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**AN INVESTIGATION INTO URBAN FORM AND TRAVEL  
BEHAVIOUR  
A Case Study Of Auckland**

*This Thesis is submitted in partial fulfilment of the requirements for the  
degree of Masters of Resource and Environmental Planning at Massey  
University*

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**January 1999**

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## **ABSTRACT**

There has been increasing awareness in recent years about the need to improve urban sustainability. One major urban sustainability issue that confronts many western cities world-wide is the trend towards increasing reliance on the automobile as the main mode of travel and the impact this has on the environment, economy and society. In recognition of the relationships that exist within the environment, economy and society this thesis seeks to investigate travel behaviour patterns as an urban sustainability issue in a holistic manner. The research examines the relationship between urban form and socio-demographic characteristics of a population with travel behaviour in an attempt to more clearly understand the way in which urban form and population characteristics influence travel choice.

Auckland is one New Zealand City exhibiting a pattern of increasing automobile reliant travel behaviour. This is having major detrimental consequences on both environmental, economic and societal well-being. Auckland has been used as the basis for the study for this research. The thesis therefore identifies the relevant legislative context for transportation management and provision within New Zealand and summaries recent initiatives undertaken within the Auckland region to greater integrate land use and transportation planning.

Researchers to date, have conducted much study on the relationship between urban form, socio-demographic characteristics of populations with travel behaviour patterns. One branch of study is research on “Neo-Traditional Developments/Designs” and the affect this has on travel behaviour. Urban areas with Neo-Traditional Developments/Designs can be characterised as having more connective street layout systems, greater mixes of land uses, higher population and residential densities and more pedestrian friendly environments. An urban form that exhibits these characteristics is associated with lower levels of automobile travel and greater levels non-vehicular and public transport use.

This thesis compares the travel behaviour (and socio-demographic characteristics) of areas within Auckland that exhibit these Neo-Traditional Development characteristics with areas that do not exhibit the characteristics in order to ascertain whether there are any differences in travel behaviour patterns. Socio-demographic characteristics or lifestyle and life cycle stage is also viewed as a significant proponent that influences travel behaviour. The thesis further compares the effect life cycle as determined by age and household role has on travel behaviour patterns.

The thesis concludes that both urban form and socio-demographic variables such as age and household role influences travel behaviour patterns within the Auckland region to varying degrees. The thesis provides support to improve the knowledge and understanding of travel behaviour and the factors that influence it in order to address Auckland’s transportation issues in a sustainable manner.

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## CHAPTER ONE: INTRODUCTION

- 1.0 The planning mission of achieving 'sustainable cities' is a complex one, one that has stimulated much debate around the world about its implication for current city management strategies. The goal of urban sustainability is defined in Agenda 21 as the ability to develop the capacity to sustain productivity, improve living conditions for inhabitants and manage natural and physical resources in sustainable way (pg.12 UNCED 1992). In order to understand urban sustainability, information is required about the environmental, economic, social and physical components that contribute to the function of the city and the relationships between these. Both urban form or the shape of settlement patterns within the city, and the characteristics of its population, can influence travel behavior patterns. Urban form has the potential to influence the frequency and mode of transportation used, the viability and patronage of public transport facilities, access to jobs, goods and services and distances travelled. The socio-demographic characteristics of the urban population can also influence travel behaviour or the frequency, purpose, mode and distance of trips. This in turn has a variety of direct and indirect effects on urban sustainability levels. These effects may include the level of fuel consumption and air and noise emissions resulting from movement around cities, the economic well-being of commerce and industry and safety and access of travellers. Information pertaining to travel behaviour resulting from differing urban form and population characteristics is thus vital to developing policies for achieving urban sustainability.
- 1.1 At present many New Zealanders place a high value on living in a semi-rural environment and driving their automobiles to work, shopping and recreational areas and in every other aspect of their daily lives. The resulting urban sprawl and automobile reliance are endemic in the metropolitan areas of many New Zealand cities. These trends are not confined to New Zealand cities alone; many American, Canadian and Australian cities are faced with these same problematic issues. This has prompted researchers from around the globe to seek solutions to curb automobile reliant travel behaviour. Researchers have investigated the relationship between urban form and travel behaviour, in particular, the effect of the 'balance and mixture of land

use', 'street layouts', 'urban limit lines', 'urban density levels' and 'pedestrian and/or transit orientated environments' to reduce or redirect demand for automobile transport within an urban area. Other research has focused on identifying the travel requirements for different population groups; for example, various age and income groups, lifestyle or life cycle groups, and household types. To date however, there have been very few attempts to fully explore the influence both urban form and socio-demographic characteristics have on travel behaviour patterns. This research therefore aims to contribute more information on this topic, and to provide a clearer indication of the relationship between urban form and socio-demographic characteristics with travel behaviour in New Zealand cities. This research is used to comment and speculate where possible 'phase changes' that could be implemented towards achieving a more sustainable urban transport future in New Zealand.

- 1.2 The research contained in this Thesis primarily examines the extent to which travel behaviour is influenced by urban form and socio-demographic characteristics within the Auckland region. The current and likely future travel behaviour patterns within the Auckland region are also determined. It is anticipated that the findings of this research will enable decision makers to prepare more informed land transport policies and plans towards achieving sustainability in the urban environment.

### 1.3 OVERALL AIM

The overall aim of this Thesis is to identify to what extent travel behaviour is influenced by urban form in the New Zealand context. The research aims to identify whether a combination of urban form policies and actions, in particular, a more connective street layout, increased residential density and mix of housing types, increased mix and balance of land uses, and provision of nearby shopping facilities is able to reduce or redirect demand for automobile travel. The research is based on a case study undertaken in the Auckland region; consisting of eight selected urban tracts with contrasting urban forms and socio-demographic characteristics. The socio-demographic characteristics of the population are examined to identify whether urban form characteristics can and do influence the travel behaviour of the residing population. The socio-demographic characteristics are also examined to determine current and predicted travel behaviour trends as a basis for comment on future transport provision. The results and conclusions of the case study are compared to the

travel behaviour of the Auckland region as a whole and other international urban travel behaviour studies. The research investigates New Zealand's travel behaviour and related urban form and socio-demographic characteristics to provide information for urban land transport policy and plan preparation, and decision making. This research also places New Zealand's travel patterns into a global context by reviewing the current research pertaining to urban form and socio-demographic and travel behaviour.

## CHAPTER TWO : GOALS AND OBJECTIVES

### 2.0 DEFINITION OF GOALS AND OBJECTIVES

A Goal can be defined as “an object of effort or ambition; destination” (The Concise Oxford Dictionary Sixth Edition 1986). Objectives refer to the specific steps towards the attainment of a goal (The Concise Oxford Dictionary Sixth Edition 1986). The goals and objectives set to attain the overall aim of the thesis, are thus listed in this next section.

### 2.1 LITERATURE REVIEW

#### 2.1.1 GOALS

- 2.1.1.1 To identify the impacts reliance on the automobile as the main mode of travel influences urban sustainability in terms of environmental, economic and social well-being.
- 2.1.1.2 To provide a rationale for why research that investigates the relationship between urban form and socio-demographic characteristics with travel behaviour is required, in order to plan for future growth within New Zealand cities.
- 2.1.1.3 To use pertinent and relevant research to determine which urban form, socio-demographic characteristics are more likely to influence travel patterns; and to select travel behaviour variables to indicate travel patterns for this analysis.
- 2.1.1.4 To review the approaches and techniques used in the relevant research in order to develop a suitable methodological process to acquire a sound analysis.
- 2.1.1.5 To review the results of recent international research, to compare and contrast with the findings of this analysis, in order to attain a wider international perspective.

2.1.1.6 To suggest reasons for the current shape and structure of Auckland's existing urban form and transportation provision using relevant economic theory about land use, historical and sociological themes.

## 2.1.2 OBJECTIVES

2.1.2.1 To justify using empirical evidence from international and New Zealand research, why automobile reliance is a urban sustainability issue of environmental, economic and social concern by identifying current and predicted travel behaviour and resource use patterns.

2.1.2.2 To use the findings and conclusions made from relevant international research pertaining to urban form and socio-demographics with travel behaviour to establish why this research is required to improve and enhance urban land transport policy and plan preparation in New Zealand cities.

2.1.2.3 To review recent international and New Zealand research pertaining to urban form, socio-demographic characteristics and travel behaviour to identify the suggested research areas, methodologies and approaches required for a sound analysis.

2.1.2.4 To review relevant research relating to urban form and travel behaviour; in particular, the influence 'residential density levels', 'mixture and balance of land use', 'connective street layout', 'provision of nearby shopping facilities' and the 'pedestrian orientated environment' approaches have on reducing or redirecting demand for the automobile.

2.1.2.5 To review recent research that addresses the relationship between travel behaviour and differing socio-demographic characteristics; in particular, lifestyles, life cycles, roles, gender and age groups. To identify which socio-demographic characteristics are most likely to influence current and future travel behaviour patterns.

2.1.2.6 To discuss theoretical concepts including economic theories of location and land use, and sociological and historical themes that concur with Auckland's existing urban form and transport provisions.

## 2.2 LEGISLATIVE ENVIRONMENT

### 2.2.1 GOALS

2.2.1.1 To outline the current legislative and institutional context for managing land transport within urban areas. The legislative context includes any relevant recognized international documents and treaties, and domestic law.

2.2.1.2 To establish how/to what extent New Zealand's legislative and institutional context allows for the above-mentioned urban form initiatives to be implemented and the treatment of socio-demographic influences on travel behaviour in urban land transport planning.

### 2.2.2 OBJECTIVES

2.2.2.1 To review relevant environmental agreements and documents that discuss urban sustainability. In particular: Agenda 21 published by the United Nations Conference on Environment and Development (UNCED) June 1992; "Our Common Future" published by the World Commission on the Environment and Development (WCED) 1987 and "Caring for the Earth" published by The World Conservation Union (IUCN) United Nations Environment Programme (UNEP) World Wide Fund For Nature (WWF) 1991. To identify the principles and approaches contained within these documents that support the basis of this research.

2.2.2.2 To outline how the urban land transport sector is currently managed under current legislation including the Resource Management Act 1991, Land Transport Act 1993, Transit New Zealand Act 1989, Transport Services Licensing Act 1989 and the Local Government Act 1989.

2.2.2.3 To review current legislation, and policy and planning documents focusing on the Environment 2010 Strategy, National Land Transport Strategy consultation document and the Draft Auckland Regional Growth Strategy and the Draft Auckland Regional Land Transport Strategy to identify how urban form initiatives and socio-demographic influences on travel behaviour are to be incorporated into the planning and management of Auckland's growth.

## 2.3 CASE STUDY

### 2.3.1 GOALS

2.3.1.1 To determine the level of automobile reliant travel patterns exhibited within Auckland.

2.3.1.2 To determine whether travel behaviour patterns are influenced by urban form within the New Zealand context, using Auckland as the case study source.

2.3.1.3 To determine the travel behaviour of differing socio-demographic groups and comment on the influence on current and future transportation requirements within Auckland.

2.3.1.4 To provide findings about the influence urban form and the socio-demographic characteristics have on travel behaviour patterns within the Auckland region; to assist in policy and plan preparation and decision making processes involving the urban land transportation sector.

### 2.3.2 OBJECTIVES

2.3.2.1 To use descriptive statistics to analyse the overall travel behaviour of the Auckland region using trip mode, purpose, distance (measured by time taken) and occupancy of car trips; to determine the level of automobile reliant travel behaviour within the Auckland region.

2.3.2.2 To use descriptive statistics to analyze the travel behaviour of residents living in areas with differing urban form characteristics; to determine the level of influence urban form may have on travel behaviour patterns within Auckland.

2.3.2.3 To use descriptive statistics to analyse the travel behaviour of different socio-demographic groups in particular, age and household groups, to determine the similarities and differences in travel behaviour patterns between these groups; to identify whether urban form has a greater influence in the travel behaviour of a particular age or household group than others.

2.3.2.4 To use results to provide evidence on whether urban form and/or socio-demographic characteristics influence travel behaviour in order to assist plan preparation and decision making in current and future urban land transport provision and management.

## 2.4 RESEARCH QUESTIONS

### 2.4.1 THEORETICAL

1. Why is reliance on the automobile as the main form of travel of concern?
2. Does Auckland exhibit the characteristics of a city heavily reliant on the automobile; and are Auckland's travel behaviour patterns consistent with worldwide trends?
3. What does it mean to have a 'sustainable city' and what implication does this have on providing/managing the urban land transport system?
4. Why is research into travel behaviour, in particular, urban form and socio-demographic characteristics, necessary to provide/manage for an urban land transport system?

### 2.4.2 CASE STUDY

1. What are the current travel behaviour patterns in Auckland?
2. How does urban form correlate with the travel behaviour of people living within Auckland?
3. How do the socio-demographic characteristics of a population, in particular, age and/or household role, correlate with travel behaviour patterns?
4. What implications do these results have on current travel and future transportation provision in Auckland and other New Zealand cities?
5. How do the findings of this research compare to other international studies and research?

## 2.5 OUTLINE OF THESIS

2.5.1 This thesis initially develops a theoretical base using relevant current research, then applies these findings to the case study developed for this research. The thesis structure is outlined below:

- 2.5.2 Chapter One: contains an introduction to the issues, overall goals, purposes and objectives of the research.
- 2.5.3 Chapter Two: sets out the legislative and institutional framework for managing urban land transportation in New Zealand, in which the theoretical concepts and research results can be applied.
- 2.5.4 Chapter Three contains a review of relevant literature. This includes a discussion of:
- concepts and definitions associated with urban sustainability;
  - why reliance on the automobile as the main form of travel is a important urban land transport planning issue for Auckland;
  - theoretical concepts associated with urban form, socio-demographic characteristics and travel behaviour;
  - implications of economic theories of location and land use and a discussion of sociological and historical themes in urban transport.
- 2.5.5 This chapter also provides an overview of the current research pertaining to the influence urban form and socio-demographics have on transportation patterns. The conclusions of this chapter will provide the foundation for the development of a methodology and a comparison for the research results.
- 2.5.6 Chapter Four: includes the methodology adopted for this research which also describes: the sources of data, sample selection criteria and other sample information, and the assumptions and limitations of the research.
- 2.5.7 Chapter Five: results are presented. The results are compared to other empirical research findings discussed in the literature review. The results identify the major trends in current travel behaviour patterns within Auckland, whether urban form has an influence on travel behaviour patterns, and the current travel behaviour patterns of differing socio-demographic groups.
- 2.5.8 Chapter Six: contains the main conclusions of this research.

## 2.6 DEFINITION OF TERMS

- 2.6.1 The dictionary defines 'urban' as "of or pertaining to, situated or living in a city or town" the term 'form' is defined as "the shape or external appearance (apart from colour); ...configuration, figure, particular arrangement, ...disposition, organization or constitution." (The Concise Oxford Dictionary Sixth Edition 1986). The term 'Urban form' therefore refers to the shape, design, layout and concentration of attributes found in urban areas for example, land uses, built structures, and infrastructure such as transport services. Urban areas have in the past, been characterised in relation to the land use patterns that exist. 'Urban form' is a broader concept that encompasses land use patterns as well as other more general urban design and infrastructure characteristics.
- 2.6.2 The term 'travel behaviour' used in this research refers to the aggregate-level characteristics of travel, that is, the purpose, mode, distance (trip time) and occupancy (passengers) of the trip made.
- 2.6.3 The term 'socio-demographics' refers to the variety of social and economic characteristics of the individual and households in a specified area. These include factors such as: age, gender, ethnicity, income, employment, car ownership, household type, dwelling type, and the role of household member.

## CHAPTER THREE: LEGISLATIVE CONTEXT

### 3.0 INTRODUCTION

This section focuses on how urban land transportation is managed within the New Zealand legislative and institutional context. The legislative context as discussed in this thesis is divided into three levels: international, national and regional. The relevant sections and themes to this thesis are discussed.

### 3.1 INTERNATIONAL CONTEXT

3.1.1 New Zealand observes many international treaties and strategies concerning the environment and is bound by international law to observe them. However, these treaties have no internal effect unless they are incorporated into New Zealand domestic law by an Act of parliament (Milne 1992). Sustainability or sustainable development are centrally important concepts discussed in recent international environmental treaties and strategies. Three international documents that produce guidelines for sustainability or sustainable development are 'Our Common Future's Brundtland Report published by the World Commission on the Environment and Development (WCED) 1987; 'Caring for the Earth - A world strategy for sustainable living', a document published by The World Conservation Union (IUCN) United Nations Environment Programme (UNEP) World Wide Fund For Nature (WWF) 1991; and 'Agenda 21' the document produced for the "Earth Summit" or the United Nations Conference on Environment and Development (UNCED) June 1992. The principle conclusions and approaches suggested in these documents and others have been endorsed by the New Zealand government. Recent legislative initiatives, for example, the Resource Management Act 1991, have sought to recognise and adopt many of the important themes discussed in these documents.

3.1.2 The concept of sustainability has evolved over the last 30 years from its earliest expression (at a recognised international forum) at the Biosphere conference in Paris 1968. This conference noted the "finite nature of resources", and called for their

“conservation in the interests of sustainable future use by human being.”(MacRae 1994 pg.49 Cervero 1996). The principle of ‘sustainable development’ was later strongly advocated in the influential Brundtland Report of 1987. In this document sustainable development was defined as “...development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (pg.6 WCED 1987). The Brundtland Report examines the critical environmental and development problems on the planet and aims to formulate realistic proposals to solve them, to ensure that human progress is sustained through development without bankrupting the resources of future generations. The IUCN/UNEP/WWF (1991) Caring for the Earth document states that sustainable development “...means improving the quality of human life while living within carrying capacity of supporting ecosystems.” (pg.10 IUCN/UNEP/WWF 1991). The document aims to attain widespread and deeply held commitment to the sustainable living ethic and to integrate conservation with development. These definitions encompass both natural and human environmental considerations. They note that sustainable development as an objective seeks to satisfy reasonable material and non-material societal needs indefinitely. The central role of decision making agencies is therefore to ensure that the actions of current generations do not substantially limit options available to future generations, and that the reasonable needs of all humans are met (pg.7 Memon and Perkins 1993).

- 3.1.3 The primary goal of the Earth Summit held in Rio de Janeiro June 1992, was to establish the basis for a global partnership between developing and more industrialised nations, based on mutual needs and common interests to ensure the future of the planet (Milne 1992). The Summit advocated the existence of a balance between the environment and development. A result of the Summit is Agenda 21, an action plan for sustainable development. It provides a hands on strategy to guide the development of the earth in a sustainable manner.

3.1.4 All the three strategies provide guidelines to build greater sustainability in both rural and urban environments. The main themes addressed in these three documents of relevance to this thesis are:

- adopting an integrated management approach;
- addressing the ‘effects’ or outcomes produced by activities;
- assessing the most efficient and effective approach;
- strengthening the knowledge base to address the above.

These four main themes are discussed in regard to goal and objective setting, policy development and implementation, and decision making for improved sustainable urban land transport management.

### 3.1.5 Integrated Management

3.1.5.1 The term ‘integrated’ implies ‘to make into a whole, to complete by addition of the parts, to combine into a whole’, while management denotes the ability ‘to conduct, to direct, to carry on, to control’ (Concise Oxford Dictionary Sixth Edition). Integrated management therefore should ensure that all different needs and interests are identified and addressed in a holistic manner. The Brundtland Report, Agenda 21 and the Caring for the Earth document recognise that human settlements are comprised of social, economic, environmental and physical needs and values. The Brundtland Report states that economic and ecological considerations should be integrated into decision making “...as they are after all integrated in the real world.” (pg.64 WCED 1987). The Agenda 21 document also states that the “...overall objective for human settlements is to ...improve the social, economic and environmental quality of human settlements and the living and working environments of all people, in particular the urban and rural poor.”(pg.173 UNCED 1992). This theme is also indicated in the following two statements in the Caring for the Earth document:

“...the planning and management of human settlements to satisfy the physical, social and other needs of their inhabitants on a sustainable basis by maintaining the balance of the ecosystems of which the settlement is an integral part.” (pg.106 IUCN/UNEP/WWF) “...harmonious combination of human-produced and natural elements to provide the habitats within which urban dwellers seek their well being.”(pg.106 IUCN/UNEP/WWF 1991).

- 3.1.5.2 An integrated approach in managing resources ensures that a common goal is established for environmental authorities, decision makers, interested parties and the general public. The Brundtland Report states that “Environmental protection and sustainable development must be an integral part of the mandates of all agencies of governments of international organisations, and of major private sector institutions (pg.312 WCED 1987). The ‘Caring for the Earth’ document states that governments should take steps to “...adopt an integrated approach to environmental policy with sustainability as the overall goal.”(pg.65 IUCN/UNEP/WWF 1991). Agenda 21 states that “The goals should be to ensure socially responsible economic development while protecting the resource base and environment for the benefit of future generations.” (pg.247 UNCED 1992). Agenda 21 supports an integrated approach when managing natural and physical resources; in this example in regard to land use, Agenda 21 states that “Goals should be set and policies formulated to address the environmental, social and economic factors involved in finding the best possible land and resource use. Out of this, policies should be enacted to encourage the efficient use, protection and management of land resources and an improved distribution of population and activities according to the productivity of the land resource.” (pg.65 UNCED 1992).
- 3.1.5.3 The Brundtland Report, Agenda 21 and the Caring for the Earth document suggest that the legislative and policy framework should be designed appropriately to consider the interrelationships between the environment, economy and society. The Brundtland Report states that “the real world of interlocked economic and ecological systems will not change: the policies and institutions concerned must.”(pg.310 WCED 1987). The document further states that “These intersectoral connections create patterns of economic and ecological independence rarely reflected in the way that policy is made. Sustainable development requires such fragmentation to be overcome...” (pg.63 WCED 1987). Chapter Eight of the Caring for the Earth document named “Providing a national framework for integrating development and conservation” states in Action 8.2 and 8.3 that governments should “...develop strategies for sustainability, and complement them directly through regional and local plans” and “establish a comprehensive system of environmental law and provide for its implementation and enforcement.” (pg.65 IUCN/UNEP/WWF 1991). The Agenda 21 further supports this by suggesting that the governments “adopt a domestic policy framework that reflects a long term perspective with and considerations of connections between various political, economic, social and environmental issues.”(pg.246 UNCED 1992). In

regard to transportation planning Agenda 21 specifically states that “...comprehensive transportation strategies must be integrated into all urban planning, with a view to reducing the environmental impacts of all modes of transportation.” (pg.137 UNCED 1992). These documents therefore recommend that transport issues should be addressed by governing authorities through an integrated legal framework of institutions and legislature.

3.1.5.4 The Brundtland Report, Agenda 21 and Caring for the Earth document all suggest that environmental, economic and social interests and values should be considered in decision making. The Brundtland Report states that “...the common theme throughout this strategy for sustainable development is the need to integrate economic/ecological considerations in decision making. They are after all, integrated in the workings of the real world (pg .62 WCED 1987). Agenda 21 states that “All countries should work to ensure the integration of economic, social and environmental considerations in decision making at all levels and in all ministries ...an integrated approach to land use will provide a broader perspective from which to make informed choices regarding the safest and most efficient use of land resources.” (pg..245 UNCED 1992). Caring for the Earth “Advocates Institutions For Integrated Decision Making” states that “the current fragmented and sectoral approach to policy must therefore be replaced (or buttressed) by new structures that ensure integration.”(pg.65 IUCN/UNEP/WWF 1991). Improved land management practices must be developed which deal comprehensively with competing land requirements for agriculture, industry, transportation, urban development, green space, preserves and other vital needs.” (pg.180 UNCED 1992). These statements clearly articulate the need to treat the environment in a holistic manner through the legislative framework, goal setting, policy preparation and decision making processes.

### 3.1.6 Effects and Outcomes of Activities

3.1.6.1 Land transport within the urban environment produces a variety of ‘effects’. The Agenda 21 and Caring for the Earth documents both suggest that addressing the effects of an activity are important in achieving sustainability objectives. This presents the challenge to “ensure that national policies, development plans, budgets and decisions on investment take full account of their effects on the environment”(pg.70 IUCN/UNEP/WWF 1991). To achieve this, the Agenda 21 document recommends

that comprehensive transportation strategies with clear goals and objectives should be produced in order to account for the wider implications actions or policies may have on the environment (pg.137 UNCED 1992). In addition, Agenda 21 states that a “...comprehensive analytical procedures for the economic, social and environmental impacts of decisions need to be adopted.”(pg.284 UNCED 1992). In regard to the management of transportation Agenda 21 concludes that the overall objective is to “...develop and promote cost-effective programs that limit, reduce or control harmful atmospheric pollution and other environmental effects from the transportation industry.”(pg.137 UNCED 1992). Agenda 21 further concludes that “...the design of urban, suburban and industrial development, including the location of dwellings and workplaces, must begin to take into account the fundamental environmental considerations, such as atmosphere pollution, noise, congestion.”(pg.137 UNCED 1992). In comparison the Brundtland Report argues that the ‘sources’ of effects should be tackled while maintaining a broader view of environmental problems (pg.311 WCED 1987). These three documents recommend that due consideration is given to address all the impacts or sources of impacts created by proposed and existing activities to the urban environment.

### 3.1.7 Adopting an Efficient and Effective Approach

3.1.7.1 The Brundtland Report, Agenda 21 and Caring for the Earth document suggest that decision makers should opt for the most efficient and effective approach to managing resources in human settlements. Within cities there are a number of competing uses for natural and physical resources. Agenda 21 recognises that “In rapidly growing urban areas, access to land is rendered increasingly difficult by the conflicting demands of industry, housing, commerce, agricultural land, ownership structures and open spaces.” (pg.179 UNCED 1992).

3.1.7.2 The ‘Caring for the Earth’ document advocates the promotion of efficient and environmentally sound transport systems (pg.107 IUCN/UNEP/WWF 1991). Agenda 21 states that “Promoting efficient and environmentally sound urban transportation systems in all countries should be a priority.”(pg.189 UNCED 1992). It emphasises that a greater effort must be applied “to develop and promote cost effective and more efficient, less polluting and safer transport systems particularly rural and urban mass transit systems.”(pg.137 UNCED 1992). Caring for the Earth suggests that authorities

should “develop an efficient and sustainable urban transport policy.”(pg.107 Action 12.3 IUCN/UNEP/WWF 1991). The Caring for the Earth document and Agenda 21 recommend that decisions and policies affecting the management of natural and physical resources should be prepared and implemented in an efficient and effective manner.

3.1.7.3 The Caring for the Earth document outlines a number of actions which can be taken to produce a more sustainable urban transport environment. These include better public transport provision, providing safer, extensive cycling and pedestrian routes, the appropriate use of road pricing schemes to incorporate the full social cost of travel, cutting distances between work and home, better road design for greater amenity, avoiding satellite settlements and dormitory developments that increase energy used for transport (pg.108 IUCN/UNEP/WWF 1991). Agenda 21 encourages the adoption of non-motorised modes, traffic management, public awareness, urban transport programs which favour high occupancy public transport and land use and transport planning to encourage development patterns which decrease transportation demand (pg.189 UNCED 1992).

### 3.1.8 Strengthening the Knowledge Base

3.1.8.1 Information is needed prior to goal setting, plan preparation and decision making, in order to ascertain with confidence that proposed actions are in line with sustainability objectives. The Brundtland Report identifies ‘making informed choices’ as one of the six priority areas for legal and institutional changes. The Agenda 21 document states that “sustainable development requires the availability of accurate and timely information to help decision makers and the general public make sound decisions” (pg.301 UNCED 1992). The integrated management of human settlements will require information that address issues in a holistic manner. The Caring for the Earth and Agenda 21 papers support this, shown in the following statements: “The information needed to integrate human development and environmental conservation depends on research”(pg.73 IUCN/UNEP/WWF 1991) and “the use of data and information at all stages of planning and management must be improved in order to make systematic and simultaneous use of social, economic, developmental and ecological data.” (pg.246 UNCED 1992).

3.1.8.2 Information is necessary to improve the decision making process to ensure that the policy option or decision action taken is most efficient and effective approach is advocated in the following statements: “Research should be undertaken with the explicit objective of assisting policy decisions and providing recommendations on improving management practices” (pg..247 UNCED 1992) and “...strengthen the knowledge base and make information on environmental matters more accessible ...to ensure that the necessary plans and actions are based on reliable and pertinent information.”(pg.73 IUCN/UNEP/WWF 1991). Information that addresses urban form and transport issues in urban areas is recognised in the Agenda 21 document. It states that “...efforts at collecting and exchanging information or the relationship between environment and transportation must be increased.”(pg.137 UNCED 1992). Caring for the Earth and Agenda 21 suggest that information is required at all phases of the planning process and is a necessary prerequisite to treating issues in an integrated manner, for determining the overall impact of activities within an environment, and assessing the most efficient and effective approach to address issues.

3.1.8.3 This research is based around the ideas suggested in these three strategies. This research aims to treat the urban transportation issue in a more holistic manner by addressing the influence that urban form and population characteristics have on travel behaviour patterns. The research aims to produce findings about the influence of urban form and population characteristics on travel behaviour to assist decision makers in evaluating the likely impact available policy options have on reducing redirecting automobile transit. It is anticipated that the findings of this research will increase knowledge on the influences of urban travel behaviour patterns in order to assist decision makers in their tasks.

## 3.2 ENVIRONMENT 2010 STRATEGY

3.2.1 The Environment 2010 Strategy is a document, prepared by the Minister for the Environment, that specifies the New Zealand government’s national environmental objectives for the next fifteen years. The importance of this document is that, while a national policy statement on land transport issues or National Land Transport Strategy (under the Land Transport Act) has yet to be enacted, some direction is provided on environmental issues that may affect land transport decisions. The Environment 2010 Strategy vision for the New Zealand environment is “A clean healthy and unique

environment, sustaining nature and people's needs and aspirations.” (pg.4 Ministry for the Environment 1995). The strategy identifies eleven priority issues or environmental goals for New Zealand's biophysical environment which relate to the quality of both rural and urban environments. The biophysical goals that are most affected by land transport activities are listed below:

1. “To maintain and enhance the quality, productivity and life supporting capacity of our soils, so that they can support a variety of viable land use option;
2. To manage the quality and quantity of surface water, ground water, coastal and geothermal water so that it can meet the current and future needs of ecological systems, communities (including Maori), primary production and industry;
3. To maintain the air quality in parts of New Zealand that enjoy clean air, and improve air quality in places where it has deteriorated;
4. To take precautionary actions to help stabilize atmospheric concentrations of greenhouse gases, in order to reduce the risk of global climate change and to meet New Zealand's commitments under the United Nations Framework Convention on Climate Change;
5. To manage the provision of transport services in a manner that minimises adverse effects on the natural and physical environment and human health.” (pg.6 Ministry for the Environment 1995).

3.2.2 The first four goals listed above, show that the maintenance and enhancement of the quality and quantity of water, air and soil are priority issues in New Zealand environmental well-being. The last goal listed, specifically identifies that the environmental effects created by transport services is an issue of national concern. The strategy notes that there are two interrelated categories of transport's environmental effects; those that affect natural and physical resources, and those that affect human health. The strategy emphasises that these “environmental effects arising from the provision of transport infrastructure and use must be explicitly considered when developing and implementing transport strategies and proposals, and operating transport systems.” (pg.12 Ministry for Environment 1995). The Environment 2010 Strategy recognises the importance of addressing the environmental effects of land transport provision and management for greater sustainability.

3.2.3 A six part management agenda is discussed in the strategy to help achieve the vision and bio-physical goals:

1. Integrate environmental, economic and social policy: The Ministry for the Environment states that “Explicit consideration should be given in all government decision making to the links between environmental, economic and social policies, both through work at ‘officials’ level and by effective use of established Cabinet decision making processes.” (pg.10 Ministry for Environment 1995). This implies that government decision making regarding land transport issues, should consider the environmental, economic and social implications of proposed actions.
2. Establish a coherent framework of law: The strategy proposes that government authorities and entities should “...develop and maintain an effective, coherent body of law and practice for achieving efficient and sustainable management of the environment.” (pg.12 Ministry for Environment 1995). Recently (1995) the Transit New Zealand Act 1989 and Land Transport Act 1993 were amended to improve the organisation and management of the transport sector, and the degree of integration of environmental, social and economic objectives in land transport planning. New Zealand legislation (Land Transport Act 1993, Resource Management Act 1991) is moving towards a more integrated approach in addressing the wider issues of urban land transport provision and management.
3. Sharpen the policy tools: For example, “...to develop a range of policy tools, to be used within the framework of law, to achieve the desired environmental outcomes that most benefit society and the economy.” (pg. 14 Ministry for Environment 1995). The strategy notes the importance of adopting an appropriate mix of policy tools to achieve goals and objectives. Information about the links between the economy, environment and society will assist decision makers in their task of assessing the ‘most appropriate mix’ of policy instruments to reduce or redirect automobile reliant behaviour.
4. Build up the information base: The strategy aims “To achieve a comprehensive and reliable information base on the environment that will aid informed and sound decisions on the protection and sustainable management of New Zealand’s natural and physical resources.” (pg. 16 Ministry for Environment 1995). The strategy implies

that reliable and relevant information is essential for an efficient and effective decision making process.

5. Promote education for the environment: The strategy aims “To encourage environmentally responsible behaviour and informed participation in decision making by promoting environmental education throughout the community.” (pg.15 Ministry for Environment 1995). This research aims to inform interested parties about current and future transport trends and the current impact these trends are having on the environment, economy and society. It also aims to inform on the potential links between urban form and/or socio-demographic population characteristics and travel behaviour in Auckland.
6. Involve people in decision making: Defined by the strategy as that which ensures “that people have the opportunity for effective participation in decision making that affects the environment.” (pg. 16 Ministry for Environment 1995).

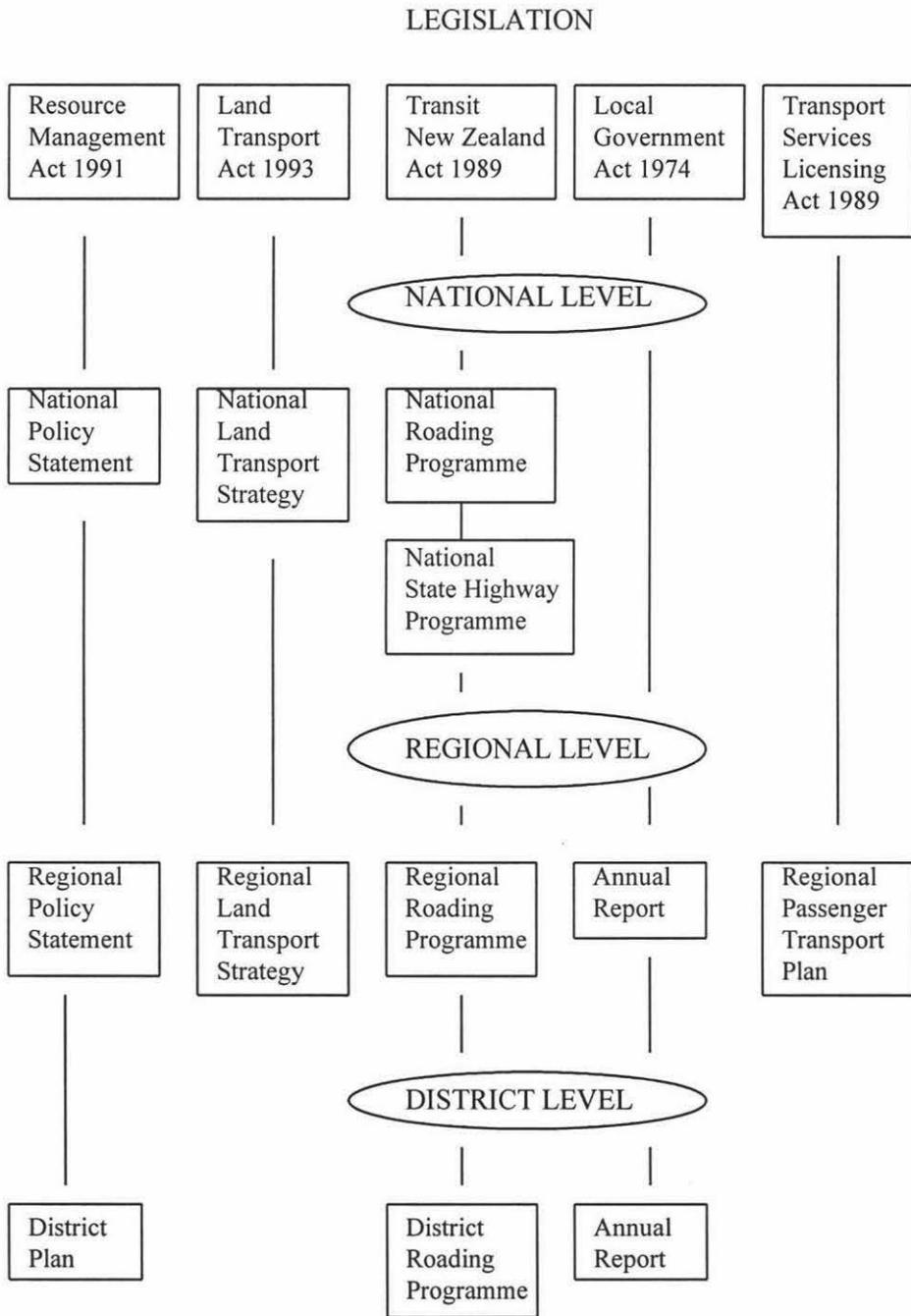
3.2.4 The Environment 2010 Strategy recognises that the environmental effects produced from land transport activities is of national concern. The strategy reinforces the principles of integrating decision making, legislation, policy and plan development regarding the environment, economy and society and supports the provision of pertinent information to improve decision making processes.

### 3.3 NATIONAL LEGISLATIVE FRAMEWORK

#### 3.3.1 INTRODUCTION

3.3.1.1 This section discusses the relevant legislation relating to urban land transportation management and provision. This is embodied in the Resource Management Act 1991, Transit New Zealand Act 1989, Land Transport Act 1993 and Local Government Act 1989, Transport Services Licensing 1989. The main goals, objectives and policies contained in the various national and regional policy documents prepared under above-mentioned legislation are discussed in terms of their relevance to this thesis. The policy structure of land transportation planning in urban areas in New Zealand is summarised in Figure 1.

Figure 1: Land Transport Statutory Policy Structure.



### 3.3.2 THE RESOURCE MANAGEMENT ACT 1991

3.3.2.1 The Resource Management Act 1991 (RMA) is the most dominant and important piece of environmental legislation governing nearly all resource use within New Zealand (Milne 1992). The RMA remains one of the most significant statutes to be passed in recent years. The Act replaces 75 pieces of environmental legislation, therefore establishing a more integrated regime for the management of New Zealand's land, air and water resources (McRae 1996). The sections of the Act that are of relevance to land transport management in urban areas are discussed below.

3.3.2.2 McDermott and Rae (1994) interpret the RMA as providing direction for the promotion of urban sustainability through the definition of 'Environment'. Section 1 of the Act, defines the 'Environment' as including-

- (a) Ecosystems and their constituent parts, including people and communities; and*
- (b) All natural and physical resources; and*
- (c) Amenity values; and*
- (d) The social, economic, aesthetic, and cultural conditions which affect the matters stated in paragraphs (a) to (c) of this definition or which are affected by those matters:*

3.3.2.3 This definition does not distinguish between rural and urban settings, but identifies the components of the environment that belong to both settings. The term 'environment' includes natural and physical resources, which are defined in Section 1 as the:

*"land, water, air, soil, minerals and energy, and all forms of plants and animals... and all structures."*

The term 'structures' is further defined in Section 1 of the Act as:

*"any building, equipment, device, or other facility made by people and which is fixed to land."*

3.3.2.4 'Environment' thus includes urban natural and physical resources such as buildings, structures, roads and streets, infrastructure and public open space. The Act therefore

applies to land transport resources in urban areas. However on initial inspection this does not appear to be a directly stated jurisdiction of the Act. Aasen (1992) suggests that this definition is problematic in urban planning terms because it is difficult to see its relevance when applied to urban settings. He argues that the RMA ignores cities and urban issues and the role they play to our societies, and that it is unclear from the Act that urbanism is at all important as a way of life in New Zealand. A good deal of this problem lies in the limited definition of 'resources'; the water, soil, land and minerals, energy, all forms of plants and animals. Memon and Perkins (1993) state that the city and urban life tend not to fit well into this regime. They argue that the city encompasses more than a built environment comprising of an amalgam of structures; it encapsulates urban social life which is not an inanimate object like water or soil, available for exploitation. Aasen (1992) suggests that to have viable and sustainable cities, there must be a strong cultural desire to have such cities. He suggests that this may not exist in New Zealand because of a very poor appreciation of cities and weak cultural desire to have cities (Khan 1996).

3.3.2.5 McDermott and Rae in a paper prepared for the Ministry for the Environment interpreted the RMA as providing direction for promotion of urban sustainability by defining natural and physical resources as including structures in Section 1. They concluded however, that the RMA provides information on urban issues, but does not presume a relationship between urban settlements and sustainable management (pg.49 Khan 1996). While provision for managing urban issues such as land transportation may be found in Section 1 of the Act, this is not directly stated, but rather implied after closer inspection.

### 3.3.3 Integrated Management Approach

3.3.3.1 Section 5 of the RMA, the Purpose and Principles, embrace New Zealand's approach to sustainability. The purposes and principles of the Act are stated below:

#### *Section 5*

*(1) The purpose of this Act is to promote the sustainable management of natural and physical resources.*

*(2) Sustainable Management means managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and*

*communities to provide for their social, economic, and cultural well being and for their health and safety while-*

*(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*

*(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*

*(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

3.3.3.2 This section of the Act, recognises the fundamental importance of adopting an integrated management philosophy to ensure that social, cultural, economic well-being, and safety and health objectives are considered in resource management decision making. McRae (1996) states that the purpose of New Zealand's 'sustainable management' is to provide a common goal despite several possible conflicting environmental values and interests.

3.3.3.3 Section 7, outlines other matters to be considered in achieving the purpose of the Act. Only Section 7 (b) and (c) are of relevance to this research and are stated below:

*Section 7*

*"...in relation to managing the use, development, and protection of natural and physical resources, shall have a particular regard to-...*

*(b) The efficient use and development of natural and physical resources:...*

*(f) Maintenance and enhancement of the quality of the environment.*

3.3.3.4 Section 7 (b) is potentially relevant in that the management of land transport, and current use and future development should be undertaken in an efficient manner. Section 7(f) 'the maintenance and enhancement of the environment' implies that changes in transport system should attempt to either maintain the current level or improve the quality of the environment.

### 3.3.4 Effects Approach to Environmental Management

3.3.4.1 As with any other natural resource, land transport operations are subject to the consent procedures of the RMA 1991. The RMA focuses on the effects produced by activities

(including transportation activities) on the environment. An 'effect' is defined in Section 3 of the RMA as:

- “(a) Any positive or adverse effect; and*
- (b) Any temporary or permanent effect; and*
- (c) Any past, present to future effect; and*
- (d) Any cumulative effect which arises over time or in combination with other effects- regardless of the scale, intensity, duration, or frequency of the effect, and also includes-*
- (e) Any potential effect of high probability; and*
- (f) Any potential effect of low probability which has a high potential impact.”*

3.3.4.2 The definition of 'effects' shows that the use, management and provision of urban land transport, is under Section 3, needs to consider the wider implication in terms of environmental effects that any action may cause. Schedule 4 Section 1(d) states that any actual or potential effect an activity has on the environment shall be considered. This is stated below:

*Fourth Schedule: Assessment of Effects on the Environment;*

*1. Matters that should be considered when preparing an assessment of effects on the environment...*

- (a) Any effect on those in the neighbourhood and, where relevant, the wider community including any socio-economic and cultural effects:*
- (b) Any physical effect on the locality, including any landscape and visual effects:*
- (c) Any effects on ecosystems, including effects on plants or animals and any physical disturbance of habitats in the vicinity:*
- (d) Any effect on natural and physical resources having aesthetic, recreational, scientific, historical, spiritual, cultural, or other special value for present or future generations:*
- (e) Any discharge of contaminants into the environment, including any unreasonable emission of noise and options for the treatment and disposal of contaminants:*

- (f) *Any risk to the neighbourhood, the wider community, or the environment through natural hazards or the use of hazardous substances or hazardous installations.*

3.3.4.3 The Fourth schedule of the Act, identifies the range of actual and potential effects to be taken into account when considering applications for use or development. McDermott et al. (1997) suggest that difficulties arise, however, because many of the environmental effects of transport are associated with mobile plant (i.e. the vehicle) and cannot be dealt with effectively under the RMA, which focuses on the use of land and other spatially fixed resources. While the numerous indirect environmental costs are significant McDermott et al. state that these have barely been approached. These are identified as including “...the impact on and consequences of urban sprawl arising from motorway extension beyond the city fringe; the consequences of community severance as a result of motorway construction; the impacts of new roads, road upgrading, or increased traffic densities on health, landscape, and rural or residential amenity values.” (McDermott et al. 1997). As urban areas have more people living closer together, the effects created from proposed developments may result in a wider range of social, economic, environmental, aesthetic and amenity impacts. The closer proximity of people in a given area may produce effects that are cumulative in nature, such as congestion and assimilation of emissions. The more urban users of vehicular modes of transport produce greater demands on natural and physical resources, discharging more waste and pollution to the confined area. The environmental impact assessment of new roading projects to date have largely omitted these more difficult to measure, wide ranging and long term consequences, focusing only on narrow corridor impacts (McDermott et al. 1997).

### 3.3.5 Adopting an Efficient and Effective Approach

3.3.5.1 The purpose of sustainable management of physical resources, both natural and artificial, and its pursuit, is flexible with respect to outcomes sought and methods adopted under the RMA. All ministers and local authorities under Section 32 of the Act, have a duty to consider alternatives and assess the efficiency and effectiveness of policy options.

*Section 32 Duties to consider alternatives, assess benefits and costs. etc.*

*(1) In achieving the purpose of this Act, before adopting any objective, policy, rule, or other method in relation to any function described in subsection (2), any person described in that subsection shall-*

*(a) Have regard to-*

*(i) The extent (if any) to which any such objective, policy, rule, or other method is necessary in achieving the purpose of this Act; and*

*(ii) Other means in addition to or in place of such objective, policy, rule, or other method which, under this Act or any other enactment, may be used in achieving the purpose of this Act, including the provision of information services, or incentives, and levying of charges (including rates); and*

*(iii) The reasons for and against adopting the proposed objective, policy, rule, or other method and the principal alternative means available, or of taking no action where this Act does not require otherwise; and*

*(b) Carry out an evaluation, which that person is satisfied is appropriate to the circumstances, of the likely benefits and costs of the principal alternative means including, in the case of any rule or other method, the extent to which it is likely to be effective in achieving the objective or policy and the likely implementation and compliance costs; and*

*(c) be satisfied that any such objective, policy, rule, or other method (or any combination thereof)-*

*(i) Is necessary in achieving the purpose of this Act; and*

*(ii) Is the most appropriate means of exercising the function, having regard to its efficiency and effectiveness relative to other means.*

3.3.5.2 Section 32, requires ministers or local authorities to consider alternatives and assess costs and benefits when forming policies and plans only (this section does not directly apply to consent granting) (Milne 1992). Ministers or Local Authorities are required under Section 32 to adopt the most efficient and effective options in managing the issue. In order to consider alternatives, assess benefits and costs, and reliable and pertinent information is required to accurately assess the efficiency and effectiveness of policy options. This research aims to provide information to New Zealand authorities about current and likely travel behaviour patterns, and the travel behaviour of different socio-demographic groups. The pursuit of urban form initiatives to curb automobile reliant travel patterns through more connective street patterns, higher

residential density and mixed land use policies is researched to enable decision makers to more effectively evaluate these policy instruments and prepare more informed policies and plans.

### 3.3.6 Building the Knowledge Base

3.3.6.1 A basic premise of this research, is to address land transport in a more holistic manner, by examining it in conjunction with both urban form and socio-demographics characteristics. The RMA advocates the treatment of resource management issues in this integrated manner in Section 5. It focuses on addressing the ‘effects’ rather than activities. While the actual and potential effects produced by travel (in particular, vehicular travel) are often difficult to measure in terms of environmental costs and benefits, this thesis addresses the impact the environment in terms of urban form and the socio-demographic characteristics have on travel behaviour patterns. The benefit of this type of research is that it addresses the ‘travel choice’ rather than the ‘travel outcome’. This research attempts to provide information to those interested authorities preparing and assessing policy and plan options under Section 32 analysis, that address urban land transport management and provision.

