Living on the Edge: transport sustainability in Perth’s Liveable Neighbourhoods

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This thesis is presented for the degree of Doctor of Philosophy of Murdoch University

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I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary education institution

..............................................................

Ryan Falconer
Abstract

Following World War Two, land use and transport policy and practice in most major Australian cities was modelled on the US experience. As such, these cities have become characterised by urban sprawl (indicated by segregated zoning and low development densities) and car dependence. In Perth, Western Australia, these characteristics are particularly evident despite, or perhaps because, the city has a strong regional planning system unlike most American cities.

Car dependence and sprawl are in turn linked to dependence on fossil fuels for transport energy. Increasingly, too, links are being found between conventional planning outcomes and public health. For example, research has linked car dependence with a variety of health conditions including respiratory illness, overweight and obesity. Moreover, research is increasingly linking sprawl and car dependence with social justice issues because people on limited income and with decreased mobility struggle to undertake their life’s work.

In response to these concerns the Western Australian planning system introduced Liveable Neighbourhoods, a new design code, which was meant to reduce car dependence and sprawl. This code has its roots in New Urbanism and appears to have been taken up more rapidly in Perth than elsewhere. No large-scale evaluation of New Urbanism has previously been conducted anywhere.

This thesis reports on an extensive literature review, travel survey (n=211), perceptual study (n=992) and environmental study, which together sought to evaluate whether the Liveable Neighbourhoods (LN) design code is contributing to a sustainable transport
agenda. In total, 46 neighbourhoods (11 LNs and 35 CNs) were compared. The research found that despite residents of Liveable Neighbourhoods driving less and walking more than residents of conventional neighbourhoods (CNs) (a switch of 9% with some associated health advantages), there was little else to indicate that LN is achieving its goals as transport VKT and fuel use was identical due to regional transport requirements diminishing any local walkability advantages.

There was strong supportive evidence that LNs were not significantly different to CNs. For example, there were few differences in perception of opportunity for more sustainable travel and residents of CNs actually had better access, on average, to key destinations, including shops (i.e. the average distance to key destinations was 2.2 kilometres compared with 2.5 kilometres in LNs). Also, residential lot densities were well below what were intended by LN and in both LNs and CNs the time for public transport to get people to work was over 90 minutes compared with around 30 minutes by car.

The results reveal that there must be significant revisions to the LN code and how it is applied, because there is no evidence that new neighbourhoods are improving regional transport sustainability. In particular, residential densities and land use mix appear to be too low to encourage community self-sufficiency, indicated by few neighbourhoods being anchored by key destinations. These matters are not mandated in the LN guidelines making them powerless to bring significant change. More generally, the thesis questions the extent to which New Urbanism can promote a sustainable transport agenda wherever it is applied unless it mandates real changes in land use and transit not just local walkability.
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List of acronyms

AAA ......................... Automobile Association of Australia

ABARE ..................... Australian Bureau of Agricultural and Resource Economics

Au ......................... Australia (typically used in a reference to Australian dollars)

BMI ......................... Body Mass Index

BP ......................... British Petroleum

CBD ......................... Central Business District

CCD ......................... Census Collection District

CDC ......................... Centers for Disease Control and Prevention (United States of America)

CN ......................... Conventional neighbourhoods

CPTED ...................... Crime Prevention Through Environmental Design

DPI ......................... Department for Planning and Infrastructure

ECan ......................... Environment Canterbury (Canterbury Regional Council, New Zealand)

ha ......................... Hectares

ISTP ......................... Institute for Sustainability and Technology Policy

km ......................... Kilometres

LN ......................... Liveable Neighbourhoods

MfE ......................... Ministry for the Environment (New Zealand)

NHS ......................... National Health Service (United Kingdom)
OPEC ......................... Organization of Petroleum Exporting Countries

PATF ......................... Premier’s Physical Activity Task Force (Western Australia)

PATREC ....................... Planning and Transport Research Centre (Western Australia)

PM ............................... Particulate Matter

POD ............................. People-Oriented Development

PT ................................. Public Transport

RA ................................. Residents’ Association

RESIDE ......................... RESIDential Environments Project (University of Western
                               Australia)

TOD ............................... Transit-Oriented Development

TSH ............................... Transport Sustainability and Health (study)

UK ................................. The United Kingdom

US ................................. The United States of America (also used to reference United
                               States dollars)

UWA ............................... University of Western Australia

WAPC ............................ Western Australian Planning Commission

WCTRS and ITPS .......................... World Conference on Transport Research Society and Institute
                               for Transport Policy Studies

WHO ............................... World Health Organization

WWII ............................ World War Two
Key concepts

Access
For the purposes of this study, access refers to the ease with which a person can get to a select physical destination (Litman, 2003). Access varies as a function of the mode of choice and all manner of trip conditions. For example, poor infrastructure between a home and a local shop may drastically affect accessibility, even if the distance is short. Even small changes to land use and infrastructure can alter how easy it is to access destinations by one or more modes.

Alternative modes/active modes
Alternative modes are modes other than the private motor vehicle. These include the various forms of public transport, such as trains, buses and ferries, and ‘active modes’, such as walking and cycling. Skateboards, foot-powered scooters and the like may also be considered active modes. As the thesis is focused on the urban passenger and individual transport task, aircraft are not mentioned in any discussions and neither is freight.

Car dependence
Newman and Kenworthy (1989; 1999) are credited with conceptualising automobile (or car) dependence. Car dependence characterises cities where transport planning has been focused on imperatives for drivers and over time, alternative modes have lost their competitiveness. People therefore come to rely on motor vehicles to conduct much of their travel because there are few, if any, suitable alternatives (Newman, 2006). Newman and Kenworthy (1999) suggest a density threshold of 20-30 persons per
hectare below which car dependence can be assumed. This is because it becomes difficult to serve people with a quality public transport system below this threshold (discussed more in Chapter 6) and distances between homes, services and places of employment become too great to walk or cycle. Intuitively, car dependence is linked to sprawl because low density development and segregation of land uses reduce the attractiveness and efficiency of public transport, walking and cycling (Hotzlczlaw, 1990; Kenworthy and Laube, 2005; Newman and Kenworthy, 1999).

Litman (1999; 2002) adds to understanding of the characteristics of a city that make it car dependent and dispels some of the vagaries associated with the term. Litman’s (2002) argument is that car dependence is the product of a range of measurable variables, such as vehicle ownership and use, and frequency of trips. In the literature review presented in this thesis (Chapters 1-7) it is explained how many areas of Perth are car dependent. Such car dependency served as a backdrop against which the Liveable Neighbourhoods policy was developed.

**Car preference**

Car preference refers to people’s choice to drive. It is distinct from car dependence, which implies that use of the car is necessary. For example, preferential rather than necessary use of a car would be a person’s decision to drive two hundred metres to local shops when they could easily and efficiently conduct the trip by walking. The distinction between preference and dependence is further developed in Chapter 3.

**Fossil fuel dependence**

Fossil fuel dependence is related to car dependence. The motor vehicle fleet presently relies almost exclusively on oil for transport energy (the implications of which are
discussed in Chapter 5). Accordingly, changes to demand for and supply of oil can have far-reaching consequences for transport systems\(^1\).

**Greenfield development**

This refers to development of land that was previously farmland, vegetated or otherwise ‘green’. It is distinct from *brownfield* development, which refers to recycling of land that previously served some other urban function (for example, conversion of disused light industrial land to housing). Conventional greenfield development, which usually occurs on the fringe of cities, perpetuates sprawl.

**Local travel**

‘Local travel’ is a subjective concept, however, for the purposes of this study, it may be defined as a short trip made within a person’s own neighbourhood. It can be easier to conceive local travel to be a trip made within a walkable neighbourhood (see below) as this gives a measure of distance.

**Mobility**

How mobile a person is, in the context of this study, is how able they are to conduct their life’s work. Mobility at the personal level is influenced by physiology. A disability, for example, may render some people unable to walk or cycle. It is also influenced by the availability of different modes of transport. The availability of a car, for example, will almost certainly make a person more mobile than if they were to rely on walking, cycling and public transport. Mobility is distinct from access.

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\(^1\) A change in demand may be instigated by significant increases in vehicle ownership and VKT (such as is occurring in China) and a change in supply may occur if the Organization of Petroleum Exporting Countries (OPEC) shifts production levels.
**Permeability/connectivity**

These terms are often used interchangeably. They refer to the ratio of the network to the straight-line (or Euclidean) distance of a trip. These values will almost always differ as routes rarely directly link an origin with a destination\(^2\). A ratio close to 1:1 represents good permeability/connectivity.

**Sprawl**

Sprawl refers to a state of decentralised urban development and often characterises cities where there are few geographical barriers to outwards growth, significant investment in road infrastructure and piecemeal urban growth over time. There are four widely accepted measures of sprawl, which together can be organised into an index (Ewing *et al.*, 2002). These measures are low densities, segregated land uses, and a lack of network permeability and urban vitality.

**Walkable neighbourhoods**

Public health academics concerned about achieving recommended levels of walking define a walkable distance as 1.5 or 1.6 kilometres (McCormack *et al.*, 2007) corresponding to a brisk 15 minutes of walking time (Saelens *et al.*, 2003a). Other research has found, based on participant feedback, that walkable neighbourhoods may actually be closer to 1 kilometre in diameter (Moudon *et al.*, 2006).

Holtzclaw (1994) used buffers of around 400 metres to define walkable catchments. The Liveable Neighbourhoods guidelines themselves refer to a 400-metre neighbourhood radius being the target for new neighbourhoods (Western Australian

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\(^2\) A good example of the contrast between network and straight-line distance is given in Chapter 2.
Planning Commission, 2004). Accordingly, the Transport Sustainability and Health study was interested in two buffers: one at 400 metres and a second at 1.5 kilometres.
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CHAPTER 1:

Introduction

Transport is more than just 'where to' and 'how do we get there'

Source: <http://www.celluloid-dreams.de/content/images/kritiken-filmbilder/2-fast-2-furious/2-fast-2-furious.jpg>

Transport is not simply about physical movements, it is about money, time, effort, comfort, safety, reliability, habit, addiction and culture (Peake, 1994: p79).
1.1 Background

Internationally, policy makers and researchers are showing increasing interest in the relationships between land use, transport, health and other sustainability issues. As such, there is a considerable amount of research now being undertaken, often from a cross-disciplinary perspective, which is seeking to explore these synergies. In the United States of America (US) and Australia, particularly, the interest in these relationships is being driven by understandings that conventional land use and transport planning is not sustainable. This is because many US and Australian cities have become characterised by urban sprawl (indicated by segregated zoning and low development densities) and car dependence.

Car dependence and sprawl are in turn linked to dependence on fossil fuels for transport energy. Increasingly, too, links are being found between conventional planning outcomes and public health. For example, research has linked car dependence with a variety of health conditions including respiratory illness, overweight and obesity. Moreover, research is increasingly linking sprawl and car dependence with social justice issues because people on limited income and with decreased mobility struggle to undertake their life’s work.

The concept of ‘sustainability’ is increasingly being integrated into land use and transport planning policy rhetoric. This research took a broad view of transport sustainability, using an extensive literature review to explain how transport patterns are increasingly being linked with changes to the built environment, energy consumption, pollution, social equity and capital, economic costs and more recently, public health.
Figure 1.1 (a model developed to guide the research) suggests that the built environment influences transport behaviour although casual relationships are yet to be proven. Even so, there are other potentially significant variables involved in transport decision-making, including personal preference and socio-demographics. Social equity, too, would seem to be affected not only by the way in which cities are designed but people’s disposable income and notions of habit and preference. Furthermore, people’s perceptions of travel may be influenced by environmental characteristics and may help predict transport behaviour. Transport sustainability is therefore not easy to assess.

It is also important to understand that transport sustainability is a process, not an end product. Additionally, it is a fluid rather than absolute concept, as transport behaviour is relatively sustainable or unsustainable. That is, public transport can be considered more sustainable than motor vehicles because more people can be moved per unit of fuel, but buses and trains still pollute the environment. Also, sustainability is something that needs to be constantly renegotiated. Certain transport behaviour may become less sustainable over time. For example, private motor vehicle mobility was sustainable prior to World War Two, relative to the present day because uptake of vehicles was still low. Consequently, the demand for non-renewable transport energy (oil) was relatively low. Nowadays, as is described in Chapter 5, high levels of car ownership and use are contributing to a global energy supply problem that presents significant challenges for sustainability.

These pressing issues, such as social injustice, pollution, poor public health and over-reliance on transport energy, informed the New Urbanism design approach, from the American Congress for the New Urbanism. Through a suite of design changes, New
Urbanism rhetoric suggests that car dependence and sprawl can be alleviated, with implied improvements in transport sustainability.

Perth, Western Australia was one of the first cities in the world to take on this American style New Urbanism in a big way. This was because the city is internationally recognised as a low density sprawled city where residents depend on their cars for much of their travel. This follows the development of the 1955 Stephenson-Hepburn Plan and the subsequent Metropolitan Regional Scheme (1963), which established a strong regional planning system for the city. From the 1960s, Perth’s conventional suburbs have spread north and south for more than 120 km, with urban systems having been designed assuming a high level of private motorised mobility amongst the public.

The State government responded to the dual issues of urban sprawl and car dependence by implementing the “Liveable Neighbourhoods” (LN) design code. This is intended to facilitate more sustainable urban development and associated transport patterns. The code is an interpretation of New Urbanism, tailored to the Western Australian context. Significantly, Perth had substantial growth occurring at the period that the planning community world-wide were being introduced to New Urbanism. The city also had a history of commitment to State intervention in the planning system which could enable a new design code to be introduced, and a committed New Urbanist public servant (Evan Jones) who was in a position to re-write the code and promote it to developers and planners. Some of the key transport-related intentions of LN are for:

- Street networks to be more permeable to reduce trip lengths
- Neighbourhoods to be more mixed use and dense to improve access, with services being anchor-points for the community
• Public transport services to be more accessible
• Neighbourhoods to be more self-sufficient, with there being greater opportunity for local trips.

Together, these characteristics should encourage reduced trip frequencies (as trip purposes can be combined), trip lengths (access to the services integral to people fulfilling their life’s work should be improved), travel times (given shorter distances to key destinations) and car use (trips by public transport, walking and cycling should be better facilitated).

In the 1990s, when LN was introduced as a voluntary code, several developers adopted it and subsequently, a number of new developments followed. Key designers from the American Congress for the New Urbanism came to Perth during this time to provide their design advice. People such as Peter Calthorpe, Andres Duany and Peter Katz were frequent visitors to Perth. The 11 LN projects evaluated in this thesis are as big a selection of New Urbanist projects as could be found in any city. Therefore, they present a laboratory of urban planning, which needs to be evaluated.

The contribution of this thesis is therefore to assess and report on the transport sustainability of Perth’s Liveable Neighbourhoods, by comparing aspects of design and transport-related data collected from these 11 LN developments with data from a sample of conventionally-designed developments. Liveable Neighbourhoods should be communities whose residents use active modes more frequently for local trips, make more trips locally, more regional trips by public transport and fewer trips by private motor vehicle overall than residents of conventional neighbourhoods (CNs). The differences should be in relative and absolute terms, and be measurable by reduced
vehicle kilometres travelled and derived transport energy use. The research anticipated that more sustainable utilitarian\(^3\) travel would reflect more opportunities for this and a perception amongst residents of such opportunities.

Evaluations of New Urbanism are rare, if any and this thesis is therefore both the first major evaluation of the transport sustainability of Perth’s LNs and a major litmus test for the underlying New Urbanist approach. The findings of the research, particularly those relating to regional transport sustainability, can be used to reinforce LN and may be used to reinforce New Urbanism.

More generally, the thesis adds to understandings of the relationships between land use, transport, public health and sustainability issues, particularly in the Perth context and serves as a useful manifesto for defining transport priorities into the future. The results presented in this thesis can help ensure future development guidelines (in Perth or elsewhere) are evidence-based.

The Transport Sustainability and Health (TSH) study (the empirical research component: explained in Sections 1.2 and 1.3) is also a sub-study of the RESIDential Environments (RESIDE) Project. The RESIDE project is based at The University of Western Australia (UWA) and has the principal aims of assessing the impact on walking, cycling and sense of community of neighbourhoods designed using Liveable and conventional subdivision design codes. It is a collaborative project involving UWA, Murdoch University, the Department for Planning and Infrastructure and the National Heart Foundation.

\(^3\) As distinct from leisure travel
Figure 1.1 – Transport sustainability model
The RESIDE project utilises a large data set, principally made up of questionnaire material from residents of 79 new neighbourhoods in greater Perth. The RESIDE study design and how the TSH study fits within it, is explained further in Chapter 8.

1.2 Research aims and objectives

The overall goal of this thesis was to conduct the first comprehensive evaluation of transport sustainability in Liveable Neighbourhoods using 11 test case suburbs of Perth. In a broader sense, the thesis was a major evaluation of New Urbanism, given LN is an interpretation of this design approach.

The thesis had several key aims. The first of these was to conduct a comprehensive review of literature relating to transport sustainability (including historical planning, transport decision-making, social justice, pollution, public health and transport energy use), to contextualise the empirical research. The aims of the empirical research were to examine whether residents of LNs reported travelling in a more sustainable way than residents of CNs, there were more opportunities for sustainable travel in LNs and residents of LNs were aware of relatively more opportunities for sustainable travel. The associated objectives were to:

1) Set a context for the need for new planning priorities and an evaluative study by analysing urban planning history, travel decision-making and sustainability issues (such as social justice, pollution, public health and energy use);
2) Examine some of the alternatives for improving land use and transport sustainability and how these informed LN;

3) Identify a sample of Perth’s new neighbourhoods, some conventional and some Liveable to allow detailed analysis of travel patterns, residents’ perceptions of access in their neighbourhoods and opportunities for more sustainable travel;

4) Consider how the self-reported travel behaviour may be associated with key health variables (including BMI), and energy use and emissions, with these being some key measures of transport sustainability;

5) Use the findings of the research to discuss whether the way in which the LN design code is being implemented is contributing to more sustainable transport in new neighbourhoods. To then use this discussion to make policy recommendations, draw conclusions and identify areas for further research.

Objectives one and two were achieved through the comprehensive literature review. The extent of the review was necessary to create a relevant and robust context for primary data collection. Objectives three, four and five were achieved by collecting and analysing primary data, and relating findings back to previous research.
1.3 Research approach

It has been argued that the majority of academic work on sustainable urban form has been conducted from an expert, rather than multi-disciplinary perspective (Crilly and Mannis, 2001). Newman and Kenworthy’s work (1989; 1999; 2006) is multi-disciplinary in combining transport, energy, environmental and planning perspectives. However, Newman and Kenworthy did not consider health perspectives. With these points in mind, a multi-methods, cross-sectional research approach was used to develop the thesis.

In Chapters 2-7 of the thesis, a substantial literature articulates how Perth was planned in the period following World War Two. This discussion is couched within a broader discussion of how city planning evolved in America and elsewhere, and how the American model of sprawl and rapid motorisation was very influential. The literature review continues by describing how transport decision-making is complex and variables other than urban form can influence people’s travel. Nevertheless, research is increasingly linking urban sprawl with car dependence and associated social injustices, forms of pollution, poor public health and transport energy concerns (see Chapters 3-5). A significant part of a sustainable transport agenda must therefore be to plan for transit (for regional trips), cycling and walking (for local trips), concomitant with developing supportive land use arrangements such as increased urban densities and mixing of businesses and homes (see Chapters 6-7).

The literature review provides the context for the Transport Sustainability and Health study, which is discussed in Chapters 8-11. The TSH study involved empirical data
collection and analyses to evaluate LN, to see if it is adequate and whether LN is being implemented as intended with respect to transport.

Hoehner and others (2005) note that few studies have simultaneously assessed people’s perceptions of their environment and objective environmental measures, and their relative association with levels of physical activity. The TSH study was calibrated to take this three-pronged approach to research, with transport behaviour in general being of interest rather than physical activity per se. The design of the study was informed by other research whereby self-reported walking behaviour, perceptual information and objective environmental measures were used to help define the concept of the walkable neighbourhood (Moudon et al., 2006).

Full details of the research methodology are given in Chapter 8. Data was collected from a sample of 11 LNs and 35 CNs. The first component of primary data collection was a travel survey of residents of the 46 study neighbourhoods. The travel survey was calibrated with reference to qualitative data, which was obtained from a series of visual audits and focus groups.

Second, RESIDE questionnaire data relating to perception of opportunities for local travel and the walkability of people’s neighbourhoods were analysed. Where RESIDE project data was used for the TSH study, it was from RESIDE’s first follow up questionnaire (refer to Chapter 8).

Finally, environmental measures were developed and then related to the reported travel behaviour and perceptual data. Of particular significance were measures of opportunity
for local travel (i.e. how accessible key local destinations were relative to where people lived) and residential lot density.

1.4 Thesis structure

There is a thematic structure to the thesis. The various chapters are described below.

2: A Vehicle of Change – urban evolution and sustainability issues. The histories of urban development and motorisation are discussed, leading to an appraisal of current transport arrangements in Perth. This provides a context for subsequent chapters that link present-day land use and transport systems with a range of implications for sustainability.

3: The Dimensions of Travel Decision-Making. It is explained how travel decisions are influenced by a range of variables including urban design characteristics. A discussion of travel choice is provided, which signposts how motor vehicles serve functions other than people movement. The chapter finishes with a discussion of social equity, as this is related to travel decision-making (i.e. some community groups are better disposed to preferential travel than others).

4: Exhausting the Air and Jamming the Arteries – environment and health linkages. Land use and transport are linked with various intermediary variables (including various forms of pollution and physical activity), which in turn are linked to a range of health variables including asthma, overweight and obesity, and various forms of cancer. It is discussed how the linkages vary according to risk and susceptibility.
5: *Low on Energy – exploring the fossil fuel issue.* Car dependence is linked to dependence on fossil fuels for energy. The role of alternative fuel technologies is discussed as a potential response to related sustainability concerns. The merits of a revised planning agenda are also discussed.

6: *Putting the Brakes on – alternative mode networks.* The prerequisites for quality public transport and active mode networks are discussed. It is described how such networks are a longer term (and therefore more sustainable) transport solution than relying on alternative fuel technologies or ‘business as usual’.

7: *Land Use and Transport Policy Cohesion – planning for sustainable transport.* This chapter describes some of the key land use and transport approaches that are intended to improve urban sustainability. It is explained how land use and transport are inseparable and as such, transport sustainability relies on a strategic urban policy package. The LN design code is unpacked and couched within the broader policy environment. Subsequently, some of the more significant challenges facing the successful implementation of LN are described.

8: *Methodology.* The TSH study is described. Neighbourhood and participant selection is discussed. Also, the formative research is described, which included a series of neighbourhood audits and focus groups. Subsequently, the three main study components – the travel survey, perceptual study and environmental study - are introduced. A guide to the overall study design is also provided.
9: **Travel survey method and results.** The travel survey is described and findings are presented. The travel survey instrument is described as are the recruitment procedures and response rates. Methods of statistical analyses are also explained.

10: **Perceptual study method and results.** The perceptual study is described and findings are presented. It is explained how the study focused on people’s perceptions of their local street network, walkability and the accessibility of key destinations (i.e. daily shopping, newsagencies, childcare facilities, medical facilities, postal facilities and public transport stops).

11: **Environmental study methods and results.** The environmental study is described and findings are presented. It is explained how environmental measures including distances to key destinations (i.e. daily shopping, newsagencies, childcare facilities, medical facilities, postal facilities and public transport stops), the permeability of neighbourhood street networks, residential lot density and work trip substitutability (public transport for the car) were analysed to identify any differences depending on neighbourhood type and to enable general discussion about opportunities for sustainable travel.

12: **Discussion.** The significant findings of the various research components are discussed. Patterns of difference depending on neighbourhood type are examined in detail as are the overall findings as they relate to transport sustainability objectives, particularly those expressed in the LN policy and the intentions of New Urbanism. Limitations of the TSH study are also acknowledged.
13: **Conclusions.** The aims and objectives of the thesis are reiterated and key conclusions are drawn from the research. Subsequently, key policy recommendations and recommended future research are provided.

### 1.5 Summary

This chapter identified a significant research gap that the thesis will fill. The thesis is the first comprehensive evaluation of the transport sustainability of Perth’s Liveable Neighbourhoods and is a major evaluation of New Urbanism. For these reasons, the findings have both local and international applicability, and contribute to making sure that planning policy is evidence-based. In the next chapter, the study context is more comprehensively developed, beginning with a critique of land use and transport development throughout the late 19th and the 20th Centuries and continuing with more in-depth analysis of Perth’s current transport arrangements.
CHAPTER 2:

A Vehicle of Change

Urban Evolution and Sustainability Issues

Detached suburban dwellings in Denver, Colorado
Source: Hayden, 2004: p33

San Bernadino – an unnerving lesson in the infinite capacity of humans to mess up their environment – the traveller can see a legion of bulldozers gnawing into the last remaining tract of green between the two cities, and from San Bernadino, another legion of bulldozers gnawing westward (Whyte Jnr., 1958: pp115-116).
2.1 Introduction

Over the last century and a half cities have undergone a profound change driven by the motorisation of transport. In Western cities, particularly in the US and Australasia the development of collective means of motorised travel, including trains and streetcars was followed by the development of inexpensive, readily available automobiles. A second key driver of change has been people’s quests for private space and a suburban lifestyle away from unwanted land uses. These quests have been aided by favourable government policy and innovations in the housing industry.

Decades ago, it was identified that urban land must be treated as a precious and scarce resource and argued that it must be used in a sustainable way (Wingo Jnr, 1961). However, in the US and Australasia, patterns of growth have not reflected this axiom. There is increasing evidence that population growth could have been better accommodated by denser developments and infill, rather than by the urban sprawl that has characterised development since World War Two (WWII). This is because sprawl and car dependence are increasingly being linked to a range of sustainability concerns (Newman and Kenworthy, 1999).

This chapter examines the complex links between urban form and transport, and provides context for the TSH study. In particular, it examines how land use and transport innovations, including the planning discipline have been important in shaping cities. In turn, it is discussed how the symbiosis between urban form and transport has led to sprawl, car dependence and associated issues in many Western cities as an outcome of planning and transport policies favouring low density development and cars above more compact designs, public transport and active transport. This discussion is
not intended to vilify historical policy and planning as much of it was formulated with people’s interests in mind: for example, highways were traditionally built to provide people with increased mobility. As a foil to this discussion, the chapter includes a short description of selected cities from Western Europe and South East Asia to demonstrate that more stringent government controls on growth and transport, amongst other variables, has produced relatively more sustainable urban forms.

Subsequently, it is discussed how transport innovations and planning policy have shaped the Perth region and provide a context for a reform agenda. It is highlighted how sustainability principles are beginning to feature more strongly in newer urban development paradigms. The chapter concludes with a review of the key issues and an introduction to the subject matter of Chapter 3.

### 2.2 The driving forces of urban evolution

There is an inseparable relationship between land use and transport. Changes to urban form, such as development of new housing areas affect transport systems and vice versa. Nevertheless, many researchers while acknowledging this association remain undecided about the exact influence of the built environment on travel patterns and whether individual mode preferences are more important than built form (see Crane, 2000; Dannenberg et al., 2003; Ewing and Cervero 2001a; Ewing and Cervero, 2001b; Frank, 2000a; Frank, 2000b; Mason, 2000; Newman and Kenworthy, 1999; Saelens et al., 2003b; Sallis et al., 2004). This is because there is a dearth of longitudinal evidence to support a casual relationship between urban change and transport outcomes. Cities are a complex collection of interacting processes and phenomena (Kenworthy, 1986)
and individual decision-making is not straightforward. Nevertheless, by charting change in land use and transport systems over time, it is possible to explore the ways in which they are interactive.

The Australian experience is similar to the US, with the evolution of different modes of transport having occurred in tandem with changes to land use patterns. While there have been vast differences in politics and civil society between the two countries, Australia has replicated many US planning practices and transport-related fashions, technologies and priorities (Davison, 2004). In the decades following WWII, for example, the US was in many ways seen as the model of urban development. For these reasons, research conducted in US is informative of land use and transport in Australia and augments the rather more limited research into the Australian context. The exploration begins in the 19th Century, with the emergence of motorised public transport and the resulting impacts on land use patterns.

### 2.2.1 Urban planning and transport revolution

#### a. Separating sensitive land uses - zoning

Until the early 1800s, cities were densely settled and land uses were mixed. There was often a clear distinction between city and country. With transport by foot or animal power, there were no means to travel great distances between homes, services and places of employment within acceptable time frames (Newman and Kenworthy, 2006). Respectable homes tended to be closer to city centres, for the purposes of easy access (Jackson, 1985) although there were examples of exurban lodges where some well-to-do people could spend their time (Bruegmann, 2005). In urban areas, there were invariably
many routes from homes to destinations, with streets typically being highly connected. Overall, cities tended to be spatially cohesive, orderly and transport-efficient.

However, over time, the compact city became associated with the ills of industrialisation. The city landscape became characterised by congestion and pollution, as there was little separation between noxious land uses and associated noise, and people’s homes (see Transportation Research Board, 2005). In response, the mid-late 1800s saw early instances of segregation rather than agglomeration of land uses (Duany et al., 2000).

Llewellyn Park, New Jersey is an example of where this occurred. This was a commuter community with curvilinear streets and lots averaging three acres in size. Other characteristics included central open space, a ban on industry in the community and prohibition of fences. For those with the means, the settlement enabled separation from noxious industry and the ills of the compact city of the time (i.e. overcrowding and disease), and an attractive suburban lifestyle (Frumkin et al., 2004; Transportation Research Board, 2005). The development of rail as a means of public transport also made this settlement functional. Settlements such as Llewellyn Park could be sited a significant distance from the city centre, while still providing residents with reasonable access.

This is an early example of ‘zoning’, or separation of housing from other land uses due to perceived sensitivity of one to the other. Relph (1987: p67-68) defines zoning as “the practice of allocating different areas of cities for different uses, much as rooms in a house serve different functions”.
The practice of zoning has had an effect on urban development that cannot be overstated. It distanced places of residence from services, facilities and places of work, thereby increasing travel times (all else being equal) and rendering some travel impractical. It is also an effect that has become more pronounced over time following innovations in transport. By the 1900s, zoning had become an important element of planning strategy. Enthusiasm for the practice in the US was based on it being a mechanism to preserve local character, social stability and property values (Hall, 2002).  

In many US and Australasian cities, zoning continues to be an integral part of planning practice. In a policy context, zoning may be defined as “legislative regulations by which a municipal government seeks to control the use of buildings and land within the municipality” (http://www.answers.com/zoning&r=67, accessed 05/05/2005: n.p.). In Australia, it has been used as a tool to “ensure orderly urban development and to protect basic residential amenity” (Gleeson, 2006: p21).

The spatial distribution of land uses is often achieved by development proposals being checked against statutory planning criteria. For example, commercial uses are often excluded from suburban areas because they do not meet standards relating to preservation of suburban character, scale of buildings and traffic maximums. It is a planning practice that has left a vast legacy and is still common-place today (Christchurch City Council, 1999; McIndoe et al., 2005).

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4 Hall goes on to discuss the social implications of zoning, including it being a tool to ensure that the middle classes could be ‘safe’ in their suburban enclaves. For more on this topic, please refer to Hall (2002).
Even within categories, such as residential, different sub-categories are separated... In addition, the practical effect is to create the long distances between different uses that are a fundamental characteristic of sprawl... These distances, in turn, contribute to a heavy reliance on automobile travel (Frumkin et al., 2004: p38).

Land use (re)integration has only recently begun to figure in policy rhetoric. Interestingly, zoning emerged as a public health response, as it was a means to separate people (usually the well-to-do) from noxious land uses (Frumkin et al., 2004; Schilling and Linton, 2005). Nowadays, the adverse impacts of zoning (amongst other features of contemporary cities) on public health are being examined (see Chapter 4) and are a key focus of this study.

Zoning codes have made it very difficult to create vibrant, higher density, mixed use neighbourhoods, which are increasingly being seen as more people-friendly and sustainable. Some commentators argue that the vibrancy stems from neighbourhoods being walkable (see Fenton, 2003). Neighbourhoods are not walkable if there are long distances between dwellings, services and places of work (Schilling and Linton, 2005). Conversely, higher density, mixed use landscapes designed with pedestrian safety as a central consideration are very supportive of walking as a mode of transport (Handy et al., 2002; Pucher and Dijkstra, 2000). Even if there is an increased focus on creating walkable neighbourhoods along with other issues of sustainability, Schilling and Linton (2005) note that because a body of law has been formed round zoning practice, it is very difficult to achieve changes (i.e. mix uses) when existing city plans prescribe land use separation.
b. Early city planning – the Garden City movement

The period 1900 to 1940 saw the development of the Garden City movement, the early architects of modern city planning (Hall, 2002). The movement enjoyed a great following in the US and Europe and was an early advocacy group for polycentric urban planning. The man most credited with influencing the movement was Ebenezer Howard, who would later become disillusioned with planning, as it broke away from his original principles of growth. Howard’s vision was for a town-country plan combining the positives of both urbanism and ruralism. As such, a garden city was to provide for economic and social opportunity, yet be characterised by gardens, agriculture and nature. Housing was to be affordable, with residents having easy access to services and jobs. Developments were envisioned to be of limited size, yet relatively self-sustaining. At a larger scale, garden cities were to be linked by public transport lines, thereby providing for regional travel where necessary (Hall, 2002).

Some 100 years later there is renewed interest in polycentric city design (fairly self-sufficient communities linked by quality public transport), with the design approach commonly known as Transit-Oriented Development (TOD)\(^5\). In Perth, the *Network City* planning approach anticipates such polycentrism (Department for Planning and Infrastructure and Western Australian Planning Commission, 2004).

Garden cities were intended by Howard to be socially just, insofar as housing was to be affordable and land ownership non-discriminatory. Moreover, local governance was to be characteristic of settlement, as was collective asset management: local people would be responsible for local upkeep (Hall, 2002). While they were envisioned as fairly low

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\(^5\) TODs are discussed in Chapter 7.
density settlements, they would provide easy access to common facilities because they would be limited in size and ringed by agriculture. Car travel was neither assumed nor designed to be necessary, given the proposed diameter of settlements. Also, cars had at the time yet to become one of the driving forces of growth.

While the garden city ‘ideal’ was informative for fledgling US planning policy, it never really was applied as Howard intended. To begin with, the model presupposed that entire urban networks could be built from the ground up. Instead, it was applied in limited contexts. Radburn Park, for example, one of very few ‘garden cities’, was integrated within an existing urban area and eventually became a dormitory suburb: it was too small and not self-sufficient, and many residents became commuters (Hall, 2002).

In a broader sense, the garden city model was undermined by urban development being too piecemeal for sufficient coordination to be achieved and considerable public backlash to Federal control over urban development (Hall, 2002). Market forces, too, appear to have been very important in compromising Howard’s vision. People did not want to be limited in their choices of where to live and in what conditions. Furthermore, increasing mobility (provided by buses and cars) began to reduce the need for easy walking access to facilities and neighbourhoods to be anchored by fixed public transport lines. Alongside these changes, government policies advocating personal mobility and relatively uncoordinated growth had significant effects on urban form.
c. Transport and housing innovations, government policy and their influence on growth

Patterns of growth were significantly influenced by transport revolutions. Beginning in the 1880s, the emergence of the tram (or streetcar) facilitated linear outward growth at lower cost than rail (World Conference on Transport Research Society and Institute for Transport Policy Studies, 2004). Trams played a critical role in separating homes from workplaces in cities around the world (Pacione, 2001). Decentralisation of cities was aided by strategic partnerships between tram operators and land developers. Linear dense settlements developed around stops since stops tended to be no more than a few hundred metres apart. Residents of these linear developments became commuters.

In the early 1900s, tram services were developed in most main Australasian cities. The first two decades of the 20th Century were also characterised by significant growth of electrified rail corridors (Laird and Newman, 2001a). During this period, Perth exemplified transit-led growth, with land use arranged around transit lines (Selwood, 1979).

Also in the late 1800s, decentralisation was facilitated by innovations in the home-building industry. Housing became more affordable and housing materials became much more easily transportable. A willingness by governments to spend public funds on utilities and favourable tax policies for decentralised housing further stimulated outward growth (Gillham, 2002). Hall (2002) argues that changing urban dynamics, new technologies, market forces and the influence of legislators overshadowed planning reactions to housing conditions and transport arrangements around this time. This is reflected in the effects of the streetcar and revolutions in the home-building industry.
From 1920 onwards in US cities development continued to be driven outwards by Federal income tax deductions for home mortgage interest and property taxes. From 1954 to 1986 there were also Federal corporate tax deductions for greenfield developments (Hayden, 2004). Tax concessions have been used extensively in Australia, too, to support the growth of greenfield settlements. It is important to understand that these mechanisms were synergistic with transport revolutions; public transport and later cars may have given mobility potential, but affordable housing and finance for land purchase gave reason to be mobile.

The advent of the diesel bus and, more significantly, the widespread adoption of the automobile as mode options meant growth no longer needed to be coordinated around public transport lines (Newman et al., 1992). These conditions became apparent in the three decades following WWII. For Australia, Gleeson (2006) describes this period as marked by convulsive growth in cities and economic boom conditions.

Returning servicemen were able to afford detached dwellings and own land thanks to the War Service Homes Scheme. This alongside rapid motorisation undoubtedly accelerated suburbanisation (Gleeson, 2006). In some respects, the War Service Homes Scheme is symptomatic of the general governmental approach to urban planning throughout much of the latter half of the 20th Century. Analysis of policy from this period suggests that it tended to be directive but not prescriptive about growth. This is despite there being regional planning strategies formulated in Australia soon after the war, such as Perth’s Stephenson-Hepburn Plan (1955). This plan formed the basis of the Metropolitan Regional Scheme (1963), which continues to be the statutory planning

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6 It is interesting that some advocators of higher-density developments are now talking about using tax concessions as a mechanism for enticement.
mechanism for the Perth metropolitan region. Ironically, the ‘strategic’ Plan – with its emphases on low development densities (particularly outside of established nodes), segregation of land uses and a lack of a rigid urban growth boundary - provides the backdrop against which Perth’s current problems associated with urban sprawl and car dependence have developed.

What then precipitated such rapid motorisation in Australia? Until the end of World War Two, there had remained a considerable reliance on public transport. In Australia, this was attributable to shortages of fuel, the relative immaturity of both the market for private motor vehicles and the road network, and as yet relatively concentrated urban development (Laird and Newman, 2001a). As an indicator, only one in every four Melbourne households owned a car at the war’s end (Davison, 2004).

However, for many people public transport was a source of frustration, given shortcomings of services, and following the war, cars became symbolic of freedom, mobility and opportunity (Laird and Newman, 2001a). Innovation, competition, mass production within the vehicle market and mass marketing undoubtedly helped on one hand to sell the private motor car to the public and on the other, to make it more accessible to the relatively less affluent. At the same time, rising relative affluence in Australia as well as elsewhere in the developed world contributed to increasing car ownership (Cameron et al., 2004; Ingram and Liu, 1999).

From the early 1960s, the rapid uptake of motor vehicles can be monitored. In Perth, for example, Kenworthy and Laube (1999) detail a continuing upward trend in vehicle ownership per 1,000 people. In 1961, there were 239 passenger cars per 1,000 people,
which rose to 357 per 1,000 in 1971, 475 per 1,000 in 1981 and 523 per 1,000 in 1991. Current levels of ownership are estimated to range from approximately 630 cars per 1,000 (Cameron, 2004) to 679 per 1,000 persons (Ashton-Graham et al., 2005). Car ownership has likewise spiralled upwards in other Australian cities (Newman and Kenworthy, 1989; Newman and Kenworthy, 1999).

At some point, the market may become saturated with vehicles. Vehicle ownership per 1,000 people is projected to continue rising in the medium term, suggesting this saturation point is yet to be reached (Cameron, 2004). Using international data and economic modelling, Dargay and Gately (1999) estimated that the saturation point may be 0.85 cars per person. Later work, however, suggests that the saturation point may vary from one country to another, but consistently, vehicle ownership has and will continue to grow alongside increasing income (Dargay et al., 2007). The implications of this analysis are significant: in developing countries, vehicle fleets are predicted to burgeon. China’s automotive fleet, for example, is predicted to reach 390 million by 2030; an increase of nearly 2,000% (Dargay et al., 2007).

Similarly, Kenworthy and Laube (1999) have identified a continual rise in per capita car kilometres (per annum) for major Australian cities, for the period 1961-1991. Cameron’s (2004) projections for 2010 and 2020 are for further increases. Again, Kenworthy and Laube’s data is used as a proxy for 1960, 1970, 1980 and 1990 to ensure consistent time periods with Australian Bureau of Statistics (2001) information for 2000 and Cameron’s (2004) projections. These data are combined in Figure 2.2.

Comparatively, motorisation in the US has been equally, if not more, dramatic. In 1950, six out of every ten households possessed at least one private vehicle. By 1967, the ratio was eight out ten (Steiner, 1978). By 1990, there was one car for every 1.8 people in the country (Gillham, 2002). In 2001, 280 million Americans owned in the vicinity of 235 million private vehicles (Hayden, 2004). Moreover, since WWII there has been a trend towards lower occupancy and increasing distances travelled (Pacione, 2001).

![Figure 2.1 – Growth in Australian vehicle ownership (including projections)](Image)

(Source: Australian Bureau of Statistics, 2001; Cameron, 2004; Kenworthy and Laube, 1999)
Figure 2.2 – Growth in per capita car kilometres (per annum) for selected Australian capital cities (including projections)

(Source: Australian Bureau of Statistics, 2001; Cameron, 2004; Kenworthy and Laube, 1999)

In 2003, the average US household drove in the vicinity of 25,000 miles (40,234 kilometres) (Hu and Ruescher, 2004). Pucher and Renne (2003: p49) argue:

The most salient trend in American travel behaviour over the past four decades has been increased reliance on the private car for urban travel, with corresponding declines in public transit and walking.

In Canada, there was likewise a ‘boom period’ of growth in private motorisation. In 1945, there were 1.1 million registered vehicles in the country. By 1952, registration had doubled and by 1961 it had doubled again, to 4.3 million (Harris, 2004). Even in the UK, where cities have stronger historical roots and there are generally greater constraints on land, there was roughly a ten-fold increase in the actual number of registered cars from around two million in 1950 to over 20 million in 1994 (Cullingworth and Nadin, 1997).
The distance travelled, on average, per person, per day has also grown rapidly. In 1950, the distance was estimated to be 8 kilometres across all modes. In 2001, this had risen to 48 kilometres. By 2025, it is projected to be 97 kilometres (Adams, 2001). The private motor vehicle is overwhelmingly the mode of choice, although again this is inextricably linked to land use planning decisions and policies that have made cars a virtual necessity for many trips.

From early on in the period of rapid motorisation, Australia reproduced many US phenomena; not only was the US seen as the model of motorisation, but for the provision of ancillary automotive services, including drive in facilities, franchised petrol stations and extensive car parking (Davison, 2004). As fast and convenient private vehicle became the most popular means of travel, life began to revolve around driving. A review of this period suggests that the car contributed to the decline of some social institutions. For example, garages ceased to be as much about social interaction as service stations and, following the development of an oil company oligopoly in Australia, are today more about drive-in and drive-out service.

So, while the shift to the suburbs was not instantaneous – it occurred over decades – rapid motorisation sped-up the process. The car became popular because it created freedom over space (and, before congestion became a significant issue, time) and went on to become the key driver of urban change in US and Australian cities (Laird and Newman, 2001a; Newman, 2003). From an international perspective, the HiTrans International Steering Group (2005) refers to the private motor vehicle as being the largest influence on urban form over the last 50 years or more. The car allowed people unprecedented flexibility in their choice of home and work. It also offered door-to-door
transport and could be used at any time of the day (WCTRS and ITPS, 2004). As cars became relatively more affordable and mass produced, more and more people had access to newly developed land. At the same time, automobile-oriented policy relating to urban growth, road network development and government financing fuelled sprawl.

Given market demand and the pre-eminence of car travel in city policy, public transport became a poor competitor to the car and as such the diesel bus and other public transport lost significance. In 1957, a study by Fortune Magazine found that members of the US public held very negative perceptions of public transport, including its efficiency (Bello, 1957). This reflects the disinvestment in public transport and systematic dismantling of tram networks across the US at the time, given the car was seen as the future of transport. As Davison (2004: p77) argues, the car reshaped cities as we know them and in doing so:

…transform[ed] the regular oscillation of commuters from city to suburb into a more complex web of movements across the metropolis…

In Australia too, while vehicle ownership was rising, public transport was becoming a poor competitor to the car. In 1954 in Melbourne, planning advice from visiting US experts was to scrap the tram system to thereby improve traffic flows, as per US practice (Davison, 2004). In the late 1950s in many Australian cities, public transport was running at an increasing deficit due to service problems and a modal split in increasing favour of the private vehicle. With a significant proportion of transport funding being collected through gasoline tax, the motoring lobby was vociferous about levies being spent on motor vehicle infrastructure not ‘out-dated’ public transport (Davison, 2004).
With the scales tipping in favour of private transport and new suburbs being designed assuming car-based mobility, the decline of public transport could only continue. In the 1950s, in Perth, all tram services ceased. In 1970, the Perth Region Transport study recommended the closure of all metropolitan passenger rail services. In Perth and elsewhere, the rationale underlying transport prioritisation was that it was costly to provide transit (particularly fixed-line transit) to far-flung suburbs and planners were dealing with communities where car culture was ingrained (Steiner, 1978).\footnote{7 These barriers to public transport provision remain significant.}

In the urban arrangements of today, people have become highly dependent on cars. People who live in the suburbs own more vehicles, spend more time in them, drive greater distances and use public transport less than people who live in the inner-city and urban areas not characterised by sprawl (Frank et al., 2000; Frumkin et al., 2004). With vehicle ownership higher than ever before and VKT increasing, supportive infrastructure must be developed.

### 2.2.2 Growth of infrastructure

The market has been important in defining transport patterns. People have embraced the automobile and the mobility it provides. However, Weyrich and Lind (1996) contended that high levels of motor vehicle use did not simply arise from demand for mobility. Instead, they argued, travel patterns have been strongly influenced by planning practice, government policies and massive subsidisation. Rapid network creation in the US and Australia was necessary to facilitate vehicle-based travel as was a shift in understanding of the functions of streets. The Department for Transport in the UK (2007: pp6-7) states:
It is all too easy to forget that streets are not just there to get people from A to B. In reality, streets have many other functions. They form vital components of residential areas and greatly affect the overall quality of life for local people…For too long the focus has been on the movement function of residential streets.

The US and Australasian experience is that modes other than the private motor vehicle have been engineered out of the lives of citizens of many cities. This is following years of highway construction, alongside policies prioritising motor vehicles, and associated land use change ((Ewing et al., 2007; Frank, 2000b; Frank et al., 2003). In the US, the National Interstate and Defense Highways Act 1956 designated $25 billion (Au$32b) in Federal taxes over 12 years for the construction of 41,000 miles (65,983 kilometres) of interstate highway (Gillham, 2002; Hayden, 2004). The Federal funding directed to road systems far outweighed that to public transport. A budget of US$100 billion (Au$127b) was projected for general road construction between 1956 and 1969 (Bello, 1957). The primary source of funds for the works was gasoline taxes (Gillham, 2002).

The 90% share of costs (of the construction of the interstate highways network) borne by the Federal government were justified on the grounds, as the name of the Act implies, that the works were for the purposes of national defence (Flink, 1999; Shoup, 2005). By the early 21st Century, the amounted invested in the US highway system was estimated to be US$4.5 trillion (Au$5.7t) (Gillham, 2002). In a way, cars became the new mode of ‘public transport’. Warner (1992: p9) argues “[the car]…is a special kind of public transportation: the public provides the road, and, to use it, you must bring the car”.
Nowadays, many states are engaged in maintaining and expanding the capacity of the road networks provided under Act (Hayden, 2004). As Hayden (2004: p11) points out, “…one must own a car to benefit from billions of dollars worth of highway construction”.

The enacting of this piece of legislation was a turning point for urban development and accessibility in the US. It was a key contributor to development pressure on hinterland around US cities. In the early 1960s, Wingo Jnr. (1961: p3) argued that it marked “…the accession of the highway engineer to a dominant position in urban decision-making…”.

Network creation in Australia occurred concurrently with rapid motorisation, vis-à-vis the US experience (Davison, 2004). In Western Australia, the 1950s were a significant period for transport, with Main Roads Western Australia taking on responsibility for traffic management and infrastructure in Perth, rather than remaining a country roads authority. It was also a period during which Main Roads was able to purchase land cheaply for future highway construction, given the growth envisaged for Perth by the Stephenson-Hepburn Plan (Edmonds, 1997). Considerable growth in the use of cars was anticipated and Perth was destined to become a city for vehicles. Furthermore, Federal funding for roads was apportioned to states on the basis of area, not population, leaving Main Roads WA rich in funds (Edmonds, 1997).

Similar growth in motor vehicle infrastructure was planned for elsewhere. In 1969, for example, the Victorian State government formulated the Metropolitan Transportation Plan for Melbourne, which promised Au$1.675b of a $2.6b transport funding package
for a 494 kilometre urban freeway system. The key aim of the Plan was to facilitate commutes between decentralised residential areas and decentralised places of employment. Comparatively, public transport only received $0.355b (Davison, 2004). Similarly, from the 1970s to the 1990s, the Australian Federal government took on national responsibility for developing roads and interstate highways with the aim of providing more seamless motor vehicle travel. Road networks were considered the modern transport framework (Newman, 2005). Comparatively, it has been argued that Federal grants for State agencies for public transport projects were given infrequently and were worth significantly less (Scheurer et al., 2005).

The focus on provision of infrastructure for motor vehicles, which makes these trips more convenient, perhaps explains community preference to travel by car rather than by other modes and perhaps to make additional trips. The phenomenon of increasing trip frequency has been facilitated by enhanced infrastructure and is known as induced demand (Buchanan, 1963; Hill, 1996) or induced traffic (Bachelis and Newman, 2001). However, some researchers do not consider highway enhancements and consequent increases in use to be negative. Instead, it is claimed that the surge in use of new roads really only reflects a shift from other, less favourable routes, that the traffic engineers “sited the road correctly to handle growing demand” and “it was often just the result of many people using new roads to expand their choices in living, working, and recreational opportunities” (Bruegmann, 2005: pp130-131).

Motorists’ lobby groups, including the Australian Automobile Association (AAA), vociferously supported policies advocating network creation. From 1945, the AAA lobbied the Federal government on matters of taxation and road financing, State
governments to divert transport expenditure from public transport and to monitor road policy, and local governments for more investment in roads (Davison, 2004). Davison argues that the AAA is not apolitical: instead, it is often affiliated with the Liberal Party (the Australian Conservative party) and with such a political alliance, has become more active and aggressive over time. The road lobby (which includes companies and advocacy groups with an interest in continuing policy support for motor vehicle transport) is argued to continue to exert a powerful influence over transport policy (Laird, 2001b).

In the early 1990s, following national transport conferencing, it was decided that various levels of government in Australia would have differing responsibilities for developing road networks. It was determined that the Federal government would principally be responsible for the national highway network, State governments for state highways and main roads, and local governments for local roads (Henneveld, 2007)\(^8\).

There continues to be significant Federal investment in infrastructure for motor vehicles but comparatively little in infrastructure for alternative modes (Newman, 2005). Between 1996 and 2000, Au$8b of Federal funds were invested in road projects: 100 times more than rail (Laird, 2001b). In contrast, near the turn of the century, the US reportedly invested about 20% of Federal transport funds in rail and mass transit (Laird, 2001b). For 2005-2006, the Federal government of Australia allocated Au$543.2m for roads in Western Australia alone. An additional Au$747m was allocated by the State and local governments for the same period (Henneveld, 2007).

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\(^8\) These arrangements, however, are likely to change under the recent Federal transport initiative (AusLink), with implications remaining to be seen.
It remains the responsibility of State and local governments to find most of the funds for alternative transport projects: a task that seems to be better handled by some governments than others. In Perth, the State government funds the public transport system. Capital works are paid for with Western Australian Treasury loans, which are then repaid (Waldock, 2007). For the 2006/2007 financial year, 16% of the Au$577.1m costs associated with public transport was recovered through fare revenue (Waldock, 2007).

In addition to direct funding for infrastructure, there is an institutional subsidy provided to road users. Laird and Newman (2001b) have calculated this to be Au$8b per annum, not including the costs of congestion in major cities. When the costs of congestion (such as loss of productive time and freight delays) are included, the subsidy is estimated to be Au$19b. However, many of these costs are externalised with taxpayers, for example, paying for the road system, costs associated with accidents, other health impacts and funding tax relief for vehicle use. The revenue from fuel tax, registration fees and insurance premiums does not nearly cover this expenditure (Laird and Newman, 2001b). The ongoing imbalance in funding, the subsidy offered to road users (compared to users of other modes) and the level of political support for road projects represent substantial barriers to more balanced Federal transport funding policy and furthering the sustainable transport agenda in local areas.

In New Zealand, there has been a similar, long-standing funding bias toward road building. The current, Labour-led government recently acknowledged that forecast oil shortages and related price rises will only worsen transport problems for the public. In response, the Minister for Energy suggested that there would be a natural behavioural
shift to alternative modes (King and van den Bergh, 2005). Meanwhile, in 2005 the government announced a NZ$390m (AU$345m) transport funding boost, of which $330 million was earmarked for roads in the Waikato and Auckland regions. Only 13% of the funding package (NZ$50m) was to be allocated to passenger rail, then only to be spent in Auckland and 13.5% (NZ$52.5m) on nation-wide transport projects, *including but not limited to* public transport (Ruscoe, 2005).

In March 2006, Land Transport New Zealand’s draft allocation of transport funding for 2006-2007 was NZ$1.34b (Au$1.19b) for roads, NZ$353m (Au$312m) for public transport and only NZ$7m (Au$6.2m) for walking and cycling. That is, for every dollar spent on roads, 26 cents were to be spent on public transport and half a cent on active modes (Land Transport New Zealand, 2006). Land Transport New Zealand’s funding would again heavily favour the Auckland area. Together, these figures represent an imbalance in funding, both geographically and in favour of motor vehicle transport.

### a. Local road networks – built for automobiles

At a finer grained level, local transport networks tend to be engineered towards cars, though this is slowly changing given projects such as traffic calming (see Chapter 7). Nevertheless, many cities remain characterised by local road networks that were developed during the boom era of motorisation. These networks were often developed without a lot of thought to routes being the most direct or the practicality of travel by modes other than the car. As a consequence, many facilities are not very accessible unless there is a car available to make the trip, as they are often located a considerable distance from residences. Moreover, local street network planning has often made trips
significantly longer than the Euclidean distance. Permeability, or the degree to which the real (network) distance of a trip mirrors the Euclidean distance, is poor.

Significant barriers to permeability include so-called loop and lollipop development – housing estates characterised by curvilinear streets and culs-de-sac – low density development and segregation of land uses (Frumkin et al., 2004; Ontario College of Family Physicians, 2005b). Gated communities, which are a fairly new style of suburban development, are distinctive barriers as they break up the contiguity of urban space. This can be particularly burdensome for pedestrians and cyclists (Burke, 2003; Burke, 2004). While gated communities cater for certain lifestyle choices and hence reflect market demand, support for such developments is often based on sociological reasoning and does not take adequate stock of important physical (including transport) implications (see Bork 1997; Manzi and Smith-Bowers, 2004)⁹.

Alongside curvilinear streets, culs-de-sac or dead ends are common features of many US and Australian cities. Frequently they limit the use of modes other than the private vehicle (Newman et al., 1997). This is because they reduce the opportunity for straight-line travel, unless alleyways are provided. Instead, pedestrians and cyclists often have to take indirect routes to destinations, including public transport stops (Beatley, 2004). By reducing the permeability of the urban fabric and thereby increasing the distance between origins and destinations, travel by active modes becomes less appealing. Motorists are also compelled to drive further when negotiating indirect street networks, which in turn results in more energy consumption and more emissions. Duany and others (2000: p25) provide an example of poor permeability:

⁹ Burke’s (2004) thesis gives a much more thorough discussion of gated communities, including research relating to the lifestyle choices they offer and findings relating to how they may influence travel patterns, especially for active mode users.
The resident of a house just fifty yards away must still get into the car, drive half a mile to exit the subdivision, drive another half mile on the collector road back to the shopping center, and then walk from car to store. What could have been a pleasant two-minute walk down a residential street becomes instead an expedition requiring the use of gasoline, roadway capacity, and space for parking.

Figure 2.3, a Google Earth image of Mandurah, Western Australia, illustrates poor permeability by contrasting the straight-line with the network distance between two points. The ratio between the two is 1:12.6 (the straight-line distance is about 100 metres whilst the network distance is about 1.26 kilometres). Ironically, the westernmost point in this example (the image is northwards orientated) is less than a kilometre from the new Mandurah train station, which is at the southern end of Perth’s new Au$1.66b rail line.

Figure 2.3 – Poor permeability in Mandurah, Western Australia
(Source: Adapted from Google Earth imagery tool, 13/08/2007)
Efficient travel requires good permeability. This is true, irrespective of mode choice. In Europe, some transport networks are highly connected for public transport, pedestrians and cyclists, whilst vehicle networks are restricted. For example, bus priority lanes and rail lines provide public transport connections whilst a fine-grained network of cycle paths and walkways provide linkages for active mode users. Such transport networks shift access in favour of alternative mode users.

Ewing (1999) recommends a dense, highly connected street layout where four-way intersections occur every 90 metres or so, to thereby ensure the network distance is a close match to the straight-line measure. This is very important as such street layouts increase the walkable catchment of around businesses; public transport stops and people’s dwellings. Different modes, however, have varying infrastructural requirements. A highly connected street network should, as a rule, also have sufficiently-well designed footpaths.

Highly connected, ‘traditional’ street networks, which are reminiscent of networks in early walkable cities, in combination with greater activity intensity make trips more direct and make it possible to combine a greater number of trip purposes together. There are more routes between different points and fewer physical barriers to movement (Frumkin et al., 2004). Ewing and Cervero (2001a; 2001b) found that such traditional designs are therefore conducive to shorter trips. Walking and cycling are more attractive mode choices given the shorter distances. Figure 2.4 illustrates how a highly connected street network facilitates more seamless movement than is possible in curvilinear and culs-de-sac configurations. In the example below, the ratio between the straight-line and network distances is 1:1.48. In relative terms, this represents about
eight and a half times better access, all else being equal, than in the Mandurah example.

Even though more direct routes increase access potential, the UK’s Department for Transport (2007) makes the argument that limited curvature of streets can be positive insofar as it can provide added visual interest. Moreover, topography and other physical constraints may render it impossible to design straight streets (Duany et al., 2000). If it is accepted that a highly connected street network is favourable, all else being equal, then many cities including Perth face a significant redesign task.

Figure 2.4 – Relatively good permeability in Nedlands, to the West of Perth city
(Source: Adapted from Google Earth imagery tool, 13/08/2007)
b. ‘Free’ parking

Parking is a key infrastructural requirement for cars and cars use. Vehicles must have somewhere to park both at the beginning and end of journeys. Rapid motorisation led to rapid growth in the demand for parking. Many American and Australian city policy-makers obliged by mandating parking minimums with all manner of land uses. Often these minimums where prescribed following limited research and to cater for hypothesised maximum demand (which may occur perhaps one or two days per year) (Shoup, 2005).

Parking provision has become a highly technical art. Developers must cater for residents, visitors, customers, staff and service vehicles in their plans. Parks must be of certain dimensions, aisles must be of certain widths, accesses must be located in certain places and turning circles must be of minimum sizes. Together, these facilities consume significant areas of land. When the various parking criteria apply in the suburbs, where much of the parking space is underutilised, city landscapes quickly become sterile (see the example from Denver, Colorado, included as Figure 4.1 on page 130).

In many instances, particularly outside of central areas, parking is not subject to tariffs. The reason for this is simple. If a business owner charges for the use of the parking they provide, people have three choices. They can pay the tariff, park nearby in an area that is not subject to tariffs, or go elsewhere to conduct their business (see Toor and Havlick, 2004). Options two and three make choosing option one very unlikely. When there is an overabundance of parking, not only are people given incentive to drive to conduct their business but they expect to be able to do it for free (see Environmental Protection Agency, 1998; Lund et al., 2004). Similarly, if local governments charge for
kerbside parking, rather than make much revenue, they can expect to shift parking into free areas.

Research shows, however, that ‘free’ parking is an oxymoron. Shoup (2005) shows that ‘free parking’ can have billions of dollars of annual indirect costs, as the areas devoted to parking are not otherwise being used productively. Parking spaces therefore represent badly underutilised urban land (Newman and Kenworthy, 1999), as are other sealed areas such as service station and car dealership forecourts.

Moreover, Toor and Havlick (2004) undertook economic analysis of car parking provision on University campuses in the US and found that there are various costs associated with providing car parks, including the construction cost, maintenance and enforcement as well as opportunity cost. In a UK case-study of National Health Service (NHS) transport characteristics, it was found that 2% of all NHS land is devoted to car parking (Davis et al., 2005). The researchers calculated that the cost of maintaining a parking space to be between 300 and 500 pounds (Au$750-1,250) per annum. This is a substantial cost burden, as the land could otherwise be used productively for service provision or ancillary activities.

There are various means to reduce the land burden associated with parking. One solution is for statutory planning mechanisms to require parking spaces to be provided under buildings, rather than on open spaces. Alternatively, standards that require a minimum number of spaces to be provided can be relaxed, depending on the use of a given property and the other transport options available. For example, parking minimums associated with strip shopping often reflect forecast demand on some of the
busiest days of the year; at other times, much of the parking will go unused. This does not appear to be a pragmatic standard for setting parking requirements.

Some cities have instituted more ‘radical’ parking policy. In Portland, Oregon for example, parking *maximums* have been applied. Even in Perth, recent Structure Planning associated with strategic transit oriented developments has recommended maximum levels of parking that are below typical minimums required by existing Town Planning Schemes.

Moreover, parking can be shared between proximal land uses depending on changes in demand during the day. A restaurant that is open in the evenings could share parking with a service provider, such as a hardware store, which might shut before the evening dining period. None of these changes to parking standards, however, can directly address the *demand* for parking. People need somewhere to park their vehicle at the beginning and end of their journeys, and if provision of car parking is uneconomic, a reduction in car trips is a prerequisite to reducing the demand for parking.

c. **Topography and land availability as an antecedent of car dependence, network creation and sprawl**

‘New cities’ or cities which had their major periods of growth marked by construction of extensive highway and freeway networks have often become the most infamous examples of sprawl (Steiner, 1978). These cities include Houston, Los Angeles and Phoenix in the US and Perth in Australia. Importantly, too, these cities are characterised by there being few geographical barriers to outward expansion.
In contrast, Hong Kong and Singapore are prime examples of affluent cities which are constrained by geography and hence have grown upwards rather than outwards. Governments in these contexts have long realised that there is literally no place for sprawl and that it simply is not sustainable for people to rely on private motor vehicles for their travel needs. Moreover, there simply is not land available for ongoing road building. Transport networks other than roads for motor vehicle travel have been required.

These points are not intended to oversimplify the urban growth process: sprawl is not simply the result of there being vast tracts of land available for new development. Governance in Singapore and Hong Kong, for example, is different to that elsewhere. Nevertheless, topography (the relative hilliness of the local terrain and the presence of natural barriers, such as rivers) does exert a fundamental influence on urban form.

### 2.2.3 Services in suburbia: assumed access by motor vehicle

As sprawl has occurred, services and facilities have decentralised in tandem with the population. Commentary early in the boom period following World War Two argued cities were rapidly becoming more fragmented and the commercial functionality of the central business district was being lost to suburban nodes. In turn, sprawl was increasing the costs of providing services and utilities, then maintaining them (Bello, 1957). In the US, for example, the primacy of city centres decreased substantially from 1950 to 1990 (Mieszkowski and Mills, 1993). Modern information systems have aided dispersal of people, services and jobs. Telecommunications, including the internet, allow physical separation between producers and consumers (Gillham, 2002). Similarly, truck transport allows flexible freight movements and for warehouses to be
situated away from tradition freight hubs, such as rail termini and ports. These are all factors that have contributed to the geographical spread of services in Australian cities (Gleeson, 2006).

Given decentralisation and the reduced strategic importance of the cores of many cities, research has found that some journeys to work are now shorter circumferential trips rather than longer radial trips (Crane and Chatman, 2004; O’Connor, 1998; O’Connor and Stimson, 1996). Nevertheless, other findings indicate that on average commutes have been getting steadily longer as cities have expanded their footprints and people have continued to travel further for specialised goods and services (Crookston et al., 1996; Kahn, 2000; Thorns, 2002). That is, the distances travelled for circumferential trips (both work and non-work) are longer than that for radial trips prior to rapid suburban growth and motorisation. This has had the effect of making people reliant on cars for travel, especially work trips (Gleeson, 2006).

While it is often difficult to identify the effects of decentralisation on the cores of cities and other, established inner-residential areas, the decline of some local shopping precincts has been both tangible and progressive. Regional shopping malls have emerged as a supply-side response to population dispersal and have threatened the survival of small, local enterprises.¹⁰

The success of the malls lies in their competitive edge. They are one-stop-shops (Gillham, 2002; Hayden, 2004). Pacione (2001) argues that malls have gone from

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¹⁰ While it is true some local precincts have suffered from the opening of regional shopping complexes, it is also true some have endured and even flourished. In the Perth experience, local shopping precincts such as in Subiaco are flourishing, almost certainly because they have been developed as part of a carefully coordinated land use-transport renewal plan.
being a service centre provided to support established residential areas, to being a concurrent development, then a stimulator for growth, to most recently, district and regional icons. They are most often located adjacent to main arteries, to ensure easy access by motor vehicles and to have as wide a catchment as possible. For example, West Edmonton Mall in Canada is a virtual mini-city 325,000m² in size, containing amusement parks, a hotel and restaurants, and countless shops. The mall is accountable for declining patronage of smaller retail precincts elsewhere in the Alberta region (Pacione, 2001).

In the US, the Mall of America in Bloomington, Minnesota exceeds the size of even West Edmonton Mall. At approximately 390,200 square metres in size, the mega-mall contains more than 520 shops, including a 14-screen cinema, 8 nightclubs, a theme park and a walk-through aquarium. During peak periods around 13,000 people are employed in the mall. Around 12,550 car-parks are provided for mall patrons (www.mallofamerica.com, accessed 26/05/2005).

