CATHERINE PARK

Residential Streets Review

11 April 2013

Prepared for

HIXSON PTY LTD

Prepared by

DEVELOPMENT PLANNING STRATEGIES

Suite 702 Level 7, 171 Clarence Street

SYDNEY NSW 2000

Development
Planning Strategies

TABLE OF CONTENTS

1. INTRODUCTION 1
2. BEST PRACTICE IN URBAN DESIGN 2
3. STREET HIERARCHY IN URBAN RESIDENTIAL AREAS 6
4. AUSTRALIAN URBAN PLANNING DESIGN STANDARDS AND GUIDELINES 8
   - 4.1 AMCORD 8
   - 4.2 NEW SOUTH WALES 9
   - 4.3 VICTORIA 11
   - 4.4 WESTERN AUSTRALIA 12
   - 4.5 QUEENSLAND 13
5. AWARD WINNING AND NOTABLE RESIDENTIAL PROJECTS 14
   - 5.1 CASE STUDY 1 – ALAMANDA 14
   - 5.2 CASE STUDY 2 – STONECUTTERS RIDGE 14
   - 5.3 CASE STUDY 3 – CARDINIA LAKES 15
   - 5.4 CASE STUDY 4 – NEWHAVEN 16
   - 5.5 CASE STUDY 5 – WARNER LAKES 16
   - 5.6 OTHER NOTABLE RESIDENTIAL DEVELOPMENTS 17
6. SUSTAINABILITY IN URBAN RESIDENTIAL STREETS 18
7. HOUSING AFFORDABILITY 20
8. ACHIEVING DENSITY 21
9. SAFETY IN URBAN RESIDENTIAL STREETS 22
10. DESIRED STREET HEIRARCHY 24
11. CONCLUSIONS 25

APPENDIX 1 – SUSTAINABILITY AND CARBON ASSESSMENT – STREET WIDTHS BY GHD 28

APPENDIX 2 – ASSESSMENT OF DCP STREET WIDTHS BY BROWN CONSULTING 29

APPENDIX 3 – COST ANALYSIS BY BROWN CONSULTING 30

1. INTRODUCTION

The purpose of this document is to consider and determine the suitable and appropriate street carriageways for residential streets within the Catherine Fields Part Precinct of the South West Growth Centre.

This report reviews and analyses the provision of streets in relation to carriageway widths in new residential estates throughout Australia, with specific focus on collector streets and local streets. This report also includes consideration of 'Access Streets' which have an important role in the street hierarchy in residential areas.

The objective of this report is to determine the best outcome for residential streets to inform the policy standards (Development Control Plan) that specify delivery of residential streets. Ultimately a high quality urban design outcome in residential streets is paramount, which provides safe and attractive places for people and vehicles.

The principles of creating quality streets are explained along with current trends in Australia for achieving high quality urban design outcomes in residential streets and their relationship with the residential community defined. The report examines National, State and local policies across Australia with specific reference to New South Wales, Victoria, Western Australia and Queensland, which have been the dominate States for urban growth in the last 10 years.

The report reviews the type of streets that are being built throughout Australia and draws on examples of high quality and award winning residential estates, which demonstrate best practice and industry benchmarks for quality design outcomes in residential development.

This review on residential streets also considers the affordability, sustainability and safety aspects in delivering new residential streets. Two specialist studies have been prepared to consider the environmental sustainability and safety aspects of differing carriageway widths, specifically for 7.4m and 9m pavements in local streets. These reports are summarised in the report and included in the Appendices.

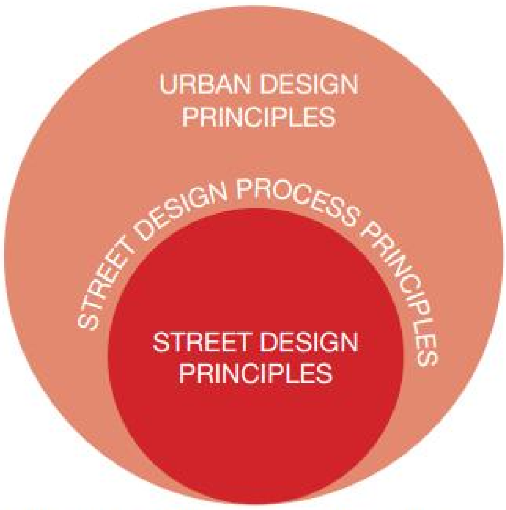
After considering the factors of good urban design, current planning policies, quality outcomes in new residential development, and the affordability, sustainability and safety issues, the findings of this report support narrower carriageway widths to the widths being proposed for the Catherine Fields Part Precinct.

2. BEST PRACTICE IN URBAN DESIGN

The relationship between street width and good urban design outcomes is well established. Streets are a key factor in influencing best practice urban design in residential areas. The role of the urban residential street is becoming increasingly important in creating a sense of place and community, which is key to the success of newly developed communities. There is significant potential to use streets as tools for enhancing the built environment and improving the quality of residential neighbourhoods, in particular residential amenity.

Internationally, current leading urban design initiatives are promoting the 'rightsizing' of streets. This typically means wider streets are being retrofitted and redesigned to achieve the perception of being narrower, demonstrating that a reduced street carriageway is considered best practice design[a]. The rightsizing of streets is in practice in Sydney which is demonstrated with the Leichhardt Council's Sustainable Living Streets Program. Taylor Street, Annandale was selected as the Leichhardt Living Streets pilot project and has now been completed.

A study prepared by the Queensland Government and South East Queensland Council of Mayors titled 'Next Generation Planning: A handbook for planners, designers and developers in South East Queensland (2011)' found that residential streets are 'as important to placemaking and neighbourhood character as they are to movement and property access'.



Street design considerations are nested within urban design considerations of wider neighbourhood areas

Source: Streets for People

There are several publications that emphasise the relationship between residential streets and good quality design. In particular, there is considerable academic and industry commentary on street design composition, its impact on urban design, and the benefits that appropriate design can bring to local neighbourhoods.

The provision of streets in residential areas with narrow pavements is often included as a key element to providing good urban environments for a variety of reasons.

Principle 1: Increased functionality

While it is essential that streets are designed for mobility and functionality, residential streets should also be designed to serve a number of additional uses. The common functions of a residential street include:

- Access to properties
- Parking
- Placemaking
- Movement
- Utilities and services
- Biodiversity

Best practice urban design increasingly promotes the residential street as an integral part of public space rather than solely a movement corridor for vehicles. The study undertaken by the Council of Mayors (SEQ) in Queensland determined that the best streets did not have a prominent traffic function[b]. Further, residential streets should be designed in such a way that a range of functions can be met and the street can play a broader role in how people relate to their residential neighbourhoods.

Accordingly, the carriageway of the street and its function in the residential neighbourhood has a direct relationship with:

- Amenity
- Public safety
- Social interaction and community development[c].

Principle 2: Improved amenity and aesthetics

Providing a reduced carriageway is proving to increase the amenity and aesthetics of residential neighbourhoods by creating an environment that is built to a human scale. The width of streets can impact the perception of environmental amenity, and designing to establish a relationship between building and street contributes to creating a more attractive environment[d]. Reducing the street pavement width in lower density residential neighbourhoods will have a positive effect on improving amenity for residents.

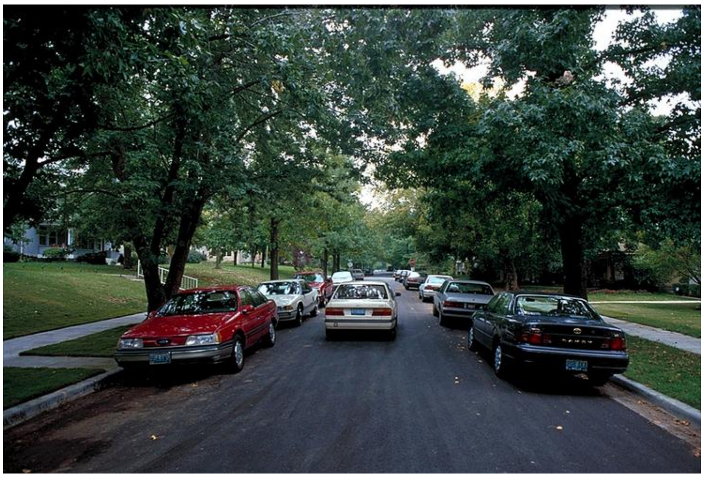
Streets in lower density residential areas should be designed to contain a pavement that is at an appropriate scale to the surrounding homes, as a street that is too wide for surrounding residential development can contribute to a sense of isolation for the user. Accordingly, designing streets to a human or pedestrian scale promotes greater pedestrian use and walkability within a neighbourhood[e]. This also has positive impacts of health and the environment due to the reduced use of motorised private transport.

Quality residential streets make a significant contribution to residential amenity (William Campbell Ave, Harrington Park)

Principle 3: Improved safety

Street design can significantly improve the safety of residential streets. Clever and purposeful street design can passively reduce traffic speeds and increase safety. Narrower pavements provide a passive traffic calming measure and remove the need for retrofitting streets with traffic calming measures such as chicanes and 'slow points'. Narrow street pavements also contribute to increased safety by allowing on-street parking which can act as a traffic calming measure by providing a point of friction between driving and parked cars, impeding traffic speed[f]. The underlying principle is the less space the driver of a vehicle has the slower they are likely to drive their vehicle.

Slower traffic speeds created by narrower pavements therefore provide safety for pedestrians and cyclists. In addition, slower traffic speeds reduce noise emissions and pollution, further enhancing the residential amenity, safety and the usability of the street area.



Pavement widths can control vehicle speeds and increase safety

Source: www.streetswiki.wikispaces.com

Principle 4: Encourage greater use by a wider range of users

There is a direct relationship between width of a street pavement and the users and useability of a street[g]. By designing local streets with pavements that are slightly narrower, the safety and amenity is significantly improved, which can encourage greater use of the space by pedestrians and cyclists as well as play a role in community interaction[h].

Narrower streets in residential areas are a key factor in creating built environments that are pleasant and aesthetically pleasing with a high level of amenity for residents. The design of streets, particularly width, contributes to the creation of an environment that is both pleasant and safe, which in turn encourages activity and community development.

Low-order Access Streets can provide vehicle access and parking and a quality design outcome in residential areas

3. STREET HIERARCHY IN URBAN RESIDENTIAL AREAS

The presence of a definitive street hierarchy in residential areas is fundamental in providing legible residential neighbourhoods. There are numerous benefits in providing distinct differences between collector streets, local streets and access streets, as described below.

Objective 1: Indicate function

Street design directly impacts upon the perceived function of a street. While it is important that streets are functional and accommodate a range of uses, it is also important to separate incompatible street uses, such as pedestrians and large trucks. The width of a street can give users a visual indication of its function. Appropriate street design is essential to dictate street function.

Objective 2: Provide a clear urban structure

The Camden DCP includes the following objective for residential subdivision:

> *"To establish a clear urban structure that promotes a 'sense of neighbourhood' and encourages walking and cycling."*

Providing a definite street hierarchy through the design of streets assists in creating a neighbourhood where the function of each street is clearly indicated.

