projects, including general green cover principles for climate change adaptation of the urban environment, and in identifying short-term, incremental, low-cost, achievable strategies.

It is intended that these strategies could be strategically integrated into existing capital works and maintenance programs to progressively contribute to a long term vision of increasing green cover in Western Sydney and cumulatively build community resilience to climate change.

1.1 Objectives

The objectives of the demonstration green cover design project are to:

- Develop potential site-specific demonstration designs for urban greencover;
- Provide opportunities to demonstrate best practice landscape design of greencover for mitigating heat impacts;
- Meet objectives of the *Metro Plan* actions;
- Enhance resilience to climate change in Western Sydney;
- Assist local governments to integrate greencover design into the planning process; and
- Have green cover principles that can be applied and replicated in other NSW local government areas.

1.2 Policy Contribution

The demonstration green cover design project is structured to contribute to the following policy objectives:

- *Metropolitan Plan for Sydney 2036 Action G2.3*: To investigate incorporating street tree planting and other green cover opportunities into grant funding programs, particularly in Western Sydney;
- *Metropolitan Plan for Sydney 2036 Action G2.4*: To incorporate climate change adaptation into centre renewal;
- Enhance community resilience and local government capacity to respond to the heat effects of climate change in Western Sydney;
- To assist NSW local governments to integrate green cover design into urban planning frameworks; and
- To identify climate change adaptation options in the context of urban design and planning.

Significant development is planned under *The Metro Plan*, with 770,000 additional homes projected to be constructed in Sydney over the next 25 years.

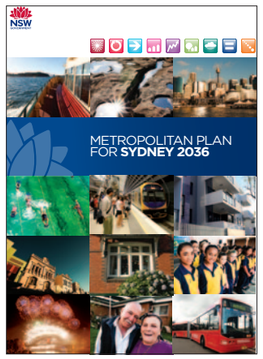
There will also be a focus on incorporating climate change adaptation into centre renewal across Sydney (DP&I, 2010).

The Green Cover Demonstration Design project will provide:

1. Guidance for integration of climate adaptation of a substantial proportion of Sydney's built environment to hotter temperatures in the planning and design phase;
2. Opportunity to target new and existing development for climate change adaptation measures, which is more cost effective than building retrofit and provides an opportunity to showcase best practice in NSW; and
3. Consistency with other State and national initiatives to improve the long-term sustainability of Sydney's built environment and to promote and drive sustainable cities.

Due to time constraints and the early-stage status of Australian green cover studies, the extent of this project was limited, and has used some studies from the Northern Hemisphere that may need to be recalibrated to have direct application to the Australian context. This is beyond the scope of this study.

The Green Cover Demonstration Design project is intended to demonstrate opportunities to initiate and implement green cover projects and to outline general principles for designing green cover for climate change adaptation to NSW councils.



Metropolitan Plan for Sydney 2036, Department of Planning & Infrastructure

Metropolitan Plan for Sydney 2036: Action G Tackling Climate Change & Protecting Sydney's Natural Environment

2.0 METHODOLOGY

The project steering group consisted of the Office of Environment and Heritage (OEH) (Climate Change Impacts & Adaptation section), the Government Architect's Office (GAO) and the Department of Planning and Infrastructure (Metropolitan & Regional Strategies Branch and Urban Assessments Branch). Consultation with the Australian Institute of Landscape Architects, Sydney Water, Liverpool City Council and Penrith City Council was also undertaken.

The demonstration project was undertaken in three phases:

1. PROJECT DEFINITION, RESEARCH AND ANALYSIS

A review of relevant strategic and planning documents, existing planning controls, supporting reports and prior studies, and other relevant documents was undertaken.

Following this a physical analysis of site influences and identification of key issues and design limitations for the site was undertaken. This included the mapping of the study area's context, existing greencover, street hierarchy, paved surface areas in the public domain (plazas, surface carparks, forecourts), roof types and colours and location of awnings. The mapped information was then used to calculate areas and quantify heat island effect contributors within the study area (refer to Appendices for Liverpool City Centre and Penrith detailed Site Analysis).

2. STAKEHOLDER STEERING GROUP WORKSHOPS

Workshops were undertaken at key stages in the project to obtain stakeholder and steering group feedback on the project opportunities, constraints and overall green cover vision.

Following site investigations, analysis and identification of green cover strategies, workshops were held with Liverpool City Council and Penrith City Council. Participants in the Liverpool workshop included the GAO and OEH project team, CBD place manager, strategic planning manager and planners.

Participants in the Penrith workshop included the GAO and OEH project team, landscape architect and urban designer, parks manager, sustainability co-ordinator and bushland management officer.

The purpose of the workshops with both councils was to obtain feedback from the stakeholders, identify issues from the stakeholder's perspective and identify opportunities for achievable demonstration projects within the study areas.

Following this, a presentation of the analysis, principles, green cover strategies and outcomes of the stakeholder workshops was made to the project steering group. Feedback and recommendations guided the next phase of the development of demonstration concept designs for the projects identified within each study area.

3. CONCEPT DESIGN PROPOSITIONS

The Greencover Demonstration Design Project is based around a series of conceptual design propositions that are typical opportunities, common to NSW councils, rather than detailed designs. The propositions have built upon a careful analysis of the study areas, locality and its context, discussed through the stakeholder workshops as well as consultation with the project steering group.

Concept designs were presented at a progress review workshop with both Liverpool and Penrith City Council stakeholders and the project steering group. The purpose of the workshop was to obtain feedback on recommendations for the project report inclusions and recommendations for 'next steps' following the completion of the green cover demonstration project.

It should be noted that the proposals are conceptual only and require more detailed information including survey plans, underground services locations, review of consistency with planning controls, maintenance and species consideration, and further site investigations to move the projects into the next phase of design development, documentation and implementation of pilot projects.

Early in the conceptual phase of implementing urban green cover, maintenance should be considered, particularly where increased heat impacts may affect water availability, plantings and ozone. A maintenance plan and budget should be developed as part of the design phase, including regular inspections of irrigation systems.

Careful consideration of appropriate species for local conditions should be undertaken in the early phase of project development to ensure planting success. Species selection can impact air quality by emission of biogenic volatile organic compounds (VOCs), potentially increasing the level of ozone (Nelson et al, 2009) and some species may have allergenic consequences. The City of Sydney has released a Draft Tree Species Selection guide (2011) which may assist councils when considering green cover implementation.

3.0 BACKGROUND

Scientific research and assessment indicates the *heat island effect* results from an increase in temperatures of urban centres due to development, hard paved and dark coloured surfaces, car engines, air conditioners, reduced green cover and global and local climate change.

3.1 Heat Island Effect Contributors

Urban Heat Island Effect can be attributed to the following:

- Growth in urban development, infrastructure and services;
- Hard pavements and surfaces such as roads, footpaths, carparks;
- Dark coloured surfaces including pavements, asphalt, bitumen and dark coloured roofs;
- Reduced open space, soft landscaping and trees;
- Local climate change and global warming with more extreme weather events and increasing average temperatures;
- Exposed surfaces with high absorption and radiation of heat and low reflectivity of heat;
- Car engines; and
- Air conditioners.

3.2 Implications Of Climate Change and Extreme Heat On The Urban Environment

The Heat Island Effect has negative impacts on the urban environment and its communities. Increased peak temperatures and decreased night-time cooling leads to greater energy demand and costs for air-conditioning, increased air pollution and greenhouse gas emissions. With reduced green cover in urban areas, there is less filtering of air pollution and airborne particles (Hopkins and Goodwin, 2011).

Sydney currently experiences temperatures above 30°C on 15 days per year. Studies have highlighted that by 2030 this is predicted to increase to between 18 and 31 days per year and by 2070 to between 22 and 117 days per year. This has important ramifications for air pollution and health, with ozone pollution events linked to the frequency of hot, sunny days and high particle pollution concentrations linked to bushfire smoke.

(DECCW 2010b)

A lack of shade and exposed areas of hard paved or dark coloured surfaces causes an increase in surface temperatures in urban environments. Higher temperatures and extreme heat events cause an increase in heat-related illness and mortality amongst vulnerable groups in the community due to heat stress and higher levels of pollution (Duc et al, 2009; Bower et al, 2010).

Over the past 50 years Australia has been getter warmer. Since 1960 the average temperature across Australia has risen by 0.7°C – 2009 was the hottest year on record for NSW, and the preceding ten years

"The urban heat island (UHI) is increasingly a problem in cities... UHI is the storage of solar energy in the urban fabric, which is released into the atmosphere, especially at night, as heat energy."

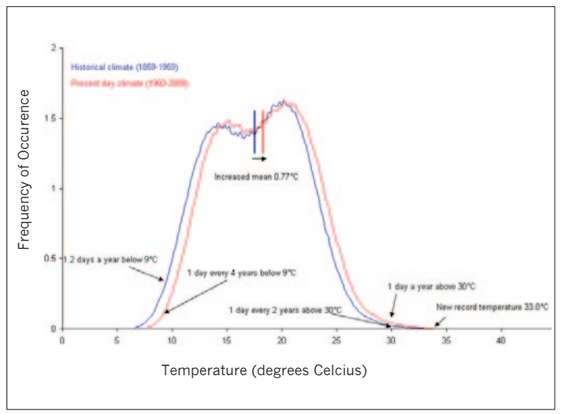
(Hopkins and Goodwin, 2011)

Urban devleopment, car engines, dark coloured exposed surfaces such as roads

Reduced soft landscaping

Air conditioners

(2000-2009) were the hottest decade on record. Since the 1970s, every decade has been as warm, or warmer, than the last (CSIRO & BoM 2010).



(Office of Environment and Heritage, 2011, Distribution of daily mean temperatures in eastern Sydney (Observatory Hill), modelled from BoM data 2011)

In Sydney, 2010 was the 18th consecutive year with above average maximum temperatures and similar conditions prevailed in Western Sydney (BoM, 2011), Climate projections for NSW suggest significant increases in the frequency of drought, increases in the frequency of hot days and increases in the frequency of high fire risk weather (DECCW, 2010b).

3.3 Increased Frequency and Intensity of Heatwaves and Impact to Air Pollution

The Australian Bureau of Meteorology defines a heatwave extreme event as three consecutive days with maximum temperatures above the 90th percentile for the month. In the Sydney-Central Coast region, the frequency of heatwaves has historically been higher in the west of the region where maximum temperatures are also higher than near the coast.

In the period 1979-2008, the north-western inland centre of Richmond had 29 spring-summer heatwave events and Parramatta had 21 spring and 19 summer heatwave events, comparative to 14 events for Sydney city (Observatory Hill) (DECCW 2010a). The importance of the sea-breeze in curtailing heatwaves is evident in the reduction in heatwave frequency in the east of the Sydney Basin (DECCW, 2010a).

"Modelling of observed frequency distributions of daily maximum near-surface temperatures at four sites in Sydney for the period 1998-2005 has shown an extended frequency of warmer temperatures for inland sites than those at the coast, as a result of the reduced maritime-climate influence seen at the coastal monitoring sites."

(CSIRO, 2008).

By 2050, maximum temperatures will increasingly exceed the 1979-2008 90th percentile. Current projections for temperature suggest increases in mean maximum temperature of 1·3°C by 2050 for all of NSW, almost certainly increasing the severity of heatwaves. Heatwaves are projected to become more severe because of higher temperatures as a result of climate change, and are likely to become more frequent (DECCW, 2010a).

Increased frequency of hotter temperatures can have significant effects on communities. Extremely high temperatures, especially prolonged over a number of days and nights, cause heat stress leading to human casualties during heatwaves (Woodruff et al. 2005) and significant increases in hospital admissions in Sydney (Khalaj et al. 2010).

The geographic structure of the Sydney Basin will exacerbate the impacts of hotter temperatures for Western Sydney, having consequent ramifications for air pollution, indicated by the link between hot, sunny days and high ozone pollution events (DECCW, 2010b; *Let's Clear the Air Trends and Projections*, OEH Clean Air Healthy Communities webpage).

It is likely that in a changing climate, future temperature-related health issues will be dependent on the adaptive capacity of populations, including improvements to building design.

(Woodruff et al. 2005).

Human health, productivity, community engagement, infrastructure and energy usage are all likely to be impacted by increased temperatures. There is a strong link between high temperatures and air quality due to the increased occurrence of ozone at higher temperatures. The projected increase in temperature is expected to increase days of high ozone and diminish Sydney's air quality (CSIRO, 2008).

High temperatures experienced during heatwaves also place enormous pressure on the electricity network and can damage transport infrastructure. All these impacts were experienced during the 2009 Southern Australia heatwave (NCCARF, 2010).

This heatwave event also had a significant impact on people, infrastructure and services in Melbourne. During this period, maximum temperatures were 12-15°C above normal. Emergency ambulance cases increased by 25 per cent and there were 374 more deaths than would be normally expected for that time of year. Almost a quarter of the city's rail services were cancelled and electricity services were under such stress that it reached a state of near collapse.

Heatwave frequency increases with distance from the coast, with Richmond experiencing almost twice the frequency of heatwaves as the Sydney Central Business District in the period 1979 - 2008.

(DECCW, 2010a).

The Office of Environment and Heritage and Australian Green Infrastructure Council (AGIC) have been working with NSW agencies, local governments and industry to develop a heatwave scenario to test the likely impacts of extreme temperature events on infrastructure assets, operations and service delivery on nominated NSW infrastructure sectors in Western Sydney. Derived from a qualitative perspective, the scenario found NSW rail and electricity infrastructure to be most vulnerable to extreme heat.

"Compared to the 100–150 years of historical observations, the 2009 heatwave in southern Australia was exceptional, producing severe, extensive and prolonged heat exposure. Climate change over the next 30–60 years will make such events more likely and test the resilience of the expanding metropolitan areas, unless forewarning and other adaptation strategies are successful."

(NCCARF, 2010)

3.4 Climate in the Sydney region

The climate of the Sydney-Central Coast region is warm-temperate. Sydney's daily summer temperatures are now 0.5-0.9°C hotter than the long term average and by 2050, the climate is virtually certain to be hotter, with temperatures ranges projected to increase by 1.5-3°C in all seasons (DECCW 2010, in the Metro Plan 2036; DECCW, 2010b).

The Sydney-Central Coast region experiences recurring, costly and significant natural hazards. The expected increases in temperature, evaporation and high fire risk days are likely to influence bushfire frequency and intensity across Sydney. Heatwaves have accounted for more deaths in Australia than any other natural hazard and place increased pressure on our hospitals and emergency management systems (NCCARF, 2010; Khalaj et al 2010; DECCW, 2010a; OEH 2011 *Climate Change Impacts- Health* web page).

It is likely that extreme heat will affect Western Sydney to a greater degree than Eastern Sydney due to topography and distance from cooling sea breezes (CSIRO, 2008; DECCW, 2010a).

Summer rainfall is likely to substantially increase across the Sydney region and the incidence of riverine flooding is likely to increase with exposure greater for communities around catchments (DECCW, 2010a).

While the exposure of individual locations to flooding and the associated impacts on flooding due to climate change need to be addressed by flood investigations in particular catchments and locations, increasing urban green cover can assist with slowing the flow of flood waters, increase absorption of run-off and water retention in the catchment.

Vegetation can increase the travel time of floodwaters, decrease downstream peak flood flows and potentially downstream flood levels. Careful local assessment should be made as increased vegetation can also result in a build up of increased upstream flood levels, therefore increasing vegetation in these areas may need a larger waterway area (see OEH Floodplains webpage, 2011). Utilising vegetation to control stormwater can replicate many of the hydrological processes in the natural environment (Hopkins and Goodwin, 2011).

CSIRO modelling shows that maximum daily temperatures currently exceed 30°C on about 40 days per year on average in the Hawkesbury basin for the current decade, and that this frequency decreases to about 25 days per year 10km inland of the coast, and reduces to about 5 days per year at the coast (CSIRO, 2008). By mid-century it is likely that there will be a 20-25 per cent increase in frequency of daily temperatures exceeding 30°C away from coastal areas.