## 3.4 RESOURCE MANAGEMENT ACT 1991 - POLICY STRUCTURE

### 3.4.1 National Policy Statements

3.4.1.1 Section 45 of the RMA allows for National Policy Statements to be prepared by the Minister for the Environment and the Minister of Conservation. A National Policy Statement is prepared to:

*Section 45(1)*

*“...state policies on matters of national significance that are relevant to achieving the purpose of this Act.”*

3.4.1.2 Under Section 45 (2)(a,b&d) a National Policy Statement can be prepared to address such themes as the reduction of transport related emissions or the adoption of urban

form initiatives i.e. compact city or mixed zoning proposals to curb automobile reliant travel patterns.

- (a) *The actual or potential effects of the use, development, or protection of natural and physical resources:*
- (b) *New Zealand's interests and obligations in maintaining or enhancing aspects of the national or global environment...*
- (d) *Anything which affects or potentially affects more than one region:*

3.4.1.3 In Britain, the central government may prepare a document analogous to the National Policy Statement called Planning Policy Guidance or the PPG. These set out the governments direction and recommendations on significant national issues. The British Government have prepared three PPG to address the management of Greenbelts (PPG 12), Transport (PPG 13), and Retail (PPG 6). At present no national policy statements have not been prepared regarding these themes.

#### 3.4.2 Regional Policy Statements

3.4.2.1 Regional Councils are charged with protecting soil, water, geothermal resources, pollution control, natural hazard mitigation, hazardous substances and coastal management in their territories. A Regional Policy Statement (RPS) prepared by the regional council (section 60(1)) provides an overview of the resource management issues of each region and integrates the regional and district management of natural and physical resources. A RPS must identify the:

- resource issues of significance to each region and iwi;
- objectives and the methods to be used for their achievement;
- policies and an explanation of them;
- reasons for adopting the chosen options;
- environmental results anticipated;
- procedures to be followed in monitoring environmental impacts;
- processes to deal with cross-boundary issues; and
- matters that must be addressed by regional plans, regional coastal plans and district plans (pg.50 Milne 1992).

3.4.2.2 A RPS can consider urban transport issues, by addressing the effects land transport activities have on the environment. The specified policies and objectives in relation to soil conservation, noise and air pollution levels, water quality in a regional policy statements can influence the provision, management, and use of urban land transport. The RPS must not be inconsistent with any national policy statement (section 62(2)). The main document by which regional councils manage urban land transport is the Regional Land Transport Strategy under the Land Transport Act 1993. This is discussed in greater detail in Section 3.6.4 and 3.10 of this thesis.

### 3.4.3 District Plans

3.4.3.1 The functions of a District Council are set out in Section 31 of the RMA. These may be summarised as:

- Formation of district plans on significant resource management issues of the district, the district plan must contains objectives, policies, methods and anticipated results;
- Primary responsibility for land use management (including those on the surface water, land use and subdivisions)
- Complementing the role of the regional councils on some issues such as natural hazard management and management of hazardous substances (pg.53 Milne 1992).

3.4.3.2 Land transport is influenced by the objectives, policies, methods and anticipated results contained in district plans in relation to the resource management issues addressed such as land use. The allocation of land for particular uses within the city as set in the district plan, can influence the demand for transport to and from residential, shopping and working areas. The intensity of land use activities allowed by the plan, may also influence the viability of transport modes for trips made.

### 3.5 TRANSIT NEW ZEALAND ACT 1989 (AMENDED 1995)

#### 3.5.1 The principle objective of the Transit New Zealand Act (TNZA) is to:

*“To promote policies that allocate resources to achieve a safe and efficient land transport system that maximises national economic and social benefits.”*

#### 3.5.2 The main emphasis of the Transit New Zealand Act is therefore on maximising the economic and social benefits in the allocation of resources rather than environmental considerations. While both the Transit New Zealand Act and the Resource Management Act both consider social and economic considerations (to varying degrees), greater emphasis is placed on environmental considerations within the Resource Management Act.

#### 3.5.3 The Transit New Zealand Act establishes a Transfund Board which is an independent non-commercial central government agency with the principle objective under Section 3B “...to allocate resources to achieve a safe and efficient roading system.” The functions of Transfund under (section (3C)) is to fund land transport, dispersing road user charges, vehicle registration, and fuel tax among the bodies responsible for the development and operation of the nations roads, specifically:

- Transit New Zealand, with responsibility for State Highway network;
- Regional councils, with responsibility for funding public transport;
- Local authorities, with responsibility for the local road network (pg.5 McDermott et.al. 1997).

#### 3.5.4 Transfund will allocate funding among modes on the basis of efficiency. Thus, the funding of the state highway system is separated from responsibility for its operations, which remains in the hands of Transit New Zealand. Section 3D gives Transfund the power to evaluate alternatives from highway construction:

- (a) *...to fund any outputs under this Act authorises the Board to fund outputs that consider to develop efficient alternatives to the provision or maintenance of roading; and*

- (b) *any such output may relate to one or more of the following, namely, passenger services, rail transport, and maritime transport; and, for the purposes of the paragraph, the terms 'passenger services', 'rail transport' and 'maritime transport' include the carriage of freight and the carriage of passengers."*

3.5.5 McDermott, et.al. (1997) suggest that the anticipated result of this is a "...change in emphasis away from catering for private motor vehicle transport through incremental extension of the highway system to the consideration of mode and sector alternatives for achieving particular transport goals." While the Act states that passenger transport including rail, buses and ferries options can be considered instead of roading, Section 3D indicates support for other transport initiatives options such as improved/funding cycle/walk ways or car-pooling, are to be considered to achieve land transport objectives.

### 3.5.6 National, State Highway, Regional and District Roothing Programmes

3.5.6.1 The Transit New Zealand Act requires the following crown entities and local authorities to approve or prepare roading programmes for the following year:

- Transfund New Zealand is required to approve the National Roothing Programme under Section 42A-C. The National Roothing Programme states those outputs and capital projects recommended in the state highway, regional, and district roading programmes, forwarded to Transfund New Zealand. The National Roothing Programme furthermore states the proposed funding of those outputs and capital projects for that financial year.
- Transit New Zealand in consultation with the Land Transport Safety Authority is required to prepare the National State Highways Programme under Section 42D-E. The purpose of this programme is to list each approved output and capital project included in any earlier national roading, or safety programme for which either payments are due, or projects that have been abandoned or suspended. The approved National State Highways Programme incorporates all aspects of Transit's management of the state highway network including: construction, maintenance, safety improvements, planning and design and administration. This programme must also prioritise capital projects for which payment is sought from Transfund, or the Land Transport Safety Authority stating the objectives, options

considered, evaluation to achieve objectives how each output or project assists the implementation of the national land transport strategy. The State Highway programme may only include roading outputs and is required to identify those outputs or projects for inclusion in the National Roding Programme.

- Regional Land Transport Committee set up under the Land Transport Act (section 29I) is required to prepare the Regional Roding Programme for its region or district (section 42F-G) for approval of the Regional Councils and Unitary Authorities. This programme must list each approved output for which payments are due from Transfund New Zealand, or any projects abandoned or suspended. As in the State Highways programme the regional roading programme must prioritise capital projects for which financial assistance is sought, stating the objectives, options considered, the evaluation to achieve objectives, and how each output or project assists the implementation of the national or regional land transport strategy. The programme must also state the outputs for inclusion in the national roading programme.
- Territorial Authorities prepare a District Roding Programme for their District under Section 42H-I of the Act. This programme must list each approved output for which payments are due from Transfund New Zealand or the Land Transport Safety Authority (LTSA), or any projects abandoned or suspended. The programme must prioritise capital projects for which financial assistance is sought stating the objectives, options considered, the evaluation to achieve objectives, and how each output or project assists the implementation of the national or regional land transport strategy. The programme must also state the outputs for inclusion in the national roading programme.

3.5.6.2 The roading programmes are documents that set out the proposed outputs and capital projects by a crown entity or local authority for that next year. The approved projects in the national roading programme can influence the way in which individuals organise their travel behaviour in particular areas, communities, or neighbourhoods with a city. Section 42K of the Act, states that all the programmes must consider the needs of the transport disadvantaged. As discussed in Section 4.2.4, the focus on providing roading for automobile travel may disadvantage different groups within society, for example, those with physical disabilities or do not hold a drivers license such as the elderly and or the under 15 years.

3.5.6.3 All these programmes must not be inconsistent with any national land transport strategy, or affected regional land transport strategy<sup>1</sup>. This is to ensure that the approved projects are in line with national and regional land transport objectives. The national and regional land transport strategies are the documents by which transport goals and objectives are set for urban and rural areas.

### 3.6 LAND TRANSPORT ACT 1993 (AS AMENDED IN 1995)

3.6.1 The principle objectives of the Land Transport Act 1993 are:

- (a) *To create a stand alone land transport safety authority; and*
- (b) *To authorise the making of rules relating to land transport; and*
- (c) *To amend certain enactment's relating to land transport.*

3.6.2 The principle role of the Land Transport Safety Authority is to promote safety in both road and rail transport. The Ministry of Transport's role is to ensure that management systems and structures exist to deliver on the long term the strategic target of "a safe sustainable transport system at reasonable cost." (McDermott et.al 1997). These documents aim to provide transport systems that meet the needs of current and future users demands and aspirations, at a price which is affordable and acceptable. Therefore both the RMA and Land Transport Act require long term planning and the sustainable use of resources. Land transport is managed under this Act through the development of national and regional land transport strategies.

### 3.6.3 National Land Transport Strategy

3.6.3.1 The Minister of Transport under Section 29A-E of the Act, must complete a National Land Transport Strategy (NLTS). This is currently being prepared by the Ministry. Sections 29A-E of the Act, outlines the purpose, procedure and currency, process, amendment and effect of the NLTS. Section 29 (2)(A) of this Act, states what the NLTS may contain:

- (a) *The Crown's goal in relation to land transport in New Zealand; and*

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<sup>1</sup> With one exception: Section 42E(8) states that a regional programme shall not be inconsistent with the regional land transport strategy, unless the implementation of that strategy is clearly impracticable.

- (b) *The policy objectives to be pursued to achieve the Crown's goals in relation to land transport in New Zealand; and*
- (c) *The measurable targets to be met to achieve those policy objectives.*

3.6.3.2 The purpose of the document is therefore "...to develop long term land transport goals and policy objectives, and measurable targets to be met to achieve policy goals." (Ministry for Transport 1997). The Ministry for Transport 1997, states that instead of being a detailed central planning exercise the NLTS will give the overall land transport direction and scope for land transport development in New Zealand. The National Land Transport Strategy provides the focus for the development and implementation of policies and strategies by crown entities and local authorities towards achieving the long term goals.

3.6.3.3 The Land Transport Safety Authority, Transfund New Zealand, Transit New Zealand, Commissioner of New Zealand Police and Ministry of Transport under Section 29E of the Act, are required to ensure that the exercise their functions, duties and powers are not inconsistent with the National Land Transport Strategy. This includes expenditure by the National Roads Fund and any legislative changes by the Crown. The Ministry of Transport aims to align the NLTS with international obligations of relevance to land transport, such as the Framework Convention on Climate Change (FCCC) to reduce CO<sup>2</sup> emissions; and with other governmental strategic documents for example, the Environment 2010 Strategy (Ministry for Transport 1997). The NLTS is the binding document that states the strategic direction of land transport in New Zealand, therefore providing the certainty for crown entities and local authorities.

#### 3.6.4 Regional Land Transport Strategy

3.6.4.1 Every Regional Council under the sections 29F-N of the Act, is required to prepare a Regional Land Transport Strategy (RLTS) for its region. In order to prepare this document, Regional Councils must establish a Regional Land Transport Committee by

appointing representatives from a whom it considers suitable from a list<sup>2</sup> stated in section 29I(2). The purpose of a Regional Land Transport Strategy is to:

*“Section 29F (2)*

- (a) Identify the future land transport needs of the region concerned; and*
- (b) Identify the most desirable means of responding to such needs in a safe and cost effective manner, having regard to the effect the transport system is likely to have on the environment; and*
- (c) Identify an appropriate role for each land transport mode in the region, including freight traffic, public passenger transport, cycling and pedestrian traffic; and*
- (d) State the best means of achieving the objectives referred to in paragraphs (b) and of this subsection; and*
- (e) Include any regional passenger transport plan (within the meaning of section 47 of the Transport Services Licensing Act 1989) that has prepared by the regional council that has prepared the strategy.”*

3.6.4.2 While regional councils are mainly charged with protecting soil, water, and other natural resources in their territories, they must also prepare a RLTS to identify future transport needs which are appropriate (in terms of safety and cost-efficiency) and environmentally sound roles for each transport mode in the region, including both motorised and non-motorised modes. The RLTS is the document where initiatives which integrate urban form and transportation together can be considered to address future regional transportation requirements. The regional transport priorities set in RLTS, become the basis for funding applications (McDermott et. al. 1997).

3.6.4.3 The provisions in the Land Transport Act, state that the RLTS must not be inconsistent or “...discordant, not suitable or incompatible...” (Sykes 1986) with a number of other statutory documents. Under section 29F(3) of the Act, the RLTS shall not be inconsistent with any regional policy statement or plans in force under the RMA, nor with any national land transport strategy in force under Section 29F(4). The Land Transport Safety Authority, Transfund New Zealand, Commissioner for Police and Secretary for Transport must all ensure that their actions in exercising functions, duties

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<sup>2</sup> Section 29I states that the regional land transport committee can include all or any, (but is not limited to) of the representatives listed.

and powers are not inconsistent with any regional land transport strategy under section 29L.

3.6.4.4 Regional councils are required to have regard to the Land Transport Strategy when preparing or changing a regional policy statement under (section 61(2)(a)(i) RMA) or a regional plan (section 66(2)(c) RMA) and district plan (territorial authorities) under (section 74(2)(b)(i) RMA). Any consenting authority if applicable, shall also have regard to the RLTS, when considering an application for a resource consent under (section 104(1)(i) RMA). As previously mentioned roading programmes must also not be inconsistent with the NLTS and affected RLTS.

3.6.4.5 The National Land Transport and Regional Land Transport Strategies are commonly viewed as the vehicle binding the gap between both policies and plans produced under the RMA, and roading programmes prepared and approved under the Transit New Zealand Act. The absence of a National Land Transport Strategy has meant that the strategic direction for land transport has essentially fallen on the regional councils through the preparation of Regional Land Transport Strategies. A consultation document has been produced by the Ministry for Transport outlining the focus and procedure in the preparation of NTLs. With respect to the Auckland situation, a draft Regional Land Transport Strategy was published in July 1998.

### 3.7 LOCAL GOVERNMENT ACT 1974

3.7.1 Every regional and district council must prepare annual reports in respect of their council, and each and every trading enterprise or other organisation under its control, including those organisations in which it has a significant interest (section 223D LGA). An annual report must outline in particular terms for the financial year in which the report is adopted and in general terms for each of the following two financial years:

- the intended significant policies and objectives of the local authority, trading enterprise etc;

- the nature and scope of significant activities to be undertaken; the performance targets and other measures by which performance may be judged in relation to its objectives;
- the costs of implementing the objectives of the plan.

3.7.2 Annual reports therefore outline the action and commitment of Council to different policies and plans for example, financial allocation to recycling projects, motorway extension or subsidies for public transport (Milne 1992). Annual reports are also subject to Section 32 or duty to assess alternatives under the RMA. Annual reporting ensures that Councils discharge this duty.

### 3.8 TRANSPORT SERVICES LICENSING ACT 1989

3.8.1 Regional councils or a territorial authority that has the functions, powers, and duties of a regional council under this Act, can prepare a regional passenger transport plan. A regional passenger transport plan under S(47(d)) must specify the passenger services the Authority proposes for its region or district, both generally and in respect of the transport disadvantaged. The term passenger service is defined in Section 47 (a)(ii) as:

*“...any harbour ferry service, passenger rail service, cable car, hovercraft, monorail, tramway, or other form of public transport (other than air transport) that is available to the public generally, (S47(b)) but does not include an ambulance service.*

3.8.2 The Regional passenger transport plan under Section 47 (2(b-c)) includes:

- “(a) may specify the conditions of the services the regional council or territorial authority concerned proposes to be provided in its region; and*
- (b) without limiting the generality of paragraph (a) of those subsection, may specify all or any of the following matters:*
  - (i) Routes, capacity, frequency of service, and fare structures:*
  - (ii) Any special provisions for users of a specified class or description of the services or any of them; and*
- (c) May specify any other matters the regional council or territorial authority thinks fit.”*

- 3.8.3 This Act, provides an appropriate forum for Regional or Unitary Authorities to address the provisions and structure of passenger transport within their region or district.

### 3.9 NATIONAL LAND TRANSPORT STRATEGY

- 3.9.1 The National Land Transport Strategy is currently being prepared by the Ministry of Transport. The consultation document produced by the Ministry in 1997 outlines the functions and role of the national land transport strategy. The Ministry's vision for the land transport sector as a whole is stated below:

*“New Zealand will have a safe, sustainable transport at reasonable cost.”*

The strategy defines the term ‘safe’ to mean “...a reasonable freedom from danger, personal physical risk and risk of property damage. ‘Sustainable’ - refers to economic, social and environmental sustainability and ‘at reasonable cost’ means the benefits to New Zealand exceed the costs to New Zealand.” (Ministry of Transport 1997).

- 3.9.2 The key issues listed in the strategy for public comment, that are of relevance to this research, are as follows:

- environmental sustainability: The strategy states that “...linkages between urban planning and transport planning” and “minimising the environmental impacts from the provision, maintenance and use of land transport infrastructure”. The first part of the statement indicates the Ministry's interest in understanding the potential relationship between urban form and transport patterns. The second part of the statement indicates that the NLTS will consider the effects created from current transport provision, maintenance and use on the environment.
- economic sustainability: The NLTS identifies that the following issue will be considered: “...efficiency and cost effectiveness in meeting the needs of land transport users; comparisons between land transport and other transport modes from an economic sustainability view; and the contribution to Government's economic growth and international competitiveness objectives.” This statement highlights the Ministry's recognition that economic considerations in terms of cost-effectiveness and overall impacts to economy are to be considered.

- social sustainability: The strategy identifies the following social concerns related to land transport: “reasonable access to parts of society including disabled groups and individuals, to land transport services; the effect of transport on community identity”. This statement identifies that the potential influence socio-demographic patterns have on current and future land transport provision and management will be considered in the NLTS.

3.9.3 The NLTS indicates the Ministry’s interest in addressing the provision, maintenance and use of transport in light of the impact this has on the environment, economy and society (in particular, the transport disadvantaged). While the exact direction the NLTS will take is not identified in this document, the relationships between environment, society and the economy with transport are to be addressed in developing national goals and objectives.

### 3.10 DRAFT AUCKLAND REGIONAL LAND TRANSPORT STRATEGY 1998

3.10.1 In July 1998, the Auckland Regional Land Transport Committee released the Draft Auckland Regional Land Transport Strategy for the Auckland Region. The purpose of the draft strategy is to:

*“ensure that the transport system contributes towards the Auckland region being a desirable place to live.” (Auckland Regional Land Transport Committee 1998).*

3.10.2 The intention of the draft strategy is therefore to map the way forward for Auckland’s regional transport system for the short term the years 1998 - 2003 through to the medium and long terms the years 2003 - 2021. The draft strategy includes a number of goals and objectives that support an integrated approach to land use and transportation planning. These are listed below:

#### *“4.1 Goal*

*A safe, efficient and environmentally sustainable transport system for the Auckland region which meets the community’s accessibility needs at reasonable cost.*

*Objective 1:*

*To ensure the transport system supports regional and local land use strategies.”  
(Auckland Regional Land Transport Committee 1998).*

- 3.10.3 Chapter Six the Region Wide Policies section of the draft strategy includes the following policies:

*“Policy 1.1*

*Introduce transport measures which will support the form of land use described in the Regional Growth Strategy.*

*Policy 1.2*

*Investigate the transport implication of intensified development proposed by the Growth Strategy and develop means of dealing with these.*

*Policy 1.3*

*District Plan Policies and Methods will ensure that the use and development of land occurs in such a way that land use and transport systems are mutually supportive.”  
(Auckland Regional Land Transport Committee 1998).*

- 3.10.4 The draft strategy therefore stresses the significance of the relationship that exists between transport and urban form by recognising that land use patterns and transportation are mutually supportive.

- 3.10.5 The Draft Regional Land Transport Strategy has a key function to meet the transport needs of the vision established in the Auckland Regional Growth Strategy. It is noted that the Growth Strategy:

*“advocates limiting expansion into new areas and concentrating growth within the existing metropolitan area. In particular, growth will be focused on the major transport corridors, including the western and southern rail corridors, major arterial roads, and close to employment centres. In many cases, passenger transport investment will be important to help support the type of land use pattern envisaged by the Regional Growth Strategy.”(Auckland Regional Land Transport Committee 1998).*

3.10.6 The Draft Regional Land Transport Strategy and Draft Auckland Regional Growth Strategy have been developed together in order to strategically identify the way in which the development of land and transport is to be managed to give support to this vision for the Auckland region (as specified in Section 3.11.3). It is noted that both these documents support the greater integration of urban form and transportation planning to manage future growth within the Auckland region.

### 3.11 DRAFT AUCKLAND REGIONAL GROWTH STRATEGY 1998

3.11.1 The Draft Auckland Regional Growth Strategy also released in July 1998, has been prepared to outline the 'vision' for the Auckland region over the next 50 years. The draft strategy was developed by the Regional Growth Forum, which is made up of 10 elected representatives from the various regional, city and district councils within the Auckland region in associated with a steering group made up of Senior staff from each council and other technical project teams. The Draft Auckland Regional Growth Strategy was developed over a two-year period and involved consultation with the regional community. The purpose of the draft strategy is stated below:

*"to ensure that growth is accommodated in a way that enables people and communities to provide for their social, economic and cultural well-being, whilst protecting the region's environment." (Auckland Regional Growth Forum: July 1998).*

3.11.2 The draft strategy is intended to reflect the responsibilities of Council under the Local Government Act 1974, Land Transport Act 1993 and the Resource Management Act 1991. The draft strategy enables regional and local authorities within the Auckland region to address the effects of the region's growth in a strategic manner. The draft strategy further provides guidance to city and district councils to ensure that there is a consistent approach in the management of the effects of future growth within the region.

- 3.11.3 The vision for the draft strategy was derived from extensive public consultation with different stakeholders for example, various the community and business groups. The vision is given below:

*“The diversity of people and communities living in the Auckland Region will continue to prosper in a manner that;*

- *ensures a high-quality living environment;*
- *protects our coast and surrounding natural environment;*
- *creates a region that is easy to get around; and*
- *promotes strong, supportive communities.”(Auckland Regional Growth Forum: July 1998).*

- 3.11.4 The vision therefore encapsulates two main elements identified as being of importance by the regional community, the opportunities of city life and the significance of the surrounding natural environment. The Draft Auckland Regional Growth Strategy contains a number of desired outcomes, priorities, principles and choices identified through the consultation process. One of the desired regional outcomes in the regional growth strategy is the desire to create:

*“more transport choices for all sectors of the community, high levels of access to all activities, a closer relationship between home and work activities, shopping, open space etc. managing traffic congestion, and a better public transport system.”(Auckland Regional Growth Forum 1998)*

- 3.11.5 The draft strategy translates these “outcomes” into “principles” which guide the location, physical form and character of regional growth. The following principle identifies the intention to adopt a more integrated land use and transport planning approach to managing future growth in the region.

*“Encourage a regional land use and transport pattern which:*

- *Recognises different types and functions of transport corridors and their relationship with adjoining land uses such as location of freight*

*forwarding/distribution near motorways and/or rail interchanges; or the location of housing and community facilities near public transport.*

- *Enables a range of business and employment locations such as industrial areas near motorway/rail interchanges; separated industrial areas for noxious activity on heavy transport routes; a variety of mixed use areas for small business in neighbourhood centres; several sub-regional or town centres for offices and services outside the CBD.*
- *Enables a good cross-regional transport network, (including passenger transport) for ease of movement for goods and services, business traffic and commuter traffic.*
- *Reduces the need to travel by car by encouraging more employment /business /retail /community facilities close to residential areas and the opportunity to walk or cycle. This patterns needs to provide a critical mass in terms of population to support a range of small local enterprises.”(Auckland Regional Growth Forum: July 1998).*

3.11.6 It is therefore noted that the Draft Auckland Regional Growth Strategy provides strong support for the greater integration of land use and transport planning to managing future regional growth.

## CHAPTER FOUR: LITERATURE REVIEW

### 4.0 SUSTAINABLE CITIES

*Sustainability for Cities: “..is the ability to develop its capacity to sustain productivity, improve living conditions for inhabitants and manage natural and physical resources in a just way.” (pg.12 UNEP 1992).*

Cities have a considerable and growing proportion of worlds population. They are centers of production, trade and consumption, large resource consumers (water, energy, food and raw materials) and generate pollution to the air, water and soil. Cities are therefore considered to be major pressure points on the global environment. How dependent a particular city is on its land and other resources to supply its citizens and absorb their pollution; will depend in part on their lifestyles. The more consumption based lifestyle of a citizen, the wider the area and the more resources needed to sustain them and their city (OECD 1995). The concept of ‘sustainable cities’ is therefore about understanding the interrelationships that exist between:

- minimising non renewable resource use;
- sustainable use of renewable resources;
- keeping within absorptive capacity of local and global wastes.

Improved understanding of the interrelationship between these, will allow more informed decision making and planning and therefore will provide a clearer picture of where a sustainable city may lay and what actions could be taken to move closer to achieving this state.

### 4.1 AN URBAN LAND TRANSPORT ISSUE - RELIANCE ON THE AUTOMOBILE

#### 4.1.1 INTRODUCTION

4.1.1.1 While providing a necessary and beneficial form of movement, reliance on the private automobile has numerous detrimental effects on urban sustainability. The next section

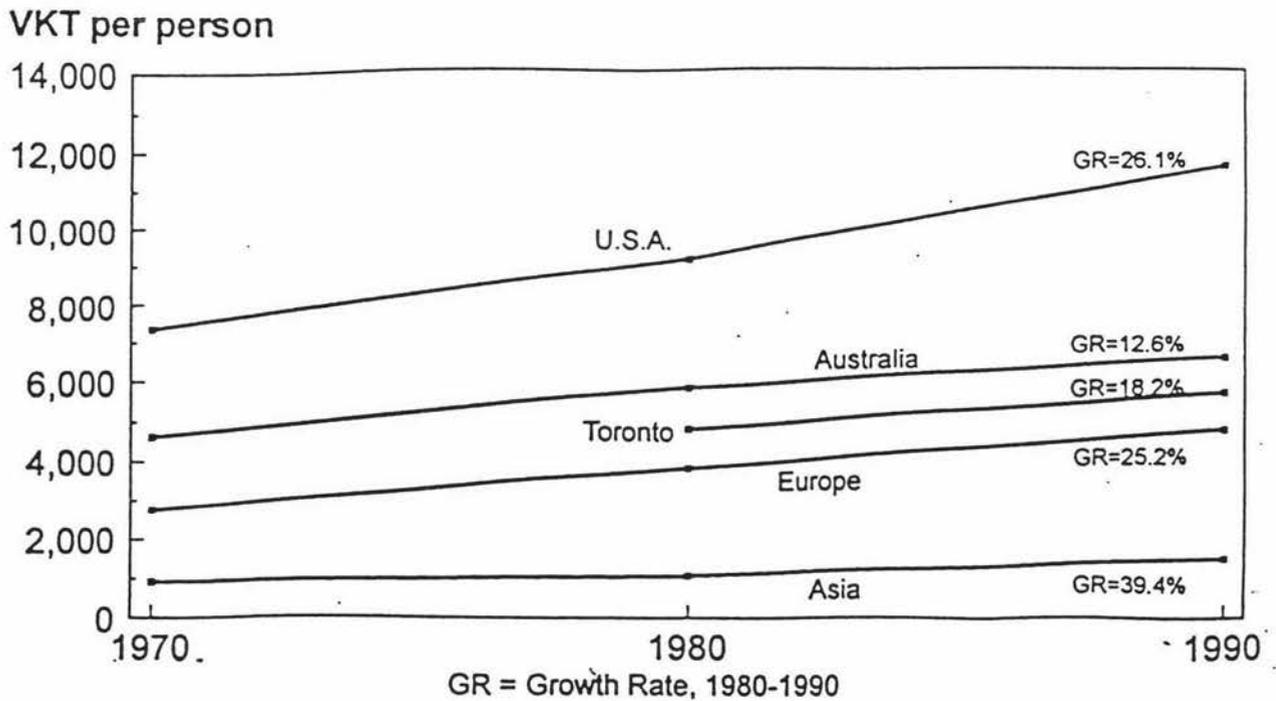
outlines the scale of the reliance on the automobile in western cities, in particular Auckland, and the impact of this on environmental, economic and social well-being.

## 4.2 AUTOMOBILE RELIANCE - A TREND FOR WESTERN CITIES

### 4.2.1 Automobile Reliant Travel Patterns

4.2.1.1 The automobile is the favoured mode of transportation in most developed countries. The Organisation for Economic Cooperation and Development (OECD) estimates that over the period of 1970 to 1990 the number of worldwide vehicles has increased from 250 million to 560 million, and the amount of kilometers driven per year in passenger cars has also increased by 2584 billion to 4489 billion in that same period (Tolley and Turton 1994). Figure 2 shows Vehicle Kilometers Travelled (VKT) rates in cities across four continents 1970 to 1990.

Figure 2: Vehicle Kilometres Rates in Cities Across Four Continents



Source: pg.48 Cervero 1996

4.2.1.2 Figure 2 shows a marked increase in the amount of vehicle kilometers travelled per person in developed countries \ around the world. Studies conducted in the United Kingdom during 1952 to 1988 further suggest that the proportion of total trips made by car is also gradually increasing over time. This is shown in Table 1 below.

Table 1 Intermodal shift in the United Kingdom 1952 - 1988 Source: Transport Statistics Great Britain 1976-1988

Passenger Kilometers (billion)	1952	1964	1976	1988
Cars and Taxis	54	204	339	517
Motorcycles	n/a	8	4	6
Buses and Coaches	81	62	53	41
Cycles	23	8	5	5
<b>Total Road</b>	<b>158</b>	<b>282</b>	<b>404</b>	<b>569</b>
Rail	39	37	33	41
<b>Total land</b>	<b>197</b>	<b>319</b>	<b>437</b>	<b>610</b>

Source: Tolley and Turton 1994

4.2.1.3 Table 1 shows that the amount of passenger kilometers travelled by car and taxi modes over a 36 year period increased nearly ten fold, while the number of passenger kilometers travelled by bus and coaches, and cycles steadily decreased over the same period. This trend towards greater automobile reliance is common to many developing countries around the world.

#### 4.2.2 Automobile Reliance Patterns In Auckland

4.2.2.1 Auckland also appears to follow international trends in private automobile use. The ARC recently calculated the total number of trips made, kilometers travelled, average length and mode split for the 'journey to work' trip to indicate changes travel within the Auckland region.

Table 2: Length of Journey to Work for Auckland Region

Year	Total Trips	Total Vehicle (km)	Average Trip Length (km)
1981	370 200	4 008 200	10.8
1986	393 700	4 686 400	11.9
1991	381 200	4 810 400	12.6

Source: Auckland Regional Council 1995

4.2.2.2 The research showed a significant increase in the total number of trips made, total vehicle kilometers travelled and the average length of the journey to work trip over the ten year period from 1981 to 1991. Table 3 below shows the mode split for the journey to work trip in Auckland region from 1981 to 1991.

Table 3: Mode Split For Journey to Work in the Auckland Region

Transport Modes	1981	1986	1991
Bus	47 600 (12.9%)	51 200 (13.0%)	25 000 (6.6%)
Rail	3 980 (1.1%)	3 814 (1.0%)	1 558 (0.4%)
Car	245 400 (66.0%)	270 800 (68.0%)	298 800 (78.5%)
Total Including Other	370 100 (100%)	393 700 (100%)	381 200 (100%)

Source: Dunlop 1996

4.2.2.3 Table 3 above shows a significant increase (12.5%) in the number of car trips made during the 1981 to 1991 period, while the proportion of bus trips decreased by 6.3% in the same period. The results further show that the proportion of automobile trips to work is increasing more rapidly over time, i.e. 2.0% during 1981 to 1986 and 10.5% during the 1986 to 1991 period. The peak period length on the Auckland harbour bridge indicates that the average time taken for the journey to work has increased for some. In 1987, the peak period length amounted to 25 minutes, in 1997 this had increased significantly to a total of 2.5 hours. The research by the ARC on journey to work trip suggests that Auckland is becoming more automobile reliant, and that for most the journey to work by car is gradually getting longer and slower (Auckland Regional Council 1995).

#### 4.2.3 Reliance on the Automobile - Environmental Effects

4.2.3.1 Despite these trends in automobile use, studies have found the private automobile to be a significant and relatively inefficient user of energy, in comparison to other modes. Transnet (1990) in the United Kingdom, compare the relative efficiencies of different transport modes to conclude that private automobile use, consumes significantly more energy per passenger kilometre than any other mode of transport (refer to Table 4 below). (Tolley and Turton 1994).

4.2.3.2 Table 4: The Relative Efficiencies of Different Transport Modes in London.

Modes	Passengers (Mega-Joules per passenger- km)
Taxi	5.00
Car (Central London)	3.73
Car (suburbs)	3.15
Motor cycle	2.50
Bus	0.90
BR Train	0.84
Underground Train	0.32

Source: Tolley and Turton 1994

4.2.3.3 Table 4 above shows that the private automobile is more than ten times as energy consuming than the most efficient mode, the underground train. This suggests that there has been a significant shift in developed countries from higher efficiency to lower efficiency modes over the years.

4.2.3.4 Energy consumption in the transportation sector is increasing world wide. Studies indicate that while world wide energy consumption has remained relatively stable since 1973, energy consumption in the transport sector has increased by 23% between 1973 and 1987, including a 27 % increase in road transport alone (pg.267 Tolley and Turton 1994). Studies have identified a notable improvement in fuel efficiency of individual cars by about 13% in the United Kingdom from 1978 to 1988 (pg.267 Tolley and Turton 1994). However this energy saving is counteracted by a trend towards larger-engined models and travelling at greater speeds which increase fuel consumption. Increased car ownership and a subsequent reduction in average occupancy per car trip (from 1.91 in 1965 to 1.64 in 1990 in the United Kingdom) reinforce increases in fuel consumption per passenger kilometre (pg.267 Tolley and Turton 1994). Cars require vast amounts of energy to manufacture, run and provide infrastructure for and produce waste disposal difficulties, in particular the disposal of used tyres, exhaust systems and batteries. Despite this they are only used at limited times, (Cervero 1996 estimates 5% of time) and when in use are occupied by an average of 1.2 people (Cervero 1996).

4.2.3.5 The production and use of automobiles create emissions which contribute to the greenhouse effect and global warming. Studies conducted by the Earth Resources Research in the United Kingdom (1988), found that while transport was only the third largest carbon dioxide source in the United Kingdom it was the fastest growing

increasing at a rate of 35% over the 1978 to 1988 period. All the other sources including, industrial, domestic, power stations and commercial uses showed a decline of about 14% over the same period (pg.272 Tolley and Turton 1994). New Zealand A Heal (1997) of New Zealand Metro Magazine states that every year "...almost two million tonnes of carbon dioxide is released into Auckland's atmosphere by cars, or 40% of the total carbon dioxide produced in Auckland annually; along with 69 000 tonnes of carbon monoxide; 13 000 tonnes of nitrogen oxides, 7 500 tonnes of hydrocarbons, sulphur oxides, particulates and metals such as zinc and copper. In addition to this car exhaust run off collected in stormwater can pollute ground water, beaches and waterways. The environmental effects of automobile use is intensified in urban areas because the traffic is more concentrated and is generally of stop, start, slow speed nature giving rise to highest level of emissions (Donnelly 1995).

4.2.3.6 Transportation and urban form are two interrelated elements that have an effect on the sustainability of a city. The structure of urban form and transportation determines the way in which citizens conduct their lives. The pattern of urban development can partially determine travel behaviour for example, affecting whether people cycle, walk or drive or use public transport, the distance they will need to travel to a destination; it determines whether a population can support economic bus or rail routes, and the degree of access to sites of employment, shopping services, recreation without the reliance on private automobile. The provision and use of the automobile has initiated environmental damage on a large scale through the construction of roads, highways, and car parks (Turton and Tolley 1994). Cars are large space consumers that require far more urban land to support their use than any other mode. Cervero (1996) states that one car can take up the same amount of road space occupied by forty bus passenger or 12 cyclists and it will also require up to 25 metres (including aisles and driveways) to park in an urban setting (Cervero 1996). Research by Kissling and Douglas (1993) states that 40% of city locations and 85% of suburban supermarket land in New Zealand is allocated for vehicle parking (Donnelly 1995). The introduction of motorised transport has also facilitated the construction of suburban low density housing development at a growing distance away from the cities core. This has led to loss of natural habitats and features, public open space and in some cases the inefficient use of productive land for low density housing. The car has therefore been described as "...the defining technology of the built environment...it sets the shape and form of cities."(pg.52 Cervero 1996).

#### 4.2.4 Reliance on the Automobile - Social Impacts

4.2.4.1 Motorised traffic has a number of social effects on human health (through road accidents, air and noise pollution), mobility, accessibility, and through visual intrusion. Worldwide more than a quarter of a million people are killed in transport accidents every year and more than 13 million are injured (pg.317 Tolley and Turton 1993). It is estimated that 90% of all casualties are due to road traffic accidents. The proportion of injuries caused by road travel accidents tends to be higher in urban than in rural settings. A New Zealand travel survey conducted by the Land Transport Authority (1989) found that per 100 million kilometers travelled in urban area (under 70 km/per hour) 2.6 drivers were killed and 124 were injured in comparison to rural areas (100 km/per hour) where 5.1 were killed and 53 injuries were reported per 100 million kilometers.

4.2.4.2 Despite these statistics, most people in developed cities find automobile travel the easiest and most convenient form of transport within a city. The comprehensive network of roading allows the driver to travel an exact destination via the most desirable route. A large proportion of society including the disabled, elderly, young (under 15 years), those with limited income, often do not have drivers license or access to a vehicle. As a result they may experience a loss of personal mobility and access within the city unless other suitable transport options are provided for. New Zealand Census 1991 figures show that 13.3% of New Zealand households are without access to a private vehicle. While public transport provides some access around the city, not all areas are on public transport routes is limited to public transport timetables. Walking and cycling are important modes of transport, but are often restricted by distance, weather or safety factors. This restricts the access of these societal groups to working, education, shopping, and recreational opportunities. Cervero (1996) notes that "...the inability to reach or even find out about job opportunities in an automobile dependent world has exacerbated urban poverty".

4.2.4.3 The effect of noise produced by transport activities depends on the sensitivity of the individual, on the location, on the time of the day and on existing noise levels. It disrupts activities, disturbs sleep, slows the learning process at school, impedes verbal communication and causes annoyance and stress. It is estimated that some 135 million people in OECD countries suffer transport noise levels in excess of 65 dB, equivalent

to the sound of a busy street through open windows (pg.328 Tolley and Turton 1994). Noise is seen as a high priority environmental concern by communities. One of the most damaging effects of transport result from the fact that vehicles are a major and growing source of air pollution. There is evidence to suggest that air pollution on the local scale is significant health hazard aggravating cardiovascular and respiratory illnesses (pg.328 Tolley and Turton 1994).

4.2.4.4 There is no doubt of the impact that land transport has on the visual landscape. The presence of roading, viaducts, flyovers and parking frequently dominate the urban scene. How a particular piece of infrastructure is perceived will vary from person to person, according to how much they use it, how far they live from it or how much it intrudes upon their familiar views (pg.328 Tolley and Turton 1994).

#### 4.2.5 Reliance on the Automobile - Economic Impacts

4.2.5.1 A monetary cost is paid by society to use, provide, and maintain their automobile and its related infrastructure. Another more indirect cost of automobile travel is the cost of travel time. The Auckland Regional Council (1995) estimates this at \$1.5 billion per year (out of a total yearly transport spend of \$7.5 billion) A significant and growing proportion of this figure, reflects delays caused by traffic congestion. As road congestion grows, there is a significant impact on road users as they lose more and more time and productivity on delays (Keep Auckland Moving 1997). Finding a car park creates an additional time delay and therefore cost to the vehicle user. For example, Auckland's Central Business District (CBD) on a typical weekday has a total of 29 300 carparks. Meanwhile the number of full time jobs held in the CBD was calculated as 53 800 in 1995, with only 14% of commuters using public transport to get to work. (Heal 1997). The shortage of parking incurs a economic cost (in finding and paying for parking facilities) to shoppers and workers in the CBD. The Keep Auckland Moving Joint Project (1997) suggest that growing congestion may be capable of undermining the efficiency and performance of Auckland's economy. The Chief Executive of Auckland Chamber of Commerce, Barnett (1997) shares this view, in a statement to New Zealand Metro Magazine he believed Auckland probably has "...another five years before grid lock starts to turn off investors and the region becomes uncompetitive relative to other Pacific Rim cities." (pg.63 Heal 1997). It may

be concluded from this that the efficient function of economy is dependent on a transport system that is not excessively congested that provides access for all groups.

4.2.5.2 The evidence suggests that Auckland and other developed cities worldwide show an increase in the level of automobile reliance for travel. As this trend gradually increases, so to will the negative impacts incurred to the environment, society and economy.

### 4.3 FACTORS CONTRIBUTING TO AUCKLAND'S AUTOMOBILE RELIANCE

4.3.1 Auckland is currently faced with a significant land transport problem that is related to the level of automobile use within the city. Trends in automobile use discussed above may be attributed to a combination of factors including, population and economic growth, socio-demographic conditions, historical development, topography, attitudes and perceptions, government policies in particular regarding urban form, and infrastructure provision.

4.3.2 Auckland is the largest city in New Zealand in terms of land area spanning an area of 75 kilometers from north to south (Orewa to Drury) and 30 kilometers from east to west. Its topography, constrained by the Manukau and Waitemata harbours creating an isthmus, naturally causes transport problems and bottlenecks (Keep Auckland Moving 1997). The total regional population in Auckland is approximately one million, or 29% of New Zealand's total population. The current population growth rate is 2.5% per year (for 1994-95 figures) or 25, 000 people per year. The projected population growth increment for the next ten years 1996 to 2016 is estimated at 300 000 people. This makes Auckland the fastest growing major city in the country.

4.3.3 The Auckland region contains approximately one third of all New Zealand economic activity. It contains a major international airport and New Zealand's largest port which handle more than half of all New Zealand's trade (Heal 1997). The level of economic activity within Auckland is greater than any other city in New Zealand and is continuing to grow at a rate of 6% for 1996, compared to 2% for the rest of the country (Keep Auckland Moving 1997). The employment rate in Auckland, is also growing at 4.6% per year (for years 1994-95).

- 4.3.4 Population and economic growth is predicted to have an effect on the supply and availability of urban land within Auckland. Although residential urban land is presently available, limits to supply have been set by the Auckland Regional Council, through a policy of containment in an attempt to reduce urban sprawl. The Auckland Regional Council stated the limit lines will mean that “Auckland may have 17 to 22 more years before all avenues for cramming in more people are exhausted. By then, all the available opportunities for metropolitan infill housing and redevelopment, new greenfield developments in rural and coastal towns, and rural-residential development are expected to be used up.”(pg.63 Heal 1997). Auckland’s reliance on the automobile, increasing population and economy, and limited land supply has assisted in creating a significant land transport issue.
- 4.3.5 The combined action of steady population and economic growth, and limited available space exert additional pressure on Auckland’s existing transportation infrastructure. The Chairman of Auckland City Council Works and Services Committee predicts that “...if Auckland population and traffic continues to grow at the same rate as in the past few years, the number of cars on our roads will double within the next 10 years.” (pg. 4 Dunlop 1996). A Heal (1997) of New Zealand Metro Magazine states that Auckland’s “... motorway system was designed to cope with the traffic only until the year 1986 and was predicated on the notion that it would be complemented with a quality rail system.” (pg.67 Heal 1997). Continued growth rates and limited resources present problems to provision and management of an adequate transport system.
- 4.3.6 Perkins and Memon et. al. (1993) have identified the economic forces which led to this rapid and concentrated urban growth over the last fifty years. These include:
- post-war industrialisation and associated periods of prosperity;
  - immigration and rural-urban migration;
  - secondary manufacturing predominated and tertiary services both became important sources of economic growth in large centres;
  - the head offices of New Zealand and overseas companies clustered in Auckland and Wellington.
- 4.3.7 These economic and demographic changes had quite dramatic effects on the internal patterns of New Zealand’s cities. High employment rates in the 1950’s and 1960’s,

combined with considerable state welfare support for many sectors of society, allowed many New Zealanders to purchase a slowly widening range of consumer items. The family car and single family homes were often high priorities. In response to this demand, the private sector (with state supported financing) built peripheral dormitory suburbs in the larger urban centres in particular, Auckland and Wellington. Central government made a significant contribution with the construction of large areas of state housing, within in South Auckland. A consistently high birth rate between 1946 and 1961 introduced a large number of young children into the population, reinforcing the demand for suburban homes in which to raise their families. High levels of car ownership also led to the establishment of urban motorways which would allow high numbers of people to work in the central city while living in the suburbs. Past development patterns have created a region with a number of urban centres and industrial areas. For some this has meant a quick trip to shop or work; for many it has required long daily trips to work across several suburbs, ensuring complete reliance on the private car (Perkins and Memon et. al. 1993).

- 4.3.8 The 1950's saw the doors opened to immigrants to a large number from the Pacific Islands who became an important source of labour in the growing factories in Auckland and Wellington. The Maori, who until World War II had been a largely rural people, also began to move to the cities and they too became an important supply of largely semi-skilled and unskilled labour in the northern cities. Early Maori and Pacific island migrant moved to low-cost housing in the centres of Auckland. But with the establishment of state housing suburbs, many new migrants began to reside on the city outskirts. They were often joined by their central city compatriots as the cost of living became too high, as a result of gentrification or inner city motorway development.
- 4.3.9 Much of Auckland's growth has occurred in an incremental fashion, without serious consideration to its functional layout and provision of services and amenities. Problems of managing rapid urban growth were exacerbated by an unwieldy local government system. While territorial local authorities were responsible for land use planning, in many instances the provision of infrastructural needs and services was undertaken by separately funded, special purpose local and regional agencies. Central government did not have an cohesive urban planning. On the contrary investment decisions on funding of roading and other public services were quite often tied up with

political patronage and election promises. Public expression of concerns relating to unplanned urban growth had been primarily focused on the four metropolitan areas of Auckland and Wellington. They were concerned about renewal of inner city areas with a significant high proportion of older, poorly maintained housing stock, and urban expansion on the periphery “...meant that urban containment to protect productive farmland from low-density suburbanisation emerged as an additional issue of policy concern.” (pg.6 Perkins and Memon 1995).

- 4.3.10 The City of Auckland is characterised as having a low residential density level at approximately 18.5 people per hectare (gross density). A low level of residential density is argued to reinforce automobile use as the distance separating activities discourages walking and cycling trips. In addition public transport services are argued to be less viable if the population is dispersed over a large area. The development of low suburban density around the periphery of Auckland city can partially be attributed to the provision of motorised transportation. Dunlop (1996) stated that the introduction of trams as first early mode of transport around city allowed Aucklanders to head to the central suburbs. The residents initially built single dwellings on large sections about 1000 square meters or larger. The motorway construction in the 1950’s and onwards and the Auckland Harbour Bridge were developed to provide “...a roading network which was a crucial factor in assisting the region’s economic and urban development (Heal 1997). This facilitated further low density suburban housing development in peripheral areas on sections about 600-650 square metres in size (Dunlop 1996). This still remains a dominant trend in Auckland’s residential development today.
- 4.3.11 Donnelly (1995) states that “...opening up new land on the periphery has catalysed suburban development and in turn the dependence on vehicle use, which is manifested both in lengthening trip duration’s and increased overall trip numbers.” There is evidence however that the councils in Auckland are allowing residential areas to begin to intensify. The minimum size of the sections, has been reduced by most Local Authorities in Auckland to accommodate denser residential development (Dunlop 1996). The draft ARLTS allows district councils to adopted policy of selective residential intensification at nodal points along transit corridors to encourage greater support for public transport use.