A clear street hierarchy is achieved through street carriageway widths:

Collector Street (Christiansen Boulevard, Moorebank NSW)

Local Street (Kowald Street, Elderslie NSW)

Access Street (The Parkway, Moorebank NSW)

Objective 3: Positive contribution to residential amenity

A lack of definition between street types may decrease amenity. Wider local streets may result in an increased number of vehicles, including larger vehicles such as trucks and buses along these streets. Additionally, collector streets often have a higher speed limit and heavier traffic volumes. This would cause an increase to noise pollution in residential neighbourhoods and may impact on the use of local streets by pedestrians and cyclists due to a decrease in perceived safety.

The provision of a 7.4m Local Street in Catherine Park will ensure the provision of the benefits listed above and a clear street hierarchy. This is consistent with the type of Local Streets being constructed in new residential estates, which generally have carriageway widths of 7-8m, while collector streets have carriageway widths of 9-11m. Providing local streets of 9m may cause confusion regarding the function of streets within Catherine Park.

In addition, the inclusion of an 'Access Street' is important for establishing a clear street hierarchy in Catherine Park. An Access Street provides a smaller street response to lower traffic volumes serving a smaller catchment of houses.

4. AUSTRALIAN URBAN PLANNING DESIGN STANDARDS AND GUIDELINES

The establishment of planning standards and guidelines has mostly been undertaken by the States and Local Governments. Notwithstanding, the Federal Government prepared Australia-wide planning guidelines for residential development to inform policy regulators titled AMCORD.

This section reviews the standards for street carriageways in new residential developments established by National, State and Local Government policy setters.

4.1 AMCORD

AMCORD was produced and evolved through the early to mid 1990s by the Federal Government to establish a 'blueprint' for residential development and neighbourhood design using 'best practice' examples of new residential estates throughout the country. The purpose of AMCORD was to set guidelines for the preparation of planning policies, codes and regulations for States and Territories, including the provision of:

- a process to achieve more efficient, effective, responsive and environmentally sustainable approaches to housing and residential development at the local level;
- a means of improving the quality and choice in housing and residential environments, and ensuring a high level of integration of housing with other elements within the urban environment;
- a framework, principles and processes for a more consistent regulatory environment for those seeking approval for residential projects.

AMCORD defines residential streets into two basic categories, being 'collector' and 'access' streets which correspond with Collector Streets and Local Streets in NSW terminology. AMCORD notes the importance between the relationship of street width and its function. Importantly, residential streets need to promote residential amenity and maintain safety through low traffic speeds. Furthermore, this is best achieved by "restricting traffic volumes and vehicle speeds (through landscape design, parked cars, built form etc)"[i]. In consideration of residential amenity, safety and the function of the street, the following carriageway requirements are provided.

COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
4.5	**7-7.5**	4.5	3.5-4	**5-7**	3.5-4	3.5	**5**	3.5

Source: AMCORD

The provisions for carriageway widths in collector streets, local streets and access streets are generally 7.4m, 6m and 5m respectively. The provision of the third tier 'Access Street' is noted as being an essential component in the street hierarchy as it provides a smaller scale street that typically has lower traffic volumes and serves a smaller catchment of houses.

4.2 NEW SOUTH WALES

In NSW planning requirements for street carriageway widths are generally established by each Council for their respective Local Government Area. However, in 2006 the NSW Government established the Sydney Region Growth Centres to streamline the supply of Greenfield land for urban development and coordinate the delivery of infrastructure through the Department of Planning & Infrastructure.

The Growth Centres incorporates numerous Councils and each Planning Precinct typically has a set of development controls in the form of a Development Control Plan (DCP). The street carriageway planning provisions in various Growth Centres DCPs are summarised in the table below.

POLICY	COLLECTOR STREET			LOCAL STREET		
	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
Turner Road DCP	4.6	**10.4**	4.6	3.5	**7.4**	3.5
Oran Park DCP	4.6	**10.4**	3.3	3.5	**7.4**	3.5
Draft Camden Council GC DCP	4.5	**11**	4.5	3.5	**9**	3.5
Blacktown Council GC DCP	4.5	**11**	4.5	3.5	**9**	3.5
Schofields DCP	4.5	**11**	4.5	3.5	**9**	3.5

Oran Park and Turner Road were two of the first release precincts, both of which have carriageways of 10.4m and 7.4m for collector and local streets respectively. The other Precincts have adopted larger carriageway widths which historically have only been evident in Blacktown Council prior to the Growth Centres.

Planning policy details on streets have been obtained for various Local Government Areas that have experienced significant urban growth within the last 5-10 years. These Councils include Blacktown City Council, Camden Council and Penrith City Council.

LGA	COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
Camden	4.5	**11**	4.5	4	**7**	4	4.25	**4.5**	4.25
Shellharbour	3.5	**9**	3.5	3.5	**8**	3.5	3	**6**	3
Blacktown	3.5	**11**	3.5	3.5	**9**	3.5	3.5	**5.5**	3.5

Other 'growth' Councils such as Penrith, Campbelltown and Liverpool do not have generic planning requirements for streets, but do have project specific DCPs which are outlined below. With the exception of Blacktown other Councils have adopted carriageway widths for local streets of 7m – 8m and there are a number of Councils with 8m – 9m for collector streets. Access streets are typically around 5m – 6m.

Several of the growth councils across Sydney have also prepared Development Control Plans for specific sites across local government areas. Site specific DCPs operate independently of general DCPs prepared by local councils in areas where residential development is being undertaken. The tables below provide an illustrative comparison on street reserve and pavement widths.

CAMDEN

SITE	COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
Harrington Grove	6.7	**8**	6.7	5	**7.2**	5	5	**6**	5
Harrington Park	3.5	**8**	3.5	3.5	**6**	3.5	3.5	**4.5**	3.5
Elderslie				4.4	**7.2**	4.4			
Spring Farm				4	**8**	4	3	**7**	4
Manooka Valley	3.5	**9.4**	3.5	4.4	**7.4**	4.4			
Mater Dei				<4	**6**	<6			

CAMPBELLTOWN

SITE	COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
Minto				3.5	**6.5**	4.5	3.5	**6**	3.5
Bardia Sub-Precinct	4.3	**11**	2	3.3	**9**	3.3			

LIVERPOOL CITY

SITE	COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
Middleton Grange				4	**7.2**	4			
Voyager Point				4	**8**	4	4	**7.2**	4
Hoxton Park				4	**7.2**	4			
Moorebank East				4	**7.2**	4			
Edmondson Park				4	**7.2**	4			
Pleasure Point				3.9	**7.2**	3.2			
Elizabeth Hills	4	**10.6**	4	4	**9.4**	4	4	**7.2**	4

BLACKTOWN CITY

SITE	COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
Second Ponds Creek	4.5	**11**	4.5	3.5	**9**	3.5	3.5	**5.6**	3.5

THE HILLS SHIRE

SITE	COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
Balmoral Road	3.5	**9.5**	3.5	3.5	**8.5**	3.5			
Kellyville	3.5	**9.5**	3.5	3.5	**8.5**	3.5	3.5	**7.5**	3.5

The site specific DCPs provide an informative overview of street design within new residential estates and release areas. In regard to the development policies for NSW, the Growth Centres of Oran Park and Turner Road support smaller carriageways for collector and local streets, but do not include provisions for an 'Access street'.

Standards vary between NSW Councils, however many Councils have provisions for collector streets carriageways below 10m and the majority have 8m widths for local streets. In addition, there are Councils that have 4.5m-6m carriageways for Access Streets, including Camden.

The site specific DCPs in South West Sydney (Camden, Liverpool and Campbelltown) typically apply 8m-10.6m carriageway widths for collectors and 7.2m widths for local streets. There are also 6m widths for Access streets/Places.

Site specific DCPs for North West Councils (Blacktown, The Hills and Penrith) typically have wide carriageways for collectors (11m-12m) and local streets (8m-10.5m). However, the provisions for Access Streets require carriageways of approximately 5.5m.

There are various parameters that Councils use to determine an 'Access Street' or alike. Camden has an up to 1000 VTD, whilst The Hills and Shellharbour Councils have up to 300 VTD thresholds. Blacktown City Council sets a maximum length of 80 metres. The 1000 VTD is considered the most appropriate as it is consistent with recognised planning policies of AMCORD and the Liveable Neighbourhood Community Design Code

4.3 VICTORIA

The more prominent urban growth areas around Melbourne are occurring to the north (Craigieburn), west (Caroline Springs), southwest (Point Cook) and southeast (Pakenham). The Victorian Government established the Growth Areas Authority to provide consistency and effective delivery of new urban land around the fringes of Melbourne.

The Growth Areas Authority is "an independent statutory body with a broad, facilitative role to help create greater certainty, faster decisions and better coordination for all parties involved in planning and development of Melbourne's growth areas" and reports directly to the Planning Minister. Furthermore, the GAA is "develop communities in growth areas that are socially, environmentally and economically sustainable" and to "plan and coordinate infrastructure provision in Melbourne's growth areas". Local Government Areas within the Growth Areas include Casey, Cardinia, Hume, Melton, Mitchell, Whittlesea and Wyndham (Refer to www.gaa.vic.gov.au).

The GAA has formulated Engineering Design and Construction Manual (April 2011) to standardise engineering requirements for subdivision development across all of Melbourne's growth area councils. The standards relating to the provision of streets are as follows.

COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
4.5	**11.6**[1]	4.5	4.5	**7.3**	4.5	4.2	**5.5**	4.2

Notes: 1. Includes 2.3m wide marked parking on either side

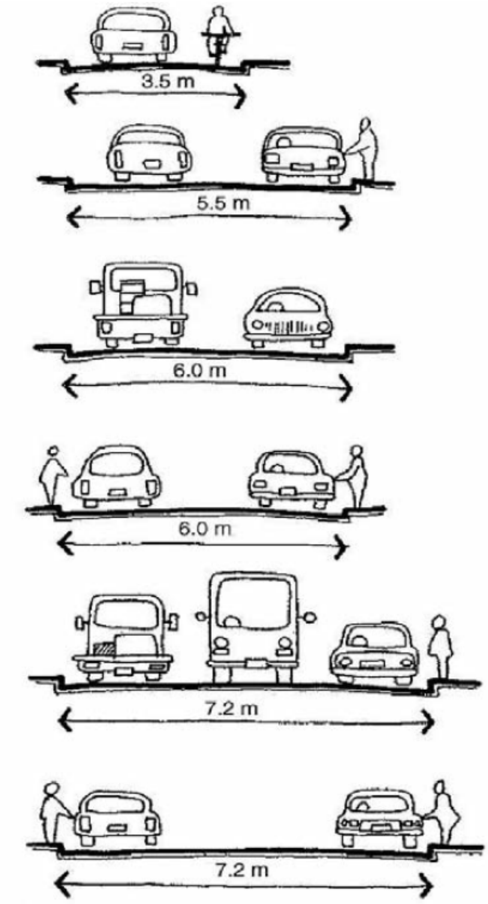
Source: www.gaa.vic.gov.au

The GAA sets a 11.6m carriageway width for collector streets, which includes 2.3m marked parking areas on either side of the street. The carriageway width for local streets is 7.3m which includes informal parking within the carriageway on either side of the street. The Access Streets has a narrower carriageway of 5.5m which is to serve traffic volumes of 300-1000 vehicle trips per day.

4.4 WESTERN AUSTRALIA

The Western Australian Government is responsible for the assessment and approvals of residential subdivision for the entire State, which is administered by the Western Australian Planning Commission (WAPC).