(CSIRO, 2008)

4.0 PROPOSITION

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4.1 The Benefits of Green Cover

Public spaces play a major role in combating the effects of climate change, from moderating rising temperatures in cities to preventing flooding. Urban green cover can assist in mitigating the effects of increased temperatures and reduce the severity of flood events. Green cover may include bushland, private and community gardens, parks, greenways and corridors, street trees, and green roofs and walls. Green cover is an effective way to manage heat impacts in cities, store carbon, improve amenity and encourage walking and cycling.

Increasing green cover in urban environments can be achieved in a number of ways, from protecting local green spaces and designing eco-friendly buildings, through to creating a green space network. The foundations of an urban environment such as the 'traditional' built infrastructure of roads and public utilities aren't the sole basis of a successful, vibrant and resilient town or city. Green infrastructure, the living network of green spaces and environmental systems that surround us, is equally necessary and should be woven into the core of urban design and planning.

A growing awareness in Australia and globally of how green spaces can moderate the urban heat island effect and air pollution is occurring. Coupling growing public awareness and government policy may assist with increased funding for parks and green spaces to make our communities more resilient to climate change.

4.2 Quantifying the Benefits of Urban Green Cover

Studies to determine the benefits of urban green cover are in the early stages of development for Sydney. Preliminary assessments quantifying the benefits of urban green infrastructure have been undertaken in the USA and UK. It should be noted that while evidence from northern hemisphere studies can be indicative of the benefits of green cover for Sydney, specific studies in the Australian and/or NSW context are needed to accurately quantify green cover benefits in locations such as Sydney.

The City of Chicago commissioned a study in the early 1990s to explore the effects of the city's trees on its environment. The Chicago Urban Forest Climate Project (1994) report found that the city's 4.1 million trees were delivering a wide range of quantifiable benefits, such as providing pollution removal valued at $1 million (1994 value), storing 855,000 tons of carbon, reducing surface rain-water run-off and reducing the need for air-conditioning by intercepting up to 90 per cent of solar energy. It found that the larger the tree, the greater the effect to reduce city temperatures (CABE, 2008, *What makes an eco-town*?).

The thermal benefit of a green roof was shown in a study of green roofs in Singapore to be 30°C lower under the vegetation than on the hard paved surface. The study showed that vegetation on roofs cools the

ambient air temperature by up to 4.2°C (Johnson, 2004).

A study by Dr Stephen Lesiuk (1982, *People, Plants and Buildings - Micro climatic modification of plants*) found one mature tree potentially provides as much cooling as five, 3kW air-conditioners. Trees can cool buildings through intercepting most of the solar radiation that arrives at the top of the canopy.

Lesiuk also found that most plants have at least 36 times as much surface area for energy interception as a canvas awning. This means that a large tree can reduce the surface temperature of an iron roof by up to 30°C (Johnson, 2004).

The UK Commission for Architecture and the Built Environment (CABE) has identified the benefits of green infrastructure as getting more out of our natural environment to provide a better quality of life, healthier communities, a stronger local economy and higher biodiversity occurrence.

Specific to climate change, CABE identifies green infrastructure as:

1. Helping to adapt to the effects of climate change by:

- Creating cooler micro-climates and reducing the need to cool buildings
- Creating cooler micro-climates and making towns and cities more pleasant in hot weather
- Storing and intercepting rainwater and encouraging natural drainage, to prevent flooding
- Storing river flood water to reduce the risk of fluvial flooding e.g. through the restoration of floodplains; and
- Providing shelter and protection in extreme weather.

2. Mitigating climate change by:

- Absorbing and storing carbon;
- Reducing travel through provision of local recreation opportunities;
- Providing walking and cycling routes to reduce carbon emissions from vehicles;
- Supplying bio-mass or bio-fuels to directly replace fossil fuels;
- Supplying timber to replace less sustainable construction materials; and
- Increasing local food production to reduce food miles.

A 2007 study of Greater Manchester found that increasing green cover by 10 per cent could keep extreme surface temperatures at current levels until almost the end of the century despite climate change.

(*Climate Change and Urban Green Spaces,* Neighbourhoods, Cities and Regions Analysis Division, Communities and Local Government, UK Government)

5.0 STRATEGIES

5.0 STRATEGIES

Key strategies that are applicable to and achievable within the case study areas of Liverpool and Penrith and other Local Government Areas of Western Sydney have been identified.

GREEN COVER STRATEGIES:

1. Cool Roofs
2. Cool Walls
3. Cool Pavements
4. Cool Streets
5. Cool Carparks
6. Cool Canopies
7. Green Infrastructure

STRATEGY 1: COOL ROOFS

To introduce green roofs where possible to decrease heat absorption and radient heat from building rooftops, reducing ambient air temperatures and mitigating heat island effect. Green roofs can be extensive (low maintenance, minimal access) or intensive (accessable and usable rooftop garden or courtyard). Where green roofs are not possible due to structural loads, light coloured or reflective roofs are recommended.

BENEFITS:

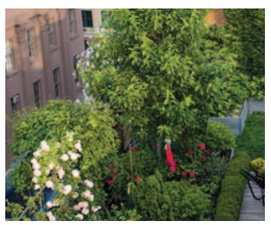
- Building heat absorption and radiation reduced
- Cooling effect
- Runoff mitigation
- Rainwater harvesting
- Air purification
- Sound insulation
- Reduced heating and cooling costs
- Amenity, increased usable square metrage
- Aesthetic value
- Habitat.

STRATEGY 2: COOL WALLS

To introduce green walls where possible to decrease heat absorption and radiant heat from buildings, reducing ambient air temperatures and mitigating heat island effect. Green walls can be low technology (suctioning climbing plants on wall with no support structure required) or high technology with structural support cables or frames or green wall technology. Heat absorption of buildings can also be reduced by shading the facade of a building.

BENEFITS:

- Building heat absorption and radiation reduced
- Cooling effect
- Runoff mitigation
- Air purification
- Sound insulation
- Reduced heating and cooling costs
- Aesthetic value
- Habitat.



Intensive green roof
New York

Extensive green roof
Ford Rouge Centre, Michigan

Low-technology green wall
Carpark, Wollongong NSW

Green facade

STRATEGY 3: COOL PAVEMENTS

Heat island effect can be mitigated through the reduction of hard paved areas and increased areas of mass planting, the use of more reflective (high albedo) light coloured pavements and permeable pavements.

BENEFITS:

- Decreased absorption of solar radiation
- Increased reflection of solar radiation with high albedo coloured pavements (light coloured)
- Greater night-time cooling
- Permeability reduces pavement temperature, reduces stormwater runoff, increases traction and safety and improves water quality.

STRATEGY 4: COOL STREETS

Cool streets can be achieved with and increase in canopy trees within the verge or carriageway, increased understorey planting, bioswales/ raingardens and verge and median planting.

BENEFITS:

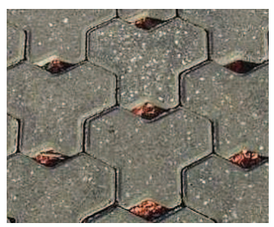
- Shade cover
- Street surface heat absorption and radiation reduced
- Cooling effect on ambient air temperatures
- Runoff mitigation
- Air purification
- Carbon store
- Aesthetic value
- Habitat
- Social and community benefits.

STRATEGY 5: COOL CARPARKS

Cool carparks include strategies of increased canopy tree plantings, median and bioswale plantings and the use of permeable pavements. Increased planted areas can be achieved through use of minimum carspace and aisle dimensions, planting to the 600mm car overhang beyond the wheel-stop and small reductions in carspace numbers if required. Rooftop carparks can include shade canopies (combining solar panels) or conversion or partial conversion to green roofs if feasible.

BENEFITS:

- Increased shade cover
- Decreased surface heat absorption and radiation
- Greater night-time cooling
- Permeable pavements reduces surface temperatures, surface runoff and improves water quality
- Planted bioswales manages stormwater runoff and decreases flooding risks
- Extended use of outdoor carparks in warmer months
- Reduced surface run-off increases traction and safety.



Permeable paving (Eco-trihex)

Light coloured, high albedo, heat reflective pavement

Tree-lined street
Cross Street, Double Bay

Bioswales and street trees
Chicago

Median planting in carpark
Penrith City Council carpark

Canopy trees in carpark

STRATEGY 6: COOL CANOPIES

Cool canopies includes the increase of canopy trees and shade provision to exposed grass areas, cycleways/footpaths, parklands and amenities. Shade structures (for example pergolas with climbing plants) also increase shade to surfaces and mitigate heat island effect.

BENEFITS:

- Reduced surface heat absorption and radiation
- Provision of shade
- Increased use of outdoor areas during warmer months
- Social, community and health benefits
- Habitat
- Aesthetic value.

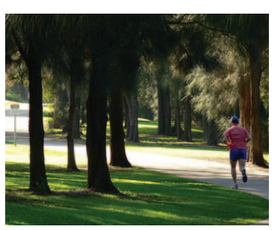
STRATEGY 7: GREEN INFRASTRUCTURE

Green infrastructure includes the use of Water Sensitive Urban Design principles to increase urban greencover and mitigate the heat island effect. This includes bioswales, raingardens, soft landscaped detention basins and dechannelisation of hard engineering to swales with mass planting and trees.

BENEFITS:

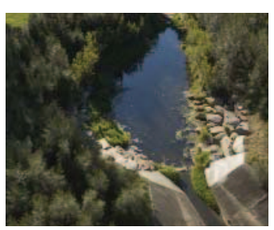
- Reduced hard surface concrete culverts and dish drains, reduces heat absorption and radiation.
- Stormwater management
- Decreased runoff
- Decreased flooding risk
- Reduced maintenance
- Improved water quality
- Flora and fauna habitat.

Shade canopy
Sydney Olympic Park



Canopy trees in parklands

Bioswale



De-channelisation
Restoring the Waters, Fairfield NSW

How to Read the Case Studies

Green icons indicate that the Green Cover Strategy was IMPLEMENTED in the case study.

Grey icons indicate that the Green Cover Strategy was NOT IMPLEMENTED in the case study.

6.0 CASE STUDIES

6.0 CASE STUDIES

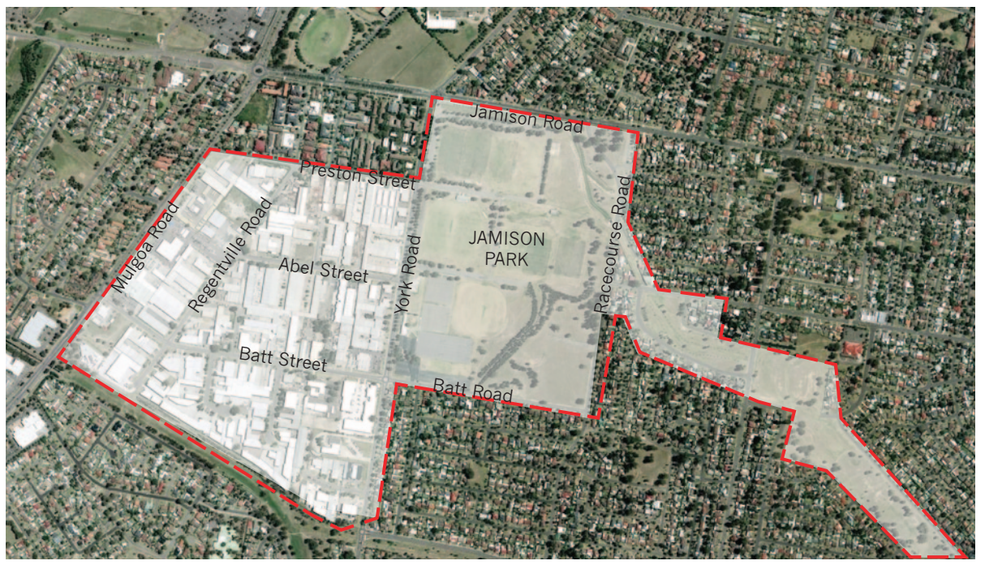
6.1 Study Areas

Liverpool City Centre and Penrith Jameson Park and Industrial area precinct were selected for their contrasting character and as examples of urban development in Western Sydney. The existing condition of both study areas were mapped to indicate the extent of heat island effect in these urban areas. Opportunities within each study area were identified to illustrate typical opportunities for heat island effect mitigation. The potential greencover was mapped if greencover strategies were applied across the study area to determine the potential benefit.

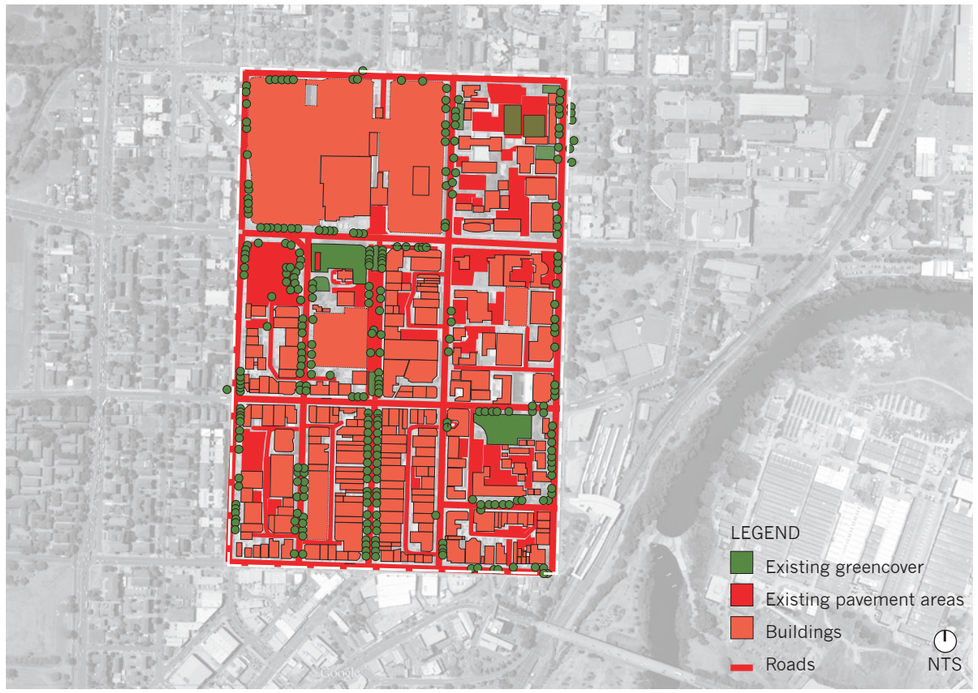
Liverpool is an urban town centre organised along a grid of streets lined with retail, civic and community buildings. While buildings are predominantly low scale there are a number of multi-storey office buildings and a large enclosed shopping centre.

The Penrith case study takes in a large scale park incorporating playing fields, netball courts and cycle path and a large adjoining industrial area.