Conventional shopping centres tend to cater generously for cars, but not for alternative modes (Naess, 2005). The areas around shopping centres can become dangerous and hostile landscapes for pedestrians and cyclists, particularly if there are insufficient raised walkways, marked crossing areas and traffic controls in car-parks. Figure 2.5 depicts how even a relatively small shopping complex in Perth presents a range of hazards for active mode users. When faced with such hazards, there is an added incentive for people to drive to the shopping complex even if they live within a comfortable walking or cycling distance.
Another feature of suburban service provision is ribbon development. In the US, many arterial roads have facilitated this type of development. Gas stations, diners and other ‘quick stop’ stores have been established adjacent to roads (Hayden, 2004). In Australia, a similar pattern has occurred in many cities, following replication of the US development model (Davison, 2004).

Strip shops gain their custom from the traffic along the main arteries. Malls, fast food eateries and the like, set back some distance from arteries are invariably fronted by their car parking areas. This type of design, ‘signposted’ by large advertising billboards and other media often detract from the aesthetic quality of the landscape, offer little passive surveillance and disaffect active mode users (Department for Transport, 2007; McKay, 2005; see Figure 2.6). Such ribbon developments are not normally distinctive. One can usually count on the same services from one location to another; a department store of some description, a McDonald’s restaurant, some franchised shops and perhaps some motor facilities like a service station (Beatley, 2004).
2.2.4 Backlash to policy favouring motor vehicle travel

Duany and others in the American Congress of New Urbanism (2000: p14) summarise what a great many urban analysts seem to be recognising: “what was once our servant [the private motor vehicle] has become our master”. However, has there always been overwhelming support for motorisation and did people just let cities become transformed, to be characterised by sprawl, highways and freeways, and dispersed facilities? As early as the 1950s, commentators were foretelling the not-so-favourable consequences of rapid motorisation and sprawl (Bello, 1957; Jacobs, 1961; Whyte Jnr, 1958; Wingo Jnr, 1961).
There is evidence of both public and political opposition to the significant investment in road building, for example, even in the days preceding the passing of National Interstate and Defense Highways Act in the US. In 1955, there was staunch opposition to plans to construct a freeway through the Golden Gate Park panhandle in San Francisco, due to concerns about the environmental damage it would wreak and how it would detract from amenity (Steiner, 1978).

By the 1970s, there were concerns amongst some Australians, policy-makers included, about the costs as well as the benefits of suburban sprawl and the mobility afforded by the motor vehicle. Some of the concerns were foreshadowed decades ago, in as much as sprawl was introducing blandness to the urban area, destructive of the environment and that car-based mobility was contributing to significant access and social equity issues (Davison, 2004; Whyte Jnr., 1958). While these issues were increasingly being understood, more and more people were facing direct adverse effects of transport projects.

In Melbourne, where inner-city residents were facing plans for freeways to cut through their neighbourhoods following the announcement of the Metropolitan Transportation Plan of 1963, opposition became radicalised. Engineering and mechanisation were increasingly being seen as symbols of sterility and waste (Davison, 2004). For the engineer, the freeway plan might have signified provision of essential arteries to the ‘heart’ that was the city, but to the inner-city resident freeways were divisive phenomena that threatened the community as an organism (Davison, 2004). In Perth, the plans to close passenger rail spawned a new era of community activism, which was

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11 There is more discussion of the issues associated with car dependence and sprawl in following chapters. Chapter 4 describes linkages between urban form, transport and health, and Chapter 5 discusses links between car dependency and unsustainable energy consumption.
not only instrumental in preventing closures but also in the development of new lines. For the disaffected in Australia, the US model was not perceived to be the Australian model.

In more recent times, transport continues to be a significant political issue. Not In My BackYard (NIMBY) sentiment remains significant amongst residents whose property values, lifestyle and amenity may be threatened by transport projects, especially road building. Moreover, the costs associated with mobility are more obvious because of recent fluctuations in the price of fuel. It is also possible that people are becoming more conservation-minded in parallel with more tangible efforts at policy level to facilitate more sustainable transport (there is a resurgence of public transport investment in some Australian cities, including Perth). As Gleeson (2006: p145) states:

In the major cities, there is a broadening consensus about the need to rescue public transport from the malign neglect of State and Federal governments. And there are slowly strengthening grounds for political opposition to the road building coalitions that would tunnel and asphalt us to penury and oblivion.

The reasons as to why public transport can significantly contribute to the transport sustainability agenda will become clearer in the following chapters of the thesis\textsuperscript{12}. All things considered, it appears not so much that people are becoming anti-mobility, but rather they are increasingly recognising that mobility comes with a cost. It therefore makes sense that policy focuses more on increasing people’s access than their mobility.

\textsuperscript{12} Chapter 6 focuses specifically on public transport and active transport as fundamental components of sustainable transport planning. It details the key essential elements of alternative mode networks.
a. Can private motor vehicles be on borrowed time?

Newman and Kenworthy (1999) argue that cars are literally ‘on welfare’. People do not pay the full cost of their motoring. The cost of providing and maintaining roads, congestion, pollution and road accidents are only partially borne by road users. While it is difficult to measure the value of the subsidy to each car owner, the authors argue that it may range from Au$3,800 to Au$5,000 annually. Other research calculates that the annual subsidy to drivers collectively is around Au$8b, not including congestion costs (Laird and Newman, 2001b).

There are additional threats, however, to the future of cheap motoring, with or without ongoing government subsidy. The forecast twilight of cheap fuel is the most significant of these. The oil crises of 1973, following a Saudi Arabian-led curtailing of supply and in 1979, following the overthrow of the Shah of (oil-producing) Iran, illustrated how society relies on fossil fuels for transport and foretold how future shortages may have devastating effects on economy and society. The more recent consequences of the attacks on the World Trade Center in New York and the war in Iraq have reinforced these realities. These crises have made the public more aware that motor vehicles are highly energy consumptive and of the significance of the effects of both fuel price rises and scarcity (Gillham, 2002; Kenworthy and Laube, 2005). Furthermore, they clearly illustrated how strongly supply-side incidents could affect markets and mobility.

The turbulence of the 1970s should have compelled governments to plan for possible future transport problems, including a time when oil would not be cheap and plentiful. Historical calculations by M. King Hubbert (1956) of a peak in US oil production and declining self-sufficiency (with the US being the greatest consumer of oil globally)
should have informed this planning. However, in many cities, land use and transport policy did not come to reflect such predictions. Instead, high levels of car use and profligate planning practice continue to be significant contributors to a new, more serious oil crisis which may well be just around the corner (Parker, 2005; Simmons, 2005).

It is unlikely governments will be able to provide ongoing subsidies to motorists to match climbing oil prices. A supply and demand imbalance will likely become direr because of rapidly growing demand for transport energy in developing economies, particularly China, where there is rapid motorisation. The dual issues of car and oil dependency are discussed at length in Chapter 5.

2.3 What about elsewhere? Urban development in Western Europe, Hong Kong and Singapore

It is useful to contrast urban development in other first world cities with the patterns of growth that have been evident in the US and Australia. The experiences of other cities show that given the right conditions, public transport can retain high patronage, walking and cycling can be popular modes for all manner of trips, the private motor vehicle is not all-powerful, and relatively consolidated cities can typify vibrancy and social synergies. For these reasons there are a number of cities, particularly in Western Europe and South-East Asia that in many ways reflect a more sustainable planning agenda.
2.3.1 Examples from Western Europe

Some findings suggest that sprawl and car dependence are not simply US and Australian phenomena (Sieverts, 1999). While this may be true in some cities, Pumain (2004) argues that the European model of urban change is a clear alternative to the widely discussed (and frequently critiqued) US model. In particular, France is a nation characterised by strong, traditional centres. These centres, in some cases, date back many hundreds (or thousands) of years. Such centres, in France and elsewhere, have retained sources of employment, accessibility by foot and public transport, significant landmarks and civic functions (Gillham, 2002). They exhibit traditional features of a compact, walkable core, including a mix of uses and relatively high densities. They have not been engineered to be car-friendly. What is more, private vehicles are not nearly as cheap to run as in the US. Fuel taxes, for example, are much higher.

France is characterised by much less state intervention in transport and land use planning than countries such as Sweden and The Netherlands, exemplifying how government policy, taxation, heritage, culture and tradition vary from city to city and across continents (Pumain, 2004; Sellers, 2004; WCTRS and ITPS, 2004). In much of Western Europe, there is a greater urban legacy than is evident in the US and Australia; cities are older and have strong historical roots. There are well-supported, historic cores, which have often not been redesigned to facilitate car travel (Pacione, 2001).

Policy and funding support for public transport is much more pronounced and has a strong legacy in many Western European cities. Policy and funding has not been in favour of motor vehicles to the extent it has been in the US and Australia. The HiTrans
research series (2005) include many good examples of where quality public transport continues to be prioritised in a range of European cities, including Freiburg, Germany and Zurich, Switzerland. This series of publications detail how careful networking can ensure continuing success with public transport and make it a mode that can seriously challenge the private vehicle for convenience and efficiency. Much is made in this series of the importance of a long-term focus on public transport provision and the importance of maintaining a built environment that is supportive of public transport.

Freiburg, Germany is an excellent model for car restraint and a quality public transport system. Land use developments have been strictly controlled to ensure active transport is a viable alternative for short trips and to link with public transport. Because of this, public transport services are well patronised (Pucher and Clorer, 1992). Zurich, Switzerland is another excellent example of where there has been a long-standing, strong emphasis on public transport planning (Newman and Kenworthy, 1999).

In Swedish cities, too, there appears to be a markedly different transport culture compared with US and Australian cities. In Stockholm, for example, the historic core of the city is both built for active modes and is very supportive of social interaction, with its many market squares and lane-way shopping. The area retains its physical characteristics from times preceding motorisation when people relied on easy foot access. Figure 2.7 shows one of the many market squares in old Stockholm. In addition, while other areas of the city have been fitted with road reserves, there remains thoughtful street design and demonstrable traffic restraint. Figure 2.8 depicts how one of Stockholm’s main streets (Karlavagen) is laid out. Pedestrians and cyclists have

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13 The publications go into great detail about the variables that contribute to successful public transport systems. They are informative for transport sustainability-minded policy.
thoroughfare along the sides of the street and along the tree-lined central reserve. The transport culture is such that cars are observant of the marked crossings and active mode users have an uninterrupted crossing with little fear of an accident.

This transport culture extends to small cities such as Västerås, located about an hour from Stockholm by fast train. In many areas of this city, especially the historic core, active modes are highly visible (Figures 2.9 and 2.10). Video 1 (on the CD-ROM) shows the mix of modes in central Västerås. Along streets, even in places not marked with crossings, it is possible to observe cars stopping and waiting for cyclists and pedestrians: something that is a rarity in cities like Perth.

Figure 2.7 – Highly walkable market square in Old Town, Stockholm
(Source: Author)
Figure 2.8 – Street design along Karlavagen, Stockholm

(Source: Author)

Figure 2.9 – Active modes are highly visible in Västerås, Sweden

(Source: Author)
Together, cities such as Freiberg, Zurich, Stockholm and Västerås offer lessons for the promotion of alternative modes, even in sprawled cities. As such, reference is made to these cities, where relevant, during discussion of public transport and active transport networking in Chapter 614.

2.3.2 Examples from Hong Kong and Singapore

Hong Kong and Singapore have been identified as extremely compact cities where land is at a premium. Topographic and geographic constraints have forced much development upwards, not outwards. Sprawl simply cannot occur. Such pressure on

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14 The reader is also encouraged to refer to the HiTrans series for much more detailed discussion of travel patterns and the eminence of public transport in many Western European cities.
land has long made careful planning, management and co-ordination of land use and transport an imperative. Governments have made car ownership and use prohibitively expensive. Such policies of restraint have been influenced by longstanding recognition people needed efficient transport choices other than the car, given the limiting factors of topography and geography, and congestion (Cameron et al., 2004; Hau, 1995). To compensate for car restraint, people’s transport needs are met by a very high quality, extensive public transport network, including ferries, rail and buses, which are accessible for modest tariffs (Figure 2.11). The public realm is also vibrant and well managed, making walking an attractive transport option.

Figure 2.11 – Public transport services operating in Hong Kong: buses support a high-quality rail system
(Source: Author)
Nevertheless, it is important to acknowledge the very different modes of governance in the two cities. Singapore has been characterised by relative authoritarianism, compared with greater liberalism in Hong Kong. Nevertheless, people in both cities have been largely accepting of transport decisions and both cities revolve around mass transport (WCTRS and ITPS, 2004). Moreover, both cities are relatively affluent and have had sufficient public funds to achieve sustainable transport policy goals.

The cities owe much of their functionality to urban density and land use mixing. Kenworthy and Laube (2005) have identified a huge variation in average urban density between US, Australian, European and wealthy Asian cities (such as Hong Kong and Singapore), based on a sample of cities from each region. US and Australian cities were found to have an average density ranging from 15-26 people per hectare (pph). European cities had between 50 and 55 pph and wealthy Asian cities 150 pph. All else equal, the higher density cities tend to have a greater mix of land uses and facilitate shorter travel distances, hence improving the attractiveness of active mode use. Furthermore, the higher density of the cities allows high patronage and therefore long-term economic stability of public transport services.

Although urban development and transport in Hong Kong and Singapore have been strongly influenced by topographic and geographic constraints and Hong Kong particularly is an extreme example of compact urbanism, it does not follow that urban growth elsewhere should be limitless and sprawling. Land use and transport policy should not be predicated on the axioms ‘there’s space there, so let’s develop it’ and ‘people want cheap mobility, cars provide it so let’s build more roads’. Lessons from these cities underline the value of a strong public transport network integrated with
more strategic and compact urban design. The value comes from, amongst other things, reduced reliance on fossil fuels for transport (Newman and Kenworthy, 1999)\textsuperscript{15}.

This and the previous section have identified that there are some profound differences in the land use and transport arrangements between Western Europe, South-East Asia, the US and Australia. Plans and policies cannot simply be transferred from one city to another. Nevertheless, the urban development experiences of overseas cities should serve as examples of how transport sustainability can be improved locally. Indeed, over the last couple of decades there has been some limited turnaround in development policy, including increased emphasis on growth control, public transport provision and local travel opportunities. Indicators of an increasingly sustainable planning agenda are given in Chapter 7.

Urban change is a slow process (Hickman and Banister, 2005) from the perspective that it is costly and time consuming to retrofit existing sprawl with more compact development. Moreover, efforts to promote infill can be compromised by continual growth of low density suburbs on the fringe of cities. As such, a firm commitment is required to a sustainable planning agenda. Small, more quickly implemented projects can only have very limited outcomes for the city and region (Hass-Klau, 2003). It is therefore important for research to analyse whether the LN design code is a mechanism that can achieve more sustainable transport patterns, contribute to better public health and raise the overall quality of the Perth metropolitan area.

\textsuperscript{15} Townsend’s (2003) thesis is a useful point of reference for transport and urbanism in Singapore. His thesis goes into much more detail of the city’s urban transport dynamics. Similarly, Cameron (2004) provides further discussion of urban transport dynamics in Hong Kong.
2.4 The Perth region: the need for sustainability to be part of the planning agenda

The Stephenson-Hepburn Plan (1955) was the first comprehensive metropolitan study conducted in Perth. It formed the basis of the Metropolitan Regional Scheme (1963), which continues to be the statutory planning mechanism for the Perth metropolitan region. The Plan reflects many of the antecedents to sprawl and car dependence that have been discussed, including forecast low development densities, particularly outside of established nodes, segregation of land uses and a lack of a rigid urban growth boundary.

Perth has embraced suburban development much more strongly than other cities in Australia and its influence on lifestyle and quality of life is pervasive (Jones, 2003: p315).

In Perth, as was the case in many other large Australian cities, rapid motorisation and demand for low density greenfield housing were key drivers of urban growth following World War Two (Jones, 2003). However, in Perth unlike elsewhere, the planning system made it mandatory. This requirement assumed that people would drive for almost everything. Since the 1960s, new suburbs have therefore been designed assuming that people will drive for the great majority of their journeys and there has been relatively little investment in infrastructure for alternative mode users (DPI, 2000; Premier’s Physical Activity Taskforce, 2006). Transport planning in the suburbs has likewise been aimed towards making car travel easier (Rural and Regional Affairs and Transport References Committee, 2006). Cameron and others (2004: p296) report that:
[Perth has had] limited if any significant physical planning, transport or economic policy interventions to manage growth in demand for private transport...[showing] the extent to which automobile dependence can grow largely unabated.

In 2004 the Department for Planning and Infrastructure and Western Australian Planning Commission reported that the average parcel size of land associated with each dwelling in the city was 789m$^2$. The average site density was 12.7 dwellings per net hectare of land (DPI and WAPC, 2004). By international standards, this is very low and contributes to a range of concerns all related to this car dependence.

In the present day, much new growth is occurring on the fringes of the existing urban area. The city now extends for more than 120 kilometres along Australia’s Western coastline (Curtis, 2005). The city is highly decentralised and there are many suburban centres throughout the metropolitan region. The large suburban population have a high vehicle ownership rate and use their cars for a high percentage of trips (Cameron, 2004).

2.4.1 The current transport situation

a. Car dependence

The Western Australian Greenhouse Task Force (2004: p63) reports that:

…every day Perth drivers travel the equivalent distance of 500 times around the world (more than 20 million [kilometres]) …in their car.

The city holds the unenviable distinction of producing the most carbon dioxide and using the most transport energy per capita, in Australia (Newman and Kenworthy, 1999;
Newman et al., 2001). Newman and others (2001) rate the city alongside Canberra Australia, and Houston and Phoenix in the US as being one of the most car dependent cities in the world.

On the whole, Australia has a poorly regulated and generally old car fleet (Newman et al., 2001). Owners are not required to get their vehicles tested for roadworthiness. Moreover, the popularisation of Sports Utility Vehicles has counteracted efforts to improve vehicle efficiencies. These issues add to the adverse effects of car dependence.

In 1991, Curtis (2001) reported that 76% of all personal trips made in Perth were by car. In 2001, this had increased to 80% of all personal trips being by car, as either driver or passenger (Socialdata Australia, 2001). More recent analyses suggest that there are around 4.8 million trips made per day in the Perth Metropolitan Region, of which 5 out of 6 are made by car, as either driver or passenger (PATREC, 2005).

The historical rise in the ownership and use of cars has contrasted with a decline in the use of public transport. In the period 1966 to 1995, the percentage share of public transport dropped from 20% to less than 7% (DPI, 1995). This should not be a surprise as all urban development was based around the car. However, in the period 1991-2001 Perth’s public transport has reversed its decline, thanks in part to greater investment in rail (Scheurer, 2005). Nevertheless, private motor vehicle travel still outweighs trips by public transport. Data from 2001 suggests that, on average, people make about 803 trips by car per annum compared with 159 trips by foot, 65 by public transport and 32 by cycle (James et al., 2001).
In Perth there appears to be a culture of driving, even for short trips. Perth drivers are reported to make somewhere in the vicinity of 250,000 car trips per day of 1 kilometre or less (Premier’s Physical Activity Taskforce, 2006). This means that more than 5% of the 4.8 million daily car trips made in Perth could be substituted for active modes, thereby potentially leading to up to 250,000 fewer vehicle kilometres travelled per day. Other estimates include that 48% of all trips by car cover less than 5 kilometres and 71% cover less than 10 kilometres (Wooldridge, 2005). Similarly, research has found that 72% of trips to local facilities are made by car while only 21% are made by foot, suggesting potential for mode substitution (DPI, 2000). Travel patterns vary considerably across Perth, however not to the degree that they do in Melbourne and Sydney, which have a higher proportion of older transit-based suburbs (Newman and Kenworthy, 2006).

Some trips require the movement of heavy goods, such as groceries, or goods that are awkward for pedestrians or cyclists to carry. Motor vehicles would seem to be the most practical mode for these trips. Nevertheless, it may be feasible for half or more of all trips made by car to be made by another mode (Ashton-Graham et al., 2005) even in low density car-based suburbs. This is aside from any reductions in vehicle kilometres travelled or car trips that could be achieved by building more accessible neighbourhoods and people undertaking more local travel for shopping and other personal business16.

The liberal provision of car parking areas throughout the metropolitan region doubtlessly contributes to high car use. Vis-à-vis the US experience, a minimum provision of car parks per building is required in city planning regulations. In addition

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16 This type of trip substitution is directly tied to choice and is discussed more in the next chapter.
to minimum requirements, there are both public and privately-run car parking areas provided throughout the city. By the mid-1990s, in the central city, there were a reported 630 spaces per 1,000 CBD jobs (Scheurer et al., 2005).

Research conducted on behalf of the Western Australian Planning Commission, the City of Perth and the Government of Western Australia indicates a drop in parking bays per 1,000 CBD jobs from 669.2 in 1993 to 640.2 in 1997 and 608.9 in 2001\(^{17}\) (Praxis Solutions, 2004). In absolute terms, however, parking provision has increased, albeit more slowly than central city employment. In 2006, there were 60,420 parking bays in the CBD registered under the Perth Parking Management Act\(^{2}\), of which 42,930 were for long stays or commercial tenants, thereby suiting full-time workers (Wannell, 2007). The level of parking provision in Perth, gauged by CBD parking, is among the highest in the developed world (Kenworthy and Laube, 2001). A high relative level of parking, much of which has a relatively low tariff (use of City of Perth parking starts at around Au$4.40 for 10 hours on a weekday, provided the car is parked before 7:30am) provides a great incentive to drive for work purposes.

In the suburbs, there are often significant areas of (free) parking attached to strip shopping and shopping centres (Figure 2.12). Parking outside the CBD is almost always free. Curtis (2005) found that in the Perth metropolitan area, around 5,000 hectares of land is dedicated to parking, whether free or subject to tariffs. While this is a small fraction of the total metropolitan area [in 1995 the Perth metropolitan area was 114,199 hectares in size and has grown since (Kenworthy and Laube, 2001)], it is still a significant area of land.

\(^{17}\) Kerbside and residential parking are not included in these calculations.
Figure 2.12 – Strip commerce with associated free parking along Leach Highway, Perth
(Source: Author)

b. Walking and cycling

In contrast to the car, walking and cycling have not been well planned for in post-war Perth. The decentralisation of services, facilities, dwellings and places of employment has rendered utilitarian trips by active modes inconvenient. Transport infrastructure, too, tends to favour private motor vehicles (Figure 2.13). Safety problems, low amenity\(^{18}\) and generally poor permeability contribute to making many parts of Perth of low quality for active mode users. This is despite there being opportunities for more walking and cycling, given the potential for trip substitution.

\(^{18}\) Beatley (2004) provides comprehensive discussion of urban amenity and how sprawl creates environments of low interest to active mode users.
James and Brög (2003) suggest that the Department for Planning and Infrastructure’s *Perth Metropolitan Transport Strategy 1995-2029* (1995) signalled a change in direction away from growth in the mode share of private vehicles towards a more balanced modal split. Even so, the MTS still reflects conventional transport planning principles. For example:

Perth’s residents and businesses enjoy excellent transport. Perth’s future prosperity and lifestyle will be largely dependent upon the extent to which the current high level of accessibility to work, schools, commercial areas, recreational and cultural activities, factories and ports can be maintained in the face of current transport trends and significant population growth. Transport in Perth is predominantly based on cars, small vans and trucks using the region’s extensive road
Tellingly, the document goes on to discuss some of the clear implications of these travel trends, including probable increases in congestion, a reduction in accessibility options for the disadvantaged and increasing impacts on regional air quality due to emissions. While the costs of pro-automobile transport policies are increasingly being recognised, in 1995 the policy response was to continue to prioritise motor vehicles:

[There is a need to] plan the regional infrastructure for cars, such as major roads and freeways in conjunction with major metropolitan development strategies to limit trip lengths and ensure most car trips will not be affected by congested roads (DPI, 1995: p40).

However, the prognosis for active modes is not all bad. Also in 1995 the State government initiated a Cycle Network Plan for Perth. By 2002 and the end of phase one of the plan, a total of 800 kilometres of metropolitan and regional cycling routes had been developed with 750 kilometres more planned for phase two. The measures undertaken to develop a comprehensive cycling network have stimulated a significant increase in daily cycling trips (Wooldridge, 2005).

Prior to work getting underway on this Plan, cyclists had little choice but to share the road with motor vehicles. This was particularly dangerous on Perth’s highway network, where speed limits are 70 kilometres per hour or higher. The alternative was to battle with pedestrians for the use of the narrow, fragmented network of footpaths throughout the city. Nowadays, an increasing number of dedicated cycleways are appearing across the city. Often, these run parallel to major arteries, such as the Kwinana and Mitchell
From 1997 to 2003 the State government, with the support of Austroads, spent millions of dollars on developing the strategic cycle network (Ashton-Graham et al., 2005).

Perth’s more recent *Network City* planning strategy (DPI and WAPC, 2004) also takes a step towards sustainable and integrated land use and transport planning in the greater metropolitan region. *Network City* is a nodes and corridors approach to urban growth where existing urban areas are better utilised. It targets 60% of new growth in established areas, leaving 40% to be in areas of new growth (DPI and WAPC, 2004). The strategy includes aims to decrease car dependence, enhance public transport and not “inequitably limit accessibility based on location or access to a private car” (DPI and WAPC, 2004: p66). An integral part of realising this objective is improving active mode networks.

Furthermore, the Premier’s Physical Activity Taskforce is in the process of drafting a comprehensive Perth pedestrian strategy. Many of the ideals underpinning the Cycle Network Plan will be incorporated. Most importantly, it recognises that quality regional infrastructure is vitally important for facilitating walking.

c. Public transport

In recent times, there has been limited turnaround in favour of public transport in Perth, reflecting an increased focus on sustainable transport planning. Under the Perth Parking Management Act 1999, parking levies collected in the central city are now being used to fund the free Central Area Transit (CAT) bus service that operates in the CBD (Waldock, 2007). An orbital bus route (bus numbers 98 and 99) is now operating in the
metropolitan region. A new *SmartRider* ticket-less system has been employed on public transport, contributing to seamless transfers from one service to another, whether the service is rail, bus or ferry. Fare discounts are also available under the scheme, depending on how credit is added to the *SmartRider* card. The cost of journeys is also ‘intelligent’, depending on the length of the trip (the metropolitan region is divided into zones).

In 1979 the Fremantle rail line was closed down as rail was not considered to be part of Perth’s transport future. After a citizen campaign the State government was replaced and the diesel trains returned with a government promise to upgrade the system (Newman and Kenworthy, 2007). Thus began a period of rebuilding the rail system which led to electrification and extension to the northern suburbs. The train system has grown from seven to 50 million passengers a year and from 1996 to 2006, Perth’s journey to work has jumped from 5% to 10% on public transport. Internationally, this modal share remains small but the increase has made a contribution to reducing car dependency in Perth. This patronage, for example, puts Perth higher than all other US cities (see Newman and Kenworthy, 2007).

Additionally, in December 2007, albeit more than a year behind schedule, a major southern rail corridor was finished with 90% approval ratings. The new rail service is similar to that in operation to the north of the city (developed in 1993) in that the rail line is embedded within a six-lane freeway for much of the route (Richardson, 2007). The rail service competes with car travel, linking the expansive southern suburbs and satellite areas with the centre and north of the city. Complementary bus services link the rail stations with outlying areas. The line adds 72 kilometres to the other 100 km of
the Perth Metropolitan passenger rail network (Australasian Tunneling Society, n.d.) and cost more than $1.66b to complete.

Prior to the development of the line, there was no southern rail service (Figure 2.14). The new line has created some great opportunities for urban growth that is consistent with the *Network City* vision. Whilst there as yet has been limited strategic development around train stations (some positive development is occurring at Wellard and Cockburn Central), the future may see greater application of TOD principles (see Chapters 6 and 7).
Figure 2.14 – Perth rail network: the new southern section is shown as a dotted orange line

2.4.2 Forward thinking – future planning?

Buxton (2001) argues that there are some serious contemporary threats to Australian cities. These include existing urban freeway systems and future road building. These, Buxton argues, have the potential to determine the direction of future growth and hence, exacerbate sprawl. Market decision-making likewise threatens. There continues to be demand for low-density greenfield housing and developers continue to build conventional neighbourhoods. Comparatively, opportunities for high-density living in rejuvenated areas of the city are less available. Market preference is not necessarily reconcilable with sustainable practice. Pacione (2001: p176) explains this point:

…the goal of sustainability is not an integral element of market capitalism and will encounter opposition from entrenched interests.

In his discussion of Australian cities a decade ago, Stretton (1996) argued that people’s values simply are not consistent with plans to reduce private space and increase densities. Conventional (suburban) living opportunities are, Stretton argued, what people want and this fuels demand for low density living. Some people place great emphasis on private space and solitude in suburbia (Breheny, 1997). Some even see increases in density as diminishing urban quality (Troy, 1996b; Williams, 2001; Williams, 2004). Others want to escape the various forms of pollution and general offence to the senses that are often associated with inner city living (Bentley, 1999; McIndoe et al., 2005; Schoon, 2001).

In Australia, traditionally the romantic ideal of suburban living has been heavily seized upon in the earlier days of sprawling development, as incentive to escape ‘crowded’
inner city localities (Davison, 2004). However, the links between these perceived ‘ills’ and higher density developments are increasingly vague. In the telecommunications age, where it is rare to find heavy (or even light) industry in built-up, mixed use areas. In addition, stringent regulations in many contexts limit polluting outputs, including noise, from industry. However, traffic pollution remains more of an issue in dense areas, which also tend to attract a higher density of slow-moving vehicles, and inevitable spot emissions and air pollution (Cameron et al., 2004).

From the perspective of general liveability, during the 1990s Troy (1992; 1996a; 1996b; 1996c) argued against urban consolidation. Instead, he argued that provision of open space sufficient to enable tree and garden planting, and recreation, which is typical in suburbia, is crucial for making the city liveable. Should infill be encouraged, he argues, people will have to fight to preserve privacy and withdraw into their increasingly diminishing personal domains (Troy, 1996c). In earlier days, commentators argued that the suburbs, not inner urban areas offered citizens hope and well-being (Stretton, 1970).

Discourse 25 years later remained consistent with this analysis: Kennedy (1995) argued that residents of consolidated cities will be forced to spend more leisure time in rural areas given the lack of private green space associated with their homes. This means trips (typically car trips) between the city and the country may increase in frequency, if cities are (re)designed to be more compact. However, these arguments really relate to urban character rather than provision of ‘sufficient’ greenspace for recreation. Highly compact cities can still have high quality greenspace that can satisfy many recreational needs. New York City is a good example.
In recent times, some are arguing that the suburbs continue to offer great lifestyle opportunities, inspire identity formation and are even hubs for creativity (Bruegmann, 2005; Gleeson, 2006). Bruegmann’s (2005) refutation of anti-sprawl research fails, however, to adequately address the transport problems that are strongly linked to sprawl development (many of which are discussed in subsequent chapters).

On a region-wide scale, a way to achieve a balance between density and provision of greenspace is to plan cities and satellites according to a polycentric or ‘network city’ model (McIndoe et al., 2005). This approach leaves green wedges interspersed with areas of settlement, ensuring good access potential to greenspace for the public, though not necessarily an increase in greenspace as a percentage of urban area. Designing a well-linked polycentric city is complex, however, as it requires careful integration of land use and transport planning, and a long-term strategic vision for a region, rather than piecemeal development.

In 2003, the Network City vision for Perth was informed by Dialogue with the City, which was organised by the Department for Planning and Infrastructure (DPI, 2003). First, 8,000 randomly-selected households were surveyed regarding their impressions of urban development in the region (1,711 people responded). Second, a forum involving 1,100 members of the public was held (DPI, 2003). This participatory procedure revealed that both low density housing and living within low density neighbourhoods remained the most popular lifestyle options for people. However, there was a common realisation, too, that a Network City approach to future development in Perth is necessary because of sustainability concerns (DPI, 2003). Approximately one half of participants reported that living in a medium density area would be attractive or
reasonably attractive but only about 10% of participants considered living in high density areas attractive or reasonably attractive. *Network City* is discussed more in Chapter 7.

Perth faces the issue of having to plan for a large projected increase in population. In 1995, the DPI speculated that 400,000 new homes would be needed before 2029. This is to cater for a projected population increase from 1.14 million persons in 1991, to 2 million persons by 2029 (DPI, 1995). In 2004, the WAPC estimated 375,000 more homes are still needed before 2031. In theory, the LN design code can play a considerable role in providing for more sustainable communities, characterised by greater local self-sufficiency and travel opportunities, even if the city is to grow to such an extent. But will present policies, including LN lead to sustainable growth in practice?

### 2.5 Summary

This chapter discussed how land use and transport have evolved in symbiosis. Present-day transport arrangements, for example, depend on the provision of infrastructure and are influenced by the dispersal of jobs, facilities and households.

Not all cities, however, have developed in the same way. The US and Australian experiences, for example, are vastly different to those in Western Europe, Hong Kong and Singapore. This is because of, amongst other things, differences in land use and transport policy, topography, urban genealogy and historical funding priorities.
Throughout the latter half of the 20th Century, in Australia, land use and transport were closely modelled on the US experience. Consequently, major cities, particularly Perth are defined by car dependence and sprawl. The discussion has provided the historical context for Perth’s move towards New Urbanism and the adoption of the LN code. Planning in Perth has not moved towards the European approach but continues to reflect the latest American planning theory.

The next chapter discusses transport decision making and makes the distinction between travel needs and choices. Further, it describes how decision making varies depending on personal circumstance.
CHAPTER 3:  

The Dimensions of Travel Decision Making

Cars are functional objects, but they do not appeal primarily to reason and rationality…Cars combine mechanical impersonality with everyday intimacy. As with clothing and shoes, people can costume themselves with cars, using the vehicle’s appearance and style to change and project their own. Cars have sculpted appearances that objectify sensation and desire (Pickett, 1998: p23).
3.1 Introduction

The preceding chapter focused on how urban sprawl and car dependence have occurred in tandem in many cities, especially in the US and Australasia. The way that urban areas have been planned has made many trips impossible or at least impractical without the use of a motor vehicle. In this chapter the focus shifts to decision-making and individual choice. It examines how the built environment and other variables, including personal preferences, influence travel decisions. Travel preferences are analysed in relation to the other decisions that people make, such as where in the metropolitan region they live and work. It continues with a discussion of car culture. Following decades of cities having been planned for motor vehicle travel and motoring being affordable, driving is often seen as a right, not a privilege. Furthermore, car use can mean more than simply getting from point A to point B.

Next, there is a discussion of how transport opportunities are limited for vulnerable groups. It is demonstrated how dependence on cars for transport means children, the economically disadvantaged, the elderly and the mobility-impaired lack the mobility other members of society enjoy (Gehl and Gemzøe, 2003). In turn, this leads to significant social equity issues. In closing, the implications of having less choice and less mobility are considered.

Overall, this chapter provides an insight into how transport behaviour is a function of choice as well as necessity. Furthermore, it is illustrative that the relationship between the built environment and transport behaviour is complex, and a causal relationship is yet to be proven.
3.2 Making travel decisions

Making transport decisions and choosing residential location are complex tasks. Transport decisions include selecting destinations, times to travel, routes and the means to make trips. Choice assumes that there is more than one option available. It is therefore important to determine those facets of transport that are flexible and those that are not. This chapter describes how there are many variables that either add to or reduce choice. Travel choice, for example, can be limited by residential location. This is important, as people may have to balance housing with transport preferences.

Naess (2005) defines four categories of trips. Bounded trips are fixed by time and geographical location. Work trips are a good example, as they typically need to be made from the home to the same location, at a set time (e.g. to meet a 9:00am start-time). Non-bounded trips are characterised by both temporal and geographical flexibility (Naess, 2005). A trip to the cinema would usually be a non-bounded trip. Intermediary trips have one fixed and one flexible aspect (Naess, 2005). A trip to the gym for a workout would be a good example, if there were only one gym in town. Finally, semi-bounded trips have some flexibility, but most occur with regularity (Naess, 2005). A trip to the supermarket or deli for food would usually be a semi-bounded trip.

The purpose of the trip aside, people can often choose the routes and modes they use to make trips. For trips that are not bounded, they can often also choose the destinations they travel to. People will not necessarily travel to the nearest facility, but may exercise the choice to travel further to an alternative facility, which they perceive as better (Handy, 2003; Naess, 2005; Williams, 2001). Analysis of driving trips in Austin,
Texas, for example, found that as many as 50% of trips to the supermarket are made to preferred stores, rather than the most accessible (Handy and Clifton, 2001).

It is important to recognise that travel is not always undertaken for utilitarian purposes. Trips can also be made for leisure (Adams, 1993; Urry, 2002). Non-utilitarian trips are examples of non-bounded trips. They also serve as indicators that travel means more to people than movement (see Section 3.4 for further discussion).

The travel choices people make can also affect the choices made by others (Gilbert and O’Brien, 2005). For example, the more often people choose to travel by car, the less appealing public transport and active modes may be for those remaining. Active modes are less appealing when roadways are choked with vehicles and movement is more hazardous. Public transport is less appealing if it is delayed by congestion (although dedicated rights-of-way can avoid this problem – see Chapter 6). If people choose to do most of their travel by car, they are also sending a strong message to policy-makers, that infrastructure first and foremost should cater for drivers (see Chapter 2).

Relative flexibility, choice and freedom over space are benefits often associated with private motor vehicles (Newman et al., 1997). They make the ownership and use of private vehicles very attractive, particularly to people who live on the periphery of cities and are often some distance from services and facilities (Naess, 2005). They are also incentive to give less attention to planning travel. If a person either does not own a car or does not choose to drive for most of their trips then more time is usually required to plan journeys. Public transport networks often do not afford the freedom of movement that cars do and active modes cannot cover the same distances, hence more journey
planning is necessary (see Chapter 6). It is therefore unsurprising that public transport users often trip-chain while car users do not (Newman and Kenworthy, 1999).

3.2.1 Activity space

Having now introduced transport choice and flexibility it is useful to discuss people’s ‘activity space’, or the space within which they engage in their life’s work. The extent of this space varies from person to person and depends upon where they live. In sprawling, car dependent areas, such spaces could be expected to be bigger, relative to people’s spaces in more traditionally designed areas. This is because decentralisation has contributed to there being greater distances between people’s home, schools, shops and other community facilities (Transportation Research Board, 2005). Olaru and Smith’s (2005) analysis of Sydney’s Household Travel Survey, for example, found that the activity space of inner-city residents is much smaller than for those in the suburbs.

Intuitively, urban space that is designed to provide people with a range of nearby destinations is likely to be more conducive to local trips. A good mix of destinations is especially important for larger families, who have relatively more needs and wants. Nevertheless, people’s activity spaces are not limited by municipal boundaries (Shore, 2006; Williams, 2001). Instead, they usually extend across regions. This is a function of the choices people can exercise when selecting both destinations for trips and where they live. By implication, many residents of Perth conduct a large share of trips outside of the neighbourhood in which they live: a point that is backed up by the data (PATREC, 2005; Wooldridge, 2005 - see Chapter 2). These findings also indicate that travel behaviour is principally a function of regional accessibility (Ewing and Cervero, 2001b). It follows that small scale urban change can only have so much effect on travel.
behaviour (Stead et al., 2001) necessitating a region-wide, strategic focus for sustainable transport planning.

Together, these points are suggestive of some relationship between urban form and travel behaviour. The more decentralised a city is, the more reason (and opportunity) there is for regional, rather than local travel.

3.2.2 Travel budgeting – time and money

Time is a pivotal consideration when making travel choices: it “…is a scarce and constrained commodity” (Transportation Research Board, 2005: p60).

Marchetti (1994) developed a value of significance in the transport literature. “The Marchetti Constant”, which is 30 minutes, was found to be the average travel time budget for people’s journey to work. It is significant because it represents an acceptable investment of time in the journey to work. People are generally unwilling to commit more than 30 minutes to a single, frequently made trip (Neff, 1996; Pederson, 1980). Moreover, people tend to budget around 60 minutes for total travel over a given day. The budget has been found to be fairly constant for large population groups over space, time and within different sized areas (Neff, 1996). This implies that any push for increased transport sustainability must ensure that people do not exceed their budgets if travelling by modes other than the private vehicle (Scheurer et al., 2005).

New Zealand research indicates that people are travelling further to work over time and that this is likely related to continual urban sprawl (Buchanan et al., 2006). While new roads and road widening projects have reduced the friction of travel (at least in the short
term) many suburbanites may now be surpassing the constant. In Perth, for example, a commute during peak hour from outlying housing estates, such as Port Bouvard in Mandurah to the central city may take three times the constant, even though most of the journey is along the Kwinana Freeway. Longer commutes also lead to more energy consumption (see Chapter 5).

For non-work trips, or trips that are usually more flexible, Lloyd and Dicken (1977) argue that travel choice is influenced by balancing the friction of distance with the relative attractiveness of different destinations. As longer trips take more time, all else equal, the more attractive a distant destination needs to be to encourage a trip. Consequently, a mode that can get a person to a destination more quickly makes the trip more attractive. Therefore, the balance between distance and attractiveness depends upon the mode choices available (Giles-Corti et al., 2005). For example, public transport, which follows set routes, may not get a person to a specific destination directly. In contrast, the private motor vehicle can provide direct access, thereby making a longer trip more attractive.

These issues of friction and preference generally relate to the less mundane of trips. For the more mundane, such as trips to the bank, attractiveness of one facility over another is not often a consideration. Instead, the distance from origin to destination is much more important. Distance is also more important than preference when a trip is borne out of necessity, rather than being discretionary (Brown, 1995). When a trip is necessary, travelling to a distant rather than near destination makes little sense.
Disposable income likewise exerts an influence on travel choices. International research into vehicle kilometres of travel from 1960-1990 suggests that increasing affluence is associated with rising urban mobility (Cameron et al., 2004). As motor vehicles have become more affordable, people have had more opportunities to drive. Similarly, trend analysis by Ingram and Liu (1999) found that car ownership increases alongside national income: as people become relatively more affluent, they own more cars. However, increasing national income also generally increases government budgets for roading and is a stimulus for new development, meaning that there is increasing need for car-based mobility (see Chapter 2).

Income can, however, influence some people more than others. People on low incomes, for example, may prefer to drive but may not have the money to do so. Instead, they may have to rely on public transport, if it is cheaper, or active modes, or otherwise forgo discretionary trips altogether. Section 3.5.2 elaborates on cost burdens for disadvantaged persons.

### 3.2.3 Opportunity cost

The time needed to complete a trip must be balanced against a person’s time budget, especially for non-work trips. People could be doing other things instead of travelling to a distant shopping mall or some other destination. If many trips are made longer because of the way in which cities have been planned, people are made to face difficult choices, such as whether to sacrifice participation in activities other than travel (Kahn, 2000). When people consider transport speed they usually think of how long an individual trip will take. Instead, Tranter and May (2006) argue that the real time sacrifice of a trip is the trip time plus the time required to earn money to pay for the trip.
For this reason, the effective speed of a trip (distance divided by all the time required for the trip) can be much less if driven rather than walked, cycled or made by public transport.

The more frequently people travel by motor vehicle, the greater the opportunity cost. Even though vehicles depreciate in value over time, people continue to be faced with the financial burdens of insurance payments, fuel, registration and maintenance. If people own one or more cars they must go without other goods and services, unless they are sufficiently wealthy to be able to afford everything they want (Newman et al., 2001).

The Royal Automobile Club (RAC) of Western Australia estimated that for 2007, a medium-sized vehicle such as a Mazda 6 (2261 cc) would cost Au$193.21 per week (Au$10,046.74 per annum) to own and operate. Comparatively, a medium-sized SUV such as a Toyota Landcruiser (3955 cc) would cost Au$283.94 per week (Au$14,764.90 per annum) (RACWA, 2007). Melbourne-based research has found that over a working lifetime, perhaps Au$750,000 additional superannuation could be saved if a household sacrificed one car (Warman, 2001). Other modes, including public transport and active modes, have a much lower opportunity cost associated with them; public transport is pay-as-you-ride, cycling requires much less capital outlay motor vehicles and walking is free. Using 1995 data, public transport in Perth, for example, was found to cost about one quarter of the cost of a trip by car (Scheurer et al., 2005).

Motor vehicles therefore generate significant ongoing costs, which impact on the broader spending patterns of most households. Nevertheless, the week-to-week costs of
ownership and operation can be quite small. Often, the only regular and frequent payment made by vehicle owners is for fuel. Other costs come as lump sum costs. It may be that if all costs were regular and frequent (perhaps weekly) people would be more aware of how much they spend on their vehicles. Consequently, they may find alternative means to conduct bounded trips, such as the journey to work, perhaps by substituting the car for public transport. People may also be more selective when making non-bounded trips, perhaps by travelling to nearer destinations rather than alternatives further away. This would seem to require, however, that the built environment be conducive to such transport behavioural change.

3.3 The influence of environmental characteristics on travel behaviour

Chapter 2 discussed how land use and transport are closely linked. The urban environment influences people’s travel decisions and overall movement patterns (Crane, 2000; Dannenberg et al., 2003; Ewing and Cervero 2001a; Ewing and Cervero, 2001b; Frank, 2000a; Frank, 2000b; Kenworthy, undated; Mason, 2000; Newman and Kenworthy, 1999; Saelens et al., 2003b; Frank et al., 2004; Sallis et al., 2004; Srinivasan et al., 2003). Whilst some doubt does remain, however, over the strength of associations, there is strong evidence to suggest that essential to encouraging people to make more sustainable transport decisions is providing people with the opportunity to reduce trip frequencies and lengths (to reduce VKT) and use modes other than private motor vehicles. Not only do there need to be quality networks provided for alternative modes (see Chapter 6) but land uses need to be arranged to be conducive to alternative mode use.
Combinations of variables have an interactive effect on transport behaviour. Mixing of land uses, relatively high population densities, high permeability and micro-scale design features, such as dual footpaths are associated with reduced car use, especially for local, non-work and light shopping trips, and increased use of active modes (see research by Cervero and Gorham, 1995; Cervero and Radisch, 1996; Frumkin et al., 2004; Fulton et al., 2001; Holtzclaw, undated; Naess, 2005; Schrank and Lomax, 2005; Van and Senior, 2001). Conversely, a low urban density and poor permeability are some of the strongest predictors of car dependence (Frumkin et al., 2004).

Other data suggest that the built environment can have significant impacts on modal split or trip lengths, though not necessarily trip frequencies (Buchanan and Barnett, 2006; Cervero, 1989; Ewing et al., 1996; Ewing and Cervero, 2001a; Winter and Farthing, 1997). Greenwald and Boarnet (2001) found that a combined measure of population density at the block level and various pedestrian-friendly characteristics (including street permeability and contiguity of footpaths) were significant predictors of non-work walking. In their study, Greenwald and Boarnet controlled for locational preferences.

Quasi-longitudinal research, relying on participant’s ability to compare their travel behaviour before and after a change in address, found that increasing accessibility (which can be achieved by increasing the activity intensity of an urban area and improving permeability) might facilitate a decrease in driving (Handy et al., 2005a). The researchers note that there are significant associations between changes in the built environment and changes in motor vehicle use, even when differences in preferences

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19 In this study conducted by Handy et al., participants were only surveyed once. The ‘intervention’ group were asked to reflect on their travel behaviour before they moved address and compare it to how they were now travelling.
have been controlled for. These findings are significant, as they lend further support for a causal relationship between urban form and transport patterns. In addition, Naess (2005) found that residential location affects travel choices, even after selected socio-economic and attitudinal variables have been controlled for. Naess used a combination of qualitative and quantitative data collection methods to strengthen his research.

Density, distinctly, is one aspect of urban form that has been found to have a strong relationship with travel behaviour. In particular, researchers have found that modal split is influenced by population density, with residents of denser areas tending to drive less (Banister, 1997; Naess and Jensen, 2004; Naess and Sandberg, 1996; Newman and Kenworthy, 1989; Newman and Kenworthy, 1999). These findings refute research that has found no such association (Troy, 1992; Gordon and Richardson, 1989), some of which is based on weak analysis [such as Bruegmann’s (2005)]. Residential density has been described as “the most effective urban variable in predicting auto ownership and driving” (Holtzclaw, 2000: p1).

A doubling in residential density has been found to decrease driving per family by 25-30%, even across different metropolitan areas (Holtzclaw, 1994). The same research found an association between a greater household density and lower vehicle ownership. A study comparing Almere, Holland and Milton Keynes, England found similarly (Roberts, 1992), as did research by Levinson and Kumar (1997). More recent research comparing the travel behaviour of residents of Chicago, San Francisco and Los Angeles found that car ownership varies as a function of residential density at the neighbourhood level and the availability of public transport. Furthermore, the average annual vehicle
kilometres travelled strongly varies depending on the same variables (Holtzclaw *et al*., 2002).

However, it is difficult to separate the transport benefits of density from those associated with mixing land uses (Alexander and Tomalty, 2002). The two urban design characteristics are synergistic. Similarly, high permeability and thus increased accessibility is synergistic with activity intensity (land use mixing and density considered together) (McIndoe *et al*., 2005; Transportation Research Board, 2005). It is difficult to weight the influences of environmental characteristics, separately or collectively (Naess and Jensen, 2004). Design elements typically come as a package: denser environments will tend to have a greater mixing of uses, better permeability, more integrated public transport and better infrastructure for pedestrians.

The discussion shows that three separate dimensions of the urban environment can be identified that seemingly influence travel behaviour. These are land use patterns (activity intensity, for example), transport systems (street networks, for example) and design characteristics (Cervero and Kockelman, 1997; Frank *et al*., 2003; Pikora *et al*., 2003; Ross and Dunning, 1997; Saelens *et al*., 2003b). The key relationships between the built environment and transport discussed in the literature are summarised in Table 3.1. This evidence strongly suggests that planners cannot consider land use policy in isolation from transport policy. Furthermore, finer-scale characteristics of the built environment must be planned carefully.
Table 3.1 – Likely relationships between characteristics of the built environment and transport

<table>
<thead>
<tr>
<th>Built environment characteristic</th>
<th>Transport outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>Transport energy use (less use of motor vehicles for travel)</td>
</tr>
<tr>
<td></td>
<td>Percentage of non-work trips made by car</td>
</tr>
<tr>
<td></td>
<td>Average trip distance</td>
</tr>
<tr>
<td></td>
<td>Car ownership</td>
</tr>
<tr>
<td>Density – at the neighbourhood level</td>
<td>Vehicle kilometres travelled + car ownership</td>
</tr>
<tr>
<td>Mix of uses</td>
<td>Average trip distance</td>
</tr>
<tr>
<td>Permeability</td>
<td>Average trip distance</td>
</tr>
<tr>
<td></td>
<td>Active transport as a mode choice</td>
</tr>
<tr>
<td>Finer-grained, pedestrian-friendly</td>
<td>Non-work walking</td>
</tr>
<tr>
<td>characteristics</td>
<td></td>
</tr>
</tbody>
</table>

3.3.1 To what extent do environmental characteristics influence choice?

Where a person lives directly influences travel choices. Certain modes can become relatively more or less practical and distances between home and places of work can increase or decrease based on a change in residential location. However, of particular interest to urban design and transport researchers is the role of self-selection. Do people choose their place of residence based on preconceived transport priorities or does the built environment within which they live shape their transport behaviour? As some people may not value access but instead prefer to drive (perhaps long distances) for
many of their trips, their travel behaviour may not only be shaped by environmental characteristics, but also by personal attitudes, preferences and other variables. Studies in New Zealand, the US and elsewhere have found this to be the case (Buchanan and Barnett, 2006; Cao et al., 2006a; Handy and Mokhtarian, 2005). The influence of locational preference remains a significant confounder to the relationship between built form and travel behaviour.

Some researchers refer to residential self-selection as a market sorting process, whereby those with an interest in travel by alternative modes outbid those who are lesser inclined this way for property near to rail stations and/or in areas with high activity intensity (Badoe and Miller, 2000; Boarnet and Crane, 2001; Chatman, 2006; Schimek, 1996). It could therefore be expected that people who are predisposed to travel by alternative modes will outbid others for property in new neighbourhoods, where opportunities for such travel is supposedly better.

However, recent research also cautions against overstating the effect of self-selection on determining transport behaviour and residential choice (Chatman, 2006). Research in the US, for example, has found that transport preferences are lower order influences on housing choice compared with the perceived quality of schools, neighbourhood amenity, and housing prices and quality (Dill, 2004). Other research indicates that there are statistically significant associations between the built environment and travel, even when self-selection is controlled for (Cao et al., 2006b). Ewing et al (2007) argue that self-selection may enhance rather than diminish the influence of the built environment on travel behaviour.
Self-selection aside, socio-demographic characteristics are also thought to exert a powerful influence on travel behaviour (Williams, 2005). A substantive literature review by Stead, Williams and Titheridge (2001) led the authors to conclude that socio-economic variables rather than environmental characteristics often seem to better explain differences in travel patterns. Moreover, Lave’s (1992) research suggested that so long as cars remain affordable people would continue to make many of their trips by car. With cars being superior consumer goods, cost may be the most significant behaviour control mechanism: people will only use ‘inferior’ modes, such as public transport, walking and cycling if car travel is too expensive.

This discussion of preference, the built environment and socio-demographics indicates how complex the decision-making process can be when it comes to travel. While there is strong evidence that the built environment exerts some influence on travel patterns, the significance of the effect would seem to vary depending on personal characteristics including trip purpose, route and individual means. The relative influence of such variables may well vary from person to person (Handy, 2005; Herz, 1982; King et al., 1995; Sallis and Owen, 1999; Sallis and Owen, 2002; Schwanen et. al., 2005; Snellen, 2002). This has implications for sustainable land use and transport strategies (see Chapter 7) as it raises the question: to what extent can transport be made more sustainable through urban design change? The next section explores car culture, which further demonstrates that travel can mean more to people than simply getting from one place to another.
3.4 Will people give up choices? Car culture

Societal norms influence an individual’s attitudes and behaviour, as do ‘official’ attitudes and policies (Davies et al., 1997). Since WWII, the norm has been to use the car. This is because the automobile industry has marketed the car as an essential consumer good (Kenworthy, 1994). Also, with many cities having been planned for car use (see Chapter 2) this has become a virtual truth: many people rely on their cars. A healthy transport policy would be to discourage car use (Tranter and Keeffe, 2001). Instead, car use has more often been promoted and even glorified.

Over time, attitudes and behaviour have been shaped by ‘norms’ and policy, so much so that cars have become part of our culture (Bachels and Newman, 2001; Falconer, 2004; Falconer and Kingham, 2007; Rees, 2003). Private vehicles can be prized assets as they provide freedom of movement. This is demonstrated by evidence of a continuing rise in vehicle ownership and usage in Western Europe, irrespective of high petrol, congestion and parking prices, carefully regulated land use and transport policies, and central city primacy (Bertaud and Richardson, 2004).

Moreover, for many people, it would seem that the choice to drive has become habitual. Over time, people may construe habitual driving to be ‘necessary’ (Handy et al., 2005b). Consequently, people may come to think they depend more on their cars than they actually do. Habit is hard is change (Frank et al., 2004). For many, driving appears a right not a privilege. Notably, British research suggests that around 58% of trips by private vehicle cover less than 5 miles and nearly 25% cover less than 2 miles (Davis et al., 2005). Similarly, in Perth, of the 4 million-odd trips daily, a quarter of a million cover less than one kilometre, 48% cover less than 5 kilometres and 71% less
than 10 kilometres (PATREC, 2005; Premier’s Physical Activity Taskforce, 2006; Wooldridge, 2005). Thus, even when destinations are close by, it seems all too easy to drive rather than use another mode. The evidence does suggest people drive more than they need to (Handy, 2003; Handy et al., 2005b).

### 3.4.1 Do cars provide benefits for people?

Travel behaviour can be influenced by a perception that car ownership is both necessary and empowering. Cars do more than just move people from point A to point B. They serve a number of other roles. They can be tools to exercise preference (travel to preferential destinations further away), recreate, provide mobile private space, construct identity and signify status\(^{20}\). The Perth Metropolitan Transport Strategy (DPI, 1995) identifies car culture as a significant issue in the city and this continues to be the case.

Since 1960, travel in Perth has become dominated by private cars using the region’s extensive road system for flexible and adaptable mobility. The car has provided most residents of Perth with very high levels of personal mobility and good access to the goods and services they desire (DPI, 1995: p38).

Motor vehicles can also provide people with recreation opportunities, not simply access to recreation (Handy, 2003; Handy et al., 2005b). Some people drive for the sake of driving, not to get anywhere in particular. The concept of a ‘Sunday drive’ is enduring (Davison, 2004).

\(^{20}\) While not the focus of this study, car culture is likely a significant influence on travel patterns and should not be overlooked. There is a substantial volume of literature dealing with issues relating to car culture and for more information the reader should access the references provided.
Gillham (2002) argues that cars serve as mobile private capsules. When they are on the move, people can be content that they are enclosed in a piece of their own property, even when they are far from home. This can provide solace and satisfaction for some and can also be linked to the desire to make trips just for their own sake (i.e. for recreational purposes). The driver is free to operate the car stereo, if there is one, smoke if they wish and otherwise tailor the vehicle according to their own desires. Pickett (1998: p31) reinforces this point, arguing that “cars can… provide mobile sanctuary in urban contexts…” Friedman (1992) argues similarly. This idea that cars can serve as mobile private sanctuaries can extend to people ascribing their own rights to the road.

The car can thus be a tool for personal promotion and serve as a distinct lifestyle signal. Research into car cultures and the motivations behind people using cars as means of self-expression illustrates this point well (Falconer, 2004; Falconer and Kingham, 2007; Naess, 2005; Pickett, 1998; Rees, 2003). Various forms of media, such as television commercials, reinforce these roles. By the 1960s, cars were being seen by consumers and advertisers alike as status symbols and props. Davison (2004: p48) comments:

The car was [in the years following World War 2 and into the 1960s, particularly] a new source of social power, opening up fresh possibilities of independence, mobility, sexual opportunity, excitement and self-expression.

Similarly, Diekstra (2003: p255) notes:

Every motorway is a breeding place for conscious and unconscious power games, played by adults who seem to have regressed to an infantile stage of development. The car has acquired
such psychological power that, for many people, the superior qualities of their own machine over those of their neighbours and other road-users no longer has to be proved on the road.

This short discussion of car culture leaves a number of perplexing questions. How do you convince people who see cars as mobile sanctuaries or tools for self-expression, to voluntarily give them up? How do you encourage more sustainable travel behaviour amongst people who are resistant to change and content to continue using cars for the majority of their travel because it is the entrenched norm? Will people oppose policy changes that make driving more difficult? While it is beyond the scope of this research to answer these questions, a good first step presents itself. Our cities must be developed so that travel by alternative modes is efficient and appealing, thereby providing convenient and accessible travel options.

At a time when global oil prices are volatile (see Chapter 5) people may find that their preferences are more influenced by cost. If the real costs of motoring were to be borne by drivers, such as the costs of pollution and infrastructure, these may outweigh the individualised benefits of driving, leading to a switch to alternative, relatively less costly modes (Shore, 2006).

### 3.5 Vulnerable populations

Previous discussions have focused on issues of preference. It was demonstrated that many transport decisions are influenced by what people prefer. People (particularly those with limited means) are less able to exercise preference, however, in sprawled, car dependent urban areas. Therefore, land use and transport arrangements have substantial effects on social justice and equity (Kenworthy, 2007). In the late 1970s it was argued:
The highly successful, automobile-orientated transportation of the 1960s rendered many Americans oblivious to the mobility problems of carless people (Steiner, 1978: p53).

The same can be said in Australia today. Many planning decisions over the last 60 years or so have been based round the presumption that people either own or have access to a private vehicle and can afford to use them for their travel needs (Davis et al., 2005). Sprawled city forms disadvantage those without a car, who cannot drive or do not have much money (Shore, 2006). This is because access to services and facilities is much more difficult for people who do not or cannot drive, including children, people with little income, the elderly and the disabled (Thorns, 2002). Children, for example, need to make regular trips to school, so the urban environment between their homes and places of education impact on their travel behaviour. Together, these four groups constitute the more vulnerable members of society. Some persons may identify with more than one of these groups. Some elderly persons, for example, are also disabled and may even have low income.

Choice, both in terms of transport and residential location, is the privilege of the more wealthy, educated and mobile members of society. They have more opportunity, for example, to conduct discretionary trips (Naess, 2005). The remainder of this chapter explores how vulnerable populations lack some of the choices enjoyed by other members of society. The section focuses more on utilitarian rather than leisure travel. The costs of sprawl and car dependence in the discussion of children’s mobility are exemplified by linking travel behaviour to selected health variables. Data from the US and Australasia are used to illustrate points, with international research referred to where appropriate.
Next, the points are drawn together with the offer of a new approach to urban planning. It expects, as a bottom line, that urban areas are developed to empower the most vulnerable members of society to conduct their life’s work with a degree of ease. Accordingly, streets that accommodate children, the elderly and the disabled will likely suit the needs of all users (Department for Transport, 2007).

### 3.5.1 Children

Parents heavily influence the travel patterns of their children. Parents and caregivers usually have the final say on mode choice, travel behaviour in general and leisure-time activity, including outdoor play. This influence can have profound and long-term effects on the travel habits that children form.

There is a wealth of research that indicates that concurrent to the rise of the private motor vehicle, streets have changed function. Historically roads served as playgrounds for children, because they were shared spaces (Cunningham and Jones, 1994a; Cunningham and Jones, 1994b). This function was implicitly understood to be acceptable (Tranter and Doyle, 1996). Streets do not constitute shared space anymore. Heavy traffic and engineering that favours speed rather than speed control has seen other functions of the road diminish (Gaster, 1991) despite some limited turnarounds in urban transport planning (see Chapter 7). However, with the rise of suburbia and development of culs-de-sac, through-traffic has been controlled in some areas. This has led to low traffic volumes on some local roads.

As parents’ appraisals of safety on the street have worsened, research suggests they have become less willing to allow their children to explore their neighbourhoods (Forward, 2003; Tranter, 1993). This is problematic as the ability to explore their local
environments is argued to be crucial for a child’s development (Tranter and Pawson, 2001; Van Vliet, 1983). Canadian research suggests that the risk to a child of being involved in a traffic accident is higher than being accosted by a stranger [The Centre for Sustainable Transportation, undated(b)]. In some areas, trips by foot or cycle have become increasingly dangerous – even trips to school – because of conventional transport planning priorities favouring speed. Children therefore have to rely on their parents or caregivers to make trips. Often, these trips are made by car. Car dependence will therefore become normalised, as children become accustomed to being driven round an urban environment that has been designed primarily for cars (Meaton and Kingham, 1998).

This highlights a significant equity issue. Children whose parents do not have access to a car are often disadvantaged. Even if it is ‘too dangerous’ for them to negotiate the streets, at least on their own, their parents do not have the means to transport them to distant sports grounds and the like (Tranter, 1993). Kenworthy (1994: p9) argues:

> Adults join in an unconscious conspiracy against their children’s opportunities for independent access to their city. They accept unwittingly that parks, play-grounds and adult-organised play and social events will somehow replace the freedoms that were once enjoyed in the street and other informal meeting places outside the home…

The outcomes of sprawl and car dependence have generally lowered personal mobility and exploration opportunities for children (Frumkin et al., 2004). Frumkin (2003) argues that children need a range of facilities within an accessible distance to allow them to do their life’s work. These facilities include schools, places to congregate and interact with peers, and sports fields.
Active modes open up much more to the senses of the child and permit much more interaction between the child and the environment (Kingham and Donahoe, 2002). Urban sprawl, in conjunction with car dependence has led to there being few social gathering points and destinations for children accessible by walking or cycling. These outcomes have been found in Australia (Kenworthy, 1994; Tranter, 1993; Tranter and Doyle, 1994).

Heavy traffic, especially, reduces the opportunity of children and youth to be independent and explore (Tranter and Malone, 2003). Such a reduction, in turn, can affect the ability of children to construct a sense of place (see Engwicht, 1992) and more generally affect their psychological development. Put simply, “independent access of children is something which may not be compensated for by increased mobility of children in cars” (Tranter and Pawson, 2001: p29).

Diminished personal mobility has been neither instantaneous nor a recent occurrence. More than two decades ago, researchers were arguing that the structure of many of our cities and the proliferation of motor vehicles impose tight limits on the range of movement afforded to children (Elliot, 1985). Tranter (1993) argues that if the loss of independent mobility had been instantaneous, there would likely have been a great public outcry. Instead, the impacts of urban development on children have compounded over the last 60-odd years, as motor vehicles have become more prevalent and suburbia has grown.
a. Changing travel behaviour – trips to and from school

The most important recurring trips that children make are to and from school. While the relationship between parental influence and habit formation appears to be intuitive, there are few formal studies that have examined the effects of mode of travel to school on both the cognitive development of children and their formation of long-term habits (Gilbert and O’Brien, 2005).

Nowadays, rather than walking or cycling to school, many children (particularly primary school-aged children) are being driven by their parents (O’Fallon et al., 2002; Savitch, 2003). In Canada, it was found that in 2001 children were being driven to school much more frequently than in 1986 (Gilbert and O’Brien, 2005). A research review in Denmark found a number of common reasons for parents choosing to drive children to school, rather than walk or cycle. These included concerns about safety, a perception that there is a lack of suitable pedestrian and cyclist infrastructure and that the distance between the home and school is too great (Jensen and Hummer, 2003).

These findings illustrate that mobility concerns are not simply US and Australasian phenomena.

New Zealand data show that safety is a pivotal concern for parents. When their child was seven years old, less than 20% of parents surveyed were prepared to let their children walk to school without supervision and less than 10% were prepared to let them cycle (Percy and Kota, 2007). US research, too, has found that parents report traffic danger as a significant obstacle to their children walking or cycling to school (Dellinger and Stauton, 2002). This is due to children’s exposure to traffic on their school routes. Older data showed Australian parents were likewise concerned with child safety (Tranter, 1993).
Over the period 1986 to 2005 in Western Australia, there has been a significant decline in the number of children who use active means to get to school, versus a dramatic increase in the proportion driven (Premier’s Physical Activity Taskforce, 2006). This undoubtedly reflects negative perceptions of safety amongst parents. In 2004, Hands and others reported that around half of all school students engaged in *no active transport at all*, reflecting both limitations on mode choice for the trip to school and broader mobility restrictions.

In the last decade or so, some concerned community groups and institutions have attempted to encourage a return to walking (and cycling) amongst school children. One of the more successful strategies is the organised ‘walking school bus’. In 1996, the first walking school bus was established in Canada (Kingham and Ussher, 2007). Since then, walking school buses have been established elsewhere, including in Australia. Some researchers credit the walking school buses with increasing the independent mobility of the children who use them (Kingham and Ussher, 2007).