4.3.12 The separation of land uses into ‘zones’ is common practice within Auckland city. A single land use pattern supports automobile travel as it facilitates the separation of housing, shopping, and employment areas by distance. Dunlop (1996) suggests that plans prepared under the Town and Country Planning Acts of 1953 and 1977 have assisted in creating Auckland’s single land use pattern. The Act allowed the clustering of similar ‘activities’ for example, commercial, residential or industrial activities into set areas. The plans prepared under the RMA now focus on ‘effects’ produced by activities and therefore can allow for a greater ‘mix’ of land uses within an area. While the single land use pattern predominates there is evidence that this is beginning to change. There are at present 1500 units within the central business area in Auckland. At the present rate of growth this is predicted to increase to 3 800 by the end of 1998 (Dunlop 1996). A number of mixed use developments have been developed within Auckland for example, on Ponsonby Road, a three storey mixed use development has been built to accommodate ground level retail and offices with residential units above (Dunlop 1996).

4.3.13 A feature of travel patterns in the Auckland region has historically been the concentration of jobs on the Isthmus and the need for many people to travel from the outer suburban areas to the Isthmus to work. The ratio of jobs to work force has changed in various parts of the region over the last 20 years as shown in Table 5 below.

Table 5: Percentage of Workforce with Jobs in Local Areas

	1971	1976	1986	1991
Northern Urban Area	47.7	50.9	54.6	57.4
Western Urban Area	47.1	47.9	45.1	44.6
Central Urban Area	92.2	89.8	85.9	81.0
Southern Urban Area	52.3	58.0	61.6	58.2

Source: Auckland Regional Council 1995

4.3.14 Table 5 shows a significant decline in the proportion of Central urban area residents working within that area, and a smaller decline in the West. The Northern urban area experienced a substantial increase in the proportion working locally, while the Southern areas have seen a more modest increase. It should be noted that if the proportion of total jobs located in the outer areas is increases, the proportion of jobs in the Central urban area must therefore decrease. However this does not necessarily

imply that job numbers in the Central area would need to decrease. Most of the cities employment is located outside the central area. The CBD presently accounts for only 12 - 13% of total regional employment. Dunlop (1996) suggests that the distribution of employment results in a “..high level of cross commuting and business trips along a diverse range of arterial routes” creating congestion along many roads within the City. The distribution of employment in Auckland poses difficulties for the public transport services as routes will need to connect a large number of residential sites with employment sites.

4.3.15 Public transport use in Auckland has declined from 62 million trips in 1984 to 27 million trips made in 1994 (Heal 1997). The provision of a multiple destination, high frequency public transport service to support complex travel patterns has been difficult task for those involved. It has been hindered by the lack of finance required to effectively and efficiently manage the public transport sector. McDermott et. al. (1997) argue that government transport funding policies under the Transit New Zealand Act 1989, did not prove adequate in meeting Auckland’s needs. They were designed to compare roading projects with each other and are not appropriate for dealing with a fast growing major urban area needing long term transport planning for roading and public transport. Expenditure on road building and maintenance has exceeded that spent on passenger transport by a factor of more than 10, in years leading up to the establishment of Transit New Zealand. State highway projects were funded with a 100% subsidy, but passenger transport along the same corridor was funded at 65% (Heal 1997). Because of its size and growth, Auckland is the metropolitan area to experience the full impact of inadequate and inappropriate funding (Keep Auckland Moving 1997).

4.3.16 The passenger transport system has also recently been deregulated under the Passenger Transport Licensing Act, and therefore expected to pay its own way in a market that does not value the net social and environmental benefit it generates.”(pg.21 Donnelly 1995). Under the deregulated system, the service is inefficient, largely uncoordinated and patronised by fewer than 10% of those who travel to work far fewer than most Western cities of Auckland’s size. Auckland’s public transport system has therefore struggled to keep pace with transport demands and has been unable to provide any significant contribution to easing the congestion or automobile reliant problem. Donnelly (1995) suggests that Auckland’s transport

problem results from a “...combination of past policy directions in which almost total private vehicle dependency is promulgated and low energy efficiency becomes an inbuilt feature of our transport system” (pg.22 Donnelly 1995).

- 4.3.17 Vehicle ownership in Auckland has steadily increased over the years, from an average of 1.38 per household in 1986 to an average of 1.47 per household in 1991. In transport terms this growth in vehicle availability reflects a considerable increase traffic volumes and has been a factor in the continued decline in the use of passenger transport. Dunlop (1996) suggests that increases in vehicle ownership may be attributed to government policies permitting the import of relatively cheap second hand Japanese vehicles.
- 4.3.18 The attitudes and perceptions held by Aucklanders about travel choices may have an influence on the level of automobile reliance. A marked increase in automobile ownership and number of automobile trips suggest that Aucklanders may preference to travel by car by than any other mode. Chandlier (1996) has produced a number of general assumptions about why people conduct travel behaviour in the manner that they do:
1. transport is a derived demand. It is the action of moving people and goods from point A to point B as safely and quickly as possible for an economic or social purpose.
  2. transport is derived from need, choices and decision of individuals.
  3. Individuals organise travel behaviour rationally according to factors contributing to choice (cost, convenience, mood, status, availability)
- 4.3.19 The first assumption argues that it is unjustified to lay blame on the automobile for current urban ills mentioned, as the automobile is both figuratively and literally a vehicle, or a means to an ends. Cervero (1996) states that “...it is the value and aspirations of Europeans, Americans, Australasians to live in low density settings and to separate home from work that has given rise to sprawl, pollution and congestion, not the car per se.” (pg.3 Cervero 1996). The second assumption identifies that travel patterns are linked to individual needs and aspirations. Travel patterns are therefore linked to how individuals view their ‘travel choice’. The third assumption identifies that travel decision are rational in terms of there own objectives but are often not

rational in terms of societal objectives, and thus do account all the costs incurred, for example, the extra pollution created for car use, beyond the environments ability to assimilate waste; of the time delay incurred to other drivers from an additional car in the traffic jam. Transportation planning or changing current trends in travel behaviour will therefore involve changing how people view there options, improving accessibility of people to create better travel choices. The goal for transport planning is therefore not simply to reduce or redirect automobile use but to investigate individuals travel choices and the factors which may contribute to this decision.

4.3.20 At present options are being considered to ease the land transport problem in Auckland and avoid a gridlock situation. However the transport problem as discussed is a complicated issue and finding solutions has resulted in much discussion and debate about what to provide. The options considered include providing more motorways, light rail or heavy rail or extend bus services in conjunction with transport technology, land use initiatives, encouraging walking and cycling. The light rail option is considered to be an expensive option with no guarantee that it deliver the desired level of patronage needed to reduce congestion. A Heal (1997) of New Zealand Metro magazine provide an example of this in Singapore, where there are 80% of people in Singapore living within one kilometer of light rail system and only 10% these use it to travel to town. Despite a decrease in overall public transport use, rail patronage has increased by 35%, over the 1994 to 1995 period. This is still limited however, to selected areas with access to rail services in the city. The fact remains that New Zealand residents are among the lowest users of public transport in the world. The dominance of buses within Auckland over the last 40 years has not resulted in large number of residents opting for this mode of transport. While the provision of more motorways is an option to address transport issue it is argued that this will simply postponing predicted 'gridlock' for another generation to worry about (Heal 1997).

#### 4.3.21 Summary

4.3.21.1 The trend towards increasing automobile reliance produces many negative impacts to the environment, economy and society. The evidence or signs highlighted above, suggest that the current urban pattern and dynamics may not be sustainable in the future. As pressure is placed on limited resources by an increasing population and economic activity, solutions must be sought to provide sustainable solutions to the

transport problem. Finding a solution to ease Auckland's transport problem will not be an easy task as travel behaviour is a complex issue which is related to the population (characteristics of population, attitudes, needs, aspirations) and the urban environment (infrastructure provision, urban form, location, topography). It is obvious from the interrelationships, that the solution will need to address the relationships between these factors. Research into the travel patterns of Auckland's population in relation to the urban form and characteristics of those trip makers is therefore required to address transport solutions in a more integrated manner. Most of the research to date, focuses on the relationship between travel behaviour and one or two other types of variables for example, travel behaviour and urban form, or travel behaviour and socio-demographic characteristics of the population. Information that integrates all these factors together may improve understanding of what influences Auckland residents travel choices. This may enable more informed decisions making in order to reduce and redirect demand for the automobile.

#### 4.4 LAND USE, LOCATION AND TRANSPORTATION - A THEORETICAL PERSPECTIVE

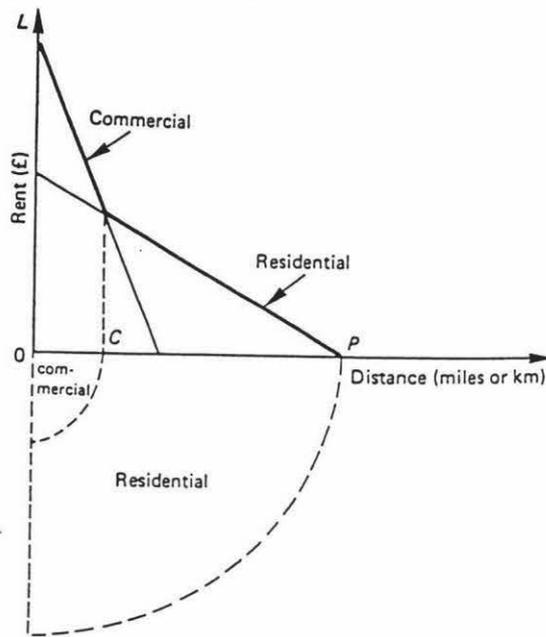
The interaction between land use and transportation is the subject of a long tradition of research, and therefore a framework for the economic understanding of this relationship has been established. Economic theories of location and land use along with social and historical themes, provide valuable insights in explaining the shape and structure of cities.

##### 4.4.1 Location Theory

4.4.1.1 Von Thunen and Ricardo observed more than half a century ago, that land, labour and capital are inputs of production, and that land use is determined in part, by location. While the theorists Von Thunen and Dunn, among others, address the location of land use within agricultural areas; Isard, Wingo and Alonso, and others, focused their research upon urbanized areas. Other theorists, Kain, Mills, Anas have extended and elaborated on the basic approaches. All of these models and theories contribute to the theory of land economics and economic concepts of optimally and equilibrium in land allocation (Harvey 1987, Deakin 1993).

4.4.1.2 Location theory assumes that a city centre has both production and distribution activities and that transport costs increase with distance from the centre. This theory suggests that to occupy a particular site a potential land user will include transportation costs into the bid to occupy land. Location theory illustrates why different land uses are found at different distances from the cities central area. If it is assumed that a) there are two types of urban land users commercial and residential; b) all urban users prefer to be near the centre of the town because of accessibility; c) commercial users can outbid residential users for the CBD; d) differences in transport routes and topography are ignored. The outcome will be a commercial zone of radius represented in Figure 3 as OC, surrounded by a residential zone. Land values decrease from the centre out to the periphery as indicated by LP which shows the highest bid at any point (Harvey 1987). All else being equal, locating in the centre minimises transportation costs and land values are subsequently higher at the centre. The outer locations therefore have lower rents reflecting their greater transportation costs (Harvey 1987, Deakin 1993).

Figure 3: Accessibility and Land Use



Source: pg.221 Harvey 1987

4.4.1.3 However even if transportation is ubiquitous, not all land uses would gain equally from a central location. Activities that are specialized and require regular face-to-face contact with other firms can potentially extract benefits of economies of agglomeration, and economies of scale. This means that they can minimise their costs by locating close together in central locations. Ancillary firms also require good access to the centre to provide goods and services to these central firms and offices and therefore often locate near, but not right in central locations. This is because they generally require less face-to-face contact with other firms (and probably have a lower salaried work force, with lower values of time) (Deakin 1993).

4.4.1.4 Activities that require less central accessibility bid less and locate further away from the centre. An example of this, is the housing market, where access to the centre is primarily for employment reasons. A balance is reached with particular uses characteristically found in central places, others in successive rings further out.”(Deakin 1993).

4.4.1.5 The locational pattern of land use is a reflection of the demand and supply for urban sites. By a process of competition, a site will be occupied by the use which can obtain the greatest return from accessibility benefits, since the site offers the highest rents. A broad zonal arrangement focused on the centre emerges, because similar or

functionally-related activities aggregate at the same distance from the centre of urban area, which other uses being excluded. Allowing for simplifying assumptions made, location theory explains: i) pattern of land use of urban area, ii) the falling land values from the centre to the periphery; and iii) how the urban area grows, since each zone expands into the next as population and economic growth occur.

4.4.1.6 Location theory further identifies that “...accessibility determines the worth of land for different uses at different locations.” (Deakin 1993). Therefore if the cost of transport changes, this will directly affect the rent paid for land. Because land use and the value of land is linked together by market processes, the potential use of land is altered. In addition, if an increase in transportation investment or an increase in real income occurs, this would decrease the cost of transportation to the place of employment; decreasing the value of the land at the centre and hence increasing the value of land at the edge of the city. The reduced transport cost to commuters may induce them to spend more money on housing and travel further. Commuters may therefore opt for peripheral locations and potentially “...decrease residential density and increase the size of the urbanized area.” (Deakin 1993). The theory suggests that the location of transportation facilities and transportation technology can also determine the location of and accessibility of places. Therefore land values as well as land uses reflect location advantages transportation systems confer.

#### 4.4.2 Business Location Theory

4.4.2.1 Business Location Theory identifies that some businesses are tied to a particular location because of the special qualities or resources only available there, while others can assess where to locate by considering the relevant costs and benefits of different selected locations. Transportation costs are therefore part of this decision as businesses need to be within reasonable proximity to their markets and resources. This includes the labour force; the cost of labour will therefore reflect commuting costs. Should a site have a low transport cost, businesses that locate there may increase real income and better able to expand out. This may attract other business to the site as they seek benefits of economies of agglomeration. In summary business location theory explains why business tend to “...congregate at sites where transportation costs are low.” (Deakin 1993).

4.4.2.2 The business location theory treats population-serving business as a separate case. Population serving businesses require goods and services to be sold on a frequent basis in order to be profitable. A competitive edge can be obtained by locating in a convenient location to near to a residential area. If residences decentralise, these businesses will locate in the new decentralised areas. This ultimately will decentralise this portion of the work force. However the location of these businesses still dependent on the relative costs of transportation to alternative locations. For example, if the cost of a shopping trip decreases, these businesses may be able to locate further away from residential areas to another location and still be convenient. The benefit to the business is that it still can benefit from lower transport costs for inputs and attract customers from a wider population base. The business location theory identifies that “...transportation improvements will tend, simultaneously, to increase employment at benefited sites and to decentralised workers’ housing. Conversely, worsening transportation services tend to decentralise jobs but support higher densities of housing.” (Deakin 1993).

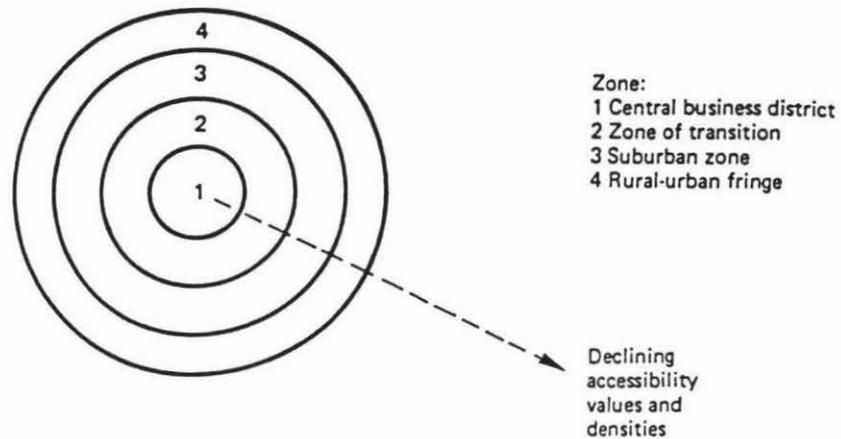
#### 4.4.3 Other Theories of Growth

4.4.3.1 The following group theories recognise and discuss the implication of historical and social factors, and stages of growth and decline, on the land use organisation and development within a city. The theories tend to be more descriptive than analytical in approach and investigate land use form and patterns for the entire city.

#### 4.4.4 Concentric Zone Theory

4.4.4.1 Von Thunen’s theory of location based on transportation costs from a central market produces a pattern of concentric zones, each zone specialising in a particular type of agricultural produce. By substituting ‘general accessibility’ for ‘transport costs’ we can apply the Von Thunen model to produce a concentric pattern of urban land use. The concentric zone theory follows logically that an actual pattern of land use was established. Burgess in 1925 developed the concentric zone theory while studying the historic development of Chicago. Burgess suggested that the “...typical progress of urban growth is through a series of concentric circles expanding radially from the CBD.” (Harvey 1987). Five broad zones were identified shown in the Figure 4.

Figure 4: The Broad Pattern of Land Use



Source: pg.222 Harvey 1987

Figure 5: Details of Concentric Zone Theory

#### The Central Business District

- Optimum location for retail, commercial uses, as it is the focus of inter-city transport;
- Greatest intensity of uses - as it has the greatest accessibility competition for limited space producing peak land values, and intensity for development in the form of multi-storey buildings;
- Development in the CBD is not only upwards but outwards as shops and offices take over from other uses - redevelopment taking place;
- exact boundary of CBD difficult to distinguish;
- functional sub-centres can exist within CBD.

#### The Zone of Transition

- Comprised of a mixture of land uses;
- Contains older large unit housing;
- Zone of constant change, dynamic forces at work including population and income growth;
- With CBD growth, subsidiary activities, such as warehousing and wholesaling move into this zone. also other labour intensive industries link office and retail core CBD and outer residential fringe;
- Zone of speculation, anticipating redevelopment - can have areas of lower income housing groups caused by speculation;

The Suburban Zone

- Zone closely linked with development of rail or motorcar, which gives rise to a ribbon development pattern along arterial roads;
- Moderate or low density use, with households in reach of urban attractions and employment sites;
- Clustering along rail or road services with some segregation by social or economic class;
- Scattering of schools, medical centres, churches, public houses, public open space, golf and racing courses and cemeteries within zone.
- Increases in the scale of urbanisation often means that it is no longer efficient to service a large city from the CBD. The construction of large establishments such as hospitals and universities on transport junctions or outskirts can occur.
- Industry located in well-defined district in the suburbs for the transport links to urban market, and to extract lower rents and potential for expansion.
- Increased development in form of satellite commercial centres.

The Rural-Urban Fringe

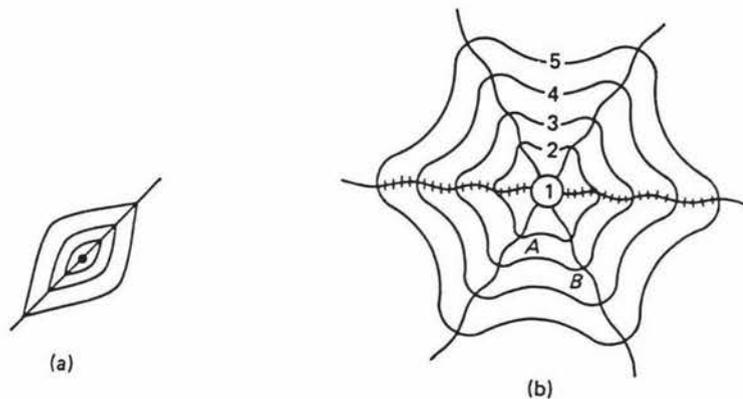
- Those who choose to live in a full country setting that are willing to commute to work from well beyond the suburban zone (Harvey 1987).

4.4.4.2 This model however can be regarded as “..indicating merely a broad structure of land use.” (Deakin 1993). The model is comprised of rigid zones that lack detail by not addressing the influence of physical and topographical features, transport systems, various aspects of special accessibility. The zone of transition is the only recognised area of change, this ignores the dynamic factors which contribute to the continual process of redevelopment.

#### 4.4.5 Radial or Axial Development Theory

4.4.5.1 The Radial or Axial Development Theory is seen as an improvement to the concentric zone theory because it modifies the zones to allow for topographical features. The theory identifies that transport improvements for example, a navigable river, harbour crossing, motorway or rail line would adjust the concentric zones. This is because the costs per unit carried are lower in some directions than in others. This is of particular importance in road and rail development, which is believed to cause the zones to assume a star shape, points of the star extending along a major transport route. This is shown in Figure 6 below.

Figure 6: Radial Development Theory



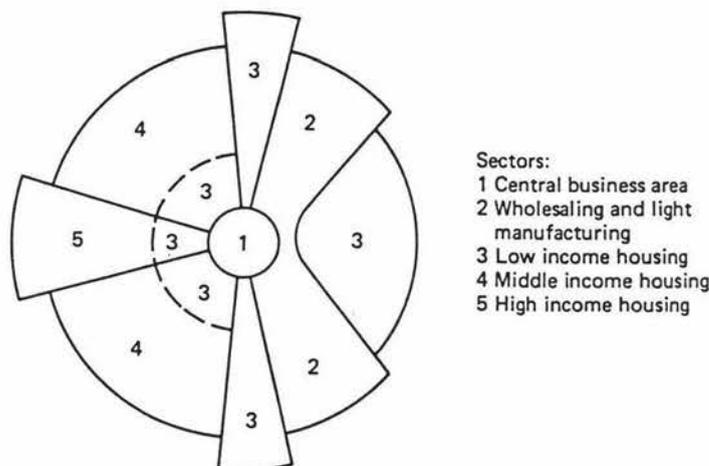
Source: pg.230 Harvey 1987

4.4.5.2 While points along transport lines are more distant from the centre, in terms of travel time and accessibility they are within the same proximity to centre (Harvey 1987). The difference between the two theories is that Concentric Zone theory is based on proximity in terms of distance, while Radial Axial Theory is based on accessibility in terms of time. The various characteristics of the four zones generally remains the same.

#### 4.4.6 Hoyt's Wedge or Radial Sector Theory

4.4.6.1 The Wedge or Radial Sector Theory developed by Hoyt (1939) is an extension of concentric zones theory by allowing for the development of a more irregular pattern. The theory mainly focuses on explaining the location of housing in urban areas, with little reference to business location. The theory identifies that there is a tendency for various socio-economic groups to segregate by locating in different areas of the city. Hoyt's theory suggests that over time high quality housing will expand outwards from the city centre along the quickest travel routes for those who can afford it. This produces wedges of development where the travel route passes through, may not conform to a zonal pattern. The theory also suggests that the low income groups tend to locate on the opposite side of the CBD, within close proximity to industrial land uses. Hoyt has therefore developed the concept of concentric zones to form 'sectors'. Residential sectors radiate outwards from the centre, constraining or segregating manufacturing or wholesaling into other sectors. This is shown in Figure 7.

Figure 7: A Wedge Pattern of Urban Structure



Source: pg.231 Harvey 1987

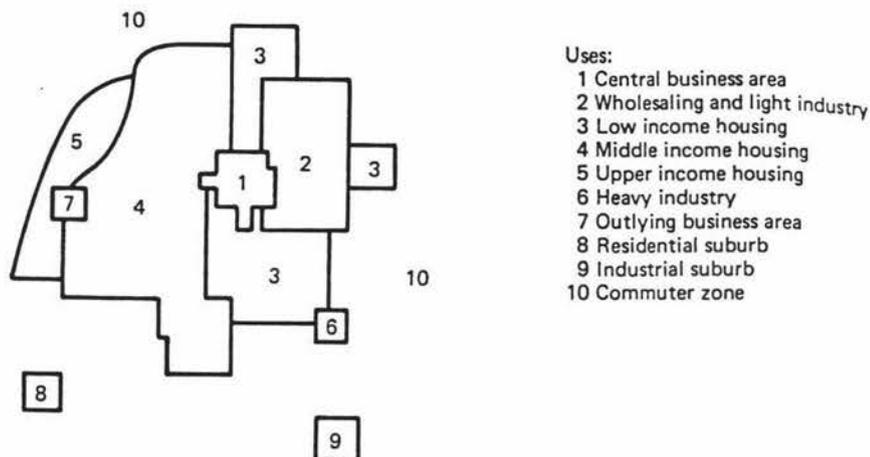
4.4.6.2 Hoyt's theory is again mainly descriptive, but does suggest a pattern of growth related to different growth rates within different parts of the city creating of a more irregular pattern of land uses. The theory still incorporates general factors determining urban land use and land values. Hoyt's theory identifies other reasons apart from transport options for sectoring high quality housing, such as housing in high lying district,

prevailing winds carrying factory pollution, and higher land prices exerting a repelling effect on dissociated activities like manufacturing and wholesaling. By concentrating on factors influencing high income housing, the theory has been criticised, for overlooking factors such as the location of employment opportunities, which are taken as given. However factors crucial to the location of low income housing, the outward expansion of which will depend upon the creation of new employment opportunities (Harvey 1987).

#### 4.4.7 Multiple-Nuclei Theory

4.4.7.1 The multiple nuclei theory was developed by Harris and Ullman in 1945. They believed that large cities have a structure which can be described as 'cellular'. This results from "...the tendency to develop a number of 'nuclei' which serve as focal points for agglomerative tendencies, some more than others." (pg.232 Harvey 1987). The form of a multi-nuclei urban structure is shown in Figure 8 below.

Figure 8: A Multiple Nuclei Urban Structure



Source: pg.232 Harvey 1987

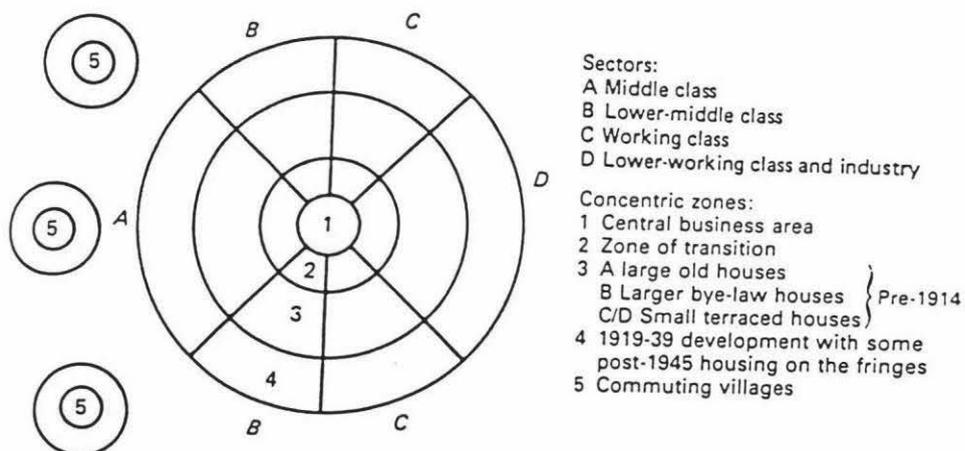
4.4.7.2 This model emphasizes the role of factors such as topographical, historical and most importantly special accessibility resulting from social and economic forces. The nuclei are described as having different origins, existing as minor settlements before city growth began or developing where the growth of population and purchasing power supports a suburban shopping or business centre or a suburban industrial area. Around the separate nuclei, distinctive land uses have developed and this existing

pattern is strengthened by the general factors determining the allocation of land to specific uses. For example, high rents in the CBD induce firms to migrate or establish themselves in peripheral areas, while the various forms of special accessibility - specialised facilities, external economies or diseconomies lead to similar activities to concentrate in particular areas. Harris and Ullman identified these types of factors as specialised facilities and mutual profitability, forced clustering of nuisances, constraints working against alternative housing location choices (lack of income or class segregation). (Harvey 1987). This theory suggest that different activities locate in a selected nuclei because of the interplay of these factors and others.

#### 4.4.8 Sector-Zone Theory

4.4.8.1 The Sector-Zone Theory developed by Mann (1965) synthesizes the previous models. The model is shown in Figure 9 below.

Figure 9: A Sector-Zone Urban Structure



Source: pg.233 Harvey 1987

4.4.8.2 It is essentially a diagrammatic model which combines aspects of the concentric-zone and sector theories. It incorporates the idea that commuting can form 'dormitory' villages outside the city limits. The theory emphasises the social structure of cities by making assumptions about prevailing winds from the west resulting in the location of

the highest income housing to west of the city and low income to the east nearer to the industrial sector (Harvey 1987).

#### 4.4.9 Summary

4.4.9.1 The various theories can be regarded as being complementary to one another, rather than mutually exclusive. The theories tend to build on each other to explain the movement and development of land uses and activity rates into different urban locations. All the theories suggest patterns that are apparent in most cities for example, a Central Business District, an older residential living in the inner city which constantly changes with city growth and redevelopment demands, and newer residential living out in suburban peripheral areas. The location of commercial and industrial areas are noted to be distributed around the city's core, depending on the resources, accessibility, and economies of scale to be obtained in the locations. The land use and location economic theories discussed give an explanation of how cities grow but they cannot explain why they continue to grow.

4.4.9.2 The relationship between land use, urban form and transportation have been extensively studied and important conclusions can be drawn from this body research. Auckland land use organisation, and development can be partially explained using land use and location theory. A single land use pattern is a feature of Auckland. Auckland can be characterised as having a central business core, older-larger style housing adjacent to the core, with newer suburban development surrounding these area. The development of newer housing areas has occurred in all directions out from the central area and is still continuing to grow outwards. The land use pattern within Auckland can broadly follows the 'Concentric Zone' pattern discussed by Burgess.

4.4.9.3 A feature of Auckland's current land use pattern is the distribution of commercial and industrial clusters or sub-centres at different distance from commercial core. As these areas are not located in one particular site or 'concentric zone' these fall more in line with Multiple-Nuclei theory, or various commercial and industrial 'nuclei' distributed all over city. Multiple-Nuclei theory suggests that the 'nuclei' of similar activities has been established over time due to the interplay of many factors. This suggests that the location of similar activities has occurred over time as a result of the mutual benefits to land users from doing so. Location theory and Business Location theory identify

the economic factors that contribute in housing and business location decision. These two theories suggest that the clustering and aggregation of commercial and industrial activities is done so in part to gain economies of scale, economies of aggregation, and to be close to markets and resources. This type of clustering contributes to the single land use pattern. The three theories suggest that a policy allowing 'mixed-use' zones to occur, may not be able to change the current clustering of activities that occurs, as mutual benefits are obtained by land users from a single land use pattern. The theories do however acknowledge that the location decision will depend on the requirements of the activity.

4.4.9.4 One feature of Auckland's growth is the existence of hubs of diverse activity outside the main CBD zone. One such area is in the Albany area, new the construction of a new commercial area, recreational facilities - stadium, and university. The development of sub-centres outside of the CBD is discussed in the Concentric Zone and Multiple Nuclei theories. The theories suggest that as development occurs over time satellite commercial areas will evolve. The development of satellite centres assists in the 'mixing of land uses' as it allow the greater decentralisation of commercial and industrial activities.

4.4.9.5 Auckland is characterised as having the highest activity levels in the central business core of the city. The density of activities in particular, residential density, is greatest in the areas adjacent to the central city core. The rest of the city is characterised as having a relatively low uniform residential density level. Concentric Zone theory, Radial Axial Theory can be applied to Auckland as these theories observe that differing levels of residential density occurs within the city; outer zones of housing have more spacious living whereas housing in the inner zones is more compact. Location theory suggests that accessibility determines the value of land, and that increases in transport investment or an improvement in real income, will assists the decentralisation of residential density by reducing the cost of commuting. Business Location theory states that changes in transport provisions affect residential and business density levels. An improvement in transport will increase employment at benefited sites and increase business density but decrease residential density, and the reverse is true.

- 4.4.9.6 Both Location theory and Business Location Theory applies to Auckland in particular the 1950-1960s period. This as previously discussed experienced both an increases in real income combined with transportation improvements with construction of motorways and the Auckland harbour bridge, allowing many Auckland families to live in suburban areas and commute to sites of employment. The cost of land on the peripheral areas was often less than in the inner areas and reducing residential density levels in these areas. These theories suggest that transportation improvements outwards will facilitate the development of low density housing on the periphery. These theories suggest that transport improvements for example, more motorways or rail tracks outwards from the city may tend to reduce residential density levels. It is difficult to determine using these theories whether a policy to increase residential density levels results in more walking, cycling or public transport trips.
- 4.4.9.7 Hoyt's Wedge or Radial Sector theory, Radial Axial Theory and Concentric Zone theory specifically address the influence of transport investments on city growth (star shape or sectoral growth outwards, ribbon development along arterial routes) and the type of development that occurs. Auckland exhibits some indication that transport investment has lead to development in and along the transport route. An example of this is the construction of the Auckland Harbour Bridge facilitated development within the North Shore area. These theories emphasis the importance of transport investment in city growth and development.
- 4.4.9.8 The theories of growth discuss how these land use patterns form over time through a series of stages. Location and land use theories suggest that transportation and land use are explicitly linked together, that can influence the growth and development of a city. Chandlier (1996) states that "...transport is a necessary activity that can be legitimately used to lead and structure urban development patterns in a more effective manner...however land use patterns have occurred incrementally over time and are complex and dynamic and often exhibit a strong resistance to change." However land use patterns have occurred incrementally over time and are complex and dynamic and often exhibit a strong resistance to change." (pg.3 Chandlier 1996).
- 4.4.9.10 While the theories offer useful insights into the land use and transportation they are limited by restrictive assumptions and partial specifications of casual factors (Deakin 1993). The recognised limitations of this class of models, include the monocentricity of

employment, the treatment of households as having only one worker, simplified treatments of topographical and temporal variations and the assumed dominance of market forces (this is the exclusion of legal, institutional and social constraints). The next section will discuss empirical research on how urban form policies, in particular, increased urban residential densities, increased mix of land uses, more connective street pattern and New Urbanism approaches have been able to redirect travel behaviour away from automobile reliance.

#### 4.5 URBAN FORM AND TRANSPORTATION

4.5.1 Interest in the urban form/transportation relationship and the effect of this on the environment has always been evident. Chandler (1996) suggest four main reasons why renewed interest in this topic has re-emerged over the last couple of years:

1. Rapid urbanisation and metropolitan growth at rates not previously contemplated;
2. Greater expectations of personal mobility and freight movement;
3. More awareness and community concern about the effects of urbanisation on the natural environment (broadening community consensus for a ecologically sustainable future);
4. Reduction in funding for provision of infrastructure. (ability to develop cities in patterns of the past is fading - some would argue is gone).

4.5.2 Chandler (1996) states that this has produced a difficult situation whereby the forces that pursue greater environmental protection now run head on into the forces that demand more from natural and physical environment. In addition, transportation problems are anticipated to gradually get worse, while the expectation of mobility continues to increase. It is fair to state that the transport problem in Auckland, is a product of the increasing pressure on resources and increased mobility expectations. Past planning approach have not always been effective in reaching transport goals and objectives.

4.5.3 Concerns about the lack of integration of land use and transportation in decision making has always existed. Past transportation planning approaches have failed to view transport issues such as congestion in an integrated manner. The planning and

design of residential areas for example, roading and infrastructure has generally been undertaken in the past, by a variety of professional staff who emphasized practicalities in order to achieve good urban design (Campbell 1993). The roles and responsibilities were clearly defined and professionals did their jobs without much interference from other departments or the public. These divisions often lacked effective commitment to, and practice of interdisciplinary and collaborative working. Limited understanding by politicians, professionals and the public on the dynamics of urban areas in general, often hindered land use/transport integration (Campbell 1993). Transport planning issues such as congestion were viewed only from a transport perspective, and solutions were only made in terms of transport options. The range of transportation options was often limited to pricing and physical measures, while other non-transport options for example, land use initiatives were seen as exogenous to process. In the past transport planning has tended to be limited to a narrow base of transport options, solutions, and information. There has often been insufficient integration between the various levels of government, the private business sector, and the community sector, to achieve effective land use/transport integration. Chandler (1996) states that land use/transport planning in practice, has often been something of misnomer, lacking both rigorous analysis and a degree of commitment necessary to make it effective. This is described as the gulf between the rhetoric or prepared policies and plans and reality or the actual form of the city.

#### 4.6 'AUTOMOBILITY' AND 'ACCESSIBILITY' PLANNING

- 4.6.1 A lack of land use/transportation integration has assisted the development of transport solutions which facilitate the movement of the automobile. This type of transportation planning which has been the focus of the past in many developed cities worldwide, is described by Cervero (1996) as the 'Automobility Planning' approach or the supply side approach to planning. The approach aims to increase the speed and ease of moving about the spread out city by identifying ahead of time points of possible congestion, and then deals with the problem by allowing more roadway capacity and highway infrastructure. Cervero states that 'automobile planning' has given rise to development of "...monumental expressways, and multi lane boulevards, that criss cross metropolitan areas of the world" which has subsequently resulted over time in urban sprawl, energy depletion, air and noise pollution, road fatalities, and separation of people by class, race and income (pg..49 Cervero 1996). While it is the aspiration

of New Zealanders to live in low density housing, separating homes from work, the automobility based planning approach has reinforced these behavioural norms.

- 4.6.2 In contrast to this, is what Cervero terms as the ‘accessibility’ or demand side approach to planning. This emphasises what cities are all about - people and places or the movement of people for day to day activities. It recognises that people want to spend less time travelling rather than just focusing on transportation provision and management. The main objective of accessibility planning is “...to manage physical space and resource so as to avoid or minimise motorised travel, and for motorised trips that are made, to reward those travelling by efficient and more environmentally sustainable modes.”(pg.49 Cervero 1996). While ‘automobility planning’ concentrated on the movement of the individual ‘accessibility planning’ focuses on community “...relegating transportation as subservient to the city at-large and the places within it.” (pg.49 Cervero 1996).
- 4.6.3 The ‘accessibility planning’ approach recommends a wide range of policy instruments including, land use initiatives to redirect urban travel towards greater accessibility and sustainability. These are shown in Figure 10. The policy instruments listed in Figure 10 are all potentially useful in influencing travel choices, however no single instrument alone is able to instigate changes needed to cure current urban land transport problems. Land use are initiatives are therefore just one part of a wider policy package. Cervero states “Certainly land use initiatives, in and of themselves, are no cure alls. When combined with other demand management strategies, like constraints on parking and guaranteed rides home for car poolers, they can exert far stronger and more enduring influences.” (pg.51 Cervero 1996). Policies and plans formation should investigate all options to determine which combination will be most successful in achieving a cities in transport objectives. Cervero identifies that an accessible and ecologically sustainable city of the future would look much different from today’s one.

Figure 10: Transportation Mitigation Approaches Under Different Planning Paradigms.

<u>Automobility Planning</u>	<u>Accessibility Planning</u>
<ul style="list-style-type: none"> <li>● <b>Road Construction/Expansion</b> <ul style="list-style-type: none"> <li>- Motorways/Freeways</li> <li>- Beltways</li> <li>- Interchanges/Rotaries</li> <li>- Hierarchical networks</li> <li>- Arterial expansion</li> </ul> </li>   <li>● <b>Intelligent Transportation Systems/ Smart Highways/Smart Cars</b> <ul style="list-style-type: none"> <li>- On-Board navigational systems</li> <li>- Vehicle positioning systems</li> <li>- Real-Time informational systems</li> </ul> </li>   <li>● <b>Transportation System Management (TSM)</b> <ul style="list-style-type: none"> <li>- One-waying streets</li> <li>- Rechannelizing intersections</li> <li>- Removing curbside parking</li> <li>- Ramp metering</li> </ul> </li>   <li>● <b>Large-Scale Public and Private Transport</b> <ul style="list-style-type: none"> <li>- Heavy rail transit/Commuter Rail</li> <li>- Regional busways</li> <li>- Private tollways</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● <b>Land Use Management/Initiatives</b> <ul style="list-style-type: none"> <li>- Compact development</li> <li>- Mixed uses</li> <li>- Pedestrian-oriented design</li> <li>- Transit villages</li> <li>- Traditional neighborhoods/New Urbanism</li> </ul> </li>   <li>● <b>Telecommunication Advances</b> <ul style="list-style-type: none"> <li>- Telecommuting/Teleworking</li> <li>- Telecommunities</li> <li>- Teleshopping</li> </ul> </li>   <li>● <b>Transportation Demand Management (TDM)</b> <ul style="list-style-type: none"> <li>- Ridesharing</li> <li>- Preferential parking for HOVs</li> <li>- Car parking management and pricing</li> <li>- Guaranteed ride home programs</li> </ul> </li>   <li>● <b>Community-Scale Public and Non-Motorized Transport</b> <ul style="list-style-type: none"> <li>- Light rail transit/Trams</li> <li>- Community-based paratransit/Jitneys</li> <li>- Bicycle and pedestrian paths</li> </ul> </li> </ul>

Source: pg.49 Cervero 1996

Its features would be "...compact, mixed-use, pedestrian friendly environs; widespread tele-working and tele-shopping; and stricter management, pricing, and regulation of the car, matched by incentives to ridesharing, public transport usage, walking and cycling." (pg.49 Cervero 1996).

## 4.7 URBAN FORM POLICY INITIATIVES

4.7.1 The connection between urban form and travel behaviour has been of interest to many researchers over the past decades. The literature identifies a number of different land use policy initiatives that may potentially reduce the reliance on the automobile as the primary mode of transit. The land use variables that will be discussed in this section include:

- 'Compact city' proposals - increased residential density levels;
- Mixed use zoning - facilitating a mix of residential, commercial and industrial development within a city - maintaining urban amenity;
- Street layout policies - creating a more connective grid street patterns;
- New Urbanism Approaches - improving pedestrian travel for example, introducing traffic calming methods, greater connectivity and quality of cycling and walking routes.

4.7.2 These policy initiatives all have varying degrees of both theoretical and documented support. However much debate still exists on which package of land use policies are the most appropriate method to use, whether implementing these initiatives will deliver the desired results and the type of urban form these policy/policies will create.

4.7.3 The next section of the literature review outlines the current research undertaken on the influence of urban form, socio-demographic on transportation patterns. The reviewed research covered in the literature review is summarised in Table 6. The type in bold identifies the approaches which have adopted as part of this research.

Table 6: Research Discussed in the Literature Review: Summary of Main Points

STUDY	LOCATION OF CASE STUDY	SELECTION CRITERIA	URBAN FORM VARIABLES	SOURCE OF TRAVEL DATA
<i>Newman and Kenworthy (1989, 1991)</i>	Various cities around the United States, North America, Europe, Asia and Australasia		<b>Population and Employment Density, City Size</b>	<b>Various State and National Organisation Agencies</b>
<i>Holtzclaw (1990)</i>	San Francisco Bay Area (5 Neighbourhoods)	Differences in Density	<b>Net Household Density, Gross Population Density and "Local Serving" Employment Density</b>	Odometer readings from emission testing program
<i>Holtzclaw (1994)</i>	San Francisco Bay Area (11 Neighbourhoods), Los Angeles Area (8 Neighbourhoods), San Diego (5 Neighbourhoods), Sacramento (3 Neighbourhoods)	Differences in Density	<b>Net household density, Gross Population Density and "Local Serving" Employment Density, Transit Accessibility Index, Neighbourhood Shopping Index, Pedestrian Accessibility Index</b>	Odometer readings from emission testing program
<i>Ewing et. al. (1993)</i>	Palm Beach County, Florida	Range of Types	Residential Density, Employment Density, Jobs Housing ratio, % Multi-family, Work Trip Accessibility, Non-Home Based Accessibility	<b>County Travel Survey</b>
<i>Brunton (1996)</i>	Metropolitan Melbourne		Residential and Employment Density, Location of Employment, Housing and Industry	Australian Bureau of <b>Statistics Census Data</b> , Victorian Integrated Travel and Land Use (VITAL) data and Geographic Information Systems (GIS)
<i>Kockelman (1995)</i>	San Francisco Bay Area		Accessibility Index, <b>Land Use Mix (Dissimilarity Index) Land Use Balance (Entropy Index)</b> , Population Density	<b>Surveys Conduction in the Area</b>
<i>Cervero and Gorham (1995)</i>	San Francisco - Oakland Region 14 Neighbourhoods, Los Angeles (12 Neighbourhoods)	<b>Traditional Neighbourhoods vrs Automobile Neighbourhoods</b>	Net Residential Density, % <b>Four Way Intersections, Three Way Intersections, Distances between Centroids, Bus Service</b>	Survey
<i>Cervero and Radisch (1996)</i>	East Bay of San Francisco - Oakland Region (Rockridge and Lafayette)	<b>Traditional Neighbourhoods vrs Automobile Neighbourhoods</b>	Older Traditional Neighbourhoods, Automobile Neighbourhoods	Survey
<i>Handy (1995)</i>	Austin Area, Texas	<b>Traditional, Early, Modern, Late Modern Neighbourhoods</b>	Commercial and Residential Street Characteristics, Pedestrian Environmental Characteristics <b>No. of Commercial Establishments by Type, Land Area Characteristics</b> , Transit System and Number of Households within walking distance, Transit System No. of Through vrs Edge Routes	<b>Survey 1995 both Travel and Attitudinal Surveys</b>

**BOLD TYPE** - Indicates Approach Adopted For This Research

STUDY	LOCATION OF CASE STUDY	SELECTION CRITERIA	URBAN FORM VARIABLES	SOURCE OF TRAVEL DATA
<i>Handy (1992)</i>	San Francisco Bay Area (4 Neighbourhoods)	Pre World War yrs Post World War II Regional Location	No. of Commercial Establishments by Type, "Average" Supermarket Accessibility, Regional Mall Accessibility (measured for households)	Focused Travel Survey for this Project
<i>Kitamura et. al. (1988)</i>	San Francisco Bay Area (5 Neighbourhoods)	Range of Density, Land Use Mix, Rail Transit Available	Dummy Variable for Transit Access, Population Density, Urban Characteristics (Sidewalks, Cycle ways, Backyards, Spaces, Distance from Nearest Bus Stop, Rail State, Grocery Stores, Gas Stations, Parks) Dummy Variables for Neighbourhood Quality	Travel Diary Survey and Other Questionnaires for this Project
<i>Hanson (1982)</i>	Uppsala, Sweden		No. of Commercial Establishments, Land Use Types, % of all Food Stores within the Area	
<i>Principio and Pas (1996)</i>	Triangle Regions, North Carolina	Stratified by Residential Density, Random and an Enriched Sample (Designed to give Information about Public Transit Use)	None	Travel Diary Survey Over 24 Hour Period
<i>Kitamura (1988)</i>	Not Stated, Review of Own and Others Research	Not Stated	None	Not Stated
<i>Vadarevu and Stopher (1996)</i>	Boston Region	Stratified Random Sample, Stratified by Geographic Location, Household Size, Vehicle Ownership	None	Travel Diary Survey - 24 Hour Period

STUDY	TYPES OF TRAVEL	TRAVEL VARIABLES	ANALYSIS TECHNIQUE	UNIT OF ANALYSIS	TREATMENT OF SOCIO-DEMOGRAPHIC VARIABLES
<i>Newman and Kenworthy (1989, 1991)</i>	All Travel Undifferentiated	Gasoline Consumption, Verified Using VMT for Each City and National Fuel Efficiency Adjusted for Average Speed	Correlation Techniques	Cities, Inner and Outer Areas Within Cities	Income and Vehicle Ownership was Tested
<i>Holtzclaw (1990)</i>	All Travel Undifferentiated	Total VMT	Non-Linear Regression	Zip Codes	None
<i>Holtzclaw (1994)</i>	All Travel Undifferentiated	Total VMT	Non-Linear Regression	Zip Codes	Average Income Found as Insignificant Independent Variables
<i>Ewing et. al. (1993)</i>	Work Related, Non Work Related	Frequency, Mode Split, Average Distance Travelled, Variety of Destinations, Total Travel for Trip Purpose	Analysis of Variance	Households	Households Situation, High or Low Incomes Eliminated
<i>Brunton (1996)</i>	Work Related Travel;	Distance Travelled	Scatter Analysis, Linear Regression	Census Collection Levels and Distance Away from CBD	None
<i>Kockelman (1995)</i>	All Travel, Non-Work, Home Based Travel	Mode Split, VMT		1,000 Traffic Analysis Zones, 1,200 Census Tracts	Socio-Economic Variables as Independent Variables
<i>Cervero and Gorham (1995)</i>	Work Based Travel	Frequency, Mode Split	Linear Regression	Neighbourhoods	Matched Pairs with Similar Characteristics, Average Income as Independent Variables
<i>Cervero and Radisch (1996)</i>	Non-Work Trips	Frequency, Mode Split, Distance, Mean Trips Per Day	Descriptive Statistics	Neighbourhoods	Median Household Income
<i>Handy (1995)</i>	Strolling Trips and Walks to the Store	Frequency, Walking Limitations, Motivations, Feelings / Reasons about Walking	Descriptive Statistics, Correlations	Individuals	Matched Pairs with Similar Socio-Economic Characteristics

STUDY	TYPES OF TRAVEL	TRAVEL VARIABLES	ANALYSIS TECHNIQUE	UNIT OF ANALYSIS	TREATMENT OF SOCIO-DEMOGRAPHIC VARIABLES
<i>Handy (1992)</i>	Supermarket Trips, Walking Trips, Local Shopping Trips, Regional Mall Trips, Regional Shopping Trips	<b>Frequency, Mode Split, Average Travel Distance, Variety of Destinations, Total Travel for Trip Purpose</b>	Analysis of Variance, Linear Regression	<b>Individuals</b>	Neighbourhoods with Similar Characteristics MANOVA with Neighbourhoods and Household Types, Socio-Economic Characteristics as Independent Variables
<i>Kitamura et. al. (1988)</i>	All Travel Undifferentiated	<b>Frequency, Mode Split</b>	Linear Regression	<b>Individuals</b>	Socio-Economic Characteristics as Independent variables, Attitudinal Characteristics as Independent Variables
<i>Hanson (1982)</i>	All Travel Undifferentiated	Trip Distance	Regression Techniques		Socio-Demographic Variables Used
<i>Principio and Pas (1996)</i>	All Travel - However Separated by Travel to an Activity	<b>Frequency, Mode Split, No. of Trips per Tour, Trip Length</b>	Cluster Analysis to Determine Different Lifestyle Groups, Analysis of Variance, <b>Descriptive Statistics</b>	Households	Amount of Time Spent by Different Lifestyle Groups on Activities - <b>Socio-Demographics Used to Define Lifestyle Groups and Explain Travel Behaviour</b>
<i>Kitamura (1988)</i>	All Travel Undifferentiated	<b>Frequency, Mode Split</b>		<b>Descriptive Statistics Other Methods Not Stated</b>	<b>Socio-Demographic Characteristics Used to Define Life-Cycle Groups and Explain Travel Behaviour</b>
<i>Vadarevu and Stopher (1996)</i>	Travel Differentiated by Travel to Activities for example, <b>Work, Shopping and Recreation</b>	Frequency of Activities in a Day and Resulting Travel	Analysis of Variance, <b>Descriptive Statistics</b>	Households	<b>Socio-Demographic Characteristics Used to Define Life-Cycle Groups and Determine Travel Behaviour</b>

#### 4.8 COMPACT CITY - INCREASED DENSITY

- 4.8.1 Population or employment density is a common measure of the urban form used in the literature to examine the integration of urban form and travel behaviour. (Ewing 1993, Pushkarev and Zupan 1977, Kockelman 1995, Newman and Kenworthy 1989) Much research has been undertaken in the past, on the issue of density or 'compactness' as a key to reducing automobile reliance. Some of the more controversial research has been produced by Australian researchers Newman and Kenworthy, who in the late eighties early nineties, evaluated physical planning policies for conserving transportation energy in urban areas. This was undertaken by comparing how gasoline is consumed in 32 cities around the world. Newman and Kenworthy began their research by extracting and analysing data from ten United States cities and then compared these results with other cities worldwide.
- 4.8.2 Newman and Kenworthy (1989) used population and employment density variables as a measure of how intensely land is used within a city. Population and employment density variables were calculated for the defined inner and outer areas of ten United States (US) cities then correlated with gasoline consumption. The gasoline consumption data used, was checked against vehicle miles travelled (VMT) for each city, and the national fuel efficiency data was adjusted for average speed (Newman and Kenworthy 1990). The results showed that a strong negative association with gasoline consumption and population density in the inner area of a city. Newman and Kenworthy, suggested the inner areas on average were four to five times as dense as the outer areas and therefore contain the greatest variation in land use. This is shown in the Figure 11 below (shown in Table US cites density vrs gasoline consumption).