Liverpool City Centre Study Area

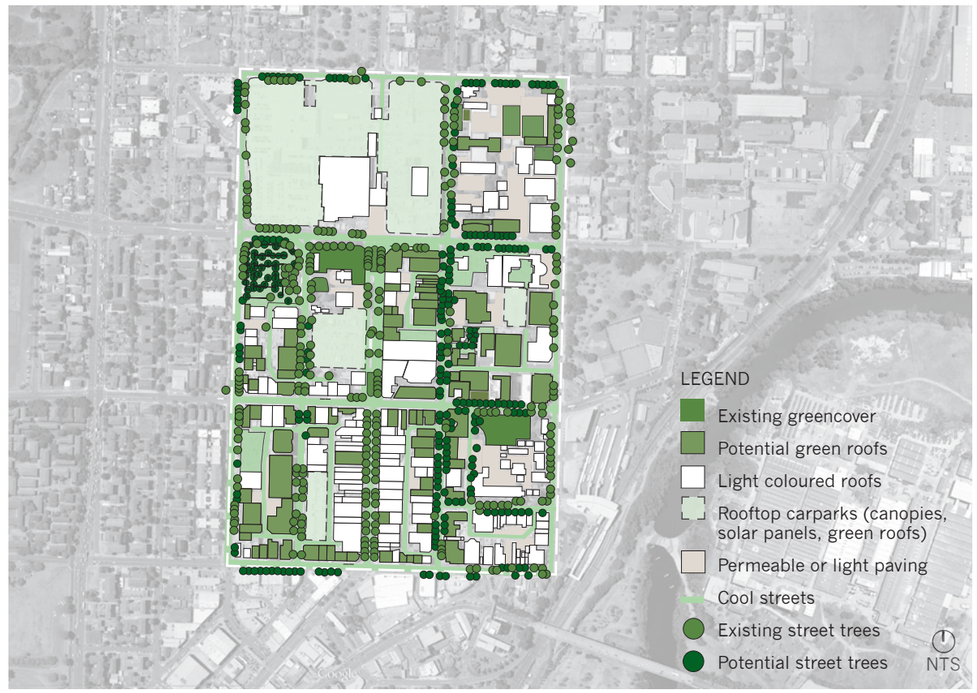


Penrith Study Area

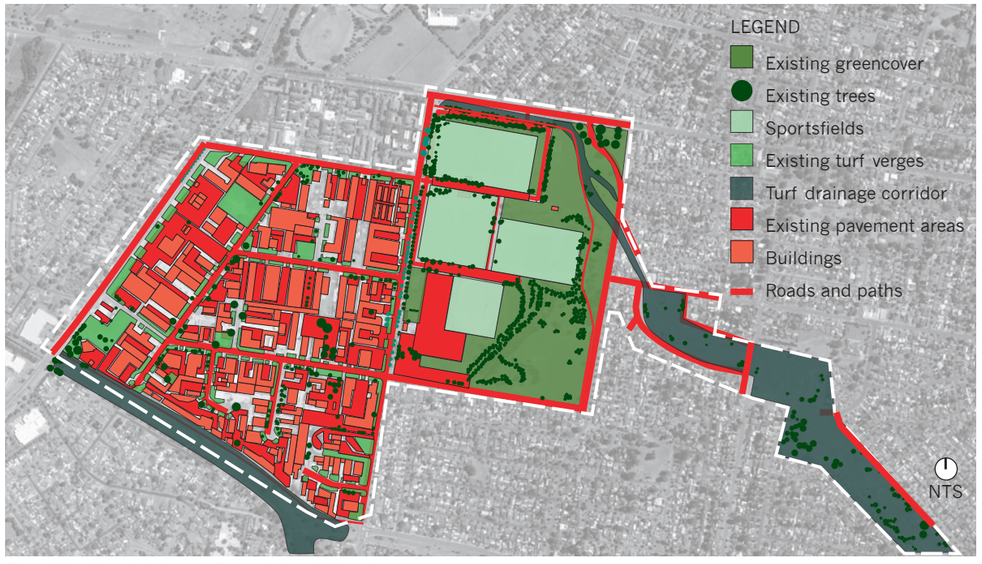


Liverpool City Centre Heat Island Effect Contributors
(roads, footpaths, carparks, paved areas & roofs)

Total = 95% of study area
42% in public domain



Liverpool Potential Greencover



Penrith Heat Island Effect Contributors
(roads, footpaths, carparks, paved areas & roofs)

Total = 40% of study area
Including unshaded grass Total = 72% of study area
= 53% in public domain

Penrith Potential Greencover

6.2 Liverpool City Centre

Demonstration projects in Liverpool City include:

1. Liverpool City Council Building Rooftops
2. Liverpool Library Forecourt
3. Bathurst Street surface carpark
4. George Street
5. Crawford Serviceway
6. Laneways

6.2.1 Issues

Issues identified during the workshop with Liverpool City Council representatives:

- Engineering Department concerns - pavements and services impacts;
- Maintenance;
- Cost of infrastructure - capital and ongoing;
- Loss of car parking;
- Vandalism – safety, security, surveillance;
- Perception that 'trees cause problems'; and
- Private sector acceptance and buy-in:
  - absentee landlords
  - retailers.

6.2.2 Opportunities

Not all situations are able to be utilised in every strategy, however these case studies aim to demonstrate the optimum potential for each situation. With the range of strategies available there is the possibility to pick and choose the appropriate solution(s) depending on resources, constraints and applications.

Opportunities identified during the workshops with Liverpool City Council representatives:

- Low hanging fruit – green lane wall, street trees;
- Council as exemplar – car parks, surface, building;
- Good property owners as exemplars;
- Education;
- PR-promotion;
- Partnering with private landowners; and
- Partnering with community groups.

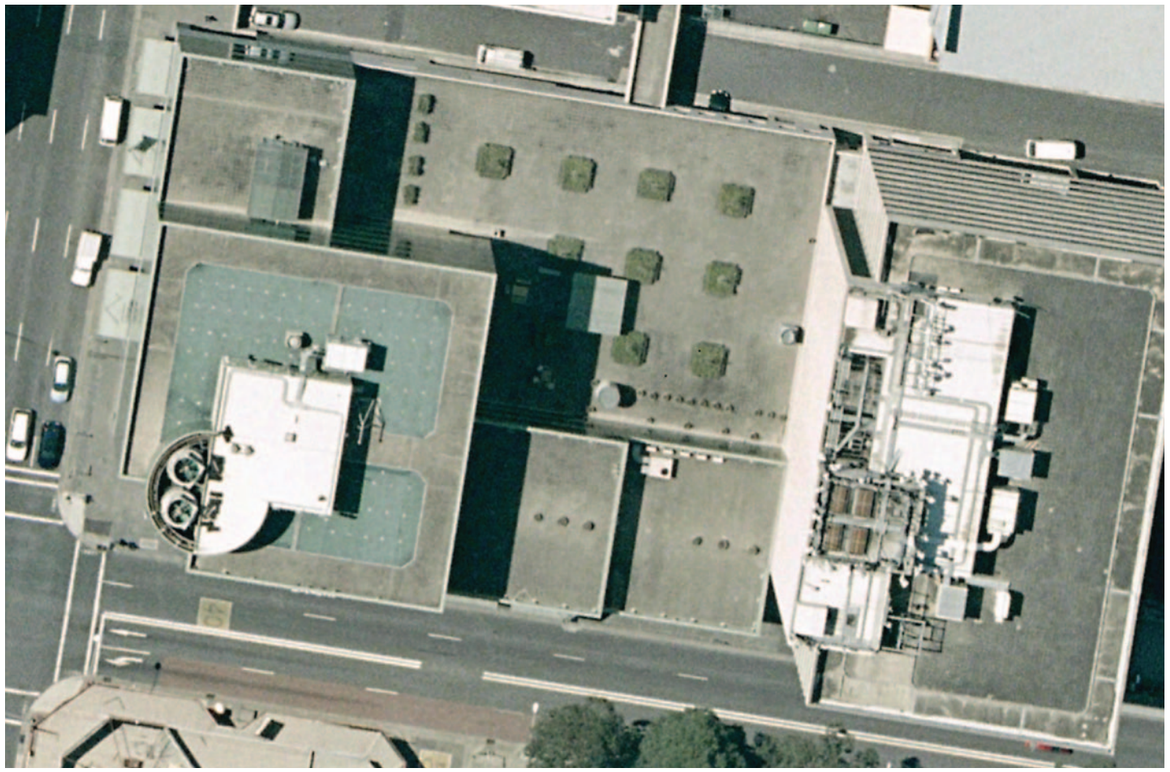
6.3 Liverpool Concept Designs

6.3.1 Liverpool City Council Building

The accessible rooftops of the Liverpool City Council offices are barren and under-utilised and offer green roof potential for staff breakout spaces.

Existing issues:

- Large surface areas of exposed hard pavement;
- High absorption of heat;
- Lack of shade;
- Glare and radiant heat from facade of adjacent building;
- Limited use due to high glare and heat;
- Lack of maintenance;
- Poor amenity (shade, seating, aesthetic value) for workers limits use of large square metreage of building; and
- Increased energy demand (air-conditioning) due to heat absorption.

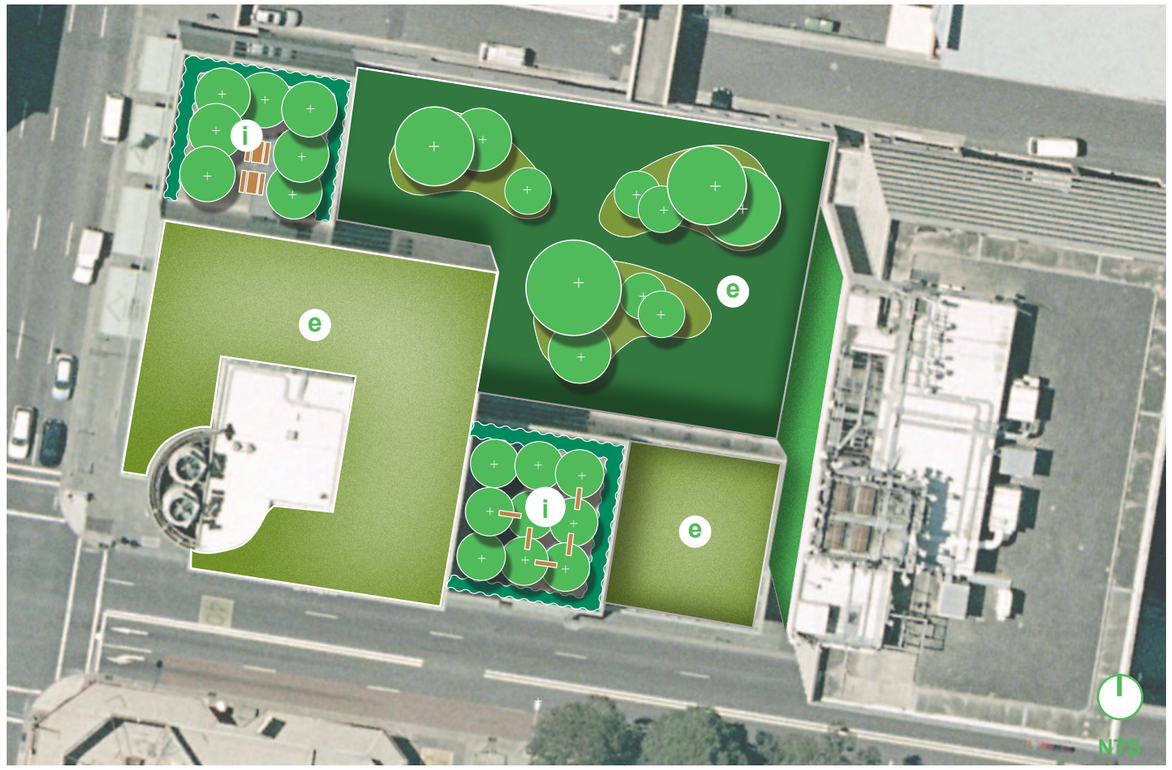


Liverpool City Council Building Rooftop: Existing Condition

Existing rooftop
Liverpool Council offices

Existing rooftop breakout area
Liverpool Council offices

Existing rooftop & adjacent party wall
Liverpool Council offices



Liverpool City Council Building Rooftop: Potential Greencover

POTENTIAL GREENCOVER

Key Moves:

- Extensive green roof;
- Intensive green roofs on accessible rooftops to provide staff amenity;
- Increased green ground cover and planter boxes to reduce exposed hard pavement surface area;
- Increase shaded areas through shade structures and canopy trees;
- Provision of seating in shaded areas; and
- Reduce glare through low tech green wall (climbing plant) and reduced hard pavement.

KEY

(i) Intensive green roof:
provides public or private amenity

(e) Extensive green roof:
infrequently accessed and low maintenance.

Strategies

Intensive green roof
New York

Extensive green roof, infrequent access

Extensive green roof

6.3.1 Liverpool City Council Building
continued

Liverpool City Council Building Rooftop: Intensive Green Roof Typical Sectional Elevation

Intensive green roof
Rockefeller Centre, New York USA

Intensive green roof
American Society of Landscape Architects Washington DC USA

Intensive green roof
City of Melbourne

Liverpool City Council Building Rooftop: Extensive Green Roof Typical Sectional Elevation

Liverpool City Council Building Rooftop: Extensive Green Roof Typical Sectional Elevation

Benefits:

- Reduced hard pavement surface area reduces heat absorption and radiant heat of building;
- Green cover provides thermal insulation;
- Increased lifespan of roof structure;
- Reduced energy demand (air-conditioning and heating) reduces emissions;
- Surface run-off minimised;
- Opportunity to collect and harvest rainwater;
- Increased shade reduces heat absorption through hard pavements and provides shade for workers, increasing usable space of building;
- Respite from urban and office environment;
- Habitat for fauna; and
- Educational tool and Council as exemplar.

Applications:

- Accessible slab rooftops or dis-used courtyards (structural engineering advice on increased loads required); and
- Commercial and medium-high density residential buildings.

Chicago City Hall green roof
Chicago USA

Extensive green roof
Ford Rouge Center, Michigan USA

Extensive green roof

6.3.2 Liverpool City Library Forecourt

The library forecourt is a popular destination point for visitors, workers, including family groups and school children visiting the library or passing through to the council carpark. Due to its lack of shade and extent of pavement it is inhospitable on hot sunny days.

Existing issues:

- Large surface areas of exposed hard pavement;
- High absorption of heat;
- Lack of shade;
- Glare and radiant heat from facade of adjacent building;
- Limited use due to high glare and heat;
- Lack of maintenance;
- Poor amenity (shade, seating, aesthetic value) for workers limits use of large square metreage of building;
- Increased energy demand (air-conditioning) due to heat absorption; and
- No deep soil planting.

Liverpool City Library Forecourt: Existing Condition

Expansive, exposed hard paved forecourt
Liverpool City Library NSW

Existing shade structure
Liverpool City Library NSW

West-facing exposed bare wall
Liverpool City Library NSW

Liverpool City Library Forecourt: Potential Greencover

POTENTIAL GREENCOVER

Key Moves:

- Raised turf and mass planting areas;
- Reduce exposed hard pavement surface area;
- Provision of informal seating on edges of raised areas;
- Incorporation of existing public artwork into raised planters; and
- Low tech green wall (climbing plant) to northern Library wall facing the carpark.

LEGEND

- Existing trees
- Proposed Trees
- Raised mass planting
- Raised turf area
- Green wall

Benefits:

- Reduced hard pavement surface area;
- Reduced heat absorption and radiant heat;
- Shading to western building frontage;
- Green wall on northern and western library wall provides thermal insulation;
- Reduced energy demand (air-conditioning and heating) reduces emissions;
- Surface run-off minimised;
- Provision of shade;
- Increased usability of space in warmer months; and
- Maintains pedestrian circulation and gathering spaces.

Applications:

- Forecourts and building aprons; and
- Civic spaces.