The WAPC formulated Liveable Neighbourhoods Community Design Code as the principal development control policy for the design and assessment of subdivision for new urban areas in the Perth metropolitan area and country centres. Liveable Neighbourhoods seeks to provide sustainable urban development through land efficiency, and achieve residential density targets and lot diversity (Refer to www.planning.wa.gov.au).



A 3.5 m pavement allows a car to pass a cyclist (or pedestrian), but is clearly too narrow for parking without blocking the street.

A 5.5 m pavement allows a car to pass a parked car or a moving car. It also allows a moving car to pass a truck, but is clearly too narrow for cars to park opposite each other without blocking the street. Staggered parking supports the function of the street.

A 6.0 m pavement is wider and also allows a car to pass a parked car or a moving car. Vehicles have to be parked appropriately.

A 7.2 m pavement is wide enough for two vehicles to pass each other while passing a parked car. It is wide enough for a moving car to pass between two parked cars, but is clearly not wide enough for two moving vehicles to pass at once. Pavements will need to be widened to 7.4 m to accommodate buses.

Figure 11: Diagram of physical determinants for the width of pavements in access streets

Source: www.planning.wa.gov.au

Liveable Neighbourhoods establishes clear guidelines on street hierarchy and street types, in particular for residential streets. As part of evolving the requirements Liveable Neighbourhood explains the relationship between the function and width of residential streets.

Liveable Neighbourhoods advocates residential streets with high amenity values and safety by designing streets to reduce traffic speeds and volumes. Liveable Neighbourhoods establishes the following standards for street design in new residential developments for carriageway widths.

COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
4.1	**11.2**[1]	4.1	4.1	**7.2**	4.1	4.1	**5.5-6**	4.1

Notes: 1. Includes 2.3m wide marked parking on either side

Source: www.planning.wa.gov.au

Liveable Neighbourhoods sets a 11.2m carriageway width for collector streets, which includes 2.1m marked parking areas on either side of the street. The defined parking areas typically require a wider carriageway than unmarked parking areas within the carriageway. The carriageway width for local streets is 7.2m which includes informal parking within the carriageway on either side of the street. For smaller residential streets (<1000 vehicles per day) a carriageway width of 6m is deemed adequate.

4.5 QUEENSLAND

The standards for carriageway widths in Queensland are predominantly determined by Local Governments. A cross section of Council policies relating to streets has been compiled to provide an overview of carriageway widths for streets in Queensland. The requirements are drawn from three 'growth' councils, being the Brisbane, Gold Coast and Ipswich City Councils, and each of these have been reviewed as outlined below.

LGA	COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
Brisbane	4.25	**11**	4.25	4.25	**7.5**	4.25	4.25	**5**	4.25
Gold Coast	4.5	**10**	4.5	4.5	**7.5**	4.5			
Ipswich	3	**8.5**	3	3	**6.5**	3			

In considering these three 'growth' Councils, 10m carriageways for collector streets and 7m – 7.5m for local streets are generally acceptable.

5. AWARD WINNING AND NOTABLE RESIDENTIAL PROJECTS

Street carriageway widths in award winning projects have been assessed to understand and appreciate the standards that are being determined as standout examples throughout new developments across Australia.

5.1 CASE STUDY 1 – ALAMANDA

Estate Name: Alamanda

Developer: Villawood Properties

Award(s): 2010 UDIA National Award for Residential Development

2009 UDIA State Award for Residential Development (more than 250 lots)

Location: Point Cook, Victoria 3030

COLLECTOR STREET			LOCAL STREET		
Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
5.25	**7.5**	5.25	4.5	**7**	4.5

Source: http://www.alamandapointcook.com.au/

5.2 CASE STUDY 2 – STONECUTTERS RIDGE

Estate Name: Stonecutters Ridge

Award(s): 2011 UDIA State Award for Residential Development

Developer: Medallist

Location: Colebee, New South Wales 2761

COLLECTOR STREET			LOCAL STREET		
Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
3.5	**11**	3.5	3.5	**7.5**	3.5

Source: www.mywisdomhome.com

Source: Google Maps

5.3 CASE STUDY 3 – CARDINIA LAKES

Estate Name: Cardinia Lakes

Award(s): 2012 UDIA State Award for Residential Development (more than 250 lots)

Developer: PEET Limited

Location: Pakenham, Victoria 3810

COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
4.5	**7.5**	4.5	4.5	**7.5**	4.5	4.3	**6.5**	4.3

Source: www.udiavic.com.au

Source: Google Maps

5.4 CASE STUDY 4 – NEWHAVEN

Estate Name: Newhaven

Award(s): 2009 UDIA State Award for Residential Development (over 250 lots)

Developer: Stockland

Location: Piara Waters, Western Australia 6112

COLLECTOR STREET			LOCAL STREET		
Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
5.4	**7.2**	5.4	4.5	**6**	5.5

Source: www.stockland.com.au

Source: Google Maps

5.5 CASE STUDY 5 – WARNER LAKES

Estate Name: Warner Lakes

Award(s): 2011 UDIA State Award for Residential Subdivision

Developer: PEET Limited

Location: Warner, Queensland 4500

COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
4.5	**7.5**	4.5	4.3	**7.5**	4.3	4.5	**6**	4.5

Source: Google Maps

5.6 OTHER NOTABLE RESIDENTIAL DEVELOPMENTS

Other notable large residential developments that are currently in construction or recently constructed are detailed below.

New South Wales

RESIDENTIAL ESTATE	COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
	Verge	Carriageway	Verge	Verge	Carriageway	Verge	Verge	Carriageway	Verge
Stonecutters Ridge	3.5	11	3.5	3.5	7.5	3.5			
Gregory Hills	4.6	10.4	3.3	3.5	7.4	3.5			
Harrington Grove	6	8	6	5	7.2	5	3.5	6	3.5
Harrington Park	5	8	5	3.5	6	3.5			
Sea Crest (Shellharbour)	3.5	9	3.5	3.5	6	3.5			
Elizabeth Hills	4.45	8.5	4.45	3.45	6.3	4.45			
Lakewood				3.95	5.1	6.45			
Newbury				5.2	5.6	5.2			
Middleton Grange	4.32	12.7	4.32	4.45	6.3	4.45			
Edmonson Park				4	7	4			
George's Fair	4	9.5	4	3.5	6	3.5			
Pleasure Point				3.75	7	3.75			
Glenfield Road	3.7	10.5	3.7	4	6	4			
One Minto				4	7	4			
Spring Farm		11		4	6.7	4			
Elderslie	4	12	4	4.5	6.5	4.5			

Other Australian States

RESIDENTIAL ESTATE	COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
	Verge	Carriageway	Verge	Verge	Carriageway	Verge	Verge	Carriageway	Verge
Marriot Waters VIC	4.5	11	4.5	4.5	7	4.5			
Ellenbrook WA	12.2	7.4	9.4	4.5	6	4.5			
Burns Beach WA	4.5	7.4	4.5	4.5	6	5			
Seascapes WA	7.7	7.5	5	4.5	6	3.5			
The Vale WA	5.4	7.4	5.4	4.5	6	3.5			

There are numerous examples of recently constructed estates with carriageways for collector streets ranging in widths of 8m-10.5m and local streets ranging in 6m-7.5m. Examining what has been constructed throughout the Sydney metropolitan area, a clear pattern is evident that local streets have carriageways of 7.5m or less.

6. SUSTAINABILITY IN URBAN RESIDENTIAL STREETS

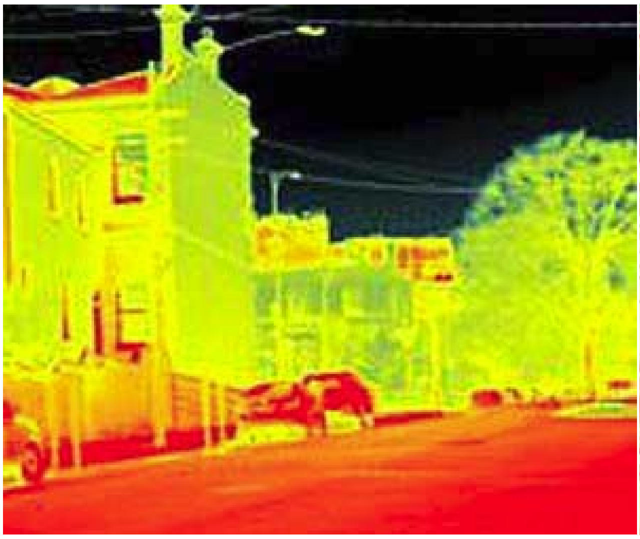
GHD has prepared a report that assesses the impact of street widths in regards to environmental sustainability (refer to Appendix 2). The report considers carbon emissions, resource use and environmental footprints in assessing the environmental impacts of streets. The report is based on a comparative investigation of the Catherine Park site using two different street widths of 7.4m and 9m.

The methodology used to inform the study included establishing the total length of local streets within the site, which was then used to calculate the total street area for each scenario. A street width of 7.4m will result in a paved area of 310,100m^2 while a 9m wide carriageway will result in 378,243m^2 of pavement. These figures were used in calculations to assess carbon emission outputs and resource use which were then compared. In addition, a typical street cross section and material composition was established. Carbon emissions were calculated based on figures defined by the Greenhouse Gas Protocol. Resource use, including water use, land use and soil waste was calculated through modelling software. The modelling was based on a kerb-to-kerb measurements.

The calculations revealed that a street carriageway of 7.4m was significantly more sustainable in all categories assessed as part of the investigation. The study found that a street width of 7.4m is significantly more sustainable than a street of 9m. The impacts of the wider carriageways include:

- During the road construction phase there is an increase of:
  - 3,377 tonnes of carbon dioxide emitted which equates to 1,133 cars operating for 1 year
  - 140,671kL in water use
  - 5,420,230kg of solid waste (this incorporates waste generated during the manufacture of construction materials i.e. gravel, bitumen and diesel)
  - 0.21ha more land used in the production of the materials
- A land area difference is 6.7ha (approximately 149 residential lots)
- Potential to increase heat island effects
- Potential to increase stormwater runoff volumes

Heat that is generated by hard surfaces are often particularly detrimental during heat wave periods. A reduction to the proportion of hard surfaces in residential areas will result in ongoing energy savings[i]. Both of these factors contribute to the environmental sustainability of residential areas.



Source: www.smh.com.au

Source: GHD

The report confirms that a carriageway width of 7.4m will result in significant positive outcomes in terms of environmental sustainability for Catherine Park. A reduced carriageway width will have minimised carbon emissions, water use, land use and soil waste when compared to a wider carriageway of 9m. In addition, there is potential to increase sustainability by reducing the impacts of heat island effect and stormwater runoff as a result of reduced pavement area and the possibility of more vegetation.

7. HOUSING AFFORDABILITY

The nature of streets in new residential developments has a direct relationship with the costs for developing land, and therefore, the ability to deliver new housing at lower costs. Specifically, narrower carriageways with resultant reduced reserves for a residential street will reduce the costs to produce new residential allotments in the South West Growth Centre.

The NSW Government advocates improving housing affordability as a matter of priority, which is demonstrated in the State's strategic plan 'NSW 2021 Plan'. Goal 5 in the Plan is to 'Place Downward Pressure on the Cost of Living' with the specific target of 'improving housing affordability and availability'.