Figure 11: Gasoline Use and Land Use Variables in Global Cities

City	Gasoline gallons per capita	Density (persons or jobs/acre)						Central city strength		Other	
		Total		Inner		Outer		Jobs in city center	Proportion of jobs in city center (%)	Proportion of population in inner city (%)	Average to-work length (miles)
		Population density	Job density	Population density	Job density	Population density	Job density				
U.S. cities	446	5.7	2.8	18.2	12.1	4.5	2.0	364,180	12	27	8.1
Australian cities	227	5.7	2.4	9.7	10.9	5.3	1.6	107,736	18	17	7.1
Toronto	265	16.2	8.1	23.1	15.4	13.8	5.8	142,645	13	36	8.1
European cities	101	21.9	12.6	36.8	32.0	17.4	8.1	265,505	19	41	5.1
Asian cities	42	64.8	28.8	18.8	119.8	46.6	17.8	785,225	19	32	2.1
Moscow	3	56.2	—	—	—	—	—	—	—	—	—
Correlation with gasoline <sup>a</sup>		-.5778	-.6571	-.3917	-.4846	-.5751	-.5912	-.1026	-.5027	-.4577	+7.6
Significance		0.000	0.000	0.0150	0.003	0.000	0.000	0.291	0.002	0.005	0.00

a. Correlations are on all 32 separate cities in the sample.

Source: pg.26 Newman and Kenworthy 1989

Figure 12: A Comparison of Modal Split and Automobile Provision Factors in Global Cities

City	Modal split						Automobile provision					
	Transit passenger miles		Total passenger miles on transit (%)	Journey to work (%)			Road supply (ft/capita)	Parking spaces (per 1,000 CBD workers)	Average speed of transit (mph)			Street car/light rail
	Total	Rail		Car	Public transportation	Walk-bike			Average speed of traffic (mph)	Bus	Tram	
U.S. cities	324	162	4.4	83	12	5	21.6	380	27	12	26	11
Australian cities	532	306	7.5	76	19	5	28.5	327	27	13	24	14
Toronto	1,227	673	16.7	63	31	6	8.9	198	—	12	21	10
European cities	1,112	801	24.8	44	35	21	6.9	211	19	12	27	11
Asian cities	1,900	1,112	64.1	15	60	25	3.3	67	15	9	22	8
Moscow	>2,647	>1,866	>95	2	74	24	1.3	—	28	13	>26	11
Correlation with gasoline <sup>a</sup>	-.7191	-.5484	-.7530	+.8733	-.8201	-.7301	+.6918	+.5754	+.7034	+.2734	-.0481	+.2602
Significance	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.072	0.410	0.184

a. All variables defined in Table 3 (rail means train and streetcar/light rail).

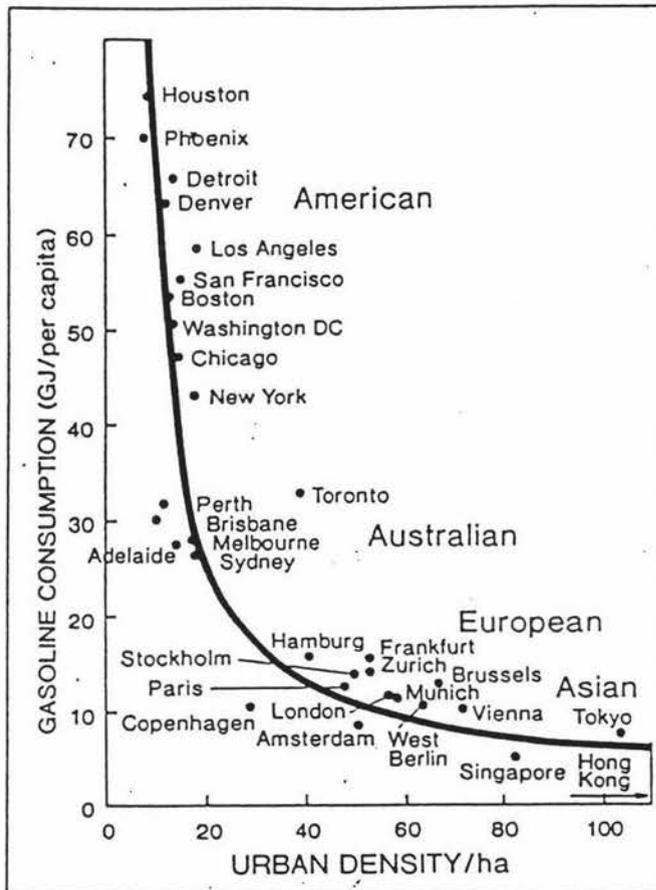
b. Correlations with gasoline use per capita are for all 32 separate cities in the sample.

Source: pg.27 Newman and Kenworthy 1989

4.8.3 The figure shows that Newman and Kenworthy examined a number low density cities such as Houston and Phoenix (with approximately 8 people per acre and 10 jobs per acre) and high density cities such as New York (with approximately 40 people per acre and 20 jobs per acre). Newman and Kenworthy (1989) then compared the research in US cities with North America, Europe, Asia and Australasia cities. Again the results

showed a strong non linear negative association between gasoline consumption per head and population density in the different cities. This is shown in Figure 13 below.

Figure 13: Gasoline Consumption and Urban Density in Thirty One Cities of the Developed World



Source: pg.24 Newman and Kenworthy 1989

- 4.8.4 The Figure 13 reveals a clear rank order in which North American cities exhibit the lowest densities and highest gasoline consumption, while European and Asian cities exhibit the highest population density and lowest gasoline consumption levels. Australian cities and Toronto are clustered midway between the two groups. Newman and Kenworthy identified that European cities on average, have four times the intensity of urban activity than US cities, with their inner centres being nearly double, and outer areas nearly four times that found in the US cities. Urban land in Asian cities however, is approximately ten times more intensively utilised than in US

examples. Hong Kong was identified as having the highest population density rate of any city world wide with an average of 120 people per acre and 400 people per acre in the inner area of the city (Newman and Kenworthy 1990).

- 4.8.5 Newman and Kenworthy further suggest that increases in density result in more than just a reduction in gasoline consumption, affecting overall transportation patterns. They suggest that increase in population density can increase the number of non-vehicular trips made and reduce distances travelled for all modes. The shape of the curve in Figure 13 indicates that a exponential relationship exists. The same shape is retained once the gasoline data is adjusted for price and income and vehicle efficiency factors. Newman and Kenworthy suggest that a strong increase in gasoline consumption occurs when population density levels are under 12 people per acre (30 to 40 people per hectare). They explain that the residents living at this density level lived too far away to regularly use public transport. Walking and cycling also was found to become impractical because distances needed to travel were often beyond the limit of most people. They suggested that 30 to 40 people per hectare is necessary to draw people to the streets and to support reasonable levels of public transport. (Other studies by Pushkarev and Zupan and Newman 1996 confirm this figure.)
- 4.8.6 Newman and Kenworthy researched whether the strength or size of a city centre influences overall transportation patterns. They concluded that cities with more jobs in the centre, would improve the strength of a city centre and would create a more viable public transport system. The results are shown in Figure 14 and 15.

Figure 14: Gasoline Use and Land Use Variables in United States Cities

City	Gasoline gallons per capita	Density (persons or jobs/acre)						Central city strength		Other	
		Total		Inner		Outer		Jobs in city center	Proportion of jobs in city center (%)	Proportion of population in inner city (%)	Average to-work trip length (miles)
		Population density	Job density	Population density	Job density	Population density	Job density				
Houston	587	3.6	2.0	8.5	10.5	3.2	1.2	173,540	12	17	9.2
Phoenix	532	3.2	1.6	7.7	9.7	3.2	1.8	25,920	4	4	8.4
Detroit	503	5.7	2.4	19.4	8.1	4.5	2.0	110,700	7	30	8.7
Denver	483	4.9	3.2	7.7	7.1	4.1	2.0	100,330	12	31	8.1
Los Angeles	445	8.1	4.5	12.1	5.8	6.9	3.8	152,920	5	31	9.2
San Francisco	422	6.1	3.2	23.9	19.4	5.3	2.0	273,160	17	21	7.5
Boston	413	4.9	2.4	18.2	13.3	4.1	1.6	218,210	16	24	8.2
Washington	390	5.3	3.2	17.8	15.4	4.5	2.4	268,700	16	21	8.7
Chicago	367	7.3	3.2	21.9	10.5	4.5	2.0	388,280	12	42	8.7
New York	335	8.1	3.6	43.3	21.5	5.3	2.4	1,930,000	23	40	10.6
Average	446	5.7	2.8	18.2	12.1	4.5	2.0	364,180	12	27	8.1
Correlation with gasoline		-.7390	-.6734	-.7803	-.5923	-.5006	-.4399	-.6367		-.6451	-.07
Significance		0.007	0.016	0.004	0.035	0.069	0.101	0.023	0.013	0.021	0.41

Source: pg.28 Newman and Kenworthy (1989)

Figure 15: Modal Split and Automobile Provision Factors in United States Cities

City	Modal split						Automobile provision					
	Transit passenger miles		Total passenger miles on transit <sup>a</sup> (%)	Journey to work <sup>b</sup> (%)			Road supply <sup>c</sup> (feet per capita)	Parking spaces <sup>c</sup> (per 1,000 CBD workers)	Average speed of traffic <sup>c</sup> (mph)	Average speed of transit (mph)		St car
	Total <sup>a</sup>	Rat		Car	Transit	Walk-bike				Bus	Tram	
Houston	80	—	0.8	94	3	3	34.8	370	32	14	—	—
Phoenix	41	—	0.5	95	2	3	34.1	1033	26	14	—	—
Detroit	70	2	0.8	93	4	3	19.0	473	27	13	26	—
Denver	135	—	1.8	88	7	5	30.8	498	28	13	—	—
Los Angeles	239	—	2.7	88	8	4	14.8	524	28	13	—	—
San Francisco	575	232	8.6	78	17	8	18.1	145	29	14	27	—
Boston	322	217	4.0	74	16	10	17.1	322	24	11	24	—
Washington	383	142	5.0	81	14	5	18.7	264	24	11	25	—
Chicago	603	402	8.0	78	18	8	16.4	91	26	11	29	—
New York	798	623	14.1	64	28	8	15.4	75	22	9	22	—
Average	324	162	4.4	83	12	5	21.6	380	27	12	26	—
Correlation with gasoline	-.9062	-.8455	-.8761	-.9234	-.9281	-.7529	+.8217	+.7140	+.7781	+.8632	+.2607	-.0309
Significance	0.000	0.001	0.000	0.000	0.000	0.006	0.002	0.010	0.004	0.001	0.309	0.000

a. All transit modes including private buses.  
b. Private car passenger miles from VMT and average auto occupancies.  
c. U.S. census data.

Source: pg.28 Newman and Kenworthy (1989)

4.8.7 Figure 14 shows that a significant correlation exists between gasoline consumption and the number and proportion of jobs in the central city. Newman and Kenworthy, argue in the literature, that the central city strength relationship is less obvious than the density relationship because the negative correlation is between gasoline consumption and proportion of jobs in the city centre, not the absolute number of jobs. Newman and Kenworthy also correlated the size of cities with gasoline consumption. This proved to be weakly significant but negative relationship, implying that smaller cities appear to have higher, not lower amount of automobile travel and the reverse applies. They

therefore concluded that city size is of less importance than other physical planning parameters for example, density (Newman and Kenworthy 1990).

4.8.8 Variables such as income, gasoline price and car ownership were tested with gasoline consumption. The results showed that median family income shared no correlation with gasoline consumption (- 0.1219). Gasoline consumption however was significantly related to gasoline price (-0.6151) and vehicle ownership (+0.6574). Newman and Kenworthy suggested that vehicle ownership is independent of other urban structures and parameters, as other previous research have shown to determine how much a car is needed (Pushkarev & Zupan 1997, Button, Fowles & Pearman 1980; Hillman & Whaley 1979 & 1983) for example, car ownership is not significantly correlated with income (+0.3836). Newman and Kenworthy studied the average vehicle speeds of cars, buses and rail, and found that the average traffic speed of rail was strongly positively correlated with gasoline consumption use per capita. This implied that rail maybe more able to compete or be substituted for car travel. (Newman and Kenworthy 1990) It was found that average bus travel speed was not able to compete with car travel. While this observation may in part explain travel choice, the degree to which rail or buses can compete with car travel will depend on other factors apart from speed including, access to, route system and timetables and price of alternatives.

#### 4.8.9 Toronto - A Paradigm For Other Cities?

4.8.9.1 One particular city praised by Newman and Kenworthy, is Toronto, Canada, because of its uniquely ranked position between the automobile orientated cities of North America and the more non-vehicular and public transport cities of Europe (Refer Figure 13). The research undertaken by Newman and Kenworthy on Toronto, suggests that this was the only city that is not demonstrating the common trends of increased vehicular motorisation, less patronage of public transport and lower density development within cities. Newman and Kenworthy attributed the success of Toronto to the following characteristics;

- a strong inner centre, the compact nature of the outer areas in terms of jobs and population densities;

- the numerous clusters of high rise building, representing nodal development around stations on the subway system;
- good public transportation systems compared to other international systems - Toronto system is ranked highly;
- effective linking of urban land use to public transport, particularly the rail system.

4.8.9.2 Newman and Kenworthy highlighted the differences between Toronto and Australian such as Sydney and Melbourne, which are of a comparable age and size to Toronto. Toronto was found to have two to three times greater population density than Australian cities. This was partially attributed to the differences in average lot sizes. A typical family house in Toronto, is rarely built on a lot size exceeding 480 square metres, while Australian family homes tends to be built on an average lot size of 700 to 800 square metres. Trends in density levels were also compared by Newman and Kenworthy. Their research showed that while United States and Australian cities declined in density by 19% and 28% respectively during 1960 to 1980, Toronto increased its population density by 8% (Newman and Kenworthy 1992 and 1994).

4.8.9.3 Newman and Kenworthy also compared the public transportation system and down town parking in Toronto with Sydney, Melbourne and Perth. They found that most (80%) of all the trips into downtown core area in Toronto, were made on public transport, in comparison to 35% for Perth. While Sydney and Melbourne reduced public transport utilisation in terms of passenger kilometers per capita by 6% and 39% respectively during 1960 to 1980, Toronto increased this number by 48%. The reason for the success of the public transportation has been accredited to many factors including public transport improvements and the development of higher density housing around public transport stations. Newman and Kenworthy state that "Toronto has had a good deal of success in building up population densities at strategic nodes, in the central city and along transit corridors." (pg.165 Newman and Kenworthy 1989). These concentrated nodes of development were built around upgraded and extended transit systems, which therefore enabled a sizable proportion of the population to live without or with limited car use if they decided to do so. Newman and Kenworthy suggest that parking is an issue facilitating automobile dependent trends. Parking in the central city of Toronto is limited to only 200 spaces per 1000 jobs, compared to 330 spaces per 1000 jobs the average for the five mainland Australian capitals (of note

is Perth with an average of 560 spaces in 1988). Sydney and Melbourne also increased its parking provision by 24% and 32% respectively during 1960 to 1980 while Toronto only increased this number by 3%.

4.8.9.4 Newman and Kenworthy state that “...Australian cities (and New Zealand cities) have the opportunity to learn from Toronto’s vision and approach to urban development”. (pg.165 Newman and Kenworthy 1989). Another feature worth noting is that Toronto began to reshape its transportation system when it had the population of 1.1 million, which is comparable to Auckland and Perth (Newman and Kenworthy 1990). The Toronto paradigm suggests that urban form policies may be able to curb automobile reliant travel patterns. However, cities have neither uniform travel or traffic conditions, because of their variances in size, topography, land use patterns, socio-demographic condition and public policies. They are often at different stages of development and their willingness and ability to deal with a problem will vary country to country.

4.8.9.5 Overall Newman and Kenworthy work concluded that urban structure (in particular density) within a city is fundamental to its gasoline consumption. They suggest that a city with a dense form, strong centre and intensively utilised suburbs (especially in the inner areas) would provide the basis for a significantly better utilised transit system, and induce more cycling and walking. They recommend the provision of good transit options and restraining the provision of automobile infrastructure to curb fuel consumption patterns.

#### 4.8.10 Criticisms of Newman and Kenworthy’s Research

4.8.10.1 Newman and Kenworthy’s research has however been criticised on a number of fundamental and methodological points (Gordon and Richardson, Jin Jun (1991), Brindle (1994) and Gomez and Ibanez). Nowland and Stewart (1991) make the following comments and criticisms about Newman and Kenworthy’s research.

“ ...the absence in most urban areas of adequate data - either consistently defined across cities for cross-sectional analyses or consistently collected over a long enough time period for time series analysis makes it difficult to undertake the sorts of measurements that are needed. Even with adequate time-series data the tendency for variables of interest - commuting flows, office space, housing and population - to change together through time constitutes a further impediment to a satisfactory statistical analysis. Such multi-

collinearity among the variables makes it difficult to identify and measure the separate effects on commuting trips of a single influence, such as housing or population. Fortunately, there do now exist in Toronto consistent data with enough independent variations over a minimally sufficient time period to allow us to undertake meaningful statistical analysis.” (pg.38 Brindle 1994).

4.8.10.2 Brindle (1994) and Handy (1995) debate the use of an average density figure for each city in research. Handy (1995) describes this as a simple characterisation of urban form, which is not only difficult to measure consistently, but masks variations in density within the city for example, differences in land use patterns and designs of cities with the same density. The use of gasoline consumption as a measure of travel has also been criticised as not distinguishing between the different trip purposes in studied cities, which therefore masks the differential impact of urban form on different types of travel. The study has been criticised by some as oversimplifying the problem. Handy (1995) states that Newman and Kenworthy’s research compares cities with different cultural, political and historical contexts, which oversimplifies complex urban systems. Brindle (1994) states that the study does not account for broader issue of urban spatial dynamics rather it focuses just on land use and transportation integration. Brindle further concludes that after reviewing several studies related to the proponents claims, that “...it is clear that the efficiency of the centralised compact city is not yet proven as the advocated would have us believe ....further debate and research needed to further determine increases in residential density is justified.”

4.8.10.3 The idea that density alone is not the only variable able to curb travel behaviour is discussed by Neuman (1991) and Handy (1995) Neuman (1991) emphasises idea that these concepts of high density verses low density or sprawl verses compact development “...polarities cast the issue in a simple way that glosses over the complexity of life today.” Neuman (1991) “History shown that a single-measured based proposal, if implemented, is more likely to create new problems than to solve existing ones.”(pg.345 Neuman 1991). Handy (1995) states that Newman and Kenworthy’s research is therefore seen to give a general understanding of the transportation and urban form issue, however that “...density alone does not have a direct effect on travel behaviour, but rather is correlated with a number of variables which may: shorten distances between activities, better transit service, higher levels of congestion, and higher parking costs.”(pg.5 Handy 1995).

#### 4.8.11 Support for Newman and Kenworthy's Research

4.8.11.1 Newman and Kenworthy's research has been supported by other studies conducted around the world. Holtzclaw (1990) research compared net household density, gross population density and "local serving" job density with Vehicle Miles Travelled (VMT) for five neighbourhoods with differing density levels in the San Francisco Bay area. The travel data was collected from odometer readings on biennial auto-inspections providing total travel estimates. Annual VMT per capita were used to calculate non-linear relationships with the different densities (net household density, gross population and "local serving job density") of the five areas. The results showed that the outer low commercial and housing density areas (2.0 people per acre) with little transit service, owned three times as many cars, and drove nearly four times as far per person, than the areas that were more densely settled (52 people per acre) with more commercial establishments and transit services (Holtzclaw 1990). Holtzclaw's (1990) results further suggested that as residential density doubled, per capita automobile driving declined by 25 - 30%, providing neighbourhood commerce was allowed to grow appropriately<sup>3</sup> (Holtzclaw 1990). The results were criticised because they did not differentiate between different travel purposes or destinations (Handy 1995). No socio-economic or household variables were included in the research.

4.8.11.2A study by Norwegian Institute for Urban and Regional Research (NIURR) (1993), tested energy consumption in 97 cities in Sweden with residential density. They concluded that when urban land per person increases from 500 to 1000 square metres, the average annual fuel consumed for transportation also increases by a margin of 25%. This study also supported Newman and Kenworthy's claim that city size and average income does not have an effect on energy consumption. No correlation was found in their research, between energy consumption and city size (measured by population size) and average income. The NIURR also conducted studies into 15 small city regions (defined by commuting trips of up to 35 kilometers), which contradicted Newman and Kenworthy's on the importance of the central city to lower gasoline consumption. They found that decentralised, multi-nuclear urban patterns are the least energy demanding, even if the component centres are small. The centralised areas were shown to have the greatest level of energy consumption 25% per capita

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<sup>3</sup> Growing appropriately was not defined in this paper.

than in the most decentralised regions. Therefore energy consumption was found to increase with the degree of urbanisation. The NIURR study overall concluded that “...central locations are important as much in frustrating the use of the car, as in encouraging the role of public transport alternatives.” (pg.132 Breheny et. al. 1993).

4.8.11.3 Another study by the United Kingdom Department of the Environment (Breheny et. al. 1993) differed in the conclusions from the Norwegian research. This research found that small towns and rural areas were associated with the highest levels of travel and automobile reliance. The study also found that neither self containment in commuting terms or intermixing of land uses, was significant in explaining the observed differences in travel behaviour between urban areas. The centralisation of workplaces, and other facilities, was shown to be an important factor in encouraging the use of public transport, rather than the availability of an automobile and parking or access to a railway station). Bartholomew (1993) found that policies that favoured high density residential development, linked to public transit will have significantly favourable effects on decreasing car ownership by 4% and increasing public transport ridership and roles of walking and cycle. (pg.156 Breheny et.al. 1993). These studies tend to confirm Newman and Kenworthy’s claims about increased density and reduced automobile travel, but differ in opinion about whether city size and central city importance is able to do the same.

4.8.12 Newman and Kenworthy’s research tends to mainly focus on “density” as the key urban form variable in their research. Holtzclaw (in later 1994 research) and Ewing (1993), have studied the level of integration between density and other urban form variables. The contents of their research is summarised below.

4.8.13 Holtzclaw (1994), updated his work by expanding the sample to include 28 neighbourhoods, and calculated additional measures of urban form including, a transit accessibility index which reflected hourly access to transit, a neighbourhood shopping index (fractions of households within walking distance to commercial establishments) and a pedestrian accessibility index (reflecting street patterns, street slopes, sidewalk, building entrances and traffic controls). Non-linear equations were used to determine the relationship between automobiles per households and VMT as dependent variables with density and the transit accessibility index as independent variables (Handy 1995). The reported regression co-efficient on density in each case is 0.25, suggesting that

doubling the density would increase both the number of cars per household and the VMT per household by about 25%. The results also argued that doubling transit accessibility, (defined as the number of bus and rail seats per hour weighted by the share of the population within a quarter mile of transit stop), would increase the number of automobiles per household and the VMT per household by nearly 8%. The street configuration is only one component of the pedestrian access measure, so this result did not in itself imply that a mere grid like pattern has no impact on VMT or the number of automobiles. Changes in the degree of pedestrian access - based on street patterns, topography and traffic or neighbourhood shopping, were calculated to have no significant effect on the dependent variables in this sample. Income was the only socio-demographic variable tested, and was found to have an insignificant relationship with both automobile ownership and total automobile travel.

- 4.8.14 The Parsons, Brinkerhoff, Quade and Douglas (1993) study of Portland Oregon, attempted to explain the pattern of VMT, as well as the number of vehicle trips using household income, the number of cars in the household, the number of workers in the household with constructed measures of the pedestrian environment, automobile access and transit access (Parsons, Brinkerhoff, Quade and Douglas 1993 in OECD 1995). The research used a household level survey (1000 Friends of Oregon 1993). The transit and access variables were defined as simple measures of the number of jobs available within a given commute time: 20 minutes by car and 30 minutes by transit. As an example, an increase in 20 000 jobs within a 20 minute commute by car is estimated to decrease daily household VMT by half a mile, while increasing the number of daily automobile trips by one tenth of a trip. The same increase in jobs within a 30 minute commute by transit reduces the number of daily car trips by six tenths of a mile, and reduces the number of daily car trips by one tenth of a trip. The pedestrian access variable is more complex in nature, based on an equal weighting of subjective evaluations of four characteristics in each of 400 zones in Portland. This includes the easing of street crossings, sidewalk continuity, whether local streets are primarily grid or cul-de-sacs and topography. The final result for each zone ranges from a low of 4 to a high of 12, with 12 being the most pedestrian friendly. The regression model reported that an increase of one step in this index for example, from 4 to 5, would decrease the daily household VMT by 0.7 miles, and increase the daily car trips made by 0.4. These point estimates are used to determine the influence changes in independent variables (such as access to employment by transit) on the

dependent variables. While the research supports the theory that more pedestrian friendly and transit orientated developments reduce car trip frequency and overall automobile travel, it does not directly measure the impact of street patterns. The use of an 'index' by both Holtzclaw (1994) and Parsons, Brinkerhoff, Quade and Douglas (1993) to characterise urban form, poses difficulties about the validity and usefulness of the results. A particular urban form variable for example, a grid versus a curvilinear pattern, is not separated out from the other urban form and topographical variables. Hence it is difficult to determine whether urban form policies such as a rectilinear street pattern will do much to influence overall travel patterns. The indexes used have also been criticised as needing a stronger empirical base with respect to both the factors included and their relative weighting.

- 4.8.15 Ewing et. al. (1993) conducted research on six communities in Palm Beach County, Florida, in the United States. The urban form characteristics measures included residential density, employment density, jobs - housing ratio, percentage of multi family dwellings and accessibility. The travel data was collected from a county travel survey, from which trip records were extracted for six separate communities, to give a representation of the travel patterns. The travel behaviour data was classified into work related or non work related trips. The trip variables calculated, included mode splits, number of trips, average travel time and total hours of travel. Analysis of variance techniques was used to determine the variation of travel behaviour between communities and variation within communities. Trips for households with very low or high incomes were eliminated from the sample, creating communities with similar incomes and household sizes (pg.8 Ewing 1993 in Handy 1995). The results concluded that only travel times and total hours of travel showed significantly greater variation between rather than within communities.

#### 4.9 MEASURES OF LAND USE MIX AND BALANCE

- 4.9.1 Allowing a mix of land uses within an area has been identified as one way of reducing travel distances and therefore encouraging the use of non-vehicular modes of transport. Brunton (1996) argues "...that it is not density on which one should be concentrating but on mixing land use; that is mixing employment, shopping, public open space with residential areas to reduce journey to activity travel distances." (pg.7 Brunton 1996). Brunton's (1996), research examines whether the mixing of workers' homes and

workers' workplaces could influence the average journey to work distances in metropolitan Melbourne. This was achieved by examining the location and distribution of individual industries and how well they matched with the location of their workers' homes. The data was collected from the Australian Bureau of Statistics Census Data, and the Victorian Integrated Travel Activities and Land-Use Survey (VITAL). Geographic Information Systems were also used to obtain the spatial distribution of workers. The data collected on the workers homes and workplaces was disaggregated to census collection district levels and by industry type. A ratio of employment and residential density was calculated for each zone to determine how well these figures corresponded. A ratio greater than one implied that there was more employment in a zone than there were workers living in that zone, whereas a ratio of less than one indicated the reverse. The research calculated trip distances for work journeys to employment sites and produced density ratios by dividing the number of destination points by the number of origin points in each zone. The results showed that approximately 80% of the working population live in zones with a ratio of less than one, and approximately 40% of jobs were in zones with ratio values less than one. This indicates that many areas within Melbourne have disproportionate levels of jobs to workers living in an area, resulting in people commuting to their place of employment.

- 4.9.2 Brunton then tested whether distance from the Central Business District (CBD) would influence trip length. Brunton divided the metro CBD area into five regions varying in distance from the central core. Again an average journey to work distance and a density ratio were calculated for each of these five regions. Scatter analysis and linear regression were used, to show relationships between average work trip distances with density ratios for each of the regions. The research showed that all the five regions displayed a negative slope indicating that average trip length of the journey to work is smaller in zones with higher density ratios. Brunton therefore concluded that "...areas with a mixture of homes and worksites tend to produce shorter journeys to work distance." (pg.6 Brunton 1996) The study also indicated that regions located further away from the CBD had higher journey to work distances suggesting that the difference between the trip distance in each region reduces as the density ratio increases. Brunton therefore argues that as long as density ratios are very high, trip lengths will be at similar low values despite the location of the zone. The results in this section of Brunton's research showed a high degree of scatter within the plots,

suggesting that the relationship between work trip length and density ratio for the many census zones is relatively weak. Brunton states this may be explained by a number of factors, in particular, that the density ratio used was a very localised form of measuring accessibility creating a problem when zones with low ratios are surrounded by zones with high ratios. Brunton ignores all other variables to explain commuting, except density and household distance from the CBD.

- 4.9.3 Brunton argues that an increase in the amount of employment sites in predominately residential areas, in order to increase the density ratio, will decrease the ratio somewhere else. This suggests that a 'balancing act' situation exists. Brunton identified two ways of reducing overall average trip length (i) by allowing greater distribution of jobs into suburbs from the CBD (a trend already occurring in cities) and (ii) moving people into and around the CBD where the highest employment ratio rates occur. Overall, the research suggests that there maybe a link between land use mix and trip distances, but this does not however appear to be a strong one.
- 4.9.4 Kockelman (1995) carried out research to "investigate the relative significance of a variety of measures of urban form, both at trip makers home neighbourhood and trip ends." (pg.1 Kockelman 1995). Urban form measures including, density, land use mixing (dissimilarity index) and land use balance (entropy index) and an accessibility index were constructed from hectare-level descriptions provided by the Association of Bay Area Governments (between 1,000 traffic analysis zones and 1,200 census tracts were analysed). The travel data was collected from Surveys conducted in the San Francisco Bay Area. The travel variables examined include Vehicle Miles Travelled (VMT), non work trips and automobile ownership and mode choice. The research concluded that after controlling for demographic characteristics, the measures of accessibility, land use mix and land use balance proved to be highly statistically significant to household VMT, automobile ownership and mode choice. The accessibility variable was found to have the most influence on VMT, and walkable probabilities than either the land use mix (dissimilarity index) or land use balance (entropy index.) Density compared with VMT and mode choice, was found to be negligible, after controlling for accessibility. Kockelman's research discussed how density was often substituted for a measure of accessibility; for example, "...high densities are often associated with higher levels of access to opportunity sites, because high land costs of accessible locations are an incentive for intense developments."

(pg.4 Kockleman 1995). The population density figures were found to be more useful than employment density measures when accessibility (a type of regional employment measure) was removed from the models. Kockelman argues that this research supports policies that promote regional growth containment, raising and/or removal of density/intensity caps, and the establishment of mixed use and flexible zoning standards throughout urban areas.

- 4.9.5 The results of both Brunton's and Kockelman's research show that a link does seem to exist between the mix of land use and travel behaviour patterns. While Brunton's research only focused on work trips, Kockelman's research only focuses on non-work home based trips. It is therefore identified that both work and non-work travel should be examined in order to achieve greater understanding of travel patterns.

#### 4.10 STREET LAYOUT AND TRANSIT AVAILABILITY

- 4.10.1 The connectivity of the street pattern has been suggested as another urban form characteristics which may reduce trip lengths and encourage non-vehicular modes. A curvilinear or cul-de-sac street pattern has been described as representing "...an advance in design and efficiency for automobile movement - and also for protection from automobile - but a step backwards in design efficiency for pedestrian and transit movement, pedestrians have to often walk exceeding long distances because through paths are cut off by cul-de-sacs, and transit vehicles cannot serve cul-de-sacs of efficiently filter through neighbourhoods with curvilinear layouts or branch nodes. Thus, many modern suburbs limit travel choice by physically designing out all but the automobile option."(pg.49 Cervero 1996). Research on the influence a rectilinear street pattern has on travel behaviour has been conducted by McNally and Ryan (1994), Anglin and Marks (1990) and Cervero and Gorham (1995). Their research is summarised in this next section.

- 4.10.2 McNally and Ryan (1994) examined a typical suburban street layout (mainly a curvilinear street pattern) with a neo-traditional style layout (mainly a rectilinear street pattern) in terms of total trips, total travel, average speeds, average trip distances and times and intersection level-of-service. The residential and non-residential densities calculated were found to be similar for two types of layouts, however the mix of the land uses differed. Assumptions about trip generation and trip distribution were used

to predict overall travel patterns. McNally and Ryan confirmed that a more rectilinear pattern street layout could reduce VMT and average trip lengths, with reductions within the 10 - 15% range. McNally and Ryan (1993) reported less driving in the rectilinear street system suburbs, however it is assumed that trip generation frequencies are unchanged. As a consequence the result more or less follows directly from the statement of the problem: if trip origins and destinations are moved closer together, which the grid system does, trip lengths must therefore decrease. The question remains as to whether the number of trips is also affected by the change in trip length. The study is criticised by Cervero and Gorham (1995) as having an over-simplified travel behavioural framework, a problem which is shared by other engineering simulations. Cervero and Gorham further identified that the neglect of trip generation issues makes the conclusions of the data difficult to assess.

- 4.10.3 Anglin and Marks (1990) used standard travel demand forecasting models to simulate neighbourhood forms with two contrasting street patterns. Their research found that the neighbourhood with the grid street pattern averaged 43% lower VMT than the curvilinear street patterns. This research therefore made the suggestion that a more rectilinear street pattern would allow more automobiles to travel via a direct route. It is noted that because these studies use a number of assumptions and simplify urban form and travel behaviour, the results produced can only be classified as speculative in nature. However, these studies do contribute valuable input into the development of methodologies to test the extent of the relationship between urban form and travel behaviour.
- 4.10.4 Cervero and Gorham's (1995) research examines the difference in travel patterns for a sample of neighbourhoods in the San Francisco Bay area and the Los Angeles area. They grouped neighbourhoods into 'matched pairs' by using various urban form variables to characterise the areas as 'transit' or 'auto' neighbourhoods. Each transit neighbourhood had a matching 'auto' neighbourhood pair and travel behaviour was compared both within and between these pairs. The differentiating urban form characteristics included: daily bus miles travelled per acre, the distance between centroids, percentage of three or four way intersections and net residential density. The sites selected for transit neighbourhoods were generally characterised as being built along a street car line or around a rail station, containing over 50% of four way intersections in the neighbourhood and largely built before 1945. The auto

neighbourhoods in contrast were generally without transit lines, containing over 50% of three way intersections and generally built-up after 1945. The study also ensured that each automobile neighbourhood had a net residential density equal to or less than the matched transit neighbourhood. The matched pairs had similar topographical features, levels of public transportation, and were located at a significant distance (four miles) away from each other. United States census data on work trip mode splits and work trip generation by mode formed the basis of the travel behaviour analysis. Socio-economic characteristics including, race, mean age, mean vehicle per household and household income were also examined in the research. Regression equations were used to estimate which urban form characteristics had the most significant influence on mode split.

- 4.10.5 The San Francisco Bay area survey found that pedestrian and cycling modal shares were in all cases higher in transit neighbourhoods than in auto neighbourhoods. Therefore “transit orientated” designs tended to increase the number of non-motorised travel made. On average it was found that transit neighbourhoods generated 70% more transit trips and 120% more pedestrian and cycling trips than auto neighbourhoods. All transit neighbourhoods were also found to have lower automobile drive alone modal shares and trip generation rates than the auto neighbourhoods did (in some cases figures in transit neighbourhoods were significantly lower than auto neighbourhoods). The level of public transport use in the San Francisco Bay area was compared with the Los Angeles area. Cervero and Gorham concluded that more public transport trips were likely in transit neighbourhoods in both San Francisco and Los Angeles. By holding income and density constant, transit neighbourhoods in San Francisco Bay area averaged 5.1% more journeys to work by public transport than auto neighbourhoods, in comparison to Los Angeles area where 1.4% more work trips are likely to be by public transport in the ‘transit neighbourhoods’ than in an auto neighbourhood. The trip regression analyses undertaken for Los Angeles county showed that for every 1000 households in a transit neighbourhood, 19 more transit work trips could be expected than in the auto neighbourhood, providing the same variables are held constant. The research in the Los Angeles area, also showed that increases in density had a stronger effect of inducing transit in transit neighbourhoods than they did in less dense neighbourhoods (auto neighbourhoods). The effect of an additional dwelling unit per acre in Los Angeles transit neighbourhoods generated 2 - 4 % increase in the share of work trips

above that for auto neighbourhoods, all else being equal. The results showed that with ten dwelling units per acre, transit neighbourhoods averaged 8% more work trips by public transport, while at thirty dwelling units per acre, they averaged 13.5% more public transport commutes.

- 4.10.6 Overall the research showed a difference in the travel behaviour for traditional neighbourhoods laid out around transit stations, and auto centric neighbourhood patterns. "Transit neighbourhoods showed lower drive alone modal shares and trip generation rates than auto counterparts." (pg.223 Cervero and Gorham 1995). The number of walking and cycling mode split was higher in traditional neighbourhoods than in the automobile centric neighbourhoods. Their research found that densities had a proportionally greater effect on inducing transit usage in transit-orientated neighbourhoods than auto neighbourhoods. The results were stronger for the San Francisco Bay Area than for the Los Angeles County samples, which showed weaker pedestrian and transit modal shares and generation rates than their auto counterparts. Cervero and Gorham suggest that this may be due to the form of the entire region that could influence modal choice as neighbourhood design or layout does. They therefore stated that the "...form of the macro-region may be too auto-dependent for the micro-pattern of any particular neighbourhood to matter." (pg.223 Cervero and Gorham 1995).
- 4.10.7 Cervero and Radisch (1996) also adopted the 'matched pair' approach by studying two distinctly different neighbourhoods in East Bay of San Francisco-Oakland region called Rockridge and Lafayette. The neighbourhood of Rockridge is described as being a relatively compact and mixed use neighbourhood with older traditional design qualities. The neighbourhood of Lafayette in contrast is described as being is a Post World War 11 community, mainly composed of suburban tract housing, spacious community design and an auto centric retail strips and plazas. These two neighbourhoods are quite similar in terms of their location (both same geographical area), provision of heavy rail transit line, provision of bus service and median household incomes. A survey of 840 residents in each neighbourhood was conducted for the research. The survey showed that the non-motorised modal split for non-work trips was 16% for traditional neighbourhoods compared to 4% in auto-orientated neighbourhoods. In the traditional neighbourhood 28% of all non work trips under one mile were made by foot compared to just 6% in the auto-oriented neighbourhood. The

survey also found that the traditional neighbourhood had a higher number of walking and cycling trips substituted for external (out-of-the-neighbourhood) automobile trips. The mean non-work trip rates (per person) for walking compared to automobile trips were notably different 1.07 walk trips and 0.90 automobile trips per day in traditional neighbourhoods; compared to 0.33 walk trips and 1.58 automobile trips per day. The research noted that both the neighbourhoods made a similar amount of trips out of home each day.

4.10.8 The research conducted by Cervero and Gorham (1995) and Cervero and Radisch (1996) demonstrates that the connectivity of street patterns may along with other urban form factors such as density levels, suburb age - reflected in the housing and street characteristics of urban environment, may have an affect on reducing automobile reliance, the use of non motorised modes such as walking and public transit use. The technique of 'matched pairs' adopted in this research and others is viewed as being a useful means of comparing actual travel behaviour of neighbourhoods with differing urban form characteristics. However the results are again limited to the variables calculated, and assumptions and limitations of variables used.

#### 4.11 NEO TRADITIONAL DEVELOPMENTS / THE NEW URBANISM

4.11.1 Neo Traditional Development (NTD) is a generic term for a set of more specific proposals that go by a variety of names including: new-urbanism, pedestrian pockets, urban villages, compact cities and compact urban development (Handy 1992). Pearson (1990) identifies five common characteristics of NTD proposal that provide a form of definition.

1. mixed use core, residents live within walking distance e.g.) 1/4 mile away core - retail and services and residential development.
2. employment centres - opportunity to live and work within the development.
3. Proposals attempt to create a sense of community public space and civic centres are focal points.
4. generate street life - pedestrian friendly environment narrower streets, more connective street systems, wider footpaths, more street trees.

5. seek sense of traditional despite newness - front porches, detached and set back garages, granny flats - typical design features. (Pearson 1990 in Handy 1992)

4.11.2 The Neo Traditional Developments therefore incorporates the urban form initiatives discussed: higher residential density, mix of land uses and connective street patterns; and concepts of a pedestrian and/or transit orientated environment. The basic premise of Neo Traditional Development proposals is that development resembling communities of the past will tend to function like those of the past. The concept was developed by American planners and architects in response to what they saw as the major issues facing their cities. The name 'Neo Traditional Development' reflects how these types of development and design, have adopted many features of suburban communities of World War II era. They are often smaller in size and denser, containing a richer mix of land use and building types than post World War II designs or newtowns and planned unit developments. Some NTD designs have also integrated ideas from European cities and New England small towns for example, narrow streets, extensive cycling and walking provisions, civic areas, mixed land use and higher density living. Neo Traditional Development designs therefore, focus on pulling together all desirable aspects of small towns for its inspiration for cities urban form (Pearson 1990 in Handy 1992).

4.11.3 The advocates of NTD proposals assert that these designs produce two main benefits; a reduction in automobile reliance instilled in deconcentrated development patterns and the creation of a greater sense of community within the areas which is of contrast to life in modern suburban development. Neo Traditional Development has therefore been viewed by many as part of a possible solution to reducing these urban ills, and thus providing a common good on which to discuss issues and alternatives (Morris 1991 in Handy 1992).

#### 4.11.4 Decrease Need For Automobile Travel

4.11.4.1 One of the major claims for adopting Neo-Traditional Development proposals is based on the argument that because there is a greater mix of land uses and residential densities etc. this will reduce the need to travel because residential areas are located in closer proximity to goods and services required. Duany (1993) an advocate of NTD

claims that these designs aim to change the amount and mode of travel by arguing that “...most of the needs of daily life can be met within 3000 - 4000 acres, mixed use development, so that “...very few auto trips would ever hit collector roads in NTD.” (pg. 28 Duany 1993 in Handy 1995). The advocates suggest that more connective street patterns, better provision of public transport, more pedestrian friendly environments and locating destinations closer together are capable of reducing the length and number automobile trips (in that some automobile trips will be replaced by other non-vehicular modes). The NTD designs therefore have been described as combining “...the convenience of the car with opportunity to walk.” (Calthorpe 1991 in Handy 1995). Pearson (1990) an advocate of NTD states that these plans “are being billed as offering solutions to many of the traffic problems that have become endemic to suburbs developed since World War II.” (pg.24 Pearson 1990 in Handy 1995).

#### 4.11.5 Increasing sense of community

4.11.5.1 The advocates of NTD claim that these design features will be able to recapture a sense of community, argued to have disappeared from typical suburban communities. They believe that this sense of community was felt more in traditional communities of the past. Heinze and Drutschmann (1977) state:

“...that a great deal could be said for master builders and planners of old towns ...they were better sociologists, psychologists and economists than those who take the decisions nowadays. The town was understood as an entity, psychologically and physically, individually and socially. This was expressed in the local and temporal mixing of social functions and implanting of the use of an area which subordinated private activities to the safety and well being of the town. Much points to a planning maxim of decentralisation as much as possible and concentrate as much as is needed.” (p58. Heinze and Drutschmann (1977) Hillman 1995).

4.11.5.2 The traditional town therefore had urban form characteristics which were considered desirable and were subsequently adopted into Neo-traditional proposals. Duany states that this has occurred because:

“...the traditional neighbourhood has several positive consequences ...By providing streets and squares of comfortable scale and defined spatial quality, neighbours, walking, come to know each other and to watch over their collective security ....By providing a full range of housing types and work places, age and economic classes are integrated and the bonds of an authentic

community are formed, By providing suitable civic buildings and spaces, democratic initiatives are encouraged and the balanced evolution of society is secured.” (pg.11 Duany 1991 in Handy 1992).

4.11.5.3 Knack (1989) suggests that this type of development will encourage and entice residents out of private realms of houses and cars therefore reviving public life (Knack 1989 in Handy 1995). The NTD designs therefore aim to recapture this sense of community which proponents argue has vanished from suburban development.