Strategies

Raised planters with tree planting & seating edge

Urban plaza with raised planters & tree plantings

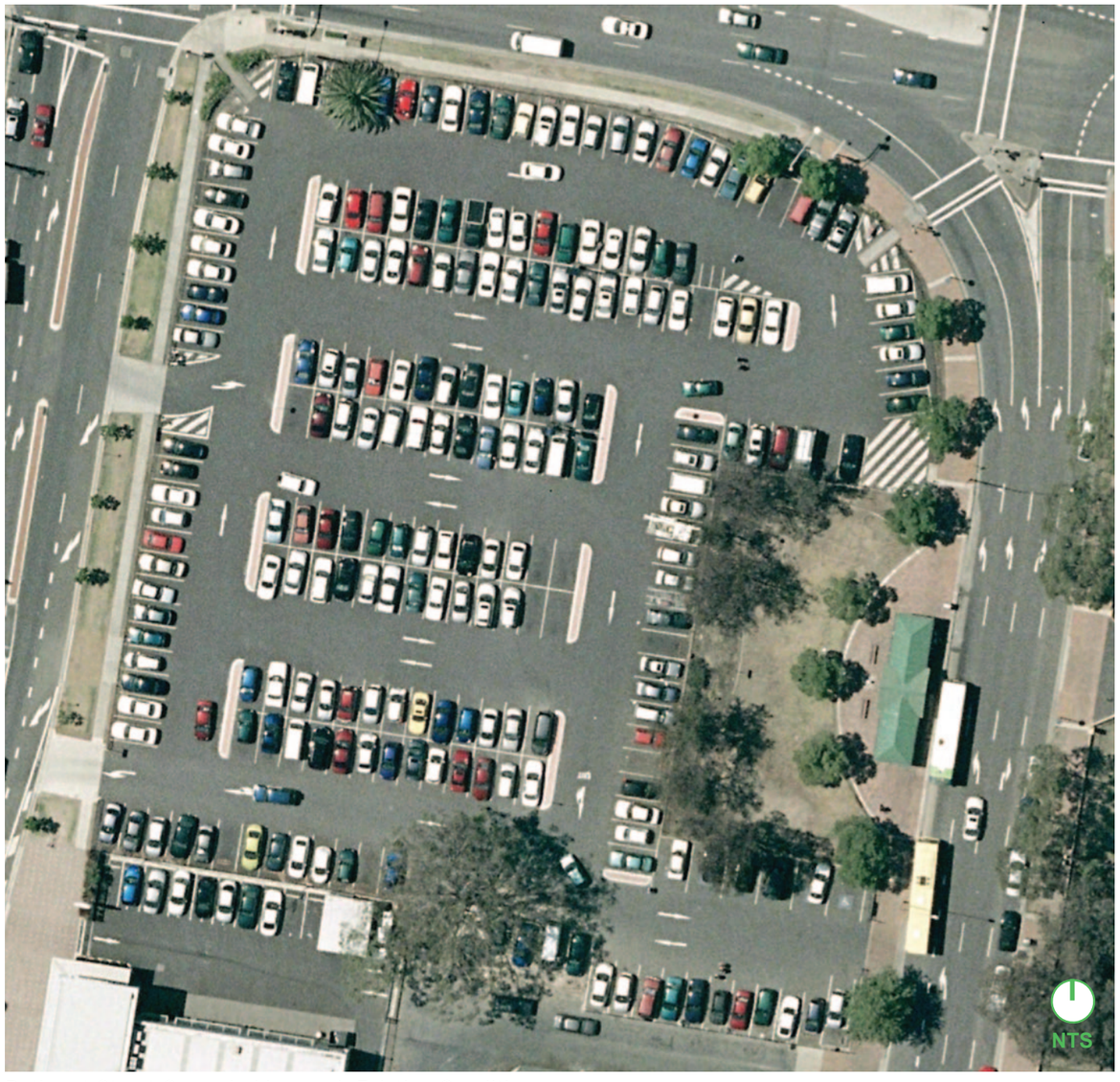
Urban plaza with raised planters & tree plantings

6.3.3 Bathurst Street Carpark, Liverpool

This surface carpark is typical of many in Liverpool and other urban centres, lacking in shade and amenity for users and a significant contribution to the heat island and surface stormwater.

Existing issues:

- Large surface areas of exposed hard pavement;
- High absorption of heat;
- Lack of shade;
- Glare and radiant heat;
- Contribution to Heat Island Effect; and
- Increased surface runoff.



Bathurst Street Carpark, Liverpool: Existing Condition

Lack of canopy trees
Bathurst Street Carpark, Liverpool NSW

Exposed hard paved areas
& absence of canopy trees
Bathurst Street Carpark, Liverpool NSW

Lack of canopy trees and shade
Bathurst Street Carpark, Liverpool NSW

Large areas of exposed pavement lead
to increased glare and radiant heat
Bathurst Street Carpark, Liverpool NSW

Bathurst Street Carpark, Liverpool: Potential Greencover

LEGEND

- Existing trees
- Proposed Trees
- Mass planting/ swales
- Permeable pavement

POTENTIAL GREENCOVER

Key Moves:

- Planted swales between parking bays introduced to reduce exposed hard pavement surface area;
- Aisle widths reduced to minimum 5800mm;
- Canopy trees to provide shade to pavement and cars; and
- Permeable pavement to carspaces.

Strategies

6.3.3 Bathurst Street Carpark, Liverpool continued

Swale

Mounded Median

Kerb Blister/ Median Planting

Bathurst Street Carpark, Liverpool: Typical Sectional Elevation A-A

Benefits:

- Reduced hard pavement surface area;
- Reduced heat absorption and radiant heat;
- Shading to pavement and cars;
- Reduced surface run-off;
- Stormwater managament;
- Increased use of carpark in warmer months;
- Aesthetic value; and
- Habitat creation.

Applications:

- Surface carparks (public and private).

Bioswale in carpark & permeable pavement to car spaces

Canopy tree and mass planting
Penrith City Council Carpark

Mounded & mass planted median with canopy trees
Penrith City Council Carpark

Canopy trees providing shade for parked cars

Canopy tree in car park

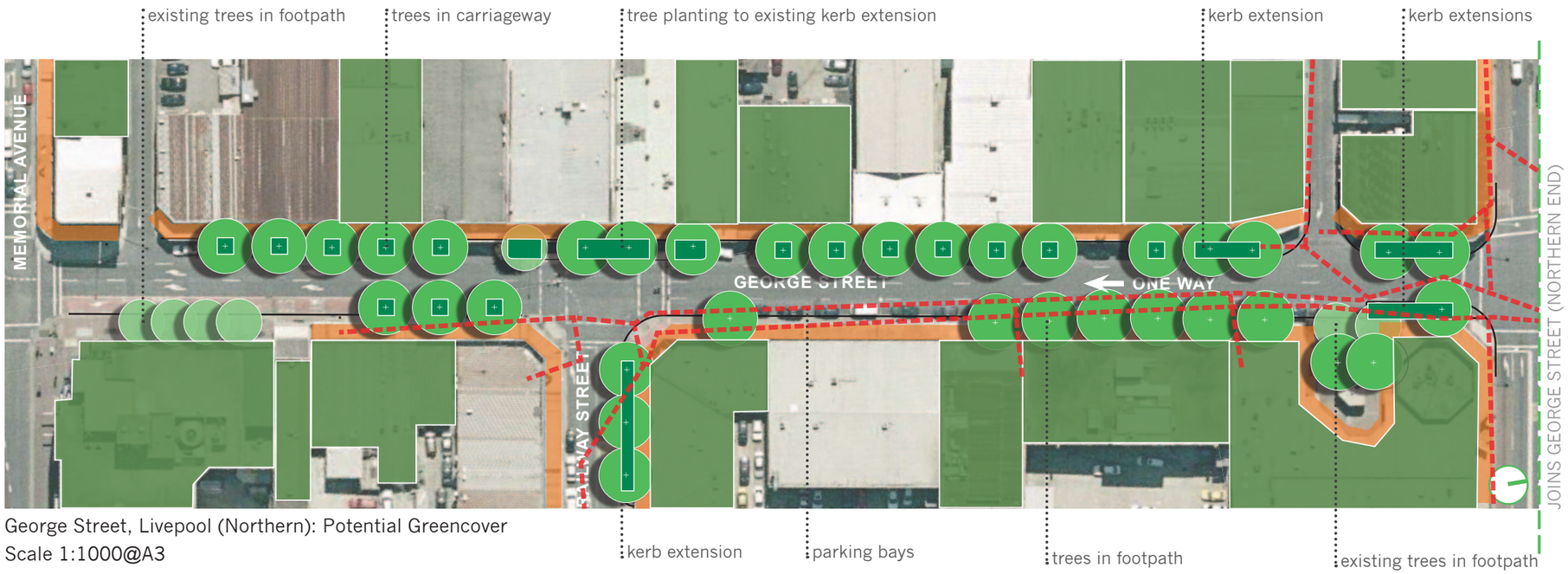
Mass planted median & tree planting in carpark
Blaxland Common, Sydney Olympic Park

6.3.4 George Street, Liverpool

George Street is the main street characteristic of most urban centres with many constraints (awnings, light poles, kerb crossings) limiting extensive planting.

Existing issues:

- Large surface areas of exposed hard pavement;
- High absorption of heat;
- Lack of shade to exposed asphalt;
- Glare and radiant heat;
- Priority to kerbside parking spaces;
- Services;
- Awnings; and
- Contribution to Heat Island Effect.



George Street, Livepool (Northern): Potential Greencover
Scale 1:1000@A3


Southern end George St, looking South


Southern end George St - awnings, exposed road and building surfaces


Corner of George St and Railway St

George St Southern end - limited existing street trees


George St Southern end - limited existing street trees


Intersection of George and Moore St, looking South

POTENTIAL GREENCOVER

Key Moves:

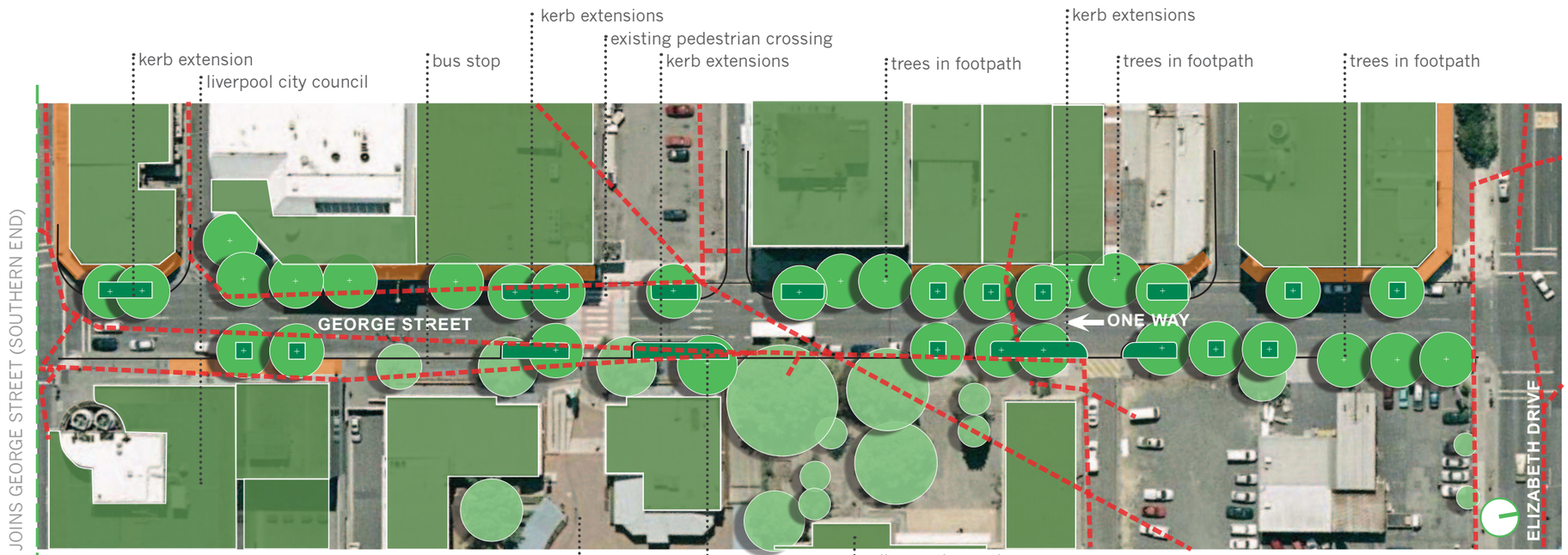
- Continuous green along kerb line;
- Opportunistic planting;
- Increase number of street trees;
- Increase mass planting in verges and tree blisters; and
- Canopy trees to provide shade to pavement.

Benefits:

- Continuous green along kerb line achieved by a flexible approach to street tree set-out according to underground services locations;
- Reduced hard pavement surface area;
- Reduced heat absorption and radiant heat, cooling effect;
- Shading to pavement and cars;
- Air purification;
- Carbon store; and
- Surface run-off mitigation;
- Traffic calming;
- Habitat for fauna; and
- Aesthetic value.

Applications:

- Streets within Council Town Centre (setout and location varies due to underground services locations);
- Council's Street Tree and Landscape Strategy (Liverpool Civic Improvement Plan, Liverpool Contributions Plan 2007); and
- Capital Works projects.



George Street, Livepool (Northern): Potential Greencover
Scale 1:1000@A3


George Street Southern end, looking South


George Street Southern end, existing street tree in pavement


George Street Southern end · bus stop


George Street Southern end · pedestrian crossing to Library


George Street Southern end · expansive hard paved verge

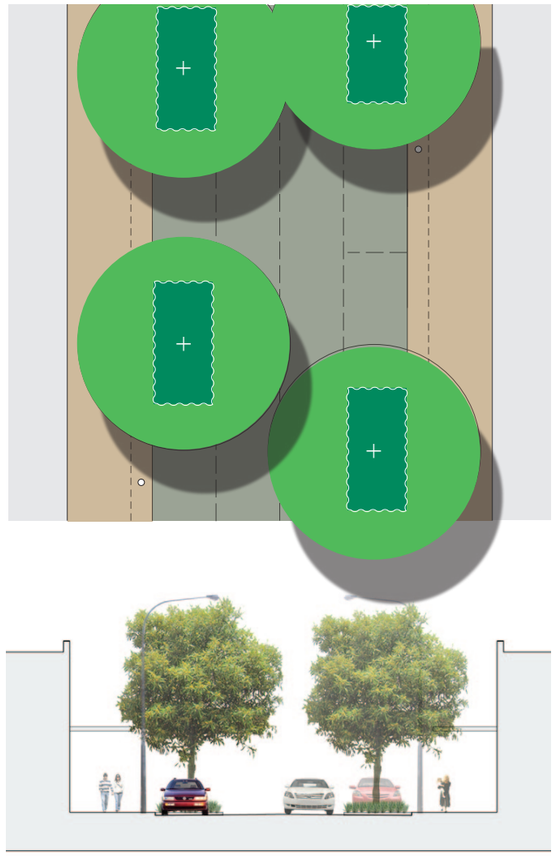

George Street Southern end, looking North · lack of street tree planting

6.3.4 George Street, Liverpool continued

A flexible approach to street tree planting and setout can be achieved using a combination of street tree planting details and opportunistic planting. Rather than one rule of detail for street tree planting in one street, an opportunistic approach increases the number of street trees by utilising the detail best suited to the immediate verge or carriageway conditions, underground or overhead service locations or obstructions.

Street tree planting details that could be used in combination along an urban street length are:

- Kerb blisters / extensions in the road carriageway, including a street tree and understorey planting;
- Street trees in the road carriageway without a kerb extension - street tree with understorey planting, a lower-cost solution than kerb extensions;
- Tree trench - a continuous trench along the verge that includes mass planting or bioswale that incorporates street tree planting;
- Trees in footpath - street tree planting in paved verges with either mass planting understorey or tree grates; and
- Kerb extensions at intersections or corners: may be used to increase opportunity for street tree planting and mass understorey planting while also reducing road crossing width for pedestrians and creating outdoor dining areas.

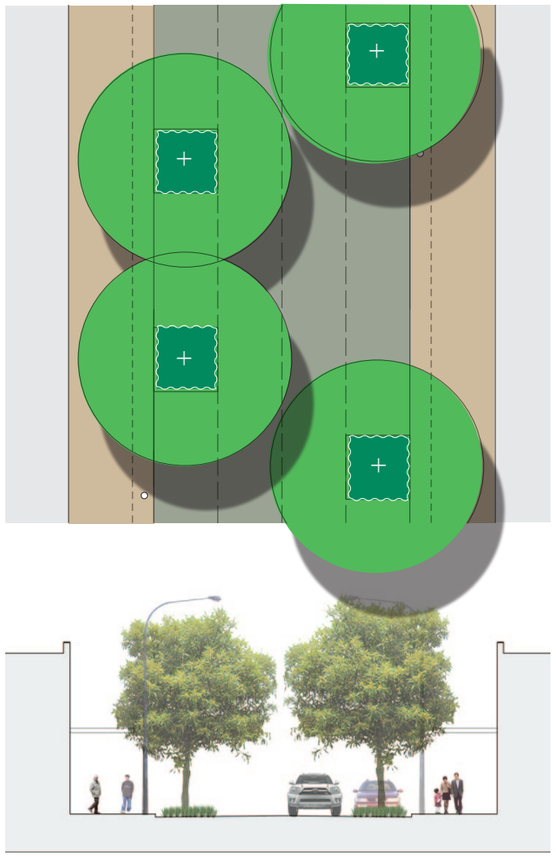


KERB BLISTERS IN CARRIAGEWAY

APPLICATIONS:

- Where services located in footpath; and
- Where awnings restrict tree growth.