Brown Consulting has undertaken a cost analysis to understand the cost implication between carriageway widths of 9m and 7.4m for a local street in the Catherine Field Part Precinct (Refer Appendix 3). The analysis considered the following cost considerations:

Construction costs – materials, drainage, earthworks and installation.

Development costs – land, servicing and estate facilities

Project costs – land holding, interest, estate and development margin

In regard to the Catherine Fields Part Precinct, the difference between a 7.4m and 9m carriageway for local streets will reduce the per lot cost by approximately $10,000 as a consequence of having a narrower pavement.

A reduction in costs of this magnitude is a significant cost saving. Accordingly, the narrower carriageway of 7.4m will enable the delivery of lower cost housing for Sydney, which is a key objective of the NSW Government.

8. ACHIEVING DENSITY

The Catherine Park Part Precinct has a set boundary and definitive land area. The Precinct has a density target of 3107 dwellings. The Catherine Fields Part Precinct Draft Precinct Planning Package includes provisions relating to the delivery of lot yields to meet the desired density targets for low and medium residential types.

Imposing wider street carriageway widths in the Precinct requires a significantly larger allocation of land for streets. Given the land areas for open space, drainage, riparian, retail and infrastructure are generally fixed for the Precinct, the additional land for the streets can only be derived from the core residential land area.

The GHD sustainability report (discussed in section 7) noted that designing local streets with a width of 7.4m rather than 9m will result in approximately 6.7ha of additional developable residential land, which equates to 149 standard residential lots at a 450m^2 average lot size.

In light of the above, the effect of having a 9m carriageway instead of a 7.4m carriageway will therefore create a significantly more difficult situation to deliver new housing product at the densities required by the planning provisions applying to the Precinct.

Accordingly, there are significant benefits for housing supply with the narrower carriageways, including:

- More developable core residential land area that will deliver more residential allotments within a defined land areas.
- Higher densities per gross developable hectare and significantly higher land efficiency, which contributes to housing affordability.
- Reduced per lot construction and servicing costs.
- Reduced pressure on releasing new land for urban development.
- More flexibility to deliver a more diverse range of lot sizes and dwelling types, as the average lot size required to achieve the dwelling targets is larger.

The provision of 7.4m carriageway widths for local streets will therefore ensure that the objectives of the Catherine Park Part Precinct are more easily achieved.

9. SAFETY IN URBAN RESIDENTIAL STREETS

A report prepared by Brown Consulting dated 6 March 2013 (refer to Appendix 2) details the safety benefits of accommodating a narrower street width in residential developments and the influence on street design to vehicle accidents. The report discusses the implications of wider streets in new residential areas through an analysis of research investigation reports and formulas established to demonstrate the relationship between road safety and street widths.

The report discusses the relationship between street widths and safety using a comparison between a 7.4m carriageway and a 9m carriageway for residential streets. A research paper titled *Narrow Residential Streets: Do They Really Slow Down Speeds?*[k] investigated the relationship between street width and traffic speeds through extensive data collection and concluded that wider streets result in a traffic speed increase of 5km/hr on average. Furthermore, in *The Streets Where We Live: A Manual for the Design of Safer Residential Estates*[l], it was found that 9m streets resulted, on average, in a 10km/h increase in maximum traffic speeds compared to 7m. This demonstrates a very clear relationship between streets and traffic speeds. The report uses this figure to demonstrate the safety implications of an increased traffic speed for both vehicles and pedestrians.

Hypothetical statistics that predict accidents occurring in Catherine Park every year were calculated based on statistics compiled using data from the Department of Infrastructure, Transport, Regional Development and Local Government and established formulas. The report derived several negative safety impacts as a result of wider residential streets, including the following:

- A statistical increase in accidents of 38%
- A statistical total of 227 more accidents in the area over a 10 year period
- Accident severity is significantly increased with at least double the amount of fatal and hospital related injuries (see table below).
- Increased pedestrian movement difficulty by impeding street crossing ability.
- Increased risk of vehicles existing driveways and entering intersections.

Table 3 – Potential Accidents on Local Streets in Catherine Fields over a 10yr Period

Injury Severity	Potential Accidents on 9.0m wide streets	Potential Accidents on 7.4m wide streets
Fatal	4.0	1.6
Hospitalised, stayed 1 night or more	50.0	25.6
Hospitalised, discharged same day	25.0	12.8
Not hospitalized estimate	523	335
All casualties	602	375 (-38%)

The report concludes that there is a significant reduction to street safety by providing a 9m carriageway compared to a narrower 7.4m carriageway. Notwithstanding the safety benefits of a reduced carriageway, a 7.4m carriageway also reduces traffic noise and increases the amenity of residential areas.

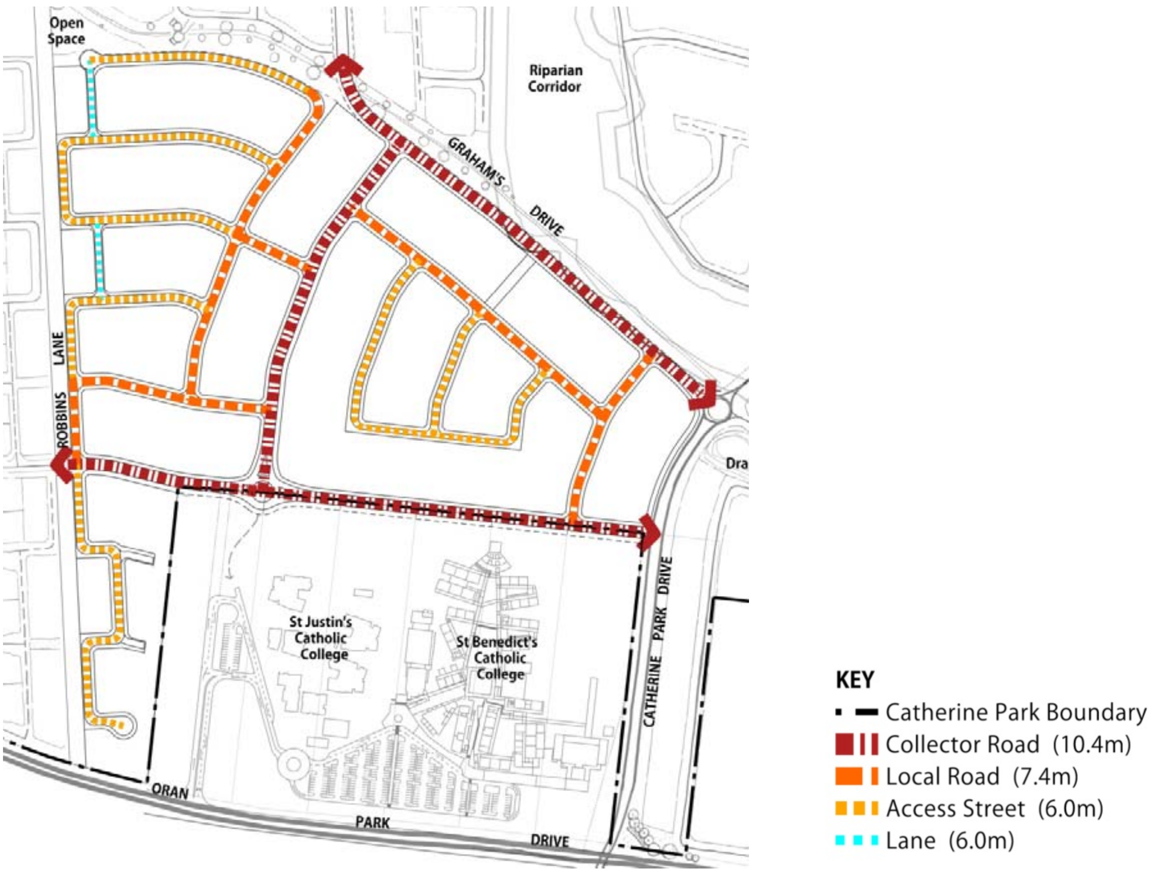
10. DESIRED STREET HEIRARCHY

It is desired to include a legible street hierarchy for the residential areas of the Catherine Fields Part Precinct, which contains three street types. These include collector streets, local streets and access streets. A description of each street is detailed below:

Street Type	Capacity	Function
Collector Streets	(3000-7000 VTD)	provide access to houses and collect traffic from smaller residential streets, and distribute traffic to sub-arterials (Oran Park Drive) and arterials (Camden Valley Way).
Local Streets	(1000-3000 VTD)	provide access to Access Streets and houses in larger streets.
Access Streets	(<1000 VTD)	provide access to house in small streets and culs-de-sacs.

COLLECTOR STREET			LOCAL STREET			ACCESS STREET		
Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge	Verge	**Carriageway**	Verge
4.6	**10.4**	3.5	3.5	**7.4**	3.5	3.5	**6**	3.5

The proposed application of the street hierarchy to the early stages of development is illustrated in the figure below.



11. CONCLUSIONS

This report discusses the important role that streets play in the creation of a high quality living environment in new residential estates and is supported by a variety of academic, industry and specialist investigations and reports.

Key principles and elements that influence street design and the positive and negative input that streets have on the residential environment include urban design, street hierarchy and widths, housing density, sustainability, safety and affordability along with achieving desirable development objectives and outcomes.

The following details negative impacts that wide carriageways have in achieving high quality residential outcomes.

Urban Design

- Promotes a more dangerous environment through faster traffic speeds, discouraging use of the street by pedestrians and cyclists, and as a result impacting upon essential social interactions and community building
- Increases the need for retrofitting streets through built-in traffic calming measures, such as chicanes
- Decreases amenity and aesthetics by impacting upon the relationship between dwellings and streets, creating a built environment that is not at a human scale
- Increases traffic noise as a result of increased vehicle speeds which in turn decreases residential amenity

Clarity of Street Function and Hierarchy

- Creates an ambiguous street hierarchy which may cause confusion about the function and purpose of a street
- A lack of definition between street types decreases amenity by encouraging higher traffic volumes and larger vehicles in residential streets and increasing risk for pedestrians and cyclists on local streets

Housing Density

- Housing yield targets are less practical and achievable as there is a lower proportion of core residential land
- Reducing the carriageway from 9m to 7.4m results in a land area difference of 6.7ha of residential land, which equates to approximately 149 less residential lots

Sustainability

- During the street construction phase there is an increase of:
    - 3,377 tonnes of carbon dioxide emitted which equates to 1,133 cars operating for 1 year

- 140,671kL in water use
- 5,420,230kg of solid waste (this incorporates waste generated during the manufacture of construction materials i.e. gravel, bitumen and diesel)

- A potential increase in heat island effects resulting in greater ongoing energy use (temperatures can be up to 5.6^0 C higher in urban areas)
- An increase in stormwater runoff volumes

Safety

- Increases traffic speeds by 10km/h in residential streets
- A statistical increase in vehicle accidents by 38%, which equates to approximately 227 accidents over a 10 year period
- Accident severity is significantly increased with the widened carriageway with at least double the amount of fatal and hospital related injuries.