### b. Independent mobility and health

Children are less active than they once were, indicated by declining independent mobility and fewer instances of walking and cycling trips to and from school (Forward, 2003), but how is this affecting their health? One of the most alarming concerns linked to a reduction in physical activity is an increase in health risk factors. Children have been found to compensate for reduced independent mobility by engaging in more sedentary leisure-time activity (Cavill, 2003). A US study found that for children aged 9-13, 65% participate in no organised physical activity when not in school whilst 23% did not engage in *any* free-time physical activity (Duke *et al.*, 2003). This is of concern,
given that children are often being driven to school and thus miss out on physical activity associated with utilitarian active travel.

A lack of physical activity contributes to overweight and obesity (Frumkin et al., 2004). In turn, low self-esteem is a product of being overweight or obese, and the teasing from peers that often comes with it (Strauss et al., 2001). The US Centers for Disease Control and Prevention has declared obesity among children to be at epidemic levels. One in every seven children in the US is clinically obese (Surface Transportation Policy Project, undated). Even so, there are health risk factors when children actually do engage in outdoor activity, including active utilitarian travel, thereby placing children in the situation whereby they can suffer either way. Transport-related pollution and traffic danger are leading concerns:

Rates of obesity in children are increasing to epidemic levels due to lack of exercise and poor nutrition; however, those who are engaged in healthy outdoors activities such as team sports are at higher risk of developing asthma. In addition, a leading cause of childhood death is from car crashes while cycling and walking. Yet transportation funding is most often spent making streets faster for cars, rather than safer for children (Surface Transportation Policy Project, undated).

Californian research found that when healthy children are exposed to smog (ozone, nitrogen and PM$_{10}$) over a lengthy period of time, they are much more likely to develop asthma. The risk is increased three-fold by involvement in outdoor sports, due to exposure to smog, when children are near to transport corridors (Surface Transportation Policy Project, undated). More broadly, asthma and respiratory disease among children
are associated with urban sprawl, extensive networks for motor vehicles and overall reliance on cars for transport (American Lung Association, 2004).

A study in Denver, US found that children who live near to major arteries (those with 20,000+ vehicle movements per day) may be as much as six times more likely to develop childhood cancers, such as leukemia, compared with those who do not (Pearson et al., 2000). Children living in areas of Europe where air quality is poor have been found to have impaired lung function. This increases the risk of future respiratory problems (WHO, 2004). Together, these findings demonstrate how the links between urban form, transport and the health of children are not straightforward. The influences of sprawl and car dependence are not easily overcome, considering the benefits of outdoor physical activity may be offset by increased exposure to vehicle emissions. Nevertheless, improving active transport and leisure opportunities for children is essential and can be tied in as an objective of a sustainable land use and transport agenda.

c. Addressing children’s mobility issues

There are an increasing number of resources available to those who are interested in improving children’s independent mobility. The internet, particularly, is a means to access a wealth of information about how to encourage and promote alternative modes of travel, thereby making them realistic choices for children. Information relating to setting up and operating walking school buses, for example, is easily accessible and very useful. Resources such as these are valuable because they facilitate grass-roots involvement in creating travel choices. They are empowering for educators and parents, not just planners and policy makers.
At a structural level, planners and policy makers must ask themselves searching questions. Are schools being sited with transport considerations in mind? If they are, do transport opportunities extend beyond good access for motor vehicles? Are we doing enough to promote alternative modes, by traffic calming and providing limited parking along access streets? Are we facilitating programmes such as walking school buses and staff travel planning? Teachers must also ask themselves searching questions. Do we, as teachers, set a good example for parents and pupils by choosing to use alternative modes? [The Centre for Sustainable Transportation, undated(a)].

While existing urban form may limit choices for children, there are a number of measures that can provide improvements in the short term. The organisation of ‘walking school buses’ is one example. In the longer term, urban redesign (including increasing access) and transport systems improvements (such as widening footpaths and improving crossings) can make the ‘choice’ to walk or cycle to school much easier. Research has found that even micro-scale design improvements can increase rates of walking and cycling, particularly if they are along popular routes to school (Boarnet et al., 2004).

3.5.2 Disadvantaged persons

For the purposes of this research, ‘disadvantaged’ persons may be defined as people who receive limited income. Disadvantaged people have less choice of housing and transport, relative to people on higher incomes. Deciding on residential location tends to be a complex process (Chatman, 2006). This is particularly true for disadvantaged persons who have to more carefully balance the costs of travel and living.
In sprawled cities such as Perth, the costs of travel can severely limit the choices available to disadvantaged persons. The public transport network is limited and many outlying neighbourhoods are not well serviced. It takes a considerable amount of time to travel from Perth’s outlying suburbs to the central city, especially when buses have to compete with other motor vehicles for road space. While the cost of using public transport is relatively low, it is still a burden for the least well off in society, particularly when they have long distances to travel.

Cars are even less affordable. Even though the cost of owning and running a car remains relatively cheap (when compared to the real cost of motoring) following many years of subsidisation, it is still often prohibitively expensive for the poor (Kenworthy, 1994). This becomes more evident when the costs of insurance, maintenance, registration and fuel are factored in as ongoing costs alongside the capital cost of vehicle purchase. Nevertheless, people with limited means will likely often still rely on cars, because they have few alternatives.

Ideally, walking and cycling would provide the disadvantaged with transport opportunities. In most areas of the city, however, there is too much separation between places of work, services and residences. In the more mixed use, higher density areas of Perth, such as Subiaco and South Perth, housing costs are generally higher, effectively putting accommodation out the reach of the poor. In a wider context, the polarisation of income has led to urban geographies of affluence and poverty (Robinson et al., 2000). The better off in society either live near to services, or have sufficient income to make travelling to services (often by car) a matter of course. Conversely, the least well off often end up in sprawled, poorly serviced communities, where housing costs are less
(Newman, 2007). The costs of travelling, however, are generally high. Thus, people who seem to be the most dependent on cars are perhaps those most unable to afford to be (Davison, 2004).

As for children, social inequity and reduced transport choices are linked to health risk factors. Those who reside in deprived areas tend also to be more exposed to air pollution (Kingham et al., 2007). Areas in the immediate vicinity of heavily-trafficked arteries tend to have lower land values. These areas become some of the few residential locations that are within the budget of those with low incomes (Acheson, 1998). These findings present some serious environmental justice issues. Despite being less likely to be able to afford to own cars or drive, disadvantaged people still tend to be most exposed to transport-related pollutants (Kingham et al., 2007).

a. Evidence and implications of the transport burden on the disadvantaged

A particularly infamous example of inequality in the provision of transport services was in Watts, Los Angeles. On the whole, Los Angeles was and continues to be a very sprawled, highly car dependent city. Watts is a suburb in south central Los Angeles, with a predominantly African American population. In 1965, a destructive large-scale riot occurred in the suburb. An investigation into the causes of the riot revealed that inadequate transport was likely a significant contributing factor (Steiner, 1978).

At the time, the Los Angeles metropolitan area was characterised by a public transport system that was left to market competition. Public transport was not treated as an essential public service as it should have been (van der Velde, 1999). It was
prohibitively priced, amongst other failings. Public transport needs to be affordable for
the least well-off in society so they can have a viable option for travelling longer
distances (Howes and Rye, 2005). It appears that Watts was characterised by very poor
infrastructure and deficient public transport services. Places of employment, education
facilities, and health and social service providers were mostly located outside the
district. Consequently, the low quality local public transport services made travelling to
these destinations difficult. The services were neither subsidised nor co-ordinated and
no free transfers were allowed. Moreover, a regional decline in public transport usage
prompted cuts in services and fare increases, which affected the Watts community
(Steiner, 1978).

The declining quality of an already substandard public transport system had such a
pronounced effect on residents of Watts because car ownership, maintenance and usage
were beyond the financial capabilities of many people. They were highly dependent on
public transport for access to services; even essential services. In car dependent Los
Angeles, where an estimated 50% of residents owned a vehicle at the time, car
ownership in Watts was only 14% (Steiner, 1978).

More recent data from the UK illustrates an ongoing transport burden for the less
affluent. Two out of every five job seekers included in a study by the Social Exclusion
Unit (2003) claimed that lack of practical transport was a barrier to employment.
Furthermore, the Unit reported that over a 12-month period, 1.4 million people missed
or turned down medical assistance because of transport problems. Finally, nearly 50% of
16-18 year old students cited transport costs as being hard to meet and therefore
impacted upon their ability to attend training courses (Social Exclusion Unit, 2003).
These examples reflect how there can be huge inequalities in transport opportunities. It also serves as an important lesson. A sustainable transport agenda needs to provide transport opportunities for all citizens, particularly those who are disadvantaged in some way, by providing quality public transport services and infrastructure for active modes, and generally improving access. These requirements include providing local employment and service opportunities. These are some of the outcomes envisaged by LN.

3.5.3 The elderly

Irrespective of wealth, as people age, they become less able to move under their own power. This has a number of impacts on older people’s transport choices. Firstly, they become less able to travel long distances by foot and may lose the ability to cycle. They therefore need services located near to their homes to minimise travel distances. As people get older, they also become more vulnerable (Beatley, 2004). Transport systems therefore must be designed to be as safe as possible for all users. In many instances, they have not been. Figure 3.1 illustrates how difficult road crossings can be at one of the many busy roads in suburban Perth. In many instances, roads have not been built in recognition of the special needs of the elderly. Again, most major roads have been designed with speed, not safety as the central consideration. Aside from the impacts on pedestrians, elderly drivers have slower reaction times and are consequently more vulnerable road users.

Public transport can also become unappealing, especially when there are considerable distances between people’s homes and stops, and stops and destinations. Physical incapability can render people unable to get to stops, even if they would otherwise use
public transport. In short, much of Perth, as with many other sprawled cities, has not been designed to be elderly-friendly. Given sprawl, the car tends to become the default mode of transport for older people. In part, this is because there are few alternatives when services are located farther away, as is often the case in the sprawled city, but also because the car offers door-to-door service, a need for many older people. If infirmity renders an elderly person unable to drive, it is very difficult for them to conduct day-to-day activities. Thus, major roads are both barriers between homes and services, thereby reducing opportunities for active transport, and are hazards for older drivers (Steiner, 1978). The elderly are yet more vulnerable members of society whose transport needs must be recognised as part of a sustainable transport agenda.

3.5.4 The disabled

Depending on the nature of their disability, disabled persons often have the fewest transport options. If they cannot travel under their own power they become dependent on motor vehicle travel. In 2004, the Australian Bureau of Statistics reported that there were 71,800 West Australians in need of assistance to be mobile. Furthermore, 82,500 West Australians required assistance to travel due to disability. This is a significant community group with special transport needs. Often, unfortunately, these needs seem inadequately catered for.

In Perth, a design issue of particular concern for disabled persons is the lack of footpaths along many local roads (see Figure 2.14 in Chapter 2). There are also many arterial roads with a footpath on only one side. Disabled persons must negotiate verges, be inconvenienced by a lack of crossings and often share road space with motor vehicles and cyclists. These are in addition to issues of distance between homes and
destinations. In Figure 3.1, a person in a wheelchair faces the prospect of crossing a six-lane road in suburban Perth. There is no signage, the crossing point is on an intersection and the traffic speed limit in the area is 70 kilometres per hour.

![Figure 3.1 – A person in a wheelchair faces the prospect of crossing a six-lane road](image)

(Source: Author)

### 3.5.5 Pulling the strands together – rethinking our urban arrangements

This section has demonstrated that vulnerable populations are often at a disadvantage when making transport decisions. Given the urban arrangements of cities such as Perth, children, those with limited income, the elderly and the disabled often face difficulties in conducting their life’s work. It follows that a crucial yardstick of how sustainable urban transport arrangements are pertains to the way vulnerable members are affected.
Children face particular difficulties getting to school. Often they are forced to rely on parents to drive them, because they live too far away from school or the infrastructure between home and school is of insufficient quality for walking or cycling. Concurrently, roads have diminished as play-spaces for children and a similar lack of nearby meeting places further restrict their independent mobility.

Low income earners are similarly affected by the distances between home, work and services in the sprawled city. They have less ability to exercise choice about where they live and how they travel. Accordingly, they are not well positioned to be able to drive everywhere, even for essential trips, which is concerning when there are few other alternatives available.

Many parts of the transport system have not been designed with the elderly in mind. Arterial roads particularly have been built for speed and as little friction as possible, severely disadvantaging elderly drivers, who have slower reaction times. Moreover, when the elderly have the option to use active modes for their travel, infrastructure is often not well designed and there tend to be few local destinations to travel to. Disabled persons are often at an even greater disadvantage. Figure 3.1 illustrates this.

Clearly, it is a complex and costly task to redevelop poor infrastructure to empower vulnerable populations to conduct their life’s work. Nevertheless, incremental change coupled with refocused planning priorities may bear fruit over the longer term. Retrofitting of existing roadways can be completed as part of routine maintenance work, therefore *transforming* rather than *rebuilding* the urban transport environment (Tranter, 1993). Moreover, by focusing planning priorities on accessibility rather than mobility,
issues of both inequity and sustainability can be better addressed. When there are more opportunities to use alternative modes for all trips, the need for car travel can be reduced. Overall, future planning should be evaluated by its impacts on the most vulnerable members of society.

### 3.6 Summary

This chapter has explored the intricacies of transport decision-making. Decisions are influenced by many factors, including characteristics of the built environment and personal preferences. In addition, it was identified how people face various choices relating to where in the city they will live and that these choices can often conflict with other considerations, such as travel.

Subsequently, it was explained how travel preferences extend beyond the notions of getting from ‘point A to point B’. For some members of society, travel is an end unto itself. In particular, cars serve as more than modes of transport. They can act as status symbols and mobile private sanctuaries. Such understandings add to the difficulty of achieving a shift towards more sustainable travel patterns.

The chapter has concluded with an exploration of how the most vulnerable members of society are not well catered for, both in terms of affordable and practical housing opportunities (for disadvantaged persons) and transport options. LN has the potential to be a design code that can address these deficiencies.
In the next two chapters it is explored in more detail how car dependence and sprawl are unsustainable. Chapter 4 examines how pollution, poorly managed traffic and physical inactivity through dependence on motor vehicles can affect public health. Chapter 5 then discusses how the present reliance on fossil fuels for transport energy is not sustainable.
CHAPTER 4:

Exhausting the Air and Jamming the Arteries

Environment and Health Linkages

Mobility is liberating and empowering. But it is possible to have too much of a good thing. The growth in the numbers exercising their freedom and power is fouling the planet and jamming its arteries (Adams, 2001: p2).
4.1 Introduction

The previous chapter examined transport decision-making and the range of factors that can influence travel behaviour. In this chapter, pollution, physical activity, traffic safety and public health issues that are associated with travel behaviour are discussed.

There is increasing interest being shown by researchers in the relationship between urban form, transport and public health (Frank et al., 2004). This interest is being fuelled by declining levels of physical activity and the overweight and obesity epidemic in many Western cities, particularly in the United States.

Generally speaking, policy makers and planners have been relatively slow to react to the impacts of conventional planning on public health (Mason, 2000). This seems counter-intuitive given zoning practice, for example, emerged as a response to the public health problems associated with industrial-age compact cities. Ebenezer Howard’s garden city movement of the early 1900s was likewise a planning response to provide people with green, ‘healthy’ living opportunities. Popular thinking in the 1900s was to separate people from sources of industrial pollutants. However, the new health crisis is not related to people’s proximity to noxious industry and overcrowding; rather it is linked to pollution and safety concerns associated with car dependence and inactive travel behaviour that is associated with urban design.

The chapter begins with a discussion of the various forms of pollution that are associated with the transport sector and how these are linked to public health. Next, the
associations between travel behaviour, physical activity and public health are examined. Subsequently, traffic safety issues are considered.

4.2 Transport pollution

4.2.1 Airborne pollutants

Private motor vehicles are now understood to be significant contributors to urban air pollution, due to the use of fossil fuels for transport energy (Cavill, 2003; Holtzclaw, 2000; Shore, 2006; World Health Organization, 2004). Both diesel and gasoline are carbon-based fuels. The processing of fuels in combustion engines produces carbon monoxide and dioxide, as well as nitrogen oxide, sulphur oxide and particulate matter (Frumkin et al., 2004). In the US, one third of CO₂ emissions are accounted for by the transport sector (Ewing et al., 2007). Volatile Organic Compounds (VOCs) - benzene, methanol and formaldehyde - are all found in fuels and all readily evaporate (Frumkin et al., 2004). Furthermore, ozone, which is harmful to people’s health, forms in the presence of pollutants emitted from vehicles (Frumkin et al., 2004).

In 2000, it was reported that 14% of green house gas emissions in Australia originated from the transport sector (Australian Greenhouse Office, 2006). Vehicles are said to be the dominant source of greenhouse gases in the country (Laird and Newman, 2001b). Each year, in the US the average new car emits as much as 7.3 tonnes of carbon dioxide, amongst other pollutants (Rees, 2003). Nearing the turn of last century, the US transport sector was responsible for 60 million tonnes of carbon monoxide production annually (Benfield et al., 1999).
Public transport generally produces much less airborne pollution per capita than private vehicles (Kenworthy, 2003), while active modes produce none at all. Vehicle kilometres of travel (VKT) can be used as a surrogate for vehicle emissions (Lyons et al., 2003). Figure 2.2 (page 31) in Chapter 2 illustrates how VKT is continuing to rise in many of Australia’s major cities. All else being equal, when rising VKT is considered alongside increasing urban area and rapid urban population growth, the data show that while there may not necessarily be large increases in the density of pollution, there are higher real levels of pollution over a larger area. Using 1980 as the baseline year, Table 4.1 shows real continual rises in VKT, population and urban area in Perth.

The volume of pollution generated from vehicles does depend on a number of intermediary factors. From 1986 to 1996, Perth’s vehicle fleet improved in performance with grams of carbon monoxide (24.55 to 19.17) and hydrocarbons (2.36 to 1.55) emitted per kilometre of travel falling and oxides of nitrogen remaining fairly static (2.33 to 2.29) (Cameron, 2004; Western Australian Department of Transport, 1995). International data suggest that modern vehicles emit 99% fewer hydrocarbons, 95% fewer nitrogen oxides and 96% less carbon monoxide than cars manufactured in the 1960s (Burns et al., 2002). These performance improvements, however, are counter-balanced by rising VKT and the emission of other pollutants such as particulate matter (Cameron, 2004).
Table 4.1 - Perth’s growing urban population compared with rising urban area and VKT

<table>
<thead>
<tr>
<th>Year</th>
<th>1980</th>
<th>1990</th>
<th>2000</th>
<th>2010 (projected)</th>
<th>2020 (projected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>898,918 (100%)</td>
<td>1,142,646 (+27%)</td>
<td>1,381,127 (+54%)</td>
<td>1,644,300 (+83%)</td>
<td>1,903,900 (+112%)</td>
</tr>
<tr>
<td>Urban area (km²)</td>
<td>835.5 (100%)</td>
<td>1,074.6 (+29%)</td>
<td>1,316.0 (+58%)</td>
<td>1,480.0 (+77%)</td>
<td>1,590.0 (+90%)</td>
</tr>
<tr>
<td>VKT (per capita per annum)</td>
<td>6,250 (100%)</td>
<td>7,203 (+15%)</td>
<td>8,472 (+36%)</td>
<td>10,071 (+61%)</td>
<td>11,409 (+83%)</td>
</tr>
</tbody>
</table>

(Source: Australian Bureau of Statistics, 2001; Cameron, 2004; Kenworthy and Laube, 1999)

European research suggests that emissions vary as a function of traffic speed (André and Hammarström, 2000). Emissions of carbon monoxide, hydrocarbons and oxides of nitrogen trend upwards at very slow speeds\(^{21}\) and, to a lesser extent, at high speeds\(^{22}\) (Cameron, 2004; Department of the Environment, Transport and Regions, 1995; Kenworthy and Laube, 2001). Consequently, in congested areas or where vehicles otherwise travel slowly or idle, more pollution is produced.

Ambient air pollution varies as a function of location. For example particulate matter (PM), especially ultra-fine particles (<PM\(_{2.5}\)), tends to accumulate at traffic lights, where vehicles often idle. The finer the particulate matter, the greater the health risk, as it is more easily dispersed by wind and inhaled into people’s lungs (Krausse and Mardaljevic, 2005). Intuitively, ultra-fine particles are very sensitive to local traffic conditions, whereas masses of larger PM (e.g. PM\(_{10}\)) are generally more reflective of local background concentrations (Harrison et al., 1999). International research shows

\(^{21}\) Less than or equal to 20 kilometres per hour.

\(^{22}\) 100 or more kilometres per hour.
that more emissions and hence more airborne pollution will be found near to major transport arteries, which not only can become congested at times but also tend to be heavily trafficked (Riedliker et al., 2003; Roemer and van Wijnen, 2001; Zhu et al., 2002).

*Exposure* to pollutants also relates to mode use. Elsom (1996) argues that car drivers and their passengers may inhale as much as 18 times more pollution while inside their vehicles than those outside. Other research has found similarly (Dickens, 2000; Kingham et al., 1998). Data from Copenhagen shows that car drivers are more exposed to air pollution than cyclists who might likewise be negotiating busy streets (Rank et al., 2001). Sydney-based research found similarly (New South Wales Department of Health, 2004). This is despite the higher respiration rate of cyclists, who are engaging in strenuous exercise, because pollutants accumulate in the cabins of vehicles. Given these understandings, urban air quality may be considered a function of motor vehicle usage per unit area, contingent on the characteristics of the vehicles and the speeds at which they are being driven (Cameron et al., 2004).

Meteorological conditions also affect the spatial distribution of pollution. Wind blows pollution away from mobile sources, creating wedges of pollution into neighbourhoods adjoining major arteries. Concentrations can occur when wind is minimal, whereas pollutants will be more dispersed on blustery days (Krausse and Mardaljevic, 2005). Moreover, emissions react with sunlight. Thus, levels of pollutants vary depending on how much cloud-cover there is.
The link between density of motor vehicle use and increased spot emissions\textsuperscript{23} forms the basis for one of the more common critiques of higher density development (see Bentley, 1999; McIndoe \textit{et al.}, 2005; Schoon, 2001). However, the preceding discussion demonstrates how complex the task is to assess the geography of urban air pollution (Smidfelt Rosqvist, 2007). Area-wide ecological and time-series studies are still needed to deepen understanding of the spatial dimensions of air pollution and then to link them to public health. As yet, relatively little is known about the sensitivity of air quality to changes in urban form, including infill, because links between land use planning and transport remain contested (Handy \textit{et al.}, 2005a).

\textbf{a. Associations between exposure to emissions, susceptibility and public health}

Exposure to pollution has implications for public health. Many researchers have identified associations between air pollution and various health conditions, such as respiratory illness (Brunekreef, 1997; Cohen, 2000; Katsonyanni and Pershagen, 1997; Ontario College of Family Physicians, 2005a; Oosterlee \textit{et al.}, 1996; Sallis \textit{et al.}, 2004). An ecological study found that people who live near to a busy road have poorer respiratory health than those who live further away (Oosterlee \textit{et al.}, 1996). A study of ozone pollution levels in Atlanta during the Summer Olympic Games found that measures to reduce downtown congestion had a corresponding effect on ozone presence (Friedman \textit{et al.}, 2001). The researchers found significantly lower rates of asthma events amongst children during the period of reduced traffic and ozone levels. Persons who are consistently exposed to high levels of particulate matter (PM), especially ultra-fine particles, may suffer constant respiratory distress and have their life expectancy

\textsuperscript{23} Concentration of pollution in a given area.
reduced by one to two years (Brunekreef, 1997; Dominici et al., 2003). Pope (2000) argues that even minimal exposure to PM can be harmful.

The constituents of diesel exhaust fumes have carcinogenic properties (Nikula et al., 1995). Epidemiological observations have linked exposure to air pollution with various cancers, including lung cancer (Cohen, 2000). Links have been found between pollutants including PM and increased mortality rates (Revkin, 2001). In Great Britain for example, research in the late 1990s found that PM is linked to 8,100 annual premature deaths (Acheson, 1998). Time-series analysis has also identified a relationship between daily fluctuations in pollution levels and mortality rates (Katsoyanni and Pershagen, 1997). Furthermore, pregnant women who are exposed to air pollution are at increased risk of adverse effects on the developing foetus (Ritz et al., 2002). The associations between air pollution and key health variables are summarised in Table 4.2. In Australia, there is increasing interest in air pollution and its health effects, given accumulating evidence of a causal link and recognition that vehicle emissions are a major contributor to pollution (Kjellstrom et al., 2002).

Susceptibility relates to how at risk individuals are of developing illness when exposed to pollution. The elderly, children, those who are frequently outdoors (particularly if they are near to major transport arteries, such as construction workers), people with chronic respiratory conditions, such as asthma and those with depressed immune systems are some of the more susceptible (Annesi-Maesamo et al., 2003; Brunekreef and Holgate, 2002; Chauhan et al., 2003; Gent et al., 2003; Thurston and Kazuhiko, 2001).
### Table 4.2 – Associations between vehicle emissions and health variables

| Vehicle emissions (i.e. particulate matter) | Adverse effects on developing foetuses |
|                                             | Asthma                                 |
|                                             | Respiratory illness                    |
|                                             | Cancer risk – including lung cancer    |
|                                             | Mortality rates                        |
|                                             | Life expectancy                        |

#### 4.2.2 Water, noise and visual pollutants

Water pollution is also associated with urban sprawl and car dependence. Sprawled urban areas are often characterised by expanses of impervious surface (see Figure 4.1). Tyre attrition leaves rubber on the bitumen, pollutants drip from exhaust pipes and other materials come from the body of vehicles (Gillham, 2002; Shore, 2006). These contaminants remain on roads, parking areas and forecourts, until water (often from rainfall) transports the contaminants into drains, gutters or standing pools on verges. Run-off often ends up in the storm and wastewater systems of the city, thus being integrated into the hydrological cycle (Brabec et al., 2002). Given fluids are often channelled into specific ‘wastewater’ systems, sudden torrential rainfall can overwhelm the urban storm and wastewater arrangements (Steiner, 1978).
Vehicles are also sources of noise and vibration (Steiner, 1978; Whitelegg and Gatrell, 1995). Intuitively, continued exposure to traffic noise is likely to affect people’s wellbeing. Nevertheless, health experts continue to disagree on the impacts of incessant traffic noise on people’s mental health, as effects are subjective (Mason, 2000; World Conference on Transport Research Society and Institute for Transport Policy Studies, 2004). Noise pollution can also have varying effects depending on people’s routines.
People may be differentially affected while they are working, for example, compared with when they are trying to sleep. Nevertheless, traffic noise does have acute effects on people while they are walking or cycling (Whitelegg, 1993).

In addition, conventional transport infrastructure tends to be a highly visible component of the urban fabric. Roads and the vehicles that use them are sources of visual pollution (Steiner, 1978). Emissions from vehicles contribute to smog, which too is a form of visual pollution. Visual pollution is increasingly being recognised as a by-product of urban activity, particularly transport (O’Riordan, 1995). Beatley (2004) argues that the liveability of places is seriously eroded by the sterility of freeways, highways and other roads. Figure 4.2, a photograph taken near Carousel shopping centre in South-East Perth is illustrative of this.

There are a number of other examples of urban blight associated with transport systems. These include the storage sites required for the oil needed to meet energy demand. In addition, vehicle owners often do not consider where their cars and tyres go once they are worn out. Most often, abandoned vehicles go to wreckers and tyres to dumps. In 2000, for example, there were a reported 500 million scrap tyres in dumps across the United States (Hayden, 2004: p105 – see Figure 4.3).

On balance, planning for sustainable transport may offer robust solutions to reduce the health impacts of various forms of pollution. However, the need to retrofit sprawled areas remains a significant issue.
Figure 4.2 – Carousel, Perth: poor quality urban space
(Source: author)

Figure 4.3 – A scrap tyre yard in Midway, Colorado
(Source: Hayden, 2004: p105)
4.3 The built environment, transport and physical activity

“Land-use and transportation are profoundly important ‘upstream’ determinants of health” (Frumkin et al., 2004: p220). Nevertheless, the relationships between urban form, transport behaviour, levels of physical activity and health indicators are complex. In part, this is because of a lack of understanding about the strength of influence of urban form on transport behaviour (see Chapter 3).

This section is divided into several segments. The first considers the relationships between physical activity and selected health indicators. The second explains how levels of physical activity are influenced by transport behaviour. The third considers how transport behaviour mediates the relationship between the built environment and physical activity. Finally, the relationship between the built environment and transport behaviour, and mental as well as physical health, is considered.

4.3.1 Links between physical activity and selected health variables

There has been extensive research into the associations between physical activity and a variety of health risk factors. Regular physical activity is recommended as a crucial public health strategy against a backdrop of increasing health concerns and has been described as perhaps the least costly and easily administered modern urban treatment regime (Rees, 2003). Research shows that adults who are sufficiently (regularly) physically active have up to 50% lower risk of developing serious chronic illnesses, including heart disease, osteoporosis, colon cancer, type II diabetes, and being
overweight or obese (Bauman et al., 2002; Davis et al., 2005; National Heart Foundation, 2004; Transportation Research Board, 2005). Conversely, insufficient physical activity increases risks (Fenton, 2003; Frumkin et al., 2004; Kaufmann, 2002; Kohl III et al., 1992; Lee and Paffenberger, 2000; Sallis et al., 2004; US Department of Health and Human Services, 2000; Wannamethee and Shaper, 1999). Table 4.3 shows the associations between physical activity and key health variables. An increase in physical activity would have the opposite effects.

Regular physical activity is also an important treatment for a range of conditions, including type II diabetes, as it contributes to improved glycaemic control and insulin sensitivity (Miller and Dunstan, 2004). Older data from the US suggested that between 32-35% of deaths related to coronary heart disease, diabetes and colon cancer were preventable if people were to increase their physical activity to recommended levels (Powell and Blair, 1994). Moreover, the literature supports the usefulness of regular physical activity in delaying the onset of age-related health problems (Hartman-Stein and Potkanowicz, 2003).

Even regular brisk walking in lieu of more vigorous forms of physical activity can reduce health risk factors (Pedestrian Council of Australia, 1999; Ploeger, 2003; Sallis et al., 2004). Walking has been described as near perfect physical activity. Amongst able-bodied persons, it is free and accessible. As such it is the predominant form of physical activity for those on lower incomes (Fenton, 2003; Morris and Hardman, 1997; Siegel et al., 1995). For all persons, it provides considerable health benefits. For society, it has the potential to reduce healthcare costs (Cao et al., 2006a).
Cycling may be even nearer to ‘perfect’, as it requires the use of major muscle groups, can elevate a person’s heart rate to a level that is of cardiovascular benefit and can expend a high number of calories (Cavill, 2003; Wooldridge, 2005). Compared with walking, cycling facilitates longer trips at greater speeds. Together, active modes provide people with important means for physical activity.

The Australian Institute of Health and Welfare (2002) suggests that even a 5% increase in physical activity can reduce risk of debility from disease for which physical inactivity is a risk factor (i.e. cardiovascular disease, type II diabetes and overweight/obesity). The World Health Organization (WHO) has recommended a target of 30 minutes of daily moderate physical activity to reduce health risks (Geurs and von Wee, 2003).

More recently, the American College of Sports Medicine and the American Heart Association revised the recommendations for adult physical activity. Healthy persons aged from 18 to 65 years are recommended to engage in five 30-minute sessions of moderate-intensity physical activity per week, three 20-minute sessions of vigorous physical activity or a combination of the two types (i.e. two 30-minute sessions and two

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**Table 4.3 – Associations between physical activity and key health variables**

<table>
<thead>
<tr>
<th>Physical activity (possible through active transport)</th>
<th>Heart disease</th>
<th>Overweight/obesity</th>
<th>Type II diabetes</th>
<th>Osteoporosis</th>
<th>Cancer risk – including colon cancer</th>
</tr>
</thead>
</table>

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20-minute sessions) (Haskell et al., 2007). Additional physical activity could provide further health benefits. Transport-related physical activity can therefore be an easy way for people to achieve some health benefits.

Canadian research has found that rates of childhood and youth obesity have risen by 50% over the past 15 years and children show a substantial decline in fitness after the age of twelve [The Centre for Sustainable Transportation, undated(c)]. US findings are equally bleak. For children aged 9 to 13 years, 22.6% do not engage in any physical activity in their free time (Duke et al., 2002). When health risk factors are exhibited at a young age, there can be significant implications for individuals later in life. Australian research has found that one in three adults is insufficiently active to experience any sort of health benefit (Bauman et al., 2002). More recent Western Australian data suggest that 45% of adults are not physically active enough to experience any sort of health benefit (Premier’s Physical Activity Taskforce, 2007a).

Sedentary behaviour offsets advancements in medicine that are extending people’s life expectations (Kuczmarski et al., 1994; Mokdad et al., 2001). Onset of type II diabetes in childhood, a disease that was previously considered to be adult-onset, is fast becoming a major concern (Kaufmann, 2002; Surface Transportation Policy Project, undated).

a. The obesity epidemic

Five years ago, Rees (2003) estimated that there were around 1 billion significantly overweight persons globally, most of whom lived in the car dependent cities of the West. In the US and Australasia, increasing levels of overweight and obesity remain
significant public health concerns. Sedentary and inactive lifestyles increase the risk of weight-gain. When an individual’s caloric consumption is greater than their energy expenditure over a prolonged period of time, they gain body mass (Department of Health and Human Services, 2002). Alarmingly, in the US being overweight is considered to be rapidly displacing tobacco as the leading cause of death (Mokdad et al., 2004). However, less than 20% of North Americans smoke, whereas more than 70% do insufficient daily physical activity (US Department of Health and Human Services, 2000).

In 1960, 24% of Americans were classified as overweight. By 2000, this figure was 64%, of which 31% were classified obese (Flegal et al., 2002). In Australia, the proportion of people classified as overweight or obese rose alarmingly from 1980 to the end of the century. In 1999, 20% of persons aged 25 or older were categorised as obese (Australian Institute of Health and Welfare, 2001). More recent data suggests nearly 60% of Australian adults and 25% of children are overweight or obese (Australasian Society for the Study of Obesity, 2005). In 2002, 35% of Western Australian adults were classified as overweight and 13% obese (McCormack et al., 2003). In 2006, the numbers had risen slightly, with 35% overweight and 14% obese (Premier’s Physical Activity Taskforce, 2007b).

If rates continue to increase at historical rates, there could be as many as 7.2 million obese Australians by 2025 (28.9% of the population) (Access Economics, 2006: pi).

Annually, in Australia, Au$380-400m in healthcare costs is attributable to physical inactivity (National Heart Foundation, 2004; Stephenson et al., 2000). A recent Access
Economics report (2006) estimated that the annual direct and indirect costs\(^2\) of obesity are Au$21.0b.

Overweight and obesity have been found to increase the risks of many other health conditions. These include various forms of cancer, diabetes, high blood pressure, heart disease, hypertension, osteoarthritis and stroke (Calle \textit{et al.}, 2003; Hu \textit{et al.}, 2001; Mokdad \textit{et al.}, 1999; Mokdad \textit{et al.}, 2003; Must \textit{et al.}, 1999; Ontario College of Family Physicians, 2005b). These findings demonstrate how health risk factors are interlinked. In particular, childhood obesity has been linked with age onset (type II) diabetes, which would help explain the rise in incidences of this disease (McFarlane \textit{et al.}, 2002).

While there are a range of variables, including diet and stress, that contribute to a sedentary lifestyle and ultimately, weight gain and other health complications, car dependence and sprawl are argued to be significant influences (Ewing \textit{et al.}, 2003; Sturm and Cohen, 2004). Weight problems could be mitigated should people engage in more physical activity, including doing more of their travel by foot or cycle. As such, there is clear incentive for planners to re-examine how cities are growing and the transport behaviour that is facilitated. Since it is understood that there is great potential for people to be more physically active during their daily lives if they were to make more trips by active modes, it would seem to make sense for such travel to be encouraged.

\(^2\) These include carer costs, lost productivity, healthcare, deadweight loss and estimated cost of loss of wellbeing.
4.3.2 Associations between travel behaviour and physical activity

Overcoming car dependence is a considerable barrier to increasing the number of trips made by active modes (Hu and Young, 1999). In cities such as Perth, the distances between origins and many destinations is often too great for walking or cycling to be feasible. Furthermore, there tend to be deficiencies in active mode infrastructure. If the car could be replaced by active modes for a sufficient number of trips, there is great potential to boost people’s level of physical activity. There is potential for such substitution in Perth, given there are 250,000 trips made every day each of which covers one kilometre or less (Premier’s Physical Activity Taskforce, 2006).

However, it is important to recognise the complexity of the relationship between mode use and physical activity. On one hand, a person’s reliance on private vehicles may reduce their physical activity (Frumkin et al., 2004) because little physical activity is derived from travel. On the other, people who rely on their cars for travel may drive to and participate in organised sports that would otherwise be unavailable to them (Transportation Research Board, 2005). Thus, there may be a substitution effect, whereby people choose to play sports rather than walk or cycle for physical activity (see research by Rodriguez et al., 2006). From a public health perspective, how much total daily physical activity people undertake is more important than their modal split (Transportation Research Board, 2005).

Comparatively, people who rely on public transport may be less physically active than active mode users or car drivers. This is because they may not be walking or cycling enough to be sufficiently physically active through transport alone, while at the same
time, they have fewer opportunities to access leisure activities than car drivers. Together, these are interesting distinctions between mode users and more research is required as part of other studies to clarify differences.

a. **Separating utilitarian from leisure activity**

Leisure or recreational activity is done for its own sake and is possible through travel or otherwise (i.e. through participation in team sports). While there may be fewer opportunities for utilitarian physical activity in suburbia, this may be offset by increases in leisure-related physical activity (Transportation Research Board, 2005).

However, the line between utilitarian and leisure activity is not clearly defined. People can make travel decisions based on their own health considerations. As such, a walk to the shops can fit two purposes (exercise and to make a purchase). Irrespective of the purpose behind the travel – whether it is done for its own sake or for some other purpose – it can be self-reinforcing. People may find they feel better as a consequence of physical activity, if they have good opportunities to be physically active (Transportation Research Board, 2005).

While there is no analysis of people’s physical activity outside of their self-reported transport behaviour as part of the present study, participants are asked to identify the purpose of their trips. This allows analysis of whether people are reaching certain levels of physical activity regularly, based on their intention to be active or as a by-product of their travel patterns. Furthermore, the main RESIDE study is collecting data relating to all forms of physical activity and a range of health measures, thereby
allowing more detailed future analysis of the relationship between physical activity and health.

**4.3.3 Associations between the built environment, physical activity and health risk factors**

Transport behaviour is inextricably linked to the built environment. As such, urban form, transport behaviour, levels of physical activity and public health are interlinked (Saelens et al., 2003a). There is interest in the health field as to how aspects of the urban environment affect levels of physical activity, with transport patterns being an intermediary variable (Booth et al., 2001; King, 1994). Sensible urban design should include planning for people and their health (National Heart Foundation, 2004).

A number of researchers argue that efforts to make our urban environment more walkable (and cycle-friendly) are consistent with a drive to re-link public health with urban planning (Coburn, 2004; Frank et al., 2003; Greenberg et al., 1994; Greenberg et al., 2005). It is a link, they argue, that was once important, but has diminished under conventional planning paradigms. What aspects of design are therefore beneficial for people’s health, or conversely, are to the detriment of people’s health? Unfortunately, there is as yet insufficient evidence to support a causal connection between the built environment and levels of physical activity (Transportation Research Board, 2005).

Nevertheless, a study in Atlanta, US found significantly lower rates of obesity among residents of compact, dense, more pedestrian-oriented neighbourhoods with good access to public transport than in car dependent neighbourhoods (Frank et al., 2003). The
implication is that residents of the former type of neighbourhood engage in more physical activity than their counterparts in the latter. Similarly, another US study found that residents of a highly walkable neighbourhood engaged in roughly 70 minutes more moderate to vigorous exercise per week, than residents of a comparatively low walkability neighbourhood (Saelens et al., 2003a). Moudon and colleagues (2006) found that higher residential densities, smaller block sizes and shorter travel distances from homes to food facilities were environmental variables positively associated with walking behaviour that was sufficient to meet health recommendations. Moreover, Perth-based research by McCormack and colleagues (2007) found that the provision of a mix of transport-related destinations, such as grocery stores sited close to residents is likely to encourage transport-related physical activity. These environmental characteristics should therefore feature in ‘walkable’ neighbourhoods.

A cross-sectional comparative study of St Louis, Missouri (relatively low walkability) and Savannah, Georgia (relatively high walkability) found associations between levels of physical activity and environmental characteristics (Hoehner et al., 2005). The researchers concluded that modifications to the environment (i.e. improving walkability) might influence the travel behaviour of the persons exposed to the changes.

Increases in activity intensity as a specific design response are argued to benefit people’s health in a number of ways. Local provision of services and facilities may promote more walking and cycling, leading to health benefits from physical activity (Frank et al., 2004). Increased permeability as part of compact neighbourhood design is conducive to physical activity and hence, can have lasting benefits for public health. People are more likely to be moderately physically active when there are a good mix of
nearby destinations and direct routes to get there (Frank, 2000a; Frank et al., 2005; Powell et al., 2003). Similarly, Greenberg et al. (2005: p90) argued that “making immediate neighbourhoods more walkable and bikeable is important to increase the likelihood of additional exercise”.

Conversely, when there are significant distances between destinations, walking and cycling are both time consuming and unattractive mode choices (McIndoe et al., 2005). It follows that the existing built environment is likely to be contributing to rising levels of obesity, as sprawl makes it unfeasible for people to walk (or even cycle) to destinations (Frank et al., 2003; Frank et al., 2004; Vandegrift and Yoked, 2004).

Other research has identified the importance of attractive recreational facilities being provided locally (Active Living Research, 2004; Giles-Corti and Donovan, 2002). Furthermore, such facilities should support multiple uses and not just cater for organised sports (Giles-Corti and Donovan, 2002). A study in Missouri, America found that people living in areas lacking outdoor recreation facilities are more likely to be overweight than counterparts in areas with a relatively high provision of facilities (Catlin et al., 2003). These findings suggest provision of quality recreation opportunities can facilitate increased physical activity, even if people drive to them.

Other research has found higher levels of moderate level utilitarian physical activity by residents of highly walkable neighbourhoods, relative to residents of lowly walkable neighbourhoods (Saelens et al., 2003a). The researchers found no significant difference, however, in vigorous and self-reported leisure activity. Similarly, Handy (1992) found significant differences in utilitarian trips, but not in walking for exercise,
between residents of highly and lowly walkable neighbourhoods. These findings illustrate how the built form may exert more of an influence on utilitarian rather than leisure activity. More research is needed, however, to support this theory.

Some other findings confuse the relationship between neighbourhood design, physical activity and health indicators. US research found no association between urban form and levels of obesity at the neighbourhood scale (Ewing et al., 2003). This would seem to reflect the variability of urban form over space and that people conduct much of their business outside of their immediate neighbourhood. Moreover, it raises questions about how successful local design and piecemeal development can be at increasing levels of physical activity.

In Perth, relatively higher density neighbourhoods outside of the CBD featuring a good mix of land uses and a well-connected street network tend to be linked to lower density, conventionally-designed neighbourhoods. Consequently, once a person leaves their compact neighbourhood they enter sprawled areas of the city and tend to have to rely on their cars for travel. It is therefore important to identify where LNs are being developed and how they are integrated with adjoining communities.

Other research has found that aspects of the physical environment are important for determining how likely people are to walk or cycle, but that such aspects are secondary to individual and social determinants of behaviour (Giles-Corti and Donovan, 2002; Stahl et al.; 2001). Furthermore, Sallis and Owen (1999) note that health researchers have examined numerous psychological and social variables that may be associated
with a person’s travel behaviour and that this in turn can have an effect on how much physical activity they get.

The discussion has identified that the relationships between the built form, transport, physical activity and health are complex. Nevertheless, much of the research suggests car dependent, sprawled environments provide people with fewer opportunities for physical activity and consequent health benefit than compact, highly walkable environments. Significantly, however, the compact, highly walkable neighbourhoods need to be coordinated to facilitate the greatest benefits.

### 4.3.4 Social capital and mental health

Over the last few decades many opportunities have been provided for people to find privacy, whether in their own car or detached home. Chapter 2 discussed how suburban development and separation of housing from industry were considered ways to provide people with respite from the hustle and bustle of city life and access to the tranquillity of nature. In tandem, mass motorisation increased people’s mobility and gave them access to lower density housing.

To the contrary, Leyden (2003) and Schmidt (2004) argue that people do not find nature and tranquillity in the suburbs. Instead, nature is pushed further away as outward growth continues. People also face the frustration of more time spent in cars, travelling from home to work and to other destinations. In general, research is increasingly linking car dependence and sprawl with diminished social capital and mental health.
a. The implications of a shift from public to private space

Suburban growth is criticised for drawing people away from public areas. The car dependence that is related to sprawl is similarly critiqued. The consequence of sprawl and car dependence is increased social isolation (Murphy, 1982; Putnam, 2000), which can undermine public health, including mental health.

In the early 1990s, Lasch (1991) and Kenworthy (1994) argued that informal associations between people and their neighbours have been allowed to wither, to the detriment of community spirit. This, Lasch argued, was a product of the low-density neighbourhoods that characterise sprawl. Sprawl limits the opportunities for people to interact on a face-to-face basis on the street (Allen, 1980). Hayden (2004) coins suburban dwellers residents of “privatopia”. In Australia, Newman and Kenworthy (1991) argued that such an emphasis on private space led to a reduced sense of ownership of the ‘commons’, or public space. Interaction between people has become more dependent on private arrangements.

Moore and Blumenthal (1998) argue that sprawl (and car dependence, by implication) can lead to or worsen depression. Increased blood pressure and a depressive mood can result when people commute by car and find themselves stuck in congestion (Novaco et al., 1979), which is often the case during peak travel periods in sprawled cities. In contrast, research has found that active mode use can heighten mood (see Gee and Takeuchi, 2004).
b. Facilitating social capital formation: ‘chance’ encounters

It is well recognised that social bonds are essential for the health and well-being of individuals (Frumken et al., 2004). Social networks provide support mechanisms, sources for advice and potential for informal care (Davis et al., 2005). This is particularly important for the elderly and for other vulnerable members of the community, such as the disabled (Cavill, 2003).

Places facilitate social interaction in a variety of ways. For example, a safe and attractive environment for pedestrians provides more encouragement for people to walk than a barren, paved area dominated by motorised traffic (Beatley, 2004). Social interaction occurs between people on foot, not people in cars (DPI, 2000). In turn, social interaction enables social capital to be generated, which increases people’s sense of community (Tranter and May, 2006).

Social capital may be thought of as community spirit, in the sense that people both possess an affinity with their community and have at least a nodding acquaintance with their neighbours. It has been argued that “…social capital is the glue that helps bind communities together” (Frumken et al., 2004: p185).

It is the segregation of land uses in suburbia that contributes directly to a lack of community vibrancy and by implication, social capital formation (Nasar and Julian, 1995). Purely residential neighbourhoods compared with mixed-use neighbourhoods have been found to have less of a collective sense of community, stemming from less use of public space (Nasar and Julian, 1995). This may be because the likelihood of
chance encounters with neighbours is lower in the suburbs and consequently, the opportunities for people to form a social community are diminished (Freeman, 2001).

Walkability has been found to enhance vibrancy, improve quality and promote the formation of social capital (Cavill, 2003; Lund, 2002; Putnam, 2000; Roberts-James, 2003). Provision of a quality public transport system can combine with these features to further enhance the quality of a community (see Burns, 2005 and Chapter 6). Together, quality alternative transport systems and these land-use characteristics help give communities a sense of place (Lucy and Phillips, 1995). Conversely, when people are shut away in cars, they miss out on the casual social interaction that active mode use and transit can afford (Wright, 2003).

Studies have found that busier streets (i.e. the more vehicle traffic there is) contribute to fragmenting social networks and reduce the satisfaction residents have with their neighbourhoods (Health Education Authority, 2000). Similarly, the more streets are dominated by car traffic, the less opportunity there is for community consolidation (Newman et al., 1992). Even if local suburban roads are not always dominated by traffic, suburbia still lacks other characteristics, such as mixing of land uses and density that tend to combine to facilitate use of the street as a social space.

In theory, LNs should possess more of the land use and transport systems characteristics that lend themselves towards the formation of social capital than conventional neighbourhoods. Other research associated with RESIDE is investigating these relationships.
c. **Social interaction is as valuable as ever**

Humans are social animals. We need to interact with other people. In the past, when the private motor vehicle and internet were things of the future, face-to-face contact was necessary not just for socialising but for economic transactions. Development of information technology and private motor vehicle transport has not removed the need for face-to-face encounters. Direct social interaction continues to be highly valued. For some businesses, face-to-face encounters can constitute the difference between success and failure (Newman *et al.*, 2001).

Telecommunications allow some people to separate themselves from their places of work and client bases, while still being involved in business. Those who choose to utilise telecommunications, however, rather than face-to-face meetings are losing social capital that direct networking brings (Adams, 2001). This can have economic implications, as clients may value the human aspects of transactions.

Aside from the economic ramifications of relying on new technologies, social needs are also of importance. Drivers miss out on the chance encounters that occur between pedestrians, cyclists and public transport users, which can contribute to people’s sense of well-being (Jacobs, 1961; Putnam, 2000).

### 4.4 Health and safety

#### 4.4.1 Traffic accidents, injuries and fatalities

Traffic accidents are by-products of motorisation. Car dependence has contributed to worrying accident statistics both in Australia and overseas. When people drive often
and for long distances, they are at greater risk of being involved in an accident and create more risk for others (Frumkin et al., 2004). Active mode users are placed at particular risk (Geurs and von Wee, 2003). Traffic deaths tend to follow the degree to which a city suffers from car dependence (Newman and Kenworthy, 1999). Consequently, the high number of traffic accidents on roads is attributable to deficiencies in transport and land use planning.

When a pedestrian is sideswiped and killed by a passing truck on Buford Highway, Atlanta, a seven-lane road lined with apartment buildings, big-box stores, and no side-walks...the health department lists the cause of death as ‘motor vehicle trauma’. Should not the actual cause of death be listed as ‘negligent road design and city governance’? (Frumkin et al., 2004: pxv).

In the US, motor vehicles contribute to the death of 120 persons on an average day (National Safety Council, 2003). Near the turn of the century, road deaths exceeded 40,000 per annum (National Highway Traffic Safety Administration, 2002; US Department of Transportation, 2000). In 1999 alone, there were 3.4 million non-fatal injuries (Centers for Disease Control and Prevention, 1999) while 3.2 million were reported for 2000 (US Department of Transportation, 2000). Healthcare costs associated with the 3.4 million injuries in 1999 were estimated at US$2b (Au$2.55b) (Centers for Disease Control and Prevention, 1999). For Americans aged 1-34, traffic crashes are the leading cause of death. Nevertheless, less than 1% of US Federal travel funds are allocated to improving facilities and safety for active mode users (Surface Transportation Policy Project, undated).

In Great Britain, 3,500 persons are killed and 250,000 injured per annum on the road network (Davis et al., 2005). In 1999 in Australia, 1,759 people were killed and more
than 20,000 seriously injured on the nation’s roads (Laird and Newman, 2001b). In 2006, there were fewer deaths, with 1,601 persons killed in 1,456 road crashes (Australian Transport Safety Bureau, 2007). These, however, are only reported statistics (the latter are only for road fatalities) therefore the real number of accidents and injuries is higher.

The rise of accidents and fatalities that has corresponded with a rise in vehicle ownership of the past few decades reflects the priority given to motor vehicle transport at the expense of other modes. Aside from new vehicle technologies, such as side impact bars and airbags designed to make vehicles safer for occupants in the event of a crash, maintenance and development of transport infrastructure tends to be aimed towards improving safety for drivers25. The significant resources that are allocated to improve safety for motorists may be better used to encourage alternative mode use and reduce dependence on cars (Newman and Kenworthy, 1999).

The focus on safety for vehicles can lead to risk compensation. Drivers feel safer so they compensate for increases in safety by driving faster. A US study of data from 1984-1997 found that improvements to highway infrastructure actually led to an increase, not a decrease in injuries and deaths resulting from accidents (Noland, 2001).

The findings of US research reflect the dangers of urban travel for active mode users. In 2001, when undertaking a journey of one mile (1.6 kilometres) a pedestrian was 23 times and a cyclist 12 times more likely to be killed than a car driver (Pucher and

25 There are numerous engineering solutions that can improve safety for active mode users, including raised crossings, clear signage and vegetated ‘buffer’ areas. These are discussed in Chapter 6.
Dijkstra, 2003). This may be expected, as active mode users are more vulnerable than drivers.

Rates of accident involvement may indicate that many motorists are not adequately aware of pedestrians’ and cyclists’ rights. A survey of Perth motorists by Main Roads found that many cannot identify situations when pedestrians have right of way (Jewell, 2007). Many of the surveyed motorists admitted that they were unaware that they were required to give way to pedestrians travelling straight when they themselves wished to make a left turn.

Even when a left-turn slipway is provided (Figures 4.4 and 4.5) the pedestrian retains right-of-way, because the motorist is crossing their path. Slip-ways can prove particularly hazardous because the driver does not really have to slow down to make the turn (unless traffic is making a right-hand turn into the same street) and pedestrians have to cross more road surface than if the turning radius was shorter (Duany et al., 2000). Safety is therefore a key issue for (potential) active mode users. If the environment is not safe for them, it is a huge disincentive to walk or cycle (see Hill and Melanson, 1999; Hill and Peters, 1998)\textsuperscript{26}.

\textsuperscript{26} Issues of safety and how these can be addressed as part of network design are discussed in greater detail in Chapter 6.
Figures 4.4 and 4.5 – Even if a left-turn slip-way is provided pedestrians retain the right of way

(Source: Author)

Main roads, which are designed to move large volumes of traffic are uniformly unfriendly to pedestrians (see Handy et al., 2002). Similarly, Australian research has found that cycling along arterial roads is more dangerous than along local roads
(Drummond and Ozanne-Smith, 1991). This is because main roads are designed to move large volumes of traffic at increased speeds. Large volumes of traffic also make it difficult for pedestrians to cross roads. This is problematic in areas where there are few controlled intersections or other safe crossing points.

Figure 4.6 depicts South Street, which abuts Murdoch University. From East to West, 2.3 kilometres of South Street is shown (marked in yellow). The speed limit along here is 70 kilometres per hour. University students who are walking or cycling to or from campus can use three controlled crossing points along this six lane major arterial road. The purple arrows indicate these. The average spacing between the crossing points is 1.15 kilometres. The centre crossing point is an underpass. The ramp at both ends of the underpass has a steep gradient and it is therefore difficult for people with mobility impairments to make use of it.

Intuitively, the problem with high traffic speeds is “the faster you go, the bigger the mess” (Land Transport New Zealand, 2006: p6). Whitelegg (1993) found that reducing speeds from 50 to 30 kilometres per hour reduces the occurrence of accidents by 50%. Moreover, he found that should a pedestrian be struck by a vehicle, there was a fatality rate of about 10% at 30 kph, 40% at 50 kph and 90% at 70 kph. Nevertheless, in the sprawled city where residents need to travel long distances, speed controls would reduce efficiency and vehicle movement.

It follows that fears for safety and a sense of vulnerability amongst prospective cyclists and pedestrians are likely to be big deterrents to active mode use (Wigan, 1995). This contributes to low rates of active mode use in the sprawled city.
a. **Putting the onus on drivers, rather than active mode users**

Making cyclists and pedestrians responsible for their own safety, through education (i.e. the mandatory use of cycle helmets) and engineering controls (i.e. restrictions on cyclists using major arteries) is not the most pragmatic way to address health and safety (Surface Transportation Policy Project, undated). Drivers may see pedestrians as random elements in the cityscape and cause of delays (given provision of pedestrian crossings) and are at all times capable of acting irrationally (for example, darting out onto the road). Nevertheless, it is a car moving at high speed, rather than a pedestrian moving at walking speed that will cause injury or death. Thus, the onus for accident prevention should be placed on drivers and educating drivers makes more sense than educating active mode users. This method of changing cultural circumstances and
rethinking urban design for improved safety is known as danger reduction (Tranter and Keeffe, 2001).

Such measures in conjunction with broader-scale traffic calming are necessary. In traffic-calmed spaces, cyclists and pedestrians have much higher visibility and drivers are more aware of their responsibilities (Wittink, 2003). Traffic danger is therefore reduced.

In Europe, authorities have been taking steps for some time to control the speed of private vehicles and to put the onus on drivers to prevent accidents. Steps include designating reduced speed zones, including near schools and implementing various traffic calming measures (Brindle, 1982). Australia has been relatively slow to adopt these initiatives. Nevertheless, with sufficient transport policy redirection, micro-scale measures can be useful whilst other strategies to reduce motor vehicle travel are implemented.

4.4.2 Crime and surveillance

The relationships between the built environment, transport and crime are also complex. Both perception and actual incidences of crime are likely to be disincentives to active travel, especially walking. Other PhD research associated with RESIDE is focusing on transport safety and crime (see Foster et al., 2007). Liveable Neighbourhoods are intended to reduce crime through urban design. In part, this is through increasing surveillance opportunities.
It has been argued that ‘eyes on the street’ are crucial for creating a safe urban environment (Gehl, 1987; Heath, 2001; Jacobs, 1961). Windows fronting on to streets rather than high fences and walls foster more passive surveillance (Duany et al., 2000). Intuitively, the more surveillance of an area, the less opportunity there tends to be for crime.

Sense of safety in the urban environment has lessened over time. This is a function of suburbanisation and people’s retreat to the private realm (Newman and Kenworthy, 1999). With there being fewer people on the street in sprawled, car dependent areas, there is no longer as much opportunity for casual interaction and as such, there are fewer eyes on the street. Conversely, areas that are supportive of active travel facilitate more eyes on the street and increased surveillance. This is because pedestrians and cyclists have more opportunities to survey their surrounds than do occupants of vehicles.

Curvilinear streets and culs-de-sac further reduce surveillance opportunities. For example, cut-throughs at the head of culs-de-sac that are intended to provide pedestrian and cycle links are often bordered by high boundary fencing and have limited lighting (Figure 4.7). They can therefore be dangerous environments, especially at night. While new neighbourhoods can be designed to minimise culs-de-sac, cut-throughs and curvilinear streets, the existing neighbourhoods of cities such as Perth require expensive retrofitting to reduce danger.

Additionally, many local ordinances require houses to be set back a certain distance from street frontages. This also reduces opportunities for surveillance. In some cases,
garages project further towards the street than dwellings, thereby obscuring the view of
the street.

Key mechanisms to design out crime and danger in new neighbourhoods include
placing limits on setbacks, orientating living area windows to streets, restricting fencing
and facilitating local active travel. The UK’s Department for Transport (2007) provide
a useful checklist for designing safe neighbourhoods for pedestrians. Its key elements
include designing public space to be overlooked by habitable rooms in buildings,
avoiding blind corners and dead ends, providing good lighting and managing anti-social
behaviour such as graffiti.

Figure 4.7 – Kardinya, Perth: a cut-through at the head of a cul-de-sac
(Source: Author)
In the US, Crime Prevention Through Environmental Design (CPTED) is proving very influential (see National Institute of Crime Prevention, 2008). Like the DfT’s guidelines, CPTED aims to develop safe urban environments for active mode users on the premise that conventional planning practice detracts from safety.

Developing neighbourhoods to relatively high densities can also be useful in this respect. Research has found no significant link between higher densities, and crime and delinquency, thereby contradicting the suggestion that ‘crowding’ provides opportunity for recalcitrant behaviour (Jianling and Rainwater, undated; University of Alaska Justice Center, undated). On the contrary, well-planned higher density developments can add to perceived and real safety by enabling greater passive and active surveillance over the public arena. Also, mixing of uses contribute to keeping areas under passive surveillance throughout both the day and night (Duany et al., 2000).

Together, these points illustrate that thoughtful urban design and carefully considered opportunities for active travel can make measurable differences to both perceived and actual community safety. Conversely, poor planning can add to the vicious cycle of retreat into private space and substitution of active travel for trips by motor vehicle, followed by diminished surveillance of public space.

### 4.5 Summary

This chapter has discussed how a range of public health issues are associated with land use and transport. Car dependence is associated with a great range of pollution. Conventional motor vehicles pollute the air, water sources, urban landscapes and
auditory environments. Research has linked this pollution to a great range of public health issues, including respiratory illness and some cancers.

In addition, travel behaviour is linked with physical in/activity. Walkers and cyclists are physically active: in contrast, drivers miss out on this ‘easy’ physical activity. In turn, physical inactivity is linked to many public health issues, including overweight and obesity, type II diabetes and cardiovascular disease. Increasingly too, research is linking travel behaviour with mental health. Aside from the effects of incessant traffic noise on mental health, which remain unclear, research is linking car dependence with diminished opportunities for social capital formation and by implication, reduced sense of community.

Also, car dependence and sprawl are associated with a variety of safety problems. Vehicular traffic is hazardous, particularly for active mode users. Landscapes that are built for cars present myriad challenges for pedestrians and cyclists. Also, conventional suburbia can pose increased risks of crime, given diminished opportunities for surveillance and increased opportunities for incivilities.

The following chapter expands the context for planning and transport policy redress by discussing transport energy. Conventional vehicles rely on oil for energy and the discussion will show how this is not sustainable.
CHAPTER 5:  

Low on Energy

Exploring the Fossil Fuel Issue

The enemies of the car believe that we are already too far down the wrong road to turn back. The costs of recovering the world’s already depleted supplies of oil will soon become prohibitive...The car’s defenders, on the other hand [say]...before the world’s oil runs out...engineers will have developed new cars that run on hydrogen, sugar cane or solar batteries. Only if you can foretell the destination of the road can you decide whether it is the wrong one (Davison, 2004: p260).
5.1 Introduction

In the 1950s, M. King Hubbert (1956) forecast the peak of oil production in the US and was confirmed in his predictions by the peak occurring in 1971. He then went on to predict the peak of world oil production being early in the 21st Century. Despite these concerns, many years of transport policy and funding, particularly in the US and Australia, have favoured motor vehicle transport and the transport sector is now heavily reliant on oil (Kenworthy, 2003). Awareness that the high price of oil may not be temporary has led to renewed calls for a review of transport policy as it relates to oil dependence. At the same time as the scarcity of oil appears to be becoming a reality, the need to price carbon in transport as well as in electricity is happening. More generally, there is a need to review the options for transport policy in a fuel constrained world.

Chapter 2 discussed how urban sprawl and car dependence are inextricably linked and that these are two outcomes facing many US and Australian cities. In Chapter 3 a clear distinction was drawn between car dependence and driving by preference. Many cities have been designed in such a way to make motorised travel the only real transport solution for many trips. At the same time, the choice to drive has become far too easy, even when it is practical to use other modes because motor vehicles allow access to distant, preferential destinations and provide mobile private space for all journeys. The evidence suggests that both car dependence and car preference are characteristic of Perth. This chapter develops the underlying theme of Chapter 4, which was that present land use and transport patterns are unsustainable, as they pose significant costs for the environment and society.
Oil dependence is linked to car dependence. As a consequence of oil dependency, oil supply has become big business. Motor and oil companies have long featured prominently in the global Fortune 500 (Hamer, 1987). In 2004, for example, three oil companies - Exxon Mobil, BP and Royal Dutch Shell Group - were amongst the ten wealthiest companies worldwide. In 2004, Exxon Mobil’s market value was US$283.6b (Au$365.4b) (Finfacts, 2005). Automobile manufacturers and suppliers have a high representation elsewhere in the list. Together, these companies with an interest in motoring and oil form a powerful international political lobby group.

The chapter continues with discussion of how oil dependence foretells a global transport crisis, given evidence of increasing supply and demand imbalances. Next, case-study data from Australia illustrates private motorised mobility may be in its twilight. Private transport will get increasingly difficult as cities struggle to provide people with sustainable access to the services and facilities that are integral to their life’s work.

The chapter goes on to discuss the limited role that technological change can play as a component of a reformed sustainable transport agenda, despite the hype that often surrounds ‘hybrid’ vehicles, bio-fuels and other innovations. The role is limited because, amongst other reasons, technological change cannot adequately address other issues associated with car dependence, including safety concerns and social inequity (see Falconer and Giles-Corti, 2007; Falconer et al., 2007; Kenworthy, 2007). Carpooling and car-sharing are also considered as measures of limited use. Instead, more fundamental means to reduce oil dependence are required, which include ‘smart’ land use and transport planning to reduce the need for private motor vehicle travel.
5.2 Global supply, demand and dependence

Cheap fuel is no longer something to be taken for granted (Tranter and Sharpe, 2007). Increasing demand for oil has pushed prices to record levels in recent times and contributed to market volatility (Simmons, 2005). There is concern even within financial circles that a real limit to oil production may have been reached. The energy market has been further affected by some countries strategically stockpiling oil to buffer against future price rises and fuel shortages, and seasonal fluctuations in demand (including record cold winter temperatures in the US in recent years).

In addition, there has been considerable growth in demand for fossil fuels by the Chinese, who have a rapidly developing economy and transport sector. By 2004, China had become the second-largest consumer of oil in the world, with daily usage having doubled since 1994 (Douglas-Westwood, 2004; Newman, 2007). Nevertheless, Chinese consumption lags well behind the US. For 2006, British Petroleum (BP) (2007) reported that the US consumed 20,589 barrels of oil daily whilst China consumed 7,445; only 36% of the US total.

If fuel use in China continues to increase, there is no way, given existing supply, that sufficient oil could be produced to allow people in China to be as mobile as Americans (Brown, 2006). In a number of other developing Asian nations, new wealth is also fuelling demand for private vehicles. Simultaneously, government policies and planning tend to be favouring private motor vehicles (Goldman and Gorham, 2006). Investment is in new roads, rather than in infrastructure for alternative modes, such as public transport, walking and cycling.
5.2.1 The global supply problem

Saudi Arabia has been the world’s largest producer of oil for many years. In 1973, following Western support for Israel during the Yom Kippur war, the Saudis led an oil supply reduction. This instigated a world oil ‘crisis’. During the crisis, the volume of oil shipped to global markets was reduced by a small percentage. Nevertheless, the threat of reduced supply was cause for panic, particularly in the heavily oil-dependent societies in the West (Simmons, 2005). In 1979, there was a further oil supply ‘crisis’ instigated by Iran, which had similar consequences. Oil supply is a potential destabilising geo-political influence of great significance. The propaganda surrounding the incursion of the ‘coalition of the willing’ into Iraq is further testimony to the seriousness of ‘oil politics’ (Kenworthy, 2003).