#### 4.11.6 New-Urbanism

4.11.6.1 New Urbanism (Katz 1994) is an umbrella term encompassing NTD which embraces the concepts of compact city, and mixed use development, while focusing on the details that make a neighbourhood enjoyable. The New-Urbanism improvements also include rectilinear street patterns - well suited to walking, narrow streets with curbside parking and back lot alleys, civic spaces for lingering and people watching, commercial cores within walking distance of most residents, generous amount of open space, street trees and pleasant vistas (Southward & Cervero 1996). Once again the central premise of New Urbanism designs, is to create communities similar to those of yesteryear, which will in turn reduce auto reliance by making it more pleasant to walk or cycle. Walking is a central part of the New Urbanism concept, as design elements are used to coerce walking “...thereby encouraging interaction and a greater sense of community and at the same time discouraging automobile dependence.” (Handy 1992). New Urbanism is not however, only focused on transport considerations, there is also strong emphasis on recognising the importance to establish cities and suburbs that are rich with a sense of culture and community. The designs are therefore focused on creating places where people can come into regular contact and are not confined to just their houses and cars (Southworth 1997). The designers also advocate a ‘strong anti-suburban bias’ stance on development within the urban environment (Katz 1994). New-Urbanism concepts therefore require a variety of characteristics necessary within the urban environment in order to change travel behaviour.

4.11.6.2 Kemp (1996) notes that Australia and much of the developed world have had dramatic increases in consumer services and self employment which has instigated businesses to locate within and near residential areas. Kemp identified that this may provide the

business economic viability and the level of employment required to support such New Urbanism improvements (Kemp 1996 in Cervero 1995). While the concept of New-Urbanism has received a wide range of support for ideas and designs it has been criticised as “...being far too concerned with appearances, that is, too architecturally based, while ignoring social concerns and regional issues of transportation and land use.” (pg.29 Southworth 1997). Southworth (1997) does accept that the real benefits of the designs on reducing automobile reliance and increasing a sense of community have been difficult to measure.

#### 4.11.7 Pedestrian Pockets

4.11.7.1 Pedestrian Pockets (PP) or Pedestrian Orientated Development (POD) or Transit Orientated Developments (TOD) are similar to NTD in their treatment of walking and access issues, but differ in that there is less emphasis placed on controlling architectural form and emulating historical styles. The Pedestrian Pocket design developed by Calthorpe and Associates is described by its designers as “...a balanced, mixed use area within a 1/4 mile walking radius of a Light Rail Station ...The design configuration, mix of use and emphasis on a pedestrian orientated environment and reinforce the use of public transport.” (Calthorpe 1991 in Handy 1995) Pedestrian Pockets are designed to be much smaller than a new town, at about 50-120 acres in size, that include housing, retail, daycare, recreation, back alleys, and public open space. Pedestrian pockets therefore aim to “...provide balanced growth in jobs, housing and services, while creating a mass transit alternative for the existing community.” All modes of transport are catered for in pedestrian pocket designs. Calthorpe describes the Pedestrian Pocket designs for the urban environment as integration of the convenience of car with opportunities to walk so that people can choose, whether to walk, use public transit or drive. Calthorpe intends these modes to be as “convenient and pleasing” to the user. The advocates of pedestrian pockets claim that the designs save resource use for example, land and energy, reduce traffic, make homes more affordable and improve accessibility for children and the elderly.

4.11.7.2 Calthorpe suggests that Pedestrian Pockets could be implanted into existing fabric by providing a new Light Rail Transit line and upzoning at each end of its situations. Pedestrian Pockets therefore aim to reorganise suburban environment, to accommodate population growth with minimum environmental impacts. The pedestrian pocket is

“...a concept for some new growth; it is not intended to displace urban renewal efforts, and it will certainly not eclipse typical suburban sprawl.” (Calthorpe 1991 in Handy 1992). Pedestrian pockets are not intended to be stand alone developments, but are to join into a network of long range growth within a region. Calthorpe identifies that the role of the public sector is to primarily create the transit system and new zoning guidelines, for example, rezoning to provide a comfortable walking distance from the residential areas to the Light Rail Transit station. This leaves the design and architectural structure up to individual and developer who will build sectors of the pocket independently. Pedestrian pockets outline a number of urban form changes to existing and new developments and therefore can be described as more a conscious choice rather than laissez faire style of planning.

4.11.7.3 Calthorpe states that “...as private world grows in breath the public world becomes more remote and impersonal.” Therefore an overriding objective of pedestrian pocket designs is to create a greater sense of community by “...reintegrating different social groups segregated by age, culture, into common spaces and local stories create a rebirth our lost sense of place.” These designs therefore aim create an urban environment which is viewed “...as the ideal model of an urban traffic system which returns human dignity and is tolerable to nature.” (Calthorpe 1991 in Handy 1992).

4.11.7.4 Although most NTD designs still exist only on paper, a few have been constructed and are at least partly occupied. Two examples of NTD are a Pedestrian Orientated Development in greater Laguna West, Sacramento California, designed by Peter Calthorpe and Associates; and a traditional neighbourhood development designed by Andre Duany and Elizabeth Plater-Zyberk in Kentlands, Gaithersbury, Maryland suburb of Washington DC. The Laguna West project contains a radial and grid street pattern, (with minimal use of cul-de-sac designs) in an effort to focus neighbourhoods around transit stops and centres. Similarly Kentlands is constructed around a “...series of through streets to allow easy accessibility by both pedestrians and transit vehicles.” (pg.30 Southworth 1996).

4.11.7.5 Cervero (1996) states that “Because few New Urbanism communities have actually been constructed researchers have sought to test the theories of New Urbanism by studying the travel behaviour in already existing neighbourhoods which incorporate characteristics of either pedestrianised or auto-centric designs.” (pg.51 Cervero 1996).

4.11.7.6 Handy (1995) conducted research that sought to identify which urban form factors encourage walking and instigate choices for pedestrian trips. The research used six neighbourhoods within the Austin, Texas Region. 'Matched pairs' were used to identify neighbourhoods as either 'traditional neighbourhoods' which were developed in the early decades of 1900's and located near centre of city; 'early modern neighbourhoods' - which were developed in Post World War II and located near the central city, and 'late modern neighbourhoods' - which were recent subdivisions located at the fringe of the city. The urban form data compiled included both qualitative and quantitative data, and was collected using a variety of techniques including, analysis of GIS databases, hard copy maps, aerial photographs and data collected through site visits. The urban form data contained specific measurements of both neighbourhood and commercial street layouts and street characteristics (e.g. width, length, volume of traffic, level of shade from trees). Handy identified the predominate housing characteristics that were present along both commercial and residential streets. The housing characteristics identified included existence of porches, facades and the presence of design variations as well as front door setbacks. The number of commercial establishments per (10 000) population was also recorded. Handy conducted a household survey on travel behaviour to collect data on two types of trips, strolling trips and walks to a destination, in particular, to the store. The survey aimed to identify what individual motivations and limitations influence whether an individual chooses to walk and what urban form characteristics may encourage or discourage this choice. Handy did this by asking respondents attitudinal questions about why and how they feel about walking trips.

4.11.7.7 The results showed that the frequency of strolling trips around the neighbourhood was greater in traditional neighbourhoods than late modern neighbourhoods, while the results for the early modern neighbourhood were mixed (one of the pairs had the second highest average frequency and the other had the second lowest frequency). The results in this section although not statistically significant, did suggest that '...either residents in the traditional neighbourhood may be somewhat more motivated to stroll or that the urban form of the neighbourhood may be somewhat more encouraging of walking or both.'(pg.8 Handy 1995). The motivation for walking was examined by asking open ended questions about why respondents went on strolling trips. The most common reason given by respondents as to why they to go on a walk,

was for 'exercise/health' reasons. Other common reasons for walking were 'for pleasure' reasons or to 'walk the dog'.

4.11.7.8 Correlation techniques were used to determine the relationship between the number of trips and different attitudes towards aspects of urban form. The survey showed that 'feeling safe walking at night' and 'seeing neighbours when walking' had the highest correlation's with strolling frequencies. While the survey gave interesting results about these strolling trips often correlation's to attitudinal questions were relatively weak. The results suggested that "urban form ...is a secondary factor encouraging or discouraging walking given the motivation to walk and the absence of limitations."(pg.10 Handy 1995). The frequency of walks to a destination were overall greater for traditional neighbourhoods than in the late modern and early modern neighbourhoods. This was explained by the fact that the households within traditional neighbourhoods were generally located closer to shopping areas, they were more neighbourhood orientated in design in that the quality of the pedestrian environment in commercial area was generally better. Urban form was therefore found to play a greater role in the choice to walk to a destination for example, to a store or a commercial establishment. The main factor that influenced this decision was distance from home to destination. This factor combined with the quality of the pedestrian environment destination outweighed the quality of the pedestrian environment around home in the choice to walk to the store (Handy 1995).

4.11.7.9 Earlier research by Hanson and Schwab (1987) tends to support some of Handy's claims. Hanson and Schwab investigated how access to commercial establishments affects trip generation within urban areas. The research showed that better access (measured by more retail and service establishments within a specified distance) decreases the proportion of trips made by automobile. This research suggested that more non-motorised walking, cycling or possibly public transport trips are made when shopping facilities are nearby to residents. The research therefore suggested that distance may play an important role in the decision to walk to shopping areas.

4.11.7.10 While advocates of NTD identify that urban form with NTD characteristics has a desirable result on urban sustainability, considerable debate exists on whether these design solutions are the most appropriate model for development; and whether the changes are really a new approach or a reiteration of the past, therefore just another

type of suburban development (Handy 1992). The changes recommended in NTD are likely to have a variety of positive and negative effects on the urban environment. While the proposed benefits have been duly noted a number of criticisms and concerns have been made regarding NTD and New Urbanism approaches which are outlined in the following Section 4.11.8.

#### 4.11.8 Criticisms and Concerns About Neo-Traditional Developments/New Urbanism Approaches

4.11.8.1A main concern about the NTD approach, is the number of simplifying assumptions and limitations used in the studies and research cited to support NTD claims. This questions the reliability of the research. One such criticism is that the assumptions and limitations identified in NTD and New Urbanism approaches oversimplify relationships between urban form and travel behaviour. As travel behaviour is a complex concept containing a vast number of contributing factors, the criticism has been made that it would be difficult to assess and draw conclusions about its direct relationship with urban form. The research has also been criticised as failing to substantiate claims with evidence for all NTD initiatives. This claim is based on the fact that many cities have not experienced actual changes in urban form (i.e. the increased density level, more mixed use zoning measures and changes in street patterns). Thereby attempting to test claims poses many problems, in particular, as the principles are often un-built or too new to evaluate. Research has often been based on simulation, or by comparing contrasting urban areas within the same existing city (Cervero and Gorham 1995). While the simulation approach only provides speculative results, the 'matched pairs' approach provides data on the impact NTD initiatives have on travel behaviour patterns within existing communities. However it could be argued that NTD can not be fully tested until functioning examples of these types of developments exist.

4.11.8.2Other critics suggest that NTD and New Urbanism approaches for example, increasing residential density and mixture of land use, may be more detrimental to sustainability than beneficial. Audirac, Sherman and Smith (1990) question whether compact development may hurt ecosystems, more than sprawl, as land is used more intensively. Research that link urban form to travel behaviour is also criticised as not identifying which specific policies may be effective at shaping travel behaviour. Crane (1996)

states that the "...available evidence is difficult to synthesise as the literature commonly addresses aesthetic, social, and transport issues simultaneously."(pg.55 Crane 1996). Others question whether these NTD proposals if implemented, would have a significant enough effect on travel behaviour patterns, to attain objectives for example, reduced CO<sup>2</sup> pollution, public transportation system use, energy use. Critics therefore warn against unquestioningly acceptance of assertions and call for more research.

4.11.8.3 Breheny et. al. (1994) argues however that "...none of the contradictions of compact city deny that the proposal has merit. What they do suggest is that the issue is complex and needs careful analysis and extensive debate."(pg.166 Breheny et. al. 1994). The majority of the critics identify that the NTD proposals do have merits, but warn against accepting all of the assertions without more research. The critics argue that there is still a continuing need for more study on the influence of NTD initiatives have on travel behaviour and the community.

#### 4.11.9 Community Acceptance of These Designs

4.11.9.1 While land use initiatives claim to be beneficial to improving urban environment, concern has been expressed by some critics on whether the land use and design changes for example, increasing the population density or increasing the land use mix, will be acceptable to the community and whether this is what the community desires. The main dissatisfaction of NTD, stems from proposed increases in residential density in urban areas. Audirac, Sherman and Smith (1990) argue that people prefer low densities and are willing to commute in order to live in lower densities. Knack (1991) states that:

"...forget all you've heard about neo-traditionalism and other innovations in cluster development. Out in the suburbs the lot size is not shrinking. One acre is still the US dream ...yet adds...that with resistance to increasing densities exists, increasing land costs provide incentives to fitting larger houses into smaller lots." (pg. 26 Knack 1991 in Handy 1995).

4.11.9.2 This trend is argued to occur within Australasia. Stretton (1994) states that space is of prime importance to Australians and that an increase in density will not be the solution for transportation problems in Australian cities. Stretton identified that space is often

more important to Australians than reduced commuting times. Stretton states that Australians have a quarter of the population density of European cities but have four times more urban space per head, with only 18% more travel time and 64% more travel mileage than the Europeans. Stretton believes that this is a relatively small increase in travel to have additional space. Stretton states that less compact cities will produce more public and private space to residents in Australian cities. It is noted that while Japan has five times the population density of Australia, research into recreational and garden space shows that the majority of Sydney households (75%) have a garden (or some form of garden) compared to a 35% figure for Japanese households. Stretton also found that more recreational space was available to those in less compact Australian cities than in more compact ones such as Tokyo. Tokyo has 260 public recreation sites per million people compared to 2040 sites in Sydney. The land prices are also ten times higher in Japan than in Australia. Stretton argues that if compact city policies are adopted "...rich and middle classes will hang on to their houses and gardens, and it will mostly be the poorest households who lose their private space."(pg.132 Stretton 1994). Troy (1995) supports this criticism on equity grounds, stating that higher income people will always be able to buy more space to live in, while lower income people will get less housing for their money in compact communities. Stretton therefore argues against adopting 'compact city' policies on the grounds that both New Zealand and Australian cities distribute space more equally than the 'compact cities' of Asia.

4.11.9.3 Stretton argues that shares of space matter as much as shares of access. It is noted that, people will tend to live where they can afford. Stretton argues that with increased density Australians and New Zealanders will have less recreation space and outdoor space. Stretton refers to research undertaken by Australian Institute of Family Services which found that people's experiences vary with their tastes and circumstances. The research found that a large majority of households are happy with where they live and how they live there, and specifically prefer their suburban locations and houses to more dense housing or inner city location. The study also revealed that many surveyed had a strong sense of neighbourhood and neighbourhoodliness and that this was highly valued. However, Neuman (1991) refers to a state wide survey, using real estate estimates and leisure activity patterns conducted in New Jersey in the United States (the most densely populated state). The results of this work found that traditional communities and their physical form are

prized by people within the New Jersey state. Neuman concluded that most people prefer to live in a small town or an older suburb, than in a new suburb or rural area. Cervero and Bosselman (1993) argue that in order for higher densities to be accepted in western cities, there is the need to incorporate more amenities i.e. public open space, quality designs and architecture. Studies also show that perceived densities can be increased by including treatments such as variation in building heights, roof lines, materials and textures or adding rear-lot and in-law units (Cervero and Bosselman 1993 in Cervero and Gorham 1995).

4.11.9.4 Another criticism of increased density is that it will increase crime in an area. Studies of crime rates in different US cities were compared using violent and property crimes. The results showed that cities with higher densities like New York had lower crime rates than low density cities like Los Angeles and Houston and Detroit (Newman and Kenworthy 1991). Increased levels of residential density produces much debate about the possibility of unfair allocation of space, perceived increases in crime, whether the increased density will be accepted by society if the standard and quality of designs is high. Therefore the rationale for adopting this policy must cover all the issues related to implementation.

#### 4.11.10 Neo-Traditional Developments / New Urbanism - Is It Physical Determination?

4.11.10.1 The question of whether planners should use NTD and New Urbanism approaches has been debated by many researchers in light of its proposed effects on the environment, economy and society. Audirac, Sherman 1991 assert that "...a physical deterministic and autocratic designer knows best attitude, pervades these urban design manifests ...their social claims are as tenuous as those of the tenets of the modern movement which they so vociferously denounce, shape environment - shape behaviour." (Handy 1992). This leads to whether or not urban structures should be manipulated to reach desirable transport outcomes. Brunton (1994) states "It could be argued that it is more important to manipulate transportation structures to reach a desired urban outcome." (pg.12 Brunton 1996). This view is supported to a degree by land use and location economic theory, which suggests that in providing for the automobile or for that matter rail this will influence urban form patterns. Other critics state that "Economists often argue that proper planning - such as congestion fees and parking surcharges - would eliminate the need for public interventions into land

markets, making New Urbanism, Transit Orientated Design, and jobs - housing balance passé”(Handy 1992). In contrast to this line of argument, Newman and Kenworthy argue that the current provision of roading and freeways and resulting sprawl is already a form of physical determinism. They state “...it is acceptable for a freeway’s higher accessibility to have a direct effect on the form of development ....rains ability to help concentrate development through its high accessibility qualities seems to be categorically denied and dismissed as physical determinism.” (pg.354 Newman and Kenworthy 1992). Newman and Kenworthy’s view poses the question to where does the line of physical determinism begin and end.

#### 4.11.11 Context Specific Solutions - Not Universal Schemes

4.11.11.1 An issue raised by some critics is the universal implementation of these NTD and New Urbanism solutions to deal with complex urban sustainability issues. They argue for proposals to be tailored to each community. Kaplan (1990) states that “The best plans ....emerge from a communities ecology, history, economy and culture”. (pg.10 Kaplan 1990). Leary (1991) further argues that “...it is better to build incrementally on what exists to create new towns in the image and spirit of the old, using the natural and already built environment and the public and private investment already there rather than creating completely new towns that simply resemble old.”(Leary 1991 in Handy 1992). The critics suggest wisely that the adoption of NTD and New Urbanism initiatives may not be appropriate in all situations and that solutions which fit within the context of the area are more likely to provide desirable results.

#### 4.11.12 Neo Traditional Development and New Urbanism Initiatives May Not Be Feasible

4.11.12.1 The changes suggested in NTD and New Urbanism proposals may take a long time to change within the existing fabric. Giuliano (1995) makes the following comment:

“Land use initiatives as an approach to demand management on the grounds that automobility in developed countries is already so pervasive, settlement patterns so well established, and preference for low-density living so ingrained that attempting to shape travel through physical planning is doomed to fail.” (pg.55 Cervero 1996).

- 4.11.12.2 Increased residential density levels within the existing urban fabric may be difficult to implement. Stretton (1994) noted for example, that proposals to increase density may not achieve a real increase in residential density for the reason that "...most of the market infilling is replacing a big house which housed five people with three small ones each housing one or two: scarcely any of the new small unites are actually increasing population density." (pg.131 Stretton 1994).
- 4.11.12.3 There is also costs involved with increasing residential density which need to be weighed against the cost of using greenfield sites to house new residents. Stretton argues that the cost of new suburban services should be considered along with the cost of connecting not one but some hundreds of thousands of new customers to the old existing urban services. Stretton notes that the cost of demolition, of expanding services in built up areas, replacement costs and overcrowding in recreational spaces places pressure on existing infrastructure and old urban services. It is noted therefore that a substantial increase in density may require some demolition and replacement as well as infilling. Stretton states that in literal terms authorities "...won't compulsory acquire occupied houses or their backyards for denser development. They won't ration internal space, as has sometimes been done in war time, by requiring small households with big houses to take on boarders or get out."(pg.133 Stretton 1994). Stretton (1994) argues that increases in residential density requiring the removal of private and public space available in less dense cities is easier than recovering public and private recreation space in more denser cities. Stretton states that "Sydney could fill its parks and playing fields and school grounds with housing more quickly and cheaply, with less demolition and replacement, than it would take to insert Sydney's public spaces into Tokyo's built-up fabric."(pg.133 Stretton 1994). It is noted that both Australian and New Zealand cities could intensify housing more readily than cities such as Tokyo could provide its residents with gardens. This however would remove valuable space that Australian and New Zealand cities already have and that Japan would find difficult to recover (if desired).
- 4.11.12.4 Critics of NTD and New Urbanism state that plans to change the current land uses within an area will encounter technical difficulties in over-hauling traditional zoning practices and that design codes would be required to implement these changes. Critics further claim that Neo Traditional Development and New Urbanism initiatives for example, increases in density, mixing of land use and a more connective street pattern

and could only be implemented within new suburban areas as existing patterns are already set. They assert that a mix of land uses could only occur in some situations whereby the commercial and industrial activities do not produce adverse effects (for example, discharges to noise and air) which are out of character with the normal activities of a residential area. Areas within the city may also be more sensitive to changes in activity levels and would not be able to withstand an increase in commercial or industrial activity. Neo traditional and New Urbanism plans are therefore identified by their critics as being 'easily proposed but difficult in reality to implement'.

#### 4.11.13 Summary

4.11.13.1 By studying existing built areas with Neo-Traditional and New Urbanism characteristics, researchers have been able to conclude with varying degrees of accuracy the influence urban form has travel behaviour. The advocates of NTD and New Urbanism claim that these approaches have a positive influence on urban sustainability levels for example, by reducing energy use and emission levels and encouraging more sustainable urban land use patterns. While not specifically measured, advocates of NTD and New Urbanism approaches also claim that these designs are able to create a greater sense of community and community spirit into urban areas. Neo Traditional Development and New Urbanism proposals have been criticised on a number of points relating to the actual research undertaken and the impact on the urban environment if the NTD changes were made. This field of research remains relatively new. Without time to develop and test NTD and New Urbanism claims, it is difficult to determine in absolute terms the advantages and disadvantages of adopting NTD and New Urbanism approaches. The critics make valid points about the acceptability to the public, the application, and implementation of the schemes in practice. It would be hard to disagree that there is a considerable need for more research into NTD and New Urbanism initiatives to provide more support for or against their implementation.

#### 4.12 SOCIO-DEMOGRAPHICS CHARACTERISTICS OF THE POPULATION AND TRAVEL BEHAVIOUR

- 4.12.1 The socio-demographics characteristics of a population is claimed to affect the travel patterns of an urban area. It is argued that individuals make travel choices based in there current situation in life, not just as a result of their physical environment. The characteristics of individuals and their household is therefore seen as a contributing factor in the travel choice. Every individual in the population has a number of different social and economic characteristics which can be grouped based on a specific selection criteria with other individuals exhibiting similar characteristics to produce differing lifestyle, life cycle and household groups. The next section of this thesis examines the current research on the socio-demographic characteristics and travel behaviour.
- 4.12.2 Major changes are occurring in the structure of society that are likely to effect the demand for travel in the next century. It is argued that socio-demographic change is part of process that will influence travel patterns along with technological advances and changes to infrastructure provision. New Zealand is predicted to have a number of significant changes in its social demographic structure which will impact on travel patterns for example, more elderly, more women in the workforce, more one parent households etc. Research on the current travel behaviour of particular groups in society will provide information to decision makers on the current and future transport demands.
- 4.12.3 The literature review so far has noted that urban travel issues, such as congestion, are not a problem in themselves, but merely a symptom. It has been identified that is our widely shared values and aspirations as New Zealanders to have a quarter acre section, two cars and homes separated from work that has increased New Zealand's urban transport problems. If societal acceptance and values is the root of the urban transport problem, then obviously a fundamental solution to the issue of congestion cannot be reached without addressing the question regarding our socio-demographic condition. Information on the socio-demographic characteristics of Auckland's population is necessary to address the extent to which travel behaviour may be attributed to urban form.

#### 4.13 URBAN FORM AND SOCIO-DEMOGRAPHIC CHARACTERISTICS WITH TRAVEL BEHAVIOUR

4.13.1 The research discussed to this point, primarily examines the influence urban form exerts on travel behaviour with some consideration of demographic and household characteristics (Kockleman 1995, Handy 1995, Cervero and Gorham 1995). However this is usually included to provide information about the population that resides in the studied area. The research does not specifically examine to what extent these socio-demographic characteristics exerts influence on travel behaviour. The research undertaken by Kitamura et. al. (1988), Handy (1992) and Hanson (1982) examines whether urban form factors directly influence travel behaviour or whether the socio-demographic characteristics of the studied area contribute to this association.

4.13.2 Kitamura et. al. (1988) conducted research on the question "Is the observed association between travel and land use real or is it an artifact of the association between land use and the multitude of demographic, socio-economic and transportation supply characteristics which also are associated with travel?"(pg.151 Kitamura et.al. 1988). The research examined five communities in the San Francisco Bay area in the United States. The data collected for this research, represented a wide range of land use densities and mixes of land uses but the five communities had relatively uniform incomes and had access to rail transit. Information about personal and household travel characteristics and attitudes towards urban form were collected using three day trip dairies and questionnaires. Data on all types of trips was collected and analysed at the individual level using multivariate analysis. The urban form descriptors in the estimated models included: "...area wide dummy variables for neighbourhood area, dummy variables for transit access, mixed land use, high density, sidewalks, bike paths; household dummy variables for presence of backyard, parking spaces, home ownership; distances to the nearest bus stop, rail station, grocery store, gas station and park; and dummy variables for various perceptions of neighbourhood quality."(pg.11 Handy 1995). Kitamura et. al. included and examined a wide range of socio-economic descriptors. Linear regression was then used to estimate the "...number of person trips, number of transit trips and non-motorised trips and fractions of auto trips, transit types and non-motorised trips." for each of the five communities (Kitamura 1988 et. al. in Handy 1995).

- 4.13.3 The research included an attitudinal survey containing 39 questions. Factor analysis was used to group these responses into eight attitudinal factors and then introduced into the estimated models. The factors were found to be strongly associated with the travel characteristics, in particular, the attitudinal factors were found to have a greater influence on travel behaviour than the neighbourhood descriptors, suggesting that urban form alone may not be able to change current travel behaviour patterns, but rather current attitudes may have been changed (Kitamura et. al. 1988 in Handy 1995).
- 4.13.4 Hanson (1982) conducted research in Uppsala, Sweden, to test the importance of urban form characteristics compared to socio-economic characteristics on travel distance and trip frequency. The study identified 51 possible dependent variables that represented different facets of travel behaviour. These were windowed down to seven factors, using principal component analysis, and the highest loading variables for each factor were used in the analysis. Location variables were defined for one kilometre increments from home, and included the number of establishments, land use types, percentage of all food stores within each increment. Again a similar windowing process was used to reduce the 21 variables to only two factors that represented 'near from home' 0.5 to 2.0 kilometers and 'far from home' 2.0-5.0 kilometers from home. The data was analysed using a "step-wise regression procedure to estimate equations for trip frequency by purpose and for trip distance, forcing the spatial factors into the equation and then testing for the significance of socio-demographic factors."(pg.19 Handy 1995). Hanson showed that "socio-demographic descriptors explain more variation than do the spatial descriptors, which, in most of the equations, account for a very small proportion of total variance." (p.g. 8 Hanson 1982 in Handy 1995). Urban form variables were found to have only a minor impact on trip generation, travel frequency however the variables were positively related to high densities of opportunities near to home (because walking trips include in total number of trips) particularly for shopping trips. Hanson did find that the spatial variables used were on the other hand "...extremely important in explaining average distance between home and destinations."(pg.19 Hanson 1982 in Handy 1995). Overall the study found that the higher density of opportunity results in the less total travel made, with the exception of social and recreational travel (which is not affected by density of opportunity).

- 4.13.5 The results of these two studies suggest that the socio-demographic characteristics of the population are of importance in explaining travel patterns. Therefore the inclusion of socio-demographics in research needs to be included to determine more clearly how travel behaviour is influenced.
- 4.13.6 Handy (1992) conducted research in the San Francisco Bay area to (i) test the link between urban form and travel behaviour and then (ii) test the importance of urban form factors in comparison to socio-economic factors on travel behaviour. The neighbourhoods were selected according to defined types of urban form characteristics for example, age of development as Pre World War II or Post World War II. Handy conducted a travel behaviour survey collecting data primarily on non-work trips for example, grocery shopping trips, trips to regional shopping malls and other local non-work trips. Data on socio-economic characteristics were also collected and found to be relatively consistent across the board. The urban form data collected was characterised both quantitatively and qualitatively and measures of accessibility to supermarkets and other commercial activities were included into the research. Analysis of variance techniques were used to test the significance of variances in urban form on a variety of travel characteristics including, frequency, average trip distance, mode split for supermarket trips and regional mall trips and for frequency of walking trips. Handy found that residents from town areas that most closely resembled Neo Traditional proposals made two-to-four more walking and cycling trips per week to retail stores than did those living in nearby areas that were served by an auto-orientated strip retail establishment. Handy was however unable to determine whether these trips replaced or were in addition to driving trips. The results suggested that for most travel characteristics the variances between neighbourhoods was significantly greater than the variation within the neighbourhoods (Handy 1995).
- 4.13.7 To test the importance of urban form factors in comparison to socio-demographic factors on travel behaviour, four household types were defined. Multivariate analysis of variance techniques was used to test between versus within group for both household types and neighbourhood. The results showed that for most travel characteristics the variation between versus within the group was greater for neighbourhoods than for the four household types. "Linear regression techniques were estimated for a number of travel characteristics as dependent variables, incorporating measures of accessibility and socio-economic variables as explanatory variables."

(pg.20 Handy 1995). The results of the regressions suggested that other factors than those measured influence travel choice.

#### 4.14 SOCIO-DEMOGRAPHIC INFLUENCE ON TRAVEL BEHAVIOUR

4.14.1 The next section of the literature review deals with the influence of socio-demographics characteristics of the population on travel patterns. Socio-demographic characteristics can be defined in a number of ways. A population can be grouped according to age, gender, employment, income and by many other characteristics. The activity approach to analysing travel behaviour, groups a population according to daily activities which can be expressed for example, as lifestyle, life cycle or the role an individual in a household unit. Some examples of researchers using his approach is outlined in the next section of this Literature Review.

##### 4.14.2 Activity - Based Analysis of Travel Behaviour

4.14.2.1 Activity based analysis has developed over the past twenty years after widespread dissatisfaction with trip based travel-demand models (Vadarevu and Stopher 1996). Traditional travel demand modeling deals with travel in terms of individual trips, where trips are primarily movement between origin and destination by a particular mode, along a route for a selected purpose. The 'Travel Demand' paradigm suggests that each trip is an entity in itself which is governed by the purpose, origin, destination, mode and route taken and therefore has been described as an oversimplification of an complex phenomenon (Stopher and Lee-Gosselen 1996). Most of the research discussed to this point in the literature review has been conducted in this way. Stopher and Lee-Gosselen (1996) describe this as not dealing adequately "...with the derived demand nature of daily travel, nor ...with interdependencies between trips and between people that are the inherent travel choices that people make." (Stopher and Lee-Gosselen 1996). An Activity-Based approach examines travel "...in the context of the activities that generate the demand for travel." (pg.55 Stopher, Lee-Gosselen 1996). While the research discussed so far does include some socio-demographic characteristics as explanatory variables, these are generally characterised by "...segmenting the population on the basis of one or more socio-demographic characteristics, and then used as ...proxies to capture the underlying differences in the population including, attitudes, perceptions, tastes and orientations."

(pg.15 Pas and Principio 1996). The Activity Based approach is thought to have a more exploratory methodology and therefore examines travel behaviour in its wider context of daily patterns of behaviour (Handy 1995). Harvey and Pas (1996), in Stopher and Lee-Gosselen (1996) has identified five common themes that recur in research conducted on the activity based approach.

- “analysis of the demand for activity participation (and the analysis of travel as a derived demand;
- the scheduling of activities in home and space;
- the constraints (spacio-temporal and interpersonal) on activity and travel choice;
- the interactions between activity and travel decisions over the course of a day as well as the interactions, between different persons;
- the structure of the households and the roles played by the various household members.” (pg.59 Harvey and Pas 1996 in Stopher and Lee-Gosselen 1996).

4.14.2.2 The Activity-Based approach integrates a variety of socio-economic characteristics into the analysis often by organising these into defined ‘roles’ or ‘lifestyles’ or ‘life cycle’ stages. Kitamura et. al. (1998) states that there are many definitions of life style; but one common theme in these definitions is the notion of lifestyle in association with behavioural patterns. The lifestyle approach is useful in that it “...offers a conceptual framework as it relates to the individuals values or orientation, which is especially the case in the analysis of adaptation behaviour.”(pg.166 Kitamura et. al. 1988). Research on lifestyle and travel behaviour has often been difficult to carry out as values and orientation are not measured in travel surveys and therefore requires demographic statistics on household characteristics i.e. household role of an individual, age, gender, employment to indicate the lifestyles within particular studied populations. Lifestyle analysis has however obvious value in that it offers guidelines in defining the dimensions of analysis; life-style offers a theoretical medium that links revealed behaviour and measurable characteristics of individuals. This is of value to the construction of an analytical framework for travel behaviour studies.

4.14.2.3 Principio and Pas (1996) aimed to examine the variations in socio-demographic and travel behaviour across lifestyle groups using time use data. Respondents were given a travel diary to record in-home and out-of-home activities and any travel used to reach

an activity over a two day period. The sample chosen for analysis consisted of a stratified (by residential density), random, and an enriched sample (designed to give information about public transit use). While the concept of lifestyle aimed at capturing individual behaviour it was found that the travel behaviour of the household unit was the more appropriate unit of analysis. Principio and Pas (1996) viewed the household as a single-decision making unit particularly in terms of lifestyle choices for example, the number of workers required to financially support the household, the number of vehicles needed and the location of the house. Cluster analysis was used to examine variations in socio-demographics to determine different sub-groups that had similar behavioural patterns. The variations in socio-demographics and travel behaviour were examined across these lifestyle groups in two phases. The first phase was to examine "...mean time use patterns in each cluster and variations in time use across the clusters." This involved examining the variations in socio-demographics and travel behaviour pattern across the identified clusters."(pg.25 Pas and Principio 1996). The second phase used analysis of variance to confirm these observations of time use, socio-demographics travel behaviour across the clusters. The results identified seven major lifestyle groups and corresponding travel behaviour of these groups. A summary of the findings of this research is summarised in Table 7 below:

Table 7: Lifestyle Groups and Corresponding Travel Behaviour

Lifestyle Groups	Socio-Demographic Characteristics	Travel Behaviour Characteristics
Workaholics	<ul style="list-style-type: none"> <li>• Adults spend on average 85% of activity classified as work therefore spend most of time on work related activities;</li> <li>• Above average children in the households;</li> <li>• Highest number of full time workers, lowest retired numbers.</li> <li>• Highest % above average number of Vehicles</li> </ul>	<ul style="list-style-type: none"> <li>• Fewer trips and tours than average (due to working people coordinating trips more efficiently - high level of trips per tour);</li> <li>• Heaviest reliance on private vehicle (94% trips made)</li> <li>• Walk / cycle 4.2%, buses 0.8% other 1%</li> </ul>
Active Workers	<ul style="list-style-type: none"> <li>• Group spends a great deal of time at work (63.1%), remainder of time spread over other activities for example, social and recreational activities;</li> <li>• Largest group identified in the sample;</li> <li>• similar demographics and employment to workaholics.</li> </ul>	<ul style="list-style-type: none"> <li>• High number of trips and tours - highest level of travel for two day period;</li> <li>• Extremely efficient in linking trips 3.12 trips per tour;</li> <li>• Rely mostly on private vehicle for mobility;</li> <li>• Use buses 2% walk and cycle 5.4% and other 0.6%.</li> </ul>

Socializers	<ul style="list-style-type: none"> <li>• Most social lifestyle group, members spend on average 59.6% of their time socialising;</li> <li>• Their participation in maintenance and recreation activities is near average for the sample, devoting less time to work and school activities;</li> <li>• Below average numbers of workers - above average retired household members;</li> <li>• Income below average;</li> <li>• Households smaller than sample average - very few children.</li> </ul>	<ul style="list-style-type: none"> <li>• Least number of trips and tours;</li> <li>• Heavily relies on private vehicle (average 1.95 vehicles per household).</li> </ul>
Leisure Enthusiasts	<ul style="list-style-type: none"> <li>• 57.3% of time spent on recreational activities participate minimally in work and school activities, likely that this group has retired persons;</li> <li>• An average of one retired person per household - very few workers;</li> <li>• Very small households - very few children;</li> <li>• Income slightly below average;</li> <li>• Least number of vehicles.</li> </ul>	<ul style="list-style-type: none"> <li>• Make very few trips;</li> <li>• Spend least amount of time travelling;</li> <li>• Rarely link trips as indicated by the low level of trips per tour.</li> </ul>
Domestic Caretakers	<ul style="list-style-type: none"> <li>• Smallest group of the sample;</li> <li>• 81.4% time spent on maintenance activities generally they do not participate in school or work;</li> <li>• The pattern of time use seems to indicate retired persons in these households - the largest number of elderly in sample;</li> <li>• Mostly adults and few or no children;</li> <li>• No time spent on subsistence activities;</li> <li>• Low number of vehicles.</li> </ul>	<ul style="list-style-type: none"> <li>• Number of trips and tours far below average for sample;</li> <li>• Average trip length is shorter;</li> <li>• Utilises car and physical modes to average extent - use bus more frequently than most.</li> </ul>
Diverse Participants	<ul style="list-style-type: none"> <li>• Wide variety of activities;</li> <li>• High proportion of maintenance and recreational activities;</li> <li>• Largest household average of 1.94 adults 0.75 children;</li> <li>• Household average one full time worker per household;</li> <li>• Very high incomes - two vehicles per household average.</li> </ul>	<ul style="list-style-type: none"> <li>• Highest car mode of all group and makes most trips;</li> <li>• Highest trip frequency.</li> </ul>
Scholars	<ul style="list-style-type: none"> <li>• Highest proportion of time pursuing academic endeavors;</li> <li>• Most likely to be students;</li> <li>• Slightly more than two people - per household very few children;</li> <li>• Average 1.4 workers per household;</li> <li>• Lowest income group and vehicles owned.</li> </ul>	<ul style="list-style-type: none"> <li>• Rely private vehicles less and use bus and walk and cycle means more.</li> </ul>

#### 4.14.3 Life-Style Based Analysis of Travel Behaviour

4.14.3.1 Kitamura et.al (1988) has also studied the influence lifestyle has on travel demand patterns. Kitamura et. al. (1988) states that the concept of lifestyle is important to travel behaviour because the automobile, the dominant mode of urban travel today, is basic to lifestyle. Kitamura et. al. cites Flink (1987) that patterns of “courtship, residence, socialization of children, education, work habits, and use of leisure time were radically altered by the adoption of the automobile.” Kitamura’s life-style concept as revealed in consumer expenditure and travel patterns are discussed in terms of life-cycle stage, age, employment, gender, income, car ownership, and license holding. Many of these parameters have been theorized to have either a primary association with the individual’s or household’s life-style as causal factors that condition and constrain life-style, as factors that determine or reflect roles (gender, employment, and life-cycle stages) or as the outcome of conscious life-style choices (e.g. employment status, presence of children, car ownership and license holding). The data for this research was collected from Consumer Expenditure Survey: Bulletin 2245 Dairy Survey 1982-1983, Consumer Expenditure Survey, and Bulletin 2246 Interview Survey 1982-1983, Bureau of Labour Statistics, US Department of Labour. The main findings of Kitamura’s life-style research are summarised in Table 8 below:

Table 8: Lifestyle Variables and Corresponding Travel Behaviour

Life-Style Variable	Expenditure Pattern by Socio-Demographic Groups	Resultant Travel Behaviour Patterns
Income (Household income per year grouped into income quintiles)	<ul style="list-style-type: none"> <li>Income has a predominant impact on household expenditure.</li> <li>Past research shows that income is not a primary determinant of trip generation. The apparent lack of significance of income is presumably due to the fact that car ownership, which is strongly correlated with income, is more directly associated with travel behaviour than is income. Being the consequence of a long-term household mobility decision, household car ownership reflects a certain type of life-style which one cannot measure with existing household interview data.</li> </ul>	<ul style="list-style-type: none"> <li>Relative expenditures on transport exhibit weak correlations with income, except for very low expenditure by the lowest income group. In terms of absolute amount of expenditure, the highest income group spent three times as much on transport as did the lowest group.</li> <li>The relative share of expenditure on gasoline shows a weak association with income. The absolute amount of expenditure, however ranges across income groups.</li> <li>Higher income households tend to own more vehicles and use each of these automobiles slightly more extensively than do low income households.</li> <li>These findings are consistent with well accepted finding that travel budgets and vehicle use increase</li> </ul>

	<ul style="list-style-type: none"> <li>• Kitamura et. al. discusses however that car ownership merely reflects a household's propensity to travel.</li> </ul>	<p>with income.</p> <ul style="list-style-type: none"> <li>• Studies show that higher income is associated with higher person-trip rates, more vehicular trips, more social trips, increased work-trip length and more frequent multi-stop trip chains.</li> </ul>
Age	<ul style="list-style-type: none"> <li>• Household income and expenditure peaks when the household member is between 45 to 54 years old.</li> <li>• Expenditures on food, transportation, gasoline, personal insurance and pensions have a similar peak, whereas housing and entertainment expenditures peak at 35 to 44 years.</li> <li>• The youngest group (less than 25 years) and the oldest group (65 and over) have simulate total expenditure levels, but their budget allocations are different. Younger spend more on eating out, alcohol, transportation, and entertainment. Health care, alcohol, apparel expenditures decrease with age.</li> <li>• Elderly - Fastest growing groups in the United States, by year 200 predicted to make 13% of the population</li> </ul>	<ul style="list-style-type: none"> <li>• Mobility peaks in the thirties and forties and that the elderly are the least mobile.</li> <li>• Expenditure on public transport peaks in the 55 to 64 years age group.</li> <li>• Lower trips rates experience among retired individuals - partly due to absence of work trips.</li> </ul>
Gender and Employment Status	<ul style="list-style-type: none"> <li>• Women spend more time than working men on household care.</li> <li>• Married women spend less time on household care than their non working counterparts, but they spend more time on this activity than do single working women.</li> <li>• The time spent on household care increases with the number of children, so women with preschool children spend the least amount of time out of home and on travel.</li> <li>• Increasing labour force participation by women is evident.</li> <li>• Increasing work-trip rate of women from households with preschool or school age children.</li> <li>• Women work fewer hours than employed men;</li> <li>• The demand for housework and child care leads to less leisure time available to women.</li> <li>• Employed men have more free time on weekdays.</li> </ul>	<ul style="list-style-type: none"> <li>• Women make less trips than men even when employment status is accounted for.</li> <li>• Women less mobile and more transit dependent.</li> <li>• Single men are more mobile then single women, higher frequency of entertainment trips and return home trips.</li> <li>• Women trips are shorter compared to men's.</li> <li>• Women's travel-time expenditures tend to be less and they tend to be passengers rather than drivers although this tendency varies with age.</li> <li>• Women in a two worker households use public transit, walk more and use the automobile less than men do. This tendency is not more pronounced among single parents suggesting that the woman's transit dependency is in part attributable to the situation whereby "the allocation of the first car appears to be to the husband and the second car to the wife."</li> <li>• Women have a higher shopping trip and personal business trip rate than men of similar life-cycle stages.</li> <li>• The highest percentage of shopping trips are associated with suburban homemakers, next by the urban employed homemakers;</li> </ul>

	<ul style="list-style-type: none"> <li>Leisure activity and visits friends are less frequent among female workers of two worker households.</li> </ul>	<ul style="list-style-type: none"> <li>Multi-day travel analysis show that women's travel patterns are more variable over time than those of men.</li> <li>Men spend more hours on work related activities and commuting than do employed women.</li> <li>The daily travel-activity patterns of adult males and females are differentially affected by the presence or absence of young children in the household, but maintains that the effect on employment supersedes this.</li> <li>Observed that the gender differences are very small among two worker households with pre-school children: in fact men in these households shop and pick up children slightly more frequently than do women.</li> </ul>
Social-Demographic Changes	<ul style="list-style-type: none"> <li>sharp decline in average size of households, increasing single person households, an increase in the proportion of non-family households and single-parent households.</li> <li>Dramatic increases in number of suburban households, and slow increased in central city households of smaller sizes;</li> <li>% of married couples with children is gradually declining, that of married couples without children remains stable, and the fraction of individuals living alone steadily has been increasing.</li> <li>The labour-force participation by women has been increasing, resulting in an increasing proportion of two-worker households with young children.</li> </ul>	<p>These social-demographic changes have resulted in increases in:</p> <ul style="list-style-type: none"> <li>the number of work trips because of an increase in working women;</li> <li>the number of person trips because of an increase in young, single individuals;</li> <li>the number of social-recreation trips because of an increase in single individuals and young couples without children; and</li> <li>the number of person trips and total travel times expenditure by women because of an increase in the number of two-worker households.</li> </ul> <p>Likewise there is likely to be a decrease in:</p> <ul style="list-style-type: none"> <li>the number of person trips and number of serve passenger trips by married women in both one-worker and two-worker households because of a decreasing number of households with children;</li> <li>the number of shopping trips by women from one-worker households because of the decreasing number of one-worker households with children; and</li> <li>mobility because of the increased number of households consisting of older individuals.</li> </ul>

#### 4.14.4 Life Cycle Analysis of Travel Behaviour

4.14.4.1 The 'life cycle' concept is used in transportation planning studies to determine travel behaviour. Life cycle stages are often characterised in terms of marital status of adults, presence and age of children in a household. The life cycle concept has been

described as "...a convenient base for empirical analysis - a composite variable combining imperfectly, but adequately, many of the major sources of variation among households."(pg.154 Kitamura et. al. 1988). The presence or absence of children in a household is a key variable for defining life cycle stage because it "...impose highly complex and binding constraints on the activities and travel patterns of all other members of the households."(pg.154 Kitamura et. al. 1988). The marital status of the individual adults in a household is another important variable in evaluating travel behaviour because of the roles created in married or cohabitation arrangements. Therefore life cycle stage "...defines an axis for travel behaviour because of its association with various roles that a household and its members play."(pg.155 Kitamura et. al. 1988). Kitamura et. al. has undertaken studies on the influence of life cycle stages have on travel behaviour. The life cycle groups defined by Kitamura et. al. are based on the presence and absence of children and the marital status of the adults in the population. The results of this research provide information about the socio-demographics of each life cycle group and the resulting travel behaviour characteristics. The results of Kitamura's research are summarised in the Table 9 below:

Table 9: Life Cycle Analysis of Travel Behaviour

Life cycle Group	Socio-Demographic Characteristics	Travel Behaviour Characteristics
Households with Children	<ul style="list-style-type: none"> <li>• Travel expectations increase towards last stage of child rearing;</li> <li>• Mean car ownership and gasoline expenditure per person peaks at households with older children 18 years and over;</li> <li>• Income on food, apparel, personal care reading and education all increases;</li> <li>• Housing expenditures greatest when oldest child is less than six years;</li> <li>• Entertainment expenditure highest when children at ages six-seventeen - shows that children need entertainment.</li> </ul>	<ul style="list-style-type: none"> <li>• Presence of preschool children 'strong inhibiting' effect on adults travel behaviour;</li> <li>• School age households have highest per person trip rates, partly to do with size of the households;</li> <li>• Households with children have lower work trip rate - overall have higher total trip rates and non-work trip rates;</li> <li>• Households where wife is employed certain activities transferred to husband;</li> <li>• No significant chance takes place in total trips or total non-work trips made by husband and wife when children are present;</li> <li>• The results indicate that the presence of children has little effect on transportation of the husband and wife in the household. The travel by the children however significantly increases total household travel.</li> </ul>
Single Individuals	<ul style="list-style-type: none"> <li>• Households without children have large per - person expenditures on eating out, alcohol beverages, outward orientation of lifestyle;</li> </ul>	<ul style="list-style-type: none"> <li>• Generally more mobile than married individuals of same age group;</li> <li>• Greater leisure activities duration and rate than</li> </ul>

	<ul style="list-style-type: none"> <li>• Largest expenditure on non-private transportation;</li> <li>• Expenditure on own dwelling is the lowest;</li> <li>• Rented dwellings is second highest;</li> <li>• Average gasoline expenditure above highest, next to couples with children;</li> <li>• Distinction between young adults and older household not made</li> </ul>	<ul style="list-style-type: none"> <li>• married couples of same age - however similar person trip rates;</li> <li>• Over 45 age group decrease has lower trip rates than married individuals;</li> <li>• Older single non-working persons, have higher trip rates than married non-working individuals.</li> </ul>
Single Parents	<ul style="list-style-type: none"> <li>• Smallest income, expenditures on eating out, alcoholic beverages, new automobiles, health care and reading - show poor economic status of the sample;</li> <li>• Number of those renting is high;</li> <li>• Average personal recreation expenditure is low;</li> <li>• Relative share of food expenditures is highest among groups;</li> <li>• Smallest overall per person expenditure in gasoline and automobiles;</li> <li>• Single parent families tend to be in the workforce more than married women with children do - but the average income earned is below average;</li> <li>• Low rate of license holding among women, primary mode of transportation is public transport.</li> </ul>	<ul style="list-style-type: none"> <li>• Least mobility due to limited transportation resources;</li> <li>• However make significantly more trips than married individuals;</li> <li>• Travel patterns are not different from married counterparts however survey response was low for this section.</li> </ul>
Couples without Children	<ul style="list-style-type: none"> <li>• Husband and wife couples with no children;</li> <li>• Expenditures on eating out highest per person of all the sample - exceeding those with children, single persons, single parents;</li> <li>• Spend larger portions of income on new automobiles, those furnishing, personal care, reading and health care than do any other groups;</li> <li>• Large share of health care older couples past child rearing stage.</li> </ul>	<ul style="list-style-type: none"> <li>• Travel patterns not provided for this life style group within the research.</li> </ul>

4.14.4.2 Vadarevu and Stopher (1996) examined the impact of household activities, life cycle and role allocation have on travel behaviour by determining what activities the population sample participate in. The data used for this study was collected from the Boston Region Household - Based Travel Survey 1991. The sample was derived using a stratified random-sampling procedure. Stratification was done by geographic location, household size, and vehicle ownership. A travel diary survey was again used for this research, however this only covers a 24 hour period. The household unit was

used as the primary decision unit, where individuals carried out those decisions by engaging in activities. The research examined four hypotheses. The first hypothesis was that household activities can be subdivided into three main categories of activities; being mandatory (work, school, sleep, some medical), flexible (shopping, eating, banking, personal business, medical) and optional activities (social, recreation, school, eating out). These activities were tested against different life cycle groups. The results of first hypothesis showed that mandatory activities were participated in by all households, some households from each life cycle group engaged in flexible and optional activities, however generally the numbers engaging optional activities were significantly lower than for flexible activities.