Table 3 – Potential Accidents on Local Streets in Catherine Fields over a 10yr Period

Injury Severity	Potential Accidents on 9.0m wide streets	Potential Accidents on 7.4m wide streets
Fatal	4.0	1.6
Hospitalised, stayed 1 night or more	50.0	25.6
Hospitalised, discharged same day	25.0	12.8
Not hospitalized estimate	523	335
All casualties	602	375 (-38%)

- Decreases reaction times for pedestrians, cyclists and drivers when crossing streets and exiting driveways
- Poorer movement within the street for non-vehicular transport types

Affordability

- Additional construction, development and estate costs increasing by approximately $10,000 per allotment
- Significantly diminished housing affordability due to ineffective use of land and increased costs

Achieving Development Objectives

- Less land available for residential development, resulting in a decrease in housing supply (equivalent to 149 less lots for the Precinct)
- Reduces efficiency in land use and servicing
- Increases pressure to produce new urban land, which is directly contrary to the objectives of the NSW Growth Centres
- Inconsistency with environmental sustainability development principles

To avoid these negative impacts, streets with reduced carriageways should be permitted. Narrower street widths are an established design standard and are representative of best practice, as demonstrated in their inclusion in several engineering design guidelines and development control standards throughout Australia. Furthermore, narrow carriageways have been utilised in many award-winning and notable developments across the country, indicating that the provision of narrow residential streets is considered best practice design and forms an industry benchmark for creating new residential communities throughout Australia.

The carriageway widths proposed in Catherine Park take into consider the adverse impacts that are associated with wider residential streets. Accordingly, narrower carriageway widths should be supported throughout the community to allow the creation of a high quality urban development and overwhelmingly positive impacts on the environment, affordability, safety and residential amenity.

APPENDIX 1 – SUSTAINABILITY AND CARBON ASSESSMENT – ROAD WIDTHS BY GHD

Harrington Estates

Catherine Park Residential Development

Sustainability and Carbon Assessment - Road Widths

March 2013

Table of contents

1. Introduction ... 3
   1.1 Background ... 3
   1.2 Purpose of this report ... 3
2. Methodology ... 4
   2.1 Data collection and calculation procedure ... 4
3. Outcomes of assessment ... 10
   3.1 Reduced carbon emissions ... 10
   3.2 Life cycle assessment ... 10
   3.3 Environmental benefits of reduced footprint ... 11
4. Conclusion ... 14
5. References ... 15

Table index

Table 2-1 Options assessed ... 4
Table 2-2 Assumed road composition ... 6
Table 2-3 Calculation assumptions ... 6
Table 3-1 Summary of scope 1, 2 and 3 emissions ... 10
Table 3-2 Life cycle assessment ... 11

Figure index

Figure 1 Proposed development plan indicating local roads ... 5
Figure 2 Typical cross section of road ... 6
Figure 3 Infra-red image showing the increased heating effect of road surfaces compared to other structures in an urban setting ... 12

Appendix

Appendix A Greenhouse gas inventory

This Environmental Study ("Report"):

1. *has been prepared by GHD Pty Ltd (GHD) for Hixson Pty Ltd;*
2. *may only be used and relied on by Hixson Pty Ltd;*
3. *must not be copied to, used by, or relied on by any person other than Hixson Pty Ltd without the prior written consent of GHD;*
4. *may only be used for the purpose as outlined in Section 1.2 (and must not be used for any other purpose).*

GHD and its servants, employees and officers otherwise expressly disclaim responsibility to any person other than Hixson Pty Ltd arising from or in connection with this Report.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

The services undertaken by GHD in connection with preparing this Report:

- *were limited to those specifically detailed in section 1 of this Report;*
- *did not include estimating activity data or deriving emission factors.*

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report ("Assumptions"), including (but not limited to) assumptions listed in section 2 of this report.

GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

Subject to the paragraphs in this section of the Report, the opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation and may be relied on until 12 months, after which time, GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with those opinions, conclusions and any recommendations.

1. Introduction

1.1 Background

Hixson Pty Ltd proposes to develop a new residential development, known as Catherine Park, near Oran Park in western Sydney. As part of the new estate, local roads will be developed in line with relevant design standards.

It is understood the NSW Department of Planning and Infrastructure (DPI) have requested a minimum road width for local roads of 9.0 metres from kerb face to kerb face, whereas the proposed road width is 7.4 metres, from kerb face to kerb face.

1.2 Purpose of this report

The purpose of this report is to evaluate the impact of a road width from kerb face to kerb face of 7.4 metre, by detailing the environmental and sustainability outcomes using ISO 14040 Environmental Management – lifecycle assessment to determine the resource use, carbon output and environmental footprint, compared to the 9.0 metre kerb face to kerb face width road alternative.

2. Methodology

2.1 Data collection and calculation procedure

A layout plan of the proposed development, with all local roads (as indicated by light grey colouring) was provided for the assessment as shown in Figure 1.

This layout plan was geo referenced to align with the MGA Zone 56 (GDA 94) coordinate system. The roads were then digitised and their lengths calculated using GIS software.

Based on the outcomes of this calculation, the total local road length for the development was calculated as 42.027 km.

As part of the Project objectives, two options were assessed for comparison.

Table 2-1 Options assessed

Option	Total road area assessed (m^2)
Option 1 – 7.4 m width	310,100 m^2
Option 2 – 9 m width	378,243 m^2

A life cycle assessment for construction materials was undertaken based on outputs from the modelling software SimaPro. SimaPro was used to source resource requirements: water use, land use and solid waste outputs for the construction materials.

Figure 1 Proposed development plan indicating local roads

2.1.1 Road construction components

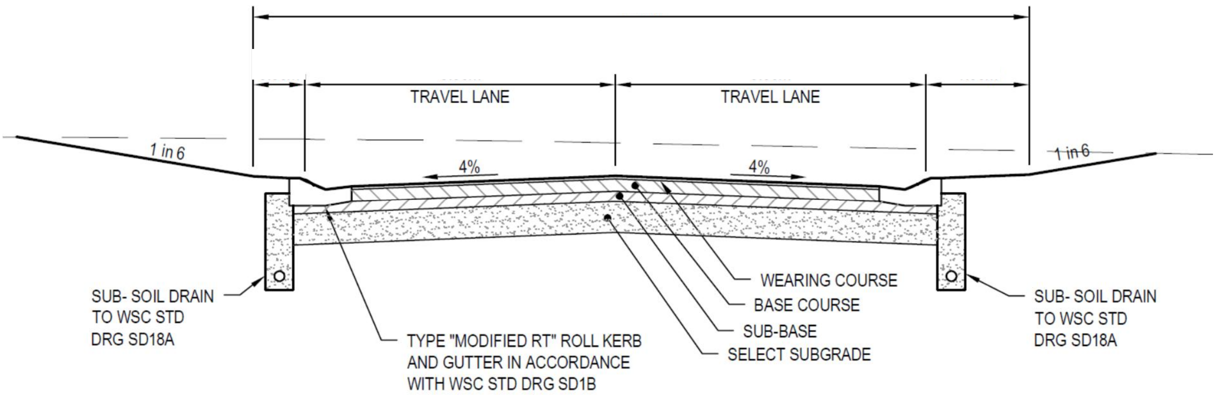
A breakdown of road construction materials was based on a typical residential pavement layout with the following assumptions.

Table 2-2 Assumed road composition

Composition / Material	Thickness (mm)
Spray seal	Assumed application of 2 L/m^2
Wearing course (asphalt)	50
Basecourse (DGB)	130
Sub base (DGS)	390

A typical cross section for a residential road used as the basis for this assessment is shown in Figure 2.

Figure 2 Typical cross section of road



Assumptions used in estimating and calculating the activity levels and associated greenhouse gas emissions for the Project are listed in Table 2-3.

Table 2-3 Calculation assumptions

Parameter measured	Assumptions
Energy	
Diesel	Carbon emission from the diesel use of construction equipment at site estimated based on VIC Road estimates. Data from the 2009 Mickleham Road duplication estimated a carbon emission factor of 190 t CO_2-e per lane km, with on-site construction equipment representing 22 % of total carbon emissions. *Option 1 (7.4 m width):* - Assumed 7.4 m width represents 2 lanes - Based on road length of 42 km - Carbon emissions calculated as 3,511 t CO_2-e based on 42 km 2-lane road

Parameter measured	Assumptions
	- Divide by Emission Factor (EF) of 2.9 for diesel for stationery use (classified as vehicles that are not road registered). Therefore quantity calculated at 1,211 kL. *Option 2 (9 m width):* - Assumed 9 m width represents 2.4 lanes - Based on road length of 42 km - Carbon emissions calculated as 4,213 t CO_2-e based on 42 km 2.4-lane road - Divide by EF of 2.9 for diesel for stationery use. Therefore quantity calculated at 1,453 kL. Emission Factor sourced from NGA Factors July 2012 Tables 3 & 39.
Materials	
Spray seal	*Option 1 (7.4 m width):* - Assumed application of 2 L/m^2 - Total required = 62,1100 L, based on area x 2 L/m^2 - Specific gravity assumed 1.05 (referenced from Boral MSDS) Therefore quantity calculated at 653,100 kg (653 t) *Option 2 (9 m width):* - Assumed application of 2 L/m^2 - Total required = 756,486 L, based on area x 2 L/m^2 - Specific gravity assumed 1.05 (referenced from Boral MSDS) Therefore quantity calculated at 794,310 kg (794 t)

Parameter measured	Assumptions
Asphalt	*Option 1 (7.4 m width):* - Assumed 50 mm thickness - Volume = 15,550 m^3, based on area x 50 mm thickness - Assumed density 2 t/m^3 Therefore quantity calculated at 31,100 t. *Option 2 (9 m width)* - Assumed 50 mm thickness - Volume = 18,912 m^3, based on area x 50 mm thickness - Assumed density 2 t/m^3 Therefore quantity calculated at 37,824 t. The Emission Factor was assumed from gravel and bitumen, based on a percentage of 95% gravel and 5% bitumen and sourced from the SimaPro Australian Database.
DGB	*Option 1 (7.4 m width):* - Assumed 130 mm thickness - Volume = 40,430 m^3, based on area x 130 mm thickness - Assumed density based on dry gravel 1.75 t/m^3 Therefore quantity calculated at 70,752 t. *Option 2 (9 m width)* - Assumed 130 mm thickness - Volume = 49,172 m^3, based on area x 130 mm thickness - Assumed density based on dry gravel 1.75 t/m^3 Therefore quantity calculated at 86,050 t. Emission Factor assumed to be the same as gravel and sourced from the SimaPro Australian Database.
DGS	*Option 1 (7.4 m width):* - Assumed 390 mm thickness - Volume = 121,290 m^3, based on area x 390 mm thickness - Assumed density based on dry gravel 1.75 t/m^3 Therefore quantity calculated at 212,257 t. *Option 2 (9 m width)* - Assumed 390 mm thickness - Volume = 147,515 m^3, based on area x 390 mm thickness - Assumed density based on dry gravel 1.75 t/m^3 Therefore quantity calculated at 258,151 t. EF assumed to be the same as gravel and sourced from

Parameter measured	Assumptions
	the SimaPro Australian Database.
Transport of Materials	
Domestic	The following road transportation estimates were assumed: ◗ Local suppliers sourced from a 30 km radius (spray seal and asphalt) ◗ Quarry materials sourced from the Blue Mountains approximately 85 km from the site (DGB, DGS) ◗ Diesel fuel from Kurnell (70 km)
SimaPro	
LCA Software outputs	Manufacture of: - Gravel 1 kg requires: - 0.00000000145 hectares land - 0.00201 kL water - 0.0802 kg solid waste - Bitumen 1 kg requires: - 0.00000022500 hectares land - 0.0101 kL water - Diesel 1 litre requires: - 0.00000001210 hectares land - 0.0000592 kL water - 0.00149 kg solid waste For the assessment, asphalt has an assumed content of 95% gravel and 5% bitumen. Spray seal was assumed to be the same as bitumen.