By the late 1990s, almost all members of the Organization of the Petroleum Exporting Countries (OPEC) had reached peak sustainable output (Simmons, 2005). This is despite continually rising global demand, thanks to growth in the transport sectors of emerging countries, such as China. Historical data show that vehicle ownership has risen with increases in affluence. The implications are considerable, as with the present boom in China, the nation’s automotive fleet is predicted to hit 390 million by 2030 (Dargay et al., 2007).

The bulk of global oil supply comes from a limited number of ageing giant and supergiant middle-eastern fields. Problematically, no new fields of significance have been discovered in the last three decades and it is unlikely producers can sustain, much less increase flows from mature high-output fields (Simmons, 2005). Over time, oil fields lose pressure, requiring injections of water to literally ‘force’ oil reserves out of the
ground. Water mixes with oil and creates gas caps, which in turn need to be separated from the crude. Moreover, mature fields have been drained of the most easily accessible crude, thereby creating problems for further extraction. Newman (2007: p15) summarises the oil field production cycle as follows:

While half of an oil well remains at the peak in its production, the other half of the oil is harder to extract; the reservoir becomes more and more filled with water and requires more and more energy to pump the oil out. Eventually the well is abandoned.

Thus, in spite of rising global transport energy demand, yields from mature fields are unlikely to sufficiently increase to keep oil prices stable. Brown (2006: p21) explains the seriousness of the impeding energy crisis:

Oil has shaped our twenty-first century civilization…When production turns downward, it will be a seismic economic event, creating a world unlike any we have known during our lifetimes. Indeed, when historians write about this period in history, they may well distinguish between before peak oil (BPO) and after peak oil (APO).

Even so, some energy industry analysts continue to question the seriousness and immediacy of the oil crisis and are critical of the likelihood of medium term rises in fuel prices (ABARE, 2006; Motavalli, 2005). In contrast, others argue that the peak in oil production may have already been reached or will soon occur (Fleay, 1995; Kenworthy, 2007; Newman and Kenworthy, 2006). Yet others have argued that the peak will be reached by 2020, followed by decline (Campbell, 2003; Campbell and Laherrère, 1998). The reality of the plateau in production is that oil supply limits appear to be approaching. This is just as reductions in oil consumption are being mandated as part of
the UN’s climate change initiative. Thus, the evidence suggests current levels of production are unsustainable: certainly increased production levels are not viable. Annual reductions in oil use must be planned for.

5.2.2 Transport energy demand in cities: refocused transport policy

Australian and US cities have high per capita transport energy consumption, relative to cities elsewhere and because of their relative wealth need to demonstrate real reductions in transport fuel use. Private vehicles are the least energy efficient mode and unfortunately, Australians and Americans use their cars for a great majority of their travel.

The reason for cities in Australia and America sprawling around the car is government funding of freeways over rail systems. Walking and cycling infrastructure, too, has long been under-funded (Laird, 2001a). There has been significant Federal, State and local investment in roads (see Chapter 2). Also, gasoline tax has not reflected the full costs of motor vehicle transport: costs that include road accidents, maintenance, and pollution from combustion engines and so on. Earlier this decade, Laird and Newman (2001b) calculated that the subsidy to road users amounts to around Au$8b per year.

Despite historical transport priorities, there is evidence that energy concerns are now being recognised at the policy level. For example, a recent Federal Senate report concluded that:
…there are credible concerns that markets will not respond in time to provide a smooth transition to a post peak oil world without government action (Rural and Regional Affairs and Transport References Committee, 2006: p15).

The final report by the Standing Committee on Rural Affairs and Transport (2007) recognised that while supply-side responses, including boosting local production of oil, synthetic fuels and bio-fuels may lessen the impacts of peak oil, demand-side responses offer important long-term solutions. These include ‘smart’ land use and transport planning, which facilitate more sustainable transport behaviour.

5.3 New technologies and transport

Technological change may offer solutions for reducing demand for fossil fuels. The World Conference on Transport Research Society and the Institute for Transport Policy Studies (WCTRS and ITPS, 2004) propose that there are three distinct types of technological innovations that can improve the efficiency of motor vehicles, and hence reduce the demand for fossil fuels. Some innovations may reduce harmful emissions from conventional combustion engines. Alternatively, the energy efficiency of conventional combustion engines may be improved, thereby reducing fuel consumption per unit of distance travelled. Otherwise, conventional internal combustion engines can be replaced with different engine designs, requiring alternative fuels. Alternative drive systems and fuel sources are considered in subsequent discussions.

The US Energy Policy Act 1992 defines an alternative fuel vehicle as one that operates on some form of fuel other than fossil fuel, either wholly or in part (US Department of Energy, 2006a). Alternative fuels include ethanol, natural gas, propane, hydrogen, bio-
diesel, electricity, methanol and p-series fuels (US Department of Energy, 2005a). In Australia, there are both Federal and State incentives for conversion of vehicles from petrol to liquid petroleum gas (LPG) driven. While LPG is still a fossil fuel, popular media suggest that it is a relatively more sustainable fuel source because there are purported to be more domestic reserves.

a. Bio-diesel

Bio-diesel is possibly the most easily created alternative fuel. There is fairly simple technology, for example, which can filter used vegetable oil for use as bio-diesel (Greasecar, 2005; Journey to Forever, undated). There are also a range of crops that can be converted into fuel at relatively low cost. Internationally, popular opinion seems to be that bio fuels may solve any future transport energy crises.

b. Electricity and solar power

Since the advent of cars, electric vehicle technology has challenged conventional drive systems. However, the economic and political power of oil industry and the automobile industry, which can turn a better profit from designing conventional drive systems, has stymied their use. In the late 1980s and early 1990s, General Motors leased a small number of electric powered vehicles. Despite significant public demand, an operating range suitng most commuters and speed potential that was comparable with conventional drive vehicles, the vehicles were eventually withdrawn from public use and destroyed (Who Killed the Electric Car? 2006). While there may be a number of reasons for the ‘death’ of mainstream electric cars, it remains that they were practical
alternatives, cost little to power and were non-polluting (Who Killed the Electric Car? 2006).

Nevertheless, there remain many websites devoted to projects to produce efficient and practical vehicles powered wholly or in part by electricity. The ZENN Motor Company, for example, markets the ZENN model. The acronym stands for ‘Zero Emission, No Noise’ (ZENN Motor Company, undated). Other examples include electric mopeds, which have sufficient capabilities to connect to and haul a small trailer (eGO Vehicles, 2006). These producers, however, operate at the grass-roots level: no major automotive manufacturer is yet to sell full electric alternatives.

In electric vehicles, electricity is stored on an onboard battery, which periodically requires recharging. Electric vehicles require frequent recharging because motor vehicles are high drain machines (US Department of Energy, 2005b). This limits their range. However, emerging battery technologies should ultimately surmount these challenges (Toshiba, 2005) making regional trips possible.

Hybrid vehicles rely both on fossil fuels and electricity for energy. Such vehicles, including Toyota’s Prius, are already on the market and compete with conventional vehicles for speed. More importantly, the hybrids can outdo conventional vehicles for fuel efficiency and produce fewer emissions (Toyota, undated). These vehicles may be considered ‘in fashion’ because they facilitate relatively more sustainable transport, by consuming less energy per unit travelled when compared to conventional cars.
c. **Hydrogen vehicles**

There has been much hype surrounding the potential for hydrogen vehicles to solve pending transport energy problems. In Perth, for example, hydrogen fuel cell buses have been trialled (but not with sufficient success for the authorities to adopt the technology permanently). Hydrogen is non-polluting when used as a source of energy for vehicles. Furthermore, in theory, hydrogen is a renewable energy source. However, the present cost of producing hydrogen (energy input) has been found to exceed the output (Abdoolakhan, 2005; US Department of Energy, 2006b). With present technology, non-renewable energy sources (i.e. fossil fuels) are necessary inputs to produce the hydrogen to power hydrogen engines. The hydrogen output from this process is less than the input energy. It remains to be seen how or if technological advancement can make hydrogen a relatively more sustainable source for transport energy.

### 5.4 A critique of technological change

While technological innovations may seem to offer solutions to ensure future mobility, sustainability extends beyond limiting oil consumption and reducing emissions. Car dependence creates other costs for the environment and society. Other research has found that, amongst other things, high levels of motor vehicle use undermine the liveability of cities, add to social dislocation and are inextricably linked to sprawl (Beatley, 2004; Falconer and Giles-Corti, 2007; Falconer *et al.*, 2007; Newman and Kenworthy, 1999).
Of concern, too, is how the production of some alternative fuels, such as hydrogen, depends on fossil fuels. Even bio-diesel, which can be sourced from vegetable oil, can often only be produced with the input of oil. There remains a dependence on oil to produce the fuel crops and the fertilisers, and the farm machinery runs on fossil fuels. As such, there are real concerns about the energy return on inputs of fossil fuels into bio-diesel and other alternative fuels (Rural and Regional Affairs and Transport References Committee, 2006). However, research by Brown (2006) suggests that some crops, such as sugarcane, may be able to yield more energy output than input, given the right investment.

Nevertheless, there remain broader implications of using crops to produce fuel. Should there become a greater reliance on crops for bio-fuel, as there is expected to be, consumers can expect to pay more for food due to food-fuel competition (Brown, 2006). The greatest impacts of this food-fuel competitiveness are likely to be felt in developing countries, where people generally have lower incomes. Also, as pressures on croplands increase, there will be greater incentives to increase cultivated areas, such as in the Amazon basin and heavily-forested areas of Indonesia and Malaysia. This could have devastating consequences for biodiversity and carbon uptake (Brown, 2006). Furthermore, it has been found that there may be unintended health consequences if ethanol (produced from corn) is relied upon as a principal fuel source. Ethanol-based vehicle emissions, for example, have been linked to increased ozone-related health complications (Jacobson, 2007).

For hybrid vehicles, it is necessary to look at how electricity is produced. Australia, for example, has long relied on coal-fired power stations for electricity generation. These
are heavily polluting. Nuclear may be an alternative power source, but this too has noxious outputs, such as radioactive waste. If, instead, the focus shifts to producing cars that *use conventional fuels more efficiently* rather than on alternative fuels, other problems arise. In Australia, technological improvements to vehicles to increase fuel efficiency have been the major policy thrust over the last 40 years (Kenworthy, 2007). Nevertheless:

...the average fleet fuel consumption of cars Australia-wide in 1963 was 11.4 litres per 100 km and in 1995 it was 11.5 litres per 100 km. Gains in fuel efficiency through better technology have been negated by, for example, power steering, air conditioning, and increased weight (Kenworthy, 2007: p67).

The Australian Bureau of Statistics (2004) reported that the average fleet fuel consumption for 2003 remained at 11.4 litres per 100 kilometres. Efficiency is being offset by add-ons to vehicles and the market uptake of more powerful vehicles (Rural and Regional Affairs and Transport References Committee, 2006). In the US, a similar affect is observable (Ewing *et al.*, 2007). It would therefore make sense for greater controls on vehicle efficiencies to be implemented, including restrictions or taxes on sports utility vehicles (SUVs) and other vehicles with large engine capacities.

Irrespective of any benefits arising from technological change, it must also be recognised that uptake of new technology is a slow process. There is no policy mechanism that requires people, for example, to substitute their conventional vehicle for hybrid cars. The production and uptake of hybrid and other types of ‘fuel efficient’ vehicles has been very slow, despite the technology having been around for a considerable amount of time. Over time, increasing petrol prices may force people to
invest in more fuel-efficient vehicles, including hybrids. Incremental change is therefore likely, whereby more and more people replace their vehicles as petrol prices rise and affordability becomes an increasing issue.

All else being equal, the Australian vehicle fleet is large. It will take many years and a lot of money to replace petrol-driven vehicles with more sustainable alternatives. Even so, there are energy industry analysts who oversell the ability for technological change to address fossil fuel dependence. In their report on Australian Commodities for the quarter ending March, the Australian Bureau of Agricultural and Resource Economics (ABARE) (2006: p92) stated that “on the demand side, technological progress is expected to lead to a continued reduction in oil dependency”.

An unintended consequence of technological change may be that people drive even more because they perceive they can travel further for their dollar. This will only exacerbate the other costs associated with motor vehicle use and offset fuel savings the new technology brings (Kenworthy, undated; Newman and Kenworthy, 1999).

5.4.1 What then is the place for alternative technologies?

Whilst technological change is not the magic bullet, it still has a role to play in redressing unsustainable transport. This is because sprawled cities cannot function without options for private, longer-distance transport. The evidence strongly suggests that the gulf between global oil supply and energy demand will widen over time. As such, there is likely to be increasing demand for alternative fuels that can be produced in a more sustainable way and more efficient engines. This is because people’s transport requirements cannot be met by alternative modes in the short to medium term,
particularly where infrastructure for public transport, walking and cycling is poor and there is significant separation between land uses.

However, technological change does not address many of the negative outcomes associated with private motorised transport. For example, it does not solve issues of social dislocation, urban sprawl and traffic safety. Technological change should therefore be secondary to facilitating a shift from private motorised transport to public transport and active modes. This shift can be made possible through smarter, long-term sustainable land use and transport planning.

5.5 Car pooling and car sharing

Car pooling and car sharing appear to be limited yet useful strategies for reducing motorised traffic. In theory, they are simple, effective ways to cut the number of vehicles on roads and hence reduce fuel consumption.

In Switzerland, car sharing is an organised practice. People can collectively own a vehicle and use it when a personal vehicle trip is necessary. Alternatively, people can ‘hire’ a community vehicle for trips, when required (Beatley, 2004). In this way, the burden of ownership, vehicle storage and maintenance is shared by many households.

In a city such as Perth, where the great majority of trips (particularly work commutes) are made by single occupancy vehicles, there is potential to substantially reduce transport energy consumption, emissions and vehicle trips overall. By sharing vehicles, people can enjoy the benefits of private travel at their own convenience, assuming no-
one else is using the share car, without having to cover the full costs of vehicle ownership. By implication, there is also less reason for people to maximise their annual mileage (and hence energy use) in order to ‘justify’ capital outlay (Brown, 2005).

Recently, a company called Nexus has begun a small car-sharing programme in the City of Fremantle. Even so, sharing schemes would seem to be less workable in sprawled cities. This is because access to the vehicle becomes more difficult when owners live some distance from each other. Moreover, it may be that there is less incentive to engage in a share scheme when private travel remains subsidised: sole ownership remains attractive and gives much more flexibility.

Car pooling may likewise be of limited usefulness. People may be choosing to pool, because of rising fuel prices, but this depends on co-workers living nearby for commutes, or alternatively, neighbours or other family members working near to one another.

As with alternative fuels, other issues associated with private motor vehicle travel are not effectively addressed by pooling and sharing schemes. This is because these schemes do not require land use change. Therefore, many of the problems associated with urban sprawl and car dependence are not addressed. Nevertheless, as part of a broader sustainable transport strategy, car pooling and sharing schemes can play a limited role, if properly funded and coordinated.
5.6 Planning for more sustainable transport

Smarter, more sustainable land use and transport planning has the potential to reduce fossil fuel dependence in the longer term. The evidence is compelling: in Perth, older data showed a correlation between distance from the central business district (CBD) and increased transport energy use, less land-use mix, fewer job opportunities per hectare and much lower development densities (Kenworthy, 1986; Mogridge, 1985; Newman et al., 1985). This corresponded to people being severely dependent on cars, even after income was controlled for (Kenworthy, 1986; Newman et al., 1985). Conversely, the relative concentration of jobs and services in the central city meant that those who lived closer to the CBD made shorter trips and overall, used less transport energy (Kenworthy, 1986). More recent Australian data also show that distance from the CBD significantly influences transport energy use (Chandra, 2006; Newman, 2006).

International research shows a similar set of relationships. After subjecting data to multiple regression analysis, density has been found to be the dominant explanatory variable for the level of transport energy use (Newman and Kenworthy, 2001) and, unsurprisingly, car use (Institute of Traffic Engineers, 1997; Newman et al., 1990; Newman et al., 1997).

Furthermore, Masnavi (2001) found that mixing of land uses increases accessibility and hence the viability of active modes, such as walking and cycling. This leads to decreased energy usage, lower vehicle emissions and the additional benefits that active mode use can bring, such as improved health (Pedestrian Council of Australia, 1999; Ploeger, 2003; Sallis et al., 2004). Together, these findings identify the potential synergies between density and land use mix. Strategically planned compact
developments, which are both highly walkable and linked together by quality public transport, may therefore be good long-term design solution.

Adam and Fleming (2005) argue that TODs, characterised by increased densities, greater mixing of land-uses, improved permeability, higher quality infrastructure for active mode users and a high quality public transport service will become more desirable as fuel becomes scarcer. It would therefore make sense to make the design of such communities a high priority.

Other research has found that affluence is linked to increasing vehicle ownership (Cameron et al., 2004; Ingram and Liu, 1999; Troy, 1992). However, Newman and Kenworthy (2001) identify that rising wealth may lead to increased levels of vehicle ownership, but not necessarily more use. They note that increased disposable income can be and often is diverted to expressions of wealth other than cars and related operating expenses. Thus, smart urban design is likely to be successful at addressing car dependence and high levels of transport energy use even if people remain or become more affluent.

Overall, the potential for smart land use and transport planning to provide for people’s access needs into the future would seem to be high (Kenworthy, 2007). The direct relationship between environmental variables, such as density, travel behaviour and energy consumption does remain contentious. Nevertheless, the benefits of shortening distances between people and destinations, and improving public transport, walking and cycling infrastructure cannot be overstated. These kinds of facilitative planning can
ensure people can conduct their life’s work even if fuel becomes prohibitively expensive. From a social equity perspective, the merits of this are compelling.

Whilst people cannot be forced to give up their cars – people can choose to drive rather than use other modes, even if they are readily available (Handy et al., 2005b) – there are strategies to complement smart design, to reduce unnecessary car use. This makes sense given transport sustainability depends on more than just limiting the use of fossil fuels. These include targeted behavioural change strategies - such as TravelSmart in Perth and GoSmarter in Christchurch, New Zealand – which have been implemented with some success (Ashton-Graham et al., 2005; Environment Canterbury, 2004; James and Brög, 2003). These and other approaches are discussed further in Chapter 7.

5.7 Summary

This chapter identified how car dependent communities rely on oil for transport energy. Given a high level of dependency on oil in the transport sector, in the US, Australia and elsewhere, oil production and supply have become big business. It is therefore unsurprising that shifts in demand and supply have global implications.

International research strongly suggests that twilight has been reached in the global era of cheap oil supply. This is due to a number of factors, including geo-politics and a lack of recent, significant oil discoveries. Most importantly, however, it is due to dwindling supplies of easily accessible and cheaply extractable oil in existing, tapped deposits in Saudi Arabia and elsewhere. These realities are increasingly affecting prices at the pump.
The role of new technology was discussed. It was argued that alternative technologies offer limited solutions to consumption of non-renewable energy and the negative outcomes of motorised transport. Whilst new fuel sources and increased efficiency standards can mitigate oil dependency, technological change cannot deal with issues such as traffic safety and social inequity. Similarly, car sharing and pooling may lessen energy consumption and cut the number of vehicles on our roads, but are not stand-alone sustainable transport solutions.

These points are drawn together with the argument that smarter, more sustainable urban planning must be placed firmly on the municipal agenda. Technological change and car pooling and sharing schemes need to be secondary to more sustainable, long-term land use and transport policy. It would make sense for statutory planning mechanisms to enable more compact urban growth. The LN planning suite may be one mechanism to achieve this. Furthermore, transport policy must give much greater priority to alternative modes, to reduce dependence on private motor vehicles and make public transport and active transport much more appealing mode choices. The following chapter develops this last point further. Also, by partnering revised planning strategies with other policy, such as targeted behavioural change, unnecessary car trips can be reduced. Reducing dependence on fossil fuels should therefore form part of a smart planning agenda that seeks to reduce car use overall.
CHAPTER 6:

Putting the Brakes on

Alternative mode networks

Good public transport can promote the accessibility of a location from the rest of the city, so promoting employment; and make living in a location more attractive because of the accessibility it provides to the rest of the city. State of the art public infrastructure can be a symbol of commitment to an area, as well as providing a futuristic image (HiTrans International Steering Group, 2005: p124).
6.1 Introduction

This chapter considers why quality public transport and active mode infrastructure are vitally important for cities and how they can be developed to a high standard. A range of transport-linked sustainability concerns have already been identified (i.e. social justice and public health issues, and oil dependence). The cause of many of these concerns is high levels of car use (measurable by VKT per capita and modal split). Whilst some car travel is preferential, a lot also stems from people’s dependence on cars to conduct their life’s work. It follows that an integral part of improving the sustainability of transport behaviour is providing viable mode alternatives for both long and short trips.

Public transport can be a substitute for car travel for longer trips if services are properly packaged. In the discussion of how to build a high quality and efficient public transport system, it is highlighted how public transport offers significant leverage over private motor vehicle travel and why a network strategy is essential for success. International research is used to demonstrate the importance of micro-scale design characteristics through to regional infrastructure and service integration. Subsequently, it is discussed why focused urban planning is essential to make public transport systems viable.

Walking and cycling are the alternatives for shorter car trips. To make these viable mode choices, there are requirements similar to those for public transport. Micro-scale environmental characteristics must be well-managed, through to infrastructure being integrated at the regional level. Also, land use must be supportive.
This chapter identifies a clear interface between public and active transport. At the core of LN and New Urbanism is the intention for people to be able to conduct much more of their life’s work locally, by walking and cycling. But when people need to travel outside their neighbourhoods, they need to be within walkable distance of efficient, high quality public transport.

### 6.2. Building the public transport network

Quality public transport is of vital importance to the modern city. It is a mass mover and allows people to travel distances not otherwise possible by walking or cycling. For longer trips, it is the alternative to the private vehicle. Furthermore, it is a mode that operates in tandem with active transport. That is, people can walk and or cycle to and from public transport stops.

There are many benefits to society and the environment from the development of good public transport networks, provided people are encouraged to use the system. Relative to private vehicles, public transport is less of a space-waster, less polluting, uses less fuel, facilitates more social interaction and adds to urban vibrancy (HiTrans International Steering Group, 2005). Also, public transport services provide means for people who cannot afford private vehicles to make longer distance trips.

Alongside social and environmental reasons, there are strong economic reasons for investment in a quality public transport network. International evidence indicates that cities with good public transport infrastructure spend less money on transport overall as
a percentage of gross domestic product (GDP). Unsurprisingly, the best systems tend to be in more compact urban areas (Newman et al., 2001).

In contrast, sprawled cities tend to spend more on providing and maintaining transport infrastructure, and are harder to service with public transport. In these cities it is difficult to entice people onto public transport services, as the services cannot compete with the speed and door-to-door convenience of the car. Does it follow, however, that planners in these cities should not bother to address public transport deficiencies? The answer is no. Development of a quality public transport network is an integral part of the sustainable transport agenda and is achievable.

6.2.1 Transit leverage

One of the most compelling reasons for developing public transport is the leverage it offers over motor vehicle travel. International data show that one kilometre of public transport travel can substitute for between 3.5 and 12 kilometres of car travel, depending on the physical characteristics of cities (Kenworthy, 2007; Neff, 1996; Newman and Kenworthy, 1992). Public transport users travel shorter distances, even if they travel for a similar amount of time as car drivers, given differences in speed (Neff, 1996). This reduced travel distance corresponds to both less energy use and pollution.

Public transport leverage may be explained in a number of ways. When quality public lines are developed, especially rail services, great development opportunities are presented around stations. By locating close to stations, businesses are provided with good potential patronage. By living near to stations, people also have good access to longer distance travel opportunities. When such Transit-Oriented Developments
(TODs) occur and there are relatively high activity intensities near to stations, people also have more opportunities to trip blend. Public transport trips can therefore serve more than one purpose (people may be able to shop near to where they work).

Newman and Kenworthy (1999) suggest that enhanced public transport services can also encourage households to sell one or more of their vehicles as they become more aware of the access potential provided by quality public transport. This further limits motor vehicle trips, as family members need to negotiate to use the remaining vehicle(s).

### 6.2.2 Treating public transport as an essential public good

Public transport can be treated as an important public service (and hence be regulated) or left to market forces (be deregulated) (van der Velde, 1999). Full deregulation leads to governments losing the ability to coordinate services. There are examples of how leaving public transport provision to the market has had profound negative impacts on cities, particularly the disadvantaged populations within those cities (HiTrans International Steering Group, 2005). Los Angeles and a number of UK cities have been affected in this way.

Regulation aside, there is no simple formula for developing a viable, high quality public transport system. It is not only a question of identifying the most efficient and cost-effective solutions. Instead, discussion will show that there are many complex and interacting factors that contribute to the success or failure of a network.
6.2.3 Radial and orbital components of the network

The centre of the city is a point of gravity for flows of people, goods and information, and public transport (Monheim, 2003; Naess, 2005). As such, many public transport networks are hub and spoke designs, whereby radial lines emanate from a central exchange (or set of closely organised exchanges). Between six and 12 departures per hour along major corridors is an appropriate range of service from central exchanges (Nielsen et al., 2005). Higher frequency services can be provided for routes where patronage (demand) is higher.

Capacity should also be demand responsive. For example, the most frequent, high-capacity services must operate along main corridors during peak hours (Nielsen et al., 2005). In contrast, services do not need to operate quite as frequently very early in the morning or late at night. Ultimately, a balance needs to be found between the cost of providing the services relative to passenger numbers and achieving an efficient and reliable level of service.

Orbital lines can be important additions to the public transport network. They can be used to link significant outlying centres. In Perth, for example, the ‘circle’ route links the city’s five universities. Furthermore, the route intersects train stations, including Oats Street and Fremantle; hospitals, including Sir Charles Gairdner and major shopping precincts, including central Fremantle (Figure 6.1).
The linking of centres by public transport is a sensible design approach, as people need destinations to travel to, just as there needs to be sufficient potential patronage along public transport lines (Pushkarev and Zupan, 1977). While this has been achieved in Perth by provision of the popular circle route and radial train lines, the sprawled nature of the city makes further public transport provision less economically feasible.
6.3 Packaging public transport

Most cities have public transport services. Where these services are deficient, the task is to overhaul what is already in place. This requires considering the whole public transport package. As such, improvements (where necessary) should be made to service frequencies, service and route connectedness and quality of services (Howes and Rye, 2005).

From 1998 to 2006, in Christchurch, New Zealand, bus patronage has increased by about 90% following the implementation of a carefully packaged public transport strategy (Atkinson et al., 2007). During this period, a new central bus exchange was built, which features dynamic stop allocation and real-time service information. The exchange now facilitates 19,000 people movements and 2,300 bus movements per day, which are significant for a small city (Atkinson et al., 2007). The rolling stock now operates within a simple, one-zone network, which simplifies billing via the ‘smartcard’ fare system. Other cost-of-travel incentives are built into the pricing mechanism to ensure loyalty to public transport is rewarded. This demonstrates that shorter-term strategies can be very useful whilst longer-term goals, such as strategic activity intensification are worked towards.

6.3.1 Service provision: bus or rail

Cities have various options when establishing or upgrading a public transport system. Service options include buses, trams, subways and rail lines of varying carrying capacities. Perth has a substantial network of bus routes and a small but expanding rail system. Laird and Newman (2001a) and Newman (2005) compare the per-hour
carrying capacities of a metro rail line (50,000 persons), light rail (25,000), a bus lane (7,000) and a freeway lane (2,500). For transportation potential, rail far exceeds the capabilities of other modes. This is very important for large cities. A key decision public authorities need to make is whether to develop bus or rail services, or a combination of both. The pros and cons of each of the three options will be discussed in turn.

Bus networks are more flexible than rail. The rolling stock does not run on track and therefore routing can be responsive to demand. However, buses have far less carrying capacity than rail. As such, bus services are most suitable in low-density areas, at least as a stop-gap measure while urban consolidation takes place (HiTrans International Steering Group, 2005) and as feeder services for rail.

Rail is more costly to provide than buses. This is because extensive infrastructure must be constructed. However, one lane of freeway costs about as much as the provision of one track for rail whilst having a fraction of the carrying capacity (Bachels and Newman, 2001). Areas of high activity intensity need to be located along rail routes to justify investment and provide good patronage (Gilbert and O’Brien, 2005). Significantly, rail can provide good opportunities for TODs, as carrying capacities are so high, thereby reflecting that public transport can be developed alongside consolidation measures, rather than having to follow them (HiTrans International Steering Group, 2005; Kenworthy and Laube, 2005). Rail investment can be a tool to both service existing, higher intensity areas and stimulate future development.
Some key advantages of rail are that it generates less air pollution, operates exclusively on a dedicated right-of-way (and therefore does not need to contend with other vehicles for road-space, as buses do), and is direct, fast and comfortable (Newman et al., 1992). Moreover, rail uses less energy than buses and substantially less than cars (Kenworthy, 2007). Rail also has the potential to challenge the speed of the car, particularly if roads are congested (Kenworthy, 2007; Newman and Kenworthy, 1999). In contrast, speed competitiveness is not often associated with buses, relative to either cars or rail, particularly if there are frequent stops along the bus-route and they are competing with cars for road-space (Kenworthy and Laube, 1999).

Californian research has found that people living in the vicinity of rail stations conduct a lower proportion of travel by cars compared to those who do not (Chatman, 2006). The association between proximity to a station and a lower automobile modal split was weaker in outlying areas, particularly where infrastructure was supportive of car travel (Chatman, 2006). This shows that rail services can be an attractive alternative to private motor vehicles but that development of services needs to be carefully coordinated with land use.

All things considered, a combination of bus and rail services would make most sense for a medium or larger sized city. High-speed rail services that link outlying centres with the central city could be augmented by a combination of radial, orbital and feeder bus routes. The rail services are the mass movement system, while the bus services facilitate linkage trips, orbital movements (where rail is not viable) and transport along lower density corridors. Combining services requires effective ‘pulse’ timetabling.
These arrangements are increasingly being seen in Perth, with the development of the southern rail line and the success of the orbital ‘circle’ bus route.

Even with the benefits that public transport can provide, it is difficult for transit services to challenge the relative convenience and other benefits afforded by the private vehicle (see Howes and Rye, 2005). These constitute significant, but not insurmountable, barriers to decreasing both the real number and modal split of trips made by car.

**6.3.2 Service coverage and reliability**

Ideally, network coverage must be such that residents of the metropolitan area can access services within a reasonable walk of their place of residence (see 6.3.3). People should also be able to travel to the core of the city without the need for a transfer. Intuitively, this becomes less feasible the more sprawled a city is. Properly planned orbital and feeder services can be a useful compromise, however, thereby presenting residents with added incentive to make mode substitutions.

Providing a good timetable of services is one thing. Service frequency tends to reflect potential patronage: sprawled areas have less frequent services because of lower patronage along routes. The reliability of services is something else. Services need to arrive at stops when they are scheduled to do so, to be attractive to potential users (Newman and Kenworthy, 1999). To assist reliability, timetables and routing information needs to be easily accessible and interpreted.

All else being equal, there are likely to be increasing problems meeting reliability targets in cities that rely on bus-based public transport (including Perth). The principal
reason is congestion. Cameron’s (2004) projections for increases in vehicle ownership and VKT between now and 2020 suggest more competition between rolling stock and private motor vehicles for road-space. This suggests that service reliability may increasingly suffer, particularly in heavily-trafficked areas where there are no dedicated bus lanes, and during peak hours. In Christchurch, for example, despite successes associated with the integrated public transport strategy that have been realised over the last eight or nine years, only 75% of trips are completed within five minutes of the scheduled time. The target set by the regional council was 95% (Atkinson et al., 2007). With congestion forecast to increase by 160% over the next 15 years, service reliability is likely to suffer further (Atkinson et al., 2007).

6.3.3 The pedestrian and cycle shed

A pedestrian shed is a measure of acceptable distance between people’s homes and public transport stops. A 400 or 450-metre pedestrian shed (ped-shed) is often applied to bus stops and an 800-metre ped-shed to railway stations (Smith and Taylor, 1994). The first is about a 5-minute walk and the second a 10-minute walk (Nielsen et al., 2005). The difference in ‘acceptable’ distance may be attributable to the relative speed by which rail can move people to desired destinations, compared to buses, given trains operate on dedicated lines and make fewer stops. Together, the trip to the stop and the ride on public transport can be balanced against a person’s travel time budget (see Marchetti, 1994).

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27 This effect may be mitigated by the new rail investment in Perth and should actually be to the relative advantage of rail commuters.
The delineation of acceptable distance is important as willingness to walk to services diminishes the further people live away from them (Cervero, 1994). This point notwithstanding, the characteristics of the terrain between home and the stop can also have an effect on people’s willingness to walk. If the terrain is hilly, people will likely be less inclined to walk as far. The ‘shed’ should therefore be considered a useful standard measure.

A 10 minute ped-shed, or public transport ‘catchment’ may be anywhere from 220 to 550 hectares, considering people typically walk at speeds ranging from five to eight kilometres per hour. For example, the elderly, disabled and children tend to walk more slowly than the middle-aged and healthy. A 300-hectare area of urban land with a density of 35 persons per hectare (a suggested minimum density for quality public transport to be viable) would be home to more than 10,000 persons, all of who are potential service users (Kenworthy, 2007; Newman and Kenworthy, 2006).

Cycle sheds are not often discussed in the literature. However, some US research suggests that two or three miles (3.2-4.8 kilometres) is a reasonable range for cycle travel to stops (Meyer and Dumbaugh, 2004). Good cycle access does require, too, that there are facilities provided for cyclists wishing to connect with public transport. These include cycle lockers at stops and stations, and provision for cycles to be taken aboard rolling stock.

Sheds can be applied as either a straight-line or network measure. The two applications can yield startlingly different results, depending on the permeability of the street network. In effect, a highly connected street layout substantially increases the
catchment of public transport and hence increases the viability of the service (Laube, 1999). Permeable street networks are crucial for pedestrians and cyclists, whether their aim is to catch a public transport service or to access other local services and facilities.

Pedestrian and cycle sheds are of great importance to the TSH study as increased local access is an intended, integral part of LN. Access to public transport is part of broader analysis to help determine residents’ opportunities to access key destinations.

6.3.4 Service integration

Public transport services must be integrated (Mees, 2000). People need to be able to reach key destinations throughout their city as directly as possible with a minimum of transfers. This is not always easy to achieve, particularly if operating costs cannot sufficiently be offset by fare revenue. In some circumstances, transfers will be required. These include between feeder and main-line services. Local bus services, for example can be coordinated with rail to provide journeys that are as seamless as possible. Pulse timetabling is the best way to achieve this. With pulse timetabling, the departure of one service is scheduled to shortly follow the arrival of another at an exchange point. Given main-line services can operate more frequently than suburban services (due to more patronage), coordination of services is more easily achieved for people travelling into, rather than out of the core.

To further reduce friction, the design of more significant stops (such as train stations) should reflect that different modes could be used to make the linkage trips. For those people who walk or cycle to stops, local infrastructure needs to be facilitative. This means provision of cycle racks or lockers and well-designed cycleways and walkways.
While it is inevitable that some people will drive to pickup points, a limit must be placed on park and ride facilities. Park and ride can reduce development possibilities, as it takes away good land around stops (Kenworthy and Laube, 2005), can detract from the quality of the walking and cycling environment, and inhibit access by feeder bus services. Nevertheless, in sprawled cities, many users of train services can be expected to drive to stations, given the difficulties of providing bus services in low density areas (Figure 6.2).

Ticketing must also be integrated to reduce the friction of transfers (Nielsen et al., 2005). TransPerth’s fare system is such that a ticket purchased for one service could then be used for a free transfer (within a two hour period) on another. This transfer was valid on trains, buses or ferries. Until mid 2007, multi-rider, pre-purchased tickets could be used in the same way. A smartcard has since replaced the multi-rider system but can be used in much the same way; passengers can board trains, buses or ferries with the same card, which has preloaded travel credit and can make one free transfer within the two-hour limit.

### 6.3.5 Service quality

Rolling stock must be of a high standard. This begins with providing vehicles with vibrant and character-giving livery, and restricting advertising. The interior of vehicles should likewise be vibrant and designed to enable ease of access and seating for the elderly, disabled and parents with prams. The Swedish Arlanda Express, for example, which links Arlanda airport with Stockholm, has distinctive teal and yellow livery (Figure 6.3). Also, there is added flexibility if space can be provided for people to bring groceries and other baggage on board with them.
Figure 6.2 – Murdoch park and ride (approximately 12 km south of Perth city) on a weekday

(Source: Author)

Figure 6.3 – Arlanda Express: distinctive livery adds to the character of the public transport service

(Source: Author)
Sound maintenance of vehicles is a further requirement. Litter cannot be left to accumulate in vehicles. Damage (including vandalism) needs to be dealt with promptly. Many TransPerth vehicles have etch-marks on the windows. Restoration of these fittings is costly, so TransPerth is looking to deal with the problem through prevention rather than remediation. Transit guards ride along on many train services, while onboard cameras (on buses too) deter recalcitrant behaviour. These measures also add to the sense of safety for passengers.

6.3.6 Micro-scale design features

Quality begins at the micro-scale. Public transport services must appear attractive, as well as operate reliably, conveniently and swiftly. Infrastructure including shelters, signage, benches, landscaping and thoughtful design of tracks and overhead wires (where needed) all contribute to attractiveness.

At stops, access features are important. These include the provision of ramps for the elderly, people with bags and prams, and the mobility impaired. Wherever possible, shelters should be provided along with real-time countdown clocks, seating, textured paving and sound signals to aid the blind, local landscaping and a minimum of advertising so as not to detract from the service livery (Burns, 2005).

Along bus routes, vehicles should be able to enter and exit traffic streams with a minimum of delay. On-road stops can assist with this, leaving vehicles free to re-enter traffic flows, rather than waiting for motor vehicles to let them back in (Figure 6.4). The addition of bus only lanes in more heavily trafficked areas ensures a more efficient service. The HiTrans (2005) series of five booklets discussing best practice in the
design and operation of public transport services is a useful tool for looking more comprehensively at quality micro-scale design.

### 6.3.7 Systems longevity

Robustness needs to be built into the public transport network to ensure a long operating life. This includes the need for ongoing funding for maintenance and expansion of services, when and where necessary (Nielsen et al., 2005). Robustness is a further signpost to the land use and transport planning symbiosis. When public transport systems are defined, they need to be sympathetic to long-term land development strategies (with those strategies, of course, being sustainability-focused). It is essential that services are not only carefully planned, taking into account the other components of good design discussed in this section, but also that they are developed alongside new commerce and housing, for example, as part of TODs (see Chapter 7).

![Figure 6.4 – An on-road bus stop in Perth](image)

(Source: Author)
6.3.8 Marketing

Good marketing is an essential part of the public transport package. Public transport must be sold to travellers; use of services and facilities does not automatically follow provision, especially in cities (including Perth) where car culture exists (Atkinson et al., 2007). People need to know how to get from origin to destination and back again; some people even need to be made aware that services are there at all. Good marketing involves disseminating information as widely as possible about the services on offer. People need to know, amongst other things, where stops are, what routes services follow, timetable information and how to contact service providers for additional information.

In addition, marketing must alleviate some of the concerns people have regarding the quality, safety and reliability of services. People want to know they are safe and comfortable when they travel and they can reach destinations with minimum delay. At the micro-scale, signboards can give people up-to-date information, provided they are well maintained. Shelters and other essential structures can be used as anchor-points for the material. Even real-time journey boards, which chart the progress of relevant services, are essentially marketing tools. It may be that enticing people to try the service leads to them becoming regular users, if their experiences are comparable to or exceed their expectations. If public transport is appropriately packaged, such positive experiences can result.

In Perth there is some good marketing of public transport. A wide array of information regarding services is easily accessible from TransPerth’s website. This information includes a journey planner facility and maps. Onboard vehicles, there are usually
service brochures available. At major stops there also tends to be signboard material. The central exchange (the Esplanade Busport) has an information centre and many signboards to direct the traveller. In suburban locations, there are a number of outlets that sell travel credit and have additional service information. Train stations, particularly those along the new southern rail route have numerous facilities to help travellers and are monitored by security personnel. However, many suburban bus stops are little more than a bench and a post.

6.3.9 Fuel systems for public transport

Chapter 5 discussed how new technology can play a limited role in improving the sustainability of the transport task. Public transport fuel systems can be made more sustainable, by finding energy sources other than fossil fuels. Upgrading urban public transport services to run on these alternative fuel technologies can serve as an example of how governments are beginning to take transport sustainability more seriously. For rail, electrification is a more sustainable option than the provision of diesel-powered services. In theory, the electricity required by the service can be generated through sustainable means, such as wind power. Not only does the rolling stock produce low levels of pollution but also the process of producing electricity can become much less polluting.

Australia, however, currently relies heavily on coal-fired power plants for energy. Nevertheless, electrified services can have the longevity to ensure that when power is generated in a more sustainable way, the infrastructure and services are there to take advantage. In Perth, this type of longer-term planning has been reflected in the development of the city’s rail lines.
6.4 Regional planning

Regional coordination is important to achieve an efficient, high quality public transport network (Howes and Rye, 2005). Identifying where routes should run and where to place stops is a considerable task. The right level of service is dependent upon settlement size, activity intensity and potential patronage.

Settlement size and the distribution of population, jobs and services within the settlement are key factors affecting how viable public transport can be and how many different services and facilities should be provided (Stead et al., 2001; Williams, 1999). It is often unfeasible to provide public transport services in small towns, as patronage is low and operating costs are not sufficiently offset (see Landry, 2004). However, service provision can still be a problem in cities where there is sprawl, compared with where the urban area is more consolidated (Bertaud and Richardson, 2004). Density and land-use mix (activity intensity) are as crucial for the viability of public transport as settlement size (municipal population) (Kenworthy, 1986; McIndoe et al., 2005).

Research has found that provision of a mix of activities at high densities close to public transport stations has a big influence on ridership (Bernick and Cervero, 1997; Cervero, 2002; Newman and Kenworthy, 1999; Pickrell, 1998). Accordingly, there need to be strong anchor-points for public transport services outside of the central city (Newman et al., 1995). TODs are one design solution to meet the critical mass required for quality public transport (light and heavy rail) and these are increasingly popular in the US and Australia. These are discussed further in the next chapter.
A settlement density of between 20 and 30 persons per hectare is argued to be the threshold under which cities become car dependent (Newman, 1994). A city must have a settlement density around potential stops within, or greater than this range, for public transport to be viable. Later research found that an urban activity threshold (residents and jobs per hectare) of 35 is necessary to appreciably reduce car dependence (Newman and Kenworthy, 2006) and make light rail systems viable (Newman, 2005). Holtzclaw (1994) argues that a threshold of 50 persons per hectare is necessary for heavier metro rail. Consequently, in areas that badly need upgraded public transport services but have low densities, there are obvious problems:

…while you can introduce higher densities in micro-environments, especially if you implement draconian changes in zoning ordinances, making region-wide density changes is like trying to turn an aircraft carrier around… (Bertaud and Richardson, 2004: p309).

It is therefore no small task to plan for quality public transport, particularly in cities characterised by sprawl and car dependence. Effective planning requires incremental change, in both land use and transport networking. In short, a committed long-term policy focus is required to integrate public transport with urban form.

It is intended that LN will facilitate development of new neighbourhoods with strong centres, with public transport stops as key anchor-points. New neighbourhoods are to be organised around town centres with relatively high activity intensity. In theory, neighbourhoods should provide sufficient patronage for a bus service and groups of neighbourhoods should provide sufficient patronage for a light rail stop (Western Australian Planning Commission, 2004).
6.5 Bringing the strands together to create a manifesto for longer trips

Nielsen et al. (2005) pull all strands together in their summary of what contributes to good practice in the supply of public transport. Components include:

- Provision of an integrated, high-quality, master-planned regional system. This includes identifying vulnerable populations and catering to their needs as a bottom line and providing a combination of bus and rail that is suitable for the context.
- Continued commitment to funding, which ensures not only that services are brought up to standard, but that the various aspects of the system can be maintained and enhanced, when and where necessary.
- Policy support for public transport, which includes supportive land use practices (i.e. TODs), selective car restraint and measures to improve networks for pedestrians and cyclists.
- Achieving a high standard of network quality and safety.
- Implementing a pragmatic combination of soft (i.e. integrated fare schemes) and hard (i.e. engineering) measures.

The preceding discussion of the various components of quality public transport systems has shown that Perth has got some things right. A full overhaul of the system is not required. However, the situation is far from ideal; land use patterns and car dependence pose considerable problems. One of the more significant of these is there is not sufficient land in built up areas designated for future public transport development. The construction of the city to Mandurah southern rail corridor was possible because the
State government owned the land on which it was built. There are, however, few other corridors in the city where a new line could be built without significant redevelopment.

Overall, public transport must be carefully packaged. It must not be planned in an ad hoc way. It must be able to successfully compete with private vehicles: “…If motorists are to choose public transport it must, of course, be attractive, efficient and well-run…” (Newman et al., 1997: p43).

Public transport is a crucial element of urban growth because it is the substitute for cars for longer journeys. It is also important to remember that there is interdependency between public and active transport (Barnes, 2005). People often walk or cycle to stops and again when they disembark from the service. From a sustainability perspective, people should be encouraged to do this, rather than driving to and from services. Therefore, alongside planning for public transport, active transport should be properly planned for.

6.6 Active transport systems

When people walk or cycle they are being physically active. This can provide great health benefits (Mason, 2000 - see Chapter 4). These modes, too, cost little or nothing. Wooldridge (2005) calculated that cycling, for example, is between 13 and 20 times cheaper to running a car, although costs depend on the type of vehicle a person owns and how much upkeep is required (see Chapter 2 – opportunity costs). Additionally, active modes are non-polluting and require very little energy input (Beatley, 2004). Consequently, the cost of active mode use to society, compared with private vehicle
use, is minimal. Walking and cycling are the most egalitarian and sustainable of modes (Kenworthy, 2006; Premier’s Physical Activity Taskforce, 2006).

All able-bodied persons walk. Trip chains typically begin and end with walking (see Brög and Erl, 2003). For example, if a person drives to work, they still walk to and from where they park their car. All things considered, it makes good sense to design urban areas to better facilitate walking as well as cycling. Consequently, more importance is now being placed on designing places in the interests of pedestrians and cyclists. The UK’s Manual for Streets (Department for Transport, 2007) recommends applying a user hierarchy to developments, with pedestrians being the most prioritised, cyclists second, public transport users third, specialist service vehicles next (including ambulances) and motor vehicle users last.

The existing research does not provide clear guidance as to the combination of design factors that best facilitate active transport (Sallis et al., 2004). Nevertheless, a range of variables is related to active transport and these are discussed below. All else equal, there is a need for active mode networks to be integrated and comprehensive (Crane and Schweitzer, 2003). It is essential that routes and infrastructure not be planned in an ad hoc way. Different parts of the city must be properly linked together. This imperative is reflected in the vision for Western Australia to be, by 2020, “a vibrant, safe, accessible place with a high-quality walking environment where all Western Australians want to walk” (Premier’s Physical Activity Taskforce, 2006: p7).

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28 In Chapter 7, the LN code is unpacked to see whether these variables, such as increasing activity intensity, are anticipated to be characteristic of new developments.
A similar vision is necessary for cycling. Moreover, for the alternative mode network to work properly there must be a good interface between active mode infrastructure and public transport.

In the vision for Perth, there are targets for a 10% increase in both the number of walking trips for distances less than two kilometres and the average number of walking trips, per person, per year. In addition, increases in access are to be measured by gauging walking distance to local services and facilities (Premier’s Physical Activity Taskforce, 2006). So how then, in a sprawled city, can walking and cycling (particularly for transport) be encouraged?

### 6.6.1 Activity intensity

Population density has been found to have a positive association with frequency of walking trips (Cervero and Radisch, 1996; Ross and Dunning, 1997). Chatman (2006) found that high retail and service density in proximity to people’s place of work is positively correlated with a higher share of non-automobile commutes. Likewise, he found high retail and service density near to people’s place of residence positively correlated with a higher share of non-work trips by alternative modes, including walking and cycling.

Combining increases in density (both urban and residential density) with mixing of land uses (increasing activity intensity) can provide cyclists and pedestrians with more opportunities for travel within a reasonable trip distance (Cervero, 1996; Frank, 2000a; Frank and Pivo, 1994; Hanson and Schwab, 1987; Kenworthy, 1986; Masnavi, 2001; Neels et al., 1977; Powell et al., 2003). That is, in activity intense environments,
pedestrians and cyclists are provided with greater access potential (Brownson et al., 2000). This is crucial, as active modes quickly become unattractive as distance increases\(^{29}\) (Forward, 2003; Naess, 2005; Naess and Sandberg, 1996). For trips to the grocers, for example, acceptable walking distance has been found to be 1,445 feet (440 metres) (Moudon et al., 2006).

The draft Western Australian Walking Strategy (Premier’s Physical Activity Taskforce, 2006) recognises that access is a vital component of an environment supportive of walking. In Perth, access is a significant issue given sprawl. Locating residences above commerce, for example, as part of an urban retrofit, can successfully increase access potential. In Perth and elsewhere, there are increasing calls for revisions to ordinances (such as allowing for housing above commerce) that will enable pedestrian-friendly (and cycle-friendly) development (Hirschorn, 2004).

### 6.6.2 Permeability

High permeability\(^ {30}\) is often argued to be an important characteristic of a pedestrian and cycle-friendly network. It can help make walking and cycling competitive with the car, speed-wise for short trips (see Ploeger, 2003).

Highly connected street patterns, such as traditional grid designs, are ideal for active transport, as they make neighbourhoods more permeable (McIndoe, 2005; National Heart Foundation of Australia, 2004; Pickrell, 1998). Chatman (2006) found that walking, at least for non-work trips, is strongly correlated with permeability. Put

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\(^{29}\) The concepts of the pedshed and cycleshed were discussed in Section 6.3.3.

\(^{30}\) To recapitulate, permeability is the ratio of network distance to straight-line distance. A ratio as close to 1:1 as possible provides best permeability.
simply, people have more incentive to walk or cycle when there are direct routes between origins and destinations. In contrast, curvilinear streets and culs-de-sac decrease permeability and hence decrease the attractiveness of using active modes. This concept of permeability was discussed in Chapter 2 (see Figures 2.3 and 2.4).

At the broader scale, both pedestrian and cycle ways need to be integrated to ensure good permeability (Wittink, 2003). This ensures that active mode users have access to a range of routes and destinations. When there are good linkages, people will be better disposed to walk or cycle more often and for longer distances. Figure 6.5 shows how networks open up much more of the city to active mode users than poorly coordinated infrastructure. The red points on the periphery represent suburban centres, the green blocks public open space and the large circle in the middle the downtown area. The network approach shows a comprehensive system linking all significant points in the town. The ad hoc approach depicts a poorly coordinated series of linkages: an outcome that may occur when planning is too fragmented and there is no strategic-level coordination.

![Network approach in town X](image1)
![Uncoordinated approach in town X](image2)

**Figure 6.5 – Network differences in a fictional setting**

(Source: Author)
Figure 6.6, Google images taken from similar altitudes, applies this principle to two case-study areas in Perth. It compares a traditionally-designed street network (Crawley, near central Perth) where there are footpaths along every street with the conventionally-designed suburb of Kardinya. In Kardinya, many local streets lack footpaths and are therefore poor environments for pedestrians. In both images, streets with footpaths on one side are marked purple and those with two are marked yellow. Streets without footpaths are not marked. Figures 6.5 and 6.6 demonstrate how inter-neighbourhood transport planning is as important as intra-neighbourhood planning. This is a point that will be revisited when the LN policy is unpacked (Chapter 7).
Figure 6.6 – Footpath networks vary depending on the setting

(Source: Adapted from Google Earth imagery tool, 31/08/2007)


6.6.3 Micro-scale design features

Local-level design is a crucial part of network development (Beatley, 2004; Jacobs, 1961). Walking is done locally and as such, it is essential that quality infrastructure be provided (Frank and Engelke, 2001; Frank et al., 2003; Jones, 2001; Pikora et al., 2003; Swinburn et al., 1999). Poor quality infrastructure can limit active travel to essential trips (Transportation Research Board, 2005).

Some researchers argue that introducing busyness into the streetscape is essential for encouraging more walking and cycling (Beatley, 2004; Gharai, 1998). In this instance, ‘busyness’ does not mean congestion, but rather visual variety, good provision of amenities such as shelters and benches, widespread greenery, good lighting, and clearly marked cycleways and footpaths. Roberts-James (2003) argues that quality networks with such characteristics can add much to the vibrancy and liveability of cities. UK policy argues that “the propensity to walk is influenced not only by distance, but also by the quality of the walking experience” (Department for Transport, 2007: p63).

Whilst the exact mix of local qualities that best facilitates active mode use is not yet clear (Handy et al., 2006), research has found associations between various separate design features, and walking and cycling. For example, a positive correlation was found between walking and subjective appraisals of community pleasantness (Calthorpe, 1993; Hill and Peters, 1998; Owen et al., 2004).

All else equal, people walk may more in neighbourhoods that are well maintained and offer good aesthetic variety (Handy and Mokhtarian, 2005). Similarly, research has found that people who live in neighbourhoods with a high level of visual amenity, such
as widespread greenery are much more likely to be physically active, including walking and cycling more than those who live in areas characterised by high levels of incivilities, including graffiti and dog faeces (Ellaway et al., 2005). Australian studies have found that if an environment is attractive, it increases the likelihood that people will walk on a regular basis (Ball et al., 2001; Giles-Corti and Donovan, 2002). In contrast, however, research by Cervero and Duncan (2003) found no strong association between the quality of the built environment and the choice of people to walk.

Despite some contrasting findings, it appears that more thoughtfully designed local environments, characterised by relatively high levels of visual amenity do encourage more walking and cycling. Nevertheless, more research is needed to differentiate the influence of visual amenity on rates of leisure and utilitarian activity.

6.6.4 Network safety

In addition to being well integrated, networks should also be designed to be legible, enjoyable and safe (Pedestrian Council of Australia, 1999). Safety must be integral to design so people feel empowered to walk or cycle when the infrastructure is in place. In Perth, safety concerns are a major barrier to people undertaking more trips by foot or cycle (Western Australian Greenhouse Task Force, 2004). Pedestrians, for example, have been found to value safety (Handy and Mokhtarian, 2005) and, by implication, poor safety reduces people’s willingness to walk (or cycle). In sprawled, car dependent cities, safety can be a considerable obstacle to facilitating more active mode use. The reasons why have been discussed in Chapter 4 and include friction between people and vehicles, and in many areas, a lack of sufficient traffic restraint.
Safety is a two-tiered issue. Firstly, people construe poor infrastructure and heavy traffic as threats to safety. Safety is therefore a *perceptual* issue. Secondly, accident statistics show that some traffic injuries and fatalities involve active mode users and motor vehicles. Safety is therefore also a *real* issue. By improving network safety, both perceptual and real safety concerns may be addressed.

Improved safety requires further development of the active mode network. In Perth, many suburban streets either have footpaths on only one side of the road, or do not have footpaths at all (Figure 2.13, page 71 and Figure 6.6). This is particularly dangerous for the mobility impaired, as they are slower to act when a motor vehicle is approaching. There is evidence from the US and Australia that if safe footpaths are not provided, people (especially older people) are less willing to walk or otherwise be physically active (Booth *et al.*, 2000; King *et al.*, 2000).

*Figure 6.7 – Suburban Perth: the footpath becomes a parking area*

(Source: Author)
In Australia, too, there are cultural issues associated with the function of footpaths. There are instances where drivers assess them as parking areas instead of walkways (Figure 6.7). It is the responsibility of law enforcement officials to deal with such infringements and for drivers to be better educated about their responsibilities.

In addition to walkways and footpaths, pedestrians also need frequent, safe places to cross streets. Again, in many of Perth’s established suburban areas, these design features are lacking. Figure 6.8 depicts a blind corner in Perth’s southern suburbs where the infrastructure requires the active mode user to cross the street where visibility is no more than about 15 metres. Video 2 (on the CD-ROM) depicts conflict between a pedestrian crossing at this location and a motor vehicle. In addition, intersection designs can be problematic for pedestrians. Where left turn slip-ways are provided for motor vehicles (see Figures 4.4 and 4.5, page 153), the pedestrian crossing point is often situated where vehicles will wait for a break in traffic. Figures 6.9 and 6.10, taken in suburban Perth, illustrate this point well.

Figure 6.8 – Suburban Perth: pedestrians face difficulties assessing the safety of crossing roads
(Source: Author)
Figures 6.9 and 6.10 – Suburban Perth: intersection crossings can be hazardous for pedestrians

(Source: Author)
For the cyclist, there remain relatively few dedicated rights-of-way in Perth despite ongoing improvements being made as part of the Bicycle Network Plan. Cycleways give cyclists discernable routes and can add to real and perceived safety. Regularly updated, clear signage and information systems for cyclists should be part of network creation as they add to a safe cycling experience (Davies et al., 1997). Research from the US, for example, has found that proximity to dedicated cycle-ways influences their use (Troped et al., 2001). Similarly, walking is positively associated with both real and perceived access to walkways (Calthorpe, 1993; Ewing et al., 2003; Hill and Peters, 1998). Sense of safety may well be an intermediary variable in these relationships.

Within the urban environment, certain phenomena present particular safety concerns for active mode users. Intersections and potential crossing points are some examples, whilst vehicle entries to shopping centres, petrol stations and parking areas also present problems (Figure 6.11). Video 3 (on the CD-ROM) shows conflict between a pedestrian and a vehicle at the entrance to the Caltex station depicted below.

All too often, shopping centres have been designed assuming access by car (see Chapter 2). Designers have seemingly forgotten that even drivers need to park their cars (perhaps some distance from the shopping centre itself) and walk into shops.

Hazard mitigation can be achieved by restricting the size of shopping centres and putting parking to the rear to create an interface between on-street pedestrian areas and shops. Furthermore, cycle access can be improved by increasing numbers of cycle parks and providing clearly marked and raised cycle paths through car parking areas. For the pedestrian, walkways can likewise be raised, provided at more points
throughout the centre’s surrounds and vehicle entrances and exits can be designed with pedestrians having the right of way.

Overall, there are two design imperatives for improving pedestrian and cyclist safety. First, the existing urban area needs to be incrementally retrofitted to improve perceived and real safety, which can then translate to better opportunities for active transport. Second, it is necessary that new developments are sensitive to the needs of active mode users. An obvious challenge to providing safe walking and cycling environments in new neighbourhoods (such as LNs) is linking new infrastructure with existing, sometimes deficient regional infrastructure.

Figure 6.11 – Suburban Perth: the access to this Caltex station is paved over the footpath, suggesting to drivers that they have right of way

(Source: Author)
Alongside design initiatives to improve safety, public education and improved legal rights for active mode users are necessities. Education cannot simply focus on the responsibilities of pedestrians and cyclists (i.e. that pedestrians need to look both ways, even at marked crossings and cyclists should always wear helmets). Instead, drivers should be educated to be both more courteous to active mode users and more aware of their responsibilities. In Chapter 4, for example, it was discussed how Perth drivers seem to be unaware of the need to give way to pedestrians when turning left (Jewell, 2007).

From a legal perspective, until February 2005 in New Zealand, it was illegal for a cyclist to overtake gridlocked traffic on the inside, even when the way was clear and there was a designated on-road cycle-lane. Prior to this law change, there were incidences when turning vehicles cut across cycle-lanes without first checking for cyclists, yet the cyclist involved in the ensuing accident was legally culpable. This illustrates the sometimes strange juxtaposition between infrastructure and policy that has not yet caught up.

6.7 Bringing the strands together to create a manifesto for shorter trips

The discussion of active modes and network creation highlights the importance of holistic design. Whilst strategic, region-wide planning is necessary, the micro-scale characteristics of the network must also be carefully considered. Walkability and cycleability are the sum of many variables, including activity intensity, access potential permeability, quality and safety (Gauvin et al., 2005; Handy et al., 2002; King et al., 2003; McIndoe et al., 2005; Pucher and Dijkstra, 2000; Saelens et al., 2003b; Wright,
High walkability and cycleability can make active modes viable alternatives to cars for shorter trips (Humpel et al., 2002; Leyden, 2003). Conversely, there are a range of disincentives to walking and cycling, including urban sprawl, poor permeability, traffic danger and a lack of local character.

However, some of the relationships between separate variables and transport behaviour remain unclear. Moreover, the evidence suggests that variables do not act in isolation: they interact to strengthen or weaken associations. Until it is possible to more accurately explain the relationships between different variables, best practice seems to be to provide as many opportunities and incentives as possible for people to use active modes. This includes using aesthetics to make people want to walk or cycle and providing nearby destinations to take away reasons for people to drive.

Yet, the challenges of putting together and then implementing an effective networking strategy cannot be underestimated. In Perth, the transport problems associated with existing urban arrangements are not readily fixable. Sprawl is a key problem and the city has the lowest level of patronage of non-motorised modes in Australia (Newman and Kenworthy, 1999). It is therefore of interest to identify the extent to which LN can contribute to the sustainable transport agenda.

### 6.8 Summary

This chapter has reviewed a suite of measures that can make cities more liveable, reclaim road-space from the private vehicle, and encourage more use of public transport and more walking and cycling. The measures described should not be applied in isolation; they are best applied together to create high quality alternative mode
networks. Alternative mode networks, for example, require quality micro-scale characteristics, such as attention to aesthetic detail and user-friendly information systems, including maps and timetabling information. They need to be safe and reliable and strategically planned.

Integral to improving alternative mode networks is land use reform. Strong, mixed use centres should be linked by strong public transport corridors. The centres, if designed to be friendly to active mode users, facilitate sustainable local travel, whilst the corridors provide sustainable regional linkages. Such a ‘nodes and corridors’ design approach is elaborated on in the following chapter.

Further to discussing some land use planning approaches that are essential for improving public transport and the walking and cycling environment, Chapter 7 describes other hard (engineering) and soft (policy-related) approaches that can mitigate car dependence and preference. These include pricing mechanisms and behavioural change strategies. Together, these approaches provide a context for LN; the design suite that was tailored to the Western Australian context and is the focus of the TSH study.
Producing the sustainability package

…the positive qualities of density (and mixed land use), such as reduced travel and better transit options, are less likely to occur, or to be as effective in magnitude, unless development is designed to bring transportation and land use together in a very coordinated and consciously planned way. That is, to build transit city or walking city characteristics, planners must do a lot better than just scattering increases in density across a cityscape (Newman and Kenworthy, 1999: pp166-167).
7.1 Introduction

In preceding chapters, sprawl and car dependence were linked with a range of problems for cities, including dependency on fossil fuels for transport energy, pollution, public health risks and social dislocation. Refocused planning priorities with the twofold aims to redress sprawl and car dependence in existing urban areas and improve sustainability in new neighbourhoods are means to combat these problems. Nevertheless, such a manifesto poses significant challenges, given the costs involved and the scale of change required (Handy et al., 2005a). Despite urban change being a slow process, environmental interventions have potential for long lasting effects on populations, rather than short-term effects on individuals (Frank et al., 2005; Giles-Corti et al., 2005).

This chapter begins with discussion of alternatives to conventional planning. Such approaches, including New Urbanism, Smart Growth and Transit-Oriented Development (TOD) are intended to facilitate relatively more sustainable city growth. New Urbanism was the design approach that was tailored to the Western Australian context to produce LN.

Subsequently, transport management approaches, including behaviour change approaches, pricing mechanisms and spatial controls are discussed. Next, it is argued how health variables can be incorporated into assessments of development plans to ensure cities are healthy places. Finally, the LN planning suite is unpacked. Its specific aims (particularly those relating to sustainable transport) are identified and potential challenges to its successful application are discussed, thereby setting the context for the empirical research.
7.2 Urban (re)development approaches

New Urbanism, Smart Growth, and the nodes and corridors development approach are discussed below. Some of the more significant outcomes intended by these approaches are listed below:

- Provision of a good mix of moderate to high density housing with some low density housing precincts, thereby ensuring a range of housing opportunities are available to suit residents’ requirements and a range of budgets
- Mixing of land uses
- Arranging neighbourhoods around public transport stops (preferably rail) and local service opportunities
- Building a reasonable level of self-sufficiency into neighbourhoods
- Linking separate development areas with quality public transport (preferably rail) to cater for necessary inter-community travel
- Designing neighbourhoods to have a pedshed of 400 metres or thereabouts to enable easy access
- Ensuring collaboration between private and public interests to ensure simultaneous land use and transport systems development
- Building walkability and cycling opportunities into neighbourhoods, through the above measures and quality local-scale design
- Restricting motor vehicle traffic through limited parking provision, low driving speeds and using other traffic management techniques
- Creating/retaining local character

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31 TODs constitute the nodes in ‘nodes and corridors’. This section focuses on the broader aims of each strategy and does not focus on micro-scale design characteristics such as street furniture. Nevertheless, such characteristics are integral parts of sustainable developments. See Chapter 6 for additional discussion.
• Making the public realm attractive and of high-quality, including provision of multi-use greenspace to meet the needs of residents

• Making use of existing urban land: promoting infill over greenfields development, thereby restricting the outwards growth of the urban frontier

• Fitting developments under a comprehensive regional strategy for sustainable development

7.2.1 New urbanism

Over the last 20 years, the New Urbanist movement has gained strength in the US (Beatley, 2004). It has also influenced designers elsewhere. The movement advocates design qualities reflective of small US cities *circa* 1900 to 1920 (Beatley, 2004; Frank *et al.*, 2004). In 2002, The Congress for the New Urbanism was reported to be 2,000 members strong (Gillham, 2002).

The defining characteristics of New Urbanist (NU) developments are intended to be walkability, high permeability, local character and compactness; all of which combine to provide residents with a highly liveable community (Charter for New Urbanism, undated; Congress for the New Urbanism, undated) supportive of public transport (Bressi, 1994). Also, “NU” developments are intended to facilitate more social interaction through the increased rates of walking and should therefore be richer in social capital than conventional neighbourhoods (Urban Land Institute, 2005).

Newman and Kenworthy (2006) note that NU developments are designed around the pedshed (see Chapter 6), where the focal point is a neighbourhood centre. The
neighbourhood should have a reasonable level of self-sufficiency, with a range of local facilities being within walking distance for the majority of residents.

Drawn in 1996, the NU charter recognises three specific design scales (Burns, 2005). These are region, neighbourhood (and links between neighbourhoods) and block. The essential characteristics of each are summarised in Table 7.1.

Marshall (2001) is somewhat sceptical of the value of the NU planning approach. He argues that NU developments are all-too-often located within an outdated transport system. Furthermore, he argues, insufficient attention is given to sustainable transport in NU planning (Marshall, 2001).