4.14.4.3 The second hypothesis was that the life cycle stage of household affects decisions on the amount of time allocated to mandatory, flexible and optional activities. The life cycle groups were defined on the presence or absence of children, workers by the ages of those surveyed. The five life cycle groups that were defined are as follows:

- Single working adults (single person households which the person is employed);
- Multiple adults (without children and where at least one person is employed);
- Young families (one or more adults at least one of whom is working, having children none of whom is of school age);
- Older families (one or more adults at least one of which is employed and having at least one child of school age); and
- Non-working adults (at least one adult whom is employed and with no children present)

The life cycle groups were examined to measure the proportion of time spent in a day on mandatory, flexible and optional activities (Vadarevu and Stopher 1996).

4.14.4.4 Thirty random samples were selected from each life cycle group to test the hypothesis that there are significant differences in the mean time allocations and activities among life cycle groups. The test performed were first to test each activity through an ANOVA to determine if grouping by life cycle resulted in any statistically significant differences. The tests showed that most activities exhibited highly significant differences. The only activities that were not significant at 5% level of significance

were personal business, eating out and social activities. Shopping activities were found to be significant at 5% level, however these were not significant at the 1% level. Life cycle group was tested against the population mean from the 150 households used in the study. Then each life cycle group was tested pair wise against each other group. If the life cycle was found to be significantly different from population mean, this indicated that life cycle, as defined in the research, was an appropriate variable to use for research. Overall the results confirmed that the selected life cycle groups provided a way to differentiate households on basis of the amount of time allocated by households to the specific activities.

4.14.4.5 The third hypothesis was “...that life cycle stage effects the amount of time allocated by individuals of same gender and work status to individual activities.”(pg. 15 Vadarevu and Stopher 1996). This section of the research determined the amount of time allocated to activities by adult male or females as a proportion of the time spent by the households on a specific activity. This section, only considers households containing adults, younger families and older families (single working adults and non-working adults are not considered). The results showed that significant differences existed in the proportion of time allocated to flexible and optional activities between male and female adults. These differences also appeared for both households in with working and non-working adults and for households in which there are only working adults. The tests revealed that the working status of the different life cycle groups had does have an effect on the amount of time allocated to activities by the particular life cycle groups. The results showed that this was apparent for:

- Shopping activities - in all cases;
- Social and pick-up and drop-off activities - in some cases; and
- Personal services - for only the non-working adults group.

There are no significant differences for recreation activities. More tests revealed that there are generally no differences within a life cycle group between working men and non working women and between non-working men and non-working women.

4.14.4.6 The last hypothesis is that life cycle stage affects the amount of time allocated by individuals of the same gender and work status to individual activities. “Households were divided by working and non-working adults by gender and the mean time

allocations determined within work status and gender groups by life cycle.” Vadarevu and Stopher found that in “...households containing both working and non-working adults, non-working adults spent more time on shopping and personal business than working adults in all life cycle groups.” Females tended to spend more time shopping and personal time than males, while males spent more time in recreational activities than females.

4.14.4.7 This research identifies that individuals and households partake in different activities according to their life cycle status. It is noted that this in turn influences the demand for certain types of travel. It is therefore important to consider travel demand in terms of the ‘activities’ deriving this demand.

#### 4.14.5 Socio-Demographic Groups Analysis of Travel Behaviour

4.14.5.1 The social demographic characteristics of a population and their related transport needs has been the focus of research conducted by Morris, Richardson and McPherson (1996) and Dodds (1997).

4.14.5.2 Morris, Richardson and McPherson (1996) research, concentrates on the transport needs of the ‘majority’ of the population referring to the women, young and old within society. Morris, Richardson and McPherson (1996) identify in their research that the activity and travel patterns of these three groups are similar in that there is high level of interdependence with other people, whether from the same or different households. It is noted however that these three groups in themselves are quite diverse. The research firstly identifies that there is an increasing number of women in the workforce. It is noted that women are still however strongly influenced by the needs of the family. This is because of the gender role that women continue to perform in relation to raising children and keeping house. Morris, Richardson and McPherson note that the demands on women’s time imposed by other family members has increased rather than decreased. An example, is the increasing restrictions placed upon the independent mobility of children and the elderly, which has added to the responsibility of women as the principal carers in our society. Women therefore can have joint responsibilities to their children and their parents at the same time. This situation has occurred because many women have postponed childbearing in the pursuit of a career, while their older parents are living longer.

4.14.5.4 The research uses data from a variety of sources including, population census undertaken by the Australian Bureau of Statistics, and several special purpose travel and activity surveys in particular the Victorian Activity and Travel Survey. This survey records all travel by modes by all people. Each household provides this information for a specified travel day. The survey is continuous covering all 365 days of the year, thereby enabling temporal variations in activity patterns to be observed. The travel patterns of three groups are analysed for metropolitan Melbourne and the results of which are shown in Table 10 below.

Table 10: Socio-Demographic Groups and Travel Behaviour

Socio-Demographic Group	Travel Behaviour and Needs
<p>Women: Their roles in society have changed and so have their travel patterns.</p> <p>While traditional women as a group have been considered to be transport disadvantaged with lower levels of license holding, reduced car availability and lower personal incomes it is shown that this appears to be changing.</p>	<ul style="list-style-type: none"> <li>• While license holding among older women is still low the uptake of drivers license among young women in contemporary urban Australia is almost as great as it is for young men.</li> <li>• The number of households in Melbourne owning two or more cars now outstrips the number of households with only one car, although some 12% of Melbourne households have no car.</li> <li>• the number of vehicles per household shows a strong positive relationship with the number of workers over household;</li> <li>• Marked growth of female participation in the workforce is reflected in significantly increased personal incomes for women;</li> <li>• women of working age undertake a significantly greater proportion of their total travel as car passengers, even among younger women in the working age bracket. This applies particularly on weekends but is also apparent on weekdays. Australian Bureau of Statistics 1991 show that women are over-represented as car passengers without exception across all regions of Melbourne raising questions about allocation of transport resources within households.</li> <li>• Concerns over personal safety and security has been assumed to be a factor which is of particular importance to women - in that it affects their use of public transport at night. Qualitative information collected suggests that fear is an important determinant of travel behaviour for women. Fear was found to underlie women's unwillingness to travel on public transport at night as well as an expressed nervousness by some women about driving alone at night.</li> <li>• Women tend to concentrate travel in the daytime hours between 8 a.m and 4 p.m., with over half of all trips at this time being made by women. After 5 PM, less than half of the travellers are women. During the morning period nearly 60% of all travellers are women, with a similar figure early afternoon peak between 4 and 5 p.m. They suggest that this concentration of travel by women into daylight hours may be related only partly to a fear of travelling alone at night. But a more significant factor, is the role that women continue to perform in household management and looking after children demonstrated by fact that women take more trips during peak periods, with proportionately more shopping trips and more chauffeuring trips (approximately 70% made by women during day only 40% at</li> </ul>

	<p>night) during the daytime.</p> <ul style="list-style-type: none"> <li>• Men and women participate equally throughout the day in social and recreational travel Overall women undertake relatively less travel at night because they have more need to go out during the day and less need to go out at night.</li> <li>• The gender based variations are consistent broadly across the socio-economic spectrum. Irrespective of field of employment, women who work part time make more trips overall than their male counterparts</li> </ul>
<p>Children :</p> <p>Young children travel needs can influence the timing and modes for travel and the level of independent trip making by parents.</p>	<ul style="list-style-type: none"> <li>• Younger children have few independent travel needs - majority of these journeys are made as car passengers with remainder by foot.</li> <li>• Once at school children are more active participants in travel - primary age still accompanied by parents - high school greater independence.</li> <li>• Fewer than 10% of all trips made by children of primary school age were independent of other household members, whereas some 25% of trips made by children older than primary school age were made independently.</li> <li>• Increased independence is reflected in greater public transport use. The most important mode of travel for children to school trips of all ages is as a car passenger.</li> <li>• Children of primary school age are more likely to walk to school or to be taken in car. This age group has a low levels of public transport use. Secondary school children mostly travel to school by bus or tram or on foot. Students in inner Melbourne walk to school more often than there suburban counterparts.</li> <li>• More children in secondary school get rides to school, use public transport or walk to go home - may be associated with parents work start times and after school activities.</li> <li>• Fear of attack on the street was mentioned consistently by parents, with between 60% and 75% citing this problem. Crossing roads in inner Melbourne 80% of all parents noting this problem.</li> </ul>
<p>Elderly:</p> <p>The elderly (over 65 years) constitutes around 12% of the population in Australia, which is a rapidly growing group. By the year 2021, this group is expected to be around 17% of the population. Elderly have relatively few constraints on time, free of work and family responsibilities. While freedom in scheduling time - constraints in declining financial resources, higher user charges, increased privatisation of community services. Cost of transportation greater financial burdens.</p>	<ul style="list-style-type: none"> <li>• Shown that the proportion of elderly at any given age without a license has decreased significantly;</li> <li>• Number of elderly males driving considerably higher for elderly females. Elderly women take more trips as passengers.</li> <li>• Expectation of elderly drivers to increase in future, as more and more females with driving experience enter into retirement age.</li> </ul>

4.14.5.5 Overall Morris, Richardson and McPherson's (1996) research identifies two opposing trends in travel patterns:

- (i) That increased participation in the workforce by women, particularly by those with children, has given rise to more complicated travel patterns and increased dependence upon the car; and conversely
- (ii) An aging society has expanded the market for public transport. albeit not as large a market as might have been expected in years gone because of the increased license holding of the elderly, particularly elderly women. In addition to this there has also been a reduction in number of young people in population implies a reduction in the traditional market of young travellers for public transport.

4.14.5.6 This research therefore gives a broad examination of the travel behaviour of women, the young and the old. The research makes two main conclusions that: (i) there is a need to devote more effort into establishing a clearer evaluative framework for transport planning; and (ii) to recognise that for the majority of the population, travel behaviour is not an isolated event rather travel decisions are strongly influenced by the needs, constraints and resources of other family members. While the results allow tentative statements to be made about the needs of the three population groups, an evaluative framework for interpreting observed differences in travel behaviour is required. It is therefore imperative that transport planners understand the needs of the users.

#### 4.14.6 Social-Demographic Change Analysis of Travel Behaviour

4.14.6.1 Dodds (1997) examined a wide range of research that had been undertaken over the years in order to investigate how the social-demographic condition of populations influences travel patterns. Dodds (1997) research draws on empirical evidence collected over the last 20 years from both Great Britain and the United States to make the following conclusions about travel patterns shown in Table 11.

4.14.6.2 Dodds (1997) has identified two major trends in travel patterns which are the direct result of changes in the social-demographic status of society. These are named the

‘motorization revolution’ and the ‘grey revolution’. Dodds states that traditional analysis of travel behaviour has assumed that the trip rate for particular age cohorts remains stable over time; and that as a population ages it adopts the travel characteristics currently undertaken by that group. The motorization revolution however suggests that all age groups particularly the elderly have experienced ‘motorization effects’ which fundamentally effect their habits and expectations. Dodds states that the elderly of the 1990s are the first to have experienced full motorization as they were the first generation of mass car ownership. Therefore it would be unrealistic to assume that these people will take on the travel behaviour of those individuals who have never experienced this type of motorization.

Table 11: Socio-Demographic Change and Travel Behaviour Patterns

Socio-Demographic Change		Travel Behaviour Patterns
The ‘Motorization’ Effect	<p>Brought on by:</p> <ul style="list-style-type: none"> <li>Increases in traffic growth: traffic will double between 1988 to 2025 within Great Britain with car ownership levels increasing from 33311 cars per 1000 population to between 529 and 608 cars per 1000 population.</li> <li>Increases in car ownership: 59% of households in 1950 had one car in 1987 this figure has risen to 87% in the United States.</li> <li>Increased levels of driver license holding; men historically have higher levels of driver license holding however between the years 1969 and 1983 there has been a huge catching up process for women in the United States. License holdership for all women has increased by 20% over three surveys.</li> <li>Men tend to drive further: however in 1983 average annual distance driven per licensed male driver in USA was 22 350 kms while women was 10 200 kms.</li> <li>Miles driven per year increasing by 2% per annum for women and men.</li> <li>Strong trends towards multiple car ownership</li> </ul>	<p>These car ownership and demographic factors are likely to result in:</p> <ul style="list-style-type: none"> <li>significant increases over the next 30 years in car drivers and in the number of cars.</li> <li>Much of this growth will occur in households where there is already one car present:</li> <li>Men already have higher rates of license holdership and this will remain stable. The greatest increase in license holdership among men will be in the youngest age group (17 to 20 years) and those in the elderly age group (70 over years);</li> <li>The increase in licence holdership for women is likely to be significant across all age groups to between 70 and 80% in Great Britain. The greater number of women drivers is likely to be a source of new travel.</li> <li>Increased levels of travel may be a result of more women entering the work force, more complex patterns of travel resulting in serve passenger trips, personal business and shopping activities as well as social and recreational activities.</li> <li>The increased expectations of young people will be raised, with many aspiring to car ownership increasing travel.</li> <li>The elderly age group traditionally has had low levels of travel demand and licence holdership.</li> </ul>

The 'Grey' Revolution	<ul style="list-style-type: none"> <li>• Kostyniuk and Kitamura (1987) have found motorization effect to be linked with aging effect.</li> <li>• Significant growth in the number of elderly due to increased life expectancy and definitional factors with the tendency to retire earlier. (Western Europe the proportion of persons over 65 years will increase from 13% in 1985 to 20% in 2020.</li> <li>• Increases in real income: for example, in Great Britain has been augmented by increased levels of inherited wealth.</li> <li>• The OECD in 1989 indicated a decline in fertility rates and growth in the elderly population. This means that the absolute number of elderly will double and the proportion of elderly will increase due to the relative decline in the younger population.</li> </ul>	<ul style="list-style-type: none"> <li>• Banister (1992) suggests that for given car availability conditions there is a certain stability in non-work trip making condition by age. If this assumption holds for the next decade, it is suggested that there will be an increase in the number of journeys made, increases in the distances travelled and increases in the number of car driver and passenger trips made by the elderly. Banister indicates that the elderly will as a result of this will no longer be a transport disadvantaged group in terms of travel patterns.</li> <li>• This will have implications for public transport use by the elderly. It is noted that while traditionally this group has been major user of public transport this may not hold true in the next decades. The traditional captive markets are diminishing and new types of services are required for the elderly, but also for the young and for women. People will choose to travel by public transport and not because they have no other alternative.</li> </ul>
Other Identified Demographic and Related Changes	<ul style="list-style-type: none"> <li>• Young adults returning home;</li> <li>• Female participation rates in the work force has increased;</li> <li>• Decline in the average household size;</li> <li>• Suburbanisation and greater complexity of work journeys;</li> <li>• Leisure time and shortening of the working week;</li> <li>• Migration patterns in Europe.</li> </ul>	<ul style="list-style-type: none"> <li>• Returning young adults results in an increase in the number of cars available in a household and in increase in the trip generation rates.</li> <li>• Increased Female Participation rates in workforce, particularly in part time work, with increased activity rates.</li> <li>• Decline in household size increases demand for smaller units in the housing market which can create parking problems.</li> <li>• Suburbanisation and greater complexity of work journeys resulting in more varied spatially and temporally movements.</li> <li>• Increased cross commuting and long distance commuting.</li> <li>• Tighter labour markets results in complicated travel patterns. The cost of transportation may present constraints to job search areas as likelihood of being successful has to be balanced against travel costs involved.</li> <li>• Leisure time and shortening of the working week.</li> <li>• Migration patterns in Europe - with the opening up of the Single European Market and breaking down of barriers between East and West.</li> </ul>

#### 4.15 SUMMARY OF SOCIO-DEMOGRAPHIC RESEARCH - TRAVEL BEHAVIOUR

4.15.1 Research conducted on socio-demographic condition with travel behaviour has produced a number of interesting results that show how travel patterns may change at different stages of lifestyle, life cycle, and by an individuals age, income, gender and household role. This research outlined in the Literature Review has also outlined a number of current and predicted socio-economic changes that already occur and are predicted to continue in the near future. This has major implications in terms of the current and future provision and management of transportation. While little can be done to change socio-demographic conditions to alter travel behaviour, what can be done is to make the necessary improvements to ensure that as many socio-demographic groups will not be forced to rely on the automobile as the main mode of transportation.

## CHAPTER FIVE: METHODOLOGY

5.0 This section describes the methodology adopted for this research, and discusses the development and organisation of the sample, methods of analysis used to obtain results, and the limitations and assumptions of the sample and any method used.

### 5.1 OUTLINE OF METHODOLOGY

5.1.1 This research selects a number of variables to indicate the type of urban form, socio-demographic characteristics of the population and travel patterns. The methodology is separated into sections that outline the processes used to collect, organise, calculate, and present the socio-demographic, urban form and the travel behaviour variables.

5.1.2 The research examines variables for both the Auckland region, and a case study of eight selected urban areas dispersed throughout the region. The methodology discusses the processes used to examine these two levels of variables.

5.1.3 The methodology adopted for this research is based on a combination of techniques and approaches discussed in the Literature Review. Table 6 shows a summary of the main aspects of the research covered in the Literature Review. The type in bold indicates the approach used to develop this research methodology.

### 5.2 SAMPLE SIZE AND COVERAGE

5.2.1 The data used in this research has been collected at two geographic levels: the regional level and the smaller urban area level. One of the major criticism of Newman and Kenworthy's (1989) and (1991) research was that they analysed urban form for the entire city which tended to mask the variations in urban form. The purpose of the case study is therefore to investigate in greater detail the influence different urban forms and socio-

demographic characteristics may have on travel behaviour. The purpose of presenting Auckland regional data is for comparison with results from the case study, and with international trends identified in the Literature Review. The following categories of data have been collected for this thesis:

AUCKLAND REGION:	-	Travel Behaviour
	-	Socio-Demographic Characteristics
EIGHT ASP ZONES:	-	Travel Behaviour
	-	Socio-Demographic Characteristics
	-	Urban Form

5.2.2 Population and travel data on the Auckland Region was readily available for this research. However, the urban form data at the Auckland regional level was not readily available. A case study has therefore been developed to examine travel behaviour with both urban form and socio-demographic characteristics.

### 5.3 DATA SOURCES

#### 5.3.1 Introduction

5.3.1.1 The data used to create the sample for this research has been extracted from the following sources:

Travel Behaviour	Home Interview Survey conducted by Auckland Regional Council in September 1992;
Urban Form	District Council Zoning Maps, Auckland Regional Council Databases;
Socio-demographic	New Zealand Statistics - Supermap 1991 Home Interview Survey conducted by Auckland Regional Council 1992.

- 5.3.1.2 Much of the research discussed in the Literature Review, analysed survey data on travel behaviour (Ewing et. al. 1993, Kockelman 1995, Cervero and Gorham 1995, Cervero and Radisch 1996 and Handy 1995). The data was either compiled from county or state level surveys or collected from their own focused travel survey. This research compiles data from the Auckland Transport Models - Home Interview Survey, as it contained data which is able to be compiled into Region wide results and results for the case study.
- 5.3.1.3 The researchers discussed in the Literature Review generally used either survey and/or census data to calculate socio-demographic statistics. This research collects socio-demographic data from these two sources. The New Zealand Census, Supermap 1991 and from the Auckland Transport Models - Home Interview Survey 1992 provide socio-demographic data about the overall population and the trip makers of the case study areas.
- 5.3.1.4 Most of the researchers the data collected to analyse urban form is derived from a number of sources including: Geographic Information Systems (Brunton 1996, Kockelman 1995, Handy 1995); Census data for employment or population density levels (Newman and Kenworthy 1989, 1991, Brunton 1996); from maps and aerial photographs and site visits etc. (Handy 1995, Cervero and Gorham 1995, Cervero and Radisch 1996). The urban form data collected for ASP Zones was gathered from maps, Auckland Regional Council land use data bases and census data.

#### 5.4 ZONING MAPS AND COUNCIL DATABASES

- 5.4.1 The district council zoning maps used in this research, assess the urban form of the eight zones selected within the Auckland region. The zoning maps provide detail about the size of the land area, mix of land uses and street layout of the eight zones. The data collected from the maps is limited to the

accuracy of the information contained on the maps. The district council zoning maps used in this research are as follows:

- Waitakere Proposed District Plan, Human Environment Maps, October 1995;
- Manukau City Proposed District Plan, Zoning Maps, 1995;
- North Shore City Proposed District Plan, Zoning Maps, 1994;
- City of Auckland Proposed District Plan (Isthmus Section) Planning Maps No.1 Zoning, 1993 (The specific maps used are contained in Appendix 1).

5.4.2 The land use databases used in this research were provided by the Auckland Regional Council. The first database contains data on the number of commercial establishments within each ASP Zones based on the classification used in the New Zealand Business Directory 1993/1994.

5.4.3 The second database contains data on the total amount of zoned and vacant dwelling, commercial and industrial land within Auckland Regional Transport Zones and contained equivalence tables to convert the data to the ASP Zone level.

#### 5.5 NEW ZEALAND CENSUS - SUPERMAP 1991

5.5.1 The New Zealand census data is contained on the Supermap 1991 computer package. The package contains specific socio-demographic population data for a range of various sized urban areas. Census data for the year 1991 was used in instead of 1996 data because the 1991 data correlated with the last travel survey (called the Home Interview Survey) undertaken by the Auckland Regional Council in 1992.

#### 5.6 AUCKLAND TRANSPORT MODELS - HOME INTERVIEW SURVEY 1992

5.6.1 The Auckland Regional Council has undertaken the Auckland Transport Model, Home Interview Survey between March and October 1992. This

constitutes a significant portion of the data used in this research. The Auckland Transport Model Project Home Interview Survey was conducted on a sample of Aucklanders to record information about:

1. Household characteristics relevant to the generation of trips;
2. Personal information relevant to the generation of trips;
3. Details of trips made during the 24 hour weekday immediately prior to the day of interview for one randomly selected individual in each household sampled; and
4. Information relating to the nature and cost of travel made by the individual whose travel was recorded.

5.6.2 The purpose of the survey was to obtain sufficient data to prepare the Auckland Regional Transport (ART) travel demand model. A total of 9 967 successful interviews were completed of which the first 4 795 interviews constitutes the sample for this research.

5.6.3 Survey Coverage:

5.6.3.1 The area covered by the survey included the Waitakere City, North Shore City, Auckland City, Manukau City and Papakura District which constitute the definition of Auckland region. The target of the survey was all people five years and older. The survey includes household and personal data on both the respondent and all other household residents. A “Household Resident” is defined as a normally resident household member and do not include those:

- absent from household more than three months;
- students at boarding school, nurses at hostels;
- members of the household who are away from time to time with no fixed place of abode are only included if they have not been absent for three months;
- guests at hotels, motels and guest houses are not included in proprietors of household;

- persons away on holiday, in hospital or mental homes, if they have been away longer than three months;
- visitors to the household, unless they have been staying for more than three months.

5.6.2.2 In order to achieve a statistically reliable basis for estimating trip generation rates, the survey is a quota based sample. The quota is expressed in terms of household types and is based upon the occurrence of each type of households in the 1986 census. The number of respondents in each household category required to meet the sample based quota is shown in the next table.

Table 12: Household Categories and Interview Quotas

Household Category	Estimated Number of Families from 1986 Census	Interview Quota
One Parent Family with dependent children only	18 873	550
One Parent Family with adult children with to without dependent children	15 042	550
Two Parent Family with dependent children only	69 495	1 000
Two Parent Family with adult and dependent children	16 341	700
Two Parent Family with adult children only	21 285	800
Couples only with one or both retired	65 274	700
Couples only neither retired*	See note below	700
Single People not retired	48 948	700
Single Retired People**	See note below	700
Total of Quota		6 400
Total Sample Quota		10 000

Note: \* The value of 65 274 is the total for all couples.

\*\* The value of 48 948 is the total for all single people.

Source: Auckland Transport Models Project Technical Working Paper 7, Home Interview Survey September 1995.

### 5.6.3 Sample Selection and Methodology

5.6.3.1 The survey was conducted using two sampling methodologies. Initially, randomly generated telephone numbers were called (Pre-Mailout Sample). The Pre-Mailout Sample was generated by randomly selecting seed phone numbers from the 1992 telephone directory and then randomising the last two digits to produce two useable phone number. The seed number was then

discarded. However, this approach resulted in a greater incidence of unusable phone numbers (disconnected numbers, business, and answer phone and fax numbers) than using numbers directly from the telephone books. The response rate and number of interviews conducted per hour were disappointing low using this approach. The advantage of this approach is that the numbers that did not appear in the telephone books had an equal chance of being included in the sample. A second modified approach (Mailout Sample) sent out an information pack explaining the background to the ATM project and requesting their assistance if they were called. The Mailout sample was generated directly from the telephone directory. Within each household the individual whose trips were recorded was selected randomly by computer using the initials of each person in the household.

5.6.3.2 The survey recorded weekday travel on the day prior to the interview. The interviews were conducted on Tuesdays, Wednesdays, Thursdays, Fridays and Saturdays. Table 13 below shows the interviews by day of the week:

Table 13: Interviews by Day of the Week.

Day of Week	Successful Interviews	% of Sample
Tuesday	930	19.4%
Wednesday	1 015	21.2%
Thursday	1 145	23.9%
Friday	1 111	23.2%
Saturday	594	12.4%
<b>TOTAL</b>	<b>4 795</b>	<b>100%</b>

Source: Auckland Transport Models Project Technical Working Paper 7, Home Interview Survey September 1995.

5.6.3.3 The table below shows the quota required for 99% confidence that the sample is both 4.5% and 4.0% of the true percentage. The quota is based on the percentage of households from the 1986 census. The distribution of survey interviews by household quota is shown in Table 14.

Table 14: Distribution of Survey Interviews by Household Quota

Household Situation	Estimated Number of Families from 1986 Census	% of Families from 1986 Census	Minimum Quota Required - 99% Confident that the Sample is 4.5% of the True Percentage	Minimum Quota Required - 99% Confident that the Sample is 4.0% of the True Percentage	Total Quota Achieved	% of Families from Sample
1 parent family with dependent children only	18 873	7.4%	182	225	252	5.3%
1 parent family with adult children, with or without dependent children	15 042	5.9%	148	183	224	4.7%
2 parent family with dependent children only	69 495	27.2%	527	651	1 205	25.1%
2 parent family with adult and dependent children	16 341	6.4%	160	197	321	6.7%
2 parent family with adult children only	21 285	8.3%	203	250	389	8.1%
Couples only with one or both retired and couples only with neither retired	65 274	25.6%	507	656	1 165	24.3%
Single people not retired and single retired people	48 948	19.2%	413	510	964	20.1%
Other (Includes Flatmates, Related Flatmates)					275	5.7%
<b>TOTAL</b>	114 222	100%	2 140	2 672	4 520	94.3%

Source: Auckland Transport Models Project Technical Working Paper 7, Home Interview Survey September 1995.

#### 5.6.4 Bias and Error in Sample Collected

5.6.4.1 An estimate of the sample reliability based on sample size is given by:

$$\text{Maximum Error} = 1.96 \sqrt{(0.5)^2 / N}$$

$$\text{Total Sample Size (N)} = 9\,967$$

$$\text{For Total Sample, Maximum Error} = \pm 1.0\%$$

(Note: this is maximum error, not the actual error)

Table 15 below shows the maximum error for each Household Category.

$$\text{Maximum Error} = 1.96 \sqrt{(0.5)^2 / N}$$

$$\text{Total Sample Size (N)} = 4\,795$$

$$\text{For Total Sample, Maximum Error} = \pm 1.4\%$$

Note: this is maximum error, not the actual error)

5.6.4.2 Table 15: Maximum Error for Each Household Category

Household Category	Estimated No. of families from 1986 Census (N)	Proportion of families in Total Population	Actual Sample Achieved (n)	Proportion of Total Sample	Maximum Error (Based on Sample Size)	n/N Sample size by Household Category
1 parent family with dependent children only	18 873	7.4%	252	5.3%	+/- 6.0%	1.3%
1 parent family with adult children, with or without dependent children	15 042	5.9%	224	4.7%	+/- 6.5%	1.5%
2 parent family with dependent children only	69 495	27.2%	1 205	25.1%	+/- 2.8%	1.7%
2 parent family with adult and dependent children	16 341	6.4%	321	6.7%	+/- 5.5%	2.0%
2 parent family with adult children only	21 285	8.3%	389	8.1%	+/- 5.0%	1.8%
Couples only with one or both retired and couples only retired	65 274	25.6%	1 165	24.3%	+/- 2.9%	1.8%
Single people not retired and single retired people*	48 948	19.2%	964	20.1%	+/-3.1%	2.0%
Related flatmates - no parents in residence			275	5.7%	+/- 4.4%	
<b>TOTAL</b>	255 258	100%	4 520	94.3%	+/- 1.4%	1.8%

Note: \* These categories are combined in this table

## 5.6.5 Processing of Data

5.6.5.1 The data was processed using a custom built FORTRAN and dbase programs. The data has been cleaned and checked for errors to ensure data integrity. The data set contains 9 967 records, each 4392 bytes long, with a total size of 43 Mb. The main data file has been separated into three files

containing the characteristics of the household, person and trips made. The structure and coding of the files is shown in Appendix 2.

### 5.6.6 Organisation of the Data Base Files

5.6.6.1 The data base is organised into three main files:

1. Household File: This file contains data about the respondent and their relationship to the other members of the household; (13.8 Mb - 9967 records)
2. Personal File: This file contains personal data about the individuals in the respondents household; (7.7 Mb - 25 834 records)
3. Trip File: This file contains data about the trip making of the respondent only. (12.6 Mb - 33 677 records)

5.6.6.2 Every respondents household, personal and trip making data is coded by a record number which enables the personal, household and trip making of the respondent to be traced. The data is coded according to the questions asked and answers made by the respondent. Figure 16 below indicates the layout the files as indicated by the first page of the household database file.

Figure 16: The First Page of the Household Database File

	A	B	C	D	E	F	G	H	I
1	RECNO	RESP	DATE	DAY	INTNO	HHOLD	CHILDREN	FIVEPLUS	UNDER5
2	1	000001	1203	4	70	6	0	0	0
3	2	000002	1303	5	58	2	3	4	0
4	3	000004	1303	5	58	3	0	2	0
5	4	000005	1303	5	58	3	0	2	0
6	5	000006	1303	5	58	2	1	2	1
7	6	000008	1603	1	19	2	1	2	2
8	7	000009	1603	1	19	4	0	3	0
9	8	000010	1603	1	19	2	1	4	0
10	9	000011	1603	1	19	2	1	2	1
11	10	000014	1603	1	69	2	1	4	0
12	11	000015	1703	2	69	2	3	6	0
13	12	000017	1703	2	69	5	0	0	0
14	13	000018	1703	2	69	2	1	2	0
15	14	000019	1703	2	69	2	1	2	0
16	15	000021	1703	2	69	2	2	3	0

5.6.6.3 The vertical labels on the database contain the record numbers for each respondent. These are shown in columns A1 to A16. The horizontal labels A1 to K1 indicate the household variable, for example, household situation is indicated label HHOLD in cell F1. The cells in column F, are coded with a number that represents the household category the respondent belongs to. For example, cell F3 and F6 contain the number 2, which indicates the respondent belongs to a two parent family. The database can be manipulated to produce both Auckland region and the eight selected ASP Zone data required for household analysis.

## 5.7 DEVELOPMENT OF THE CASE STUDY

### 5.7.1 Common Unit of Analysis - The Auckland Strategic Planning Zone

5.7.1.1 The common unit found (or able to be created) in all the sets of data is called the Auckland Strategic Planning Zones or ASP Zone. This is an urban land area with boundaries stipulated for an Auckland Strategic Planning Model developed by the Auckland Regional Council. The Auckland Strategic Planning Model is a study into policy options for Auckland's future regional development (Auckland Regional Council 1994). The model follows on from the Regional Development Study which is a qualitative based study addressing the opportunities and constraints with the a more quantitative model which uses interactive land-use and transport computer models. The ASP model allows the quantitative assessment of effect and implications of different development scenarios, under different growth projections (Grant and Jones 1996). The ASP model is developed to:

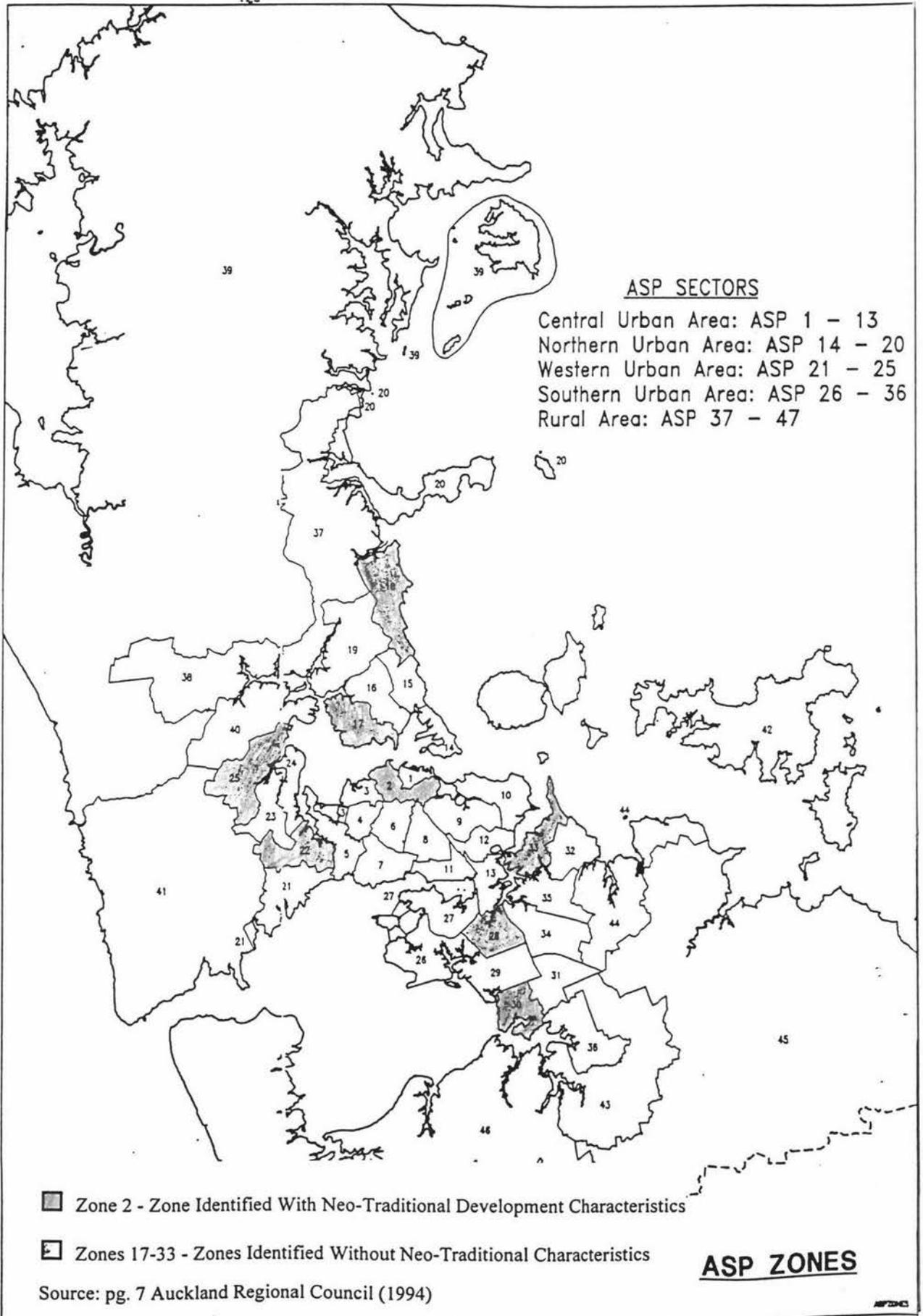
1. assist in reviewing urban policy direction;
2. assess development policy alternatives as a section 32 (RMA) process;
3. assist in formulating a regional (development/growth) plan as outlined in the Proposed ARPS, including any review of the metropolitan urban limits;
4. aid development of a Regional Land Transport Strategy (RLTS) under the Transit New Zealand Act;

5. assist ongoing monitoring of the effects of regional development policy;
6. inform infrastructure and utility providers and Territorial Authorities of the regional context for their own strategic and asset management policy (Grant and Jones 1996).

5.7.1.2 The model takes base data on possible population figures, economic futures and development futures and then allocates households and jobs over the region for the relevant zone, development policy option, economic and population futures context, and time period. The results from this study enables "...a better understanding of how quickly the urban area will reach capacity under present zoning; how much intensification might be needed to maintain the existing metro limits for the next 25 years; the differences in environmental implications, infrastructure costs and social implications; between development options; and the relationship between; land use policy and transportation." (Grant and Jones 1996).

5.7.1.3 In order to evaluate possible scenarios, the Auckland region is divided up into 47 areas or 'ASP Zones' which are shown in Figure 17. The zones are based on Census Area aggregates, transport factors and communities of interest and were drawn up by the Auckland Regional Council and in consultation with Territorial Local Authorities (Auckland Regional Council 1994). The eight ASP Zones evaluated in this research are zones 2, 17, 18, 20, 22, 25, 28, 30 and 33.

Figure 17: Auckland Strategic Planning Zones (ASP Zones) in the Auckland Region.



5.7.1.4 The three main sources of data used in this research are the Supermap New Zealand Census data 1991, two Auckland Regional Council databases, and district council zoning maps and the Auckland Transport Models, Home Interview Survey 1992. Each of these sources of data can be used to create data for this ASP Zone unit. New Zealand Census Statistics 1991 Supermap programme divides the Auckland region into a number of “Urban Areas” or suburbs. A combination of these aggregated together form the ASP Zone unit. This is shown in Table 16 below.

Table 16: Urban Areas within Selected ASP Zones

ASP ZONE 2	ASP ZONE 17	ASP ZONE 18	ASP ZONE 33
Freemans Bay	Windy Ridge	Awaruku	Bucklands & Eastern Beaches
Newton	Northcote South	Glamorgan	Bucklands Beach South
Grafton	Beachhaven North	Torbay	Pidgeon Mountain North
Herne Bay	Beachhaven South	Waiake	Pidgeon Mountain South
St Marys	Birkdale North	Browns Bay	Elsmore Park
Ponsonby West	Birkdale South	Oaktree	Halfmoon Bay
Ponsonby East	Kauri Park	Rothsay Bay	Pakuranga North
Grey Lynn West	Chelsea	Murrays Bay	Sunnyhills
Grey Lynn East	Birkenhead East	Mairangi Bay	Pakuranga Central
Arch Hill		Campells Bay	Edgewater
Eden Terrace		Long Bay	Pakuranga East
Parnell East			
Parnell West			
Newmarket			

ASP ZONE 22	ASP ZONE 28	ASP ZONE 25	ASP ZONE 30
Tangutu	Middlemore	Ranui North	Burbank
Woodglen	Papatoetoe West	Royal Road West	Homai West
Glen Eden East	Papatoetoe North	West Harbour	Rowandale
New Lynn North	Papatoetoe Central	Lucken Point	Homai East
Fruitvale	Dingwall	Royal heights	Weymouth
Rewarewa	Papatoetoe East	Birdwood	Clendon
Glendene South	Puhinui	Waimumu North	Leabank
Kelston Central	Grange	Waimumu South	Wattle Farm
Parrs Park	Mangere East		
	Aorere		
	Kohuora		

5.7.1.5 When the selected “urban areas” in the census are aggregated together to form the corresponding ASP Zone the boundary around the “urban areas” exactly matches the shape of the ASP Zone; with one exception - ASP Zone 25. The discrepancy here exists on the southern most edge of the zone

(Figure 17) therefore the variables collected from this zone from New Zealand Census data have been adjusted for this discrepancy.

5.7.1.6 The district council zoning maps and databases kindly supplied by the Auckland Regional Council are constructed to form the ASP Zone unit. The Auckland Regional Council conducted the Home Interview Survey to assist in developing two planning models for the Auckland region, the Auckland Regional Transport Model and the Auckland Strategic Planning Model. The Auckland Regional Transport Model contains 171 zones called the Auckland Regional Transport Zones or ART Zones when aggregated together form the larger ASP Zones (shown in Figure 17). The data collected from the Home Interview Survey is tagged with the ART locations and therefore is able to be prepared for the ASP Zone unit.

#### 5.7.2 Selection of the Case Study

5.7.2.1 Many researchers use zip codes, census tracts, traffic analysis zones, neighbourhoods as the unit of analysis (refer Table 6). The case study used in this research is based on the matched pairs analysis of Cervero and Gorham (1995), Cervero and Radisch (1996) and Handy (1992), (1995). These researchers investigated the travel behaviour of a more traditional neighbourhoods or transit-orientated with a more modern auto-orientated neighbourhoods. The benefit of this type of study is that the travel behaviour of these two different neighbourhoods can be compared and is not just theoretical or hypothetical analysis. The eight ASP Zones selected for the case study are therefore grouped into four matched pairs. The preliminary investigations revealed that the urban form throughout Auckland is relatively similar once out of the central Auckland suburbs. It was found that only ASP Zone 2 contained the urban form patterns for example, a mixture of land uses and dwelling types, a more grided street system and higher residential density characteristics required for a comparison. The other 45 ASP zones generally did not contain the combination of these urban form qualities and therefore are characterised as having: a relatively unmixed land use pattern with mainly single detached housing types, a curvilinear street pattern and low residential density levels. Thus, only ASP Zone 2 could be

used to compare with all the other ASP Zones. The ASP Zone 2 was matched with ASP Zone 17 for comparative purposes, as this zone represented the most similar socio-demographic characteristics for residing populations and geographic location. The ASP Zone 2 circles the perimeter of the Central Business District (CBD), while ASP Zone 17 is located on the North Shore it is linked by the Auckland Harbour Bridge therefore in close proximity to the CBD. These two zones are compared to examine the influence of urban form variations on travel behaviour.

Decision to make ASP Zones based:

1. Differences in Urban Form;
2. Socio-Demographic Characteristics;
3. Location;
4. Topography;
5. Number of Travel Surveys.

5.7.2.2 The three other matched pairs selected for analysis contain varying socio-demographic characteristics to attain a cross section of data for differing populations. The zones were selected according to the following criteria:

1. trends in socio-demographics characteristics of the population in the zones to display a range of different socio-demographic groups.
2. Similar urban form patterns
3. Survey Data: the ASP Zones with a high response rate;
4. Location within the city: the matched pairs located at different distances away from the city centre away from the other matching zone;
5. Topography: The matched pairs of ASP Zones were selected to have similar topographical settings within the city.

5.7.2.3 A total of 24 ASP Zones were examined prior to selecting the six zones used in this research. Each of the paired ASP Zones are in quite different locations within the city, but have notably similar socio-demographic characteristics for their residing population. The purpose of having matched

ASP Zone pairs is to ensure that the different population groups were representative of the range of socio-demographic populations in more than one location in the city. This is to allow greater comparative base with ASP Zone 2.

## 5.8 DATA ORGANISATION

### 5.8.1 Introduction

5.8.1.1 The data collected from the Supermap New Zealand Census 1991, district council zoning maps and the two ARC databases required a limited amount of organisation to form data for the Auckland regional and ASP Zone levels. The Auckland Transport Models - Home Interview Survey database however had to be required organised to attain just the records for the eight separate Auckland Strategic Planning zones in both the household, personal and trip files. The process for organising the data is outlined in the steps below:

### 5.8.2 Step One: Splitting the Files

5.8.2.1 The first stage was to split the three files into a number of smaller files in order to allow the data to be organised for the next steps.

### 5.8.3 Step Two: Construction of ASP Zone Files

5.8.3.1 Every respondents record in the trip file is tagged with a Auckland Regional Transport Zone which identifies the zone of the respondents home location. The excel "data filter" tool was used to filter through the records in the trip file to select only those that had a home location in the specified ART zone. (which make up the ASP zones studied). The trip file was therefore used to gather the trip records for all of the eight ASP Zones.

#### 5.8.4 Step Three: Construction of Associated Personal and Household Files for ASP Zones

5.8.4.1 As mentioned every respondents records are tagged with a common record number in the trip file, household file and personal file. The next stage is to construct the corresponding personal and household files for the eight ASP Zones. The respondents record numbers listed in the ASP Zone files are recorded and used to filter through the household and personal files to select only the their corresponding personal and household records. This creates eight separate personal and household files for each of eight separate ASP Zones.

#### 5.8.5 Step Four: Construction of Age and Role of Household Member Files for ASP Zones

5.8.5.1 The last stage of data organisation process is to create files for the selected age and household groups for the eight ASP Zones. This is compiled only for the eight selected ASP Zones and not the entire database as due to the complexity and the length of this process. The trends in travel behaviour from certain age groups can be indicated through the analysis at the ASP Zone level. The four age groups used in this research are the 5 to 24 years, 25 to 44 years, 45 to 64 years and over 65 years. The respondents record numbers were aggregated together to form each of the five year age groups. The “advanced autofilter” tool in excel was used to match these respondents record number in each of the four age groups with their trip records. The result is the construction of files that contain the trips records of the four age groups for each of the ASP Zones. The same process was undertaken to create files for the four groups of the role of household member. Upon analysis it was revealed that there was not enough respondents in each of the age groups and household groups for each ASP Zone, to make a statistically significant sample in every case. This was resolved by combining the three matched pair files for example ASP Zones 18 and 33 age group 5 to 24 years files together to form one larger sample (This was not undertaken for the ASP Zone 2 and 17 files).

## 5.9 METHODOLOGY FOR DATA CALCULATION

### 5.9.1 Introduction

5.9.1.1 The methodology used to calculate data is discussed in three main sections urban form, travel behaviour, socio-demographics.

## 5.10 SOCIO-DEMOGRAPHIC VARIABLES

5.10.1 The socio-demographic variables included in this section describe characteristics of the trip maker to assist in understanding of the travel behaviour of individuals. The data for the socio-demographic variables is collected from two sources the Supermap New Zealand Census 1991 and Auckland Transport Models Project, Home Interview Survey 1992. The socio-demographic variables from these two sources has been calculated for both the total Auckland region and for each of the ASP Zones. These are listed in Table 17 below.