All energy consumption and emissions data has been converted into quantities of carbon dioxide equivalent as shown in Appendix A.

3. Outcomes of assessment

3.1 Reduced carbon emissions

Total carbon emissions were calculated based on Scope 1 and 3 emissions for the two road width options. There are no Scope 2 emissions as there is no electricity sourced from the grid assumed for construction activities. Scope 1, 2 and 3 emissions are defined by the Greenhouse Gas Protocol as follows:

- Scope 1 emissions are greenhouse gas emissions created directly by a person or business from sources that are owned or controlled by that person or business (such as fuel combustion)
- Scope 2 emissions are greenhouse gas emissions created as a result of the generation of electricity, heating, cooling or steam that is purchased and consumed by a person or business. These are indirect emissions as they arise from sources that are not owned or controlled by the person or business who consumes the energy (such as purchase of electricity)
- Scope 3 emissions are greenhouse gas emissions that are generated in the wider economy as a consequence of a person or business's activities. These are indirect emissions as they arise from sources that are not owned or controlled by that person or business but they exclude Scope 2 (such as construction materials and transport of materials).

The greenhouse gas assessment indicated total Scope 1, 2 and 3 emissions for the two options as summarised in Table 3-1.

Table 3-1 Summary of scope 1, 2 and 3 emissions

Scope	Quantity (t CO_2-e) – Option 1 (7.4 m width)	Quantity (t CO_2-e) – Option 2 (9 m width)
1	3,269	3,922
3	12,615	15,338
Total	**15,884**	**19,261**

Based on comparison of the two options and overall greenhouse gas emissions resulting from embodied emissions from construction materials and energy use from on-site fuel use, reduction in the road width from 9 m to 7.4 m results will save approximately 3,377 t CO_2-e or equivalent to taking 1,133 cars of the road per annum (ABS, 9208.0, NTC Australia 2010).

3.2 Life cycle assessment

The three primary material components required for road construction works (gravel, bitumen and diesel) will result in the following water use, land use and generation of solid waste during their manufacture. The assessment is undertaken using ISO 14040 Environment Management Lifecycle Assessment principles and framework to quantify the impacts on water, land use and solid waste used for the production of materials through the life cycle stages including resource extraction, production and transport to site by applying accredited factors.

Table 3-2 Life cycle assessment

Option	Water use (kL)	Land use (hectares)	Solid waste (kg)	Land area (m^2)
Option 1 – 7 m width	650,609	0.96	25,068,699	311,000
Option 2 – 9 m width	791,280	1.17	30,488,929	378,243
Difference (saving)	**140,671 kL**	**0.21 ha**	**5,420,230 kg**	**67,243 m^2**

As indicated above, the direct land saving from applying the 7.4 metre road width compared to a 9.0 metres road width on the residential estate is 6.7 hectares or equivalent to 149 residential blocks at an average of 450 m^2 per block.

3.3 Environmental benefits of reduced footprint

Heat island impacts are becoming a major focus of urban design and development as peak and average temperatures in our cities and towns are increasing. This has led to integration of a range of environmentally sustainable design (ESD) measures such as increasing vegetated areas, designing buildings with lighter colours or reflective surfaces and also minimising the heat island impacts of road and footpath pavement areas. Heat islanding effects can cause increases in temperatures in suburbs and cities by as much as 5.6 ^{o}C compared to surrounding rural areas.

Figure 3 Infra-red image showing the increased heating effect of road surfaces compared to other structures in an urban setting

Road pavement (in particular asphalt) is as one of the most significant factors in heat island impacts and has been known to raise the temperature of the road surface over 70^{0}C during the late afternoon on a hot day (US EPA, ACPA) . This effect occurs due to the large thermal mass area of the road surface and the dark colour of the asphalt absorbing and retaining the heat mass with the road surface structure.

Through convection of the heat at the pavement surface heat island impacts in suburban areas are known to stilt air flow and raise overall temperatures increasing demand for residential air conditioning during peak electricity demand times. Depending on the thermodynamics of wind flow and other parameters hot air flow from the road surface may cause localised impacts that raise temperatures to higher levels than the overall average temperature increase due to temperatures at the road surface rising above 70^{o}C (US EPA, ACPA).

Road heat islanding impacts are further exacerbated by the diurnal effect in which road surfaces cool very slowly overnight in warmer temperatures still retaining much of their heat mass. The next morning when day time temperatures start to rise this thermal mass is already at an elevated temperature and acts as a heat bank.

Although difficult to quantify at this stage the proposed plan to minimise road pavement area within the Catherine Park residential development will play some role in assisting reduce heat island impacts and combined with other initiatives such as increasing the vegetated surface area will assist in providing a moderating impact to temperature increases.

The reduction in road width and increase in vegetated surfaces will also have a minor impact on reducing stormwater run-off volumes which may have some impact on reducing localised flooding through increased take up of water run-off through vegetated areas. This impact will be minor but improve the environmental performance of the estate and also reduce storm water run-off into the local catchment area.

4. Conclusion

This report has been prepared to evaluate the impact of the 7.4 metre road width in comparison to a 9.0 metre width road width for local roads within the Catherine Park residential estate, by assessing the environmental and sustainability impacts.

Comparison in greenhouse gas emissions as a result of embodied energy in construction materials and fuel energy were assessed, along with the savings in water, land use and solid waste generated as a result of the manufacture construction materials.

The assessment shows that a 7.4 metre road width would provide significant environmental and sustainable outcomes including:

- A reduction in carbon emissions by 3,377 t CO_{2}-e (equivalent to taking 1,133 cars off the road for one year)
- A saving of 140,671 kilolitres of water (equivalent to water from approximately 56 Olympic size pools)
- A saving of 5,420 tonnes of solid waste (equivalent to waste from approximately 1,003 households over a one year period)
- A saving of 6.7 hectares of land (149 average residential blocks)

Although not quantifiable at this stage further environmental benefits include a reduction in the heat island effect of pavement surfaces and a reduction in storm water run-off within the residential area.

5. References

Australian Bureau of Statistics (ABS), 2010 Survey of Motor Vehicle Use Australia 9208.0 http://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0/

National Transport Commission (NTC) -2010 Carbon dioxide Emissions from new Australian Vehicles – Information Paper

The Commonwealth Department of Climate Change and Energy Efficiency (DCCEE), 2012, *National Greenhouse Accounts (NGA) Factors*, July 2012.

United States Environmental Protection Agency, *Reducing Urban Heat Islands: Compendium of Strategies – Cool Pavements*

United States Environment Protection Agency, Measuring Heat Islands: http://www.epa.gov/hiri/about/measuring.htm

American Concrete Pavement Association – (ACPA)- Hot Pavement http://www.pavements4life.com/QDs/Environment_1HeatIsland.asp

VIC Roads, calculating the Carbon Footprint of Road Construction- 2009 National Local Government Asset Mgt & Public Works Engineering Conference http://www.ipwea.com/cp09/Adam%20Maguire.pdf

World Business Council for Sustainable Development and World Resources Institute, 2004, *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, revised edition, http://www.wbcsd.org/

Appendix A – Greenhouse Gas Inventory

Greenhouse Gas Emissions Calculator

OPTION 1 - 7.4 m

Component	Value		Scope 1 Emission Factor	Scope 2 Emission Factor	Scope 3 Emission Factor	Total Emission Factor		Source	Method	Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Total Emissions	Proportion of Total Inventory
	(Q)	Units	t CO_2-e / units	t CO_2-e / units	t CO_2-e / units	t CO_2-e / units	Units			(t CO2-e)	(t CO2-e)	(t CO2-e)	(t CO2-e)	%
Energy														
Diesel	1,211	kL	2.70	0.00	0.20	2.90	kL	NGA Factors July 2012 Tables 3 & 39	Q x EF	3,269	0	242	3,511	22.1%
Total for energy										3,269	0	242	3,511	22.1%
Materials														
DGB	70,752	t	0.0	0.0	0.017	0.017	t	SimaPro Australian database	Q x EF	0	0	1,196	1,196	7.5%
DGS	212,257	t	0.0	0.0	0.017	0.017	t	SimaPro Australian database	Q x EF	0	0	3,587	3,587	22.6%
Spray seal	653	t	0.0	0.0	0.427	0.427	t	Ecoinvent Database v1.3	Q x EF	0	0	279	279	1.8%
Asphalt	31,100	t	0.0	0.0	0.037	0.037	t	SimaPro Australian database	Q x EF	0	0	1,163	1,163	7.3%
Total for materials										0	0	6,225	6,225	39%
Transport														
DGB	70,752	t	0.0	0.0	0.021	0.021	t	SimaPro Australian database	Q x EF	0	0	1,473	1,473	9.3%
DGS	212,257	t	0.0	0.0	0.021	0.021	t	SimaPro Australian database	Q x EF	0	0	4,420	4,420	27.8%
Diesel	1,211	t	0.0	0.0	0.017	0.017	t	SimaPro Australian database	Q x EF	0	0	21	21	0.1%
Spray seal	653	t	0.0	0.0	0.007	0.007	t	Ecoinvent Database v1.3	Q x EF	0	0	5	5	0.0%
Asphalt	31,100	t	0.0	0.0	0.007	0.007	t	SimaPro Australian database	Q x EF	0	0	229	229	1.4%
Total for product distribution	284,221									0	0	6,148	6,148	39%
GROSS GHG EMISSIONS - OPTION 1 (7.4 m width)										3,269	0	12,615	15,884	

OPTION 2 - 9 m

Component	Value		Scope 1 Emission Factor	Scope 2 Emission Factor	Scope 3 Emission Factor	Total Emission Factor		Source	Method	Scope 1 Emissions	Scope 2 Emissions	Scope 3 Emissions	Total Emissions	Proportion of Total Inventory
	(Q)	Units	t CO_2-e / units	t CO_2-e / units	t CO_2-e / units	t CO_2-e / units	Units			(t CO2-e)	(t CO2-e)	(t CO2-e)	(t CO2-e)	%
Energy														
Diesel	1,453	kL	2.70	0.00	0.20	2.90	kL	NGA Factors July 2012 Tables 3 & 39	Q x EF	3,922	0	291	4,213	26.5%
Total for energy										3,922	0	291	4,213	26.5%
Materials														
DGB	86,050	t	0.0	0.0	0.017	0.017	t	SimaPro Australian database	Q x EF	0	0	1,454	1,454	9.2%
DGS	258,151	t	0.0	0.0	0.017	0.017	t	SimaPro Australian database	Q x EF	0	0	4,363	4,363	27.5%
Spray seal	794	t	0.0	0.0	0.427	0.427	t	SimaPro Australian database	Q x EF	0	0	339	339	2.1%
Asphalt	37,824	t	0.0	0.0	0.037	0.037	t	SimaPro Australian database	Q x EF	0	0	1,415	1,415	8.9%
Total for materials										0	0	7,571	7,571	48%
Transport														
DGB	86,050	t	0.0	0.0	0.021	0.021	t	SimaPro Australian database	Q x EF	0	0	1,792	1,792	11.3%
DGS	258,151	t	0.0	0.0	0.021	0.021	t	SimaPro Australian database	Q x EF	0	0	5,376	5,376	33.8%
Diesel	1,453	t	0.0	0.0	0.017	0.017	t	SimaPro Australian database	Q x EF	0	0	25	25	0.2%
Spray seal	794	t	0.0	0.0	0.007	0.007	t	SimaPro Australian database	Q x EF	0	0	6	6	0.0%
Asphalt	37,824	t	0.0	0.0	0.007	0.007	t	SimaPro Australian database	Q x EF	0	0	278	278	1.8%
Total for product distribution	345,654									0	0	7,477	7,477	47%
GROSS GHG EMISSIONS - OPTION 2 (9 m width)										3,922	0	15,338	19,261	