Marshall continues by criticising NU for being too focused on micro-scale design features and aesthetics. New Urbanism, he argues, does not necessarily limit greenfields development and often does not include specific efforts to increase urban densities (Marshall, 2001). Some US developments that have been designed using NU principles reflect these criticisms. Consequently, there is a gulf of sorts between NU theory and practice, suggesting that it might not be the NU vision that is flawed, but the translation of vision to practice requires improvement. This is an important idea that needs to be explored in relation to LN.
Table 7.1 – Charter for New Urbanism: development scales and respective characteristics

<table>
<thead>
<tr>
<th>Region</th>
<th>Metropolitan regions should be seen as fundamental economic units of the world</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>They have a fragile relationship with the agrarian hinterland</td>
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<td></td>
<td>There should be a distinct urban edge and infill should be encouraged to preserve this</td>
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<td></td>
<td>New developments should be integrated into the existing urban system</td>
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<td></td>
<td>Affordable housing should be well distributed throughout the urban area, along with necessary services and facilities</td>
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<tr>
<td></td>
<td>Automobile dependence should be reduced through the provision of a network of quality transport alternatives</td>
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<tr>
<td></td>
<td>Revenues and resources should be shared between districts to promote equity across space and rational coordination of service provision</td>
</tr>
<tr>
<td>Neighbourhood</td>
<td>These are identifiable areas. Development at this scale is fundamental for the evolution of the metropolis</td>
</tr>
<tr>
<td></td>
<td>Neighbourhoods should be mixed use, compact and facilitate active transport, especially near transit stops</td>
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<tr>
<td></td>
<td>Transit corridors should help organise urban structure, linking new centres with existing centres. They should not draw investment away from existing centres by by-passing them</td>
</tr>
<tr>
<td></td>
<td>The corridors linking neighbourhoods need to fit within a highly interconnected network, making movement as seamless as possible</td>
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<tr>
<td></td>
<td>There should be a range of housing options and costings to encourage civic and social bonding</td>
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<tr>
<td></td>
<td>Services and facilities should be embedded into neighbourhoods, not concentrated in mega-malls</td>
</tr>
<tr>
<td></td>
<td>Public open space should be used to connect neighbourhoods</td>
</tr>
<tr>
<td>Block</td>
<td>The primary purpose of streets and public spaces is for them to be shared-use areas</td>
</tr>
<tr>
<td></td>
<td>Safety and security needs to be balanced with accessibility and openness</td>
</tr>
<tr>
<td></td>
<td>Automobiles must be adequately accommodated, but not at the expense of other modes</td>
</tr>
<tr>
<td></td>
<td>Public spaces must be interesting to the pedestrian</td>
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<tr>
<td></td>
<td>Local context should be reflected in design</td>
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<tr>
<td></td>
<td>Civic buildings and spaces require special emphasis, so as to reinforce community identity and democracy</td>
</tr>
<tr>
<td></td>
<td>Natural heating and cooling methods should be built into dwellings, thereby making lot layouts important</td>
</tr>
<tr>
<td></td>
<td>Existing important features should be preserved – i.e. historic buildings and conservation areas</td>
</tr>
</tbody>
</table>

7.2.2 Smart growth

Smart growth is focused as much on long-term as short-term outcomes (Smart Growth Network, undated). Gillham (2002: p156) defines smart growth as:

Managed growth that attempts to fulfil the need to provide for growth (both economic and in population) while at the same time limiting the undesirable impacts of that growth.

In 1996, the Smart Growth Network was formed in the US by the Environmental Protection Agency. It now includes more than 30 different organisations with an interest in sustainable growth (Frumkin et al., 2004). High level strategic planning is considered to be an integral part of smart growth (Frumkin et al., 2004). This is to avoid piecemeal development and ensure a high level of connectedness between new and existing neighbourhoods.

Smart growth can best be realised by a focus on infill rather than greenfields development. As van Vliet and Gade (2001: p310) argue, “urban renewal is a good example of recycling”. Consequently, cities reflecting smart growth patterns will be more compact. Overall, smart growth aims to (Smart Growth and Transportation Conference Report, 2002: p12):

1. Create a range of housing opportunities and choices
2. Create walkable neighbourhoods
3. Encourage community and stakeholder collaboration
4. Foster distinctive, attractive places with a strong sense of place
5. Make development decisions predictable, fair and cost-effective
6. Mix land uses
(7) Preserve open space, farm land, natural beauty and environmental areas

(8) Provide a variety of transportation choices

(9) Strengthen development and direct it toward existing communities

(10) Take advantage of compact building design

In theory, one of the key strengths of ‘smart’ (compact) city structures is they allow agglomeration and mix of services and facilities with housing. Consequently, service providers can benefit from the competencies of others, creating an environment where consumers can find a variety of different opportunities in close proximity (see Llewelyn-Davies Consultants, 2000; McIndoe et al., 2005; Montgomery, 1995; Naess, 2005). Given the need to travel long distances is mitigated there is less need for people to drive. There are, however, challenges to the successful implementation of smart growth (challenges that also apply to LN – see Section 7.6.2) (Frumkin et al., 2004). These are included below.

(1) Governance is typically fragmented across space and this is a barrier to high level strategic planning

(2) It is difficult to reconcile the interests of many stakeholders

(3) Smart growth approaches limit consumer choice, which may favour conventional suburban living opportunities

(4) Higher density, mixed use living may not be particularly attractive for some people (see Patrick Troy’s arguments presented in Chapter 2 and elsewhere)

(5) Gentrified, high quality neighbourhoods may price many potential buyers out of the market (see Chapter 3)
7.2.3 The nodes and corridors approach

There are many similarities between this approach and smart growth, as both focus on the development of walkable precincts, infill and high-quality public transport linkages. When development is focused on major activity centres, which may be spread throughout the city, the city becomes polycentric. These activity centres are the nodes. The corridors are the high-quality, high-speed and efficient public transport links (preferably rail services) between the nodes, complemented by some direct routes for motor vehicles.

Nodes should be designed to be pedestrian and cyclist friendly. Relatively high development densities and mixing of land uses should be key characteristics of the nodes (Newman and Kenworthy, 1999; Newman and Kenworthy, 2001). Higher activity intensities at people’s origins and destinations can ensure support for public transport and provide people with a range of opportunities within walking distance of stations (see Chatman, 2006).

The Network City or linking of a series of strategically planned nodes via quality (public) transport corridors is a strategic vision for Perth. Newman and Kenworthy (2006) argue that the nodes within Network City must be 20 to 30 kilometres in diameter. Each node should be made relatively self-sufficient to minimise the need for internodal travel. Necessary internodal travel can be facilitated by the quality rapid public transport services on offer (Newman, 2005).

There are a number of issues that need to be addressed for Network City to be of value to Perth. The urban structure assumed in Network City would require significant changes to the existing urban area. The strategy is not prescriptive about how nodes are
to be consolidated. Moreover, there is no designated urban growth boundary, which would limit further sprawl. Also, there is no formal mechanism to encourage public and private collaboration, whereby land use and transport can be strategically integrated (Newman, 2005).

More generally, despite the merits of strategic urban consolidation, there are often significant statutory barriers to the development of higher density mixed used areas (see Chapter 2). In cities with rigid zoning, it is often difficult to obtain planning approval for developments where a mix of land uses are coordinated with quality alternative transport systems.

a. Transit-Oriented Development

Transit-Oriented Developments (TODs) are emerging in the US and Australia as a European-style development paradigm, where land use and transport is coordinated (Renne and Wells, 2004).

TOD focuses compact growth around transit stops, thereby capitalising on transit investments by bringing potential riders closer to transit facilities and increasing ridership (Arrington, 2005: p2).

TOD draws on many of the planning principles espoused by advocates of NU and smart growth (Arrington, 2005), including:

- Providing a mix of moderate and high density housing
- Mixing land uses
- Constructing a pedestrian oriented public realm, including streets
• Orientating buildings to the street to enable easy public transport and pedestrian access

• Providing a highly interconnected and therefore permeable street network

• Strategically linking public open spaces to enable better (and potentially longer) walking trips

TODs may be defined as:

…compact, socially diverse and active communities that include shops, offices, a range of medium-density houses and apartments. These communities are easily ‘walkable’, have attractive streetscapes and landscaped open spaces and are within a ten-minute walk of a transit centre (PATREC, 2005).

The key to producing successful TODs is collaboration between private and public interests (Burke and Brown, 2005; Cervero, 2005). With collaboration, expertise, risks and rewards can be shared (Kenworthy, 2003). Housing in TODs can often be quite expensive, reflecting the desirability of living in a quality development (Cervero, 2005) and the increased value people tend to place on good access (Levinson and Krizek, 2008). US research, for example, found that land value near to rail stations is generally at a premium (Cervero et al., 2004). Similarly, Bruegmann (2005) critiques increased investment in public transport (particularly rail) associated with TOD development for being skewed towards the affluent: people of lower incomes cannot afford to live in TODs and enjoy the benefits of quality public transport.

The costs of housing in TODs can be offset by the involvement of government, should it be required, to ensure sufficient affordable housing is included in the development.
Following renewal of inner north-east Brisbane, for example, an area that has a train station as an anchor-point, the website for the Brisbane City Council (n. p.) mentions that there are:

211 low-cost housing units, boarding house rooms and detached houses [in the renewal area], whereby developers contribute to the Brisbane Housing Company for low-cost dwellings

Public involvement can ensure that public transport services are provided to a standard suitable for the scale of development, pedestrian and cyclist infrastructure is properly planned, and transport system and land use development are simultaneous. This is important, as neighbourhood functionality depends upon a transport system that is supportive of all modes, not only motor vehicles (Marshall, 2001).

Furthermore, there is potential for the design characteristics of TODs to encourage people who would otherwise drive to use public transport for longer trips and active modes for shorter trips (see Ashton-Graham et al., 2005; Dock and Swenson, 2004; Greenwald, 2003). The design should not simply entice existing users of bus services to new train services. Beltzer and Autler (2002) argue that TODs should really be PODs (‘People-Oriented Developments’). That is, they should be designed with people not vehicles in mind. Thus, walkability and cycle access are essential elements to build into ‘PODs’. If master-planned, these developments can mitigate car dependency by making travel by alternative modes simultaneously reliable, safe, efficient and attractive (Wooldridge, 2005).

Designing TODs to better facilitate active mode use and restrict motor vehicle traffic can, however, have a number of impacts. It can increase spot congestion and detract
from the quality and vibrancy of development when modes are in conflict (Cervero, 2005). From a different point of view, congestion can be a good thing, as it is further encouragement for people to mode shift. If enough people shift modes, congestion may only be a temporary community nuisance.

From an economic perspective, properly designed TODs can be commercially vibrant. Economic activity occurs on foot, not in motor vehicles (Roberts, 1988; Roberts, 1989). A community characterised by shopping opportunities near to homes, where there is good permeability and walking is both easy and attractive is an ideal environment for the exchange of goods and services. Residents are also provided with local employment opportunities (see Morris and Kaufman, 1996).

For both home-buyers and business owners, the economic value of land can increase, particularly in higher density areas with good access to public transport (with rail being best), thereby justifying investment (Gibbons and Machin, 2005; Haughton and Hunter, 1994; Hoch, 1979; Klaasen and Jacobs, 1999). The market does value good access (Chatman, 2006).

Overall, this discussion provides good evidence for targeted consolidation. Undoubtedly there remains market demand for a range of lifestyle opportunities and the imperatives of targeted consolidation should not be confused with a uniform policy of densification throughout the city. With TODs, for example, the focus is on density gradients whereby densities are higher closer to the public transport and commercial anchor-point. Areas slightly further away from the anchor-points can still retain good access and opportunities for walking and cycling even if they are built to comparatively lower densities. Furthermore, feeder bus services to outer areas can complement the
corridor services with the level of service determined by potential patronage (see Chapter 6).

7.3 Managing transport behaviour

In this section, several transport management approaches are explored. The approaches assume minimal, if any change to land use and are therefore complements to urban redesign. With the exception of traffic calming, they are ‘soft’ measures, relying on behavioural change, or spatial or price controls to facilitate a modal shift.

7.3.1 Behaviour change mechanisms

Both governments and non-governmental agencies should proactively educate the public about transport sustainability (Pedestrian Council of Australia, 1999). Education makes people more mindful of the trips they make and how they make them. It can be an effective tool to change habitual behaviour, which is borne out of choice rather than necessity (Bamberg et al., 2003; Garling and Axhausen, 2003).

People do not often reflect upon routine trips because they are common and repetitious (Naess, 2005). Behavioural change approaches can be useful because they empower people to critically reflect upon their travel. With the aid of the institution implementing the approach, people can identify more sustainable ways of fulfilling their travel wants and needs.

Behaviour change approaches can be cost-effective relative to infrastructural changes. However, they rely on the public to be amiable to change. In general, participants must
be furnished with compelling reasons to change their behaviour and then sustain the changes through various stages of follow-up. This is important, as attitudes towards travel can be strengthened by habit (Forward, 2003). Researchers note the incredible difficulty of achieving any behaviour change, particularly sustained change given car culture and car dependence in many cities (Sallis and Owen, 1999; WCTRS and ITPS, 2004). Behaviour change approaches are therefore most useful when partnered with other approaches supporting more sustainable transport.

a. GoSmarter

In Christchurch New Zealand, Environment Canterbury (the Regional Council) bears primary responsibility for transport management. The Canterbury Land Transport Strategy 2002-2007 identified the need for a behaviour change strategy to complement other sustainable transport initiatives. From spring 2002 to summer 2003, GoSmarter was pilot tested in the northern suburb of Papanui to fulfil this need. The project’s main objectives were to decrease rates of single vehicle occupancy during peak periods, encourage travel blending and increase the modal split of public transport, cycling and walking. Participants were recruited via a door-knocking procedure (ECan, 2004).

The programme involved surveying the participants on their travel behaviour, analysing the results, then providing personalised feedback, consistent with the objectives of the project. The project was supported by various material, including information brochures, flyers and stickers, and community events. Feedback was personalised and helpful (i.e. it pointed out the savings when short trips were walked or cycled rather than driven). Follow-up surveys were conducted six months and one year following the report-back.
A key goal of the project was a 10% reduction in the number of trips people were making as car drivers. After surveying participants a year after personalised feedback was given, the achieved reduction was 7.2%. While the project had positive outcomes, it was limited in a number of respects. The study organisers obtained a small sample and experienced a moderate drop-off rate, which reflected both the voluntary nature of the programme and the burden placed on participants to report back on a number of different occasions. Second, the project was not coordinated with any land use or transport systems changes. Finally, the redevelopment of a large nearby shopping mall may have had an influence on the travel patterns of some households. Behavioural changes may or may not endure over the longer term, particularly if urban systems are not improved to make travel by alternative modes more appealing (Bryan, 2005).

b. TravelWise

In Auckland New Zealand, TravelWise is the Auckland Regional Travel Authority’s (ARTA) behaviour-change programme. Percy and Kota (2007:p4) report that:

*TravelWise* is currently working with over 100 TravelWise schools with over 70,000 pupils, 45,000 tertiary staff and students and 20,000 workplace staff. Our most recent evaluation in November 2006 indicated that the programme is already taking 3,275 car trips off the road each morning peak, and reducing CO2 emissions by over 700 tonnes each year.

As part of the programme, data relating to transport decision-making was collected. This added to understandings of travel and is informative for future interventions. It was found, for example, that the most significant factor influencing parents’ decisions concerning their children’s journey to school was perceived safety. When their children were aged 7, less than 20% of parents would allow them to walk and less than 10%
would allow them to cycle to school independently. When their children were aged 9, half of the parents would allow them to walk. Only at age 10 would more than 50% of parents be satisfied that their children could safely cycle to school (Percy and Kota, 2007).

These data deepen understandings of the problems confronting the more vulnerable members of society, including children (see Chapter 3). It also indicates that future interventions need to address issues of safety (see Chapters 4 and 6).

c. TravelSmart

TravelSmart (see DPI, undated) is an ongoing Western Australian governmental initiative to help achieve mode share targets by empowering people to travel using alternative modes. It is similar in many respects to GoSmarter and TravelWise.

First, a target group of persons is identified. Second, those who agree to participate in the programme are administered a travel diary, which they complete and return. After the diary is analysed, a trained operator conducts an interview with the participant. The participants receive personalised feedback about their travel behaviour including suggestions about how certain trips could be made without use of a private vehicle. It is a labour-intensive strategy that aims to add to people’s knowledge about alternative modes, routes and opportunities (James and Brög, 2003).

Implementation of the approach in South Perth (n=35,000 persons) reduced the relative number of car trips by 14% amongst participants, while increasing walking trips by 35% and cycling trips by 61% (James and Brög, 2003). The administration of
TravelSmart in greater Perth has yielded a 10% reduction in car trips, with 80% of behavioural changes sustained for four years (Ashton-Graham et al., 2005). TravelSmart is an approach that is best applied in areas of the city that lend themselves favourably to alternative mode use (i.e. where there is good access to public transport, particularly rail, and there are good opportunities for local travel) (Ashton-Graham et al., 2005).

### 7.3.2 Pricing mechanisms

Pricing mechanisms can be a useful part of any policy suite. Motorists in the US and Australasia have long enjoyed low-cost mobility, although this is not likely to last (see Chapter 5). The costs paid by motorists do not reflect the financial burden that motor vehicle usage imposes on society (Laird and Newman, 2001b). Consumer costs should therefore rise to more accurately reflect real costs, especially for trips that are made out of choice rather than necessity (Handy, 2006).

The price of vehicles, parking, registration and fuel can be raised through tax increases. In Copenhagen, heavy taxes on car ownership contribute to making the city relatively car free (Newman et al., 1997). In London, congestion charging in central areas has been a successful policy and has served as inspiration for other cities, such as Stockholm (Goldman and Gorham, 2006). In Singapore, there is a long history of price controls to substantially mitigate use of motor vehicles. Certificates of Entitlement, which people must have to own a motor vehicle, are limited in number and prohibitively expensive. The rate of increase in the number of cars of the island has been capped at 3% per annum (WCTRS and ITPS, 2004).
To complement this, the Singaporean government has instituted a comprehensive strategic vision for public transport. It includes that every commuter must have a bus service within 400 metres of their place of residence and be able to make 95% of their trips with a maximum of one transfer (WCTRS and ITPS, 2004).

…near-complete control over urban growth and design, and a pro-transit government, has produced one of the most efficient transit-land use symbioses in the world (Pacione, 2001: p261).

Price controls are partnered with substantial investment in public transport and infrastructure for active modes to minimise effects on people’s access and mobility (Rees, 2003). As such, there are obvious challenges to implementing price controls in sprawled cities were public transport and active transport systems are deficient.

All else equal, there are emerging pricing technologies, such as on-board ‘smart drive’ units, that can ensure a fairer, ‘user pays’ system. These technologies ensure people are billed depending on when, where and how much driving they do. However, price controls can be problematic, as driving can become prohibitive for the least well off. This would generate significant social justice problems.

Pricing mechanisms will also be politically volatile. Many members of the public will not be very amiable to increased motoring costs. Also, price controls may lead to less motoring, less uptake of new vehicles and less use of oil. This is not in the interests of the automotive lobby. All things considered, price controls may only be of limited use in the sprawled city.
7.3.3 Spatial control mechanisms

There are a range of spatial controls that can be used to manage motorised traffic. In 1975, an Area Licensing Scheme was introduced in Singapore to reduce morning peak flows into the city’s central business district. The scheme imposed substantial costs on motorists entering the licensed area (Newman and Kenworthy, 1999). In 1998, an electronic road pricing scheme was introduced to replace the Area Licensing Scheme. Drivers are charged based on the time they drive and where they drive to. It is a high-tech approach to congestion pricing, as an onboard unit triggers the charge (WCTRS and ITPS, 2004). London is another city where traffic is controlled in the centre of the city, thereby easing congestion and making streets more pedestrian and cyclist friendly.

Other controls include remedial engineering to ‘calm’ streets. This practice can be traced back to 1960s Denmark (Newman and Kenworthy, 1999). The Danes are responsible for designing the *Woonerf*, or street that is a ‘living space’ (see Pedestrian and Bicycle Information Center, undated). Integral to the *Woonerf* is multifunctionality. This type of redesign can reinvigorate the streetscape by building in visual interest, greenery and street furniture. It can turn spaces into places, thereby giving users a greater appreciation of the commons. Moreover, the introduction of speed humps, narrowing of the carriageway and increasing the visibility of active mode networks can both slow motorised traffic and facilitate more travel by foot and cycle.

Infrastructural changes such as street calming can be the most effective way to slow traffic speeds, thereby increasing safety (Newman and Kenworthy, 1999). Such changes are far more useful than ‘educating’ vulnerable road users to be careful near roads (Tranter, 1993) (see Chapters 4 and 6). Streets can be retrofitted as part of routine maintenance work and hence be *transformed*, rather than *rebuilt* (Tranter, 1993).
Whilst changes to infrastructure tend to be costly, paint can be a cost-effective way to achieve some objectives, such as provision of cycle lanes. The colour differentiation between traffic lanes and cycle lanes raises the visibility of cyclists.

Prioritisation for public transport should be included as a key feature of traffic calmed streets. In Christchurch, New Zealand for example, there have been recent efforts to designate bus only ways in the central city. There are also bus only lanes marked in some parts of Perth. These can enable buses to travel more quickly, thus increasing their competitiveness with cars and making public transport more appealing. When bus lanes are marked along busier roads, such as the freeways in Perth, they can provide a considerable advantage for public transport during peak flows.

Street calming is most effective if it is coordinated and metropolitan-wide (Hass-Klau, 1990; Tranter, 1993). Otherwise, traffic tends to be redirected to streets that are not calmed, where motor vehicles tend to be able to be driven faster.

7.4 Strategic master planning: a unified land use and transport agenda

A strong sustainability agenda requires that a range of measures are combined. Challenges including market preferences and the urban redesign task are not insurmountable if planning takes a longer term focus. In the shorter term, there are also bridging measures that can be effective, including implementation of programmes such as TravelSmart.

Longer term planning requires input from a wide range of persons with different areas
of expertise, such as land use planners, transport planners, health professionals, urban social geographers and architects. In the UK, for example, where the impacts of urban change on public health are coming under increasing scrutiny (Department of Health, 2004), some groups advocate health impact assessments of land use and transport projects as part of the approval process (National Institute for Health and Clinical Excellence, undated).

Those involved in the planning process need to be familiar with the objectives of the sustainability agenda, which include reducing sprawl and mitigating car dependence. Public participation, too, is vital to the planning process, as it can ensure the agenda better ‘fits’ expectations (Sanoff, 1990). The public must also be well informed about the sustainability challenges facing the region. In 2003, the value of public participation was evident when the Government of Western Australia organised Dialogue with the City (DPI, 2003).

Whilst participatory planning is important, policy-makers must also be willing to make hard decisions. This becomes difficult when the policy makers are elected representatives. McKay (2005) points out that there must not be an over-reliance on public consultation. No consultation can be open-ended as it is unlikely a consensus can be reached on sensitive issues such as the future of Perth’s land use and transport systems, particularly when there is still money to be made from conventional growth.

### 7.4.1 Regional planning

Regional planning is vitally important for ensuring coordinated development (Duany et al., 2000). In Perth, where governance is not fractured between city councils as in most
US cities, as a regionally-coordinated planning body the Western Australian Planning Commission processes decisions from all councils according to its regional plan requirements. However, the WAPC’s plans require suburban sprawl, which is heavily car dependent. Thus, it is difficult to achieve a policy of reducing car dependence unless the regional plan requires it. This will be seen later in the assessment of the LN policy, which is attempting to reduce car dependence but within a suburban structure set in place over 40 to 50 years of conventional suburban planning.

Neighbourhoods are not closed systems. They are part of districts. Likewise districts are not closed systems; they are part of cities. Cities, meanwhile, are part of regions. The coordination of different levels of government clearly remains one of the significant challenges to successfully implementing the sustainability agenda. Newman and Kenworthy (1999: pp166-167) illustrate the importance of coordinated planning in their discussion of more public and active transport-friendly urban design:

…the positive qualities of density (and mixed land use), such as reduced travel and better transit options, are less likely to occur, or to be as effective in magnitude, unless development is designed to bring transportation and land use together in a very coordinated and consciously planned way. That is, to build transit city or walking city characteristics, planners must do a lot better than just scattering increases in density across a citiescape.

In Perth, land development has been well integrated but it is integrated around car use with some limited bus services. As the city now tries to reduce its car dependence the success of LN may well rest on how well coordinated new development is around sustainable transport modes rather than the car.
7.5 Liveable Neighbourhoods: a comprehensive design solution for Perth?

When Litman’s (2002) model for predicting car dependency is applied to Perth, it becomes clear that effective policy is required to improve transport sustainability. This is because the city scores poorly on most of the variables (Table 7.2). Some older data is used (from the Millennium Cites Database) to make this assessment and the last three measures are not particularly reliable. Nevertheless, this information forms a transport context for Perth.

Table 7.2 – Rating car dependence in Perth

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle ownership</td>
<td>Per capita vehicle ownership per 1,000 people</td>
<td>*630 – <strong>High dependence</strong></td>
</tr>
<tr>
<td>Vehicle use</td>
<td>Per capita annual vehicle miles travelled (VMT)</td>
<td>*5,590+ (9,000+ kilometres) – <strong>Medium dependence</strong></td>
</tr>
<tr>
<td>Vehicle trips</td>
<td>Automobile trips as a percentage of all personal trips</td>
<td>**83% - <strong>High dependence</strong></td>
</tr>
<tr>
<td>Quality of alternative modes</td>
<td>Relative convenience, cost, speed, comfort etc.</td>
<td>^Somewhat-very inferior – <strong>Medium-high dependence</strong></td>
</tr>
<tr>
<td>Relative mobility of non-drivers</td>
<td>Relative to drivers</td>
<td>^Severe disadvantage – <strong>High dependence</strong></td>
</tr>
<tr>
<td>Market distortions favouring automobile use</td>
<td>Relative advantage to motor vehicles in planning, tax, policy, funding etc.</td>
<td>^Significant bias – <strong>High dependence</strong></td>
</tr>
</tbody>
</table>

*From Cameron’s (2004) projections
**From PATREC, 2005
^Based on substantial review of relevant literature and policy, anecdotal evidence and observation
Improved transport sustainability requires strong statutory planning mechanisms and consistency in how the mechanisms are implemented. LN may be such a mechanism, as many of its principles reflect a shift away from convention. Accordingly, the present research asks searching questions of LN. Are the ways in which it is being implemented actually achieving improvements? Are land uses and transport being coordinated in new neighbourhoods? And, is the design code being consistently applied? The Western Australian Greenhouse Task Force (2004: p65) reports that LN is:

...a voluntary planning design code that promotes the development of sustainable communities with mixed land use and a balanced transport system. It encourages reduced car usage, better use of public transport, more walking and cycling, improved access to services and more efficient land use.

Since February 1998, the code has been on trial. It was formulated and reviewed by a steering committee representing a number of stakeholders (Table 7.3) and public submissions were invited. Whilst developers can voluntarily accept it over the conventional code and it is therefore an *optional set of standards*\(^{32}\), at the time of writing, the code is on the verge of becoming mandatory.

The design code was developed by the DPI through a process of retooling the *Australian Model Code for Residential Development 1995* and tailoring of New Urbanism to facilitate a better fit for the West Australian context. Furthermore, LN is argued to reflect a wider paradigmatic shift towards more sustainable urban planning in

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\(^{32}\)The voluntary nature of the code has been a significant challenge to it being a useful part of the sustainability agenda. This is discussed more in 7.5.2a.
Australia (Taylor Burrell Barnett, 2004). LN is based on nine overarching principles. These are shown in Table 7.4.

The purpose of LN is for it to be a performance-based vehicle to meet the objectives of the State Planning Strategy. As part of the vision for Western Australia 2029, it is intended to facilitate the development of more sustainable communities. LNs are intended to be facilitative of active mode use, well-linked to public transport, have higher relative densities and increased lot diversity. Development is to be focused around activity centres and public transport nodes (WAPC, 2004). The design code is to be applied to development proposals on *greenfields*[^1] sites encompassing two or more lots and larger infill sites (WAPC, 2004).

**Table 7.3 – Membership of the LN steering committee**

<table>
<thead>
<tr>
<th>Western Australian Planning Commission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Development Institute of Australia</td>
</tr>
<tr>
<td>Housing Industry Association</td>
</tr>
<tr>
<td>WA Local Government Association</td>
</tr>
<tr>
<td>Australian Association of Planning Consultants</td>
</tr>
<tr>
<td>Planning Institute of Australia</td>
</tr>
<tr>
<td>Institute of Public Works Engineering Australia</td>
</tr>
<tr>
<td>Statutory Planning Committee of WAPC</td>
</tr>
<tr>
<td>Main Roads WA</td>
</tr>
<tr>
<td>Department of the Environment</td>
</tr>
<tr>
<td>Property Council of WA</td>
</tr>
<tr>
<td>Sustainable Energy Development Office</td>
</tr>
<tr>
<td>Development Industry Representative</td>
</tr>
</tbody>
</table>

(Source: WAPC, 2004: p3)

[^1]: It is significant to note that the code anticipates *greenfields* development and does not require (at least a minimum of) infill.
Table 7.4 – Guiding principles of LN

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Town Structure</strong></td>
<td>The town structure should be compact and well-defined. It should consist of a clustering of highly interconnected neighbourhoods, which are mutually supportive of both neighbourhood centres and the town centre.</td>
</tr>
<tr>
<td><strong>Neighbourhood Structure</strong></td>
<td>A neighbourhood is typically defined as a 400-450 metre radius circle (5 minute walking distance) with a shop supplying daily needs, or another type of community focus, at its centre.</td>
</tr>
<tr>
<td><strong>Neighbourhood Walkability</strong></td>
<td>Walking is the most energy efficient mode of travel. It can be encouraged by an interconnected street network that provides pedestrians with a choice of routes at intersections to enable access to neighbourhood facilities via a safe and attractive environment.</td>
</tr>
<tr>
<td><strong>Walkability to Facilities and Public Transport</strong></td>
<td>As a measure of efficiency, at least 60% of the dwellings in a neighbourhood should be within a 400-450 metre walk of a neighbourhood centre or bus stop, or 800 metres of a rail station.</td>
</tr>
<tr>
<td><strong>Safety and Surveillance</strong></td>
<td>To reduce opportunities for crime, a clear definition is required between public places and private backs. Development should provide frontages with windows and entrances onto the public realm.</td>
</tr>
<tr>
<td><strong>Choice/Flexibility/Variety</strong></td>
<td>The urban lay-out should respond to the current and future needs of society. Buildings and lots should be designed to be adaptable in order to accommodate either changes in land use or additions over time.</td>
</tr>
<tr>
<td><strong>Environmentally and Culturally Responsive Design</strong></td>
<td>Key environmental and cultural features should be identified and protected within the design.</td>
</tr>
<tr>
<td><strong>Site Responsive Design – Character and Identity</strong></td>
<td>Local identity should be complemented or created by responding to site features, context, landscape and views.</td>
</tr>
<tr>
<td><strong>Cost and Resource Efficiency</strong></td>
<td>The development should promote neighbourhood sustainability in terms of the efficient use of infrastructure, the promotion of affordable and energy efficient housing, and satisfying the daily needs of the residents through access to appropriate types of community facilities.</td>
</tr>
</tbody>
</table>

Its particular strengths are suggested to be that it is contextual, practical and facilitative (Taylor Burrell Barnett, 2004). Moreover, the code is a regulatory tool, not simply an advisory document. Also, it can be applied to town or larger-sized structural plans, local structural plans or subdivisions. Figure 7.1 shows the various development scales. The level of detail to be provided with applications is variable, depending on the scale of the proposal. The requirements are listed in Table 7.5. For example, a local structure plan must show the detail required under (1), but also the added detail required under (2).

Figure 7.1 – Liveable Neighbourhoods development hierarchy
Table 7.5 – Scale of development and requisite detail to be provided with proposals

<table>
<thead>
<tr>
<th>1. Town and larger size structural plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neighbourhoods as represented by approximate circles of 400-450 metre radius, together with town and neighbourhood centres</td>
</tr>
<tr>
<td>Density targets expressed as dwellings per urban hectare</td>
</tr>
<tr>
<td>Existing and proposed neighbourhood centres</td>
</tr>
<tr>
<td>Arterial routes and neighbourhood connector streets</td>
</tr>
<tr>
<td>Natural features such as water courses and vegetation</td>
</tr>
<tr>
<td>Major open spaces and parkland</td>
</tr>
<tr>
<td>Major public transport routes and facilities</td>
</tr>
<tr>
<td>Proposed land use distribution</td>
</tr>
<tr>
<td>Proposed schools and community facilities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Local structure plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walkable neighbourhoods, represented by approximate circles of 400-450 metre radius around proposed neighbourhood and town centres, superimposed over the structure plan</td>
</tr>
<tr>
<td>Density targets expressed as dwellings per site hectare</td>
</tr>
<tr>
<td>Existing and proposed commercial centres</td>
</tr>
<tr>
<td>Proposed natural features to be retained</td>
</tr>
<tr>
<td>Proposed street block layout</td>
</tr>
<tr>
<td>Proposed street network, including street types and path networks</td>
</tr>
<tr>
<td>Proposed transportation corridors, public transport network and cycle and pedestrian networks</td>
</tr>
<tr>
<td>Proposed land uses, including distribution of medium and lower-density residential</td>
</tr>
<tr>
<td>Proposed schools and community facilities</td>
</tr>
<tr>
<td>Public parkland</td>
</tr>
<tr>
<td>Proposed urban water management measures</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Subdivisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed street network…and cross-sections for any special streets</td>
</tr>
<tr>
<td>Location of proposed footpaths and shared paths</td>
</tr>
<tr>
<td>Proposed lot pattern and sizes</td>
</tr>
<tr>
<td>The location of any proposed detailed area plans</td>
</tr>
<tr>
<td>Location and size of proposed public open space</td>
</tr>
<tr>
<td>Location of proposed urban water management measures</td>
</tr>
</tbody>
</table>

(Source: WAPC, 2004: pp12-14)
The LN code has eight distinct elements (WAPC, 2004). These are bullet-pointed below. Each is unpacked in turn, with special emphasis placed on community design, movement network and activity centres.

a) Community design

b) Movement network
c) Lot layout
d) Public parkland
e) Urban water management
f) Utilities
g) Activity centres and employment
h) Schools

a. Community design

…good design can add enormously to the quality and vitality of the urban or rural setting. Indifferent design, or endless rows of standardised buildings and ill-fitting developments can cumulatively contribute to a form of urban entropy, a general deadening of the visual and even spiritual qualities of the places in which we live and work…(Worpole, 2000: p53, cited in McIndoe, 2005: p68).

The design code aims to facilitate residential development at a range of densities, land use mix and local employment opportunities. The guidelines target densities of at least 15 dwellings per urban hectare (i.e. 15 dwellings per 1 hectare of urban land) in most new areas. A density of 22 dwellings per site hectare (i.e. 22 dwellings per 1 hectare of residential land) is targeted. Higher densities of 20-30 dwellings per site hectare are anticipated within 400 metres of local centres and public transport stops. In ‘strategic’
areas in the vicinity of town centres and rail stations (800 metres radius) the housing density should be 30-40 dwellings per site hectare.

Local centres are to be provided for each neighbourhood. Local centres should serve as community anchor points with amenities provided to meet the daily needs of local residents. Amenities may include a post box, public transport stop and small-scale shops, such as a deli. The importance of providing daily shopping needs in the local centre cannot be understated, given research has found that grocers and similar food service facilities are important neighbourhood anchor-points, while recreation and education facilities are not (Moudon et al., 2006).

Town centres are to be the anchor-point for clusters of neighbourhoods. These centres should be built to a much larger scale and feature a range of shops, including a supermarket. LN assumes there will some provision of jobs for locals, although it can be expected that those in specialised occupations will have to leave the neighbourhood for work. Local jobs will likely be few in number, relative to how many residents are of working age, in retail and require fairly generic skills. A rail stop in a town centre is desirable.

While the development area should have a flatter road hierarchy than is conventional practice, significant local roads, minor arterial and arterial roads should bisect centres, not run along the edges of development areas. Figure 7.2 shows the intended arrangement of neighbourhoods, towns and various centres. The figure shows that sensitive land uses, such as light industry, should be situated adjacent to, not within towns.
New developments should be site-responsive to help form local character. Moreover, developments should be well integrated with the existing, surrounding environment\(^\text{34}\). The development area should therefore be properly linked with adjoining transport networks. Developers are encouraged to liaise with transport planners for the administering authority early in the planning process.

Various social, health and safety, cultural and conservation goals are also specified. These include that site-specific features must be identified through intensive site analysis and retained where possible.

b. **Movement network**

Networks should be designed to balance their multiple functions. These include efficient traffic movement, pedestrian activity, being settings for business, living and

\(^{34}\) Chapter 3 emphasised how many people conduct their life’s work across neighbourhoods, not only within the one they live in.
community activity, and parking. There should be a contiguous development frontage to add to amenity, encourage social interaction and increase passive surveillance. No more than 15% of lots should front dead ends\footnote{Culs-de-sac can be significant obstacles in the urban transport network – see Chapter 2.}. Furthermore, gated communities are not intended to be part of LNs.

LNs should be highly permeable. There should be few dead ends and streets should be straight rather than curvilinear. Local roads should be designed to balance vehicle speed with capacity and safety. Also, there should be sufficient opportunity for vehicles to park on the street to slow traffic, relative to the volumes of traffic using the road. Cycle lanes and parking bays should be coloured to reduce the appearance of the road as an open channel. Plantings in the street scene can also assist with this. Further, short distances between intersections and tight turning radii add to keeping traffic speeds low on local roads.

Pedestrians should be provided with a high level of amenity, with networks providing safe, efficient and legible travel. The guidelines specify a standard footpath width of 1.5 metres, which would enable two wheelchairs to pass comfortably. Kerb corners should serve as ramps for prams and wheelchairs. Crossing distances should be minimised along local roads. Lighting should be placed regularly along the network and not obscured by foliage. There is particular emphasis on major routes from public transport stops. Adequate surveillance must be retained, through contiguous development frontages, late-night shopping opportunities\footnote{Just as developers cannot control what businesses establish themselves in new neighbourhoods, neither can they guarantee trading hours.}, mix of uses and minimal setbacks. Lots must not be left vacant for any length of time.
The Western Australia Walking Strategy makes special mention of the interagency collaboration that is required to achieve the principles of LN (Premier’s Physical Activity Taskforce, 2006). The DPI and WAPC are state level agencies, whereas it is local government authorities who are assessing development proposals. However, it is developers who are actually designing the new communities. This is an important point and one that applies to all aspects of LN. Developers, being the ones who design communities, need to be aware of the fine-grain characteristics of neighbourhoods that contribute to making them facilitative of sustainable transport. Yet, these requirements are not necessarily well communicated by the design code (see the challenges discussed in Section 7.5.2).

Features of the cycle network should include cycle parking facilities, marked lanes on busier streets and appropriate lane widths to enable cyclists to share roads. Shared paths and routes should be developed parallel to arterials where appropriate, thereby providing links between key landmarks. Curtis (2005: p197) argues that in existing LNs “the experience for pedestrians and cyclists is significantly better” than can be expected in conventional neighbourhoods.

Good access to public transport is also promoted. Stops must be provided at regular intervals and they should be characterised by safe (raised) street crossings, shelters and other street furniture. Overall, internal public transport routes must be cohesive with routes through abutting estates. Analysis of access and permeability are important parts of the TSH study and are enabled through GIS.
c. **Lot layout**

Liveable Neighbourhoods should be characterised by a range of lot sizes to encourage a range of housing opportunities, including affordable housing. Higher density development should be encouraged in the vicinity of centres and public transport stops. Consequently, lot sizes in LNs should be smaller compared with conventional neighbourhoods.

Lots should be rectangular to enable future subdivision. In addition, housing should be adaptable to allow future redevelopment without substantial demolition (see Brand, 1994). This is important with any type of development as it minimises future costs (Loe, 2000).

d. **Public parkland**

The LN design code recognises parkland as an essential feature of new neighbourhoods. Parkland should be provided on edges of neighbourhoods (between neighbourhoods), not in centres (see Moudon et al., 2006). The code recommends neighbourhood parks of 3,000-5,000m² to serve 600-800 dwellings. These parks should be within a 400-metre walk of most of the housing catchment. Town parks of 2.5-4 hectares should be provided for a notional catchment of three neighbourhoods. These must be a 600-1,000 metre walk from most dwellings. All parks must be multi-use (see Giles-Corti et al., 2005). They are to meet the needs of all demographic groups and cater for a variety of interests, including sports and other forms of recreating. Natural and cultural features
must be retained, developed and enhanced, where possible. Moreover, surveillance must be facilitated and lighting provided to maximise safety.\footnote{Analysis of parkland and access to parkland is not included in the TSH study. However, the main RESIDE study does include this analysis.}

e. **Urban water management**

The more significant elements of the urban water management suite include the aim for LNPs to achieve ‘appropriate’ quality and quantity targets for runoff. There is encouragement for developers to use water sensitive design techniques, such as porous paving to facilitate groundwater infiltration. Landscapes should be designed to encourage runoff into vegetated areas rather than concrete channels. Naturalised waterways are prioritised over lined ditches. Swales, contours and reed beds are naturalised design features which can add to water management.

f. **Utilities**

Key requirements include identifying and documenting the location of existing utilities, in relation to the development area. Connection plans can then be formulated to help ascertain the potential burden on existing lines.

g. **Activity centres and employment**

The LN code states that most land uses can be comfortably located within activity centres. However, heavier industry needs to be situated in strategic, single-use precincts. Lighter industry and storage services should likewise be in singular use areas but strategically placed to be on public transport routes and within walking distance of a neighbourhood or larger centre. It is anticipated that mixed-use hubs will provide local
opportunities for a range of goods and services for communities. Centres need to incorporate a range of opportunities such as community facilities, public transport stops, post boxes and daily-use shops (i.e. delis). Parking requirements can be reduced, where access opportunities for alternative modes are maximised (refer Shoup, 2005). Development in centres should be adaptable so tenures can change over time in reaction to changing economic conditions. Higher density residential development should be adjacent to centres, especially town centres.

Universities, hospitals and other urban complexes should be integrated with town centres, so as to avoid development of suburban-style, sprawled campuses. Retail that interacts with the streetscape is encouraged whilst conventional malls are discouraged. Activity centres should be public arenas, as much as possible, not dominated by private land.

**h. Schools**

Schools should be located outside of centres (see Moudon et al., 2006). As they generally serve more than one neighbourhood, they need to be strategically located to serve their catchment (relative to where other schools are). They must be cohesively interfaced with abutting land uses. The surrounding street network must be permeable and well-designed for walkers and cyclists. Public transport access should likewise be good. Moreover, sufficient on-street parking should be provided. It should be noted, however, that provision of on-street parking is an incentive for parents to continue to drive their children to and from school.
7.5.1 Design trends post activation of LN

In their 2004 report, Taylor Burrell Barnett (2004) review design trends in Perth from 1996 to 2002. They report a reasonable take-up rate by developers and note a trend towards neighbourhood design in accordance with LN policy. They note consistent distribution of parkland and more connected street layouts in new neighbourhoods. However, they report that retail continues to follow previous trends, with ‘mall’ style developments remaining typical and main-street style developments the exception. Retail developments are built anticipating most people will drive to them and have abundant parking.

In addition, there appears to be little in the way of increases in residential density and lot sizes continue to be relatively large. This reflects a ‘mixed bag’ of reported outcomes for LN and is informative for the TSH study design. It is important to look at why intended outcomes may not be achieved under LN. As such, the next section identifies some of the significant challenges facing the successful implementation of the policy in the Perth metropolitan region.

7.5.2 Challenges to more sustainable urban planning

Some of the more significant challenges to more sustainable urban planning in Perth are listed below then discussed in turn.

a) Uptake of sustainable design codes needs to be mandatory, not voluntary
b) Codes must require bottom-line outcomes and not be excessively flexible
c) They must be consistently applied
d) They must not excessively burden developers
e) There should be incentives for developers to plan in a more sustainable way

f) Codes need to facilitate increases in residential densities and land-use mixing

g) Development must be coordinated rather than piecemeal

h) More new developments should be in existing areas, not so frequently on greenfields sites

i) Land use and transport planning codes cannot address other influences on people’s travel behaviour

a. Uptake of sustainable design codes needs to be mandatory, not voluntary

Whilst LN is an operating design code, its uptake by developers is entirely voluntary (although it is now on the verge of becoming mandatory). The slow take-up rate of the code (Zadeian, 2006) is reflected in the number of Liveable versus conventionally designed neighbourhoods that are being developed in the Perth region. It is important that relatively more sustainable planning codes do not remain on trial for too long. If outdated policies remain in place, existing problems (such as car dependence and sprawl) may increase.

b. Codes must require bottom-line outcomes and not be excessively flexible, and

c. Codes must be consistently applied

Since the code went on trial, developers have been able to choose to meet some standards and not others yet still apply to have the subdivision branded ‘Liveable’
The WAPC will consider any requests to vary Liveable Neighbourhoods in this circumstance where the key principles and objectives of this document cannot otherwise be accommodated (WAPC, 2004: p2).

LN is not prescriptive. The code *encourages* conformity with the underlying principles rather than *expecting* developers to conform. While flexibility can allow developers to create unique character within new neighbourhoods, the more fundamental criteria (i.e. those facilitative of increased developments densities and mixing of uses) should be essential. By including bottom-line criteria, thereby ensuring bottom-line outcomes, the sustainability of new developments can be improved. Bottom-line criteria ensure a level of consistency in the application of the code.

d. **Codes must not excessively burden developers,** *and*

e. **There should be incentives for developers to plan in a more sustainable way**

LN applications have to be much more detailed, relative to conventional applications. This increases costs (money and time) for developers. By implication, government planning departments must more thoroughly scrutinise applications, particularly those for larger scale developments. It is therefore important that incentives be offered to developers in return. Tax relief and an expedited assessment process are possibilities.

f. **Codes need to facilitate increases in residential densities and land use mixing**

The LN code aims to facilitate increases in residential density and housing variety. Design codes in Perth and elsewhere have typically focused on keeping residential
densities low outside of centres, to preserve character (i.e. Christchurch City Plan, 1995). However:

LN ha[s] not delivered on the wider range of densities, mixed use development and main street neighbourhood centres, principally due to the small scale of applications...Many applications were considered LN ‘hybrids’ – utilising selected portions to suit (Taylor Burrrell Barnett, 2004: p16).

g. **Development must be coordinated rather than piecemeal**

Many of Perth’s newer neighbourhoods appear to be pepper-potted around the region, as the map of RESIDE’s study neighbourhoods shows (Figure 7.3). LNs are frequently interspersed with existing low density, car dependent neighbourhoods. Also, conventionally-designed neighbourhoods will continue to be built throughout the metropolitan region whilst the uptake of the LN code remains voluntary. Moreover, LNs vary considerably in size. The LNs in the main RESIDE sample (n=79) range from 5.1 to 575.14 hectares. Most are less than 100 hectares.

Piecemeal development has a number of consequences. Research in the UK found that piecemeal development (even if it is relatively sustainable) can only have limited effects on travel behaviour (Williams, 2001). In part, this is because people often still need to travel outside their neighbourhoods for employment. Moreover, there is no guarantee that people will shop locally. District and regional shopping complexes retain significant draw-power (Williams, 2001). Sydney-based research found that suburbanites have regional travel patterns (Olaru and Smith, 2005). That is, they leave their community often and for many reasons. They frequently make decisions to travel
outside their local communities (see Chapter 3). When LNs are not coordinated, people will tend to travel through conventional, sprawled neighbourhoods for many purposes.

In general, transport linkages between neighbourhoods should be well coordinated (Department for Transport, 2007). This helps to improve regional access and the walking and cycling environment. However, cohesion is difficult to achieve when adjacent developments are managed by different developers and are built at different times. Some developers place more emphasis on transport infrastructure than others.
h. **New developments should be in existing areas, not so frequently on greenfields sites**

Many new neighbourhoods are being built on the urban fringe, thereby perpetuating, not limiting sprawl. Williams (2001) notes that unsustainable travel patterns are difficult enough to change without further fringe development being allowed. Fringe growth can therefore undermine the sustainable transport agenda.
i. Land use and transport planning codes cannot address other influences on people’s travel behaviour

The built environment is not the only influence on transport decision-making. Chapter 3 explained how travel behaviour is influenced by personal preference, socio-demographics and a range of other factors. Perth drivers, for example, make somewhere in the vicinity of 250,000 car trips per day, each of which covers one kilometre or less (Premier’s Physical Activity Taskforce, 2006). Moreover, 48% of all trips by car are estimated to be less than 5 kilometres and 71% less than 10 kilometres (Wooldridge, 2005). In addition, slightly older data shows that 72% of trips to local facilities are made by car while only 21% are made by foot (DPI, 2000). All else being equal, given the short distance of so many trips, people could walk or cycle rather than drive. Personal preference helps to explain why they do not.

As such, planning suites such as LN may contribute to the sustainable land use and transport agenda but should not be implemented in isolation. Complementary policies, such as TravelSmart, are very important.

7.6 Summary

“No growth is not an option; the challenge is how to grow in ways that are healthy, socially just, and environmentally sustainable” (Frumkin et al., 2004: p202). Perth will continue to evolve as a city and the challenge for planners and policy-makers is to see land use and transport development occur in a durable, equitable and environmentally sensitive way.
This chapter has explored a range of approaches that have emerged as alternatives to conventional planning practice and to facilitate more sustainable transport. The various strengths and weaknesses of each were discussed, as was the contribution they can make to the sustainable planning agenda. Subsequently, it was argued that a significant degree of intergovernmental collaboration is necessary to ensure sustainability aims and objectives are met.

Next, the ‘Liveable Neighbourhoods’ design code was unpacked. LN is a Western Australian iteration of New Urbanism. Finally, a range of challenges to more sustainable urban planning were identified and related to the implementation of LN in the Perth metropolitan region.

Chapters 2 to 7 have provided a context for the empirical research. They have identified how, by international standards, Perth is a sprawled and car dependent city. Consequently, there is an urgent need for land use and transport planning redress because sprawl and car dependence are linked with a wide range of sustainability concerns, including social injustice, poor public health (i.e. pollution and physical inactivity) and oil dependence.

LN is considered to make a significant contribution to the sustainability agenda. However, there is a need for this assumption to be qualified. Until now, LN has not been evidence-based policy, therefore the principle research gap the TSH study aimed to fill was to show whether LN, as it is being implemented, is making differences as intended.
The next chapter outlines the TSH study methodology. The formative research, neighbourhood selection procedure and three main empirical research components are discussed.
Increasingly, evaluation researchers are recognising the benefits of combining qualitative and quantitative procedures, resulting in greater methodological mixes that strengthen the research design (Krueger, 1988: p39).
8.1 Introduction

Chapters 2-7 have synthesised a great deal of discourse relating to land use and transport planning, sustainability, and health. Some of the key concepts arising from this synthesis are that Australian land use and transport planning has replicated many aspects of the American approach - an approach that has favoured low density development and private vehicular mobility - and this has contributed greatly to current social justice, economic, environmental, public health and energy-related concerns. Whilst the thesis has highlighted the complexities of transport decision-making (refer to Chapter 3), strategic planning remains a very important mechanism for addressing deficiencies (including those related to transport) in our urban systems.

New Urbanism is a movement that has been well supported in Australian planning circles. The Liveable Neighbourhoods code was directly informed by New Urbanist theory and is an attempt to provide a sustainable planning mechanism in Perth. The TSH study was therefore calibrated to provide the first comprehensive analysis of the LN code to ascertain whether change is being achieved as intended. With it including such a large sample of study neighbourhoods (11 Liveable and 35 conventional) the TSH study was also calibrated to critique the New Urbanist theory underlying LN.

This Chapter outlines how primary data were obtained and used to conduct these analyses and help form a critique of LN and New Urbanism. First, it is explained how the TSH study was a sub-study of RESIDE. Second, the processes of neighbourhood and household selection are discussed. Third, the formative research is discussed, with this having helped to triangulate quantitative data collection. Fourth, the travel survey,
perceptual study and environmental study are introduced. Finally, the study design is summarised.

8.2 Overview of RESIDE

The TSH study was a cross-sectional sub-study of the longitudinal RESIDential Environments (RESIDE) project. It was funded by an Australian Research Council (ARC) grant, which was acquired to add three additional studies to the Healthway-funded RESIDE project, including a sustainable transport and health study. Through being a sub-study of RESIDE, the TSH study had access to expertise and data from the main project.

The main RESIDE project aims to evaluate the impact of the Department for Planning and Infrastructure’s ‘Liveable Neighbourhoods’ subdivision control policy on walking, cycling, use of public transport, and sense of community in communities designed according to these design principles. The main project design is shown in Figure 8.1.
8.3 Neighbourhood and household selection

Neighbourhoods and households were selected for the TSH study from the main RESIDE sample. A number of factors determined eligibility for the TSH study. To avoid overburdening RESIDE participants only those who were not scheduled to receive a RESIDE questionnaire in 2006\textsuperscript{38} were approached. These people had completed their baseline and first follow-up RESIDE questionnaires (Figure 8.1). As at 20 January 2006 (the selected cut-off date for eligibility), a total of 663 RESIDE study participants (and therefore 663 households) were eligible for the TSH study. These study participants were not scheduled to receive another RESIDE questionnaire until

\textsuperscript{38} The travel survey was administered in 2006.
2007. They were distributed throughout most of the 79 conventional and Liveable
neighbourhoods in the RESIDE sample.

Given the aims of the study, hybrid neighbourhoods, which have some Liveable and
some conventional characteristics, were not eligible for inclusion. Neighbourhood
selection was also informed by requirements for the travel survey.

Whilst the TSH study was being conducted, the Department for Planning and
Infrastructure (DPI) were approaching members of the Perth community as part of the
TravelSmart project (see Chapter 7). There were 26 RESIDE households involved in
the programme and they were omitted from the TSH study.

Neighbourhoods with two or fewer study households enrolled in the RESIDE study
were also deemed ineligible. These were excluded to improve data manageability.
Subsequently, two other neighbourhoods were removed because they were both near to
the coast and had relatively high average lot prices compared with other developments.
This helped to control for income amongst the sample.

Thus, the final sample included 497 RESIDE participants and their households,
distributed throughout 46 neighbourhoods. Table 8.1 shows how they were distributed
according to neighbourhood type. The number of CNs relative to LNs reflects the fact
that there were more conventional than Liveable neighbourhoods being developed in the
metropolitan region at the time of the study (refer also to Figure 8.2). The northernmost
neighbourhood is Ocean Lagoon, a CN, which is a straight-line distance of 49
kilometres from the Central Business District. The southernmost neighbourhood is
Mariners’ Cove, an LN, which is 65 kilometres from the CBD. Qualitative appraisal of
the sample of LNs indicated that they were representative of the population of LNs throughout the metropolitan region at the time of the research in regards to their locations near the urban fringe and broader design characteristics.

The travel survey was initially powered to 85% to enable detection of a difference between groups of 0.4 standard deviations (i.e. \( n=224 \) households). This balanced maximising the likelihood that relatively small variability in results could be identified with ensuring a manageable sample size.

Table 8.1 – RESIDE participants by neighbourhood classification

<table>
<thead>
<tr>
<th>Neighbourhood classification</th>
<th>Number of developments</th>
<th>Number of RESIDE participants/households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liveable</td>
<td>11</td>
<td>153</td>
</tr>
<tr>
<td>Conventional</td>
<td>35</td>
<td>344</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>46</strong></td>
<td><strong>497</strong></td>
</tr>
</tbody>
</table>

The sample size was then inflated to adjust for intra-neighbourhood clustering, as people’s travel behaviour and individual health variables can be influenced by neighbours and common environmental characteristics:

\[ [1 + (m - 1) \text{ corr}] \times n \]
This value was further inflated by 1.2 assuming a reasonable rate of refusal based on the recruitment procedure and the participation of households in the RESIDE project. The final value was thus 388. This was less than the total count of households initially approached for the study. Finally, the figure was inflated again to adjust for intra-household clustering. As more than one person was to be surveyed in most households it was assumed that members of the same household would have some common lifestyle characteristics. This was important for later multivariate analysis using individual-level data:

$$1 + (h - 1) \text{corr}$$

---

39 The TSH study was interested in the travel behaviour of all members of households aged five years or older, not only the travel behaviour of RESIDE participants.
In this formula $h$ is the average number of persons aged five years or over per household and $\text{corr}$ is the degree of correlation between members of the same household. The average household size in Perth has been estimated to be 2.7 persons following estimates that the figure would decrease over the long term from 2.9 in 1991 (DPI, 1995). This was a useful estimate for the purposes of this formula, although children less than five years of age were not to be included in the study. A $\text{corr}$ value of 0.6 was estimated given a relatively high likelihood that members of the same household would have some common lifestyle characteristics. The output value was therefore 2.02. The minimum number of households required to complete the study was 323. This figure, multiplied by 2.02 to control for intra-household clustering, could then be inflated by 1.2 again assuming a reasonable rate of refusal:

$$323 \times 2.02 = 652$$

Total number of persons required for the study

$$\therefore 652 \times 1.2 = 782$$

This (782) was the minimum number of persons to be invited to complete the travel survey, to meet the level of power required. This was less than the number of people who could potentially complete a travel diary ($497 \times 2.7$, minus a small number of people less than five years of age). The travel survey method and results are discussed in Chapter 9. In Chapter 9 it is also discussed how poor response and recruitment rates necessitated a second research cohort. This second cohort was recruited from the neighbours of the RESIDE participants.

The main RESIDE study provided the relevant perceptual and environmental data for all RESIDE participants (n=992) in the TSH study neighbourhoods (n=46). The
perceptual study methods and results are discussed in Chapter 10. The environmental study methods and results are discussed in Chapter 11.

8.4 Formative research

Formative research, including a series of visual audits and focus groups was included to inform the TSH study; to refine the various sub-studies and particularly, to help calibrate the travel survey.

8.4.1 Visual audit

Four LNs and four CNs were audited, with time and budget constraints, and data manageability limiting the sample. The sample neighbourhoods were selected by first grouping the study neighbourhoods (n=46) depending on how far they were from the Perth CBD and their size. Distance to the CBD was selected because it may be related to car dependency, which may be reflected in local infrastructure (i.e. fewer footpaths). However, distance to the CBD was not controlled for as part of quantitative analysis comparing the two types of neighbourhoods (LNs and CNs) because proximity to the CBD (or any other major activity centres) is not a prerequisite under the LN code. Neighbourhood size was selected because of the potential for environmental characteristics to be related to neighbourhood size. Using random numbers, a single neighbourhood was then selected from each of the eight groups. The grouping procedure is shown in Figure 8.3. Table 8.2 shows the randomly selected neighbourhoods and their characteristics.

40 Smaller neighbourhoods would not be expected to have a strong centre characterised by a range of services.
Figure 8.3 – Grouping procedure to select neighbourhoods for visual audit

Table 8.2 – Neighbourhoods selected for visual audit

<table>
<thead>
<tr>
<th>Code</th>
<th>Explanation</th>
<th>Name</th>
<th>Neighbourhood Code</th>
<th>Neighbourhood Size (hectares)</th>
<th>Distance to CBD (kilometres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Large, long</td>
<td>Beaumaris</td>
<td>NW54</td>
<td>93.66</td>
<td>33.81</td>
</tr>
<tr>
<td>2</td>
<td>Large, short</td>
<td>Banksia Grove, Brighton</td>
<td>NW30</td>
<td>461.26</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>Small, long</td>
<td>Beachside, Frankland Springs</td>
<td>NW44</td>
<td>18.9</td>
<td>37.38</td>
</tr>
<tr>
<td>4</td>
<td>Small, short</td>
<td>Sheffield Park</td>
<td>SW80</td>
<td>53.26</td>
<td>21.87</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Explanation</th>
<th>Name</th>
<th>Neighbourhood Code</th>
<th>Neighbourhood Size (hectares)</th>
<th>Distance to CBD (kilometres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Large, long</td>
<td>The Grove, Lansdale Gardens</td>
<td>NW154</td>
<td>364.44</td>
<td>23.48</td>
</tr>
<tr>
<td>6</td>
<td>Large, short</td>
<td>Gardens</td>
<td>NW12</td>
<td>194.68</td>
<td>15.78</td>
</tr>
<tr>
<td>7</td>
<td>Small, long</td>
<td>Meve</td>
<td>SW10</td>
<td>39.34</td>
<td>24.84</td>
</tr>
<tr>
<td>8</td>
<td>Small, short</td>
<td>Sheffield Park</td>
<td>E48</td>
<td>11.53</td>
<td>12.74</td>
</tr>
</tbody>
</table>
The visual audit tool (Appendix 1) was based on the Liveable Neighbourhood guidelines (WAPC, 2004) and the Sustainable Urban Design Practical Fieldwork Project guide (2005) from Murdoch University. Extensive field notes were taken as part of the auditing procedure, to allow for later analysis (see Loflund, 1971). Whilst most attention was paid to the transport-related audit items, the full range of audit items was:

- Neighbourhood structure
- Neighbourhood walkability
- Walkability to public transport and facilities
- Safety, surveillance and visual appeal
- Choice/flexibility/variety
- The extent to which design is responsive to the environment and culture
- Site-responsive design – character and identity
- Cost and resource efficiency
- Appraisal of traffic levels by mode

In February 2006, the visual audits were conducted over three separate weekends. Between 60 and 90 minutes were spent auditing each neighbourhood. A digital camera was used to take pictures of more significant neighbourhood features.

Upon completion of the visual audits, the notes on the audit tool were summarised and entered into framed tables in Microsoft Word (Appendices 2-9). In these tables, a value between one and five (one being poor/low and five being excellent/high) was assigned to each attribute for each neighbourhood. The values did not reflect rigorous appraisals of each attribute but rather were intended as guiding values. Comparisons were then
made between the framed tables for each neighbourhood to help contextualise the results of quantitative research.

8.4.2 Focus groups

Three focus groups were run, although four were planned\footnote{Despite a number of attempts, I was unable to arrange the fourth focus group, although two Residents’ Associations for two different LNs were approached.}. Human Ethics Committee approval for the focus groups was obtained from both Murdoch University and The University of Western Australia (refer Appendices 10 and 11). The aim of the focus groups was to ask residents of LNs and CNs about their attitudes towards and perceptions of access and transport in their neighbourhoods (see Bartunek and Louis, 1996). The author had been trained in conducting focus groups and thus was well positioned to moderate these sessions. Through the use of a defined set of guiding questions, the sessions remained on task (see Kumar et al., 1999; Vaughn et al., 1996).

The focus groups were formed from the Residents’ Associations (RAs) for each of the following neighbourhoods\footnote{Two LNs and two CNs were originally selected from the eight neighbourhoods that were audited.}:

1. Meve
2. The Grove
3. Frankland Springs

RAs were approached by email. Contact persons were identified through the Creating Communities network. Once contact was established with these ‘gate keepers’, a cover
The guiding questions (refer Appendix 13) used to frame the sessions were developed with reference to Krueger’s (1988) principles. These include that meaningful discussions arise when questions are appropriately contextualised and there cannot be an excess of issues to discuss. It was also designed to deal with the relevant issues in a systematic manner. To allow a full transcript to be prepared later, each session was tape-recorded. This also allowed the sessions to be effectively moderated without there being the distraction of note-taking. The participants gave both verbal and written permission for the recording. Each session had an attendance of between four and twelve people. This was to ensure they were large enough for a diverse range of opinions to be heard yet small enough so all participants had the opportunity to contribute (Krueger, 1988).

All were conducted between May and November 2006. Each was held in the local RA meeting venue. The sessions lasted for between 35 and 45 minutes (not including preamble and refreshments). During the preamble, when consents were obtained and general information was given out, participants were offered tea, coffee or a cold beverage and a selection of biscuits. This was to create an informal and relaxed atmosphere, which in turn would encourage involvement in the substantive part of the session (see Morgan and Spanish, 1984).

Following the focus groups the guiding questions were used to frame the reporting of findings (Krueger, 1988). First, a table was constructed in Microsoft Word. A row was appointed for each of the guiding questions. Summary comments where then entered.
into each row, for each neighbourhood. These comments were derived following a full review of the relevant transcripts. Particularly meaningful quotations were added to enrich the summaries. Dissenting comments were also entered verbatim, where relevant. This was important, as focus groups are intended to be a forum to identify subjectivities. As expected, people had differing points of view. The results are included as Appendix 14. Overall, the findings helped to triangulate and contextualise the quantitative components of the TSH study.

8.5 TSH study components

In research, combining several approaches is pragmatic, as the weaknesses of one approach can be compensated for by the strengths of another (Marshall and Rossman, 1989; Morgan, 1997; Puchta and Potter, 2004; Tashakkori and Teddlie, 1998; Wilkinson, 1998).

Hoehner et al. (2005) have argued that few studies have simultaneously assessed people’s perceptions of their environment and objective environmental measures, and their relative association with levels of physical activity. The TSH study aimed to take this three-pronged approach to research, with transport behaviour in general being of interest rather than physical activity per se. The design of the study was informed by US research where self-reported walking behaviour and perceptual information and objective environmental measures were used to help define the concept of the walkable neighbourhood (Moudon et al., 2006).
**8.5.1 Travel survey**

A travel survey was the first key component of the research. Travel surveys or diaries are an important part of travel behaviour research as they can produce robust findings (Burke, 2004). Survey findings can be subjected to rigorous statistical testing, which in turn can yield significant results.

Travel surveys usually require that the respondent keep a record of their travel behaviour for between one and seven days, depending on sample size, data requirements and level of statistical significance required. Frank and Pivo (1994) for example, designed a two-day diary for their cross-sectional study. Bagley and Mokhtarian (2002) and Kitamura *et al.* (1997) designed a three-day diary for their respective studies.

In their Swiss study, Axhausen and colleagues (2007) argue that longer duration diaries can be superior to the one and two day diaries commonly used in transport studies because they allow researchers to gain an understanding of intra-personal variance in travel choices, mode use and other aspects of travel behaviour. Furthermore, they allow a clearer picture of people’s activity spaces to be drawn. While there is some concern that longer diaries can be off-putting and can contribute to participant attrition (Stopher *et al.*, 2007), the researchers found respondent ‘fatigue’ in their study to be insignificant. The travel survey is discussed further in Chapter 9.