Table 17: Socio-Demographic Variables Used in the Research

AUCKLAND REGION		ASP ZONES	
CENSUS	SURVEY	CENSUS	SURVEY
Gender	<b>Not Available</b>	Gender	<b>Not Available</b>
Age Structure	Age Structure	Age Structure	Age Structure
Income (per capita, mean, average, median household, average household)	Income (combined household income)	Income	Income (combined household income)
Occupancy Rate	Occupancy Rate	Occupancy Rate	Occupancy Rate
Household Situation	Household Situation	Household Situation	Household Situation
	Relationship with Main Income Earner		Relationship with Main Income Earner
Family Situation	<b>Not Available</b>	Family Situation	<b>Not Available</b>
Car Availability	Car Availability	Car Availability	Car Availability
Labour Force (Part-time/Full time)		Labour Force (Part-time/Full time)	
Women in Workforce	<b>Not Available</b>	Women in Workforce	<b>Not Available</b>
Households with Superannuitants	<b>Not Available</b>	Households with Superannuitants	<b>Not Available</b>
Households with Persons under the Age of Five Years	Households with Persons under the Age of Five Years	Households with Persons under the age of Five Years	Households with Persons under the Age of Five Years
Total Population	Total Number of Respondents	Total Population	Total Number of Respondents

5.10.2 The Auckland Transport Models Project, Home Interview Survey contains the socio-demographics characteristics of the actual trip makers. The purpose of including the Supermap 1991 Statistics New Zealand is to show the overall socio-demographic context for the Auckland region or the ASP Zone. The data categories in Supermap generally correspond to most of the categories used within the Auckland Transport Models Project, Home Interview Survey. The benefit of having both sets of data is that the socio-demographics of the actual survey sample can be placed in the wider ASP Zone and Auckland regional contexts and can be used to compare with the socio-demographic characteristics of the overall population of trip makers.

5.10.3 The socio-demographic variables included in this research have been selected on the basis that they were identified in the literature as potentially being able to influence the travel patterns. Table 6 summarises the socio-demographic variables examined in the Literature Review. While most of these variables are not statistically tested or correlated with travel behaviour patterns, (as in some research in the Literature Review) they present information that might be relevant in explaining travel behaviour outcomes in the results section.

## 5.11 SOCIO-DEMOGRAPHIC VARIABLES - SURVEY

5.11.1 All the socio-demographic data in this section is extracted from the household and person files made from the Auckland Transport Model, Home Interview Survey 1992. The data for the Auckland Region is calculated from either the hhfile or perfile and contained all respondents. The file used to calculate the data is listed with each socio-demographic variable below. The same type process of is used to calculate each variable. This process is demonstrated using the using the age variable as working example. The age data for each respondent is listed in one column in the household files. The total number respondents in each age group and the percentage of the total sample population can then be calculated.

5.11.2 The socio-demographic variables examined for this section of the research include:

5.11.2.1 Age: All respondent are classified into four age groups: Ages 5 to 24 Years, Ages 25 to 44 Years, Ages 45 to 64 Years, Ages 65 Over. The under five years are not surveyed in the Auckland Transport Models Project Home Interview Survey sample and therefore the age groups start at five years and over. The twenty year age groups are used to create age groups sample sizes that are statistically significant.

5.11.2.2 Income: This is defined in the survey as combined household income and is shown in units of \$10 000 starting from less than \$10 000 up to \$80 000. This is calculated as both the total number and as a percentage.

5.11.2.3 Dwelling Occupancy Rate: This is defined as the average number of people residing in a dwelling. This is calculated by dividing the total population by the number of households.

5.11.2.4 Household Type: The respondents household is categorised as either a one parent, two parents, couple one or both retired, couple neither retired, single not retired, single retired, unrelated flatmates or related flatmates - no parents resident households. The data is calculated as both the total number and as a percentage of the total number of households.

5.11.2.5 Relationship with Main Income Earner: This describes the respondents relationship with the main income earner in a household. The respondent is classified as either the main income earner, husband/defacto/partner, wife/defacto/partner, son, daughter, other relative, non-relative or flatmate. The data is calculated as both the total number and as a percentage of the total number of households.

5.11.2.6 Car Availability: This measures the number of private and company cars available to a household. This is classified as either none, one, two, three, four, five or more cars per household. The data is calculated as both the total

number and as a percentage of the total number of households. The total sample population that either own a private or company car is calculated.

5.11.2.7 Households With Persons Under Five Years of Age: This measures the whether a household. has any children under the age of five years. The data is calculated as both the total number and as a percentage of total households.

5.11.2.8 Total Number of Respondents: This measures the total number of respondents and the total number household members. This is calculated as the total number.

## 5.12 SOCIO-DEMOGRAPHIC VARIABLES - NEW ZEALAND CENSUS DATA

5.12.1 The variables collected from the Supermap programme give regional figures on the socio-demographic characteristics of the Auckland Region and four main areas: Northern, Western, Central and Southern Auckland. The socio-demographic variables for the ASP Zone populations are also collected from the New Zealand Census.

5.12.2 The social-demographic data is classified according to Statistics New Zealand definitions in contained in the census. The socio-demographic variables examined as listed below:

5.12.3 Gender: All individuals classified into Males or Females. This is calculated as the total number and as a percentage of total population.

5.12.4 Age: All individuals classified into four age groups: Under Five Years, Ages 5 to 24 Years, Ages 25 to 44 Years, Ages 45 to 64 Years, Ages 65 Plus. This is calculated as both the total number and as a percentage of the total population

- 5.12.5 Income: Income is defined by five different measures including; Median Total Income, Average Total Income, Per Capita Income, Median Household Income and Average Household Income.
- 5.12.6 Household Type: Household type is classified as one family, two families, three families and non-family or one person households. This is calculated as both the total number and as a percentage of the total population.
- 5.12.7 Occupancy Rate of Dwellings: This is defined as the average number of individuals living in a dwelling and is calculated by dividing the total population figures by total number of dwellings.
- 5.12.8 Labour Force: This is defined as the total number of part time and full time employed people in the labour force and is calculated as the total number and as a percentage of the total population.
- 5.12.9 Women in the Workforce: This is the total number of women in the work force in terms of population and total number of households with women in the Workforce. This is calculated as both the total number and as a percentage of the total population.
- 5.12.10 Households with Superannuitants: This is defined as the total number of households with that have at least one superannuitant member. This is calculated as both the total number and as a percentage of the total population.
- 5.12.11 Households with Children Under the Age of Five Years: This is calculated as the total number of households that have one or more children under the age of five years. This is shown as both the total number and as a percentage of the total population.
- 5.12.12 Car Ownership Rate: This is measured in terms of the number of cars grouped as none, one through to three or more available to a household. This is further measured as the percentage of the population with access/own a car.

## 5.13 TRAVEL BEHAVIOUR DATA - SURVEY

### 5.13.1 Survey Definition of a "Trip"

5.13.1.1 The Auckland Transport Models Project - Home Interview Survey defines a trip as "...one-way travel from one place to another for a particular purpose. The characteristics of a trip are described as:

5.13.1.2 "Return travel, such as from home to work and return, would include at least two trips. Even a continuous drive from home back to home without any stops must be divided into two trips at the furthest point from home."

5.13.1.3 "A journey may have several legs and these must be treated as separate trips if they direct the route of travel, that is, if each leg has a separate purpose."

5.13.1.4 "A stop which is incidental to the journey and is very brief does not constitute a trip. Stops made as a result of traffic conditions and where a person does not leave the are to be disregarded."

5.13.1.5 "A stop which is the motivating purpose of a trip is the destination and becomes the origin of the next trip. thus the origin of all trips after the first will be the same as the destination of the previous trip, except where the two points are separated by walk, or cycle of a definite purpose but of less than 5 minutes."

5.13.1.6 "Where a trip involves more than one mode of travel the information of each mode will be collected, but it will all be treated as one trip. This is because the purpose of a park and ride leg of a journey to work is travel to work, not a bus station."

### 5.13.2 Characterising Travel With Trip Variables

5.13.2.1 Some researchers have used total vehicle miles, total gasoline consumption as a measure of travel behaviour (Newman and Kenworthy 1989, 1991 and

Holtzclaw 1990, 1994). This was criticised because it does not differentiate between different trip purposes, lengths and provided data only on vehicular transport. The analysis of urban form and socio-demographics can be argued to better examined with trip variables such as mode, length, purpose for this research as the two different urban form patterns for example, can be assessed to determine if different urban form pattern incur changes in different types of travel rather than just an overall or decrease in travel. The trip variables used in this research as based on those discussed in the Literature Review (Refer Table 6).

5.13.2.2 The types of travel variables examined in this research is dependent those collected in the survey. The wide range of travel variables can be calculated from the survey, however only trip purpose, length, mode split, number of occupants in car trips are examined. The travel behaviour is examined for the Auckland region, the eight ASP Zones; for the age groups (5 to 24 years, 25 to 44 years, 45 to 64 years and 65 and over years) for different household member (main income earners, wife/defacto/partner, single retired people and flatmates). This is shown in Table 18.

Table 18: Travel Variables Used in the Research.

AUCKLAND REGION	ASP ZONES		
	Total ASP Zones	Age Groups	Household Role
1) Total Trips Made	1) Total Trips Made	1) Total Trip Made	1) Total Trip Made
2) Trip Purpose	2) Trip Purpose	2) Trip Purpose	2) Trip Purpose
3) Trip Modes	3) Trip Modes	3) Trip Modes	3) Trip Modes
4) Trip Length (measured in minutes)	4) Trip Length (measured in minutes)	4) Trip Length (measured in minutes)	4) Trip Length (measured in minutes)
5) Number of Occupants (car trips only)	5) Number of Occupants (car trips only)	5) Number of Occupants (car trips only)	5) Number of Occupants (car trips only)
* See Note 1)	6) Trip Purpose by Trip Modes	6) Trip Purpose by Trip Modes	6) Trip Purpose by Trip Modes
7) Trip Purpose by Trip Length (measured in minutes)	7) Trip Purpose by Trip Length (measured in minutes)	7) Trip Purpose by Trip Length (measured in minutes)	7) Trip Purpose by Trip Length (measured in minutes)
8) Trip Mode by Trip Length (measured in minutes)	8) Trip Mode by Trip Length (measured in minutes)	* See Note 2)	* See Note 2)
* See Note 1)	9) Trip Purpose by Number of Occupants (car trips only)	9) Trip Purpose by Number of Occupants (car trips only)	9) Trip Purpose by Number of Occupants (car trips only)

Note 1) Trip purpose by Trip Mode is not calculated for the Auckland region as this can be indicated by the ASP Zone Case Study.

Note 2) These have not been calculated.

5.13.2.3 These variables have been selected as they provide information about the travel choice of the individual and the main characteristics of a trip made. The method to determine these travel behaviour variables is undertaken through the following steps. The characteristics of the respondents trips contained in both the tripfiles and the ASP trip files are organised according to the variables listed above and others. To demonstrate how the data is analysed the trip purpose variable will be used as an example of the method adopted.

Figure 18: Layout of Page in TripFile Database.

	A	B	C	D	F	G	H	I	J	K
1	RESP	TRIP	OPUR	DPUR	AMODE	STIME	FTIME	MINUTES	ARTHOME	NUMREC
2	000001	1	1	04	01	0930	0935	5	116	1
3	000001	2	4	01	01	0946	0950	4	116	1
4	000002	1	1	02	03	0730	0735	5	058	2
5	000002	2	2	01	03	1755	1800	5	058	2
6	000004	1	1	04	01	1030	1040	10	160	3
7	000004	2	4	01	01	1145	1155	10	160	3
8	000005	1	0	00	00	0000	0000	0	165	4
9	000006	1	1	04	11	1400	1420	20	052	5
10	000006	2	4	01	11	1615	1640	25	052	5
11	000008	1	1	02	09	0800	0805	5	122	6
12	000008	2	2	01	09	1600	1605	5	122	6
13	000009	1	1	07	01	0930	0935	5	064	7
14	000009	2	7	01	01	0936	0940	4	064	7
15	000009	3	1	05	01	0941	1000	19	064	7

5.13.2.4 The same process is used to calculate travel behaviour variables. This process is shown by calculation the trip purpose variable as a working example. The respondents trip purpose data is shown in the columns C and D in the figure above. The origin of the trip is shown in column C and the destination of the trips are shown in column D. The number of working trips made is calculated by using the autofilter function on the files. The datafilter is placed onto the trip origin cell C1 and the data is filter to extract those trips made only from home (indicated by a 1 in the cells of column C). The autofilter is then placed on to cell D1 the trip destination cell which can then filter the data according to each different destination for example, work trips only can be filtered (indicated by a 02 in the cells of column D). The filter can also placed on column F, which records the mode used for trips to extract the trips only made by particular modes. For example, the 01 in column F, represents a trip made as a private car driver, or 11 indicates a trip made as a bus passenger. Therefore different trip purpose with a different modes, number of lengths can be assessed using this process.

### 5.13.3 Total Number of Trips

5.13.3.1 The total number of trips made calculates the total number of trips made within a particular area or by a particular group. The average number of trips made per day per respondent is calculated by dividing the number of

trips made in an area by the total number of respondents in that area. The average number of trips per day per respondent is a more accurate measure of the frequency of travel and was used by Cervero and Radisch (1996) in their research.

#### 5.13.4 Trip Purpose:

5.13.4.1 The trip purpose is described as the reason for the trip for example, to go to work, school, shopping, visiting friends or relatives etc. The researchers that use the trip purpose variable as a measure of travel patterns include Ewing et al. (1993) all travel, Brunton (1996) for work related travel, Kockelman (1995) non-work related - home based travel, Cervero and Gorham work based travel, and Cervero and Radisch (1996) non-work trips. While others assess the amount of time devoted to different activities within a day and the resultant travel, for example work, shopping or recreation (Vadarevu and Stopher 1996, Principio and Pas 1996). The Auckland Transport Models: Home Interview Survey can be used to measure trip purpose. The survey defines trip purpose in terms of the origin and destination of a trip, for example a "home to work" trip, or a "work to social-recreation" trip. Figure 18 shows how the data is organised. The survey definition of these trips is given below:

*Home Trips:* are those made to the respondent's usual residential address;

*Work Trips:* are those made to the respondent's usual place of work; (work trips do not include trips done by tradesmen etc. who have no fixed place of work (and have recorded their usual work place as "home") to their first destination to begin work. these trips are coded as "home" to "employers business." The definition of the normal place of work is stated as "A person's normal place of work is the address of their main job. For people with no fixed work place this is the address of the headquarters or depot from which they operate. For those who have no fixed reporting point but travel from home to various locations to work then "home" is the normal work address. For those that work at home, the home address is the normal work address."

*School trips:* are those made by a primary or secondary school student for tuition, also a trip by a student to a tertiary education institution for tuition.

*Shopping trips:* are those made for the purchase of goods or services of any kind, including window shopping, and personal business (banking, visits to the doctor) - this is a combination of the more usual shopping and personal business purposes.

*Social-Recreational trips:* Are those trips made for entertainment, social and recreational purposes - sports, theatres, dances, hotels, visiting friends, etc.

*Serve passenger trips:* are those which is made in order to transport some one else to a destination, such as driving a spouse to work so that the car may be available for use during the day. The overall purpose is work in this case.

5.13.4.2 This research examines only the trips made to and from the 'home' for work, shops, social-recreation, school or as a serve passenger trips. Analysing all the data for many different origins and destinations involves a complex and lengthy process, therefore the trips made to/from the home is used to give an indication of overall travel made. The majority of all the trips made in the survey are to/from home locations and therefore provide a statistically significant samples. The advantage of investigating trips made to/from the home is that the travel at some stage is through the respondents ASP Zone. As the urban form and socio-demographics of the population in these zones is examined, this can more clearly identify whether the travel behaviour of the residents in the studied area alters with the pattern of urban form.

5.13.4.3 Trip purpose is calculated as the total number and as a percentage of all trips made. Trip purposes are also calculated as the average number of trips made per day per respondent.

### 5.13.5 Travel Modes

5.13.5.1 Mode split analysis is a popular form of analysis used by most of the researchers discussed in the Literature Review including; Ewing et. al. (1993), Kockelman (1995), Cervero and Gorham (1995), Cervero and Radisch (1996), Handy (1992), Kitamura et. al. (1994), Principio and Pas (1996), Kitamura (1991). While some researchers have focused on a particular mode for example, Handy (1995) on walking trips, most study a range of travel modes. These main travel modes of interest are both motorised - by private car trips both as drivers and passengers, public transport trips and non-motorised modes walking and cycling. Where there is more than one mode of transport used on a trip, this has been recorded.

*Private Car:* are those trips made in a car, van or utility owned by household members and not financed by an employer or a company.

*Company Car:* are those made in a car, van, utility that is owned or financed by an employer or a company but is unmarked and not plainly identifiable as a "commercial" vehicle. This includes vehicles owned by the members of the household but financed by the employer, where all or a high proportion of the operating costs are met by the employer. If the employer or company pays for the initial cost and operating costs of the vehicle either in total or in large part, so that the driver faces a very different set of costs than faced by a private motorist.

*Walk/Cycle Trips:* are those made by walking or bicycle only. A walking or cycling trip has only been recorded if the walk or cycle trip has a defined purpose. All walking or cycling trips for which the origin or destination purposes is home, school or work shall be recorded. If other purposes are involved the trip must be longer than 5 minutes before it will be recorded. This is of importance when considering walking trips around shopping centres. Recreational walking, jogging etc. that is from home to home has not been recorded. Recreational cycling that is from home to home has not been recorded.

*Public Transport Trips:* are those made where a respondent is in a bus, train or ferry passenger. A bus trip is a trip on any scheduled fixed route public passenger transport services operated by buses and taxis. A ferry trip is a trip on any scheduled fixed route public passenger transport services by boats on the water, and including water taxis. A train trip is a trip on any scheduled public passenger transport services by train, including both suburban and inter-city train services. Trips made by drivers of scheduled public transport will only be recorded in the home interview survey if one end of the trip is at home.

*Other Modes:* are those made by truck drivers or passengers, Light Commercial driver or passenger, Heavy commercial drivers or passengers, motorcycle/scooter, taxi passengers, duplicate modes and refused to state.

The trip mode is calculated as the total number of trips made using a mode and as a percentage of all trips made. This figure is also shown as the average number of trips made per day per respondent using the specified modes.

#### 5.13.6 Trip Length

5.13.6.1 Trip length can be measured in a number of ways including, time taken from the origin to the destination, distance in terms of kilometres travelled or the distance between the origin and destination points. Trip length was measured by Holtzclaw (1990) & (1994) as the total of vehicle miles travelled from odometer readings while Ewing et. al. (1993) measured the average travel time and total hours of travel. Brunton (1996) measured average journey to work distance in kilometres. This research uses the average trip length measured by the number of minutes required to get from the origin to the destination.

5.13.6.2 Trip length identified by the location of the origin and destination can be calculated using the data, however this has not been undertaken, as the trips recorded, have multiple origin and destination points in 171 different ART Zones around the Auckland region. The calculation of this variable is a

complex process to complete. The location of origin and destination points while giving an indication of the trips made out of the ASP Zones, the trip distance is difficult to measure as the route taken is not specified with the data. The combined analysis of both these two variables would provide the best indication of travel length, location and distance. Additional research to calculate this variable would be a useful addition to this research.

#### 5.13.7 Number of Occupants

5.13.7.1 This is described as the number of occupants including both the driver and passengers on each company or private car trip. While this is not specifically measured in any of the research discussed in the Literature Review, a number of researchers have investigated the number of serve passenger trips for specific activities for example, driving children to school (Morris, Richardson and McPherson 1996). The purpose of investigating this variable is to determine whether the number of occupants in a car trip varies because of the socio-demographic situation of the respondent in terms their age and household groups or to see whether urban form factors have any influence. The number of occupants is categorised from one to five or more per car trip. The data is presented as the total number of occupants and as a percentage of all car trips made.

#### 5.14 URBAN FORM VARIABLES

5.14.1 The urban form variables examined in this research include the following:

1. Total Land Use;
2. Mix of Land Use;
3. Street Layout;
4. Number of Commercial Establishments;
5. Dwelling Types;
6. Population and Dwelling Density.

5.14.2 These six variables as indicators of urban form have all been studied in relation to travel behaviour by the researchers discussed in the Literature

Review. The variables have been selected as they characterise the type of urban form patterns that exist within the eight ASP Zones.

#### 5.14.3 Total Land Use:

5.14.3.1 Total land use is defined in this research, as the total amount of land currently used or zoned for use residential, commercial or industrial uses. The total land use variable is not mentioned as being calculated for the research discussed in the Literature Review. This variable gives an indication of the proportion of land allocated for different uses within a ASP Zone. The total land use figures, exclude council or community land including, public open space, recreation areas, schools, hospitals, motorways and roading, unless these structures or areas are included in commercial, industrial or residential zones.

5.14.3.2 The source of the data is from the Auckland Regional Council 1993. The data is organised into the amount (check hectares) of land in each ART Zones. The data was built up to ASP zones using a Equivalence tables that showed which ART zones grouped together form an ASP zones. The data for industrial, commercial and residential of land uses is categorised into vacant and the total amount of zoned land for each of these uses. The amount of occupied land use is calculated:

$$\text{Occupied Land} = \text{Zoned Land Use} - \text{Vacant Land}$$

5.14.3.3 The zoned commercial and zoned industrial data from ART Zone 8 (which is one of the five ART Zones that comprise the ASP Zone 18) was not available. The data for ASP Zone 18 has therefore been averaged among the other four ART Zones. The data is organised into the percentage (%) of vacant and functioning land uses for each of the eight ASP zones.

#### 5.14.4 Mixture of Land Use:

5.14.4.1 The mix of land use is described as the distribution of the different land uses throughout the zone. Kockelman (1995) constructed a land use mix

(dissimilarity) index to calculate the dissimilarity of land uses influences travel patterns. While this research does not calculate whether this variable alone has any effect on travel behaviour, this concept has been adapted to form a land use mix variable that assists in the characterisation of the urban form patterns. The index constructed for this research is a more simplistic version of the one calculated in Kockelman's research.

5.14.4.2 The mix of land uses within a ASP zone is classified into three types of uses zoned residential, public open space and commercial/industrial land. The district council zoning maps used show the land uses that are allowed/or exist under special use rights within particular sections within a city. The location and size of these land uses is shown in the zoning maps. The residential, commercial/industrial and public open space land uses are used to calculate the land use mix variable as these categories are common to all four council's district plan zoning maps. A box was constructed for each of the different scaled maps based on a box size of 5 cm x 5 cm for 1: 10, 000 scale map. This was measured at 5 cm intervals to obtain 50% coverage of the sample. (figures and box size adjusted for different scales of maps) The number of squares allocated to each of the land uses was then calculated. As the zoning maps contain other land uses including community Services, hospitals, community halls, fire stations, schools and motorway and roading provision, works areas these were calculated but are excluded in the presentation of the results. This is because the purpose of the land use was not always stated on the maps. The data is determined as a percentage for each box, approximately 30 to 37 boxes of data were sampled for each ASP Zones. The data is organised into the percentage of different land uses for each ASP Zone. Data is limited because restricted to what is zoned or proposed on zoning maps not actually what is built.

#### 5.14.5 Street Layout

5.14.5.1 The Street layout is defined as the number of three or four way street intersections in each ASP zone. The street layout variable is calculated in both Cervero and Gorham (1995), Cervero and Radisch (1996), and Handy (1995) research. The street layout variable has been calculated from the

approach used in their research. The source of this data is the four district council zoning maps listed above for each ASP zone. This variable is calculated by counting the number of three and four way street intersections that are either in/or the street faces into the ASP Zone. The five or six way intersections of were included into the four way intersection number and accounted for less than 0.5% of the total number in each zone. The data is presented as the percentage of three and four way street intersections for each of the eight ASP zones.

#### 5.14.6 Number of Commercial Establishments

5.14.6.1 The number of commercial establishments variable calculates the number of different types of shops and services that operate within a ASP Zones. This variable is calculated in Handy (1992) and (1995) research to identify whether more shopping trips were made in those zones with a higher proportion of shops and services per population. The commercial establishments examined in research are selected because they may induce local travel within a ASP zone. The data is organised from the ARC database into the total number each type commercial establishments for the eight selected ASP Zones. As the land and population size of each of the eight ASP Zones differ, the number of commercial establishments were divided by total population for each of the ASP Zones and multiplied by 10 000 to calculated the number of units per 10,000 of population. The data is classified according the New Zealand Standard Industrial Classifications (Refer Appendix 3).

#### 5.14.6 Dwelling Types

5.14.6.1 Handy (1995) identified the number of different dwelling types of houses within the zone. The purpose of calculating this variable is to determine whether there is any differences in types of household accommodation between ASP Zone 2 and the other zones. The classifications of dwelling types to determine whether the range of housing is more diverse in any particular zone. Particular note will be made in reference to the two or three

or more joined flats - which suggests more denser living, and flats attached to a shop categories - suggesting greater mix of uses within the zone.

5.14.6.2 This is calculated as the number of households residing in different dwelling types for the eight ASP Zones. The data is extracted from the Supermap Statistics New Zealand Census 1991. The census data has been classified into the following categories for this thesis.

Data Classifications:    Separate House;  
                                       Two Flats or Houses Joined Together;  
                                       Three or More Flats or Houses Joined Together;  
                                       Flat or House Joined to a Business or Shop;  
                                       Hotel, Motel or Guest House;  
                                       Home for the Elderly;  
                                       Not Specified Private Dwelling;  
                                       Other Dwelling Types (Bach, Crib or Hut - not in  
     work camp);  
                                       Caravan, Cabin or Tent in a Motor Camp; Boarding  
     House; Other Non- Private; Other (Private)  
                                       Total

The data organised into the percentage of dwelling types for households per ASP Zone.

#### 5.14.7 Population and Dwelling Density

5.14.7.1 Population, employment and residential density are commonly used variables that characterise the urban form of an area. Population density is a figure that shows the amount of people living per hectare in for a specified area and has been calculated in research such as Newman and Kenworthy (1989) & (1991) for different cities, Kockelman 1995 for traffic analysis zones and census tracts, Holtzclaw (1990) & (1994) “gross population density” figure for neighbourhoods. Other variables such as “net household density” calculated by Holtzclaw (1990) & (1994) indicates the number of households per neighbourhood. “Residential density”, calculated by Ewing

et. al. (1993), Brunton (1996), and Cervero and Gorham's (1995) "net residential density" figures indicate the average number of people per unit of residential land. These density variables are calculated to determine whether a higher level will result in more public transport or walking, cycling modes than automobile transit. A population density, household or dwelling density variable have been calculated for this research.

5.14.7.2 An employment density variable has also been calculated in Holtzclaw (1990) & (1994), Ewing et. al. (1993), and Brunton (1996) research. This figure indicates the number of jobs per land area to indicate if more travel incurs within the zone with a higher employment density figure. requires data on the amount of jobs that exist within a land area. This variable requires data on the amount of jobs per zone, unfortunately attempts to collect this data revealed that it was not available.

5.14.7.3 The population density figure is calculated by dividing total population by total land area to determine the number of people living per hectare for each of the ASP Zones. There are two sources of data used calculate this figure; total land area (measured in hectares) was calculated from district council zoning maps, and the total population for each of the eight ASP Zones was collected from the New Zealand Census - Supermap 1991. Total dwelling density is calculated as the total number of dwellings per hectare for each of the eight ASP Zones. The data for the total number of dwellings was collected from the Supermap New Zealand Census 1991.

5.15 CASE STUDY - CHARACTERISTICS OF ASP ZONES

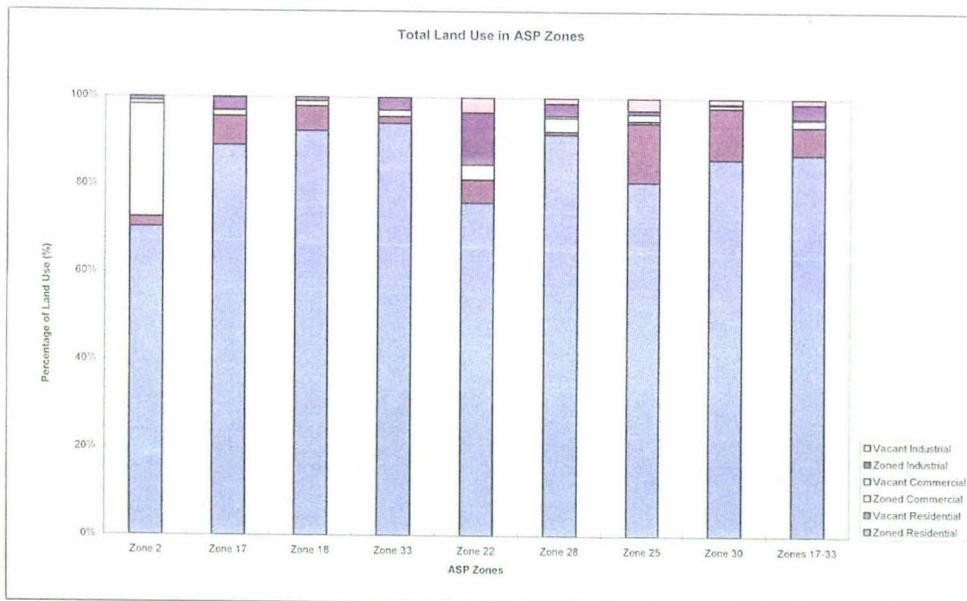
URBAN FORM VARIABLES

The urban form of the eight ASP Zones is characterised in the following graphs.

5.15.1 Total Land Use

5.15.1.1 Figure 19, below shows total amount of land vacant and zoned for residential, commercial or industrial purposes. The land use differences are discussed below for the matched pairs.

Figure 19: Total Land Use



5.15.1.2 Figure 19 shows that available land in Zone 2 is mostly (70.3%) used for residential purposes. However a significant proportion (25.7%) of available land is used for commercial purposes; an amount considerably larger than the other zones. This may be due to its location adjacent to the CBD area; therefore containing commercial activities that wish to locate near to the

CBD. Zone 2, is characterised as containing a minimal proportion (0.9%) of land available for industrial uses. The amount of vacant land in the zone is also low (2.2% residential, 0.9% commercial, and 0% for industrial uses). This indicates that Zone 2, is a predominately developed zone. Zone 17, is mainly (95.6%) comprised of land dedicated to residential uses; a proportion (6.6%) of which is still vacant. The location of Zone 17, (in close proximity to the CBD linked by the Auckland Harbour bridge) therefore has not instigated the level of commercial and industrial development evident in Zone 2.

5.15.1.3 Nearly all of the land available in Zone 18 and 33 for residential purposes (98% and 95.6% respectively). The main difference between these two zones is that Zone 18 has generally more (5.6%) vacant residential land than Zone 33 (1.5%).

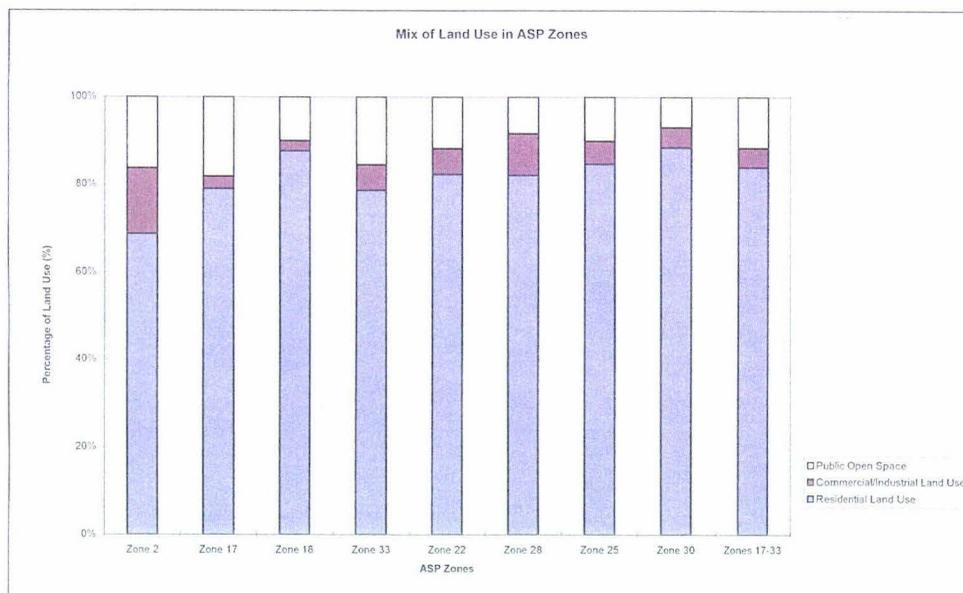
5.15.1.4 Zone 22, has the largest (15.3%) amount of industrial land available of all the zones; of which only (3.4%) is unoccupied. The amount of industrial land in Zone 28, however is relatively low (4.1%) in comparison to its matched pair Zone 22. Both the zones have a similar level of commercial activities (3.4% and 3.1% respectively). The proportion of vacant residential land in Zone 22 is higher (5.6%) than in Zone 28 (0.7%).

5.15.1.5 Residential activities predominate in Zones 25 and 30, comprising of 80.6% and 86.1% respectively. A further 13.6% and 11.8% of land is vacant residential land. Both these Zones are located on the periphery of the cities urban areas. This indicates that these zones are still being urbanised.

## 5.15.2 Mix of Land Use

5.15.2.1 Figure 20 below indicates the 'mix' or distribution of residential, commercial/industrial and public open space within the eight ASP Zones.

Figure 20: Mix of Land Use



5.15.2.2 Figure 20 shows that Zone 2, has the greatest distribution of the land uses around the zone. The results identify that within an area of 500 square metres in Zone 2, approximately 68.7% of all zoned land is for residential uses, 15% for commercial and 16.3% is public open space. Zone 17, can be characterised as having a relatively low (2.8%) distribution of commercial and industrial land. This is supported by results in Figure 19 which indicate that Zone 17 contains significantly less commerce and industry than Zone 2. Both these zones contain a generally greater distribution of public open space than the other zones. (Zone 2 - 16.3%, Zone 17 - 18.2%)

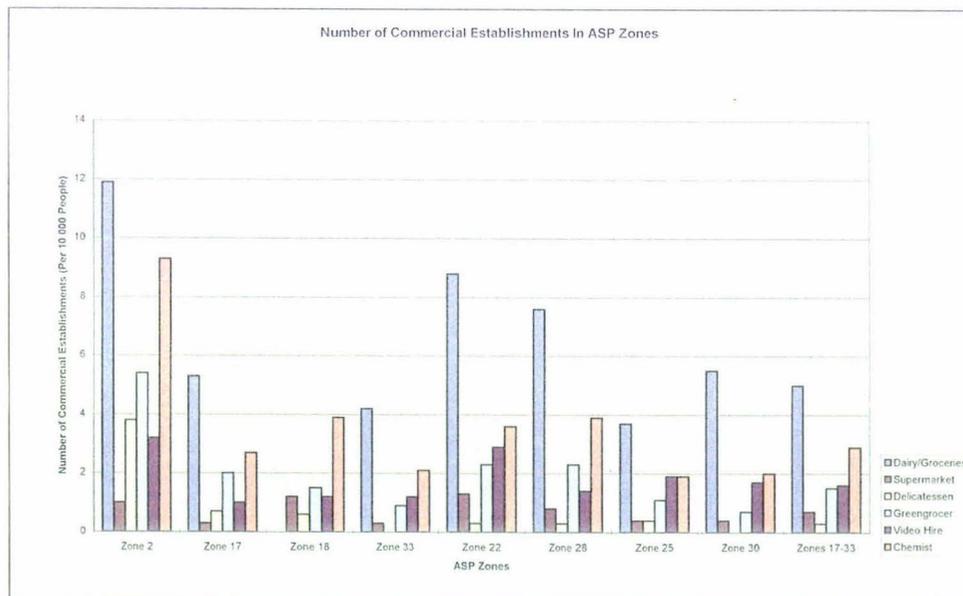
5.15.2.3 While Zone 18 and 33 have similar proportion of residential, commercial and industrial land uses, Figure 20 shows that the different land uses are more evenly distributed in Zone 33. The results also show that Zone 33 has a slightly greater (15.5%) distribution of public open space than in Zone 18 (10.0%). It should be noted that the Northern side of Zone 18 contains a significant area devoted to rural land which was not incorporated into the public open space calculations.

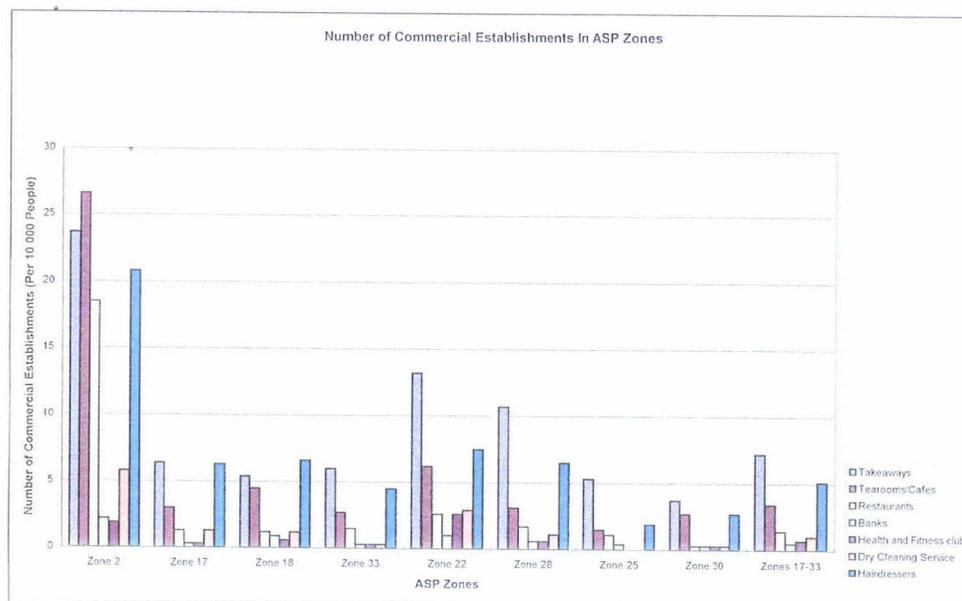
5.15.2.4 Figure 20 shows that the average distribution of land uses is similar for Zones 22 and 28. Zone 28 has slightly (9.6%) greater distribution of commerce and industry throughout the zone than Zone 22 (5.9%). Zone 25 and 30 again have a similar average distribution in land uses, with Zone 25 containing a slightly greater (10.0%) distribution of public open space than Zone 30 (6.9%).

5.15.3 Amount of Commercial Establishments

5.15.3.1 Figures 21 and 22 below indicate the amount of different types of commercial establishments per 10 000 people in each of the ASP Zones.

Figure 21 and 22: Amount of Commercial Establishments



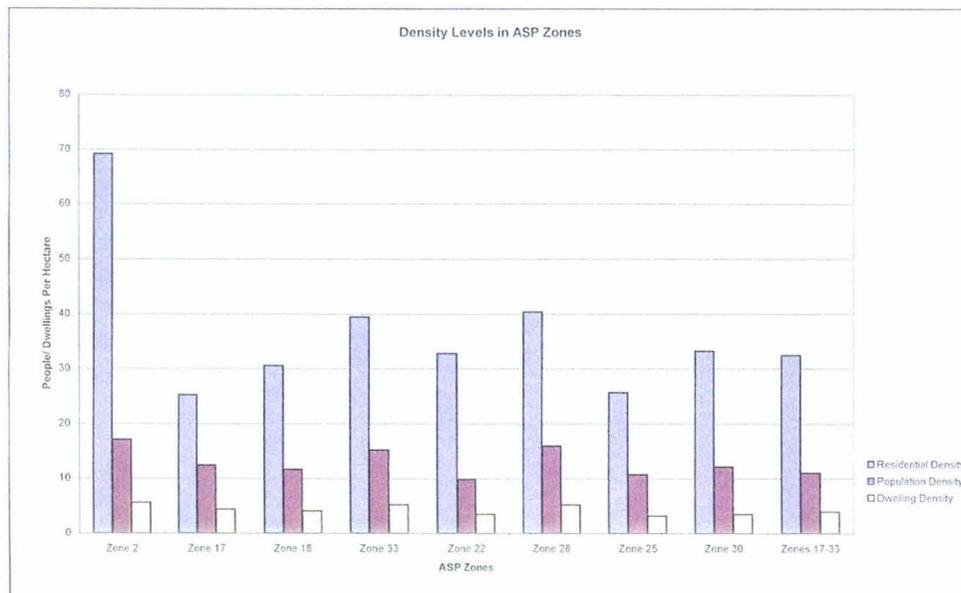


5.15.3.2 Figure 21 and 22 shows that the most common commercial establishments within the zones are mainly food outlets including the takeaway, tearooms/cafes dairies/groceries outlets, and hairdressers, and chemists are more commonly found in the ASP zones. Overall Zone 2, has significantly more of the commercial establishments than the other zones containing significantly more takeaways, tearooms/cafes, restaurants and dairies/groceries than the other zones. The number of chemists, video hire, hairdressers, drycleaners and banks in Zone 2 is slightly higher than the other zones. However the amount of supermarkets in Zone 2 is similar to the amount in the other zones. This data supports the results shown in Figure 19 which shows that Zone 2 has the largest proportion of occupied commercial land of all the zones.

#### 5.15.4 Population, Residential and Dwelling Density

5.15.4.1 Figure 23 shows the population density and dwelling densities for the eight zones.

Figure 23: Population, Residential and Dwelling Density

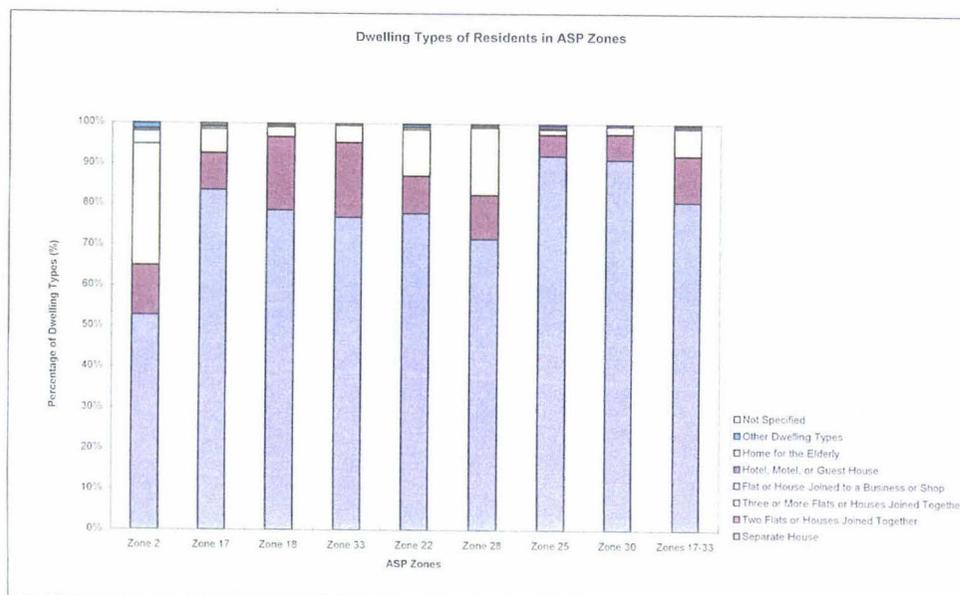


5.15.4.2 Figure 23 shows that residential, population and dwelling density levels follow the same pattern. Zone 2, has the greatest population (17.2 people per ha), dwelling (5.9 dwellings per ha) and residential (69 people per ha) density levels. The residential density level is significantly higher in proportion than the other density measures. This may be attributed to the lower proportion of residential land within ASP Zone 2, concentrating residential population density. Zone 33 (15.3 people per ha, 5.2 dwellings per ha, 39.5 per residential ha) and 28 (16 people per ha, 40.4 people per residential ha) exhibit next highest density levels. The zone with the lowest density levels is Zone 23 with 10.8 people per ha, 3.2 dwellings per ha and 25.7 per residential ha.

### 5.15.5 Dwelling Characteristics

5.15.5.1 Figure 24 shows the percentage of different dwelling types for the eight zones.

Figure 24: Dwelling Characteristics



5.15.5.2 Nearly half (52.8%) of all the dwellings in Zone 2 are separate houses. This amount is significantly less than for the other eight zones. A large proportion of dwellings in Zone 2 are either three or more flats or houses joined together (approximately 30%) or two flats or houses joined together (approximately 12%). The New Zealand census does not identify whether these the flats or houses are part of a multi-storey apartment building or ground level attached flats or houses. It should be noted that the proportion of flats or houses joined to a business or shop (3.2%) is higher in Zone 2 than the other zones. This supports the theory that Zone 2 is a more mixed land use than the other zones within Auckland.

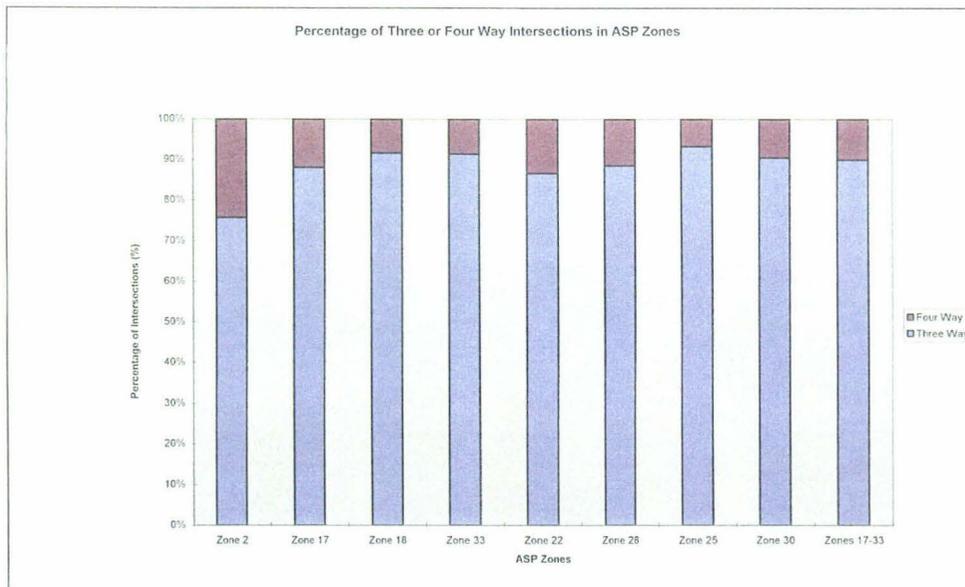
5.15.5.3 Most (83.6%) of the dwellings in Zone 17, are separate houses; the remainder of dwellings is mainly comprised of joined houses and flats.

Figure 24 shows that both Zone 18 and 33 have a similar proportion of dwellings within the zones. Zone 18 (78.5%) and 33 (76.9%) mainly consist of separate houses. The two zones do however have the greatest proportion of two houses and flats joined together than any of the zones (18.2% and 18.5% respectively). While Zones 22 and 28 have mainly separate house dwellings, the two zones contain the greatest number (11.5% and 16.7% respectively) of three or more houses and flats joined together, after Zone 2. A significant proportion of all dwellings are also two flats and houses joined together in Zone 22 (9.3%) and 28 (10.8%). Zones 25 and 30 again have similar proportions of dwelling types, most of which are separate houses (92.2% & 91.3%).

5.15.6 Street Layout

5.15.6.1 Figure 25 below shows the percentage of three and four way intersections in each of the ASP Zones.

Figure 25: Street Layout



5.15.6.2 While the street pattern in Zone 2 is predominately curvilinear (75.7%), it contains the highest number of four way intersections (24.3%) of all the zones. All the other zones have between 7% and 13% of all intersection being four way. Zones 22, 17, and 28 all contain about 11% to 13% of four way intersections.

5.15.6.3 The results shows that Zone 2, differs in urban form characteristics from the other seven zones. It can be characterised as having a greater:

- mix of land uses and dwelling types;
- number commercial establishments within the zone;
- residential, population and dwelling density levels; and
- number of four way intersection and therefore a more grided street pattern.

5.15.6.4 Zone 2, can be described as the oldest and most well established zone which is indicated by the low (3.1%) percentage of vacant land in the zone. The zone is located in a semicircle surrounding the southern side of the CBD area. The Zone therefore has the highest amount of commerce (25.7%) and distribution (15.0%) of this, throughout the zone of all the zones studied. The residential density ratio is significantly higher than the other zones at 69.2 people per ha. This may be a product of the number of joined flats and houses in the zone, which account for 45.3% of all dwellings in the zone. While the street layout is mainly curvilinear (75.7% three-way intersection) the results suggests that portions of the zone, take on a grid like pattern. These areas may have been laid out prior to the popular implementation of curvilinear street patterns which are predominately found throughout the rest of the City. These attributes are identified in Neo-Traditional Development researchers, as potential ways of reducing automobile travel and redirecting demand for non-vehicular modes of travel. Both the results shown here and preliminary investigations indicate that Zone 2 is the only zone to contain the combination and scale of NTD characteristics discussed in the Literature Review.