(Source: Department of Planning and Infrastructure, *Draft Centres Design Guidelines*, 2011)

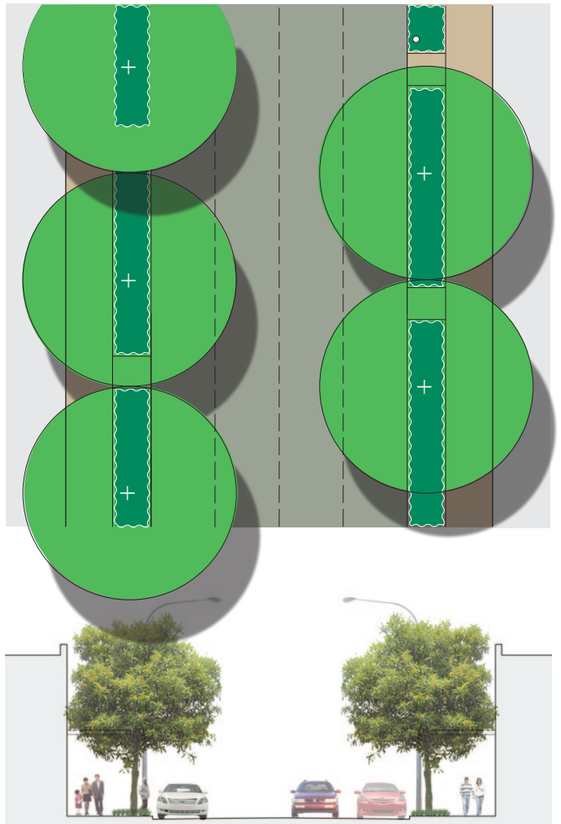


TREES IN CARRIAGEWAY WITHOUT KERB BLISTER

APPLICATIONS:

- Where services located in footpath;
- Where new kerb extensions not possible or viable; and
- Where awnings restrict tree growth.

Street trees in parking lane without kerbing
Cross Street, Double Bay NSW

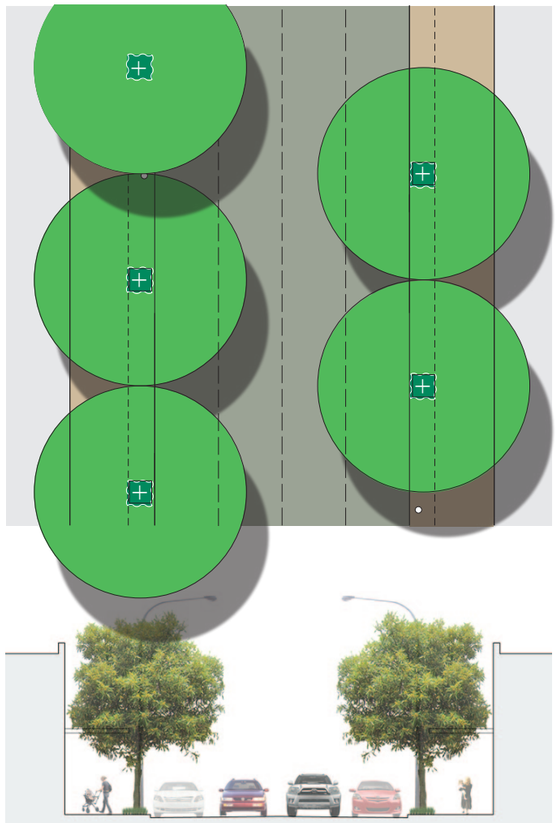


TREE TRENCH

APPLICATIONS:

- Where services located in carriageway;
- Where there is an absence of awnings;
- High foot traffic; and
- Where there are bus lanes, turning lanes or carriageway can not be obstructed.

Bioswale and street tree planting
Portland

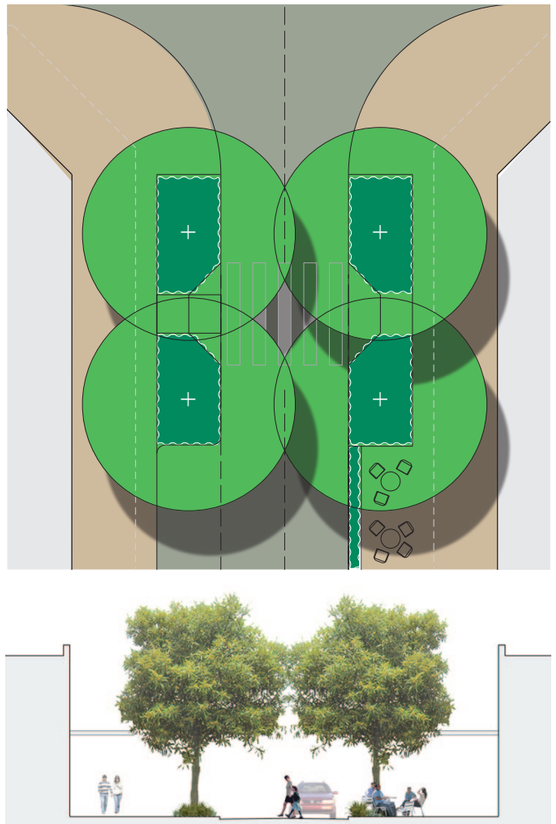


TREES IN FOOTPATH

APPLICATIONS:

- Where services located in carriageway; and
- Where there is an absence of awnings.

(Source: Department of Planning and Infrastructure, *Draft Centres Design Guidelines*, 2011)



KERB EXTENSIONS AT INTERSECTIONS

APPLICATIONS:

- Corners;
- Pedestrian crossings;
- Outdoor dining areas;
- Where turning lanes are not required; and
- Where traffic calming is required.

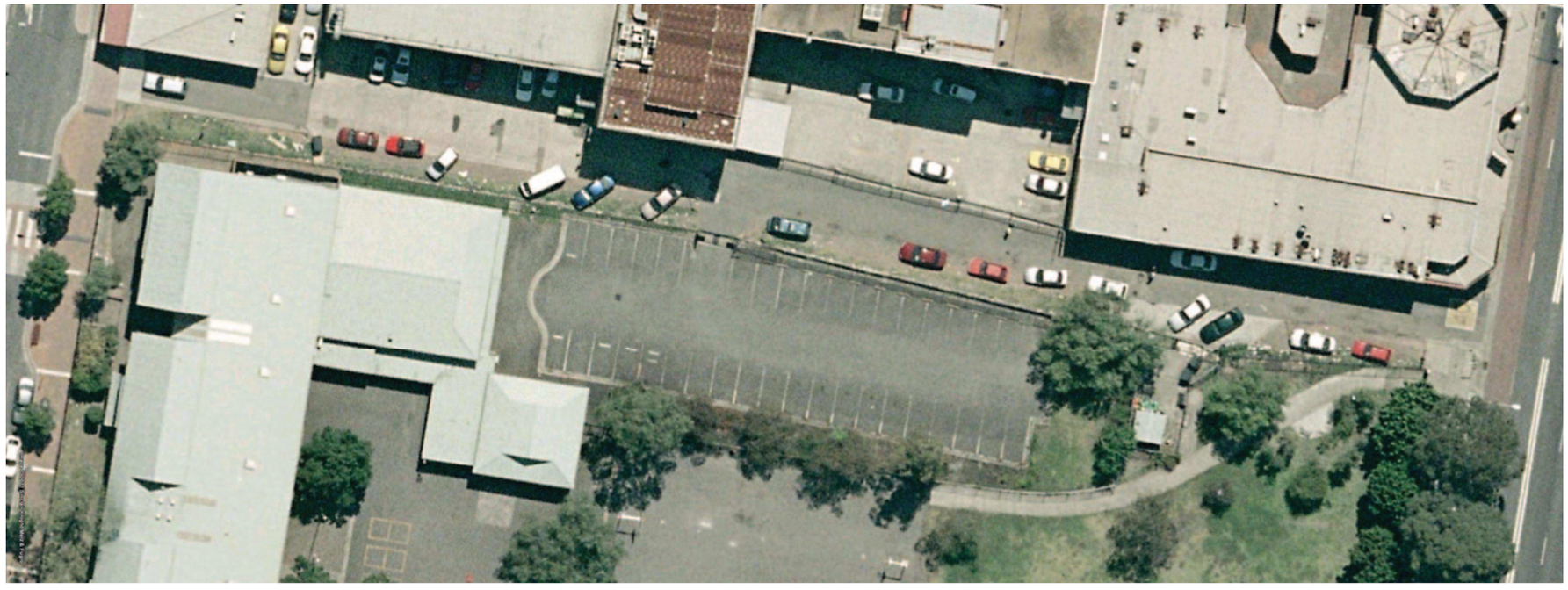
(Source: Department of Planning and Infrastructure, *Draft Centres Design Guidelines*, 2011)

6.3.5 Crawford Serviceway, Liverpool

The service laneway is typical of most town centres with no footpaths or verge. The right of way is hard pavement from boundary to boundary, exacerbating hard surface absorption, albedo and surface run-off.

Existing issues:

- Large surface areas of exposed hard pavement;
- High absorption of heat;
- Lack of shade;
- Glare and radiant heat from facade of adjacent building;
- Limited use due to high glare and heat; and
- Lack of maintenance;
- Poor amenity (shade, seating, aesthetic value) for workers limits use of large square metreage of building; and
- Increased energy demand (air-conditioning) due to heat absorption.



Crawford Serviceway, Liverpool: Existing Condition

View South of Crawford Serviceway from Council Offices rooftop

View of Crawford Serviceway with rear of George Street retail property

Looking East at Intersection of Crawford Serviceway & Moore Street

POTENTIAL GREENCOVER

The approach is opportunistic with green walls being the simplest and easiest to implement for this site.

Key Moves:

- Parking along laneway ordered to parallel parking;
- Permeable pavement to parking spaces;
- Footpath along school fence with mass planting to both sides of fence;
- Kerb blisters incorporating street tree planting and mass planting in carriageway;
- Permeable or light coloured pavement to carpark within school;
- Median or swale tree planting in school carpark; and
- Low technology green walls (climbers).

Benefits:

- Reduced heat absorption and radiated heat of hard paved areas reduces ambient air temperatures;
- Shade provision to cars and pedestrians;
- Reduced surface run-off;
- Aesthetic value; and
- Habitat creation.

Applications:

- Laneways, serviceways and share-ways;
- School drop off zones; and
- Surface carparks.

Potential Green wall and street tree planting (view North)

Crawford Serviceway, Liverpool: Potential Greencover

Strategies

LEGEND

- Existing trees
- Proposed Trees
- Mass planting/ swales
- Permeable paving

6.3.6 Serviceways and Laneways, Liverpool

There are a number of serviceways in Liverpool City centre that are typical of most town centres with no footpaths or verge. The right of way is hard pavement from boundary to boundary exacerbating heat island build up and surface run-off.

Existing issues:

- Large surface areas of exposed hard pavement;
- High absorption of heat;
- Glare and radiant heat from facade of adjacent building;
- Hot air from air-conditioning units;
- Lack of maintenance or care for back-of-house service entries;
- Service access, delivery truck turning circles and clearance; and
- Increased energy demand (air-conditioning) due to heat absorption of hard surfaces.

POTENTIAL GREENCOVER

Key Moves:

- Low-tech green wall - creeping plants on bare wall surfaces;
- Opportunistic planting;
- Permeable paving; and
- Water Sensitive Urban Design.

Benefits:

- Green walls reduce exposed hard surfaces and provide cooling effect on ambient air temperatures;
- Reduced energy demand and operational costs;
- Run-off mitigation;
- Improved aesthetic value for typically neglected back of house laneways; and
- Habitat.

Strategies

Low-technology green wall at rear of property

Non-invasive climbing plant

Permeable soak pit in laneway
Chicago Green Alleys

Non-invasive climbing plant

Existing *Parthenocissus* green wall in a Liverpool laneway

6.4 Penrith

Demonstration projects in Penrith included:

1. Jameson Park
2. Jameson Park drainage culvert
3. Jameson Park Batt Street Carpark and Netball precinct
4. Batt Street
5. Industrial Precinct - green roofs

6.4.1 Issues

Issues identified during the workshop with Penrith City Council representatives include:

- Engineering Department concerns - pavements and services impacts;
- Maintenance and including street sweeping;
- Cost of infrastructure both capital and ongoing;
- Vandalism – safety, security, surveillance;
- Perception that 'trees cause problems';
- Private sector buy-in - partnerships with industrial asset or property owners;
- Deciduous trees for winter sun;
- Fruiting trees around netball courts can create slip-hazards; and
- Lighting of netball courts - ensuring that trees do not obstruct or overshadow.

6.4.2 Opportunities

Not all situations are able to be utilised every strategy, however these case studies aim to demonstrate the optimum potential for each situation. With the range of strategies available there is the possibility to pick and choose the appropriate solution(s) depending on resources, constraints and applications.

Opportunities identified during the workshop with Penrith City Council representatives include:

- Low hanging fruit – green lane wall, street trees;
- Council as exemplar – car parks, surface, building;
- Good property owners as exemplars;
- Education;
- PR-promotion;
- Partnering with private landowners and the community; and
- A program for Jameson Park, such as creating a destination and attraction (e.g. large children's playground).

6.5 Penrith Concept Designs

6.5.1 Jameson Park, Penrith

Jameson Park is typical of many parks, predominantly containing playing fields and netball courts. There is little shade or amenities to enable extended hours of usage.

Existing issues:

- Large surface area of exposed dark asphalt carpark and netball courts absorbing and radiating heat;
- Large areas of exposed turf/ limited canopy trees to central areas of park;
- Lack of shade to cycle/pedestrian path;
- Lack of shade for sports spectators; and
- Concrete drainage culverts.

Jameson Park, Penrith: Existing Condition

Existing amenities building, exposed concrete apron & concrete dish drain

Playing field and cycleway with lack of shade

Dark coloured exposed netball court surface and expansive unshaded turf

Expansive unshaded turf and cycleway

Unshaded playground & amenities

New tree plantings near dog park

Jameson Park, Penrith: Potential Greencover

POTENTIAL GREENCOVER

Key Moves:

- Increase shade through canopy tree planting;
- Reduce exposed turf areas;
- De-channelisation of drainage network;
- Cool car parking;
- Permeable paving in carparks; and
- Replace court surface with lighter pavement.

Benefits:

- Reduced heat absorption and radiant heat;
- Shade cover;
- Reduced ambient air temperatures;
- Runoff mitigation;
- Cooler surrounding air temperatures;
- Reduced maintenance costs (removal of mown turf);
- Increased use of park and cycle network in warmer months;
- Social and health benefits;
- Air purification;
- Carbon store;
- Aesthetic value; and
- Habitat creation.

Applications:

- Local and regional parks and sports fields;
- Drainage channels and corridors; and
- Open space.

LEGEND

- Existing trees
- Proposed Trees
- Mass planting/ swales
- Permeable or light coloured pavement

Strategies

6.5.2 Drainage culvert, Jameson Park

Open concrete stormwater channels are typical of the urban setting. While managing stormwater, there is little positive contribution to the amenity, ecology and hydrology of the locality.

Existing issues:

- Large surface area of exposed dark asphalt carpark and netball courts absorbing and radiating heat;
- Large areas of exposed turf/ limited canopy trees to central areas of park;
- Lack of shade to cycle/pedestrian path;
- Lack of shade for sports spectators; and
- Concrete drainage culverts;

POTENTIAL GREENCOVER

Key Moves:

- De-channelisation of drainage network;
- Replace exposed turf drainage corridors with bioswale, native grass and reed plantings;
- Canopy tree planting along corridor perimeters;
- Canopy tree planting along cycle network;
- Cool car parking; and
- Permeable paving in carparks.

LEGEND

- Existing trees
- Proposed Trees
- Mass planting/ swales
- Permeable or light coloured pavement
- Cycle path

Strategies

Jameson Park Drainage Channel and Cyclepath Typical Section: Potential Greencover

Benefits:

- Increase in green cover and reduction of hard surfaces;
- Urban stormwater management;
- Increased stormwater infiltration to water table;
- Flood management;
- Connected green recreation corridor of pedestrian and cyclepaths;
- Cooler surrounding air temperatures;
- Reduced maintenance costs (removal of mown turf);
- Increased use of park and cycle network in warmer months;
- Social and health benefits;
- Air purification;
- Carbon store;
- Aesthetic value; and
- Habitat creation.