**8.5.2 Perceptual study**

Perceptions are considered to be intermediary in the relationship between the built environment and travel behaviour. Perceptions rather than environmental features may be more predictive of travel behaviour, because people need to be aware of destinations
and routes to reach them. It has been argued that people are “more likely to report the presence, rather than the absence of particular land uses when those land uses were closer to and more abundant around their homes” (Moudon et al., 2006: s108). One aim of the TSH study was therefore to consider whether there were consistencies between the environmental measures (actual opportunities), perceptual data (people demonstrating they are aware of opportunities) and the self-reported travel behaviour (people’s transport reflecting both awareness and the provision of opportunities). In the case of LNs, residents should, amongst other things, be undertaking relatively more local travel and using active modes more, which should be consistent with both higher relative awareness and provision of local opportunities (i.e. destinations to travel to). A range of perceptual measures were accessed from the main RESIDE study for 992 participants (these are discussed more in Chapter 10).

8.5.3 Environmental study

Four sets of environmental measures were derived with the assistance of RESIDE’s GIS analysts and transport professionals at Main Roads Western Australia. The first set of measures that were developed related to access to key destinations. They were derived for RESIDE households who, as of May 2007, both had a family member who had completed RESIDE’s first follow-up questionnaire and were situated in one of the TSH study neighbourhoods (n=992: 323 in LNs and 669 in CNs)43. The method and choice of destinations was informed by similar work by Holtzclaw (1994) and development of the Land Use and Public Transport Accessibility Index (LUPTAI) (Pitot et al., 2005). Holtzclaw’s (1994: p15) neighbourhood shopping index (NSI) measured “the fraction

43 That there were more than twice as many households in CNs than LNs included in the analysis is indicative of there being more RESIDE participants in CNs overall and many more CNs than LNs in the RESIDE neighbourhood pool.
of the community’s population which has five critical local commercial establishments within ¼ mile [402 metres] walking distance”.

Holtzclaw (1994) found that five destinations formed a credible measure of daily access: including fewer destinations was found to be significantly less reliable. Six destinations were chosen for the TSH opportunities index, as all could be anticipated to help anchor new neighbourhoods. Increasing the number of destinations from five to six also made the measures of access both more robust and a better proxy for land use mix. The selected destinations included:

1. Local shopping (a supermarket, deli or local general store)
2. Post facility (post box or post office)
3. Daycare centre
4. Newsagent
5. Medical (doctor or pharmacy)
6. Public transport stop (bus or rail)

Notably, a measure of green-space was not included in the TSH study. Previous studies have found that walkable neighbourhoods tend to be anchored by basic daily retail and food activities (Moudon et al., 2006). Moudon and colleagues also found that access to open space, such as parks, may be associated with increased physical activity, but were not important as anchor points in the walkable neighbourhood.

Key destinations (such as grocery stores) tended to be those associated with necessary rather than discretionary spending (Moudon et al., 2006). The LN code is not very
prescriptive about the type of retail activities that should be in local centres. Rather, the code states that:

A small retail store with a bus stop and post box, with some associated home-based business opportunities and some higher density housing…[would be the minimum components] of a neighbourhood centre under LN (WAPC, 2004; p122).

The second set of environmental measures related to network permeability. These used the access-related data discussed above. Permeability is a crucial factor in improving design to encourage more sustainable transport behaviour as it has the potential to significantly reduce the distance between homes, jobs and key facilities. An example of how permeability can differ in the urban landscape is given in Chapter 2 (Figures 2.3 and 2.4).

The third set of measurements that were developed related to residential lot density in the sample neighbourhoods. These were interpreted alongside the proxy measures of land use mix (access measures) to help evaluate activity intensity in the sample neighbourhoods. The measures of density were derived from information provided by and with the permission of the Western Australian Land Information Authority (Landgate) (2007). The principal reason for calculating residential lot density rather than population density was that census data, which is organised according to census collection districts (CCDs), could not be matched with households in the study neighbourhoods, because the CCDs and neighbourhoods had different boundaries.

Residential lot density was measured both with and without control for the size of the sample neighbourhoods and both with and without the inclusion of a neighbourhood
with exceptionally large residential lot sizes (i.e. four summary tables of findings were generated). In each of the analyses, average lot sizes, lots per site hectare (equivalent to an $R$ standard) and lots per urban hectare were calculated, depending on neighbourhood type. The method used to conduct the analyses was based on Forsyth’s (2007) GIS-related work and is discussed further in Chapter 11.

The fourth and final set of measures related to work trip substitutability and was an important complement to the access data. These measures were developed for those of the 992 RESIDE participants who reported that they drove to work in RESIDE’s first follow-up questionnaire. The participants must also have provided complete origin and destination data and reported working inside the metropolitan region. A total of 480 people (170 LN and 310 CN) met these criteria.

Work trips are the key daily, bounded trips that people make. Often, these will be regional rather than local trips, because of difficulties supplying specialised employment locally in sprawled cities. From a sustainability perspective, it is therefore important that people can undertake longer trips (for which it is not feasible to walk or cycle) by public transport without significant burden (measurable as a time sacrifice). While residents of LN are anticipated to have better access to public transport (measured by the opportunities indices), it is important that services then provide efficient access to other parts of the metropolitan region. A work trip substitutability measure was therefore a key gauge of this access potential.
8.6 Overall study design

The research was conducted across several phases. The formative research began in early 2006, followed by the travel survey some months later. The perceptual and environmental data were provided by the main RESIDE study and were received in June and October 2007, respectively. This information is summarised in Table 8.3.

Table 8.3 – A summary of the different research components and when research was conducted

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual audit of eight neighbourhoods</td>
<td>Completed over three weekends in February 2006</td>
</tr>
<tr>
<td>Focus groups with residents from three neighbourhoods</td>
<td>1. Meve (conventional) – 31 May 2006</td>
</tr>
<tr>
<td></td>
<td>2. The Grove (conventional) – 14 June 2006</td>
</tr>
<tr>
<td></td>
<td>3. Frankland Springs (Liveable) – 15 November 2006</td>
</tr>
<tr>
<td></td>
<td>4. *Brighton (Liveable) – no response</td>
</tr>
<tr>
<td>Travel survey</td>
<td><strong>Cohort 1:</strong></td>
</tr>
<tr>
<td></td>
<td>1. Recruitment – 11 April to 22 May 2006</td>
</tr>
<tr>
<td></td>
<td>2. Diaries posted – 22 May 2006</td>
</tr>
<tr>
<td></td>
<td>3. Follow-up – 9 to 20 June 2006</td>
</tr>
<tr>
<td></td>
<td><strong>Cohort 2:</strong></td>
</tr>
<tr>
<td></td>
<td>1. Recruitment – 7 September 27 October 2006</td>
</tr>
<tr>
<td></td>
<td>2. Diaries posted – 27 October 2006</td>
</tr>
<tr>
<td></td>
<td>3. Follow-up – 17 November to 1 December 2006</td>
</tr>
<tr>
<td>Environmental data</td>
<td>Accessed from the main RESIDE study. Data originally provided by Landgate and derived from the Perth metropolitan Yellow Pages. Information accurate for 2007. Data received October 2007 and March 2008</td>
</tr>
<tr>
<td>Perceptual data</td>
<td>Accessed from the main RESIDE study. Data originally collected in RESIDE’s first follow-up questionnaire. Data received June 2007</td>
</tr>
</tbody>
</table>

8.7 Summary

This chapter discussed how the TSH study is a sub-study of the RESIDE project. It has explained the process for selection of study neighbourhoods, participant households and study subjects. It has discussed the formative element of the research, which included
visual audits and a series of focus groups. These qualitative data collection techniques were used to help calibrate the quantitative components of the research. In addition, the various components of the TSH study, including a travel survey, perceptual study and environmental study were introduced, and the rationale underpinning each was described. Next, a data collection timeline was presented to give the reader an overall sense of the study design.

The following chapter describes the method used to conduct the travel survey. Subsequently, the findings of the survey are presented.
CHAPTER 9:

Travel survey

Method and results

A ‘starter castle’ in Beaumaris, a Liveable Neighbourhood

Source: Author

There’s not a lot of reason to walk or bicycle round here…You cannot get to the path along the freeway…you cannot get across Russell Road…you’d probably get bowled by a truck [Resident of Frankland Springs (a Liveable Neighbourhood), 2006].
9.1 Introduction

This chapter outlines the travel survey method and results. First, the diary design is described. Second, the pilot study is discussed. Third, participant selection, recruitment and response rates are explained. Fourth, data preparation is discussed. Fifth, the various analyses are explained (these were conducted at the trip, individual and household levels) and findings are presented. Finally, the key findings are summarised.

9.2 Diary design

A trip and activity diary was used to conduct the travel survey (see Goulias, 1997; Pas and Harvey, 1997). It asked respondents to record all characteristics of their trips, including purpose. The Transportation Research Board (2005: p223) notes “travel surveys are typically focused on purposeful travel and ignore physical activity for exercise or recreation”. The inclusion of a trip purpose field was therefore important for later analysis to compare discretionary with necessary trips and purposeful with incidental active travel.

The travel diary used in the TSH study was based on those used for the Perth Regional Travel Surveys 1976, Perth and Regions Travel Survey 2002-2006 and Burke’s (2004) research into gated communities in the city of Brisbane. These are, in turn, representative of the innumerable similar household travel surveys that have been conducted around the world over the last 50 years as part of major land-use and transport studies. Dr Peter Lawrence, a travel diary specialist, and transport professionals at Main Roads Western Australia and the Department for Planning and Infrastructure provided comments on the diary design.
The instrument was designed to capture a range of data relating to transport behaviour, individual health variables and energy consumption. The inclusion of health variables was important to enable investigation of linkages between risk factors (including body mass index) and self-reported transport behaviour.

Items in the survey were limited to avoid overburdening participants. Thus, relevant perceptual data were derived from RESIDE’s first follow-up questionnaire (see Chapter 10). A range of demographic variables was included in the survey, such as gender, age and education. Household income was omitted because it was regarded as sensitive and all precautions were taken to minimise non-response\footnote{Some household income data was provided by RESIDE, as it was collected in the first follow-up questionnaire.}.

The supporting material sent with the diary encouraged participants to record their travel details immediately after a trip, on notepaper if necessary (so the diary could be updated later). This helped to avoid recall bias. As the TSH study was particularly concerned with active transport, it was important that linkage trips were recorded, as these are often walked. Walking is often underestimated in travel surveys because participants fail to report these linkage trips (Hass-Klau, 2003). Therefore, support material sent with the diaries requested that participants pay particular care to reporting these trips.

\subsection*{9.3 Pilot study}

Prior to administration, the survey instruments were piloted tested with staff and postgraduate students from the Institute of Sustainability and Technology Policy at Murdoch University. Members of their households were also recruited, giving a total of
30 participants. In November 2005 the diaries were administered. Participants were invited to both complete the diary and provide feedback on the instrument. By the end of January 2006, 17 had been completed and returned. Though the response rate was disappointing, at around 57%, invaluable feedback was received. Based on the feedback provided, the survey instrument was finalised.

9.4 Diary design, participant selection, recruitment and method and response rates

Although it was initially planned for there to be a single research cohort, a poor response and recruitment rate necessitated recruitment of a second cohort. The first cohort was recruited from participants in the main RESIDE study. The second was recruited from their neighbours. The particulars of each cohort are described below.

9.4.1 Cohort One

In Cohort One, participants completed a seven-day travel diary. This ensured that data relating to both weekday and weekend activity would be included. Participants who were already part of the main RESIDE study were sent a different diary to those who were not to avoid duplication of collection of data (Appendices 15 and 16). The RESIDE participants completed a travel diary containing mobility questions for the whole household. Participants not otherwise involved in RESIDE completed a diary containing health-related questions (information already captured from RESIDE participants). The trip entry pages in the diaries were standardised for all participants.
Cohort One was selected from the main RESIDE study sample (the process was explained in Chapter 8). An administration database was developed to keep track of the respective participants and their households, along with all related paperwork. Prior to sending out any formal requests for people to participate in the study, human ethics approval was obtained from both Murdoch University and The University of Western Australia (Appendices 10 and 11). The recruitment procedure is detailed in Table 9.1. All members of the household aged five years and over were invited to participate. Follow-up recruitment and later reminder letters were sent to households that had not responded or returned the diaries, respectively. Copies of all the letters and associated paperwork are included in the Appendices (refer Appendices 17-24).

A bicycle was offered as a major prize with those who completed diaries entered in the draw. The Department for Planning and Infrastructure also provided T-shirts and walking guidebooks as minor prizes. No inducements were offered to individuals or households to encourage participation as it was assumed that ongoing participation in the RESIDE study demonstrated a willingness to complete associated questionnaires.

The response to the RESIDE sub-study was poor. Thus, on 16 May a RESIDE telephonist contacted 37 households that had not responded to the invitation letters in an attempt to identify any problems that might explain the response. Three households responded that they were not interested in the study, nine agreed to participate and the remainder either said they had not received any paperwork despite their addresses being matched in the RESIDE database, or were 'in the process of replying'. Of the nine positive responses, three households returned six completed diaries. This suggested that had funding been available, further telephone follow-up may have yielded a higher level of recruitment.
Table 9.1 – Recruitment procedure for Cohort One

<table>
<thead>
<tr>
<th>Recruitment phase</th>
<th>Postal date</th>
<th>Included material</th>
</tr>
</thead>
<tbody>
<tr>
<td>First recruitment</td>
<td>11 April 2006</td>
<td>Introductory letter, a reply-paid envelope, a copy of the Frequently Asked Questions (FAQs), a consent form for the household to complete and keep and one to complete and return</td>
</tr>
<tr>
<td>Second recruitment</td>
<td>25 April 2006</td>
<td>Second recruitment letter</td>
</tr>
<tr>
<td>Administration of travel diaries</td>
<td>22 May 2006</td>
<td>Travel diaries, a cover letter with instructions and a reply-paid envelope</td>
</tr>
<tr>
<td>First follow-up</td>
<td>9 June 2006</td>
<td>First follow-up letter</td>
</tr>
<tr>
<td>Second follow-up</td>
<td>20 June 2006</td>
<td>Second follow-up letter</td>
</tr>
</tbody>
</table>

A postal cut-off date for the travel diaries of 22 May was set, to minimise the likelihood that the travel behaviour of participants would be affected by winter weather. By the cut-off point a total of 88 households (189 people) had agreed to participate. A total of 68 households had either declined to participate or were ineligible and had returned a reply-paid card provided with the invitation stating so. A further 7-10% attrition rate was assumed, once the diaries were posted, based on the experiences of other researchers (see Burke, 2004). This was because some people either choose to pull out of the study or provide ineligible responses (see Table 9.2).

By mid-July, 27 participants had withdrawn from the study while two diaries were returned but unusable. A further 54 were unaccounted for. A total of 110 completed, usable diaries had been received back from 52 households (see the third last entry in Table 9.2). This was well below projections and also too small a sample to achieve the level of statistical power required. The non-response rate had been underestimated and the willingness of RESIDE participants to be part of the TSH study had been overestimated. Accordingly, plans were developed to recruit a second cohort.
Table 9.2 – Recruitment and response statistics for Cohort One

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Households Approached</td>
<td>497</td>
</tr>
<tr>
<td>Estimated Households to Accept</td>
<td>414 (83.3%)</td>
</tr>
<tr>
<td>Estimated Total Person Acceptance</td>
<td>1,000-1,100</td>
</tr>
<tr>
<td>Actual Household Acceptance</td>
<td>88 (17.7%)</td>
</tr>
<tr>
<td>Actual Total Person Acceptance</td>
<td>189</td>
</tr>
<tr>
<td>Household Refusals/Ineligible</td>
<td>68</td>
</tr>
<tr>
<td>Household No Response</td>
<td>341 (68.6%)</td>
</tr>
<tr>
<td>Estimated Total Person Count After Attrition</td>
<td>170</td>
</tr>
<tr>
<td>Actual Number of Completed, Useable Diaries</td>
<td>110 (16.87% of required) (78 in CNs, 32 in LNs)</td>
</tr>
<tr>
<td>Total Number of Persons Required for the Study</td>
<td>652</td>
</tr>
<tr>
<td>Shortfall of Participants</td>
<td>542 (83.13% of required)</td>
</tr>
</tbody>
</table>

The feedback received throughout the recruitment procedure partially explained why the response and recruitment rates were so poor. In summary, some prospective participants were apathetic towards the study because they saw no personal benefit and a few persons felt overburdened, which prevented their participation.

9.4.2 Cohort Two

Given the poor response to the survey from RESIDE study participants, it was decided to attempt to recruit the neighbours of the original households (n=497) to form a second cohort. This enabled the later use of RESIDE environmental data, given the close geographical proximity of the households involved in Cohort Two and RESIDE households. A research review forecast a positive response rate of around 22-25% to ‘cold’ mail recruitment. At least 1,270 households would then be targeted to recruit sufficient participants to cover the shortfall. It was expected, too, that some addresses would be vacant sites, non-existent or commercial premises.
Additional human ethics approval was obtained from both Murdoch University and The University of Western Australia. In September 2006, funding from the City of Mandurah was secured to assist with this additional data collection. Recruitment for Cohort Two was postponed to avoid the effects of winter weather on travel patterns (particularly incidences of walking and cycling) and commenced in September.

In Cohort Two, a two-day rather than seven-day diary was administered. The shortened length of the diary was intended to reduce respondent burden (yet ensure sufficient data was collected for detailed analyses) with a view to improving the response rate. Participants were directed to complete a diary for one weekday and one day in the weekend. Members of Cohort Two were also asked additional socio-demographic and health questions, as these data were not already available as they were for the main RESIDE participants. One person per household was administered a travel diary including household mobility questions (refer Appendices 25 and 26).

Using a spreadsheet of the 497 original addresses from Cohort One, addresses one number below and two above were identified. All post office box addresses were omitted beforehand. In instances where an original address was 1 N Street, addresses two and four higher were selected instead. Given that RESIDE study participants may have been neighbours, care was taken to avoid including households in Cohort Two that had already been approached for participation in Cohort One. Subsequently, 982 addresses were identified as eligible for inclusion in Cohort Two.

To further inflate this number, all addresses four higher than those in the original list were added (minus any duplicate addresses from Cohort One). This produced an

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45 Each weekday was assigned to 20% of participants and each weekend day to 50% of participants.
additional 417 addresses, making the total 1,397. Once again, an administration
database was developed to keep track of paperwork and participants. Examples of the
selection procedure are in Table 9.3.

A research assistant was hired for the recruitment phase. Table 9.4 outlines the
recruitment procedure. All members of households aged five years and over were
invited to participate. Follow-up recruitment and later reminder letters were sent to
households that had not responded or returned the diaries, respectively. There was no
telephone follow-up of non-respondents as telephone numbers were not available as
they were for the RESIDE group. Copies of all the letters and associated paperwork are
included in the Appendices (refer Appendices 27-34).

In an effort to improve response and recruitment rates, people were offered a chance to
win a $50 Bunnings voucher if they replied to the recruitment letters (either yes or no).
Those households that accepted the invitation also were sent a Video Ezy movie
voucher with their travel diaries, as a small token of appreciation for their participation.
Also, those persons who returned completed diaries were offered the chance to win a
second bicycle in a prize draw.

Table 9.3 – Sample selection for Cohort Two

<table>
<thead>
<tr>
<th>Cohort One address</th>
<th>Cohort Two address</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 Sarah Street</td>
<td>79 Sarah Street</td>
</tr>
<tr>
<td>1 Sarah Street</td>
<td>2 Sarah Street</td>
</tr>
<tr>
<td>3 Sarah Street</td>
<td>2 Sarah Street</td>
</tr>
<tr>
<td></td>
<td>5 Sarah Street</td>
</tr>
<tr>
<td></td>
<td>7 Sarah Street</td>
</tr>
</tbody>
</table>
The response and recruitment statistics for Cohort Two are summarised in Table 9.5. Overall, 132 people in 63 households were recruited in Cohort Two. A total of 130 households refused, 550 letters were ‘returned to sender’ and the remaining households were non-responsive. The actual positive response rate was therefore a very low 7.43% (acceptances relative to eligible households). By January 2007, 101 completed diaries had been returned from 51 households giving a final response rate of 1.96 per eligible household. Four further households had withdrawn. The remaining households did not respond.

The final two rows in Table 9.5 illustrate the total number of diaries completed by both cohorts and this figure as a percentage of the originally required sample size (so as to be powered to 85% to enable detection of a difference between groups of 0.4 standard deviations). After consulting with RESIDE’s biostatisticians, it was concluded that significant statistical analysis could still be undertaken with the available data. Moreover, triangulating the survey data with the perceptual and environmental studies would strengthen the interpretation of the findings.
**Table 9.5 – Recruitment and response statistics for Cohort Two**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households Approached</td>
<td>1,397</td>
</tr>
<tr>
<td>Estimated Households to Accept</td>
<td>307-349 (22-25%) – ineligible households</td>
</tr>
<tr>
<td>Estimated Total Person Acceptance</td>
<td>660-750 (assuming similar response/household to Cohort 1)</td>
</tr>
<tr>
<td>Actual Household Acceptance</td>
<td>63 (7.43%)</td>
</tr>
<tr>
<td>Actual Total Person Acceptance</td>
<td>132</td>
</tr>
<tr>
<td>Household Refusals/Ineligible</td>
<td>680 (48.7%)</td>
</tr>
<tr>
<td>Household No Response</td>
<td>654 (46.8%)</td>
</tr>
<tr>
<td>Actual Number of Completed, Useable Diaries</td>
<td>101 (78 in CNs, 23 in LNs)</td>
</tr>
<tr>
<td>Cohort One + Cohort Two</td>
<td>101 + 110 = 211 (156 in CNs, 55 in LNs)</td>
</tr>
<tr>
<td>Total participants as percentage of originally required sample size</td>
<td>32.36% (211 of 652)</td>
</tr>
</tbody>
</table>

### 9.5 Data preparation

A codebook was developed following the pilot survey (Appendix 35). It was loosely based on the codebook used for the Perth Household Travel Survey 1986. It was designed to rationalise the data and render it manageable for statistical analysis. For example, trip purpose was coded according to one of six categories. These were journeys to or from:

1. Work
2. Education
3. Shopping
4. For the benefit of others (an interesting measure of travel dependency)
5. Leisure
6. Other
Data from completed surveys were cleaned and participants were telephoned to clarify any ambiguous responses. This process of follow up was done as soon as possible after the surveys were returned to ensure that travel details were fresh in the minds of participants. Where doubt remained (most often when a link trip or return journey was missed), no details were added. This was because it is sometimes better to avoid speculating, because even when a few details are left out “a satisfactory and fairly uniform picture emerges” (Brög et al., 1983: p16). Across both cohorts, only two diaries proved unusable (these were not included in the 211).

Where relevant, all responses were recoded according to the codes prescribed in the codebook. Many participants did not complete the health fields in the survey or indicated they were unsure of any medical conditions. This rendered the health information unreliable. Height and weight information, however, was consistently provided. This allowed for calculation of BMI.

Following coding, in March 2007 the 211 completed diaries were entered into excel spreadsheets by rORE data, a Perth-based data entry company, before being exported into SPSS (version 15.0). Prior to analysis the data were cleaned.

Online street directories were used to complete all trip-related fields. This ensured a geographic point could be provided for each trip origin and destination, even if this was the nearest street intersection. Additionally, in instances where a street name but no suffix was given (e.g. N Road or N Street), street directories were used to triangulate intersections, thereby confirming the suffix and adding to accuracy.
9.5.1 Modelled travel distances and times using network models

Main Roads Western Australia assisted by modelling distances and times for all trips using their zone-based network models and trip formulae. The derived information reflected rational travel behaviour: i.e. people taking the shortest possible route between origin and destination. For circular trips, (i.e. trips with the same origin and destination) the measures were estimated using the data available, such as mode used and zone data.

9.5.2 Key derived trip-level variables

The mode data were recoded into four categories: motor vehicle, public transport, walking and cycling (i.e. train, bus and ferry were all recoded as public transport). To enable a finer-grained examination of trip characteristics, reported trip information was used to derive a range of other relevant variables. The most important of these are shown in Table 9.6.

The trip purposes of most interest for this study were work, shopping and leisure. Work trips represent the most significant and regular bounded trip most individuals make (Naess, 2005). Shopping trips were of particular interest given the intention of LN to facilitate a certain degree of neighbourhood self-sufficiency: an outcome that may be gauged by shopping trip patterns. Leisure trips were also important, as they were distinct from utilitarian travel.
Table 9.6 – Derived trip-related variables

<table>
<thead>
<tr>
<th>Original variables</th>
<th>Derived variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reported mode</td>
<td>Was the chosen mode a motor vehicle, public transport, walking or cycling? (Motor vehicle=1, Public transport=2, Walking=3, Cycling=4)</td>
</tr>
<tr>
<td>Mode choice and reported vehicle occupancy</td>
<td>Was a vehicle trip single or multiple-occupancy? (Single=1, Multiple=0)</td>
</tr>
<tr>
<td>Trip purpose and mode choice</td>
<td>What was the mode used for work, shopping and leisure trips? (Motor vehicle=1, Public transport=2, Walking=3, Cycling=4)</td>
</tr>
<tr>
<td>Trip distance</td>
<td>Was it a short trip? (i.e. ( \leq ) 1,500 metres) (Yes=1, No=0)</td>
</tr>
<tr>
<td>Whether or not a trip was short and mode choice</td>
<td>What mode was used for a short trip? (Motor vehicle=1, Public transport=2, Walking=3, Cycling=4)</td>
</tr>
<tr>
<td>Trip purpose, and distances and times</td>
<td>Work, shopping and leisure trip distances and times</td>
</tr>
<tr>
<td>Trip purpose</td>
<td>Was it a utilitarian or leisure trip? (Utilitarian=1, Leisure=2)</td>
</tr>
<tr>
<td>Mode choice</td>
<td>Was an active mode used? (Yes=1, No=0)</td>
</tr>
</tbody>
</table>

Self-reported travel times were also derived for walking and cycling trips (using reported departure and arrival times), given these were typically short. These could then be compared to the modelled data. Standardised Main Roads figures were less reliable for short trips, because of the inability of the zone-based transport model to accurately predict the characteristics of trips that did not cross over zone boundaries.

9.5.3 **Key derived individual-level variables**

The travel survey contained a range of individual-level, socio-demographic variables, including gender; age; occupation; education; whether or not the participant had a mobility impairment and if so, how serious the impairment was; height and weight.
US Centers for Disease Control (CDC) BMI interpretations for both adults and children were used (refer Tables 9.7 and 9.8). Participant’s BMI was calculated using the standard formula of weight (kilogrammes) divided by height$^2$ (in metres):

$$\text{Weight} = \frac{\text{BMI}}{\text{Height}^2}$$

A range of other key individual-level variables was also derived. These are reported in Table 9.9.

**Table 9.7 – Interpretation of BMI for adults**

<table>
<thead>
<tr>
<th>BMI</th>
<th>Weight Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 18.5</td>
<td>Underweight</td>
</tr>
<tr>
<td>18.5 – 24.9</td>
<td>Normal</td>
</tr>
<tr>
<td>25.0 – 29.9</td>
<td>Overweight</td>
</tr>
<tr>
<td>30.0 and Above</td>
<td>Obese</td>
</tr>
</tbody>
</table>

(Source: CDC, 2007a)

**Table 9.8 – Interpretation of BMI for children and teens**

<table>
<thead>
<tr>
<th>Weight Status Category</th>
<th>Percentile Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>Less than the 5th percentile</td>
</tr>
<tr>
<td>Healthy weight</td>
<td>5th percentile to less than the 85th percentile</td>
</tr>
<tr>
<td>At risk of overweight</td>
<td>85th to less than the 95th percentile</td>
</tr>
<tr>
<td>Overweight</td>
<td>Equal to or greater than the 95th percentile</td>
</tr>
</tbody>
</table>

(Source: CDC, 2007b)
Table 9.9 – Derived individual-level variables

<table>
<thead>
<tr>
<th>Original variables</th>
<th>Derived variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip distance data and total number of reported trips</td>
<td>Average trip distances</td>
</tr>
<tr>
<td>Trip time data and total number of reported trips</td>
<td>Average trip times</td>
</tr>
<tr>
<td>Mode choice data and vehicle occupancy</td>
<td>Average vehicle trip occupancies</td>
</tr>
<tr>
<td>Trip distance and mode choice data, and average number of trips per day</td>
<td>Daily private VKT per person</td>
</tr>
<tr>
<td>Mode choice data</td>
<td>Proportional use of motor vehicles, public transport, walking and cycling</td>
</tr>
<tr>
<td>Mode choice and trip purpose data</td>
<td>Modal splits for reported work, shopping and leisure trips</td>
</tr>
<tr>
<td>Trip purpose and trip distance data</td>
<td>Purpose of short trips</td>
</tr>
<tr>
<td>Mode choice and trip distance data</td>
<td>Modal split for reported short trips</td>
</tr>
</tbody>
</table>

9.5.4 Key derived household-level variables

Four measures were originally collected at the household level. These were household size (people per household), motor vehicles available, the number of licensed drivers in each household and cycles available. The original measures were used to derive the number of motor vehicles and cycles per person in each household, and the ratio of licensees to household size.

9.5.5 Transport energy use and emissions

Online motor vehicle resources were used to identify the cylinder capacity (cc) ratings of vehicles, in instances where this information was not reported. Next, motor vehicle trip distance and time values were entered into a power-based model to calculate vehicle
emissions and transport energy use (Leung and Williams, 2000). The computations assumed average tuning of engines (maintenance of vehicles was not controlled for) but controlled for cylinder capacity (cc rating) and production year. Output values included average speed (kilometres per hour), fuel consumption (millilitres per minute), carbon monoxide, hydrocarbons and nitrogen oxide (all grams per kilometre). Trip measures were then developed by multiplying fuel consumption by trip time and the other values by trip distance.

9.6 Statistical analyses

Descriptives and bivariate statistical tests (chi squares for categorical data and t-tests for independent means for scale data) were undertaken on the trip-level, individual-level, household-level data and the transport energy use and emissions information. Some multivariate (discriminant) analyses were also conducted to validate patterns of differences between LN and CN. The discriminant analysis involved finding the best linear combination of variables for discriminating between LN and CN. The relative discrimination value for each variable in the model is calculated as the estimated linear discriminant function (unstandardised) coefficient multiplied by the standard deviation of the variable.

The overall performance of the model in discriminating between LN and CN is assessed by the percentage correctly predicted/classified by the model and the cross-validated percentage correct, which removes bias associated with using the same data for model estimation and prediction. The results of the analyses are reported below.
9.7 Results

9.7.1 Trip-level data

a. Bivariate analyses findings

Table 9.10 shows the associations between neighbourhood type and the basic trip-level variables, including mode, purpose and motor vehicle particulars if a motor vehicle was used to conduct a trip. Table 9.11 shows the descriptive statistics for mode use depending on trip purpose, whilst Table 9.12 shows them for the characteristics of short trips. In all instances, significant findings are emboldened in the tables. Figures 9.1 and 9.2 are histograms showing mode use for all trips and mode use for short trips, respectively.

Irrespective of neighbourhood classification, the most notable finding was the high level of motor vehicle use. Overall, 79% of all trips were made by motor vehicle. Nevertheless, there were significant differences in mode use (i.e. driving and walking) between the two types of neighbourhood. Figures 9.1 and 9.2 illustrate these patterns. For example, 72% of trips made by residents of LNs were by motor vehicle and 21% were by walking, compared with 82% and 12% by residents of CNs, respectively. Whilst a relatively small proportion of all trips were short, the associated modal splits tell a similar story of difference, depending on neighbourhood type (refer Figure 9.2). However, the motor vehicle trips by residents of LNs were significantly more likely ($p<0.01$) to be single-occupancy (i.e. 49% compared with 41%) and had a significantly lower average occupancy (i.e. 1.83 compared with 2.07) ($p<0.01$).
Furthermore, there were significant differences in average trip times and distances (both $p<0.05$) (see Table 9.10). Trips reported by residents of CNs were consistently longer. Compared with LN residents, residents of CNs also reported a relatively low proportion of short compared with regional trips, a much higher proportion of utilitarian rather than leisure trips and a relatively low proportion of active mode use (walking and cycling). In addition, the motor vehicles used by residents of CNs tended to have more cylinder capacity, but generally had a later production year.

Differences in mode use depended upon the three key trip purposes (work, shopping and leisure) (see Table 9.11). Whilst most trips overall were conducted by motor vehicle, residents of CNs were significantly more likely to drive for work trips ($p<0.01$). However, for both shopping and leisure trips there were no significant differences between types of neighbourhood in motor vehicle use ($p=0.548$ and $p=0.345$, respectively).

The results suggest that trip times and distances did not vary significantly when trips were for the purposes of work or shopping. They did vary significantly, however, when the trips were for leisure. These trips were significantly longer (both time and distance-wise) for residents of CNs ($p<0.01$). However, residents of CNs tended to drive for leisure and therefore did not achieve more transport-related physical activity than residents of LNs.

Overall, 24% of trips made by residents of LN were short, compared with 16% by residents of CNs ($p<0.01$) (refer to Table 9.12), although these trips were not necessarily made within study participants’ neighbourhoods of residence. Some work
trips, for example, were conducted throughout the working day: they were not the journey to or from work.

Table 9.12 also shows that a higher proportion of short trips made by residents of CNs were by motor vehicle (35%), compared with those made by residents of LNs (29%), although the finding did not reach statistical significance ($p=0.075$). An examination of the raw data helps explain these results. Many of the short motor vehicle trips occurred as part of a trip chain (i.e. during a journey home from work, a person might make a trip to a grocers, then to pick a child after their participation in an after-school activity).
Table 9.10 – Basic trip-level variables, including mode, purpose and motor vehicle particulars if a motor vehicle was used to conduct a trip by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=1,191)</td>
<td>Conventional (n=2,690)</td>
<td>(n=3,881)</td>
</tr>
<tr>
<td><strong>Mode (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle</td>
<td>72.10</td>
<td>81.50</td>
<td>78.60</td>
</tr>
<tr>
<td>Public transport</td>
<td>3.90</td>
<td>3.60</td>
<td>3.70</td>
</tr>
<tr>
<td>Walk</td>
<td>21.30</td>
<td>12.30</td>
<td>15.00</td>
</tr>
<tr>
<td>Cycle</td>
<td>2.70</td>
<td>2.60</td>
<td>2.70</td>
</tr>
<tr>
<td><strong>Was the trip made by motor vehicle? (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>72.10</td>
<td>81.50</td>
<td>78.60</td>
</tr>
<tr>
<td>No</td>
<td>27.90</td>
<td>18.50</td>
<td>21.40</td>
</tr>
<tr>
<td><strong>Was the trip made by public transport? (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3.90</td>
<td>3.60</td>
<td>3.70</td>
</tr>
<tr>
<td>No</td>
<td>96.10</td>
<td>96.40</td>
<td>96.30</td>
</tr>
<tr>
<td><strong>Was the trip made by foot? (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>21.30</td>
<td>12.30</td>
<td>15.00</td>
</tr>
<tr>
<td>No</td>
<td>78.70</td>
<td>87.70</td>
<td>85.00</td>
</tr>
<tr>
<td><strong>Was the trip made by cycle? (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2.70</td>
<td>2.60</td>
<td>2.70</td>
</tr>
<tr>
<td>No</td>
<td>97.30</td>
<td>97.40</td>
<td>97.30</td>
</tr>
<tr>
<td><strong>Was an active mode used for the trip? (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

309
<table>
<thead>
<tr>
<th>Yes</th>
<th>23.90</th>
<th>14.90</th>
<th>17.70</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>76.10</td>
<td>85.10</td>
<td>82.30</td>
</tr>
</tbody>
</table>

**Model year of vehicle if motor vehicle used for trip [mean (SD)]**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1998.94 (4.79)</td>
<td>1999.40 (5.31)</td>
<td>1999.27 (5.17)</td>
</tr>
<tr>
<td>No</td>
<td>2258.16 (858.58)</td>
<td>2436.70 (809.49)</td>
<td>2386.42 (827.38)</td>
</tr>
</tbody>
</table>

**Cylinder capacity of vehicle if motor vehicle used for trip [mean (SD)]**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>2.07 (1.22)</td>
<td>2.07 (1.22)</td>
<td>2.00 (1.17)</td>
</tr>
<tr>
<td>No</td>
<td>1.83 (0.99)</td>
<td>2.07 (1.22)</td>
<td>2.00 (1.17)</td>
</tr>
</tbody>
</table>

**Vehicle occupancy if motor vehicle used for trip [mean (SD)]**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>48.90</td>
<td>40.50</td>
<td>42.90</td>
</tr>
<tr>
<td>Multiple</td>
<td>51.10</td>
<td>59.50</td>
<td>57.10</td>
</tr>
</tbody>
</table>

**If the trip was a vehicle trip, was it single or multiple-occupancy? (%)**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>48.90</td>
<td>40.50</td>
<td>42.90</td>
</tr>
<tr>
<td>Multiple</td>
<td>51.10</td>
<td>59.50</td>
<td>57.10</td>
</tr>
</tbody>
</table>

**Trip time (in minutes) [mean (SD)]**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>13.31 (13.95)</td>
<td>14.53 (13.57)</td>
<td>14.16 (13.70)</td>
</tr>
<tr>
<td>No</td>
<td>11.34 (13.41)</td>
<td>12.44 (13.34)</td>
<td>12.10 (13.37)</td>
</tr>
</tbody>
</table>

**Trip distance (in kilometres) [mean (SD)]**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>20.60</td>
<td>18.50</td>
<td>19.10</td>
</tr>
<tr>
<td>No</td>
<td>20.20</td>
<td>18.50</td>
<td>19.10</td>
</tr>
</tbody>
</table>

**Purpose (%)**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Yes</th>
<th>No</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Work related</td>
<td>20.60</td>
<td>18.50</td>
<td>19.10</td>
</tr>
<tr>
<td>Education</td>
<td>7.60</td>
<td>6.50</td>
<td>6.80</td>
</tr>
<tr>
<td>Shopping</td>
<td>20.20</td>
<td>22.30</td>
<td>21.60</td>
</tr>
<tr>
<td>For the benefit of others</td>
<td>13.80</td>
<td>14.90</td>
<td>14.50</td>
</tr>
<tr>
<td>Leisure</td>
<td>9.90</td>
<td>8.90</td>
<td>9.20</td>
</tr>
<tr>
<td>Other</td>
<td>27.90</td>
<td>29.00</td>
<td>28.70</td>
</tr>
</tbody>
</table>

**Was the trip for utilitarian or leisure purposes? (%)**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Yes</th>
<th>No</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilitarian</td>
<td>90.10</td>
<td>91.10</td>
<td>90.80</td>
</tr>
<tr>
<td>Leisure</td>
<td>9.90</td>
<td>8.90</td>
<td>9.20</td>
</tr>
</tbody>
</table>
Table 9.11 – Mode use depending on trip purpose by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=1,191)</td>
<td>Conventional (n=2,690)</td>
<td>(n=3,881)</td>
</tr>
<tr>
<td><strong>Work trip mode (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle</td>
<td>68.20</td>
<td>80.20</td>
<td>76.20</td>
</tr>
<tr>
<td>Public transport</td>
<td>11.00</td>
<td>7.90</td>
<td>8.90</td>
</tr>
<tr>
<td>Walk</td>
<td>17.60</td>
<td>8.30</td>
<td>11.30</td>
</tr>
<tr>
<td>Cycle</td>
<td>3.30</td>
<td>3.60</td>
<td>3.50</td>
</tr>
<tr>
<td><strong>Was a work trip made by motor vehicle? (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>68.20</td>
<td>80.20</td>
<td>76.20</td>
</tr>
<tr>
<td>No</td>
<td>31.80</td>
<td>19.80</td>
<td>23.80</td>
</tr>
<tr>
<td><strong>Work trip time (minutes) [mean (SD)]</strong></td>
<td>22.12 (15.50)</td>
<td>21.71 (13.43)</td>
<td>21.84 (14.14)</td>
</tr>
<tr>
<td><strong>Work trip distance (kilometres) [mean (SD)]</strong></td>
<td>18.97 (15.45)</td>
<td>18.63 (13.97)</td>
<td>18.74 (14.47)</td>
</tr>
<tr>
<td><strong>Shopping trip mode (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle</td>
<td>90.00</td>
<td>91.30</td>
<td>90.90</td>
</tr>
<tr>
<td>Public transport</td>
<td>0.00</td>
<td>2.30</td>
<td>1.70</td>
</tr>
<tr>
<td>Walk</td>
<td>10.00</td>
<td>6.00</td>
<td>7.20</td>
</tr>
<tr>
<td>Cycle</td>
<td>0.00</td>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Was a shopping trip made by motor vehicle? (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>90.00</td>
<td>91.30</td>
<td>90.90</td>
</tr>
<tr>
<td>No</td>
<td>10.00</td>
<td>8.70</td>
<td>9.10</td>
</tr>
<tr>
<td><strong>Shopping trip time (minutes) [mean (SD)]</strong></td>
<td>12.13 (12.66)</td>
<td>10.73 (9.83)</td>
<td>11.13 (10.73)</td>
</tr>
<tr>
<td><strong>Shopping trip distance (kilometres) [mean (SD)]</strong></td>
<td>10.47 (12.32)</td>
<td>8.85 (9.41)</td>
<td>9.32 (10.35)</td>
</tr>
</tbody>
</table>
### Leisure trip mode (%)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor vehicle</td>
<td>44.10</td>
<td>49.40</td>
<td>47.60</td>
</tr>
<tr>
<td>Public transport</td>
<td>0.00</td>
<td>0.80</td>
<td>0.60</td>
</tr>
<tr>
<td>Walk</td>
<td>52.50</td>
<td>39.30</td>
<td>43.70</td>
</tr>
<tr>
<td>Cycle</td>
<td>3.40</td>
<td>10.50</td>
<td>8.10</td>
</tr>
</tbody>
</table>

### Was a leisure trip made by motor vehicle? (%)

<table>
<thead>
<tr>
<th>Answer</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>44.10</td>
<td>49.40</td>
<td>47.60</td>
</tr>
<tr>
<td>No</td>
<td>55.90</td>
<td>50.60</td>
<td>52.40</td>
</tr>
</tbody>
</table>

### Leisure trip time (minutes) [mean (SD)]

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.08 (7.53)</td>
</tr>
<tr>
<td>2</td>
<td>9.28 (11.73)</td>
</tr>
<tr>
<td>3</td>
<td>7.90 (10.70)</td>
</tr>
</tbody>
</table>

### Leisure trip distance (kilometres) [mean (SD)]

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.14 (6.61)</td>
</tr>
<tr>
<td>2</td>
<td>7.67 (10.67)</td>
</tr>
<tr>
<td>3</td>
<td>6.51 (9.66)</td>
</tr>
</tbody>
</table>
Table 9.12 - Characteristics of short trips by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=1,191)</td>
<td>Conventional (n=2,690)</td>
<td>(n=3,881)</td>
</tr>
<tr>
<td>Was the trip a short trip? (less than or equal to 1,500 metres) (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>23.3</td>
<td>15.1</td>
<td>17.6</td>
</tr>
<tr>
<td>No</td>
<td>76.7</td>
<td>84.9</td>
<td>82.4</td>
</tr>
<tr>
<td>What mode was used for a short trip? (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle</td>
<td>28.90</td>
<td>35.40</td>
<td>32.70</td>
</tr>
<tr>
<td>Public transport</td>
<td>0.70</td>
<td>1.20</td>
<td>1.00</td>
</tr>
<tr>
<td>Walk</td>
<td>69.00</td>
<td>58.00</td>
<td>62.40</td>
</tr>
<tr>
<td>Cycle</td>
<td>1.40</td>
<td>5.40</td>
<td>3.80</td>
</tr>
<tr>
<td>Was a motor vehicle used for a short trip? (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>28.90</td>
<td>35.40</td>
<td>32.70</td>
</tr>
<tr>
<td>No</td>
<td>71.10</td>
<td>64.60</td>
<td>67.30</td>
</tr>
<tr>
<td>Was a short trip for work purposes? (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>17.30</td>
<td>8.40</td>
<td>12.00</td>
</tr>
<tr>
<td>No</td>
<td>82.70</td>
<td>91.60</td>
<td>88.00</td>
</tr>
<tr>
<td>Was a short trip for shopping purposes? (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>12.30</td>
<td>21.60</td>
<td>17.80</td>
</tr>
<tr>
<td>No</td>
<td>87.70</td>
<td>78.40</td>
<td>82.20</td>
</tr>
<tr>
<td>Was a short trip for leisure purposes? (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>29.60</td>
<td>27.30</td>
<td>28.20</td>
</tr>
<tr>
<td>No</td>
<td>70.40</td>
<td>72.70</td>
<td>71.80</td>
</tr>
</tbody>
</table>
Figure 9.1 – A comparison of mode use by residents of Liveable and conventional neighbourhoods, and overall percentages

Figure 9.2 – A comparison of modal use by residents of Liveable and conventional neighbourhoods, and overall percentages for short trips (≤1,500 metres)
b. Multivariate analyses findings

Multivariate (discriminant) analyses were undertaken in order to examine the independent influence of variables identified as significant in the bivariate analyses. The discriminant analyses were also used to identify the relative influence of various trip-related variables on determining neighbourhood type (group standard deviation x unstandardised canonical coefficient).

Before inputting variables into discriminant models, trip time and distance were tested for consistency. The resulting alpha score was high (0.986>0.7), indicating significant similarity between the variables. Consequently, trip distance was inputted into the discriminant models whilst trip time was not.

A combination of original and derived measures was then inputted into a series of models (Tables 9.13-9.16). The models tested the relative influence of mode choice – motor vehicle, public transport, walking and cycling – in predicting neighbourhood type. A summary table of classification results is provided (Table 9.17).

The results tables (Tables 9.13-9.16) show that neighbourhood type was best predicted by motor vehicle and walking trips. Consistent with the bivariate findings, after adjustment, trips by residents of LNs were more likely to be by walking and less likely to be by motor vehicle. In Tables 9.14 and 9.16, where the relative influence of public transport and cycling trips was tested, the findings indicate that whether or not a trip was short becomes a much more important predictor. These findings were also consistent with the results of bivariate analyses. Nevertheless, when the measures of discrimination were used to classify trips (see Table 9.14), none of the models were
very successful in discriminating between trips taken by LN and CN residents. The percentage correctly classified by these models was around 55%, thus being only a little better than random classification to a type of neighbourhood (see Table 9.17).

In summary, the various analyses found a consistent pattern of difference in mode use depending on neighbourhood classification. Generally speaking, after adjustment, a trip made by a resident of an LN was more likely to be by walking, whilst one made by a resident of a CN was more likely to be by motor vehicle. Mode use varied somewhat, however, depending on the purpose of trips.

**Table 9.13 – The influence of trip purpose, occupancy and distance variables, and whether or not trips were made by motor vehicle in predicting type of neighbourhood**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor vehicle or other mode</td>
<td>0.41</td>
<td>-1.86</td>
<td><strong>-0.76</strong></td>
</tr>
<tr>
<td>Trip distance (km)</td>
<td>13.37</td>
<td>0.00</td>
<td>0.06</td>
</tr>
<tr>
<td>Vehicle occupancy</td>
<td>0.47</td>
<td>1.12</td>
<td>0.53</td>
</tr>
<tr>
<td>Was it a short trip?</td>
<td>0.38</td>
<td>1.20</td>
<td>0.46</td>
</tr>
<tr>
<td>Work trip</td>
<td>0.39</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>Shopping trip</td>
<td>0.41</td>
<td>0.27</td>
<td>0.11</td>
</tr>
<tr>
<td>Leisure trip</td>
<td>0.29</td>
<td>0.72</td>
<td>0.21</td>
</tr>
</tbody>
</table>
Table 9.14 – The influence of trip purpose, occupancy and distance variables, and whether or not trips were made by public transport in predicting type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT or other mode</td>
<td>0.19</td>
<td>0.91</td>
<td>0.17</td>
</tr>
<tr>
<td>Trip distance (km)</td>
<td>13.37</td>
<td>0.01</td>
<td>0.11</td>
</tr>
<tr>
<td>Vehicle occupancy</td>
<td>0.47</td>
<td>0.76</td>
<td>0.36</td>
</tr>
<tr>
<td>Was it a short trip?</td>
<td>0.38</td>
<td>2.52</td>
<td><strong>0.96</strong></td>
</tr>
<tr>
<td>Work trip</td>
<td>0.39</td>
<td>-0.30</td>
<td>-0.12</td>
</tr>
<tr>
<td>Shopping trip</td>
<td>0.41</td>
<td>0.46</td>
<td>0.19</td>
</tr>
<tr>
<td>Leisure trip</td>
<td>0.29</td>
<td>0.52</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Table 9.15 – The influence of trip purpose, occupancy and distance variables, and whether or not trips were made by walking in predicting type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk or other mode</td>
<td>0.36</td>
<td>2.22</td>
<td><strong>0.79</strong></td>
</tr>
<tr>
<td>Trip distance (km)</td>
<td>13.37</td>
<td>0.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Vehicle occupancy</td>
<td>0.47</td>
<td>0.93</td>
<td>0.44</td>
</tr>
<tr>
<td>Was it a short trip?</td>
<td>0.38</td>
<td>0.91</td>
<td>0.35</td>
</tr>
<tr>
<td>Work trip</td>
<td>0.39</td>
<td>-0.16</td>
<td>-0.06</td>
</tr>
<tr>
<td>Shopping trip</td>
<td>0.41</td>
<td>0.27</td>
<td>0.11</td>
</tr>
<tr>
<td>Leisure trip</td>
<td>0.29</td>
<td>0.64</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Table 9.16 – The influence of trip purpose, occupancy and distance variables, and whether or not trips were made by cycle in predicting type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle or other mode</td>
<td>0.16</td>
<td>0.07</td>
<td>0.01</td>
</tr>
<tr>
<td>Trip distance (km)</td>
<td>13.37</td>
<td>0.01</td>
<td>0.10</td>
</tr>
<tr>
<td>Vehicle occupancy</td>
<td>0.47</td>
<td>0.70</td>
<td>0.33</td>
</tr>
<tr>
<td>Was it a short trip?</td>
<td>0.38</td>
<td>2.52</td>
<td><strong>0.96</strong></td>
</tr>
<tr>
<td>Work trip</td>
<td>0.39</td>
<td>-0.39</td>
<td>-0.15</td>
</tr>
<tr>
<td>Shopping trip</td>
<td>0.41</td>
<td>0.46</td>
<td>0.19</td>
</tr>
<tr>
<td>Leisure trip</td>
<td>0.29</td>
<td>0.53</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Table 9.17 – Summary table: classification results

<table>
<thead>
<tr>
<th>Model</th>
<th>Classification success</th>
<th>Cross validation success</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>54.1%</td>
<td>54.0%</td>
</tr>
<tr>
<td>Two</td>
<td>56.9%</td>
<td>56.6%</td>
</tr>
<tr>
<td>Three</td>
<td>56.9%</td>
<td>56.8%</td>
</tr>
<tr>
<td>Four</td>
<td>57.6%</td>
<td>57.4%</td>
</tr>
</tbody>
</table>

9.7.2 Individual-level data

a. Bivariate analyses findings

Table 9.18 shows there were no significant associations between neighbourhood type and a range of demographic variables. However, Table 9.19 shows there were some significant associations between neighbourhood type and transport-related physical activity. Whilst a very low proportion of participants achieved an average of 30 minutes or more of active transport per day (17% overall), residents of LNs reported significantly more active transport than residents of CNs (20.4 minutes compared with 12.4 minutes per day) \(p<0.01\). Generally, people’s self-reported active transport may have been more reliable than the modelled times because it was difficult to model circular trips (i.e. where the same origin and destination are given) and trips where the zone boundaries in the models used by Main Roads Western Australia were not crossed. These factors may have contribute to the modelled times generally being lower.

At the individual level, differences in average trip distances and times attenuated to become insignificant\(^{46}\), whilst differences in average vehicle trip occupancy diminished. Also, despite the mode use differences previously identified, there were virtually no

\(^{46}\) Trip-level analyses show significance differences in trip distances and times, with residents of CNs travelling, on average, further for longer.
differences in average daily private VKT ($p=0.92$). On average, participants reported 42.9 kilometres of motor vehicle travel per day. This can be extrapolated to 15,659 km of motor vehicle travel per year (42.9 kilometres multiplied by 365 days in the year).

Table 9.20 shows there were no significant differences in public transport use or cycling. However, differences in motor vehicle use and walking remained significant (both $p<0.01$), with residents of LNs driving relatively less and walking relatively more than residents of CNs. To help illustrate these findings, average modal splits are depicted as a comparative histogram (Figure 9.3). Together, Table 9.20 and Figure 9.3 reinforce the patterns already identified: there were little differences in reported public transport usage and cycling between residents of LNs and CNs, but pronounced differences in motor vehicle use and walking.

Table 9.20 also shows there were few differences in trip purposes. However, residents of LNs reported a significantly higher proportion of short trips ($p<0.05$). Whilst this was consistent with the trip-level findings, the pattern of difference was less evident at the individual level.

Table 9.21 shows some significant associations between neighbourhood type and mode use for selected purposes. However, once again, the significance of some variables was lost following aggregation from the trip to the individual level$^{47}$. For work trips, there were no significant mode use differences. For shopping trips, residents of LNs were significantly more likely to have walked and significantly less likely to have taken public transport (both $p<0.05$). For leisure trips, residents of CNs were significantly

$^{47}$ At the trip level there are some significant differences in mode use depending on trip purpose, particularly leisure.
more likely ($p<0.05$) to have driven. Residents of LNs walked for a relatively higher proportion of leisure trips (58% compared with 40%), but at $p=0.087$, the finding was not significant.

Table 9.18 - Individual-level socio-demographic variables by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=56)</td>
<td>Conventional (n=105)</td>
<td>(n=211)</td>
</tr>
<tr>
<td>Gender (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>46.4</td>
<td>43.9</td>
<td>44.6</td>
</tr>
<tr>
<td>Female</td>
<td>53.6</td>
<td>56.1</td>
<td>55.5</td>
</tr>
<tr>
<td>Age [Mean (SD)]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36.1 (17.5)</td>
<td>39.1 (17.2)</td>
<td>38.3 (17.3)</td>
<td>0.275</td>
</tr>
<tr>
<td>Education (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary or less</td>
<td>50.0</td>
<td>49.7</td>
<td>49.8</td>
</tr>
<tr>
<td>Trade/apprentice/certificate</td>
<td>26.8</td>
<td>27.7</td>
<td>27.5</td>
</tr>
<tr>
<td>Bachelor or higher</td>
<td>23.2</td>
<td>22.6</td>
<td>22.8</td>
</tr>
<tr>
<td>Occupation (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management/admin</td>
<td>14.3</td>
<td>9.0</td>
<td>10.4</td>
</tr>
<tr>
<td>Professional</td>
<td>16.1</td>
<td>28.4</td>
<td>25.1</td>
</tr>
<tr>
<td>Blue collar</td>
<td>5.4</td>
<td>9.7</td>
<td>8.5</td>
</tr>
<tr>
<td>Clerical/sales/service</td>
<td>16.1</td>
<td>9.7</td>
<td>11.4</td>
</tr>
<tr>
<td>Not in workforce</td>
<td>25.0</td>
<td>26.5</td>
<td>26.1</td>
</tr>
<tr>
<td>Other</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Student</td>
<td>23.2</td>
<td>16.8</td>
<td>18.5</td>
</tr>
<tr>
<td>Mobility impairment (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>8.9</td>
<td>5.2</td>
<td>6.2</td>
</tr>
<tr>
<td>No</td>
<td>91.1</td>
<td>94.8</td>
<td>93.8</td>
</tr>
<tr>
<td>Body Mass Index [mean (SD)]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.1 (4.9)</td>
<td>25.6 (5.2)</td>
<td>25.5 (5.1)</td>
<td>0.529</td>
</tr>
<tr>
<td>BMI categories (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>5.4</td>
<td>6.5</td>
<td>6.2</td>
</tr>
<tr>
<td>Healthy weight</td>
<td>48.2</td>
<td>43.2</td>
<td>44.6</td>
</tr>
<tr>
<td>Overweight</td>
<td>37.5</td>
<td>34.8</td>
<td>35.6</td>
</tr>
<tr>
<td>Obese</td>
<td>8.9</td>
<td>15.5</td>
<td>13.7</td>
</tr>
</tbody>
</table>
Notably, the analyses did not indicate any significant overall associations between neighbourhood type and BMI (a key health measure) although a significantly higher proportion of residents of CNs were obese (15.5% compared with 8.9% of residents of LNs). Many residents may not have been in their neighbourhoods for very long and it is therefore unlikely that present transport patterns have had any impact on the health of study participants at this stage of the main RESIDE study.

Table 9.19 - Key individual-level variables, including trips per day, average trip times and distances, motor vehicle occupancy and active transport by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=56)</td>
<td>Conventional (n=105)</td>
<td>(n=211)</td>
</tr>
<tr>
<td>Trips per day [mean (SD)]</td>
<td>4.39 (2.13)</td>
<td>3.85 (1.78)</td>
<td>4.00 (1.89)</td>
</tr>
<tr>
<td>Average trip time (minutes) [mean (SD)]</td>
<td>13.51 (7.69)</td>
<td>15.22 (7.49)</td>
<td>14.77 (7.56)</td>
</tr>
<tr>
<td>Average trip distance (kilometres) [mean (SD)]</td>
<td>11.52 (7.13)</td>
<td>13.12 (7.80)</td>
<td>12.70 (7.67)</td>
</tr>
<tr>
<td>Average vehicle trip occupancy [mean (SD)]</td>
<td>1.65 (0.31)</td>
<td>1.64 (0.33)</td>
<td>1.64 (0.33)</td>
</tr>
<tr>
<td>Average daily motor vehicle kilometres travelled (VKT)</td>
<td>42.59 (31.03)</td>
<td>43.05 (28.32)</td>
<td>42.93 (28.99)</td>
</tr>
<tr>
<td>Self-reported active travel time per day [mean (SD)]</td>
<td>20.41 (20.78)</td>
<td>12.39 (18.70)</td>
<td>14.51 (19.55)</td>
</tr>
<tr>
<td>Modelled active travel time per day [mean (SD)]</td>
<td>4.46 (11.81)</td>
<td>3.34 (8.81)</td>
<td>3.64 (9.68)</td>
</tr>
<tr>
<td>Was equal to or more than 30 minutes of active travel time achieved (self-reported)? (%)</td>
<td>23.21</td>
<td>14.84</td>
<td>17.06</td>
</tr>
<tr>
<td>No</td>
<td>76.79</td>
<td>85.16</td>
<td>82.94</td>
</tr>
<tr>
<td>Was equal to or more than 30 minutes of active travel time achieved (modelled)? (%)</td>
<td>1.79</td>
<td>3.23</td>
<td>2.84</td>
</tr>
<tr>
<td>No</td>
<td>98.21</td>
<td>96.77</td>
<td>97.16</td>
</tr>
</tbody>
</table>
Table 9.20 - Mode use proportions, proportion of short trips and trip purpose proportions by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=56)</td>
<td>Conventional (n=105)</td>
<td>(n=211)</td>
</tr>
<tr>
<td>Proportion of all trips by motor vehicle [mean (SD)]</td>
<td>0.72 (0.23)</td>
<td>0.82 (0.22)</td>
<td>0.79 (0.23)</td>
</tr>
<tr>
<td>Proportion of all trips by public transport [mean (SD)]</td>
<td>0.04 (0.09)</td>
<td>0.04 (0.10)</td>
<td>0.04 (0.10)</td>
</tr>
<tr>
<td>Proportion of all trips by foot [mean (SD)]</td>
<td>0.21 (0.19)</td>
<td>0.12 (0.17)</td>
<td>0.14 (0.18)</td>
</tr>
<tr>
<td>Proportion of all trips by cycle [mean (SD)]</td>
<td>0.03 (0.07)</td>
<td>0.02 (0.08)</td>
<td>0.03 (0.08)</td>
</tr>
<tr>
<td>Short trips as a proportion of all trips [mean (SD)]</td>
<td>0.21 (0.18)</td>
<td>0.15 (0.19)</td>
<td>0.16 (0.19)</td>
</tr>
<tr>
<td>Work trips as a proportion of all trips [mean (SD)]</td>
<td>0.22 (0.23)</td>
<td>0.19 (0.25)</td>
<td>0.20 (0.24)</td>
</tr>
<tr>
<td>Shopping trips as a proportion of all trips [mean (SD)]</td>
<td>0.20 (0.18)</td>
<td>0.23 (0.21)</td>
<td>0.22 (0.20)</td>
</tr>
<tr>
<td>Leisure trips as a proportion of all trips [mean (SD)]</td>
<td>0.11 (0.18)</td>
<td>0.10 (0.17)</td>
<td>0.10 (0.17)</td>
</tr>
</tbody>
</table>
Table 9.21 - Mode use proportions depending on trip purpose by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=56)</td>
<td>Conventional (n=105)</td>
<td>(n=211)</td>
</tr>
<tr>
<td>Proportion of work trips by motor vehicle [mean (SD)]</td>
<td>0.80 (0.32)</td>
<td>0.85 (0.31)</td>
<td>0.84 (0.31)</td>
</tr>
<tr>
<td>Proportion of work trips by public transport [mean (SD)]</td>
<td>0.06 (0.15)</td>
<td>0.04 (0.14)</td>
<td>0.05 (0.14)</td>
</tr>
<tr>
<td>Proportion of work trips by foot [mean (SD)]</td>
<td>0.08 (0.16)</td>
<td>0.06 (0.19)</td>
<td>0.07 (0.18)</td>
</tr>
<tr>
<td>Proportion of work trips by cycle [mean (SD)]</td>
<td>0.06 (0.24)</td>
<td>0.04 (0.19)</td>
<td>0.05 (0.21)</td>
</tr>
<tr>
<td>Proportion of shopping trips by motor vehicle [mean (SD)]</td>
<td>0.87 (0.26)</td>
<td>0.93 (0.19)</td>
<td>0.92 (0.21)</td>
</tr>
<tr>
<td>Proportion of shopping trips by public transport [mean (SD)]</td>
<td>0.00 (0.00)</td>
<td>0.03 (0.13)</td>
<td>0.02 (0.11)</td>
</tr>
<tr>
<td>Proportion of shopping trips by foot [mean (SD)]</td>
<td>0.13 (0.26)</td>
<td>0.04 (0.14)</td>
<td>0.06 (0.18)</td>
</tr>
<tr>
<td>Proportion of shopping trips by cycle [mean (SD)]</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.03)</td>
<td>0.00 (0.03)</td>
</tr>
<tr>
<td>Proportion of leisure trips by motor vehicle [mean (SD)]</td>
<td>0.29 (0.39)</td>
<td>0.49 (0.45)</td>
<td>0.44 (0.44)</td>
</tr>
<tr>
<td>Proportion of leisure trips by public transport [mean (SD)]</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.03)</td>
<td>0.00 (0.03)</td>
</tr>
<tr>
<td>Proportion of leisure trips by foot [mean (SD)]</td>
<td>0.58 (0.42)</td>
<td>0.40 (0.44)</td>
<td>0.45 (0.44)</td>
</tr>
<tr>
<td>Proportion of leisure trips by cycle [mean (SD)]</td>
<td>0.13 (0.33)</td>
<td>0.11 (0.26)</td>
<td>0.11 (0.28)</td>
</tr>
</tbody>
</table>
b. Multivariate analyses findings

First, a combination of key socio-demographic and active transport-related variables was inputted into a discriminant model (see Table 9.22). Second, combinations of variables relating to trip purpose, occupancy, distance and mode use were analysed in a series of four models (Tables 9.23-9.26). These models tested the relative influence of mode choice – motor vehicle, public transport, walking and cycling – in predicting whether an individual resided in an LN or CN. Average daily private VKT was not included in any of the models because of there being virtually no difference depending on neighbourhood type.
In the first model (Table 9.22) the two emboldened values were particularly high and inferred that self-reported active travel time per day and relative numbers of people who reported active mode use equal to or exceeding 30 minutes per day were the most important predictors of neighbourhood classification. Higher self-reported active travel time and modelled active travel time $\geq 30$ minutes per day were predictive of a person living in an LN. Overall, the model correctly classified 68.9% of individuals into LN and CN and the cross-validated measure of performance was 61.2%. These measures of success suggested that the discriminant functions were of some use.

The classification results for the remaining four models (refer Tables 9.23-9.26) are reported in Table 9.27. These findings show that the proportion of reported motor vehicle and walking trips were the strongest predictors of neighbourhood type. A lower proportion of motor vehicle use and a higher proportion of walking for all trips suggested a person lived in an LN. Tables 9.24 and 9.26 show that the proportion of public transport trips and cycling were relatively much less influential in predicting where a person lived. In the respective models, the relative influence of short trips and work trips became more pronounced. However, when the models were used to classify subjects, the success rates suggested that the models including motor vehicle use and walking were moderately accurate, and those that included public transport use and cycling were not much better than if subjects were randomly assigned.