GHD

133 Castlereagh St Sydney NSW 2000
-
T: 2 9239 7100   F: 2 9239 7199   E: sydmail@ghd.com.au

n:\au\sydney\projects\21\22284\WP\188071.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft	L Slechta	S Thompson		S Thompson		
0	L Slechta	S Thompson		S Thompson		21/2/13
1	L Slechta	S Thompson		S Thompson		28/2/13
2	L Slechta	S Thompson		S Thompson		13/3/13

www.ghd.com

APPENDIX 2 – ASSESSMENT OF DCP ROAD WIDTHS BY BROWN CONSULTING

Our Ref: X12249.R

Mr Trevor Jenson
Harrington Estates Pty Ltd

11 April 2013

Via email: trevor@harrington.com.au

Dear Trevor

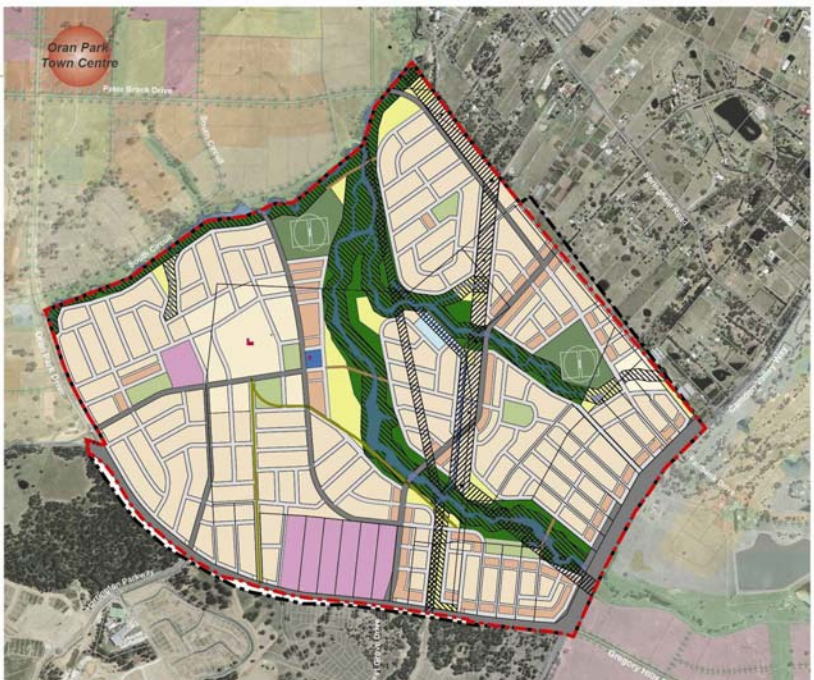
South Catherine Fields – Assessment of DCP Road Widths

As requested we have reviewed the proposed road widths for 'local' streets as specified in the Catherine Fields Development Control Plan (DCP). The findings of this review are presented below.

Background

The South Catherine Fields precinct forms part of the South West Growth Corridor and is located adjacent to the rapidly developing Oran Park Precinct and Town Centre. The location of the precinct is shown in **Figure 1** below:

Figure 1 – South Catherine Fields Precinct Draft ILP



Level 2, 2 Burbank Place, Norwest Business Park, Baulkham Hills NSW 2153
PO Box 8300, Baulkham Hills NSW 2153 Australia
Telephone +61 2 8808 5000 **Facsimile** +61 2 8808 5099

Brown Consulting (NSW) Pty Ltd
ABN 30 109 434 513
brownconsulting.com.au

At ultimate development of Catherine Fields, the development will provide approximately 3300 dwellings in addition to commercial / retail developments to service the population of some 10,000 persons. On a larger scale, the south west growth corridor as a whole will provide 110,000 homes and expected growth in population of 300,000 people.

<u>AECOM 2012 Report</u>

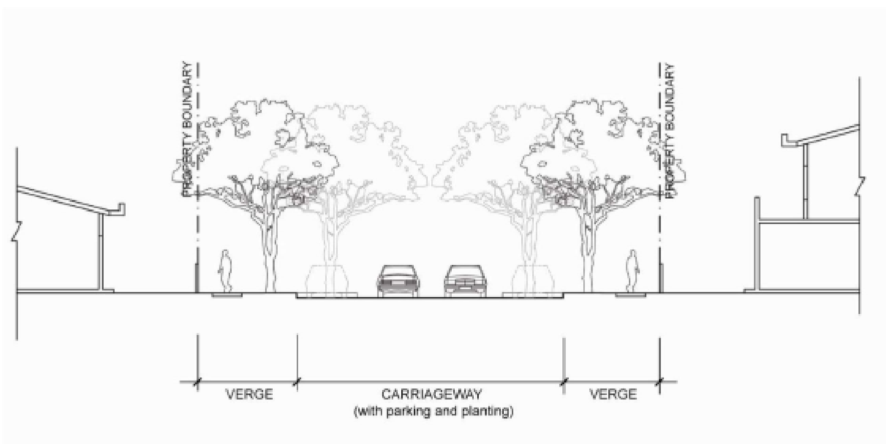
The recommended road widths for streets in Catherine Fields can be found in the 'Traffic and Transport Assessment Catherine Field (Part) Precinct - Transport and Access Strategy' report prepared by AECOM dated 20 February 2012. This report cited the *Oran Park DCP* as the guiding document for road widths. However, the report incorrectly recommended the following cross section for a 'local' street:

Figure 2 – AECOM 2012 Report Suggested 'Local' Street Cross Section

Table 13: Local Street Cross Section

Collector Street	Foot path	Planting	Parking/ Landscape	Vehicle Lane	Vehicle Lane	Parking/ Landscape	Foot path	Planting	Total Width
Oran Park DCP	1.8m (1.2m)	1.7m	2.1m	2.75m	2.75m	2.1m	-	3.5m (2.9m)-	16.7m
Austral and Leppington Precincts	2.1m (1.3m)	1.4m	9.0m				1.4m	2.1m (1.3m)	16.0m

Figure 17: Local Street Typical Cross Section (Oran Park DCP)



The road width for a local street of 9.0m does not comply with the recommended road width of 7.4m in the Oran Park DCP with roll top kerb.

<u>The Issue</u>

It is understood the NSW Department of Planning and Infrastructure (DPI) have requested a minimum road width of 9.0 metres for 'local' streets. However, the development proposes 'local' street widths of 7.4 metres with roll top kerb.

Impacts of Providing 'Wide' Local Streets

Compared with 'local' road widths of 7.4m, there are clear disadvantages to providing wider local roads. These include but are not limited to:

1. Higher general traffic speeds
2. Higher risk of accidents
3. Higher severity of accidents
4. Poorer amenity for residents
5. Greater difficulty for vehicles exiting side roads at intersections
6. Greater difficulty for crossing pedestrians
7. Greater difficulty to exit driveways
8. Increases the need to retrofit traffic facilities in the future
9. Increased need for greater sight distances at intersections at the expense of landscaping / parking
10. Greater noise impacts

A 9.0m wide road allows two vehicles to pass unimpeded whilst vehicles are parked on either side of the street. A 7.4m wide local road, a width recommended by AMCORD - A National Resource Document for Residential Development does not allow two vehicles to pass. Therefore, general speeds in local streets would be greater as vehicles move through streets unabated.

Published Research / Policies on Repercussions of Providing Wider Streets

Wider streets which allow unabated travel by opposing vehicles in turn allow higher general traffic speeds.

There is extensive research on the implications that higher traffic speeds have on the safety of users, the amenity of residents and most importantly the severity of accidents which can occur.

The Streets Where We Live – A Manual for the Design of Safer Residential Estates

This pioneering document provided a detailed assessment of the influence of best practice design on all facets of residential precincts including speeds, pedestrian amenity, resident amenity, nature strips, road widths and the like.

The publication included an assessment of the relationship between road width, type of road user and resulting maximum speeds of vehicles which travel internal to the precinct and those which are passing through. For local streets, it is expected that traffic is generally limited to internal trips as good precinct design provides higher order roads for traffic travelling through precincts. Further, the manual provides an assessment of expected maximum speeds of vehicles in a range of street widths.

For relatively flat roads with a 7.0m wide and 9.0m carriageway, the manual estimates the resulting maximum speed would be 40km/hr and 50km/hr respectively. That is, the wider street would result in speeds 10km/hr greater than the narrower alternative irrespective of the posted speed limit.

Impacts of Higher Speed Streets

The Australian Department of Transport Infrastructure maintains the Australian Road Deaths Database. Of interest is the number of fatalities which occurred in NSW in 2012 based on posted speed limit (and in turn the speed at which vehicles were enabled to travel at as a result of the road configuration). This is shown in **Table 1** below:

Table 1 - 2012 Fatalities in NSW by Posted Speed Limit up to 60km/hr

Posted Speed Limit	No. of Fatalities in 2012
10	0 (0%)
20	1 (0.7%)
25	0 (0%)
30	0 (0%)
40	6 (4.4%)
50	64 (47.4%)
60	64 (47.4%)
Total	135

From **Table 1** it is noted that of the 135 fatal accidents which occurred on roads with a posted speed limit of 60km/hr or less, 94.8% of fatalities occurred on streets with speed limits greater than 40km/hr. This would indicate posted speed limits, and the road environment which allows those speeds has a marked influence on severity of accidents which can occur. Further, limiting general traffic speeds to 40km/hr through passive road design saves lives notwithstanding the posted speed limit.

Cost of road crashes in Australia 2006 – Department of Infrastructure, Transport, Regional Development and Local Government

Every 10 years this publication provides a snapshot of the costs of accidents to the Australian public and how accident rates have changed each 10 years. Some of the key findings are presented below:

- *There were an estimated 653 853 road crashes in 2006 involving approximately 1.16 million vehicles, compared with an estimated 618 600 crashes involving approximately 1.13 million vehicles in 1996.*
- *1602 people died as a result of road crashes in 2006, down from 1970 people in 1996.*
- *31 204 people injured in road crashes were admitted to hospital in 2005–06. Of these, 20 958 people stayed one night or more (down from 21 189 in 1996).*
- *BITRE estimated that there were 4619 people who suffered a disability as a result of road crashes in 2006, up from an estimated 3997 in 1996.*
- *BITRE estimated that there were an additional 216 500 people treated for road crash injuries in 2006 who were not admitted to hospital.*
- *There were 496 fatalities in NSW in 2006.*
- *There were 7.28 fatalities per 100,000 population in NSW.*
- *There were 150.6 hospital injuries[1] from road crashes per 100,000 population in NSW*

[1] Injuries caused by an accident which required hospitalisation for a period

Across Australia for all accident types, the rates per 100,000 population are shown in **Table 2** below which includes an estimate of accidents potential number of accidents which will occur in Catherine Fields:

Table 2 – Annual Accident Rates by Type

Injury Severity	No. Persons	Rate per 100,000 population*	Rate for Catherine Fields**
Fatal	1,602	7.74	0.8
Hospitalised, stayed 1 night or more	20,958	101.3	10.1
Hospitalised, discharged same day	10,246	49.6	5.0
Not hospitalized estimate	216,500	1046.9	104.7
All casualties	249,306	1,205.5	120.6

*(20.68 million population in 2006)
** 10,000 population

From **Table 2** it is noted that some 121 accidents are statistically likely to occur in Catherine Fields every year.