Applications:

- Concrete drainage culverts;
- Drainage easements; and
- Adjacent roadways and carparks.

Exsiting concrete culvert, Jameson Road

Restoring the Waters de-channelisation project, Fairfield

Bioswale
Blaxland Common, Sydney Olympic Park

6.5.3 Batt Street Carpark, Jameson Park

This surface carpark is typical of many found at local and regional parks and other urban centres, lacking shade and amenity for users. Surface carparks are a significant contributor to the heat island effect and stormwater run-off.

Existing issues:

- Large surface area of exposed dark asphalt carpark and netball courts absorbing and radiating heat;
- Large areas of exposed turf/ limited canopy trees;
- Lack of shade to cycle/pedestrian path;
- Lack of shade for sports spectators; and
- Concrete drainage culverts.

Batt Street Carpark, Jameson Park, Penrith: Existing Condition

Expansive, exposed dark coloured, heat absorbing asphalt car park

Expansive, exposed dark coloured, heat absorbing netball courts

Carpark, looking East along Batt St

Looking East along Batt St

Expansive, exposed dark coloured, heat absorbing netball courts & exposed amenities

Concrete dish drain between netball courts

Batt Street Carpark, Jameson Park, Penrith: Potential Greencover

GREENCOVER

Key Moves:

- Increase canopy trees in carpark;
- Reduce exposed turf areas with increase in canopy trees;
- Swale planting between rows;
- 600mm beyond wheel stop mass planted - minimum area of carspace hard paved;
- Permeable paving to carparks and high albedo pavement (high solar reflectivity) to road surface;
- Lighter pavement colour (high albedo) to netball courts;
- Increase shade for sports spectators with shade structures and canopy trees (non-fruiting);
- Concrete dish drain (north of netball courts) replaced with bioswale; and
- Street trees along Batt Street.

LEGEND

- Existing trees
- Proposed Trees
- Mass planting/ swales
- Permeable or light coloured pavement

Strategies





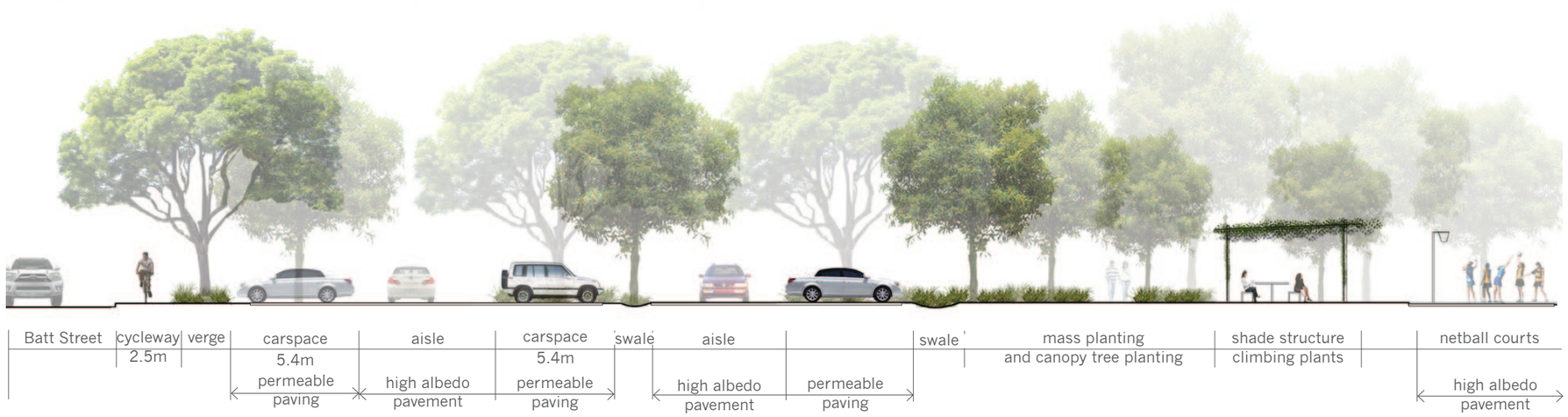

6.5.3 Batt Street Carpark, Jameson Park continued

Benefits:

- Shade provision for carparking and sports spectators;
- Reduction of ambient air temperatures;
- Reduced hard paved area;
- Run-off mitigation through swales, mass planting and permeable pavements;
- Increased use of park in warmer months;
- Social and health benefits;
- Aesthetic value; and
- Habitat creation.

Applications:

- Local and regional parklands, and
- Surface carparks (city centres and parks).



Batt Street Carpark and Netball Courts, Jameson Park, Penrith: Typical Section Potential Greencover

Kerb Blister/ Median Planting

Mounded Median

Swale

6.5.3 Batt Street, Penrith

Batt Street is characteristic of most streets in the industrial area with wide carriageways, little or no street tree planting, wide turf verges and building setbacks. There is little demand for on-street parking. Constraints include overhead powerlines to one side of the street, numerous driveways entries and frequent truck access requiring larger turning circles. The expansive dark coloured asphalt pavement is a significant contribution to the heat island effect.

Existing issues:

- Large surface areas of exposed hard pavement (roads and concrete aprons to industrial buildings);
- High absorption of heat;
- Lack of street trees and canopy trees;
- Expansive turf verges;
- Glare and radiant heat;
- Low demand for on-street parking spaces;
- Services;
- Overhead powerlines;
- Driveway entrances;
- Turning circles for trucks entering industrial / commercial properties; and
- Contribution to Heat Island Effect.

Batt Street, Penrith: Existing Condition

SCALE 1:2000 @ A3

Wide carriageways and low demand for on-street parking

Generous building setbacks and expansive turf verges

Wide carriageways, low demand for on-street parking, overhead powerlines

Wide carriageways, lack of street trees, low demand for on-street parking, overhead powerlines

POTENTIAL GREENCOVER

Key Moves:

- Opportunistic planting;
- Increase number of street trees;
- Increase mass planting in verges;
- Canopy trees to provide shade to pavement;
- Trees in carriageway on side of street with powerlines;
- Trees in verge where no powerlines overhead; and
- Trees in verge to both sides of footpath.

Batt Street, Penrith: Potential Greencover

SCALE 1:2000 @ A3

Strategies

6.5.3 Batt Street, Penrith continued

Benefits:

- Flexible approach to street tree set-out according to underground and overhead services;
- Reduced hard pavement surface area;
- Reduced heat absorption and radiant heat, cooling effect;
- Shading to pavement and cars;
- Air purification;
- Carbon store;
- Surface run-off mitigation;
- Traffic calming;
- Habitat for fauna; and
- Aesthetic value.

Applications:

- Streets within industrial area (set-out and location varies according to underground and overhead services locations).

Batt Street, Penrith: Typical Road Plan and Section

6.5.4 Industrial Precinct

POTENTIAL GREENCOVER

Key Moves:

- Lightweight extensive green roofs (structural engineering advice on increased loads required);
- In instances where a green roof is not possible, roof to be white or light coloured reflective finish;
- Partnership with private sector businesses that are encouraging sustainability programs;
- Mass planting to replace turf verges;
- Street trees;
- Permeable pavements to carparks; and
- Low tech green walls - climbing plants trained to expansive bare walls.

Benefits:

- Green roof provides thermal insulation;
- Increased lifespan of roof structure;
- Reduced energy demand (air-conditioning and heating), lower operational costs and reduction in green house gas emissions;
- Surface run-off minimised;
- Opportunity to collect and harvest rainwater;
- Increased shade reduces heat absorption through hard pavements;
- Habitat for fauna; and
- Property owners or businesses as exemplars.

Applications:

- Flat roofed industrial buildings or big box retail developments

LEGEND

- Existing trees
- Proposed Trees
- Extensive green roof
- Mass planting/ swales
- Permeable paving

Strategies


Expansive green roof on commercial building
Germany


Expansive green roof on industrial building


Expansive green roof
Ford Rouge Center, Michigan USA


Low-technology green wall on commercial building


White, reflective industrial roof


White, reflective industrial roof

7.0 CONCLUSION

The key findings of this study were:

• There are a range of potential strategies to reduce urban heat impacts in NSW, including:

- Cool Roofs;
- Cool Walls;
- Cool Pavements;
- Cool Streets;
- Cool Carparks;
- Cool Canopies; and
- Green Infrastructure.

The case studies of the Green Cover Demonstration Design Project aim to demonstrate the optimum green cover potential of the focus sites in Liverpool and Penrith local government areas.

The green cover strategies outlined in this report may not be possible to apply in entirety to every potential site. This report is intended to exhibit a range of green cover principles and strategies available to NSW councils and property owners to pick and choose the appropriate solution(s) depending on resources, constraints and applications. Furthermore, different strategies can be employed over time to build up the total green cover picture over the long term under an adaptive management approach.

The development of pilot projects are intended to draw attention to the issues and benefits of green cover in an urban environment.

For example, low cost, low technology and 'business as usual' strategies can be implemented in the short-term to increase urban green cover and contribute to mitigating the urban heat island effect incrementally.

Some short-term achievable strategies include:

• low-technology green walls planting non-invasive climbing plants at the base of bare walls (e.g. serviceways, carparks). Where deep soil is not available for planting climber, small saw-cuts in the pavement or planter boxes provide adequate soil;

• tree planting in schools, parks and open space through community and bush regeneration programs; and

• implementing changes in surfaces to permeable or lighter coloured pavements as part of capital works maintenance and replacement programs.

This study demonstrated that existing programs such as capital works, street improvements, routine paving programs could be recalibrated to capture additional benefits over and above amenity and utility to address heat island effect and mitigate climate change. This can be done with only minor adjustment to councils forward planning and programming.

Through this approach and by taking 'low hanging fruit' opportunities, council can achieve quick wins on the ground and over time make a significant impact on the heat island effects, liveability and amenity of Western Sydney.

The scope of this project was necessarily limited in scope due to its limited time frame, however a number of follow up actions are recommended to complement this work.

8.0 RECOMMENDATIONS AND NEXT STEPS

The scope of this project was necessarily limited in scope due to its limited time frame, however a number of follow up actions are recommended to complement this work.

8.1 Recommendations beyond the Green Cover Demonstration Project:

Communication

a) Present the Green Cover Demonstration project to Penrith and Liverpool Councils.

b) Communicate the Greencover Demonstration Project results to local governments, State agencies, industry and the community.

c) Develop education and outreach programs that target both school children and the broader community.

d) Publicise pilot projects

e) Advise Australian Institute of Landscape Architects (AILA) members of project outcomes and opportunities.

Further Studies

f) Improve the evidence-base on the micro-climate impacts of green cover.

g) Improve the evidence-base on the co-benefits and cost benefits of green cover.

h) Develop practical, technical guidelines and typical details for council staff and built environment professionals to demonstrate applications of green cover.

Implementation

i) Investigate options to promote green cover through the planning systems. For example, controls that encourage green roofs and where green roofs are not feasible, light coloured roofs.

j) Develop indicative costings for the detailed design and construction of green cover projects based on Green Cover Demonstration Project examples. Assess options from the Green Cover Demonstration Project for consistency with the Civic Improvement Plan for the Liverpool City Centre prepared by Liverpool Council and the Department of Planning and Infrastructure.

k) Investigate grant funding options to fund construction of pilot projects based on the Green Cover Demonstration Project.

l) Encourage Liverpool Council to incorporate the options in the Green Cover Demonstration Project in the Liverpool Council building refurbishment.

m) Encourage councils to investigate options to fund the construction of pilot projects based on the Green Cover Demonstration Project.

n) Investigate incentives to encourage property owner investment in green cover initiatives.

o) Develop recognition program for exemplary green cover projects that promote heat island mitigation undertaken by local government, State agencies, community and the private sector.

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APPENDIX

ANALYSIS AND PRINCIPLES: LIVERPOOL CITY CENTRE AND PENRITH

Greencover Demonstration Project

prepared for Greencover Demonstration Project
for the Department of Environment, Climate Change and Water (DECCW)
April 2010

NSW GOVERNMENT Environment, Climate Change & Water

Public Works
Government Architect's Office

LEGEND

Liverpool City Centre

NTS NORTH

CONTEXT: LOCATION

LEGEND

Study area

STUDY AREA =427,300 M²

EXISTING GREENCOVER

NORTH

LEGEND

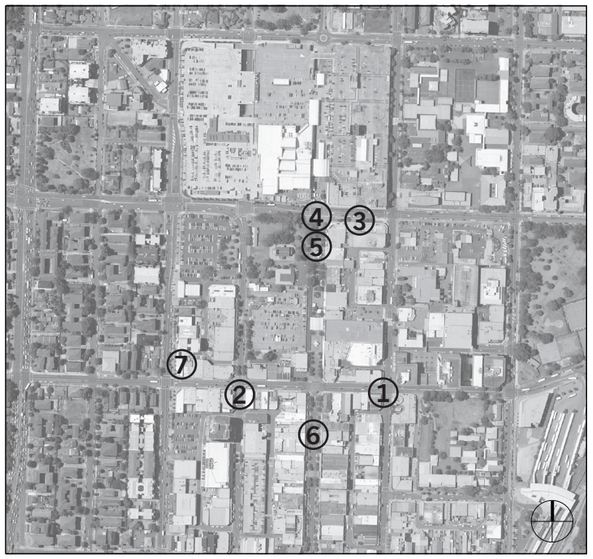
- Street Trees
- Planter Boxes
- Parks
- Schools - green space

EXISTING GREENCOVER

George Street Southern End

Northumberland Street Southern End

Elizabeth Street



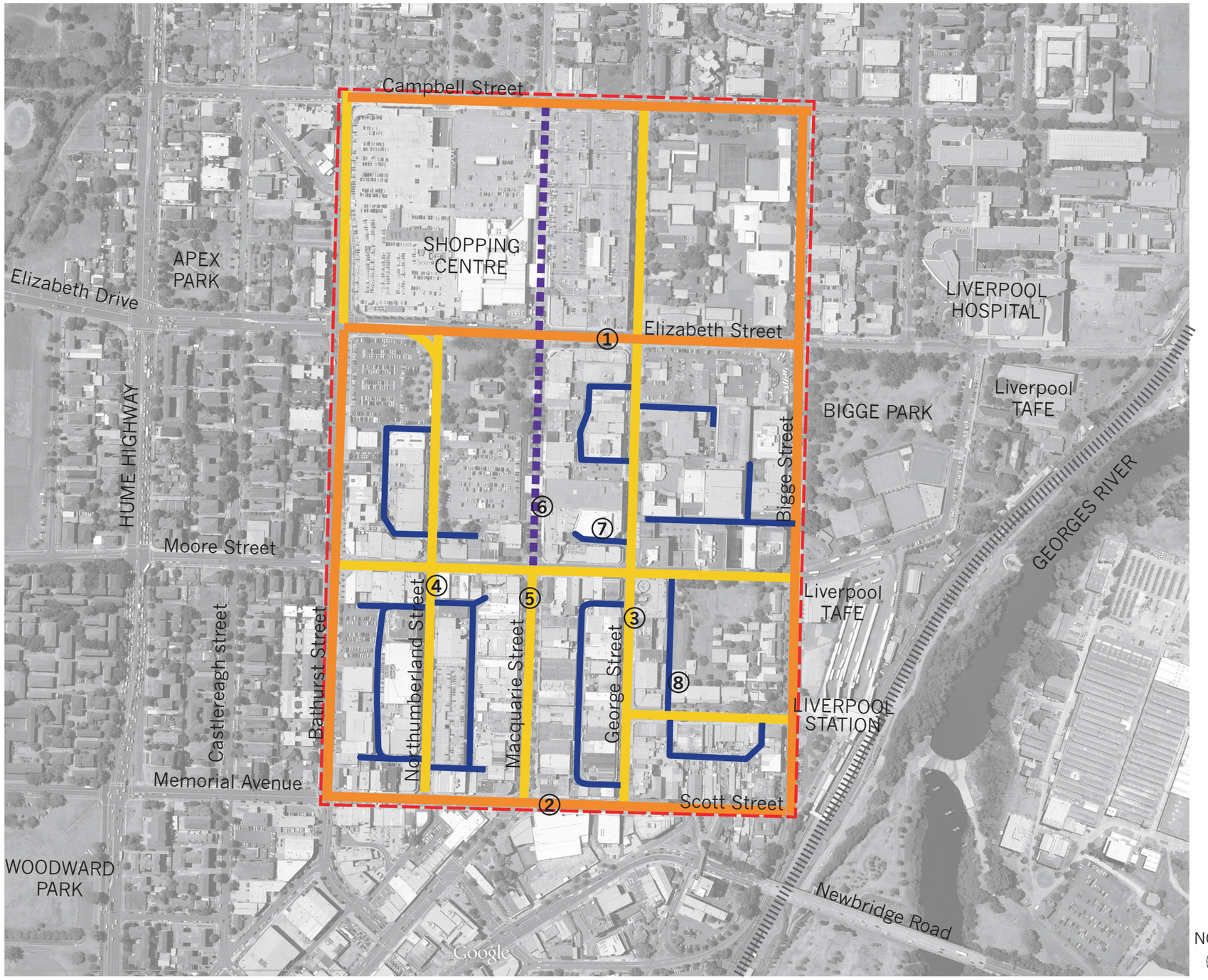
Elizabeth Street cnr Macquarie Mall view West