Overall, the multivariate analyses confirmed the bivariate results. The data consistently show that residents of CNs drove significantly more overall and for some key trip purposes (particularly leisure). In contrast, residents of LNs reported significantly more walking.
Table 9.22 – The influence of key socio-demographic and active transport variables in predicting type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trips per day</td>
<td>1.90</td>
<td>0.08</td>
<td>0.14</td>
</tr>
<tr>
<td>Personal mobility impairment</td>
<td>0.24</td>
<td>-1.78</td>
<td>-0.43</td>
</tr>
<tr>
<td>Gender</td>
<td>0.50</td>
<td>-0.43</td>
<td>-0.21</td>
</tr>
<tr>
<td>Age</td>
<td>17.27</td>
<td>-0.02</td>
<td>-0.33</td>
</tr>
<tr>
<td>Occupation</td>
<td>1.99</td>
<td>0.06</td>
<td>0.12</td>
</tr>
<tr>
<td>Education</td>
<td>0.81</td>
<td>0.07</td>
<td>0.06</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>1.90</td>
<td>0.06</td>
<td>0.11</td>
</tr>
<tr>
<td>BMI categories</td>
<td>0.80</td>
<td>-0.67</td>
<td>-0.53</td>
</tr>
<tr>
<td>Self-reported active travel time per day</td>
<td>19.42</td>
<td>0.05</td>
<td>1.03</td>
</tr>
<tr>
<td>Self-reported active travel time ≥30 min?</td>
<td>0.37</td>
<td>1.06</td>
<td>0.40</td>
</tr>
<tr>
<td>Modelled active travel time per day</td>
<td>9.72</td>
<td>0.07</td>
<td>0.71</td>
</tr>
<tr>
<td>Modelled active travel time ≥30 minutes?</td>
<td>0.17</td>
<td>6.12</td>
<td>1.02</td>
</tr>
</tbody>
</table>

Table 9.23 – The influence of purpose, occupancy and distance-related variables, and the proportion of a person’s reported trips that were made by motor vehicle in predicting type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion motor vehicle trips</td>
<td>0.23</td>
<td>4.01</td>
<td>0.92</td>
</tr>
<tr>
<td>Proportion short trips</td>
<td>0.19</td>
<td>-1.61</td>
<td>-0.30</td>
</tr>
<tr>
<td>Average trip distance</td>
<td>7.65</td>
<td>0.04</td>
<td>0.31</td>
</tr>
<tr>
<td>Average vehicle trip occupancy</td>
<td>0.33</td>
<td>1.18</td>
<td>0.39</td>
</tr>
<tr>
<td>Work trips proportion</td>
<td>0.24</td>
<td>-1.13</td>
<td>-0.28</td>
</tr>
<tr>
<td>Shopping trips proportion</td>
<td>0.20</td>
<td>0.21</td>
<td>0.04</td>
</tr>
<tr>
<td>Leisure trips proportion</td>
<td>0.17</td>
<td>1.16</td>
<td>0.20</td>
</tr>
</tbody>
</table>
Table 9.24 – The influence of purpose, occupancy and distance-related variables, and the proportion of a person’s reported trips that were made by public transport in predicting type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion PT trips</td>
<td>0.10</td>
<td>-0.21</td>
<td>-0.02</td>
</tr>
<tr>
<td>Proportion short trips</td>
<td>0.19</td>
<td>3.62</td>
<td><strong>0.69</strong></td>
</tr>
<tr>
<td>Average trip distance</td>
<td>7.65</td>
<td>-0.06</td>
<td>-0.44</td>
</tr>
<tr>
<td>Average vehicle trip occupancy</td>
<td>0.33</td>
<td>0.33</td>
<td>0.11</td>
</tr>
<tr>
<td>Work trips proportion</td>
<td>0.24</td>
<td>2.45</td>
<td><strong>0.60</strong></td>
</tr>
<tr>
<td>Shopping trips proportion</td>
<td>0.20</td>
<td>-0.85</td>
<td>-0.17</td>
</tr>
<tr>
<td>Leisure trips proportion</td>
<td>0.17</td>
<td>0.23</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Table 9.25 – The influence of purpose, occupancy and distance-related variables, and the proportion of a person’s reported trips that were made by walking in predicting type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion walk trips</td>
<td>0.18</td>
<td>5.59</td>
<td><strong>1.01</strong></td>
</tr>
<tr>
<td>Proportion short trips</td>
<td>0.19</td>
<td>-0.08</td>
<td>-0.01</td>
</tr>
<tr>
<td>Average trip distance</td>
<td>7.65</td>
<td>-0.05</td>
<td>-0.40</td>
</tr>
<tr>
<td>Average vehicle trip occupancy</td>
<td>0.33</td>
<td>-0.60</td>
<td>-0.20</td>
</tr>
<tr>
<td>Work trips proportion</td>
<td>0.24</td>
<td>1.68</td>
<td>0.41</td>
</tr>
<tr>
<td>Shopping trips proportion</td>
<td>0.20</td>
<td>-0.24</td>
<td>-0.05</td>
</tr>
<tr>
<td>Leisure trips proportion</td>
<td>0.17</td>
<td>-0.88</td>
<td>-0.15</td>
</tr>
</tbody>
</table>

Table 9.26 – The influence of purpose, occupancy and distance-related variables, and the proportion of a person’s reported trips that were made by cycle in predicting type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion cycle trips</td>
<td>0.08</td>
<td>1.11</td>
<td>0.09</td>
</tr>
<tr>
<td>Proportion short trips</td>
<td>0.19</td>
<td>3.75</td>
<td><strong>0.71</strong></td>
</tr>
<tr>
<td>Average trip distance</td>
<td>7.65</td>
<td>-0.06</td>
<td>-0.43</td>
</tr>
<tr>
<td>Average vehicle trip occupancy</td>
<td>0.33</td>
<td>0.23</td>
<td>0.08</td>
</tr>
<tr>
<td>Work trips proportion</td>
<td>0.24</td>
<td>2.39</td>
<td><strong>0.58</strong></td>
</tr>
<tr>
<td>Shopping trips proportion</td>
<td>0.20</td>
<td>-0.80</td>
<td>-0.16</td>
</tr>
<tr>
<td>Leisure trips proportion</td>
<td>0.17</td>
<td>0.11</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Table 9.27 – Summary table: classification results

<table>
<thead>
<tr>
<th>Model</th>
<th>Classification success</th>
<th>Cross validation success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two</td>
<td>67.3%</td>
<td>62.1%</td>
</tr>
<tr>
<td>Three</td>
<td>60.7%</td>
<td>56.4%</td>
</tr>
<tr>
<td>Four</td>
<td>67.3%</td>
<td>64.5%</td>
</tr>
<tr>
<td>Five</td>
<td>60.7%</td>
<td>55.5%</td>
</tr>
</tbody>
</table>

9.7.3 Household-level data

a. Bivariate analyses findings

Table 9.28 examines household motor vehicle, driver’s license and cycle availability. There were no significant associations between neighbourhood type and each of the household-level variables. Notably, however, there was a high level of reported household car ownership overall (1.93) irrespective of type of neighbourhood.
Table 9.28 – Vehicle, driver’s license and cycle availability to households by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=30)</td>
<td>Conventional (n=72)</td>
<td>(n=102)</td>
</tr>
<tr>
<td>Number of people per household [mean (SD)]</td>
<td>2.53 (1.20)</td>
<td>2.89 (1.25)</td>
<td>2.78 (1.24)</td>
</tr>
<tr>
<td>Vehicles available to the household [mean (SD)]</td>
<td>1.83 (0.70)</td>
<td>1.97 (0.71)</td>
<td>1.93 (0.71)</td>
</tr>
<tr>
<td>Number of licensed drivers per household [mean (SD)]</td>
<td>1.87 (0.68)</td>
<td>2.08 (0.55)</td>
<td>2.02 (0.6)</td>
</tr>
<tr>
<td>Number of cycles available to household [mean (SD)]</td>
<td>1.80 (1.52)</td>
<td>1.71 (1.47)</td>
<td>1.74 (1.48)</td>
</tr>
<tr>
<td>Vehicles per person [mean (SD)]</td>
<td>0.82 (0.34)</td>
<td>0.78 (0.34)</td>
<td>0.79 (0.34)</td>
</tr>
<tr>
<td>Licensees relative to household size [mean (SD)]</td>
<td>0.82 (0.25)</td>
<td>0.81 (0.25)</td>
<td>0.81 (0.25)</td>
</tr>
<tr>
<td>Cycles per person [mean (SD)]</td>
<td>0.66 (0.49)</td>
<td>0.58 (0.48)</td>
<td>0.61 (0.48)</td>
</tr>
</tbody>
</table>
b. Multivariate analyses findings

Whilst the bivariate tests revealed no clear pattern of difference, discriminant analysis was conducted to confirm the findings after adjustment. Only the derived household measures were entered into the model, as these controlled for variations in household size (see Table 9.29).

After adjustment, the average number of vehicles per person (in a given household) most strongly predicted neighbourhood type. A higher ratio of cars to people in a household predicted it being in an LN. The average number of cycles per person was slightly less predictive.

However, the model was barely better than random classification with only 51% successful at classifying the original grouped cases and this reduced to 45.1% when cross-validation was used. Overall, the findings suggested that the derived household variables were not useful for predicting neighbourhood type.

Table 9.29 – The influence of vehicle, driver's license and cycle availability per household in determining type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles per person</td>
<td>0.34</td>
<td>2.60</td>
<td>0.87</td>
</tr>
<tr>
<td>Licensees relative to household size</td>
<td>0.25</td>
<td>-1.87</td>
<td>-0.46</td>
</tr>
<tr>
<td>Cycles per person</td>
<td>0.48</td>
<td>1.46</td>
<td>0.70</td>
</tr>
</tbody>
</table>
### 9.7.4 Energy and emissions

Table 9.30 shows no significant associations between neighbourhood type and each of the trip-level energy and emissions variables. Overall, residents of LNs and CNs used very similar levels of energy and generated similar levels of pollution when making motor vehicle trips.

However, when energy use and emissions were analysed by trip purpose, a range of significant findings emerged (refer Tables 9.31-9.33). For work trips, energy use \((p<0.01)\) and all types of emissions \((p<0.05)\) were higher, on average, for residents of LNs. For shopping trips also, hydrocarbons and nitrogen oxide emissions were significantly higher \((p<0.05)\) for residents of LNs. However, for leisure trips, energy use and all emissions were significantly higher \((p<0.01)\), on average, for residents of CNs despite leisure trips accounting for a low proportion of all trips reported. These findings prompt further inquiry into patterns of car use depending on trip purpose and how these vary according the neighbourhoods subjects live in.

The trip-level energy and emissions data were also used to calculate individual daily energy use and emissions. Table 9.34 shows the associations between type of neighbourhood and these variables. The analyses reveal no significant differences, which is counter-intuitive given other findings relating to mode use.
Table 9.30 – Energy use and emissions of nitrogen oxide, hydrocarbons and carbon monoxide relating to all car trips by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=846)</td>
<td>Conventional (n=2157)</td>
<td>(n=3003)</td>
</tr>
<tr>
<td>Nitrogen oxide in grammes [mean (SD)]</td>
<td>15.85 (17.71)</td>
<td>15.66 (18.66)</td>
<td>15.71 (18.39)</td>
</tr>
<tr>
<td>Hydrocarbons in grammes [mean (SD)]</td>
<td>20.12 (20.40)</td>
<td>19.97 (20.63)</td>
<td>20.01 (20.56)</td>
</tr>
<tr>
<td>Carbon monoxide in grammes [mean (SD)]</td>
<td>106.16 (106.35)</td>
<td>106.95 (111.00)</td>
<td>106.71 (109.68)</td>
</tr>
<tr>
<td>Fuel consumption in millilitres [mean (SD)]</td>
<td>804.24 (785.86)</td>
<td>812.24 (786.52)</td>
<td>809.89 (786.10)</td>
</tr>
</tbody>
</table>

Table 9.31 – Energy use and emissions of nitrogen oxide, hydrocarbons and carbon monoxide relating to work car trips by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=161)</td>
<td>Conventional (n=391)</td>
<td>(n=552)</td>
</tr>
<tr>
<td>Nitrogen oxide in grammes [mean (SD)]</td>
<td>27.29 (18.44)</td>
<td>23.03 (20.11)</td>
<td>24.28 (19.72)</td>
</tr>
<tr>
<td>Hydrocarbons in grammes [mean (SD)]</td>
<td>33.86 (21.47)</td>
<td>28.70 (21.21)</td>
<td>30.20 (21.39)</td>
</tr>
<tr>
<td>Carbon monoxide in grammes [mean (SD)]</td>
<td>171.67 (109.06)</td>
<td>147.97 (118.23)</td>
<td>154.89 (116.03)</td>
</tr>
<tr>
<td>Fuel consumption in millilitres [mean (SD)]</td>
<td>1,324.42 (815.14)</td>
<td>1,124.19 (795.61)</td>
<td>1,182.59 (805.78)</td>
</tr>
</tbody>
</table>
Table 9.32 – Energy use and emissions of nitrogen oxide, hydrocarbons and carbon monoxide relating to shopping car trips by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=216)</td>
<td>Conventional (n=544)</td>
<td>(n=760)</td>
</tr>
<tr>
<td>Nitrogen oxide in grammes [mean (SD)]</td>
<td>12.01 (12.83)</td>
<td>9.65 (11.66)</td>
<td>10.31 (12.03)</td>
</tr>
<tr>
<td>Hydrocarbons in grammes [mean (SD)]</td>
<td>15.61 (15.79)</td>
<td>13.06 (13.71)</td>
<td>13.79 (14.36)</td>
</tr>
<tr>
<td>Carbon monoxide in grammes [mean (SD)]</td>
<td>84.85 (87.75)</td>
<td>73.26 (75.30)</td>
<td>76.54 (79.10)</td>
</tr>
<tr>
<td>Fuel consumption in millilitres [mean (SD)]</td>
<td>637.88 (633.02)</td>
<td>557.66 (552.62)</td>
<td>580.37 (576)</td>
</tr>
</tbody>
</table>

Table 9.33 – Energy use and emissions of nitrogen oxide, hydrocarbons and carbon monoxide relating to leisure car trips by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=51)</td>
<td>Conventional (n=110)</td>
<td>(n=161)</td>
</tr>
<tr>
<td>Nitrogen oxide in grammes [mean (SD)]</td>
<td>8.43 (10.06)</td>
<td>15.63 (16.69)</td>
<td>13.35 (15.25)</td>
</tr>
<tr>
<td>Hydrocarbons in grammes [mean (SD)]</td>
<td>10.99 (11.88)</td>
<td>20.48 (18.87)</td>
<td>17.47 (17.50)</td>
</tr>
<tr>
<td>Carbon monoxide in grammes [mean (SD)]</td>
<td>58.34 (59.10)</td>
<td>109.03 (99.49)</td>
<td>92.98 (91.62)</td>
</tr>
<tr>
<td>Fuel consumption in millilitres [mean (SD)]</td>
<td>452.98 (472.50)</td>
<td>847.58 (743.30)</td>
<td>722.58 (692.86)</td>
</tr>
</tbody>
</table>
Table 9.34 – Daily energy use and emissions of nitrogen oxide, hydrocarbons and carbon monoxide associated with car use, per person by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=56)</td>
<td>Conventional (n=155)</td>
<td>(n=211)</td>
</tr>
<tr>
<td>Nitrogen oxide in grammes [mean (SD)]</td>
<td>47.15 (36.51)</td>
<td>48.98 (37.45)</td>
<td>48.50 (37.12)</td>
</tr>
<tr>
<td>Hydrocarbons in grammes [mean (SD)]</td>
<td>61.08 (45.57)</td>
<td>63.03 (42.94)</td>
<td>62.51 (43.55)</td>
</tr>
<tr>
<td>Carbon monoxide in grammes [mean (SD)]</td>
<td>325.6 (244.04)</td>
<td>338.82 (236.11)</td>
<td>335.31 (237.72)</td>
</tr>
<tr>
<td>Fuel consumption in millilitres [mean (SD)]</td>
<td>2,492.25 (1,872.38)</td>
<td>2,585.14 (1,709.55)</td>
<td>2,560.49 (1,750.17)</td>
</tr>
</tbody>
</table>
9.8 Summary

This chapter has described the travel survey study design and results, including the design of the survey instrument; pilot study; participant selection and recruitment for the two study cohorts; data preparation; the various analyses and results.

There were some clear patterns of difference in trip characteristics by type of neighbourhood (particularly relating to mode use), although these were most distinguishable at the trip level. Residents of LNs reported a significantly higher proportion of walking trips, whilst residents of CNs reported a significantly higher proportion of motor vehicle trips (with differences especially evident when trips were for leisure purposes). This is despite average motor vehicle trip occupancy being lower when reported by residents of LNs. However, consistently, there were no significant differences in public transport use and cycling. Furthermore, residents of LNs were much more likely to travel shorter distances and for less time, relative to residents of CNs. These findings notwithstanding, the data show that the residents studied used their cars for the great majority of trips regardless of the type of neighbourhood they lived in and had regional travel patterns.

At the individual level, the mode use differences tended to remain, although other differences diminished, with some having lost statistical significance. At the household level, no variables appeared useful for differentiating households based on the type of neighbourhood they were in. Surprisingly, analyses of the energy and emissions did not yield many significant findings despite the differences already referred to. This can be attributed to the length of car trips, the characteristics of vehicles, driving speeds and vehicle occupancy. It is therefore more difficult to conclude that residents of LNs
reported travelling in a more sustainable way than residents of CNs. In the next chapter, the findings of the perceptual study are described, which are subjective measures of local walkability, access and distances to key destinations.
CHAPTER 10:

Perceptual study

Method and results

An ocean of parking in Lansdale Gardens, a conventional neighbourhood

Source: Author

It's a nice place to live. Yeah, there is a distinct character. People want to move here. We get talked about! People do come together...we have our community atmosphere with our events, like the Christmas party and market and so on [Resident of Frankland Springs (a Liveable Neighbourhood), 2006].
10.1 Introduction

This chapter outlines the methods used to analyse the perceptual data and presents the results. Perceptual data were included in the Transport Sustainability and Health study because perceptions may mediate the relationships between the built environment and transport patterns. At the end of the chapter, a summary is provided.

10.2 Method

Perception data were obtained from the first follow-up questionnaires from the main RESIDE study for 992 participants (refer Chapter 8). Socio-demographic characteristics were also obtained from this source (refer to Appendix 36 for details of the items). The perception data included perceptions of access to local facilities, the walkability of the local street network and walking distances to the nearest key destinations.

10.2.1 Derived variables

The original variables relating to perceptions of walking distance to key destinations were also recoded to indicate whether or not they were perceived to be within a 15 minutes of people’s homes (1=Yes, 2=No). No further new variables were derived.

The modified NEWS scale, which was used in the RESIDE questionnaire, differentiated between local shops and supermarkets; doctor’s practices and pharmacies; post boxes and post offices; and bus stops and train stops. For consistency, the variables were recoded to give a shortest perceived distance to each type of key

---

48 Key destinations were matched with the environmental data.
destination (i.e. local shops, a medical facility, a postal facility and public transport).

Table 10.1 shows the various recodes.

### 10.2.2 Statistical analyses

Descriptive analyses were conducted and bivariate statistical tests (chi squares for categorical data and t-tests for independent means for scale data) undertaken.

### 10.3 Results

Table 10.2 shows the socio-demographic characteristics of the study sample. These variables did not appear to vary by neighbourhood type. Overall, 38% of study participants were male, the average age of participants was 42, 24% had a tertiary education (slightly more residents of LNs reported having a bachelors degree or higher: p=0.055), 79% were employed, two out of five were employed in either a professional, management or administrative capacity and only 23% reported a household income of less than Au$50,000 per year.

### Table 10.1 – Minimum distances to key destinations (recoded)

<table>
<thead>
<tr>
<th>Recoded variable</th>
<th>Definition of destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum distance to shops</td>
<td>Local shops or supermarket</td>
</tr>
<tr>
<td>Minimum distance to medical facility</td>
<td>Doctor's practice or pharmacy</td>
</tr>
<tr>
<td>Minimum distance to postal facility</td>
<td>Australia post box or post office</td>
</tr>
<tr>
<td>Minimum distance to public transport</td>
<td>Train or bus stop</td>
</tr>
</tbody>
</table>
Table 10.2 – Socio-demographic characteristics of the sample by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=323)</td>
<td>Conventional (n=669)</td>
<td>(n=992)</td>
</tr>
<tr>
<td>Gender (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>36.8</td>
<td>39.2</td>
<td>38.4</td>
</tr>
<tr>
<td>Female</td>
<td>63.2</td>
<td>60.8</td>
<td>61.6</td>
</tr>
<tr>
<td>Age [Mean (SD)]</td>
<td>41.9 (12.7)</td>
<td>42.1 (11.6)</td>
<td>42.0 (12)</td>
</tr>
<tr>
<td>Education (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary or less</td>
<td>33.4</td>
<td>40.1</td>
<td>37.9</td>
</tr>
<tr>
<td>Trade/apprentice/certificate</td>
<td>38.8</td>
<td>38.2</td>
<td>38.4</td>
</tr>
<tr>
<td>Bachelor or higher</td>
<td>27.8</td>
<td>21.7</td>
<td>23.7</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>6</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Work status (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work</td>
<td>79.9</td>
<td>78.2</td>
<td>78.8</td>
</tr>
<tr>
<td>No work</td>
<td>13.2</td>
<td>15.9</td>
<td>15.0</td>
</tr>
<tr>
<td>Retired</td>
<td>6.9</td>
<td>5.9</td>
<td>6.2</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Occupation (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management/admin</td>
<td>16.7</td>
<td>14.9</td>
<td>15.5</td>
</tr>
<tr>
<td>Professional</td>
<td>25.9</td>
<td>26.7</td>
<td>26.4</td>
</tr>
<tr>
<td>Blue collar</td>
<td>14.5</td>
<td>13.4</td>
<td>13.8</td>
</tr>
<tr>
<td>Clerical/sales/service</td>
<td>21.8</td>
<td>22.5</td>
<td>22.2</td>
</tr>
<tr>
<td>Not in workforce</td>
<td>20.2</td>
<td>21.9</td>
<td>21.3</td>
</tr>
<tr>
<td>Other</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Student</td>
<td>0.3</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Household income (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;$49,999</td>
<td>24.8</td>
<td>21.8</td>
<td>22.7</td>
</tr>
<tr>
<td>$50-69,999</td>
<td>24.1</td>
<td>23.2</td>
<td>23.5</td>
</tr>
<tr>
<td>$70-89,999</td>
<td>25.4</td>
<td>23.7</td>
<td>24.2</td>
</tr>
<tr>
<td>$90,000+</td>
<td>25.7</td>
<td>31.3</td>
<td>29.5</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>20</td>
<td>40</td>
<td>60</td>
</tr>
</tbody>
</table>
Tables 10.3-10.6 show the association between type of development and perceptions of local access, the local street network, walking distance to key facilities and whether or not the distance to key facilities is less or greater than 15 minutes. Significant p values are emboldened. The results show that residents of CNs were significantly more likely ($p<0.01$) to agree that the streets in their neighbourhood are hilly, making it difficult to walk. Furthermore, residents of CNs were significantly more likely ($p<0.01$) to report a shorter walking time to a childcare facility and for this time to be equal to or less than 15 minutes ($p<0.01$).

Residents of LNs on the other hand, were significantly more likely ($p<0.01$) to report a shorter walking time to a medical facility, but this time was not significantly more likely to be $\leq$ 15 minutes. Although residents of LNs were significantly more likely ($p<0.05$) to report a shorter walking time to public transport, residents of CNs were significantly more likely ($p<0.05$) to report a 15-minute or less walk to public transport. Given this range of findings, it appears that there is no overall consistent pattern of difference depending on neighbourhood type. Generally speaking, the majority of participants perceived moderate barriers to walking for utilitarian purposes within their neighbourhood and fairly long distances between their homes and most key destinations.
Table 10.3 – Perceptions of local access by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=323)</td>
<td>Conventional (n=669)</td>
<td>(n=992)</td>
</tr>
<tr>
<td><strong>I can do most of my day to day shopping in my local area (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>27.9</td>
<td>25.3</td>
<td>26.1</td>
</tr>
<tr>
<td>Disagree</td>
<td>21.4</td>
<td>23.7</td>
<td>22.9</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>3.7</td>
<td>2.8</td>
<td>3.1</td>
</tr>
<tr>
<td>Agree</td>
<td>22.0</td>
<td>25.1</td>
<td>24.1</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>25.1</td>
<td>23.1</td>
<td>23.7</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>There are many shops within easy walking distance of my home (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>39.6</td>
<td>38.0</td>
<td>38.5</td>
</tr>
<tr>
<td>Disagree</td>
<td>25.7</td>
<td>32.8</td>
<td>30.5</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>6.8</td>
<td>6.7</td>
<td>6.8</td>
</tr>
<tr>
<td>Agree</td>
<td>18.3</td>
<td>15.1</td>
<td>16.1</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>9.6</td>
<td>7.3</td>
<td>8.1</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>There are many places to go within easy walking distance of my home (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>23.2</td>
<td>24.1</td>
<td>23.8</td>
</tr>
<tr>
<td>Disagree</td>
<td>42.1</td>
<td>40.7</td>
<td>41.2</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>14.2</td>
<td>12.9</td>
<td>13.3</td>
</tr>
<tr>
<td>Agree</td>
<td>14.9</td>
<td>18.1</td>
<td>17.1</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>5.6</td>
<td>4.2</td>
<td>4.6</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>----------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>It is easy to walk to a public transport stop from my home (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>5.3</td>
<td>5.4</td>
<td>5.3</td>
</tr>
<tr>
<td>Disagree</td>
<td>13.0</td>
<td>9.0</td>
<td>10.3</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>11.8</td>
<td>9.6</td>
<td>10.3</td>
</tr>
<tr>
<td>Agree</td>
<td>40.6</td>
<td>49.0</td>
<td>46.2</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>29.4</td>
<td>27.1</td>
<td>27.9</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>The streets in my local area are hilly, making it difficult to walk (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>38.1</td>
<td>35.2</td>
<td>36.1</td>
</tr>
<tr>
<td>Disagree</td>
<td>53.3</td>
<td>45.4</td>
<td>47.9</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>6.2</td>
<td>11.2</td>
<td>9.6</td>
</tr>
<tr>
<td>Agree</td>
<td>0.9</td>
<td>6.4</td>
<td>4.6</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>1.5</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>There are major barriers to walking in my local area making it difficult to get from place to place (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>34.4</td>
<td>36.1</td>
<td>35.5</td>
</tr>
<tr>
<td>Disagree</td>
<td>50.2</td>
<td>47.8</td>
<td>48.5</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>5.3</td>
<td>8.2</td>
<td>7.3</td>
</tr>
<tr>
<td>Agree</td>
<td>6.2</td>
<td>5.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>4.0</td>
<td>2.7</td>
<td>3.1</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 10.4 – Perceptions of the local street network by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=323)</td>
<td>Conventional (n=669)</td>
<td>(n=992)</td>
</tr>
<tr>
<td><strong>The streets in my local area do not have many culs-de-sac</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>6.2</td>
<td>3.6</td>
<td>4.5</td>
</tr>
<tr>
<td>Disagree</td>
<td>28.3</td>
<td>32.9</td>
<td>31.4</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>17.7</td>
<td>15.8</td>
<td>16.4</td>
</tr>
<tr>
<td>Agree</td>
<td>38.2</td>
<td>39.7</td>
<td>39.2</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>9.6</td>
<td>8.0</td>
<td>8.5</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>There are walkways in my local area that connect culs-de-sac to streets</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>4.3</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Disagree</td>
<td>28.0</td>
<td>29.6</td>
<td>29.1</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>34.2</td>
<td>30.2</td>
<td>31.5</td>
</tr>
<tr>
<td>Agree</td>
<td>29.8</td>
<td>32.5</td>
<td>31.6</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>3.7</td>
<td>3.2</td>
<td>3.3</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>The distance between intersections in my local area is usually short</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0.6</td>
<td>1.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Disagree</td>
<td>19.9</td>
<td>20.9</td>
<td>20.6</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>30.4</td>
<td>29.0</td>
<td>29.5</td>
</tr>
<tr>
<td>Agree</td>
<td>43.5</td>
<td>46.3</td>
<td>45.4</td>
</tr>
<tr>
<td>------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>5.6</td>
<td>2.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**There are many four-way intersections in my local area**

| Strongly disagree | 4.7  | 5.3  | 5.1  |
| Disagree         | 41.6 | 46.8 | 45.1 |
| Neither agree nor disagree | 25.5 | 21.1 | 22.5 |
| Agree            | 27.6 | 25.3 | 26.0 |
| Strongly agree   | 0.6  | 1.7  | 1.3  |
| Missing (cases)  | 1    | 4    | 5    | 0.236 |

**There are many alternative routes for getting from place to place when walking in my local area**

| Strongly disagree | 0.6  | 1.2  | 1.0  |
| Disagree         | 11.5 | 9.5  | 10.1 |
| Neither agree nor disagree | 12.7 | 11.6 | 12.0 |
| Agree            | 63.7 | 64.4 | 64.1 |
| Strongly agree   | 11.5 | 13.4 | 12.8 |
| Missing (cases)  | 1    | 4    | 5    | 0.651 |
Table 10.5 – Perceptions of distance to key destinations by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=323)</td>
<td>Conventional (n=669)</td>
<td>(n=992)</td>
</tr>
<tr>
<td><strong>Perceived distance to local shops (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than five minutes</td>
<td>0.9</td>
<td>2.1</td>
<td>1.7</td>
</tr>
<tr>
<td>Five to ten minutes</td>
<td>11.6</td>
<td>14.3</td>
<td>13.4</td>
</tr>
<tr>
<td>Ten to fifteen minutes</td>
<td>23.8</td>
<td>21.6</td>
<td>22.3</td>
</tr>
<tr>
<td>Fifteen to twenty minutes</td>
<td>20.1</td>
<td>20.4</td>
<td>20.3</td>
</tr>
<tr>
<td>More than twenty minutes</td>
<td>43.6</td>
<td>41.6</td>
<td>42.2</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>4</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td><strong>Perceived distance to a newsagent (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than five minutes</td>
<td>0.6</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Five to ten minutes</td>
<td>6.0</td>
<td>8.5</td>
<td>7.7</td>
</tr>
<tr>
<td>Ten to fifteen minutes</td>
<td>17.3</td>
<td>16.6</td>
<td>16.8</td>
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<tr>
<td>Fifteen to twenty minutes</td>
<td>16.4</td>
<td>18.3</td>
<td>17.6</td>
</tr>
<tr>
<td>More than twenty minutes</td>
<td>59.7</td>
<td>55.4</td>
<td>56.8</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>5</td>
<td>23</td>
<td>28</td>
</tr>
<tr>
<td><strong>Perceived distance to a childcare facility (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than five minutes</td>
<td>7.1</td>
<td>11.6</td>
<td>10.3</td>
</tr>
<tr>
<td>Five to ten minutes</td>
<td>12.2</td>
<td>21.0</td>
<td>18.4</td>
</tr>
<tr>
<td>Ten to fifteen minutes</td>
<td>12.9</td>
<td>17.4</td>
<td>16.1</td>
</tr>
<tr>
<td>Fifteen to twenty minutes</td>
<td>10.2</td>
<td>12.3</td>
<td>11.7</td>
</tr>
<tr>
<td>More than twenty minutes</td>
<td>57.6</td>
<td>37.7</td>
<td>43.6</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>68</td>
<td>59</td>
<td>127</td>
</tr>
<tr>
<td>Perceived distance to a medical facility (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Less than five minutes</td>
<td>2.5</td>
<td>0.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Five to ten minutes</td>
<td>11.2</td>
<td>9.4</td>
<td>10.0</td>
</tr>
<tr>
<td>Ten to fifteen minutes</td>
<td>19.0</td>
<td>18.0</td>
<td>18.3</td>
</tr>
<tr>
<td>Fifteen to twenty minutes</td>
<td>22.4</td>
<td>17.4</td>
<td>19.0</td>
</tr>
<tr>
<td>More than twenty minutes</td>
<td>44.9</td>
<td>54.7</td>
<td>51.4</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>2</td>
<td>18</td>
<td>20</td>
</tr>
</tbody>
</table>

**Perceived distance to a postal facility (%)**

| Less than five minutes                     | 5.0| 2.4| 3.3|
| Five to ten minutes                        | 13.6| 16.3| 15.4|
| Ten to fifteen minutes                     | 24.0| 22.9| 23.3|
| Fifteen to twenty minutes                  | 16.7| 18.7| 18.1|
| More than twenty minutes                   | 40.7| 39.7| 40.0|
| Missing (cases)                            | 6| 11| 17|

**Perceived distance to public transport (%)**

| Less than five minutes                     | 38.3| 41.0| 40.1|
| Five to ten minutes                        | 26.3| 32.3| 30.3|
| Ten to fifteen minutes                     | 16.5| 12.8| 14.0|
| Fifteen to twenty minutes                  | 8.9| 5.2| 6.4|
| More than twenty minutes                   | 10.1| 8.7| 9.2|
| Missing (cases)                            | 7| 15| 22|

0.007

0.193

0.043
Table 10.6 – Perceptions of whether or not key destinations were within 15 minutes walk from participant’s homes by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=323)</td>
<td>Conventional (n=669)</td>
<td>(n=992)</td>
</tr>
<tr>
<td><strong>Local shops (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>36.4</td>
<td>38.1</td>
<td>37.5</td>
</tr>
<tr>
<td>No</td>
<td>63.6</td>
<td>61.9</td>
<td>62.5</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>4</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td><strong>Newsagent (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>23.9</td>
<td>26.3</td>
<td>25.5</td>
</tr>
<tr>
<td>No</td>
<td>76.1</td>
<td>73.7</td>
<td>74.5</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>5</td>
<td>23</td>
<td>28</td>
</tr>
<tr>
<td><strong>Childcare facility (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>32.2</td>
<td>50.0</td>
<td>44.7</td>
</tr>
<tr>
<td>No</td>
<td>67.8</td>
<td>50.0</td>
<td>55.3</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>68</td>
<td>59</td>
<td>127</td>
</tr>
<tr>
<td><strong>Medical facility (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>32.7</td>
<td>28.0</td>
<td>29.5</td>
</tr>
<tr>
<td>No</td>
<td>67.3</td>
<td>72.0</td>
<td>70.5</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>2</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td><strong>Postal facility (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>42.6</td>
<td>41.6</td>
<td>41.9</td>
</tr>
<tr>
<td>No</td>
<td>57.4</td>
<td>58.4</td>
<td>58.1</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>6</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td><strong>Public transport (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>81.0</td>
<td>86.1</td>
<td>84.4</td>
</tr>
<tr>
<td>No</td>
<td>19.0</td>
<td>13.9</td>
<td>15.6</td>
</tr>
<tr>
<td>Missing (cases)</td>
<td>7</td>
<td>15</td>
<td>22</td>
</tr>
</tbody>
</table>

**10.4 Summary**

This chapter reported the results of how 992 RESIDE study participants perceived their neighbourhood with respect to walkability and access. Whilst there were few differences depending on neighbourhood type (LN or CN), overall, participants perceived moderate barriers to local utilitarian walking and fairly long distances between their homes and key destinations. In the next chapter the findings of the
environmental study are presented, which are objective measures of walkability and access.
CHAPTER 11:

Environmental study

Method and results

A post box amongst housing in Frankland Springs, a Liveable Neighbourhood

Source: Author

We have to leave the estate for pretty much everything...there's no shop...to get a newspaper...there's no deli within walking distance...within two kilometres...it's not long, but it's a long way to walk...you've got to leave the estate to get a paper [Resident of The Grove, 2006].
11.1 Introduction

This chapter presents the environmental study. It outlines the methods used to derive environmental measures, analyses of measures and presents the main findings. Environmental measures were included in the Transport Sustainability and Health study to identify associations between the built environment and transport behaviour. Measures of access are discussed, as are measures of permeability, residential lot density and work trip substitutability.

11.2 Measures of access (opportunities indices)

11.2.1 Method

‘Opportunities indices’ were developed as proxy measures of land use mix. The network distances between each RESIDE household included in the study (n=992) and the nearest of each key destination (local shops, newsagents, childcare facility, medical facility, postal facility and public transport) were estimated using a geographical information system. At the time of estimation (October 2007), RESIDE had geocoded 18,000 destinations throughout the Perth metropolitan region. Yellow pages address information was used for local shopping, newsagencies, childcare facilities and medical facilities, valid for 2007, which was sourced from Sensis Pty Ltd. Location information for postal facilities and public transport stops was sourced from Australia Post and TransPerth, respectively.
a. Derived variables

New variables were derived to indicate whether or not each type of key destination was within 400 metres (a 5 minute walk) and/or 1,500 metres (a 10-15 minute walk) of participant’s homes. Additional derived variables indicated whether or not participant households in LNs were within 450 metres of public transport. Also, average distances to the destinations were computed for each household, as were the proportion of destinations within each of the thresholds (400 metres and 1,500 metres).

11.2.2 Results

a. Bivariate analyses findings

Table 11.1 shows the associations between neighbourhood type and network distances (in metres) to the nearest of each type of key destination. Table 11.2 shows the associations between neighbourhood type and average network distances to the key destinations, and the proportion of key destinations within 400 and 1,500 metres of people’s homes. In both tables, significant findings are emboldened.

The results show high mean distances to each type of key destination, irrespective of neighbourhood type, with the exception of public transport. The average distance to shops was 2.96 km, a newsagency is 3.98 km, a childcare facility was 2.77 km, a medical facility was 1.78 km, a postal facility was 1.47 km and public transport was 604 metres. Consequently, the proportion of destinations within 400 metres and even 1,500 metres of people’s homes was very low.
Also, the findings in Table 11.1 show significant ($p<0.01$) differences depending on neighbourhood type across all characteristics, with the exception of childcare. There were significantly shorter distances between homes in LNs, and medical facilities (1.35 km compared with 1.99 km) and public transport (510 metres compared with 649 metres). However, there were significantly shorter distances between homes in CNs, and daily shopping (2.78 km compared with 3.32 km), newsagencies (3.33 km compared with 5.33) and postal facilities (1.37 compared with 1.68).

Table 11.2 shows that key destinations were significantly more likely ($p<0.01$) to be within 400 metres of people’s homes in LNs than people’s homes in CNs. However, only one destination of the six, on average, was within 400 metres of the study homes and most often, this was public transport. Good access to public transport may perhaps be the least desirable, when compared with the other key destinations to which people could walk. This is particularly the case if the public transport service cannot then provide efficient regional transport (see work trip substitutability results). Furthermore, the average network distance to all types of key destination was significantly lower in CNs than LNs (2.15 km compared with 2.49 km) ($p<0.01$). Together, these findings prompt further inquiry into the types of destinations that are most accessible, the relative accessibility of different destinations and differences between neighbourhood types.

In addition, access to public transport should be analysed in relation to the level of access anticipated under LN. The LN guidelines give a target of 60% of new homes to be within 450 metres of public transport (WAPC, 2004). Table 11.3 demonstrates that this target is not being achieved in the sample of LNs.
Table 11.1 – Network distances to the nearest of each type of key destination by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=323)</td>
<td>Conventional (n=669)</td>
<td>(n=992)</td>
</tr>
<tr>
<td>Network distance to shops [mean (SD)]</td>
<td>3,316.9 (1,452.1)</td>
<td>2,784.2 (2,109.9)</td>
<td>2,957.6 (1,936.1)</td>
</tr>
<tr>
<td>Network distance to newsagent [mean (SD)]</td>
<td>5,331.3 (3,666.1)</td>
<td>3,334.8 (2,145.8)</td>
<td>3,984.8 (2,889.1)</td>
</tr>
<tr>
<td>Network distance to childcare [mean (SD)]</td>
<td>2,762.6 (2,356.8)</td>
<td>2,776.0 (1,996.0)</td>
<td>2,771.6 (2,119.1)</td>
</tr>
<tr>
<td>Network distance to medical facility [mean (SD)]</td>
<td>1,350.9 (863.3)</td>
<td>1,990.3 (2,201.4)</td>
<td>1,782.1 (1,897.0)</td>
</tr>
<tr>
<td>Network distance to postal facility [mean (SD)]</td>
<td>1,684.7 (793.2)</td>
<td>1,366.2 (580.4)</td>
<td>1,469.9 (673.6)</td>
</tr>
<tr>
<td>Network distance to public transport [mean (SD)]</td>
<td>509.8 (312.2)</td>
<td>649.4 (863.5)</td>
<td>603.9 (733.9)</td>
</tr>
</tbody>
</table>

Table 11.2 – Average network distance to the key destinations and the proportion of key destinations within 400 and 1,500 metres of people's homes by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=323)</td>
<td>Conventional (n=669)</td>
<td>(n=992)</td>
</tr>
<tr>
<td>Average network distance to key facilities [mean (SD)]</td>
<td>2,492.7 (910.8)</td>
<td>2,150.1 (1,385.2)</td>
<td>2,261.7 (1,260.5)</td>
</tr>
<tr>
<td>Proportion of key facilities within 400 metres of people's homes [mean (SD)]</td>
<td>0.11 (0.12)</td>
<td>0.09 (0.10)</td>
<td>0.09 (0.11)</td>
</tr>
<tr>
<td>Proportion of key facilities within 1,500 metres of people's homes [mean (SD)]</td>
<td>0.47 (0.20)</td>
<td>0.49 (0.25)</td>
<td>0.48 (0.24)</td>
</tr>
</tbody>
</table>
Table 11.3 – Accessibility of public transport in Liveable Neighbourhoods

<table>
<thead>
<tr>
<th>Number of homes in LNs</th>
<th>Are homes within 450 metres of nearest public transport stop?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>323</td>
<td>161 (49.8%)</td>
</tr>
</tbody>
</table>

b. Multivariate analyses findings

The original network distance measures and derived measures of permeability (see Section 11.3) were inputted into a discriminant model (see Table 11.4). The average network distances, average permeability measures and proportions of key destinations within 400 and 1,500-metres of people’s homes were inputted into a second model (see Table 11.5).

In the first model, the three emboldened values were particularly high and inferred that distance to shops (such as delis); newsagents and medical facilities were the most important predictors of neighbourhood type. Shorter distances to medical facilities were a relatively strong influence in predicting a home being in an LN. However, shorter distances to daily shopping and newsagencies were influential predictors of a home being in a CN. The model was very successful at classifying both the original grouped cases (84.1% success) and when cross-validation was used (83.6% success), indicating the measures of access were very useful for predicting neighbourhood type.

Table 11.5 indicates that average network distance was easily the most influential variable of those included in the second model for predicting neighbourhood type. The findings infer that a shorter average distance to key destinations strongly predicts a home is in a CN. Notably, average permeability was the least strong influence.
However, this model was less successful than the first at classifying both the original grouped cases (65.5% success) and when cross-validation was used (65.2% success).

Table 11.4 – The influence of network distances to key destinations and measures of permeability between homes and key destinations in predicting type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network distance to shops</td>
<td>1,936.05</td>
<td>0.00</td>
<td>0.89</td>
</tr>
<tr>
<td>Permeability of street network between homes and shops</td>
<td>0.23</td>
<td>2.30</td>
<td>0.54</td>
</tr>
<tr>
<td>Network distance to newsagent</td>
<td>2,889.11</td>
<td>0.00</td>
<td>1.19</td>
</tr>
<tr>
<td>Permeability of street network between homes and newsagent</td>
<td>0.23</td>
<td>1.70</td>
<td>0.39</td>
</tr>
<tr>
<td>Network distance to childcare</td>
<td>2,119.05</td>
<td>0.00</td>
<td>-0.03</td>
</tr>
<tr>
<td>Permeability of street network between homes and childcare</td>
<td>0.38</td>
<td>0.22</td>
<td>0.08</td>
</tr>
<tr>
<td>Network distance to: medical</td>
<td>1,897.03</td>
<td>0.00</td>
<td>-1.61</td>
</tr>
<tr>
<td>Permeability of street network between homes medical</td>
<td>0.34</td>
<td>-0.99</td>
<td>-0.34</td>
</tr>
<tr>
<td>Network distance to postal</td>
<td>673.64</td>
<td>0.00</td>
<td>0.36</td>
</tr>
<tr>
<td>Permeability of street network between homes and postal</td>
<td>0.24</td>
<td>-0.54</td>
<td>-0.13</td>
</tr>
<tr>
<td>Network distance to public transport</td>
<td>733.86</td>
<td>0.00</td>
<td>-0.41</td>
</tr>
<tr>
<td>Permeability of street network between homes and public transport</td>
<td>0.88</td>
<td>-0.09</td>
<td>-0.08</td>
</tr>
</tbody>
</table>
Table 11.5 – The influence of average network distance, average permeability and proportions of key destinations within 400 and 1,500-metre buffers in predicting type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SD</th>
<th>Coefficients</th>
<th>Measure of discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average network distance to key destinations</td>
<td>1,260.47</td>
<td>0.00</td>
<td>1.03</td>
</tr>
<tr>
<td>Average street network permeability between homes and key destinations</td>
<td>0.22</td>
<td>-1.31</td>
<td>-0.29</td>
</tr>
<tr>
<td>Proportion of key destinations within 400m of people’s homes</td>
<td>0.11</td>
<td>5.75</td>
<td>0.64</td>
</tr>
<tr>
<td>Proportion of key destinations within 1,500m of people’s homes</td>
<td>0.24</td>
<td>2.11</td>
<td>0.50</td>
</tr>
</tbody>
</table>

11.3 Network permeability

11.3.1 Method

For each study household (n=992) a measure of neighbourhood permeability was derived from the access measurements as follows:

\[
\text{Network distance to each key destination} = \text{Measure of Permeability}
\]

Values closer to one represented greater route directness. Average permeability measures were then derived for each household.
11.3.2 Results

Table 11.6 shows the association between neighbourhood type, and the permeability of the street network between people’s homes and key destinations, and average network permeability. The findings indicate a more permeable street network between homes in LNs and most types of facilities. The findings were significant ($p<0.01$) for childcare, medical and postal facilities and close to being so for public transport ($p=0.052$). However, a significantly more permeable street network ($p<0.01$) was found between homes in CNs and daily shopping facilities. The street network average was found to be significantly lower ($p<0.01$) in LNs than in CNs (1.37 compared with 1.41). Multivariate analyses that included permeability measures are discussed in Section 11.2.2.
Table 11.6 – Permeability of street network between people’s homes and key destinations, and average network permeability by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=323)</td>
<td>Conventional (n=669)</td>
<td>(n=992)</td>
</tr>
<tr>
<td>Permeability between homes and shops [mean (SD)]</td>
<td>1.41 (0.24)</td>
<td>1.32 (0.22)</td>
<td>1.35 (0.23)</td>
</tr>
<tr>
<td>Permeability between homes and newsagent [mean (SD)]</td>
<td>1.30 (0.26)</td>
<td>1.32 (0.21)</td>
<td>1.31 (0.23)</td>
</tr>
<tr>
<td>Permeability between homes and childcare [mean (SD)]</td>
<td>1.35 (0.28)</td>
<td>1.41 (0.42)</td>
<td>1.39 (0.38)</td>
</tr>
<tr>
<td>Permeability between homes and medical [mean (SD)]</td>
<td>1.40 (0.28)</td>
<td>1.50 (0.36)</td>
<td>1.47 (0.34)</td>
</tr>
<tr>
<td>Permeability between homes and postal [mean (SD)]</td>
<td>1.35 (0.17)</td>
<td>1.39 (0.27)</td>
<td>1.38 (0.24)</td>
</tr>
<tr>
<td>Permeability between homes and public transport [mean (SD)]</td>
<td>1.39 (0.52)</td>
<td>1.51 (1.01)</td>
<td>1.47 (0.88)</td>
</tr>
<tr>
<td>Average permeability of network [mean (SD)]</td>
<td>1.37 (0.16)</td>
<td>1.41 (0.25)</td>
<td>1.39 (0.22)</td>
</tr>
</tbody>
</table>
11.4 Residential lot density

Four separate analyses were conducted to measure residential lot density in the sample neighbourhoods. These analyses included different combinations of control or no control for the size of each neighbourhood and the inclusion or omission of one particular neighbourhood (a CN) containing residential lots of considerable average size (i.e. the average lot size in this neighbourhood was 3,878.65m² compared with an overall average lot size of 698.74m²). There were reasons for analysing the data both with and without control for neighbourhood size. On one hand, bigger neighbourhoods present more opportunities for density gradients to be developed (thereby being reason for control), whilst on the other hand, all neighbourhoods should be developed with a degree of diversity and self-sufficiency (thereby being reason for all neighbourhoods to be weighted equally). Together, the measures of residential lot density were important complements to the measures of access (which were proxies for land use mix).

11.4.1 Method

First, using a geographical information system, the boundaries of the sample neighbourhoods were redrawn to remove undeveloped land. The excluded land was often zoned for future development (i.e. R20 residential development or simply, URBDEV) but had yet to be subdivided into separate parcels. This land was excluded because subdivision was not certain; even if subdivision did occur, the size of the subdivided parcels was unknown; and it was not known where roads and non-residential land uses would be situated.
Where the cadastre showed subdivided land that was not yet built on, the land use was verified from Landgate’s taxation information and was included in the analyses. Also, where a parcel was found to support more than one land use (i.e. residential and market gardening), the parcel was included as residential land area providing a dwelling was on the site. If there was no dwelling (i.e. one of the land uses was not residential), the parcel was only included the analyses as urban land area. Land zoned as reserve (including bushland) was also included as part of the urban land area.

Second, parcels identified as retirement villages and/or care homes were removed from neighbourhoods. Whilst there were relatively few of these, they were removed because many of them included high-dependency facilities. Furthermore, the retirement villages were often located on the fringe of neighbourhoods and semi-gated, thereby being urban barriers rather than parts of the general residential landscape. Finally, the age restriction on living in the retirement villages made them a special type of accommodation, which would complicate analyses of residential lot density.

Third, the residential and urban land areas in each neighbourhood were summed. Also, the total number of residential lots per neighbourhood was calculated. In order to control for strata residential lots (the residential lot density analyses ‘assumed’ one dwelling per lot), a query was run using GIS to identify the size of all strata lots in each neighbourhood. As there was no easy way to control for the exact number of dwellings on each strata lot, the number of dwellings per strata lot was estimated by applying the R40 standard. Therefore, it was estimated that on each strata lot there were 40 dwellings per hectare and the total number of residential lots per neighbourhood was inflated accordingly (i.e. strata lots were ‘divided’ into ‘separate’ 250m² parcels).
R40 standard was applied because inspection of the strata lots using GIS software identified that in most test cases (approximately 50 inspections) the underlying zoning was R40. The exception was several test cases in one particular Liveable Neighbourhood where strata lots were zoned ‘special purpose’. The R40 standard was assumed for these lots.

There were shortcomings with using this method of calculating residential lot density (these are discussed further in Chapter 12), particularly because of the difficulties with controlling for strata titles. However, there were few strata lots in the study neighbourhoods. Therefore, any inaccuracies arising from the method of control used would have been slight. Table 11.7 shows the percentage of strata lots relative to all residential lots per type of neighbourhood.

Using the summed residential and urban areas, and number of residential lots (with control for strata lots) in each neighbourhood, average lot sizes and measures of site density and urban density were derived.

Table 11.7 – Strata lots as a percentage of all residential lots by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=11)</td>
<td>Conventional (n=35)</td>
</tr>
<tr>
<td>Strata lots</td>
<td>144</td>
<td>88</td>
</tr>
<tr>
<td>All residential lots</td>
<td>14,884</td>
<td>20,083</td>
</tr>
<tr>
<td>Strata lots as a percentage of all residential lots</td>
<td>0.97%</td>
<td>0.44%</td>
</tr>
</tbody>
</table>
11.4.2 Results

Table 11.8 shows the various results of the first analysis. The average residential lot size in LNs (584.89m²) was noticeably smaller than in CNs (714.96m²), although the difference was not statistically significant. Similarly, the number of lots per site hectare and urban hectare in LNs (17.33 and 9.94) was higher than in CNs (15.88 and 9.69), but the differences were not significant.

Table 11.9 shows the results of the second analysis. With the cases having been weighted depending on the area of neighbourhoods, residential densities dropped, but the differences depending on neighbourhood type became significant. The average lot size in LNs was 603.44m² compared with 820.21m² in CNs ($p<0.01$), the number of lots per site hectare was 16.67 in LNs compared with 14.88 in CNs ($p<0.01$) and the number of lots per urban hectare was 8.81 in LNs compared with 8.64 in CNs ($p<0.01$).

The results of the third analysis (refer to Table 11.10) indicate that with the outlying conventional neighbourhood having been excluded, the differences between LNs and CNs attenuated. The average residential lot size in LNs (584.89m²) remained the same but in CNs it reduced to 621.92m² (the difference remained insignificant). Similarly, the number of lots per site hectare and urban hectare in LNs remained the same (as in Table 11.8) but both values increased in CNs (to 16.27 and 9.91, respectively) (again the differences remained insignificant).

Notably, the results of the fourth analysis (refer to Table 11.11), where again cases were weighted depending on the area of neighbourhoods, show smaller average lot sizes and more lots per site hectare in LNs, but more lots per urban hectare in CNs. The average
Lot size in LNs was 603.44 m$^2$ compared with 646.62 m$^2$ in CNs ($p<0.01$). The number of lots per site hectare in LNs was 16.67 compared with 15.58 in CNs ($p<0.01$). The number of lots per urban hectare in LNs was 8.81 compared with 9.01 in CNs ($p<0.01$).

Overall, despite the differences, whether statistically significant or otherwise, the results show that the residential lot densities being achieved in the study neighbourhoods are very low. This has profound implications for provision of local services and facilities (including public transport), and neighbourhood self-sufficiency. These implications are discussed in Chapter 12.

**Table 11.8 – Residential lot density by type of neighbourhood with no control for neighbourhood size**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total (n=46)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=11)</td>
<td>Conventional (n=35)</td>
<td></td>
</tr>
<tr>
<td>Average lot size (m$^2$)</td>
<td>584.89 (65.66)</td>
<td>714.96 (554.60)</td>
<td>698.74</td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td></td>
<td></td>
<td>0.445</td>
</tr>
<tr>
<td>Lots per site hectare (equivalent to R standard)</td>
<td>17.30 (2.01)</td>
<td>15.88 (2.94)</td>
<td>15.81</td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td></td>
<td></td>
<td>0.143</td>
</tr>
<tr>
<td>Lots per urban hectare</td>
<td>9.94 (2.11)</td>
<td>9.69 (2.24)</td>
<td>9.49 (2.05)</td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td></td>
<td></td>
<td>0.736</td>
</tr>
</tbody>
</table>
Table 11.9 – Residential lot density by type of neighbourhood with control for neighbourhood size

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total (n=46)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=11)</td>
<td>Conventional (n=35)</td>
<td></td>
</tr>
<tr>
<td>Average lot size (m²)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td>603.44 (45.91)</td>
<td>820.21 (730.63)</td>
<td>683.86</td>
</tr>
<tr>
<td>Lots per site hectare (equivalent to R standard)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td>16.67 (1.37)</td>
<td>14.88 (3.22)</td>
<td>16.22</td>
</tr>
<tr>
<td>Lots per urban hectare</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td>8.81 (1.73)</td>
<td>8.64 (2.11)</td>
<td>9.75 (2.19)</td>
</tr>
</tbody>
</table>

Table 11.10 – Residential lot density by type of neighbourhood with no control for neighbourhood size and outlying neighbourhood removed

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total (n=45)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=11)</td>
<td>Conventional (n=34)</td>
<td></td>
</tr>
<tr>
<td>Average lot size (m²)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td>584.89 (65.66)</td>
<td>621.92 (68.41)</td>
<td>612.87</td>
</tr>
<tr>
<td>Lots per site hectare (equivalent to R standard)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td>17.30 (2.01)</td>
<td>16.27 (1.83)</td>
<td>16.52</td>
</tr>
<tr>
<td>Lots per urban hectare</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td>9.94 (2.11)</td>
<td>9.91 (1.83)</td>
<td>9.92 (1.88)</td>
</tr>
</tbody>
</table>

Table 11.11 – Residential lot density by type of neighbourhood with control for neighbourhood size and outlying neighbourhood removed

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total (n=45)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=11)</td>
<td>Conventional (n=34)</td>
<td></td>
</tr>
<tr>
<td>Average lot size (m²)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td>603.44 (45.91)</td>
<td>646.62 (55.51)</td>
<td>627.70</td>
</tr>
<tr>
<td>Lots per site hectare (equivalent to R standard)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td>16.67 (1.37)</td>
<td>15.58 (1.36)</td>
<td>16.06</td>
</tr>
<tr>
<td>Lots per urban hectare</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[mean (SD)]</td>
<td>8.81 (1.73)</td>
<td>9.01 (1.45)</td>
<td>8.93 (1.59)</td>
</tr>
</tbody>
</table>
11.5 Work trip substitutability

The work trip substitutability indices measured the real and relative time sacrifices of participants switching from motor vehicles to public transport for work trips. The indices were intended to reflect the efficiency of the regional public transport system.

11.5.1 Method

Work trip origin and destination information for 480 RESIDE participants (see Chapter 8) was given to Main Roads Western Australia, who calculated trip times. The data were also given to an administrative assistant who used TransPerth’s Journey Planner\textsuperscript{50} to calculate the quickest public transport travel time. For consistency, the travel times were calculated assuming the trip was made after 7am on a Monday morning, to correspond with early peak travel time and a high level of public transport service\textsuperscript{51}.

Four work trip substitutability measures were derived from the three trip times (self-reported car trip time, modelled car trip time and public transport time). The first measure compared public transport with self-reported trip time. The second compared public transport with modelled trip time:

\[
\begin{align*}
\text{Public transport travel time} & \quad \text{Self-reported travel time} = \text{Measure One} \\
\text{Public transport travel time} & \quad \text{Modelled travel time} = \text{Measure Two}
\end{align*}
\]

\textsuperscript{50} Journey Planner is an online resource administered by TransPerth.
\textsuperscript{51} Work trip departure times were not provided by participants in RESIDE’s first follow-up questionnaire: refer Appendix 36.
When interpreting these measures (or ratios), an output closer to one would signify greater substitutability, because there would be less of a time sacrifice travelling by public transport (a measure of three, for example, would infer a work trip made by car would take three times longer by public transport). Measures three and four indicated the real time sacrifice of switching to public transport, based on the self-reported trip time and modelled trip time, respectively:

\[
\text{Public transport trip time - self-reported trip time} = \text{Measure Three}
\]

\[
\text{Public transport trip time - modelled trip time} = \text{Measure Four}
\]

**11.5.2 Results**

Table 11.12 shows the association between neighbourhood type and the original work trip data (self-reported and modelled travel times by car, and derived public transport travel time). Table 11.13 shows the association between neighbourhood type and the four measures of work trip substitutability. The significant values are emboldened. The frequency histograms associated with the real time sacrifices (Figures 11.1 and 11.2) show fairly normal distributions.

A test for internal consistency between the two separate measures of car trip time (self-reported and modelled) produced an alpha score of 0.902. With this exceeding the threshold of 0.7, the test found a high (but expected) degree of association between the times.
Table 11.12 shows that residents of CNs had significantly shorter self-reported ($p<0.05$), modelled ($p<0.01$) and derived public transport work travel times ($p<0.01$) compared with residents of LNs. However, Table 11.13 shows that whilst there were absolute differences in all travel times, the substitutability of public transport for the car for work trips was not significantly different depending on neighbourhood type. In relative terms, a change from car to public transport travel would have a heavy time cost for residents, irrespective of the neighbourhood they lived in. For example, the measures of substitutability show a half-hour work trip by car would take, on average, between 82.2 and 89.1 minutes by public transport. The real time costs (Table 11.13), however, suggested a slightly higher average burden for residents of LNs, even though the differences were not statistically significant.

Thus, these results strongly suggest that residents of the study neighbourhoods are heavily car dependent. It is highly unlikely that people will substitute a public transport trip for a car trip when faced with such a time sacrifice. The results also show that the existing, car dependent urban environment surrounding new neighbourhoods can significantly influence travel patterns, which has profound implications for transport sustainability.
Table 11.12 – Original work trip data: self-reported and modelled travel times by car, and derived public transport travel time by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=170)</td>
<td>Conventional (n=310)</td>
<td>(n=480)</td>
</tr>
<tr>
<td>Self-reported car travel time [mean (SD)]</td>
<td>33.87 (17.94)</td>
<td>30.04 (16.98)</td>
<td>31.40 (17.41)</td>
</tr>
<tr>
<td>Modelled car travel time [mean (SD)]</td>
<td>32.67 (16.89)</td>
<td>26.63 (14.94)</td>
<td>28.77 (15.91)</td>
</tr>
<tr>
<td>Public transport travel time [mean (SD)]</td>
<td>75.1 (25.68)</td>
<td>68.62 (31.77)</td>
<td>70.91 (29.89)</td>
</tr>
</tbody>
</table>

Table 11.13 – Work trip substitutability: public transport for car by type of neighbourhood

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Type of development</th>
<th>Total</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liveable (n=170)</td>
<td>Conventional (n=310)</td>
<td>(n=480)</td>
</tr>
<tr>
<td>Proportional time sacrifice (public transport/self-reported travel time) [mean (SD)]</td>
<td>2.83 (1.83)</td>
<td>2.68 (1.29)</td>
<td>2.74 (1.51)</td>
</tr>
<tr>
<td>Proportional time sacrifice (public transport/modelled travel time) [mean (SD)]</td>
<td>2.86 (1.59)</td>
<td>3.03 (1.46)</td>
<td>2.97 (1.51)</td>
</tr>
<tr>
<td>Real time sacrifice (public transport compared to self-reported travel time) [mean (SD)]</td>
<td>41.23 (22.08)</td>
<td>38.57 (24.99)</td>
<td>39.51 (24.01)</td>
</tr>
<tr>
<td>Real time sacrifice (public transport compared to modelled travel time) [mean (SD)]</td>
<td>42.43 (19.85)</td>
<td>41.99 (21.97)</td>
<td>42.15 (21.22)</td>
</tr>
</tbody>
</table>
Figure 11.1 – Distribution of real time sacrifices: public transport – self-reported car trip time

Figure 11.2 – Distribution of real time sacrifices: public transport – modelled car trip time
11.6 Summary

This chapter reported the results of access and permeability analyses relating to 992 RESIDE households, residential lot density analyses for 46 study neighbourhoods and work trip substitutability analyses for 480 RESIDE participants. The results showed that access to a range of facilities, most notably local shopping was much better in CNs than LNs, which is contrary to the intentions of the LN policy. However, access to public transport was notably better in LNs (although not necessarily in terms of a 15-minute walk), despite this being of limited use given the findings of the work trip substitutability analyses. Street network permeability was found to be consistently better in LNs, which was anticipated by the LN policy.

Evaluation of the residential lot density data reveals some differences, mostly higher relative residential lot densities in LNs, but is suggestive of low residential lot densities overall. Indeed, the density data show that the LN code has failed to produce the recommended densities and this contributes to the suburbs remaining highly car dependent. Finally, and not unexpectedly, the work trip substitutability analyses found a heavy burden for residents of all neighbourhoods if they changed from motor vehicles to public transport. However, there was no pattern of difference depending on neighbourhood type. The next chapter draws all the results together in a discussion of transport sustainability in the sample of Perth’s new neighbourhoods.
CHAPTER 12:

Discussion

*Where is the road taking us? A streetscape In Brighton Beachside, a Liveable Neighbourhood*

Source: Author

It’s a nice place to live. Yeah, there is a distinct character. People want to move here. We get talked about! People do come together…we have our community atmosphere with our events, like the Christmas party and market and so on

[Resident of Frankland Springs (a Liveable Neighbourhood), 2006]
12.1 Introduction

This chapter first highlights the key findings of the TSH study. Subsequently, the findings are discussed in relation to historical land use and transport planning priorities (refer to Chapter 2), transport decision-making (refer to Chapter 3), environmental sustainability and public health (refer to Chapter 4), transport energy and the twilight of cheap fuel (refer to Chapter 5), a sustainable transport agenda (refer to Chapter 6) and alternative transport and land use planning approaches (refer to Chapter 7). Third, the various points are drawn together to provide a succinct evaluation of how the LN policy is being implemented with respect for transport. Lastly, the limitations of the TSH study are described.

To recapitulate, LN has nine fundamental principles (see Table 7.4, page 247). Four of these (listed in Table 12.1) are particularly relevant to the present study. The various findings are interpreted in the context of these core principles.

The travel survey aimed to capture the trip characteristics of study participants (n=211) over the course of either seven (Cohort One) or two days (Cohort Two). This self-reported travel information could then be analysed for differences depending on neighbourhood type (LN or CN). Some limited health data was also collected from participants and the reported trip information was used to derive energy use and emissions variables. Overall, the travel survey data reflected the actual transport behaviour of residents of Perth’s new neighbourhoods.
Table 12.1 – Four principles of LN expressly related to transport

| Town structure | The town structure should be compact and well-defined. It should consist of a clustering of highly interconnected neighbourhoods, which is mutually supportive of both neighbourhood centres and the town centre. |
| Neighbourhood structure | A neighbourhood is typically defined as a 400-450 metre radius circle (5 minute walking distance) with a shop supplying daily needs, or another type of community focus, at its centre. |
| Neighbourhood walkability | Walking is the most energy efficient mode of travel. It can be encouraged by an interconnected street network that provides pedestrians with a choice of routes at intersections to enable access to neighbourhood facilities via a safe and attractive environment. |
| Walkability to facilities and public transport | As a measure of efficiency, at least 60% of the dwellings in a neighbourhood should be within a 400-450 metre walk of a neighbourhood centre or bus stop, or 800 metres of a rail station. |


The perception study aimed to compare self-reported perceptions of the neighbourhood street network, walkability and distances to key destinations between residents of LNs and CNs. Perceptual data can be intermediary in the relationship between aspects of the built environment and transport behaviour.

Finally, the environmental study aimed to compare actual access to key destinations; street network permeability; residential lot density and work trip substitutability (as an indicator of sustainable regional transport opportunity) between households in LNs and CNs. It was intended that the environmental measures would be key indicators of whether LNs are being designed as anticipated and were therefore significantly different to the CNs included in the study. The environmental measures could then be related
back to any measurable differences in residents’ transport behaviour and perceptions of access, walkability and the street network.