Speed, Speed Limits & Safety – Swedish National Road & Transport Research Institute – Andersson G & Nilsson G (1997)

The Swedish National Road and Transport Research Institute, is an independent and internationally prominent research institute in the transport sector. Historically they have been at the forefront of developing assessment tools for accident statistics and influences on accident type and rates. This work has informed the use of the International Road and Traffic Accident Database (IRTAD) in order to improve and increase its usage.

The relationship of increased speeds on accident potential is calculated using a well-established relationship by Nilsson 1984.

This is shown below:

$$n_A = (v_A/v_B)^P \text{ x } n_B$$

where nA = number of crashes after the speed change

nB = number of crashes before the speed change

vA = mean or median speed after

vB = mean or median speed before

p = exponent depending on the injury severity of the crashes where:

- p = 4 for fatal crashes
- p = 3 for serious injury crashes
- p = 2 for minor injury crashes

The above is represented in graph form below:

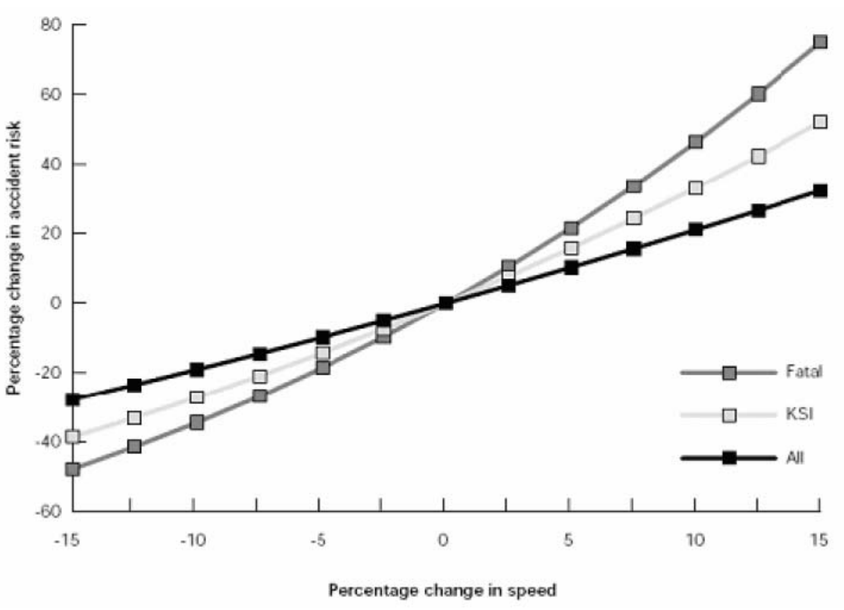


Figure 1. Relationship between change in speed and change in accidents (from Andersson and Nilsson, 1997).

The research which is represented in the graph in **Figure 1** shows a 10km/hr speed in speed would reduce fatal accidents by approximately 40% and all accidents by some 20%.

Reduction in Accidents in Catherine Fields

Table 2 provided an estimate of potential accidents by type per annum at full development of Catherine Fields. In our view and having regard to the speeds suggested by the 'The Streets Where we Live' recommendations, a 7.4m wide street would allow general speeds of 40km/hr whereas a 9.0m wide carriageway would allow general speeds of 50km/hr.

It is noted that not all accidents would occur in local streets and Catherine Fields would include a range of street types. Therefore for the purpose of this assessment, it has been assumed 50% of the potential accidents would occur within 'local' streets. Thus the resulting potential number of accidents in Catherine Fields with 7.4m and 9.0m 'local' streets over a 10 year period is shown in **Table 3** below.

Table 3 – Potential Accidents on Local Streets in Catherine Fields over a 10yr Period

Injury Severity	Potential Accidents on 9.0m wide streets	Potential Accidents on 7.4m wide streets
Fatal	4.0	1.6
Hospitalised, stayed 1 night or more	50.0	25.6
Hospitalised, discharged same day	25.0	12.8
Not hospitalized estimate	523	335
All casualties	602	375 (-38%)

From **Table 3** and based on international best practice standards for investigations into influences which can reduce accidents, it has been estimated that local roads at 7.4m widths which allow maximum speeds of 40km/hr would result in 38% less potential accidents than the same roads at 9.0m widths.

Conclusion

The provision of 9.0m wide local roads in Catherine Fields precinct would result in increasing the potential accidents that may occur by 38% compared with providing the same roads at 7.4m in width. Over a 10 year period, this would equate to a reduction of approximately 227 accidents.

Despite the clear benefits to accident reduction, the provision of 7.4m wide 'local' streets also result in:

1. Greater levels of amenity for residents and road users
2. Increased reaction time allowances for vehicles exiting driveways and side streets
3. Increased reaction time allowances for pedestrians
4. Lower noise levels
5. Reduced need to provide retrofitted traffic facilities in the future.

Despite the fact that the suggestion to provide 9.0m wide 'local' roads in South Catherin Fields stems from an incorrect reference to the Oran Park DCP, there are clear safety benefits in providing Oran Park DCP compliant 'local' roads at widths of 7.4m.

We trust the above assessment assists in your planning for the precinct. Please do not hesitate to contact myself on 02 8808 5000 should you require any additional information.

Yours sincerely
Brown Consulting (NSW) Pty Ltd

DEAN BRODIE
Principal Engineer – Traffic and Transport
Encl.

APPENDIX 3 – COST ANALYSIS BY BROWN CONSULTING

CATHERINE PARK

CONSTRUCTION COSTS COMPARISON

LOCAL ROADS WIDTHS
9.0m width to 7.4m width

DATA

ROAD LENGTH	37350	ln.m	20/03/2013
WIDTH REDUCTION	1.6	m	
AREA	59760	sq.m	
ALLOTMENTS	3100	Precinct	

ITEM	DISCRIPTION	QTY	UNIT	RATE	AMOUNT
	Construction Costs				
1	Earthworks				
	Assume 1.0m nominal cut to fill over area of pavement	59760	sq.m	$ 5.00	$ 298,800
2	Pavements				
	Subgrade			$ 1.20	
	Sub Base 320mm			$ 20.46	
	Base 120mm			$ 15.08	
	Flush Seal			$ 3.34	
	AC - 1st layer			$ 12.00	
	AC - 2nd layer			$ 12.00	
		59760	sq.m	$ 64.08	$ 3,829,421
3	Stormwater drainage				
	Reduction in pipe size resulting from reduced impervious area	9337.5	ln.m	$ 20.00	$ 186,750
	Say 25% of road length				
	1 pipe size reduction				
	SUB TOTAL				**$ 4,314,971**
4	Detention / Water Quality Basin				
	Reduced area impervious 90% for road pavements to				
	75% for lots @ Say 50% allowance	6453	sq.m	$ 200.00	$ 1,290,600
	Allowance 3% of catchment for water quality				
	SUB TOTAL				**$ 1,290,600**
	TOTAL Construction Costs				**$ 5,611,246**
	Per Lot Items 1 - 4				**$ 1,810**
	Development Costs				
5	Land Component				
	Typical Allotment				
	Additional available land area = 15m x 0.8m (half road width)	12	sq.m	$ 450.00	$ 5,400
	SUB TOTAL				**$ 5,400**
6	Electrical / Sewer / NBN				
	Additional Utility Servicing costs				
	12 sq.m additional land area per lot / 450 typical lot = 2.7%				
	Electrical @ $6,000 / lot				
	Sewer @ $4,000 / lot				
	NBN @ $200 / lot				
	Total $10,200 @ 2.7%	1	Item		$ 275
	SUB TOTAL				**$ 275**
7	Estate Major Works Items				
	Sewer Carrier, Riparian Corridor, general wide estate works				$ 222
	$15,000,000 @ 3100 lot yield = $4,838 / lot				
	LESS additional 149 lot yield = $4,616 / lot				
	$222 / Lot				
	SUB TOTAL				**$ 222**
	TOTAL Development Costs / Lot				**$ 5,897**
	Per Lot Items 5 - 7				**$ 5,897**
	TOTAL DEVELOPMENT COSTS + CONSTRUCTION COSTS ITEMS 1 - 7				**$ 7,707**
8	Margin				
	Land holding cost, interest and developers margin @ 30%	$ 7,707		30%	$ 2,312
	SUB TOTAL				**$ 2,312**
	TOTAL Additional Cost Per Lot				**$ 10,019**

REFERENCE LIST

[a] Seth Ullman n.d., *Rightsizing Streets*, accessed 8 March 2013, <http://www.pps.org/reference/rightsizing/>

[b] Council of Mayors (SEQ) 2011, *Next generation planning.: A handbook for planners, designers and developers in South East Queensland*, Council of Mayors (SEQ), Queensland, p. 32.

[c] Western Australian Planning Commission 2009, *Liveable Neighbourhoods: a Western Australian Government sustainable cities initiative*, vol. 2, Western Australian Planning Commission, Western Australia, p.21.

[d] Government of South Australia 2012, *Streets for People: a compendium for South Australian Practice*, Government of South Australia, South Australia, p.B6.

[e] Gehl, J. 2010, *Cities for People*, Island Press, Washington D.C.

[f] Western Australian Planning Commission 2009, *Liveable Neighbourhoods: a Western Australian Government sustainable cities initiative*, vol. 2, Western Australian Planning Commission, Western Australia, p.2.8; NSW Department of Infrastructure, Planning and Natural Resources 2004, *Planning guidelines for walking and cycling*, NSW Department of Infrastructure, Planning and Natural Resources, New South Wales, p.30.

[g] Richards, L.D. 1985, 'The Streets Where We Live: A Manual for the Design of Safer Residential Estates', *Australian Planner*, vol. 23, no. 4, p. 26.

[h] Commission for Architecture and the Built Environment (CABE) 2009, *This way to better residential streets*, Comission for Architecture and the Built Environment, London.

[i] Commonwealth of Australia 1995, *AMCORD: a national resource document for residential development*, Australian Government Publishing Service, Canberra.

[j] Power, J. 2013, 'Shady deal for neighbourhoods that want to turn down the heat', *Sydney Morning Herald*, 9 March 2013, accessed 9 March 2013, <http://www.smh.com.au/environment/conservation/shady-deal-for-neighbourhoods-that-want-to-turn-down-the-heat-20130308-2fqv0.html>

[k] Daisa, J.M. and Peers, J.B. 1997, *Narrow Residential Streets: Do They Really Slow Down Speeds?,* Institute of Transportation Engineers, Washington D.C.

[l] Richards, L.D. 1985, 'The Streets Where We Live: A Manual for the Design of Safer Residential Estates', *Australian Planner*, vol. 23, no. 4, p. 26.