Macquarie Mall Northern End

Macquarie Street Southern End

Corner Bathurst and Moore Street

GROUND PLANE - ROADS AND STREET



LEGEND

- Secondary Roads = **2,300 linear m = 46,000 M²**
- Local Roads = **2,210 lin m = 44,200 M²**
- Laneways = **1,995 lin. m = 17,946 M²**
- Pedestrian Mall (Macquarie Street) = **500 lin. m = 10,000**
- ① Photos (refer folllowing page)
- Railway line

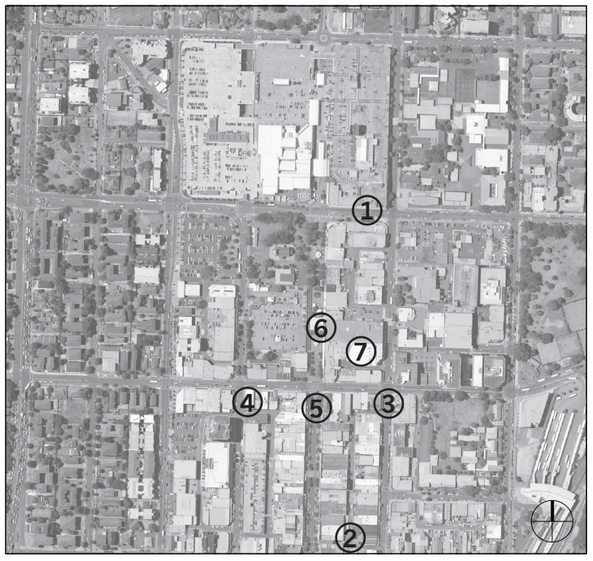
TOTAL = 118,146 M²

GROUND PLANE - ROADS AND STREET

Elizabeth Street

Memorial Avenue

Macquarie Street



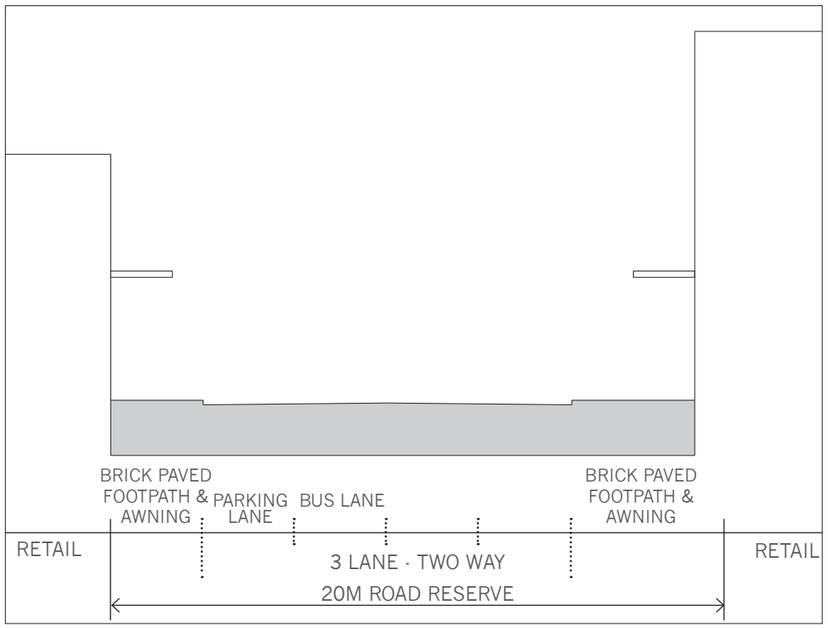
George Street

Northumberland Street

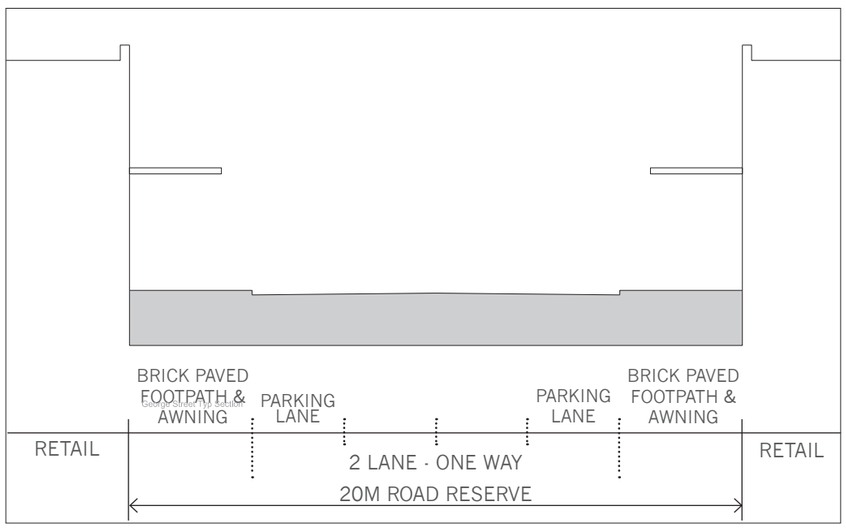
Macquarie Mall

Serviceway

GROUND PLANE - ROADS AND STREET - SECTIONS

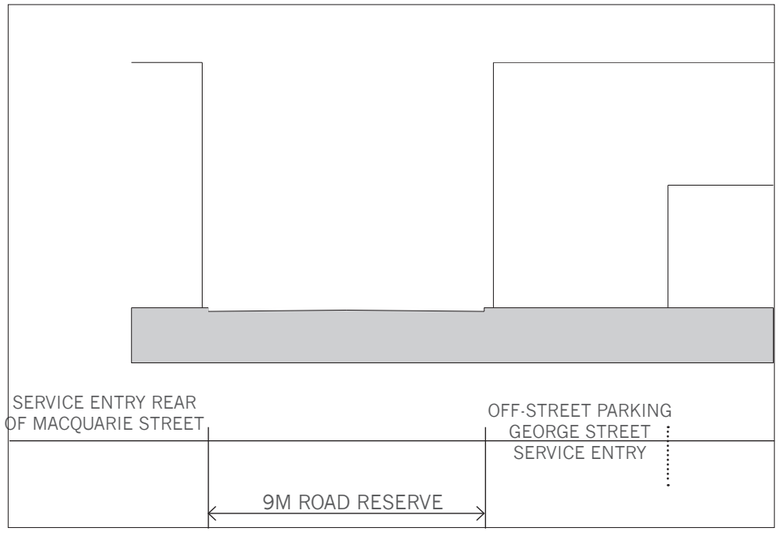


TYPICAL STREET SECTION - MEMORIAL AVENUE



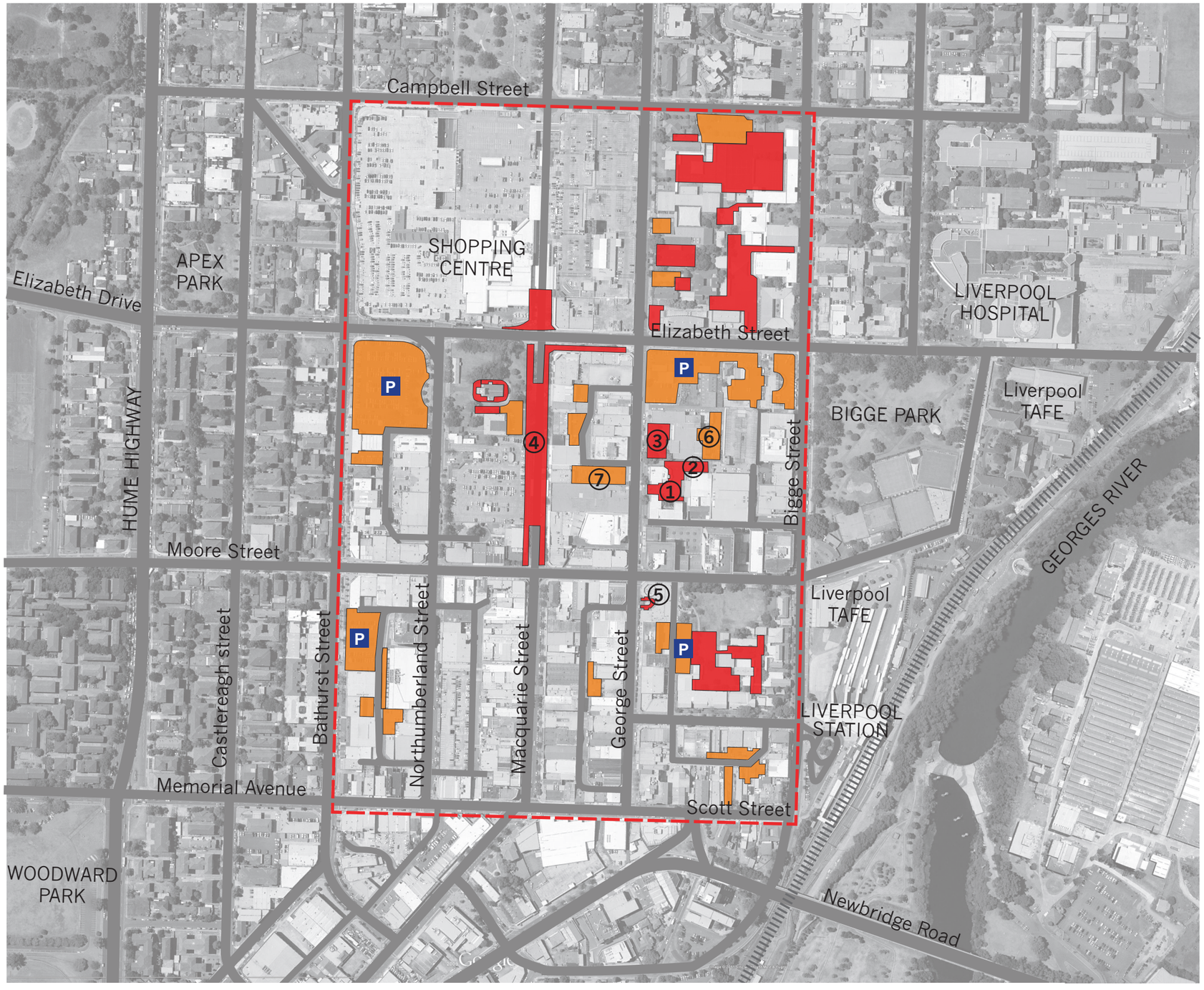
TYPICAL STREET SECTION - GEORGE STREET

GROUND PLANE - ROADS AND STREET - SECTIONS



TYPICAL STREET SECTION - SEVICEWAY

GROUND PLANE - SURFACE CARPARKS / PLAZAS / FORECOURTS



NORTH

LEGEND

- Surface Carparks
- Hard Paved Areas: Forecourts, Plazas & Malls
- ① Photos (refer following page)
- Study Area

TOTAL AREA = 59,500 M²

GROUND PLANE - SURFACE CARPARKS / PLAZAS / FORECOURTS

Liverpool City Library Forecourt ·
unit pavers

Library Forecourt (North) · access to carpark ·
dark concrete pavers

Liverpool Police Station Forecourt ·
unit pavers

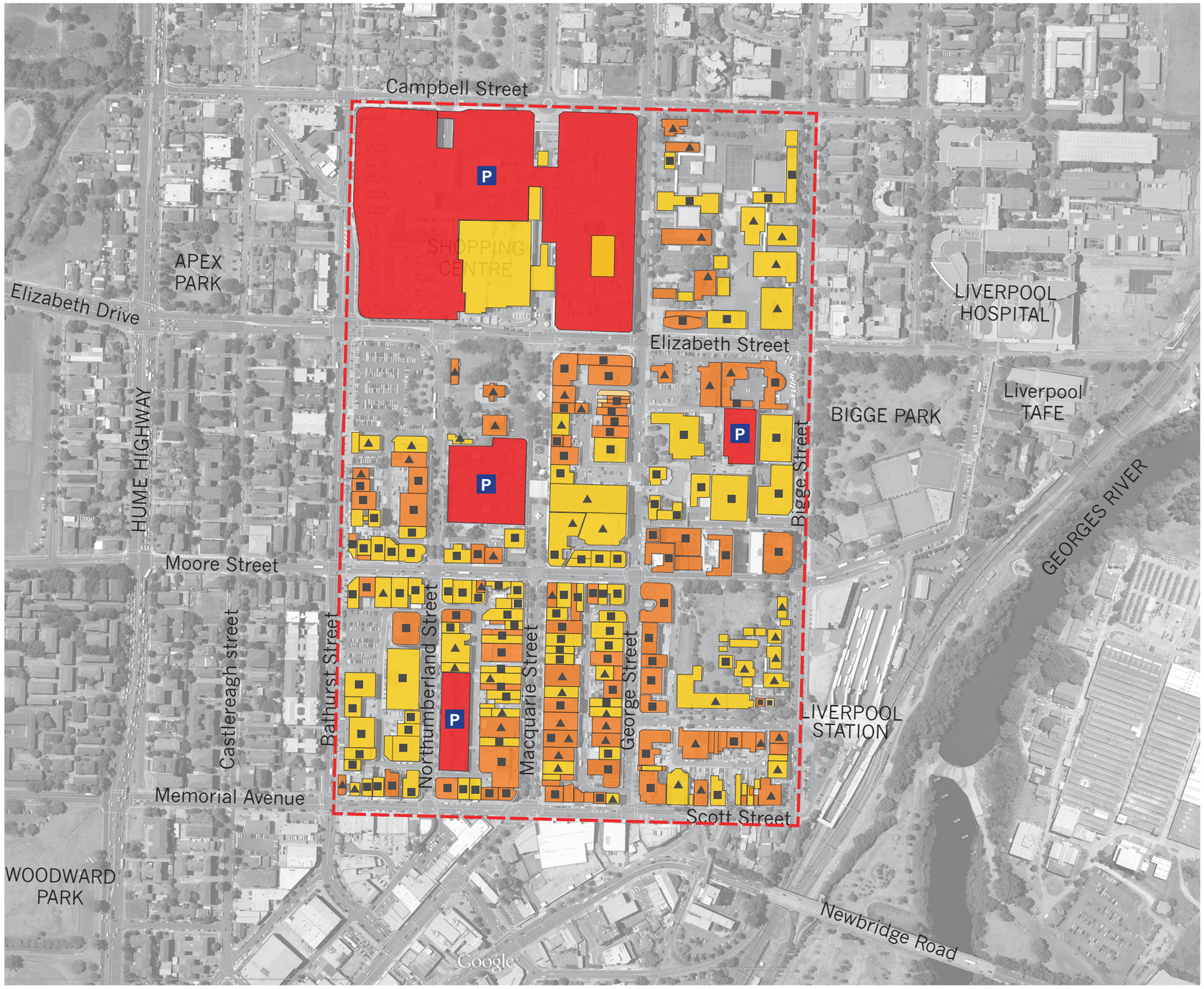
Macquarie Mall · brick paving

Retail Plaza (George Street) · pebble crete

Surface Carpark · to rear of Police Station ·
· asphalt

Surface Carpark
· Hanwell Serviceway & George Street
· asphalt

BUILDINGS - ROOFS



LEGEND

- Dark Roof
- Light Roof
- Flat Roof
- Peaked/ Sloped
- Rooftop Carparks
- Study Area