12.2 Key findings of the Transport Sustainability and Health study

The key findings of the TSH study are presented in Tables 12.2-12.4. Table 12.2 shows the key findings of the travel survey, Table 12.3 shows the findings of the perceptual study and the key findings of the environmental study are presented in Table 12.4. The findings are then discussed and brought together in Section 12.3.
Table 12.2 – Key findings of the travel survey

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Finding</th>
<th>Liveable Neighbourhoods</th>
<th>Conventional Neighbourhoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control variables</td>
<td>No significant differences</td>
<td>Motor vehicle 72%</td>
<td>Motor vehicle 81%</td>
</tr>
<tr>
<td>Trip level modal split</td>
<td></td>
<td>Public transport 4%</td>
<td>Public transport 4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walking 21%</td>
<td>Walking 12%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cycling 3%</td>
<td>Cycling 3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motor vehicle 72%</td>
<td>Motor vehicle 82%</td>
</tr>
<tr>
<td>Individual level modal split</td>
<td></td>
<td>Public transport 4%</td>
<td>Public transport 4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walking 21%</td>
<td>Walking 12%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cycling 3%</td>
<td>Cycling 2%</td>
</tr>
<tr>
<td>Proportion of motor vehicle trips reported as single-occupancy</td>
<td></td>
<td>49%</td>
<td>41%</td>
</tr>
<tr>
<td>Car ownership per person</td>
<td></td>
<td>0.82</td>
<td>0.78</td>
</tr>
<tr>
<td>Car ownership per household</td>
<td></td>
<td>1.83</td>
<td>1.97</td>
</tr>
<tr>
<td>Average trip distance</td>
<td></td>
<td>11.34</td>
<td>12.10</td>
</tr>
<tr>
<td>Short trips (&lt;1.5km) as a proportion of an individual's travel</td>
<td></td>
<td>21%</td>
<td>15%</td>
</tr>
<tr>
<td>Short trips conducted by walking</td>
<td></td>
<td>69%</td>
<td>58%</td>
</tr>
<tr>
<td>Average daily private VKT</td>
<td></td>
<td>42.59</td>
<td>43.05</td>
</tr>
<tr>
<td>Energy use and emissions</td>
<td>Inconsistent pattern of difference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily reported transport-related physical activity</td>
<td>20.41 minutes</td>
<td>12.39 minutes</td>
<td></td>
</tr>
</tbody>
</table>
### Table 12.3 – Key findings of the perceptual study

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control variables</td>
<td>No significant differences</td>
</tr>
<tr>
<td>Walkability of the local street network</td>
<td>Inconsistent pattern of difference</td>
</tr>
<tr>
<td>Perceived distance to key destinations</td>
<td>Inconsistent pattern of difference, but typically long (with the exception of distance to the nearest public transport stop)</td>
</tr>
</tbody>
</table>

### Table 12.4 – Key findings of the environmental study

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Liveable Neighbourhoods</th>
<th>Conventional Neighbourhoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to daily shopping</td>
<td>3.3km</td>
<td>2.8km</td>
</tr>
<tr>
<td>Distance to newsagency</td>
<td>5.3km</td>
<td>3.3km</td>
</tr>
<tr>
<td>Distance to childcare facility</td>
<td>2.8km</td>
<td>2.8km</td>
</tr>
<tr>
<td>Distance to medical facility</td>
<td>1.4km</td>
<td>2.0km</td>
</tr>
<tr>
<td>Distance to postal facility</td>
<td>1.7km</td>
<td>1.4km</td>
</tr>
<tr>
<td>Distance to a public transport stop</td>
<td>510 metres</td>
<td>649 metres</td>
</tr>
<tr>
<td>Average network distance to a key destination</td>
<td>2.5km</td>
<td>2.2km</td>
</tr>
<tr>
<td>Average street network permeability</td>
<td>1.37</td>
<td>1.41</td>
</tr>
<tr>
<td>Average residential lot size*</td>
<td>603.44m²</td>
<td>820.21m²</td>
</tr>
<tr>
<td>Lots per site hectare*#</td>
<td>16.67</td>
<td>14.88</td>
</tr>
<tr>
<td>Lots per urban hectare*</td>
<td>8.81</td>
<td>8.64</td>
</tr>
<tr>
<td>Average residential lot size^</td>
<td>603.44m²</td>
<td>646.62m²</td>
</tr>
<tr>
<td>Lots per site hectare^#</td>
<td>16.67</td>
<td>15.58</td>
</tr>
<tr>
<td>Lots per urban hectare^</td>
<td>8.81</td>
<td>9.01</td>
</tr>
<tr>
<td>Work trip substitutability</td>
<td>No significant differences, however, the average work trip would be 2.74-2.97 times longer if made by public transport rather than the motor vehicle and would take 39.51-42.15 minutes longer (one way)</td>
<td></td>
</tr>
</tbody>
</table>

*with control for neighbourhood size
^with control for neighbourhood size and outlying conventional neighbourhood excluded
#equivalent to an R standard
12.3 Self-reported trip data

12.3.1 Mode use and vehicle ownership

The various statistical tests indicate a clear pattern of mode use difference depending on neighbourhood classification, even though the vast majority of trips by study participants, irrespective of neighbourhood, were by motor vehicle. The reliance on motor vehicles for most trips is unsurprising given the new neighbourhoods tend to be situated on the urban fringe. Whilst LN and more broadly, the New Urbanist movement intend for car dependence to be lessened in new developments, Chapter 5 discussed how distance to the CBD strongly influences car use and by implication, transport energy use.

The prevalence of walking by residents of LNs was almost double that of residents of CNs with a 9% switch being evident between car trips and walking for people in LNs. However, the significance of these differences in walking and motor vehicle use was attenuated by car ownership per person being slightly higher and motor vehicle trip occupancy lower amongst residents of LNs (49% of single occupancy trips as opposed to 41% in CNs). Thus, overall there was little difference in VKT per person (which is the most important variable influencing fuel use and emissions) between residents of LNs and CNs.

There were no consistent differences at the trip or individual level with respect to public transport use or cycling. This was unexpected given the principles of LN, including that better access to public transport52 should be observable in LNs and there should be more

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52 Work trip analyses as part of the environmental study do offer some explanation.
supportive infrastructure for cyclists. The car remains the favoured mode for longer trips. For shorter trips, the remains little incentive to cycle as most investments in cycling infrastructure are occurring in central areas and major corridors, such as Perth’s freeways, and are not evident in the LN areas or CN areas.

Despite differences in modal split in favour of residents of LNs, car ownership per person was higher in LNs (0.82 cars, on average, per household member) compared with CNs (0.78), although the difference was not statistically significant. International research suggests that the saturation point may be 0.85 cars per person thereafter people find additional car ownership to be unnecessary (Dargay and Gately, 1999). If this is accurate, rates of car ownership in Perth’s new neighbourhoods appear to be almost at this threshold.

A car ownership rate per 1,000 people can be derived for the TSH study findings. Expressed in these terms, the estimated rate is 820 per 1,000 residents in LNs and 780 per 1,000 residents of CNs. Thus, whilst residents of LNs reported driving less than residents of CNs, they still have a high level of car ownership (both per household and per person), which poses challenges for ongoing transport sustainability.

The study neighbourhoods have to be recognised for what they are. Uniformly, they are new developments on or near the fringe of the city and they do not share key characteristics with inner-city areas, such as relatively high population and job densities, mixing of uses and good access to public transport (these points are discussed more in 12.4), which are facilitative of less dependency on cars. This is despite the intention for LNs to be new neighbourhoods that were more like inner areas. In this respect, the LN

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53 Also, despite a resurgence in cycling in Perth as noted by Wooldridge (2005).
code appears to have failed. Consequently, high car ownership and use may be expected in the study neighbourhoods as may the lack of consistent and substantial difference in car ownership between LNs and CNs.

Given the high level of car ownership, from an economic perspective, residents of the study neighbourhoods are sacrificing a great deal of income on private transport, whether they drive their car or not. Costs such as the purchase price, vehicle depreciation and insurance tend to be fixed rather than relative to the degree of driving people do.

12.3.2 Trip purposes, distances and times

LN and New Urbanism aim to reduce trip distances and travel times, especially for utilitarian purposes, to thereby create more incentive for people to switch from the car to other forms of transport. These approaches contend that improving permeability can achieve these ends. The literature offers some support, with permeability being one particular design characteristic that can encourage behaviour change. However, the discussion in Chapter 3 shows that increased permeability may achieve little in isolation from the other key, synergistic design features (such as increased population and service densities and land use mix) that facilitate behaviour change.

In general, participants reported significantly more utilitarian rather than leisure trips and many more regional than short trips\(^\text{54}\). At 12.1 kilometres, the average trip distance (for all trips) was high. Relatively speaking, residents of LNs reported a higher proportion of ‘short’ trips than residents of CNs, as well as shorter average trip

\(^{54}\) Trips equal or less than 1,500 metres.
distances and times overall. Notably, reported distances and times did not vary significantly between neighbourhoods when they related to work or shopping trips, but they did for leisure trips. However, this does not mean residents of CNs reported more transport-related physical activity: instead, their leisure trips tended to be by motor vehicle. Some of this leisure-related motor vehicle travel was for its own sake, rather than to a particular destination (like a sports hall). This suggests that motor vehicles can provide people with recreation opportunities, not simply access to recreation (Davison, 2004; Handy, 2003; Handy et al., 2005b).

Following aggregation of the trip distance and time data to the individual level, differences between neighbourhoods attenuated. A number of study participants travelled significantly further for longer for many of their trips. Even so, residents of LNs were still significantly more likely to make short trips (21% of trips, on average, compared with 15% of trips by residents of CNs).

However, both the trip and individual-level data show that ‘short’ trips were not necessarily conducted within people’s own neighbourhoods. Short trips were frequently conducted as part of regional trip chains or elsewhere in the metropolitan area, perhaps during a person’s working day. For purposes other than leisure, the data show people are leaving their neighbourhoods to conduct almost all of their life’s work. Short trips by residents of LNs were significantly more likely to be walked (69%) than those undertaken by residents of CNs (58%). This is consistent with the overall mode use differences between LNs and CNs. Nevertheless, many short trips were still driven (i.e. 33% overall).
Other Perth-based research has found that 48% of car trips are less than 5 kilometres and 71% less than 10 kilometres (Wooldridge, 2005). In comparison, the TSH survey data show that only 29.3% of all reported car trips were less than 5 kilometres and 55.3% less than 10 kilometres. These findings still show significant opportunity for mode substitution and at least some preferential rather than necessary car use (refer Bachels and Newman, 2001; Handy, 2003; Handy et al., 2005b; Rees, 2003).

Notably, average daily private VKT per person was found to vary little depending on neighbourhood type (p=0.92). Rather, at an average of 42.9 kilometres for all participants, daily private VKT per person was very high (refer to Table 12.3 and Litman, 2002). If participants drove this distance consistently for a year, their annual VKT would be 15,659 km. Such high VKT and a lack of difference depending on neighbourhood type challenge the significance of differences in mode use or design between LNs and CNs.

Overall, the self-reported travel behaviour strongly suggests residents of the sample neighbourhoods are highly car dependent. This can be explained by the findings of the environmental study (see 12.5), with access to services (and hence more opportunities to alter travel plans) undoubtedly being poorer on the fringes of the city than is experienced in inner-city (more mixed use and denser) areas. Good access is not simply a function of improved permeability. Importantly, people will use their cars when they have no other option (i.e. when it is not feasible to walk to the store because it is too far away) and thus an environment supportive of sustainable travel must improve people’s access to destinations that are integral to their life’s work (i.e. shopping and workplaces). The necessity for good access will undoubtedly increase as transport fuel costs and other costs of living rise.
12.3.3 Key qualifiers of transport sustainability and health

Whilst differences in mode use and trip distances can be important, relative transport sustainability is more quantifiable when differences in transport energy use and emissions levels can be identified. Oil, the principal source of transport energy, is a finite resource and is predicted to be in short supply.\textsuperscript{55} Chapter 5 discussed how many analysts have argued that peak oil has been or will soon be reached (see Campbell, 2003; Campbell and Laherrère, 1998; Fleay, 1995; Kenworthy, 2007; Newman and Kenworthy, 2006; Parker, 2005a; Simmons, 2005). Chapter 5 goes on to explain how this will have dramatic consequences for the transport task, including private vehicular mobility.

Moreover, Chapter 4 explained how conventional vehicle emissions are understood to be significant contributors to urban air pollution (refer to Cavill, 2003; Holtzclaw, 2000; Shore, 2006; World Health Organization, 2003), which in turn can have serious implications for people’s health (refer to Brunekreef, 1997; Cohen, 2000; Katsonyanni and Pershagen, 1997; Oosterlee \textit{et al.}, 1996; Ontario College of Family Physicians, 2005a; Sallis \textit{et al.}, 2004). Reduced per capita transport energy use and emissions in LNs compared with CNs would therefore be crucial indicators of LN and New Urbanism achieving the change desired.

The energy and emissions data did not yield a consistent pattern of significant difference as would be expected from the total VKT data. There were no significant differences in transport energy use and emissions (carbon monoxide, hydrocarbons and nitrogen oxide) by neighbourhood type. However, significant differences were found after adjustment for trip purpose. For work trips, residents of LNs, on average, used

\textsuperscript{55} Discussed more when all the findings of the TSH study are drawn together – refer Section 12.5.
significantly more transport energy and emitted more of all types of pollutants. For shopping trips, residents of LNs emitted more hydrocarbons and nitrogen oxide. However, for leisure trips, residents of CNs used significantly more transport energy and emitted more of all types of pollutants. More rigorous analyses may help explain the differences for work and shopping trips, but the differences for leisure trips can be explained by residents of CNs driving for many more of these trips compared with residents of LNs.

The literature shows that energy use and emissions are not simply a function of VKT. They depend on the characteristics of vehicles, driving conditions and trip speeds (Cameron et al., 2004). Some vehicle characteristics, including cylinder capacity, and average trip speeds were taken into account by Leung and Williams’ (2000) power-based model, which was used to make the transport energy and emissions calculations for the TSH study. This may be causing some of the variations between trip types: i.e. work trips are likely to be more stop-start. However, whilst residents of CNs generally reported driving more and for longer than residents of LNs, at least for some purposes, when other trip-related characteristics were controlled for, transport energy use and emissions levels did not appear indicative of residence in one particular type of neighbourhood. The overall effect of VKT appears to dominate despite some trip purpose variability.

Chapter 4 explained how public health, alongside transport energy use and emissions, is an important indicator of transport sustainability. Whilst people can be physically active in many ways other than walking or cycling for transport, the health literature does associate sufficient overall physical activity with up to a 50% lower risk of serious chronic illnesses, including heart disease, osteoporosis, colon cancer, type II diabetes,
and overweight and obesity (see Bauman et al., 2002; Davis et al., 2005; National Heart Foundation, 2004; Transportation Research Board, 2005). Utilitarian walking or cycling can therefore be an easy way to increase people’s total physical activity to help them achieve recommended daily levels (refer Geurs and von Wee, 2003; Haskell et al., 2007) and therefore improve their health. Chapter 7 discussed how LN and New Urbanism intend for new neighbourhoods to be more conducive to active transport compared with conventional suburbs.

The individual-level data show low levels of transport-related physical activity, irrespective of neighbourhood type, suggesting that the study neighbourhoods and their surrounds are not very facilitative of travel patterns that do not depend on the car. However, relatively speaking, residents of LNs reported significantly higher levels: they averaged 20.41 minutes per day of transport-related physical activity compared with 12.39 minutes by residents of CNs. This was consistent with the 9% switch found from motor vehicle to walking trips in the LNs and is the most positive outcome from the study.

The BMI data showed some differences depending on the neighbourhood participants lived in. Significantly more people living in CNs (15.5%) were obese than people in LNs (8.9%). This again was consistent with the differences in walking. Although overall more people living in CNs were overweight or obese (50.3%) than those living in LNs (46.4%), this did not reach statistical significance. These levels of overweight and obesity are remarkably similar to other Western Australian state-wide survey data of adults aged 18 and above. In 2002, 35% of Western Australian adults were classified overweight and 13% obese (McCormack et al., 2003). In 2006, 35% were classified overweight and 14% obese (Premier’s Physical Activity Taskforce, 2007b).
However, many residents have not lived in the study neighbourhoods for very long, making any link between self-reported transport behaviour and health data tenuous. If neighbourhood design is affecting transport behaviour (i.e. influencing rates of walking), it may take a much longer period of time for people’s health to measurably change.

12.3.4 The overall significance of the travel survey findings

Overall, the travel survey data produced a mixed set of results from the perspective of evaluating the effectiveness of the LN guidelines for facilitating sustainable transport behaviour. The results suggest that the LNs were relatively more sustainable than CNs in terms of active mode use, particularly for leisure trips, whilst the energy and emissions data suggested that CNs may be performing better for work and shopping trips, but not leisure trips. The pattern of difference also becomes a little unclear when there is further examination of where in the metropolitan area participants reported making trips and for what purposes.

The data suggest that the new neighbourhoods may not be supportive environments for sustainable transport because participants report a dependency on cars. Cars were used for the majority of trips and most trips were over long distances. The consequences of this car dependency will likely increase as an era of transport fuel vulnerability continues. The environmental data collected by the study and discussed below sheds considerable light on why there is such a dependency on cars. The study neighbourhoods are characterised by features typical of sprawl development: little mixing of key uses, low residential densities and inefficient public transport services. Furthermore, the new neighbourhood are diffuse and often on the fringe of the city.
12.4 Access and perception of access: can the travel characteristics be explained?

12.4.1 Neighbourhood walkability

The perceptual study aimed to evaluate how residents of the study neighbourhoods perceive their local areas with respect to opportunities for utilitarian walking and access, because perception may be intermediary in the relationships between transport and the built environment. The environmental study aimed to evaluate key characteristics of the built environment in the study neighbourhoods including access to key destinations, street network permeability and residential lot density. At the regional scale, the environmental study also aimed to evaluate work trip substitutability (public transport for car trips). The perceptual and environmental data were then related to the travel survey data.

Chapter 3 linked people’s perceptions of their environment with their travel behaviour. People need to be aware, for example, of increased opportunities to travel locally (perhaps by walking) or else they will travel regionally to conduct their life’s work. LN and New Urbanism intend for access to key destinations (such as shops) to be better in new developments, when compared with conventional neighbourhoods. Once people have resided in their neighbourhoods for long enough, they should become aware of the increased accessibility of shops and other facilities. The underlying assumptions of LN and New Urbanism are therefore that, in practice, accessibility will be improved and people will become aware of these improvements through the course of their daily lives.

Analysis of the environmental perception data revealed that residents perceived there to be significant distance between their homes and local shops, newsagencies, childcare
facilities, medical facilities and postal facilities. However, the perceptual data showed that people in CNs perceived access to public transport to be relatively easier (though the differences were not significant), even though residents of LNs perceived there to be relatively shorter distances to public transport stops in their neighbourhoods (a finding that was statistically significant). Notably, residents of LNs were not significantly more likely to report a more permeable and active mode-friendly local street network.

Across the range of indicators, there was no general pattern of difference in appraisals of the street network or access. Overall, the environmental perception data revealed no significant and consistent pattern of difference depending on neighbourhood type. In general, participants perceived their neighbourhoods to be of low walkability principally because key destinations, with the exception of public transport, were relatively inaccessible by walking.

Contrary to expectations, the environmental study found a significantly shorter average distance to selected key destinations (i.e. local shops, a newsagency, childcare facility, medical facility, postal facility or public transport stop) in CNs (2.15 km) than LNs (2.49 km). The data revealed that those living in CNs had significantly shorter average distances to local shops, newsagents and postal facilities compared with those living in LNs. However, the average distance to medical facilities was significantly shorter in LNs. In addition, those in LNs had significantly better access to public transport stops, which is a key aim of the LN policy (WAPC, 2004). Nevertheless, only 49.8% of study households in LNs were within 450 metres of a public transport stop, which falls well below the target of 60%.
Consequently, few facilities were found to be within 400-metre and 1,500-metre street network buffers around people’s homes. Typically, where there was a destination within 400 metres of a person’s home, it was a public transport stop. Public transport stops were easily the closest destination, irrespective of neighbourhood classification and the relatively closer proximity of these to homes in LNs strongly influenced the finding that there were more destinations within 400 metres of homes in LNs than in CNs. However, because there were shorter overall average distances to key destinations in CNs, significantly more destinations were within 1,500 metres of those living in CNs than LNs.

Analyses of street-network permeability found that direct routes were significantly more likely to be found in LNs than CNs. Chapter 7 highlighted how this is intended by the LN policy (and New Urbanism) given also discussion in Chapter 2 of how poor permeability can reduce the attractiveness of active modes and add significant travel times and distances to even short (straight line) trips (see also Beatley, 2004; Frumkin et al., 2004; Newman et al., 1997). The reasons for a more permeable network in LNs include provision of fewer dead ends, relative to CNs, and a generally more connected street network. These street network design features are promoted in Chapter 2 and recommended in the literature (Ewing, 1999) as a means to provide more pedestrian legibility and a choice of routes. Also, Chapter 4 highlighted how connected networks promote active transport (see also Chatman, 2006; McIndoe, 2005; National Heart Foundation of Australia, 2004; Pickrell, 1998).

Chapter 2 highlighted how increased densities (particularly residential densities) are critical to facilitating more sustainable travel. This is because increased densities, in conjunction with increased mixing of land uses, puts people in closer proximity to
goods, services and employment. This decreases car dependence and increases opportunities for people to use active modes for transport and is therefore integral to walkability. It also increases both the access to and viability of transit, particularly rail, which is essential for enhanced regional transport sustainability. Chapter 7 explained how increased densities are intended to be characteristic of Liveable Neighbourhoods.

Residential lot density analyses found statistically significant differences in average lot sizes, lots per site hectare and lots per hectare between LNs and CNs but only when the size of neighbourhoods were controlled for. When all of the study neighbourhoods were included in the analysis (and neighbourhood size was controlled for), the average lot size in LNs was found to be 603.44m$^2$ whilst in CNs it was 820.21m$^2$ ($p<0.01$). The number of lots per site hectare was 16.67 in LNs compared with 14.88 in CNs ($p<0.01$) and the number of lots per urban hectare was 8.81 in LNs compared with 8.64 in CNs ($p<0.01$).

However, when the outlying CN (with an average lot size of 3,878.65m$^2$) was excluded from the analysis, the direction of differences changed somewhat. The average lot size in LNs was 603.44m$^2$ compared with 646.62m$^2$ in CNs ($p<0.01$). The number of lots per site hectare in LNs was 16.67 compared with 15.58 in CNs ($p<0.01$). Yet, the number of lots per urban hectare in LNs was 8.81 compared with 9.01 in CNs ($p<0.01$).

Despite walkability being one of the key objectives of LN, overall, the data suggest that the new neighbourhoods are not very walkable. The Premier’s Physical Activity Taskforce (PTAF) (2006) anticipates that walkability can be measured by analysis of the walking distance to local services and facilities. These facilities, including local shops, should anchor the community (Moudon et al., 2006). Whilst there are significant
differences in access depending on neighbourhood type, mainly in favour of CNs, the
distances between people’s homes and key destinations are consistently too great for it
to be feasible for people to walk.

The average distance to local shops is one of the most important findings in the TSH
study. Arguably, local shops are the most necessary for facilitating a degree of
neighbourhood self-sufficiency through providing people with a local opportunity to
purchase perishables and other daily necessities. Local shops can also provide some
opportunity for local employment. The significant difference depending on
neighbourhood classification is one reason for concern. The very high average distance
to local shops irrespective of neighbourhood classification is another.

Chapter 3 explained how the delineation of acceptable distance is important as
willingness to walk to facilities diminishes the further people live away from them (see
also Cervero, 1994). Chapter 3 also explained that whilst willingness to walk varies
depending on contextual factors (such as topography and the quality of the pedestrian
network), personal considerations and the purpose of trips (for example, whether a trip
is discretionary or not), all else being equal, people must weigh how long a trip will take
against their travel time budgets to ascertain whether it is feasible or not (see also
Marchetti, 1994; Neff, 1996).

Based on distances that people actually walk, prior Perth-based research has found that
1.5 or 1.6 kilometres is a realistic maximum that the average person could be expected
to walk to conduct daily business (McCormack et al., 2007), which is equivalent to a
brisk 15 minute walk (Saelens et al., 2003a). Others have argued that 400-450 metres
(or a five minute walk) is characteristic of a walkable neighbourhood (Holtzclaw, 1994;
Moudon et al., 2006). The LN guidelines refer to 400 metres being the target radius for new neighbourhoods (Western Australian Planning Commission, 2004).

These lower estimations of acceptable walking distance reflect that a walking journey to and from a typical destination (such as shops) constitutes a small proportion of the daily travel the typical person must make. The average person will not want to expend their entire daily travel time budget to conduct a single return walking journey. Thus, with distances to key destinations in this study generally being far in excess of even a brisk 15 minute walk, it is simply not feasible for the average study participant to walk (or even cycle) to the nearest shop or other destination.

Also, from a health perspective, because the environmental indicators do not show much possibility for mode substitution, there appear to be very limited opportunities to encourage transport-related utilitarian physical activity. Poor access helps explain why the default mode choice for shopping (as reported in the travel survey) tends to be the car and why nearly all shopping is done outside of the neighbourhood in which people reside. The results suggest that rather than shopping locally, people tended to travel to elsewhere in the metropolitan region for this purpose.

With few local key utilitarian destinations being present, it appears that new neighbourhoods are being anchored by other community facilities. In the small sample of neighbourhoods that were audited, the most common anchor-points were parkland and water features. These can serve as significant focal points for leisure-related walking and may help explain the leisure-related travel reported in the travel survey, but do not contribute to utilitarian transport sustainability. Curtis (2005: p197) argues that in existing LNs “the experience for pedestrians and cyclists is significantly better”.

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Given the findings of the TSH study, the differential experience must be explained by leisure, rather than utilitarian trips.

The differences in permeability that were identified are rendered less significant because of the long distances between people’s homes and key destinations. In theory, relatively good permeability should be conducive to shorter trips (Ewing and Cervero, 2001a; Ewing and Cervero, 2001b). In the travel survey, for example, residents of LNs reported a higher relative share of short trips. However, many of these short trips occurred outside of the study neighbourhoods (often as part of trip chains). This is a function of there being few local utilitarian destinations to travel to. Permeability can therefore be considered a component of an urban design package, where other characteristics including activity intensity and quality micro-scale network design are critical to a sustainable transport environment.

Residential lot density is also an indicator of access because businesses (particularly non-specialised service providers) require a sufficient nearby population to make them viable. In areas where population density is low (which is a function of how many residential lots there are in neighbourhoods and how many dwellings are on those lots), it tends to be infeasible for local shops, newsagencies, childcare facilities, medical facilities and postal facilities to become established. Infeasibility increases in neighbourhoods that are both small and have low residential densities, unless there is significant latent demand for facilities from adjoining neighbourhoods.

The results of the residential lot density analyses therefore help to explain why the TSH study found considerable separation between homes and key destinations in the sample neighbourhoods. Despite some differences between LNs and CNs, overall, residential
lot densities were very low. In Chapter 7, it was discussed how the LN guidelines target 22 dwellings (in the TSH study, residential lots were used as proxy for dwellings) per site hectare (equivalent to an average standard of R22), and 15 dwellings per urban hectare. Higher densities of 20-30 dwellings per site hectare are anticipated within 400 metres of local centres and public transport stops. In ‘strategic’ areas in the vicinity of town centres and rail stations (800 metres radius) the housing density should be 30-40 dwellings per site hectare (WAPC, 2004).

When neighbourhood size was controlled for, there were only 16.67 residential lots (with control for strata titles) per site hectare in the sample LNs. There were only 8.81 lots per urban hectare. These figures are both well below the intended densities and contribute directly to the neighbourhoods being of very low walkability and having very limited public transport services, and therefore being highly car dependent. Together, these findings are consistent with earlier work by Taylor Burrell Barnett (2004) (described in Chapter 7), which found “LN had not delivered on the wider range of densities, mixed use development and main street neighbourhood centres, principally due to the small scale of applications” (Taylor Burrell Barnett, 2004: p16).

Whilst new development continues to unfold in the new neighbourhoods, there is little evidence that residential lot densities will significantly change. Moreover, in a number of the sample neighbourhoods (both LNs and CNs), large blocks remain where owners have chosen not to sell to the developer or have not exercised the right to subdivide. These large lots drag overall densities down and will continue to compromise the contiguity of development.
Whilst low residential lot densities and poor access may compromise walkability, it could be argued that people may still cycle rather than use the car. For example, US research has argued that 2-3 miles (3.2-4.8 kilometres) is a reasonable distance to cycle to public transport stops (Meyer and Dumbaugh, 2004). However, good cycle access requires a number of things; first, that people own cycles; second, that they are prepared to cycle; third, that supportive infrastructure is in place; fourth, that people feel safe enough cycling; fifth, that they can securely store their cycles at destinations; sixth, that they can carry purchases home with them; and seventh, that it would not just be easier to drive given the distances involved. The travel survey data showed that people cycled for a very small proportion of trips overall; even short trips. This suggests that there are insufficient incentives to cycle in the study neighbourhoods.

The size of the new neighbourhoods [as mentioned by Taylor Burrell Barnett (2004)] and how they are diffused throughout the Perth metropolitan region can help explain some of the findings relating to access, residential lot density and walkability. Almost three quarters of the 46 study neighbourhoods are less than one square kilometre in size (without controlling for undeveloped land). Even taking into account network distance and differences in the shape of neighbourhoods, the access measures show that key destinations are well outside neighbourhoods. If a key characteristic of sprawl is significant distance between people’s homes and key facilities (Transportation Research Board, 2005), then the study neighbourhoods are good examples of sprawl development.

Figure 7.3 (page 263) shows how the study neighbourhoods are diffused throughout the Perth metropolitan region. This shows how the development of new neighbourhoods is not being regionally coordinated. Often, adjoining neighbourhoods are not built by the
same developer and developers refer to the LN guidelines in their design to varying
degrees, presenting problems for linking infrastructure together. UK-based research has
found that *ad hoc* development can only have limited effects on travel behaviour, which
is especially true when developments are small (Williams, 2001). Suburbanites have
*regional* travel patterns (Olaru and Smith, 2005) and this must in part be a function of
*ad hoc* development.

Again, development is still unfolding in many new neighbourhoods. Often, land is
released in stages and often, areas are set aside as future commercial precincts. Nevertheless, the market rather than developers control what businesses locate where. Also, the potential lack of coordination in planning new and adjacent developments suggests that the needs of residents will not necessarily be met locally as development unfolds.

### 12.4.2 Regional transport opportunities

The substitutability of public transport for the car for work trips was assessed to indicate
potential for sustainable *regional* travel. The study found that public transport is
consistently the most accessible key destination in the study neighbourhoods. Does it
follow that if people can easily reach public transport that the service can then provide
efficient regional travel opportunities?

In this part of the study, modelled, self-reported and public transport work trip times
were estimated using Main Roads WA networks models, the data provided by
participants in RESIDE’s first follow-up questionnaire and TransPerth’s Journey
Planner, respectively. In each case, work trip travel time was significantly lower for
residents of CNs. This infers residents of LNs are generally travelling further for work. Overall, six of the derived public transport travel times were actually less than the self-reported motor vehicle travel times. In each of these cases the participants had good access to the northern suburbs rail line, which appeared to offer a real time advantage over driving. Also, a number of derived public transport times included significant walking legs, with one participant required to walk nine kilometres as part of their journey to work.

Whilst the findings revealed no significant differences in time sacrifice depending on the type of neighbourhood participants live in, they did show an overall average trip time 2.7-3.0 times longer for a public transport compared with a motor vehicle trip. Thus, an average participant who spent 30 minutes driving to work may have to travel for 89 minutes if taking public transport instead. Analyses also found the average real time sacrifice to be between 39.5 and 42.2 minutes. The average commuter therefore faces a significant time burden if they make the mode substitution. A one-way work trip increases from 31.4 to at least 70.9 minutes. Following the return journey, their total work travel has increased from 62.8 to 141.8 minutes. There is cause for concern here, because “(time)...is a scarce and constrained commodity” (Transportation Research Board, 2005: p60).

The literature identifies that people are generally unwilling to commit more than 30 minutes to a single, frequently made trip (Neff, 1996; Pederson, 1980). The concept of a travel maximum or constant reflects an acceptable investment of time in a regular journey, especially the journey to work (Marchetti, 1994). If, as discussed in Chapter 3, people tend to be unwilling to spend more than about 60 minutes travelling per day, the

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This bodes well for the new southern rail line and is evidence of how successful public transport can be.
average TSH study participant would exceed their total daily travel budget before they reach work, if they travelled by public transport. This helps explain why virtually no one reported using public transport for work trips in the travel survey.

These findings present great challenges for public transport. Whilst Chapter 6 discussed how public transport can provide significant leverage over motor vehicle travel (see also Kenworthy, 2007; Neff, 1996; Newman and Kenworthy, 1992), the TSH study results reveal that time competitiveness, one of the essentials of quality public transport, is not evident for study participant’s journey to work. As argued in Chapters 3 and 6, any push for increased transport sustainability must ensure that people do not exceed their budgets if travelling by modes other than the private motor vehicle. Therefore, the findings suggest a need for future research into substitutability for other types of trips.

The poor substitutability of public transport for the motor vehicle, at least for work trips, is linked to urban design. Chapter 6 explained how density and land-use mix (together, activity intensity) are as crucial for the viability of public transport as settlement size (municipal population) (see also Kenworthy, 1986; McIndoe et al., 2005). These points say as much about the metropolitan region (in that high activity intensity is not being achieved across much of the urban area) as the new neighbourhoods that form the focus of the TSH study.

Diffusion of work places and population are almost certainly linked to the poor substitutability of public transport for car trips (see Holtzclaw, 1990; Kenworthy and Laube, 2005; Newman and Kenworthy, 1999). The many work-related circumferential rather than radial trips reported by study participants is evidence of the diffusion of homes and places of work (refer Crane and Chatman, 2005; O’Connor, 1998; O’Connor
and Stimson, 1996). This raises concerns about how effectively and efficiently public transport could get people from their homes to work and back again, given the sprawled nature of Perth and the generally radial design of the Perth public transport system.

12.4.3 Qualifiers of car dependence and sprawl

Together, the environmental study evidence strongly suggests that the study neighbourhoods are not self-sufficient. They are small and appear not to be coordinated, which is a function of different developers handling adjacent projects. Furthermore, the differences in travel behaviour indicated in the travel survey cannot be linked to neighbourhood design because fundamental objectives, including quantifiably improved access (see Litman, 2003), mixing of land uses and increased residential densities are not being achieved.

Poor access and low densities have been described as key qualifiers of car dependence (Newman and Kenworthy, 1989; Newman and Kenworthy, 1999; Newman, 2006). If the results of the TSH study are extrapolated so that they may be compared with Litman’s (2002) predictors of car dependence (discussed in Chapter 7) participants and the neighbourhoods they live in score poorly. Table 12.5 provides this comparison.

The environmental evidence also suggests that the study neighbourhoods - both LN and CN - are contributing to sprawl. Ewing and others (2002), for example, cite four key measures of sprawl - low densities, segregated land uses, and a lack of permeability and urban vitality - which, with the exception of permeability, the new neighbourhoods do not score well on. With urban vitality having been argued to be a function of
neighbourhood walkability (Fenton, 2003), then it may be considered low in the study neighbourhoods.

Irrespective of how neighbourhoods are branded, the environmental data do not signal a significant movement away from conventional planning, which remains based on the Metropolitan Regional Scheme (1963) and anticipated by the Stephenson-Hepburn Plan (1955). New neighbourhoods still appear to be designed assuming people will drive for the great majority of their journeys (refer DPI, 2000; Premier’s Physical Activity Taskforce, 2006; Rural and Regional Affairs and Transport References Committee, 2006). The travel survey data shows residents of new neighbourhoods are doing exactly this.

Table 12.5 – Litman’s (2002) predictors of relative car dependence

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
<th>Qualifier of automobile dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Vehicle ownership</td>
<td>Per capita vehicle ownership per 1,000 people</td>
<td>Less than 250 per 1,000</td>
</tr>
<tr>
<td>Vehicle use</td>
<td>Per capita annual vehicle miles travelled (VMT)</td>
<td>Less than 4,000 (6,437 kilometres)</td>
</tr>
<tr>
<td>Vehicle trips</td>
<td>Automobile trips as a percentage of all personal trips</td>
<td>Less than 50%</td>
</tr>
<tr>
<td>Quality of alternative modes</td>
<td>Relative convenience, cost, speed, comfort etc.</td>
<td>Competitive</td>
</tr>
<tr>
<td>Relative mobility of non-drivers</td>
<td>Relative to drivers</td>
<td>Low disadvantage</td>
</tr>
<tr>
<td>Market distortions favouring automobile use</td>
<td>Relative advantage to motor vehicles in planning, tax, policy, funding etc.</td>
<td>Minimal bias</td>
</tr>
</tbody>
</table>

(Source: Cameron, 2004; Litman, 2002)
Even if more care is being taken, as part of the planning process, to improve street layouts and pedestrian infrastructure (reflected in the differences in permeability depending on neighbourhood classification), there would still appear to be confusion over the ingredients needed to facilitate more sustainable utilitarian transport. Again, good network permeability is not very useful unless it is partnered with neighbourhood characteristics including increased development densities and mixing of land uses (including key facilities such as local shops). Also, at the broader scale, neighbourhoods need to be strategically located and well linked together by transit.

Looking specifically at physical activity and health, the study neighbourhoods do not appear to be the right types of environments for transport-related utilitarian physical activity, although they may encourage some leisure-related walking. Chapter 4 described how the local provision of services and facilities – which is not being achieved in the study neighbourhoods - may promote more walking and cycling, leading to health benefits from physical activity (see also Frank et al., 2004).

Also, people are more likely to be *moderately* physically active when there are a good mix of nearby destinations and direct routes to get there (Frank, 2000a; Frank et al., 2005; Powell et al., 2003). Similarly, Greenberg and Renne (2005: p90) argue that “making immediate neighbourhoods more walkable and bikeable is important to increase the likelihood of additional exercise”.

Conversely, as is the case in the study neighbourhoods, urban design that reduces the feasibility of walking (or even cycling) to local destinations may be contributing to rising levels of obesity (Frank et al., 2003; Frank et al., 2004; Vandegrift and Yoked,
2004). However, the inconsistencies between the travel survey data and the results of the environmental study infer further investigation of this link is necessary.

Moreover, with LNs and CNs being insufficiently different in design (at least according to the measures controlled for in the TSH study), it is impossible to expand on earlier research that has found residents of highly walkable neighbourhoods, relative to residents of lowly walkable neighbourhoods, report higher levels of moderate level utilitarian physical activity (Saelens et al., 2003a). This suggests that planning interventions to improve transport sustainability have come up short.

12.5 Evaluating the implementation of LN with respect to transport

In Chapter 7, some searching questions were posed. These included; are the ways in which LN is being implemented actually achieving improvements in community design? Are land uses and transport being coordinated in new neighbourhoods? And, is the design code being consistently applied?

When all the findings of the TSH study are drawn together, some robust answers to these questions can be given. First, there is little evidence to suggest that LN is achieving improvements, measurable by increased land use mixing and densities, more efficient public transport and consequent better access. However, there is clearly a gulf between the LN principles and practice. In many sample neighbourhoods, even the nominal increases in density intended by the LN code are not being realised.
Also, there is little evidence of enhanced land use and transport coordination in new neighbourhoods as there are few opportunities for utilitarian active mode use. Furthermore, work trip substitutability analyses strongly infer that relatively improved access to public transport stops can have little impact on the viability of public transport for regional trips, because of the time sacrifices required for a modal shift.

In Chapter 7, some of the other key challenges to the successful implementation of LN were also discussed. The TSH study shows that the current flexibility built into LN is likely to be contributing to some of the more unfavourable environmental outcomes on the ground. For example, developers do not seem to be delivering on the targets for higher densities and greater mixing of land uses.

With LNs typically being on greenfields sites and not self-contained (neither are CNs), these developments are not contributing to the core aims of Network City, such as for 60% of new growth to be in established areas. Network City also aims to decrease car dependence, enhance public transport and not “inequitably limit accessibility based on location or access to a private car” (DPI and WAPC, 2004: p66), which are other targets that new development appears not to be contributing to.

The more rigorous planning process that developers of LNs are choosing to go through does not seem to have resulted in many fundamental differences on the ground. This would seem to be because developers are not providing fundamentally different development proposals to be audited, they are just more detailed. Furthermore, there seem to be insufficient incentives for developers to develop more in accordance with the LN criteria. These points generate questions as to why certain elements of LN are
adopted by developers (i.e. increased network permeability) and others are not (i.e. increased residential densities).

With the travel survey findings being irreconcilable with the perceptual and environmental study results, there are difficulties explaining the observed differences in modal splits, amongst other reported transport behaviour. Whilst the study did not control for self-selection and personal preference, these appear to be likely explanations. Other researchers have defined self-selection as a market sorting process (Badoe and Miller, 2000; Boarnet and Crane, 2001; Chatman, 2006; Schimek, 1996). Thus, people who are more inclined to travel by modes other than the motor vehicle, for example, may select to live in LNs because they are branded as being walkable and better linked to public transport infrastructure. Other research associated with the RESIDE project is investigating marketing and the effects it may have on homeowners (Nathan et al., 2007).

There is a growing body of research, much of which was explored in Chapter 3 that links factors other than environmental characteristics - personal attitudes, preferences and similar variables - with transport behaviour (Buchanan and Barnett, 2006; Cao et al., 2006a; Handy and Mokhtarian, 2005). Socio-demographic characteristics have also been argued to exert a powerful influence on travel behaviour (Stead et al., 2001; Williams, 2005), although socio-demographic controls in the TSH study suggest they are not so influential. All things considered, further investigation is needed to try to explain travel behaviour in Perth’s new neighbourhoods with control for people’s preferences. A thorough investigation into people’s transport decision-making would also be valuable.
Putting attempts to \textit{explain} the transport behaviour aside, there are some worrying implications of the behaviour itself. Again, irrespective of differences in mode use and so on, the transport behaviour of the average participant remains unsustainable. By reporting high average VKT and energy use as symptomatic of car dependence, the future looks fairly bleak if the pessimistic forecasts relating to energy futures prove to be accurate.

As discussed in Chapter 5, reputable energy analysts have foretold a coming shortage of transport energy (Campbell, 2003; Campbell and Laherrère, 1998; Fleay, 1995; Kenworthy, 2007; Newman and Kenworthy, 2006; Parker, 2005a; Simmons, 2005), which may contribute to a transport crisis in the foreseeable future. Whilst everyone will likely be affected by the crisis, people living in sprawled, car dependent areas will be disproportionately affected. People on lower incomes will be burdened most of all.

The Standing Committee on Rural Affairs and Transport (2007) accurately details that supply-side fixes to the transport energy problem offer limited hope. Instead, demand-side responses offer more robust solutions. The types of ‘smart’ growth projects anticipated by the Committee would require some fundamental changes to current development practice.

There are also consequences for public health and concerns about pollution that are associated with the reported transport behaviour and urban environment. Once more, future research is required to investigate the full extent of what these might be. Car dependence and sprawl, for example, are argued to be significant influences on a physically inactive lifestyle (Ewing \textit{et al.}, 2003; Ontario College of Family Physicians,
2005c; Sturm and Cohen, 2004). Unfortunately, insufficient data could be collected as part of the TSH study to draw more conclusions about such links.

Buxton (2001) argues that a significant threat to Australian cities is market decision-making. The evidence overwhelmingly suggests that present forms of urban development and transport are not sustainable, yet they continue to occur. In 2004, the WAPC estimated 375,000 more homes are still needed before 2031. Accordingly, there are some key challenges to ensuring growth is well managed.

12.6 Limitations of the Transport Sustainability and Health study

The TSH study had several limitations and these are discussed here. First, although part of the longitudinal RESIDE project the TSH study was cross-sectional on account of the limited time available to conduct the study, limited manpower, and to limit costs. Despite being cross-sectional, the TSH study was calibrated to deepen understandings of the links between urban form, transport and sustainability in Perth’s new neighbourhoods and filled an important research gap.

Cross-sectional studies do not show conclusively that the built environment is affecting people’s travel behaviour. Instead, it may be that residents of compact neighbourhoods self-select their neighbourhoods based on preconceived travel preferences, such as desires to walk, cycle and travel by public transport. In contrast, residents of conventional neighbourhoods may have selected to live there on account of a preference to do most of their travel by motor vehicle. However, there is still considerable doubt
as to the influence of self-selection, particularly whether it enhances or diminishes the influence of the built environment on travel behaviour (Ewing et al., 2007).

Longitudinal studies, on the other hand, are designed to control for self-selection by basing analysis on time series data. While sample neighbourhoods may be selected on the basis of design contrasts (for example, some compact and some conventional), longitudinal studies take before intervention and after intervention measurements. In doing so, change in behaviour over time can be measured and, assuming similarity in the attitudes, preferences and socio-demographic characteristics of the study groups before the intervention, findings can be more reliably attributed to changes to people’s physical environments.

Second, although the study was initially powered to 85% to enable detection of a difference between groups of 0.4 standard deviations, the desired numbers were not recruited to participate in the travel survey. This limits the potential external validity of the overall findings. In addition, two different cohorts were recruited. Some of the participants were already part of the main RESIDE study whilst others were not (but were living nearby). The response rate was consistently low across both cohorts. Small incentives were offered to the second cohort (i.e. video hire vouchers) but there was little evidence that these incentives proved effective.

Another strategy employed was to reduce the length of the travel diaries from seven to two days. It cannot be concluded, however, that this increased participation. Although at least two follow-up letters were sent to prospective participants, it was also unfortunate that budget, manpower and time constraints did not allow more thorough

57 Whilst the study neighbourhoods were selected under the assumption that CNs and LNs would have observable design differences, the results show few contrasts in design.
following-up. It is possible that a different recruitment protocol may have been more successful at achieving the desired level of participation.

Nevertheless, 211 people were surveyed and these people provided details of almost 3,900 trips. These data enabled some very useful analyses to be undertaken, the results of which prompted some meaningful discussion. Additionally, when the travel survey was partnered with the perceptual and environmental studies, a more comprehensive picture of travel behaviour (and opportunity) could be developed.

The travel survey design itself may also have introduced some bias to the results. Members of Cohort One who were also members of RESIDE had a demonstrated willingness to complete complex questionnaires. They were the gatekeepers to their households. Even persons not otherwise involved in RESIDE (Cohort Two) demonstrated a certain willingness to complete multi-day surveys. Participants may therefore not have been representative of the wider population of interest (those living in Perth’s new LNs and CNs). This, however, was not a significant problem, as the TSH study was interested in differences between LNs and CNs and the people who live in them, rather those who were willing to complete complex questionnaires and those who were not.

Seasonal effect was another minor concern. Given the problems experienced with recruiting for Cohort One, diaries were not sent to households until late May 2006. Many households would not have begun completing diaries until the first month of winter. Relatively bad weather may have had an influence on travel behaviour as intuitively; walking and cycling are less appealing in the rain and cold. Purposefully,
the second cohort was not sent diaries until late October to capture travel data during spring.

It was also difficult to draw any firm conclusions about levels of physical activity amongst the TSH study participants as they likely engage in non-transport-related physical activity. Other sources of physical activity, such as team sports, were not controlled for in the TSH study. Also, poor responses to the health-related questions in the travel survey, other than height and weight (used to derive BMI), made it impossible to link the available physical activity data with health indicators.

Notably, there is interest being shown in the use of Global Positioning Systems (GPS) instead of travel diaries to capture transport behaviour. New-technology GPS units are argued to be more reliable than diaries, because as long as they are carried with the participant, they will record all movement to a high degree of specificity. The GPS unit also does not suffer from ‘recall effect’, whereby a participant forgets to record trip details (Rietveld, 2002; Stopher et al., 2007). It is because of this ‘recall effect’ that self-reported travel data is sometimes critiqued for having limited validity (Sallis et al., 2000; Transportation Research Board, 2005). Nevertheless, self-completed questionnaires remain a cost-effective means to collect detailed travel information and have been used in numerous transport studies.

There were also some limitations to the environmental data. Sensis Pty Ltd, a commercial company that geocodes the Yellow Pages58 provided the information that was used to develop the measures of access. Whilst there were clear benefits associate with using this data source, including that the information was current and specific (i.e.

58 For the TSH study, the Yellow Pages 2007 was used.
delis could be differentiated from other land uses, such as bakeries, thereby adding to accuracy), there were shortcomings.

First, it was assumed that the data sourced from Sensis Pty Ltd was accurate. Second, there may be inconsistencies between geocoded destinations and what is actually on the ground. If a business does not list in the yellow pages they will not be represented in the access database. Also, some businesses could not be categorised correctly because of how they were named. For example, a shopping centre that was referred to as a ‘forum’ in the Yellow Pages would not have been geocoded as a shopping centre and therefore would not be included as a key destination in the TSH study analyses. Furthermore, if a listed business supplied a Post Office Box number rather than a street address, it likewise would not have been geocoded.

Unfortunately, there was no feasible way to identify the degree of error in the access data. This would have required a cost and manpower-intensive audit of all study neighbourhoods, including visual inspection of all streets and street corners. The method used to derive measures of access was therefore the most comprehensive ‘best estimate’ possible, given the iterative nature of GIS work and the need to continually update destination databases.

An additional limitation of the environmental data was that the transport network used in the analysis did not take into account all possible informal routes, such as paths through parks. Moreover, the quality of local pedestrian and cycle infrastructure was not appraised. This may help explain some of the reported leisure-related local travel. These additional layers of information would be very useful but producing them is very time-intensive and could not be done for the TSH study.
The residential lot density measures should also be treated with some caution. There may have been some inaccuracies in the calculation of average lot sizes, lots per site hectare and lots per urban hectare, given development is ongoing and the information in the geographic information system may not have been entirely consistent with what was on the ground. Moreover, the method for controlling for strata titles did not take stock of the peculiarities of each individual strata lot; retirement villages and care homes were not included in the analyses; and there may have been some minor inaccuracies when the boundaries of neighbourhoods were redrawn to exclude undeveloped land. However, the measurements were still the best estimate possible and relevant for the present stage of development, given the data available and the constraints of the TSH study. The method used also reveals a lack of formal mechanisms to monitor and evaluate densities in new neighbourhoods, which would seem to be vital for ensuring that planning policy is reinformed.

Furthermore, the data used to derive the work trip substitutability measures varied somewhat in accuracy. The origin and destination information reported by participants did not always include exact street addresses. As such, it was necessary to approximate using the nearest reported street intersection. Nevertheless, the long length of many work trips diminished the influence of these inaccuracies.

Finally, the distance of neighbourhoods from the Perth CBD was not controlled for. This variable may help explain some of the differences in accessibility. Proximity to the CBD (or any other major activity centres) is not a prerequisite under the LN code. Qualitative analyses found that nearly all of the study neighbourhoods were in fact on the fringe of existing urban development.
Overall, it is important to recognise that development is still unfolding in many of the study neighbourhoods. This means access measures will likely change over time as will density, which may impact on people’s travel behaviour and some of their attitudes and perceptions. This should not, however, diminish the significance of the findings, as large changes in land use and density simply are not anticipated in the study neighbourhoods.

Whilst a range of limitations was discussed in this section, the TSH study, on balance, still provides some engaging and robust findings. Each component of the research was carefully designed with reference to previous, published research. In particular, the travel survey was modelled on numerous earlier transport studies. Also, the TSH study is one of few studies that have compared actual transport behaviour with perceived and actual opportunity for more sustainable travel. It is also critical for providing feedback to policy makers on how the LN design code is being applied.

12.7 Summary

This chapter has discussed the various findings of the travel survey, perceptual study, and environmental study. Whilst some of the travel survey findings are very promising, considering the key aims of LN and the wider need for a sustainable transport agenda, they can neither be reconciled with people’s perceptions of their neighbourhoods nor (more problematically) a range of environmental findings.

Research that has sought to identify differences in urban form, people’s perceptions and transport behaviour has instead uncovered some concerns about how the LN code is being applied. The following chapter offers some conclusions that can be drawn from
the research. These are complemented with a range of policy recommendations that can be used to reinform LN and perhaps address some of these concerns. Subsequently, some directions for future research are offered.
CHAPTER 13:

Conclusions

Is ‘Liveable Neighbourhoods’ being implemented as intended?

As you creep along a highway that was widened just three years ago, you pass that awful new billboard: COMING SOON: NEW HOMES! Already the bulldozers are plowing down pine trees, and a thin layer of mud is oozing onto the roadway. How could this be happening? (Duany, Plater-Zyberk and Speck, 2000: pix).
13.1 Introduction

This chapter provides a conclusion to the thesis. First, the aims and objectives of the thesis are revisited and the main findings of the thesis are related to these. Subsequently, some reasoned appraisals of transport sustainability are given for the study neighbourhoods. Next, a range of policy recommendations are drawn from the various discussions presented throughout the thesis. Some recommendations for future research are then offered.

13.2 Revisiting the aims and objectives of the thesis

The overall goal of this thesis was to conduct the first comprehensive evaluation of transport sustainability in Liveable Neighbourhoods using 11 test case suburbs of Perth. In a broader sense, the thesis was a major evaluation of New Urbanism, given LN is an interpretation of this design approach.

The thesis had several key aims. The first of these was to conduct a comprehensive review of literature relating to transport sustainability (including historical planning, transport decision-making, social justice, pollution, public health and transport energy use), to contextualise the empirical research. The aims of the empirical research were to examine whether residents of LNs reported travelling in a more sustainable way than residents of CNs, there were more opportunities for sustainable travel in LNs and residents of LNs were aware of relatively more opportunities for sustainable travel. The associated objectives were to:
1) Set a context for the need for new planning priorities and an evaluative study by analysing urban planning history, travel decision-making and sustainability issues (such as social justice, pollution, public health and energy use);

2) Examine some of the alternatives for improving land use and transport sustainability and how these informed LN;

3) Identify a sample of Perth’s new neighbourhoods, some conventional and some Liveable to allow detailed analysis of travel patterns, residents’ perceptions of access in their neighbourhoods and opportunities for more sustainable travel;

4) Consider how the self-reported travel behaviour may be associated with key health variables (including BMI), and energy use and emissions, with these being some key measures of transport sustainability;

5) Use the findings of the research to discuss whether the way in which the LN design code is being implemented is contributing to more sustainable transport in new neighbourhoods. To then use this discussion to make policy recommendations, draw conclusions and identify areas for further research.

The comprehensive literature review (which satisfied objectives one and two) found that transport and land use in Perth has been strongly influenced by US practice. This has contributed to Perth becoming a sprawled and car dependent city. Transport decision-making by residents of Perth is undoubtedly influenced by urban form, although some doubts remain as to how strong these influences might be.
Also, the review found that social justice, pollution, public health and transport energy use are key indicators of how sustainable transport arrangements are. Generally speaking, urban areas that are sprawled and car dependent (such as Perth) tend to score poorly on the key indicators than those that exhibit more Transit-Oriented Development characteristics (i.e. are denser, mixed-use, walkable and served by quality transit services). Comprehensive, region-wide systems approaches to coordinate land use with transport were identified as the means to facilitate the more sustainable types of developments.

Furthermore, Chapter 7 described how New Urbanism strongly informed the LN design code, which is a planning approach that was intended to further the sustainable planning agenda in Perth. The Transport Sustainability and Health study, involving a travel survey, perception study and environmental study, met objectives three, four and five, and made the following key findings.

First, there is some evidence that the travel behaviour of residents of LNs is slightly more sustainable. The mode use data consistently shows residents of LNs drive 9% less and walk 9% more than their counterparts in CNs.

Residents of LNs also reported significantly more transport-related physical activity than their counterparts (8 minutes more transport-related physical activity) and this may be linked to there being 7% fewer obese people in LNs. Unfortunately, the differences in transport-related physical activity could not be consistently associated with differences in select health variables because of a paucity of reliable data. Moreover, non-transport-related physical activity, such as team sports, was not controlled for.
The ‘9% switch’ factor that was found (walking for driving) may be related to the different design of LNs in that they do have more direct streets with more footpaths thus making them more walkable (although many ‘short’ trips were conducted outside of people’s neighbourhoods). Thus, a small positive outcome in LNs may be claimed.

Despite the observed mode use differences, individual-level analyses showed little evidence of reduced transport energy use or fewer vehicle emissions. This appears to be due to the lower car occupancy rates, which means that people in LNs are driving just as much as CNs when total VKT is considered. Moreover, energy and emissions analyses showed no real differences depending on neighbourhood type. Thus, the small local advantage of more walkable streets is overwhelmed by the regional transport and land use context in which the LNs are set.

Even though the travel survey suggested some patterns of difference in walkability, these were not reconcilable with the findings of the perceptual and environmental studies. The perceptual study found virtually no differences in people’s perceptions of access, their local street networks or distances to key destinations, including shops, newsagencies, childcare, medical facilities, postal facilities and public transport stops. Thus, the findings suggest residents of LNs were not aware of relatively more opportunities for sustainable travel.

The environmental study found some planning deficiencies in the study neighbourhoods. Whilst street network permeability was found to be consistently better in LNs than CNs, access was significantly better in CNs. The average distance to key destinations was significantly lower in CNs compared with LNs. Also, whilst residential lot densities in LNs were mostly higher than in CNs (depending on which
controls were used), the overall finding was LNs simply are not dense enough to contribute to transport sustainability.

It is therefore no surprise to find that residents of the study neighbourhoods do not really have a viable public transport option. The findings of work trip substitutability analyses revealed significant time burdens for people if they were to use public transport rather than motor vehicles for the journey to and from work, irrespective of the neighbourhood they live in. With the average burden being between 39.5 and 42.2 minutes (one way), there is little reason to suggest people will willingly make the switch. Overall, the environmental data show that there may actually be fewer opportunities for sustainable travel in the sample LNs than in the CNs, although both types of neighbourhoods score poorly.

Ultimately, the study has neither reinforced nor challenged many previously identified associations between land use and transport. The differences in self-reported transport behaviour are not associated with differences in the design of neighbourhoods. However, the results show that there is a strong likelihood of associations between deficient access - where there is a lack of inter-neighbourhood coordination, low densities and little mixing of land uses - and a necessity for residents to drive for most trips (even residents of LNs report a high percentage of car trips, even for local trips), and often for long distances.

Furthermore, there is strong evidence of a gulf between the underlying LN principles and practice. This suggests that the design code is too flexible and developers are not observing some of the more important design criteria and/or that the existing policy is not the mechanism to promote sustainable transport. Even though the LN code may be
helping to create a few small benefits for local walkability, it is failing to contribute to the creation of a sustainable city. Instead, the evidence strongly suggests LN is contributing to the problem. This is because the density increases intended by the code are not significantly different to conventional practice; the code is not calibrated for piecemeal development (it requires development of towns to achieve any sort of activity intensity); conventional planning remains an alternative for developers; and the LN code does not prohibit development on the urban fringe. It is both vital that a development code is properly calibrated to contribute to the sustainability agenda and that it is consistently applied.

The thesis opens new fields of inquiry relating to land use, transport and health in Perth and suggests a need for more research into people’s transport decision-making and citywide policy-making. The wider implications of this thesis are that New Urbanism (as applied in Perth) has had some limited successes in increasing local walking but has failed to address the more regional issues of car dependence and sprawl. Urban planning more closely modelled on the European experience (refer to Chapter 2) is probably required to begin addressing the sustainability issues discussed in the literature review of this thesis.

In the next section, policy recommendations that can be drawn from the study are given. These are followed by suggestions for future research priorities.
13.3 Policy recommendations

There are several important policy recommendations that arise from this thesis and the TSH study:

- It is critical that the LN code is completely reassessed. This may involve conducting further research, which is similar to the TSH study (to evaluate how the development code is being applied) and more policy-focused evaluative research (to assess how the code itself needs to be recalibrated to achieve the overriding vision of LN: i.e. are the quantitative guidelines sufficiently strong). The data collected here suggest that the LN code is failing to produce sufficient density increases and mixed use neighbourhoods. This is signposted by the low provision of local services and low substitutability of transit for the car for work trips. It is anticipated that design trends in Perth will change (particularly as government and developers become more aware of sustainability priorities) and there will either have to be changes to the ways in which the code is interpreted or else it should be replaced by a more effective code.

- A retuning of LN to make it more prescriptive about density increases and mixing of uses should enable quality Transit-Oriented Development. This would assist with neighbourhoods becoming more walkable and improve their regional transport access. Increased densities may be achieved by setting some minimums as well as maximums and requiring minimum residential lot densities in strategic areas, such as near to proposed centres. Mixing of uses could be achieved by requiring certain percentages of mixed-used zoning in new neighbourhoods and even facilitating development of multi-story units where street-level businesses are topped by...
dwellings. Success elsewhere (i.e. in Subiaco) demonstrates there is demand for high-quality, higher density and mixed used developments.

- With its present configuration, LN does not seem to be able to achieve the strategic-level coordination of neighbourhoods that is anticipated. The evidence suggests that coordination is an important prerequisite for access. Thus, regional planning and even redevelopment of areas may be required to enable the LN code to achieve the desired outcomes. When neighbourhoods (even LNs) are planned in an *ad hoc* way (particularly when they are small), it is difficult to ensure shops, places of work and other facilities are provided nearby. Suggestions for improving coordination include providing more incentives for private partnerships (such as tax concessions and expedition of applications) and more private-public collaboration. Overall, however, the most significant factor would be genuinely regional planning rather than piecemeal development. The *Network City* framework could provide the necessary perspective but it will require political will to implement. In Perth, the development of TODs rather than LNs (as they are presently being developed) should be the priority, as this would be likely to contribute to more regional integration. With the completion of the southern rail line, there are new opportunities for turning LNs into genuine TODs.

- The State government is presently developing integrated transport guidelines. These are an essential complement to development policy such as LN as they have the potential to ensure new infrastructure is properly linked with surrounding networks. If good transit (preferably light rail) can be built back into suburbs there is a good basis for improved regional sustainability and local walkability. Also, higher-
quality walking and cycling networks are essential complements to increased activity intensities.

- LN should be geared more towards redevelopment of underutilised urban land, rather than greenfields development. This would be consistent with the objectives of Network City: to facilitate 60% of new growth in the existing urban area.

- It is questionable whether developers are familiar with best practice and sustainability objectives, and can apply LN as intended. Further education is vital to help sell the benefits of smarter, more sustainable growth to developers. These can include improved returns (note again the successes in Subiaco), alongside environmental and social benefits.

13.4 Recommended future research

The first policy recommendation was to regularly assess and reinforce the LN policy. Several of the key areas for future research are related to this. More investigation is required to assess whether some of the transport deficiencies in new neighbourhoods are arising because of the ways in which LN is being implemented or because the policy itself is not consistent with the guiding principles.

To gain a clearer picture of relative transport sustainability, a future study is necessary to compare Liveable Neighbourhoods with some genuinely dense, mixed-use areas of Perth. Cross-sectional analyses usually compare neighbourhoods that are significantly different in design. Future research of this nature can add to context-specific understandings of urban design and transport linkages. Associated research may also
analyse demand for more compact development, with results hopefully informing future dialogue with developers regarding urban growth. Where there is resistance to compact design, research can also identify policy points that can allay people’s concerns.

Future research may also compare two or more samples of Liveable Neighbourhoods with neighbourhoods being grouped depending on their distance from the CBD. Chapter 5 discussed how transport energy use is related to distance from the CBD (see also Chandra, 2006; Newman, 2006). Such research may help to further demonstrate that the location as well as the design of new developments is undermining sustainability.

Due to a lack of data, the TSH study was unable to thoroughly investigate the associations between urban design and transport, and public health. Additional, carefully calibrated research is required to better understand such associations. In particular, research needs to focus on physical activity and pollution, and how these might be dependent on where people live and their travel patterns.

Additional research should investigate transport decision-making amongst residents of Perth’s new neighbourhoods. Whilst it is assumed to an extent that people have to drive for many of their trips because of relatively poor access, a greater understanding is needed of how people make choices. This is particularly relevant for semi-bounded and unbounded trips, where people can be flexible. An interesting extension of this would be to analyse how the TravelSmart programme, discussed in Chapter 7, influences people in LNs and CNs. Education and empowerment (which are at the heart of TravelSmart) are likely to be crucial complements to reformed urban design packages.
Future research could also examine links between household sizes, demographics and the purposes of trips. Theoretically, children who are frequently being driven around by their parents may become beholden to cars. Also, parents chauffeuring their children around may explain differences in mode use.

Transport cost analysis is another useful focus for future studies. The influence of cost in people’s decision-making could be analysed and the full costs of people’s travel behaviour could be calculated to identify any inter-neighbourhood differences. Consequently, through education, people could be provided with incentives to curtail their use of the private motor vehicle.

Additional analyses of density are warranted. The TSH study analysed residential lot density at the neighbourhood classification level. There are opportunities for future research to analyse patterns of density within new neighbourhoods (particularly larger neighbourhoods). This would allow a more thorough appraisal of whether any sort of density gradient is being achieved [i.e. whether R40 (or denser) development is being clustered around centres and public transport stops].

More generally, the evidence overwhelming suggests that increased densities are critical for improving transport sustainability so robust mechanisms must be developed to assess densities in new neighbourhoods. This will help ensure that planning policies are reinforced.

To add to understandings of the potential for people to substitute other modes for motor vehicle trips, more rigorous substitutability analyses could be undertaken. The TSH study focused on work trips. Future research could focus on shopping trips or other trip
purposes. There are obvious difficulties with this, however, as semi- or non-bounded trips are flexible. For example, a long-distance shopping trip that is driven may be more easily substituted for a trip to a nearer shopping centre, rather than a burdensome trip to the original destination by public transport. Nevertheless, there is a great opportunity for future, comparative work trip substitutability analysis, as the completion of Perth’s southern rail line should drastically improve public transport work trip times for some residents.

Finally, this review of potential research has focused on land development in Perth. However, the work here is set in a global context as New Urbanist projects are occurring all over the world, especially in the US. Many of these, from their descriptions and photos, are similar in style and seem to have the same failings in terms of inadequate densities and land use mix, which may likely result in poor centres, weak regional transit systems and limited local transport options. An evaluation of these developments needs to occur to see whether they too have the same transport outcomes as discovered in the Perth study covered in this thesis.

13.5 Summary

This chapter has revisited the aims and objectives of the thesis and provided an appraisal of transport sustainability in a sample of 46 Liveable (n=11) and conventional (n=35) neighbourhoods. Chapters 2 to 7 provided a context for primary data collection, highlighting how a range of sustainability concerns, including social injustice, pollution, and poor public health and transport energy constraints, contributed to the adoption of the Liveable Neighbourhoods code in Perth. The Liveable Neighbourhoods code was modelled on American New Urbanist principles. The evidence from the Transport
Sustainability and Health study conducted in this thesis reveals that whilst there are some small quantifiable benefits in local transport behaviour between residents of Liveable Neighbourhoods and conventional neighbourhoods, there were few differences in key indicators of regional transport sustainability, including transport energy use and emissions. Moreover, the perceptual study showed little differences depending on neighbourhood classification.

Critically, too, the environmental study demonstrated access to key destinations in the study neighbourhoods is generally low. This reduces the opportunity for more sustainable transport. Relatively poor access is almost certainly a product of low development densities and little mixing of uses in the neighbourhoods. Also, work trip substitutability analyses found a significant time burden for residents giving up the use of their car. Overall, the core transport-related principles of LN are not reflected in the study neighbourhoods. The LN code is not doing what it was intended it should do for sustainable urbanism and the city is not benefiting from its present application.

These findings are of international significance and should suggest caution in recognising New Urbanism as a mechanism to reduce car dependence and urban sprawl through a limited set of design changes. Improving sustainability in cities will require much more than LN (an application of New Urbanism) has been able to provide.

The thesis has recommended that the Liveable Neighbourhoods code is completely reassessed. A mechanism that implements the principles of Network City and facilitates Transit-Oriented Development is required instead. This mechanism must be more prescriptive about increases in both population and service densities, and mixing of uses to promote neighbourhood vibrancy, access and support for transit services. Also,
development needs to be strategically targeted towards existing urban areas rather than the urban fringe and coordinated as part of a sustainable regional (Network City) vision for Perth. Furthermore, best practice (i.e. the implementation of TOD and Network City design principles) must be better encouraged amongst developers. Both State and local government have pivotal roles in facilitating this.

The thesis has also recommended several areas for future research. The more important of these is to compare a sample of Liveable Neighbourhoods with some genuine TODs, to give clearer indications of how design may influence transport (and associated indicators of sustainability, such as transport energy use).
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