TOTAL AREA = 220,320 M²

BUILDINGS - WALLS / OVERHEAD STRUCTURES / AWNINGS

LEGEND

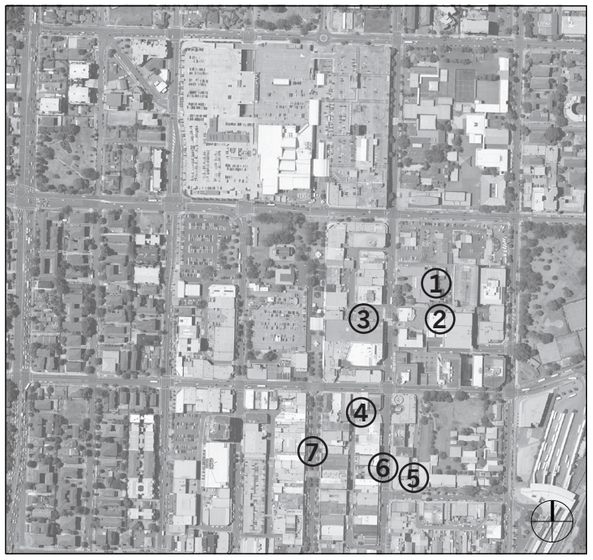
- Overhead Structures - canopies, shade structures, overhead bridges
- Bare Walls - large exposed
- Awnings = **3,530 linear metres = 10,590 M²**
- ① Photos (refer following page)
- Study Area

BUILDINGS - WALLS / OVERHEAD STRUCTURES / AWNINGS

Liverpool Police Station Southern Wall

Liverpool City Library Entrance

Hanwell Serviceway



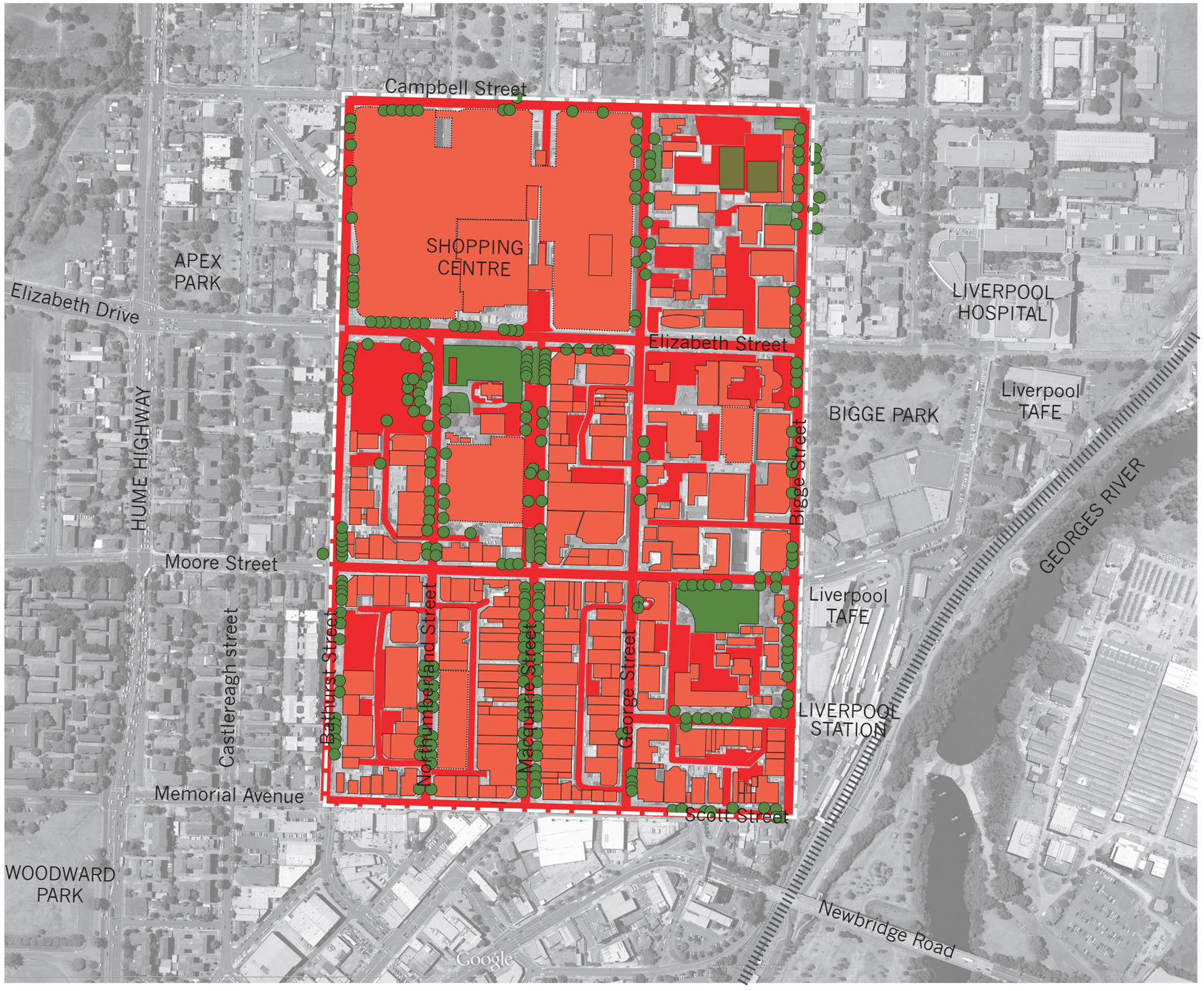
George Serviceway

Crawford Serviceway

George Street- awnings

Macquarie Street - awnings

EXISTING URBAN ENVIRONMENT AND GREENCOVER



LEGEND

- EXISTING GREENCOVER
- PAVED/ HARD SURFACE AREAS
- BUILDINGS
- ROADS

HEAT ISLAND CONTRIBUTORS (ROADS, FOOTPATHS, CARPARKS, PAVED AREAS & ROOFS)

TOTAL = 408,590 M²
= 95% OF STUDY AREA

CONTEXT

LEGEND

Penrith LGA areas

Study Area

NTS

NORTH

LOCATION

LEGEND

Study Area

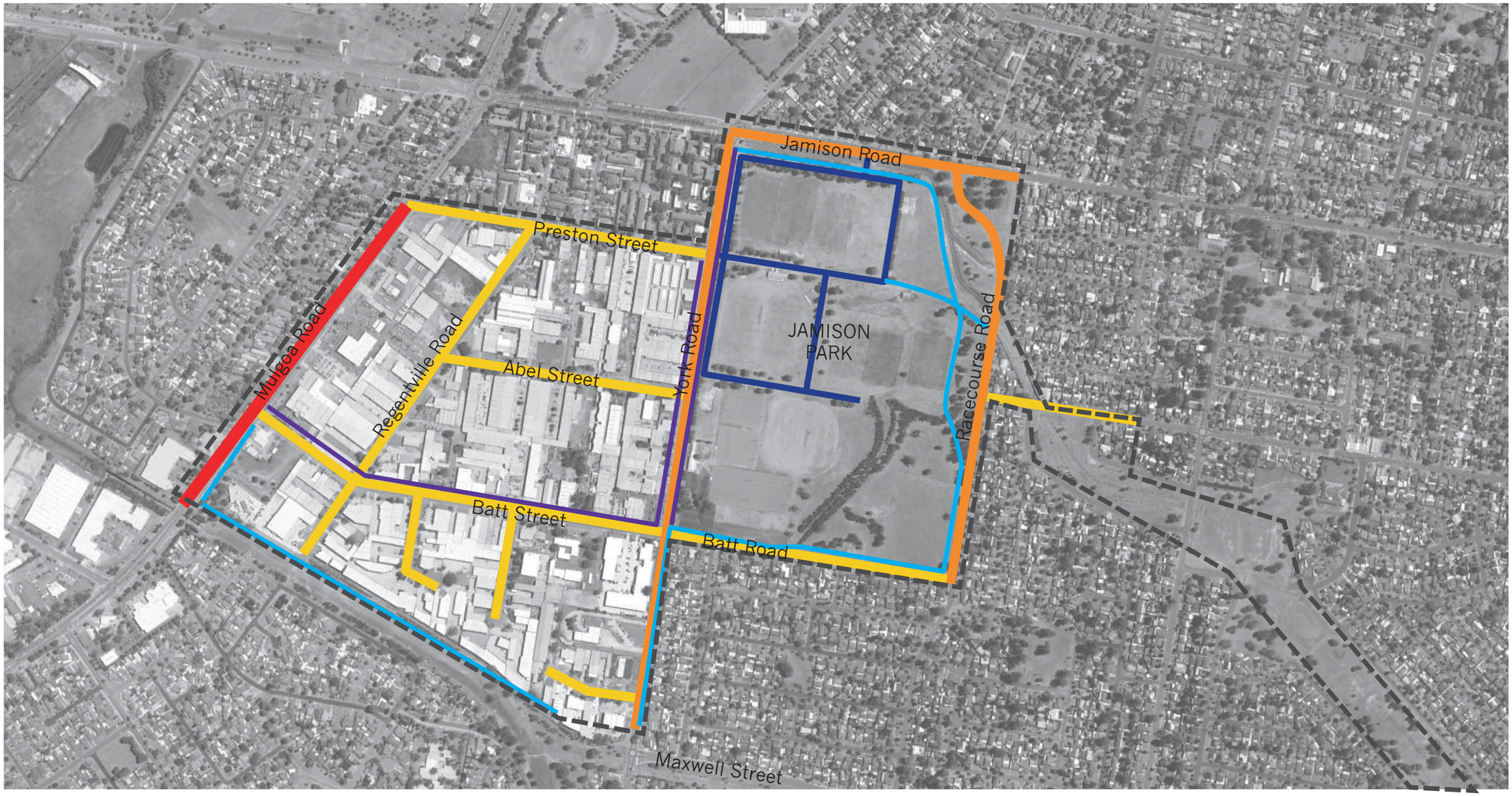
EXISTING GREENCOVER

LEGEND

- Street Trees
- Trees
- Park/ Open Space
- Waterway/ drainage corridor
- Sportsfields
- Grass verges (industrial area)
- Study Area

TOTAL = 401,375 M²

GROUND PLANE - ROADS AND STREET



LEGEND

- Primary Roads = **475 linear m = 10,925 M²**
- Secondary Roads = **2,395 lin m = 31,135 M²**
- Local Roads = **4115 lin. m =49,380 M²**
- Jamison Park Roads = **1,690 lin m =12,675 M²**
- Cycleway = **3,155 lin. m = 7,890 M²**
- Footpath = **2,260 lin. m = 2,710 M²**
- Study Area

TOTAL = 114, 715 M²

GROUND PLANE - ROADS AND STREET

York Road

Batt Street

Batt Street

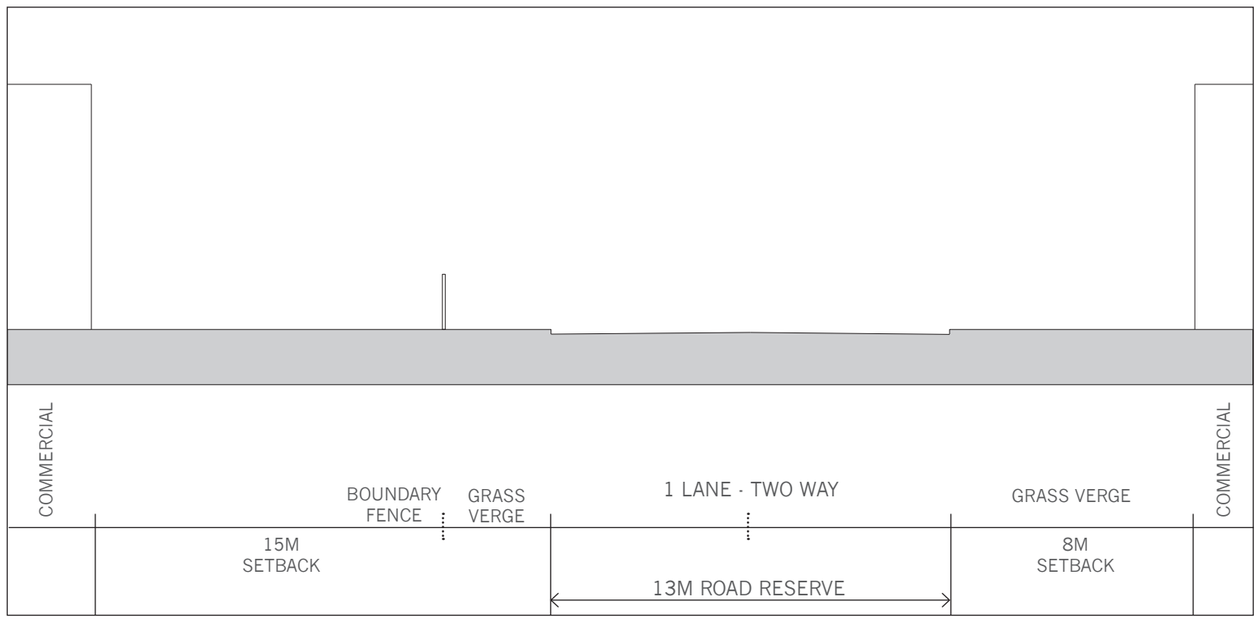
Jamison Park Cycleway

Preston Street

Abel Street

Batt Street (West)

GROUND PLANE - ROADS AND STREET - SECTIONS



TYPICAL STREET SECTION - ABEL STREET

GROUND PLANE - SURFACE CARPARKS / PLAZAS / FORECOURTS

LEGEND

Surface Carparks

Study Area

Hard Paved Areas:
Forecourts, concrete aprons

TOTAL AREA = 216,000 M²


①


②


③


5
4
3
1
2


④


⑤

BUILDINGS - ROOFS

LEGEND

Dark Roof

Light Roof

Study Area

TOTAL AREA = 179,460 M²

DRAINAGE - HARD STORMWATER

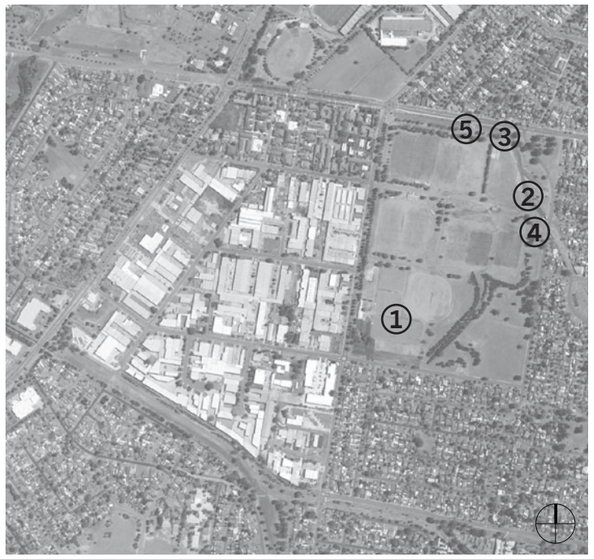
LEGEND

Concrete drainage canal

Concrete dish drain

Study Area

DRAINAGE - HARD STORMWATER



EXISTING URBAN ENVIRONMENT AND GREENCOVER

LEGEND

HEAT ISLAND CONTRIBUTORS
BUILDINGS
PAVED/ HARD SURFACE AREAS
EXISTING GREENCOVER
ROADS

HEAT ISLAND CONTRIBUTORS — **TOTAL = 40% OF STUDY AREA**
(ROADS, FOOTPATHS, CARPARKS, PAVED AREAS, ROOFS)

+ UNSHADED GRASS — **TOTAL = 72% OF STUDY AREA**