5.15.6.5 While Zone 17 is linked to the CBD area by the Auckland Harbour Bridge, it does not exhibit the urban form characteristics that exist in Zone 2. The results show that the zone has relatively low level of commercial and industrial activity (4.1%) and relatively low density living, comprising mainly separate houses (83.6%). The zone has an average density ratios compared to other zones and has an average number of commercial establishments within the zone. The zone has a predominately curvilinear street pattern (88% of all intersections are three way). The zone can therefore be characterised as being a predominately residential or suburban zone.

5.15.6.6 Zones 18 and 33, similarly have a low level of commercial and industrial activity within the zone (2.1% and 4.4% respectively) and distribution of this (2.3% and 5.9% respectively) within the zone. Zone 33 has a generally higher residential density (39.5 people per ha) level than Zone 18 (30.6 people per ha). However Zone 33 has only slightly higher population and dwelling density than Zone 18. The proportion of dwelling types is almost identical for the two zones. This may potentially be explained by the proportion of vacant residential land in the zones. (Zone 18 - 5.6%, compared to Zone 33 1.5%). Both the zones predominately have curvilinear street patterns (Zone 18 - 91.6% and Zone 33 - 91.4% three way intersections). The results indicate that the two zones are once again residential or suburban zones.

5.15.6.7 Zone 22 and 28 have the highest proportion of land uses for commercial activities after Zone 2. Zone 22 has the most (11.9%) land used for industrial activity than any of the zones. The two zones also have the greatest number of commercial establishments after Zone 2, these predominately including food outlets such as dairies and groceries, takeaways, cafes and tearooms. Residential, population and dwelling density is relatively higher in Zone 28 than in Zone 22. This may be attributed to the proportion of joined houses or flats (approximately 27.9% of all dwellings). Zone 22, has a relatively low residential, population and dwelling density rate, despite the fact that 21.3% of all dwellings are joined houses or flats. This may be partially attributed to the greater proportion of vacant

residential land (5.3%) in Zone 22 than Zone 28 (0.7%). The two zones both have a predominately curvilinear street pattern (Zone 22 - 86.6% and Zone 28 - 88.5%) while these zones exhibit slightly more NTD characteristics than the other zones studied these are not of the scale or combination of that found in Zone 2.

5.15.6.8 Both Zones 25 and 30 are characterised as containing the lowest amount and distribution of commercial and industrial activity of all the zones. The two zones have the largest amount of vacant land (commercial, industrial and residential) which totals 18% in Zone 25, and 13.1% in Zone 30. The two zones generally have the lowest level of commercial establishments per zone, with the exception of dairies and grocery establishments. Zone 25 has the lowest residential, population and dwelling density ratios and the lowest proportion of joined flats or houses of all the zones with 92.2% of all dwelling being separate houses. These two zones again are primary curvilinear street patterns. Zones 25 and 30 can therefore be characterised as being primarily newer residential zones due to the notable proportion of vacant residential land in the zones. While there is slight differences in land uses, dwelling types, street patterns, and density levels, all the zones apart from Zone 2 do not exhibit NTD characteristics.

#### 5.15.7 Public Transport Provision - Bus Provision

5.15.7.1 The Yellow Bus Company is a major bus transport provider in Auckland City. Table 19 below indicates the frequency of bus services within the ASP Zones. The data contained in the table only includes standard bus routes, Flyer and Express buses were not included in this data collected.

Table 19: Bus Routes within the ASP Zones

BUS ROUTES	Zone 2	Zone 17	Zone 18	Zone 33	Zone 33	Zone 28	Zone 25	Zone 30
Main Individual Bus Route	9	N/A*	4	N/A*	10	6	1	1
Less Frequent Bus Routes	4	N/A*	2	N/A*	5	2	2	0
Roads Served by a Number of Bus Routes to Different Designations	3	N/A*	0	N/A*	1	0	0	N/A*
Major Streets Not Served by Bus Route	23	N/A*	0	N/A*	9	2	N/A*	N/A*

\*N/A - Data Not Available Source: The Yellow Bus Company Network Map Printed in 1993.

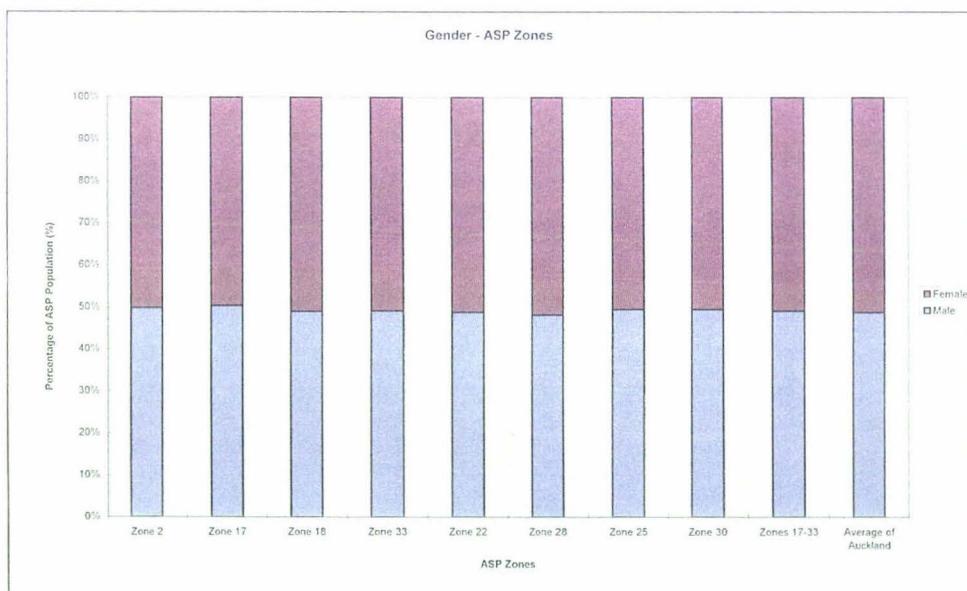
## 5.16 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF ASP ZONES

5.16.1 The socio-demographic characteristics of the populations residing in the eight ASP Zones is shown below. The source of data is both from New Zealand Census and Household Travel Survey. The average for the Auckland region from the New Zealand Census is included in the Figures 26 to 36 below.

### 5.16.2 Gender

5.16.2.1 Figure 26 shows the gender ratio for the eight Zones. This data is collected from the New Zealand Census.

Figure 26: Gender

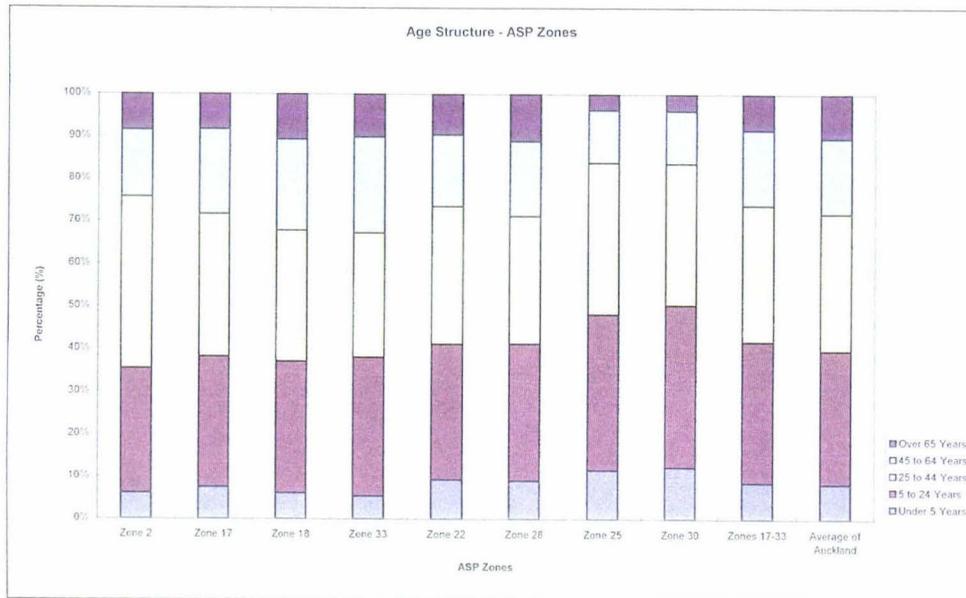


5.16.2.2 Figure 26 shows that all the eight zones have an equal gender ratio.

5.16.3 Age Structure

5.16.3.1 Figure 27 below, shows the age structure of the respondents in the eight ASP Zones. This data is collected from New Zealand Census data

Figure 27: Age Structure



5.16.3.2 Figure 27 shows that while the matched pairs generally have similar age structures, they differ between the pairs. The first major observation is that the largest age group is those aged between 25 to 44 (32.0%) which is slightly higher than the 5 to 24 age group (31.4%). Of note is the number of elderly (10.4%) exceed the number of children under five years (8.3%).

5.16.3.3 The major difference between Zone 2 and 17, is that Zone 2 has more people aged 25 to 44 (40.2%) than Zone 17 (33.5%) with a difference in the age group 45 to 64 (4.2%) between the two zones. The other two age groups have a difference of less than 2%. While both the zones have a similar proportion of people in the under five, 5 to 24 age groups the zones have an above average proportion of people in the age group 25 to 44 years, by about 1.5% for Zone 17 and 8.2% for Zone 2. Only Zone 17 has an above average

figure in the 45 to 64 age group by about 2.0%, Zone 2 is below this by 2.0%. The percentage of people in the over 65 age group is about 2.0% lower in both the zones than the Auckland average. The two zones can therefore be characterised as a mid - adult population base.

5.16.3.4 Zone 18 and 33 have remarkably similar age structures, the greatest difference of +/-1.7% in the 25 to 44 age group. The two zones have the lowest number of children aged under five of all the zones (Zone 18 - 6.1% and Zone 33 - 5.4%), this is also below the average for the Auckland (8.3%) region. The two zones also have an average proportion of people in the 5 to 24 and 25 to 44 years and over 65 years age groups. The two zones do however have significantly more people in the 45 to 64 years age group than any of the other zones, approximately 5.0% higher than the average for Auckland. These two zones can therefore be characterised as having the most similar distribution of ages to the average of all the zones.

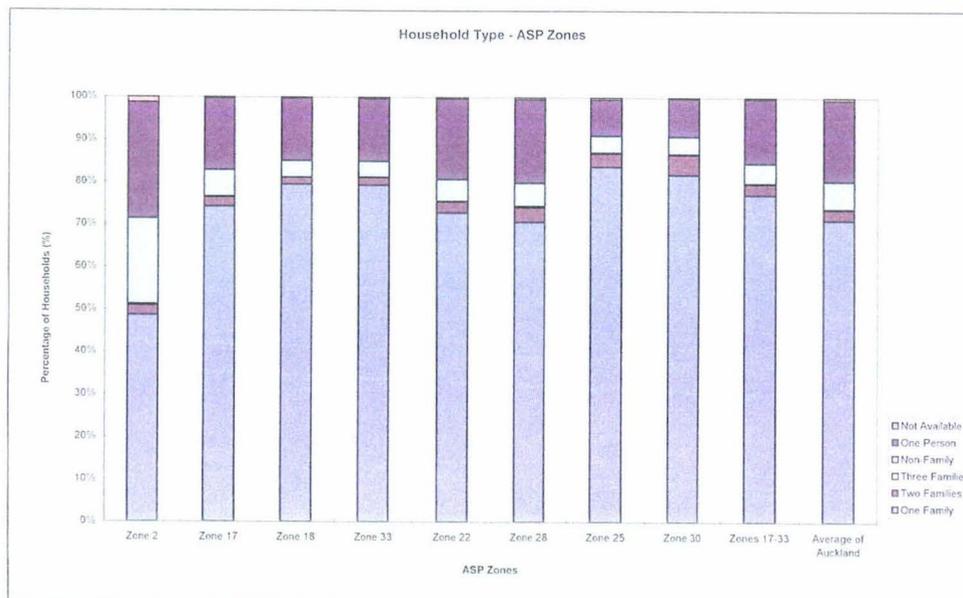
5.16.3.5 Both Zone 22 and 28, again have a highly similar in age structure pattern, the greatest difference of 2.4% in the 25 to 44 age group. The age structure for the two zones is quite similar to the average for Auckland. The variations from the average, are all less than 2.0 %. This zone can be characterised as having the most similar distribution of ages to the average of all the zones.

5.16.3.6 Zones 25 and 30, also have a highly similar age structure pattern, with the largest difference of +/- 2.5% in the age group 25 to 44 years. Zones 25 and 30, are comprised of the greatest proportion of children under five years of all the zones (11.6% and 12.3% respectively), compared to 8.3% the average for Auckland. The two zones have predominately more people aged between 5 to 24 years (36.6% and 38.1% respectively) than any of the other zones, this figure is above the average for Auckland by approximately 6.0%. The two zones both have lowest number of people aged 45 to 64 years (5.4% less than the average) and over 65 years (5.0% lower than the average) of all the zones. These zones can therefore be characterised as having a youthful population.

#### 5.16.4 Household Type

5.16.4.1 Figure 28 shows the percentage of different households types that exist within each zone. The data is calculated from New Zealand Census 1991.

Figure 28: Household Type



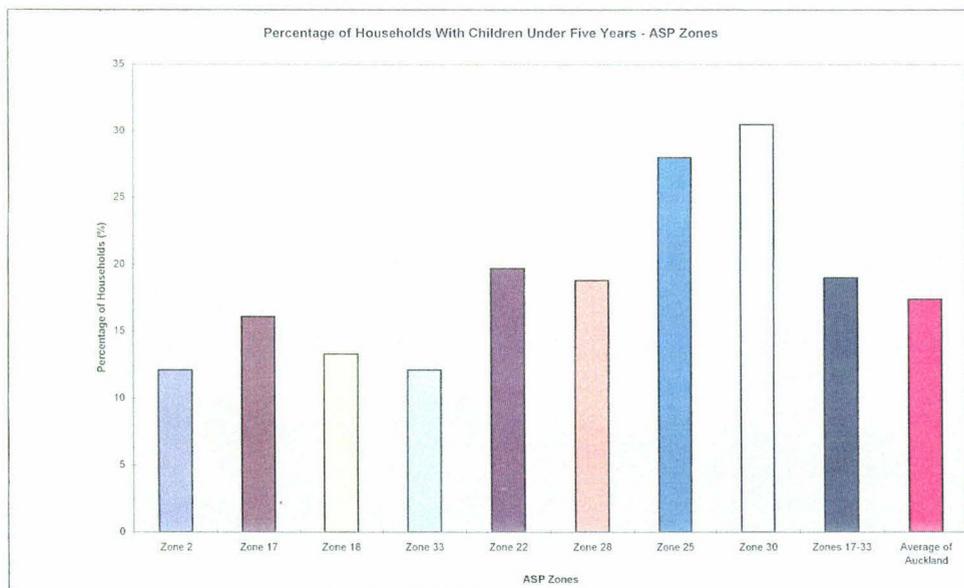
5.16.4.2 Nearly half (51.3%) of all the households in Zone 2 are comprised of families. This is a significantly lower proportion than the other zones (Zones 17-33 - 77%) and compared to the average (73.4%). The remaining proportion of households are non-family (20.1%) and one person (27.4%) households. The majority (76.5%) of households in Zone 17 are families. All the other three pairs of zones have highly similar household type patterns, with less than 2% between each category in the pairs. Zones 18 and 33 are mainly (81.1% for both zones) comprised of family type households. The number of two and three family households is the lowest for these two zones (1.6% and 1.8%) These two zones have the lowest number of non-family households (3.9% and 3.7% respectively) of all the zones. This is somewhat lower than the average for Auckland of 6.7%. Zones 22 and 28 are mainly comprised of family-type households (75.4% and 74.3% respectively), this is

slightly lower than the average for Auckland (76.4%). These two zones contain an above average proportion of single person households (18.9% and 19.6% respectively) than the other zones (after Zone 2); this is slightly above the average for Auckland (16.6%). Zones 25 and 30 have the greatest proportion of family households of the other zones (87.1% and 86.7% respectively); this is significantly greater than the average for Auckland (76.1%). These two zones have the greatest proportion of two and three family households (3.3% and 4.9% respectively) The two zones have significantly lower proportion of one person households 8.5% and 8.9% compared to 16.6% the average for Auckland.

### 5.16.5 Households With Children Under Five Years

5.16.5.1 Figure 29 shows the percentage of households that have one or more children under five years. This data has been calculated from the New Zealand Census 1991.

Figure 29: Households With Children Under Five Years

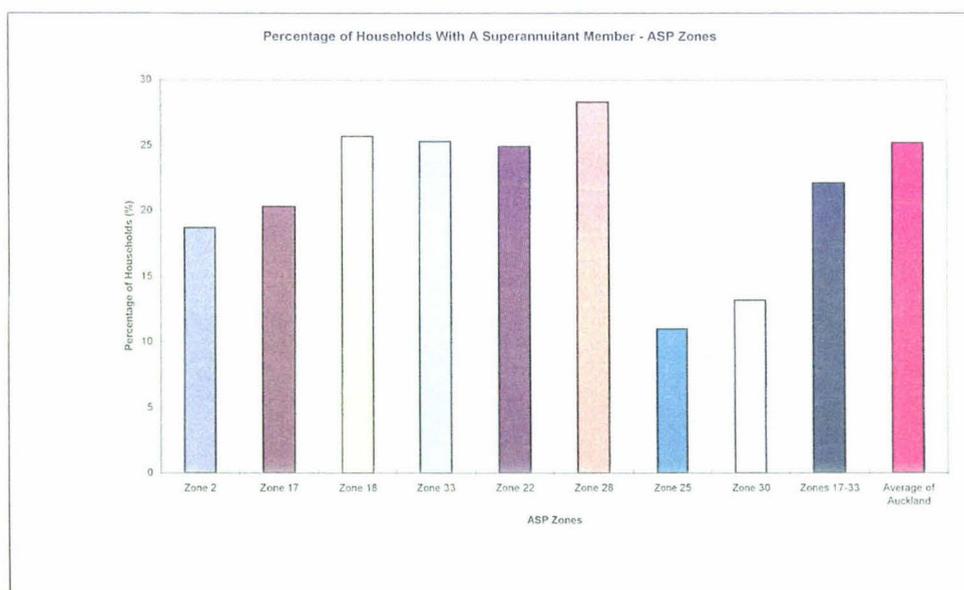


5.16.5.2 Zone 2 (12.1%), 18 (13.3%) and 33 (12.1%) all have slightly below average proportion of households with children under five years; compared to 14.1% figure for the Auckland average. Zone 17 has slightly more households with children (16.1%) than Zone 2. Zones 22 and 28 have slightly more households with children than the average (19.7% and 18.8%); while Zones 25 and 30 have over twice the proportion of households with children under five (28.0% and 30.5%), than the average for Auckland (14.1%). This figure is significantly higher than the other zones.

### 5.16.6 Households With Superannuitants

5.16.6.1 Figure 30 shows the number of households with one or more superannuitant members. This data is calculated from the New Zealand Census 1991.

Figure 30: Households With Superannuitants



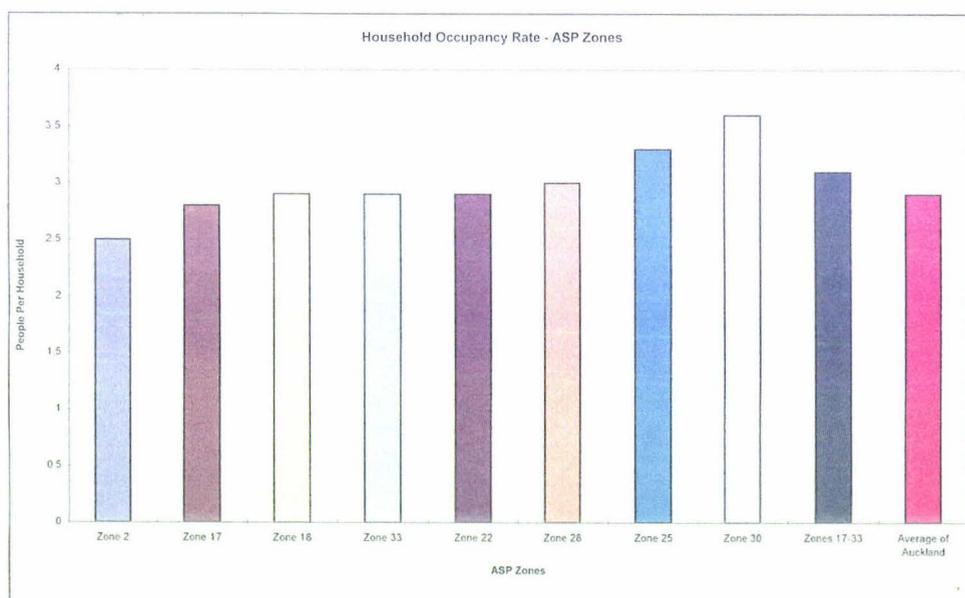
5.16.6.2 Zones 2 and 17 contain a smaller proportion of households with superannuitants (18.7% and 20.3% respectively) than the average for Auckland (21.7%). Zones 18, 33, 22 and 28 all have slightly higher proportion of superannuitants than the average for Auckland. It should be

noted that Zone 28 has significantly more superannuitants than any of the other zones at 28.3% of all households in the zone. Zones 25 and 30 have significantly lower proportion of households with superannuitants (11.0% and 13.2% respectively), than the other zones and the average for Auckland (21.7%).

#### 5.16.7 Household Occupancy Rate

5.16.7.1 Figure 31 shows the average number of occupants in each household for the eight zones. The data is calculated from New Zealand Census 1991.

Figure 31: Household Occupancy Rate



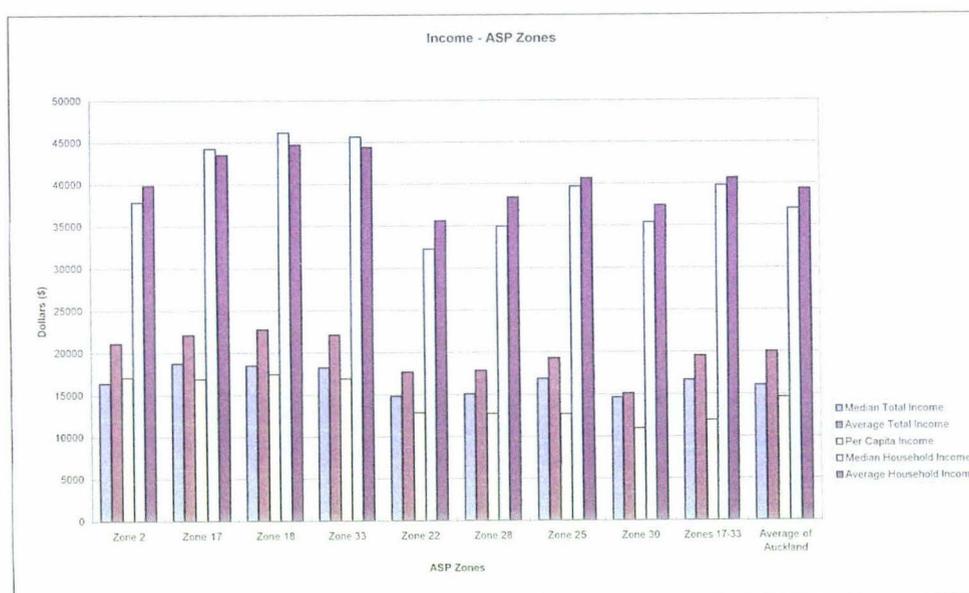
5.16.7.2 Figure 31 shows that Zones 17, 18, 33, 22 and 28 all have similar household occupancy rates; these values are also within +/- 0.1 variation of the average for Auckland (2.9 people per household). All of these five zones are mainly comprised one family households and contain a lower proportion of one person households than Zone 2. Zones 25 and 30 have higher values (3.3 and 3.6 people per household) than all the other zones and are above the average for Auckland (2.9 people per household). This may partly be explained by

both these two zones containing the lowest proportion of one-person households of all the zones. The two zones also contain the greatest number of two and three family households of all the zones.

### 5.16.8 Income

5.16.8.1 Figure 32 shows five different measures of income for the zones, from the New Zealand Census 1991.

Figure 32: Income



5.16.8.2 Figure 32 shows that level of income varies according to the measurement.

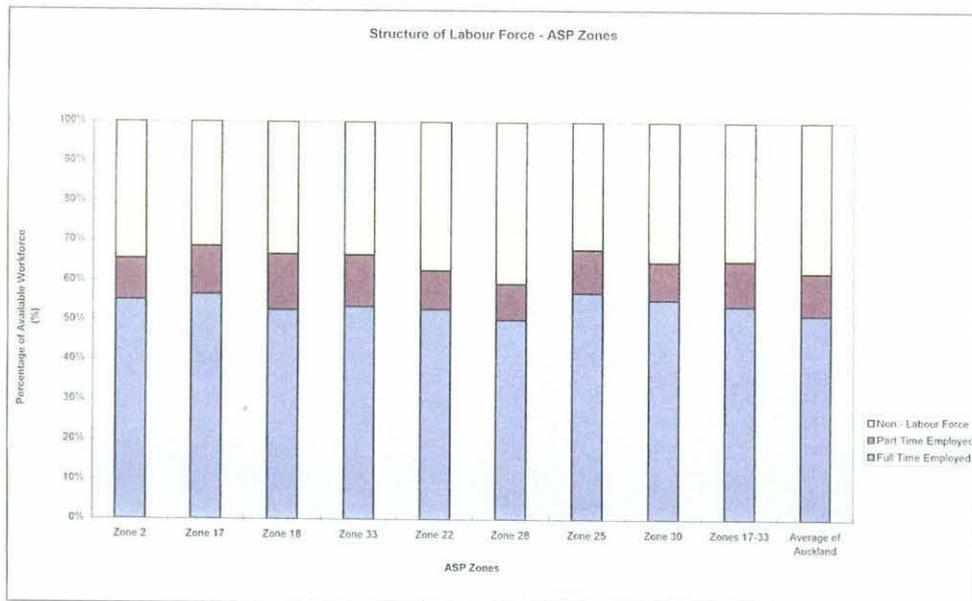
Overall the results indicate that Zone 18 and 33 have the highest income level. These two zones are above the Auckland average by approximately 2 000 dollars per person or 4 000 to 9 000 dollars per household. Both Zone 2 and 17 vary according to the different measurements. Overall the level of income in Zone 2, is slightly lower than Zone 17, however the income for Zone 2 are comparable to the average for Auckland. Zone 22 and 28 are relatively similar across the different measures (Zone 28 is slightly higher than Zone 22 in household income measures). These two zones are

consistently below the average for Auckland and are the lowest overall level of income of all the zones. Zone 25 and 30 differ slightly in income levels across the different measurements. Zone 25 tends to be slightly higher than Zone 30 in all the measurements. Zone 25 tends to be slightly higher than Zone 30 in all measurements. Zone 25 tends to be slightly higher than Zone 30 in all the measurements. Zone 25 tends to be similar to the average for Auckland but just slightly lower in some measurements, (per capita income, average income) while Zone 30 tends to be lower than the average in all five measurements.

5.16.9 Structure of Labour Force

5.16.9.1 Figure 33 below, shows the percentage of full time, part time and non-working people of the able working population for each zone. The data is calculated from New Zealand Census.

Figure 33: Structure of Labour Force



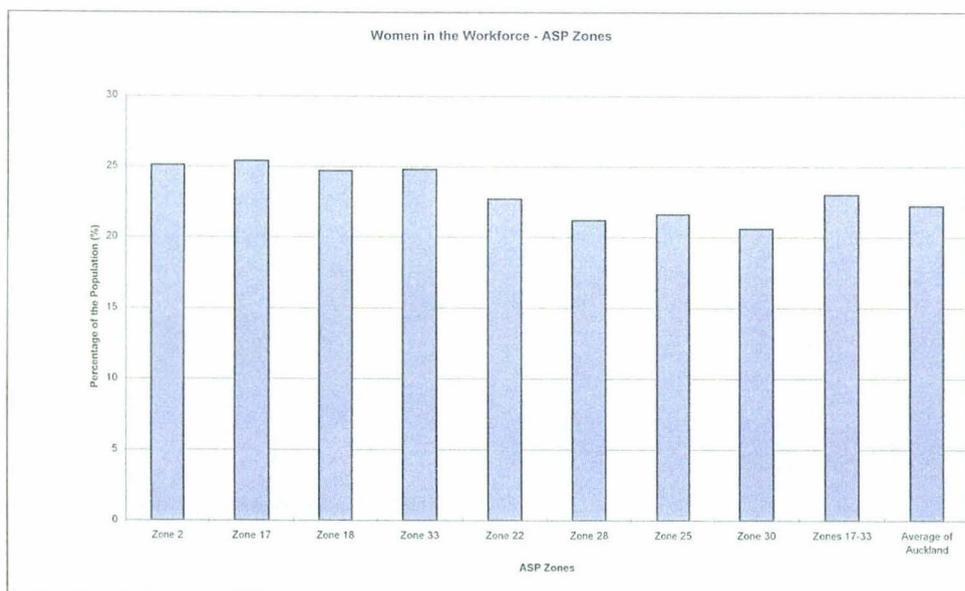
5.16.9.2 All the zones are relatively similar to their matching pair within +/- 3.0 difference for each category. All the zones vary only slightly from the

average for Auckland in all the categories. Overall zones 22 and 28 have a slightly lower proportion of full time workers than the other zones and the average. Zones 2, 17, 25 and 30 all have a slightly above average proportion of full time workers (55.2%, 56.6%, 57.1% and 55.4% respectively). Zones 18 and 33 have the highest number of part time employed (14.0% and 12.9% respectively) of all the zones. This is also slightly above the average for Auckland (11.1%) Zones 22 and 28 have the greatest proportion of non-workforce of all the zones (37.4% and 40.7% respectively); and compared to the average of 34.9% for Auckland.

#### 5.16.10 Women in the Workforce

5.16.10.1 Figure 34 shows the percentage of households with one or more working women. This data is calculated from New Zealand Census data.

Figure 34: Women in the Work Force



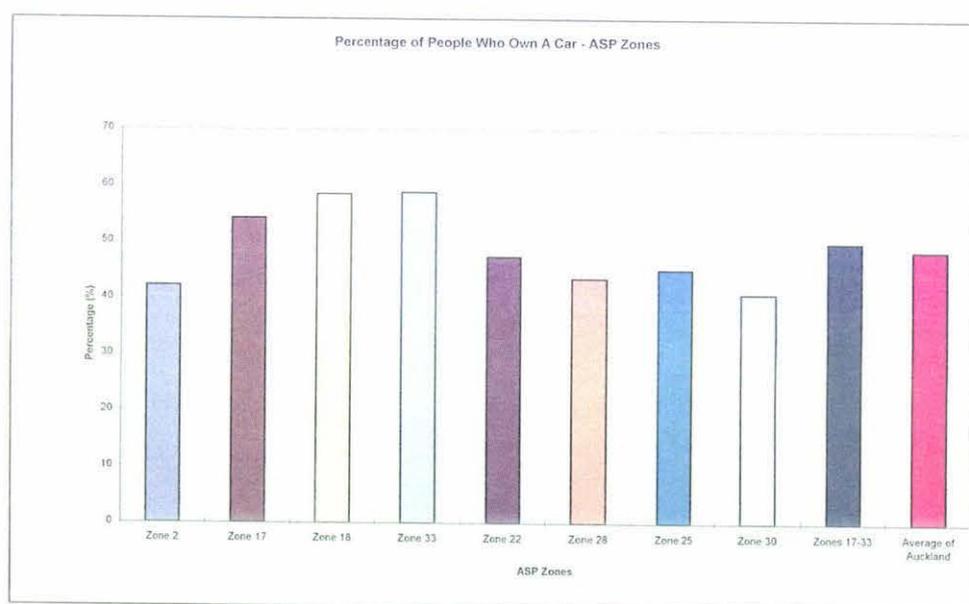
5.16.10.2 All the data for the eight zones is within +/-2.5% difference of their matching pair. The majority (74.8%) of all households in Zone 2 have one or more working women. This proportion is greater than the other zones and

is higher than the average for Auckland (66.2%). This is comparable to Zone 17 that has 72.9% of households with one or more working women. Zones 18, 33, 22 and 28 have comparable levels working women in households. Zones 25 and 30 have the least proportion of working women in households of all the zones. This may partially be explained by the slightly below average employment rate of these two zones.

#### 5.16.11 Car Ownership

5.16.11.1 Figure 35 shows the percentage of people that own a private car within the zones. This data is calculated from New Zealand Census data.

Figure 35: Car Ownership



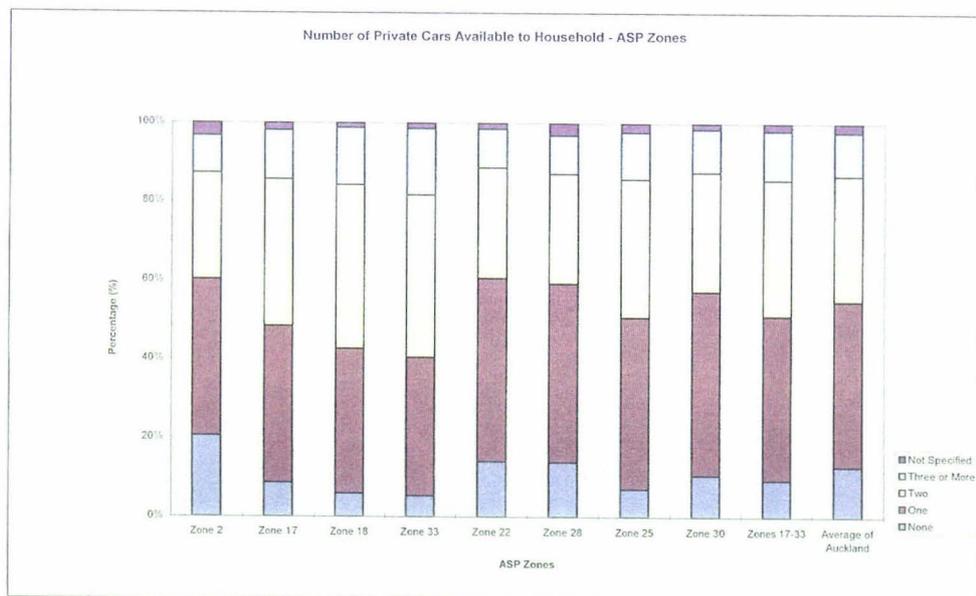
5.16.11.2 Zones 2 and 17 vary in car ownership levels. Under half (42.2%) of the people in Zone 2 own a car, whereas 54.2% of people in Zone 17 own a private car. More people in Zone 18 and 33 (58.5% and 58.8% respectively) own a car than in the other zones. This value is notably higher than the average for Auckland of 48.6%. Zones 28 and 30 have the lowest level of car ownership of all the zones (43.6% and 40.9%); and is notably lower than

the average (48.6%). One attributing factor could be the level of income, which can be demonstrated that while the income level in Zones 18 and 33 is higher than the other zones, this is combined with the highest level of car ownership. The lower income levels for example Zones 30 and 28, also tend to have a corresponding lower level of car ownership. Income therefore may in part explain trends in car ownership patterns.

#### 5.16.12 Number of Private Cars in Each Household

5.16.12.1 Figure 36 shows the number of cars owned by each households for the zones. The data is calculated from New Zealand Census data.

Figure 36: Number of Private Cars in Each Household



5.16.12. A significant (20.5%) proportion of Zone 2 population do not own a car, this is higher than the average for Auckland of 12.8%. In comparison, this differs from Zone 17 where only 8.6% of the households do not own a car. Nearly half of all households in Zone 17 own more than one car (49.7%) compared to (36.4%) for Zone 2. Zones 18 and 33 have similar car ownership patterns. Both Zone 18 and 33 have the highest level of car

ownership for households of all the zones; with only 5.9% in Zone 18 and 5.3% in Zone 33 of households do not own a car. Half of all households in Zones 18 and 33 have more than one car per households (56.1% and 58.1% respectively). This is the highest level of all the zones and above the average for Auckland (42.9%). Both the Zones 22 and 28 have more households that do not own a car (14.1% and 13.9% respectively) than the average for Auckland (12.8%). The majority of households in these zones have only one car (46.5% and 45.3%). Zones 25 and 30 are relatively similar with a higher level of household car ownership in Zone 25 than Zone 30. Overall these Zones have a similar pattern of household car ownership as compared to the average for Auckland. Income is suggested as one component in influencing vehicle ownership levels. Income in Zone 2 is near average for Auckland and about average for all the zones. Income is the lowest in Zone 30 which concurs with the low level of car ownership. Income is the greatest in Zones 18 and 33, and is above the average for Auckland. These two zones also have the highest rate of car ownership. This suggests that income in part may influence the level of car ownership.

#### 5.6.13 Summary of Socio-Demographics of Zones

5.6.13.1 Zones 2 and 17 can be characterised as having a mid to adult population base as the above average proportion of the people are in the age group 25 to 44 years. Zone 22 does differ from Zone 17 in that this feature is more predominant. Both the zones have a below average proportion of households with children aged under five years and households with superannuitants. Zone 2 has a sizable proportion of non-family (20.1%) and single person (27.4%) households, which is well above the average for Auckland. However this feature is not so prevalent in Zone 17, where the majority of households (76.5%) are family type households. Zone 2 has the lowest household occupancy rate of all the zones. This figure is also lower than the average for Auckland. A possible attributing factor to these may be the high number of single person households within this zone. In comparison, Zone 17 has a slightly higher household occupancy rate than Zone 2, this however is only 10.1% different from the average for Auckland. Zone 2 and 17 have one of the highest proportion of full time workers than the average for

Auckland. Car ownership levels in Zone 2 is the lowest of all the zones and Zone 2 has the greatest proportion of households without a car. Zone 17, however has similar car ownership patterns to the average for Auckland.

5.16.13.2 Zones 18 and 33 can be characterised as having highly similar socio-demographic characteristics. The two zones can be described as containing an adult to aging population base. This is demonstrated by the high proportion of people in the 45 to 64 years age group which is the highest of all the zones and above the average for Auckland. The two zones have a below average proportion of households with children under five years, the lowest of all the zones and an average proportion of households with superannuitant members. Most of the households in Zones 18 and 33 are families (81.1% for both the zones), which is higher than the average for Auckland (76.4%). The household occupancy rate is highly similar to the average for Auckland and also about average for all the zones. Zone 18 and 33 have the highest income and car ownership levels of all the zones, this is well above the average for Auckland. The proportion of full-time employed is also greatest in Zones 18 and 33 of all the zones, and is slightly above the average for Auckland. The two zones have an about average proportion of women in the workforce.

5.16.13.3 Zones 22 and 28 have again highly similar socio-demographic characteristics across a variety of variables. The two zones can be characterised as having a similar age structure to the average for Auckland. The two zones have a slightly average proportion of households with children aged under five years, and an average proportion of households with superannuitants. Zone 28 has the most households with superannuitants of all the zones and is above the average for Auckland. The number of one person households is relatively higher than the other zones for Zone 28, however this is not as great as Zone 2. The two zones are also primarily comprised of family type households. The two zones have an average household occupancy rate compared to the other zones and the average for Auckland. The level of income in the two zones is slightly below the average and the other zones. This may be reflected in the high proportion of

households without a private car and the highest proportion of non-workforce of all the zones.

5.16.13.4 Zones 25 and 30 have highly similar socio-demographic characteristics to each other across a variety of different variables. The two zones can be characterised as having the greatest proportion of children and people aged between 5 and 24 years. These results are both significantly above the average for Auckland. The two zones have a significantly more households with children aged under five years and significantly less households with superannuitant members. The two zones have the highest proportion of families of all the zones (87.1% and 86.7% respectively) which is higher than the average for Auckland (76.1%). The two zones also have the highest households occupancy rate of all the zones and higher than the average for Auckland and therefore may be attributed to the higher occurrence of families and children present. The overall level of income in the two zones is proportionately lower than the other zones and the average for Auckland. Car ownership rates are also lower than the average for Auckland, however these are not as low as Zones 22 and 28. The two zones have similar proportions of full-time, part-time and non-work force participants as the average for Auckland and a slightly above average proportion of women in the work force.

## CHAPTER SIX: PRESENTATION OF RESULTS

### 6.1 INTRODUCTION

6.1.1 The results are presented into four main sections the travel behaviour of the:

- Section One: Auckland region - the entire sample;
- Section Two: ASP Zones - all respondents in the ASP Zones;
- Section Three: Age Groups - all respondents in each of the four age groups in ASP Zones; and
- Section Four: Household Groups - all respondents in each of the four household groups in ASP Zones.

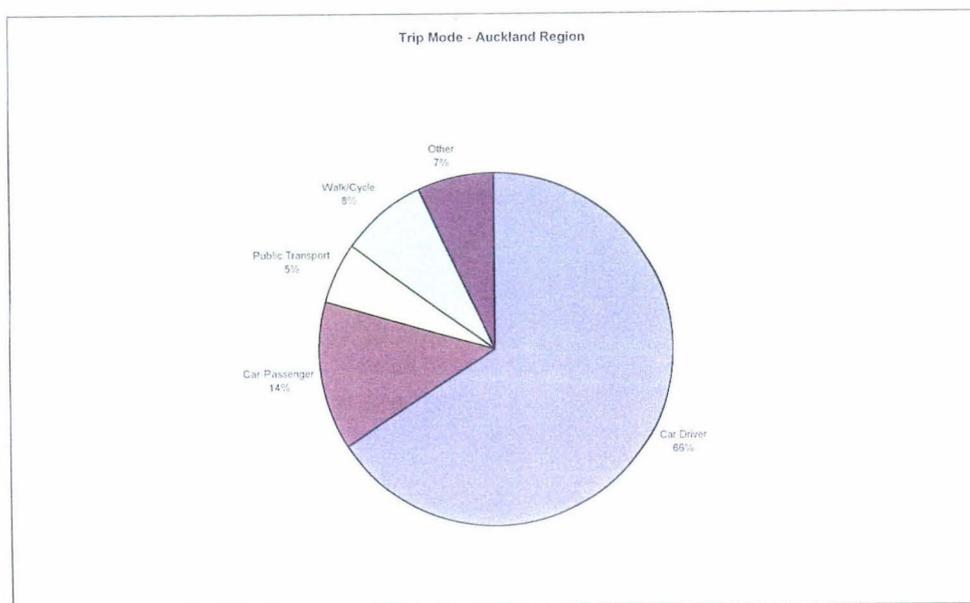
### 6.2 SECTION ONE: TRAVEL BEHAVIOUR TRENDS FOR AUCKLAND

6.2.1 The travel behaviour trends for the Auckland region, is calculated using the entire Auckland sample (4795 respondents).

## 6.2.2 Trip Mode

6.2.2.1 Figure 37 shows the proportion of trip modes used for all travel within the Auckland region.

Figure 37: Trip Modes

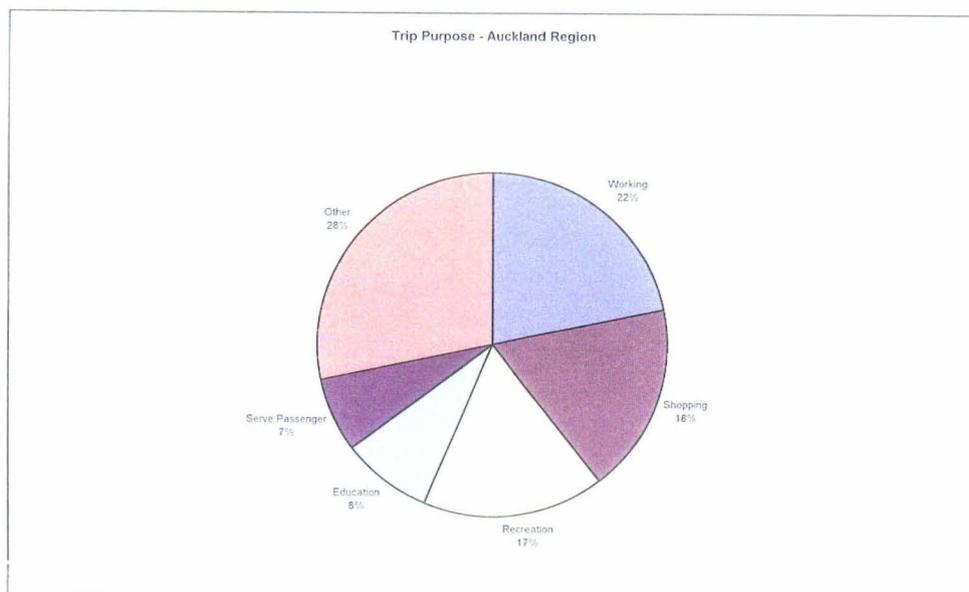


6.2.2.2 The results shows that most of the trips made by Auckland residents are by car (79.5%), the majority of which are made as the car driver (65.8%). Non-motorised modes (i.e. walking and cycling) are used for only 8.2% of all trips made, public transport is used for 5.5% of all trips. The results in Figure 37 therefore show that the majority of Aucklanders prefer to travel by automobile. This result shown in Figure 37 can be compared to Australian cities. Stretton (1994) identifies that Australian cities average 12% of urban journeys by foot, bike and public transport. This result is similar to the figure calculated for Auckland's urban journeys (13.7%). The results suggest that New Zealand and Australian cities exhibit a similar preference for automobile travel.

### 6.2.3 Trip Purpose

6.2.3.1 Figure 38 shows the proportion of trips made for different purposes within the Auckland region.

Figure 38: Trip Purpose

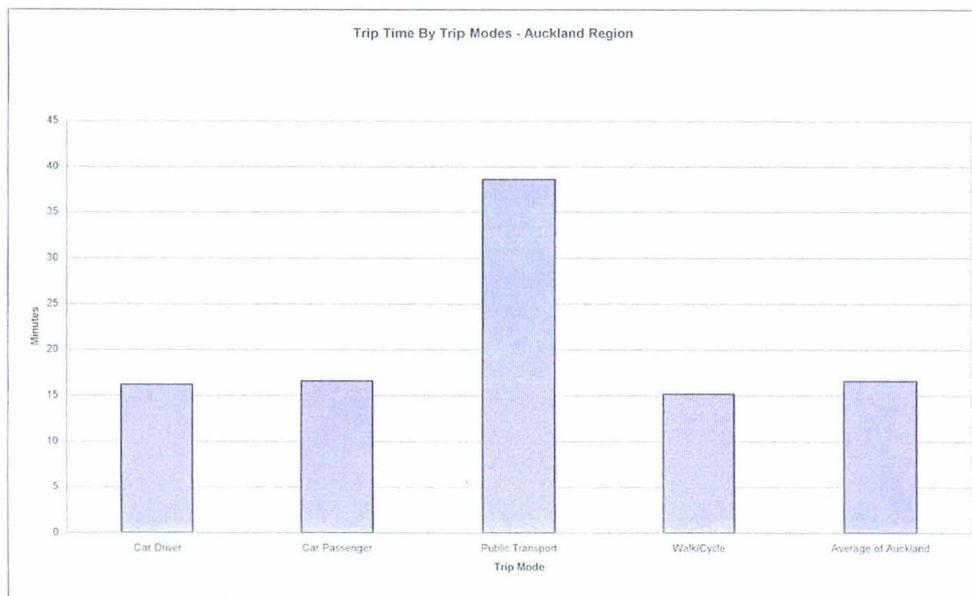


6.2.3.2 Figure 38 shows that the greatest proportion of trips made are working trips (22.0%). This is slightly higher than the proportion of shopping (18.0%) and recreation (17.0%) trips. The other two main types of travel are for education (8.0%) or serve passenger (7.0%) purposes. The results in Figure 38 suggest that only a minority (22.0%) of all the travel within Auckland is made commuting to and from work. The results indicate that half of all travel (50.0%) is non-work travel or trips for recreation, shopping, education/school or serve passenger purposes. Thus the automobile is not only the favoured mode for working trips, but for a range of other trip purposes.

#### 6.2.4 Trip Time By Trip Mode

6.2.4.1 Figure 39 shows the average trip time for all trip modes for all travel within the Auckland region.

Figure 39: Trip Time By Trip Mode

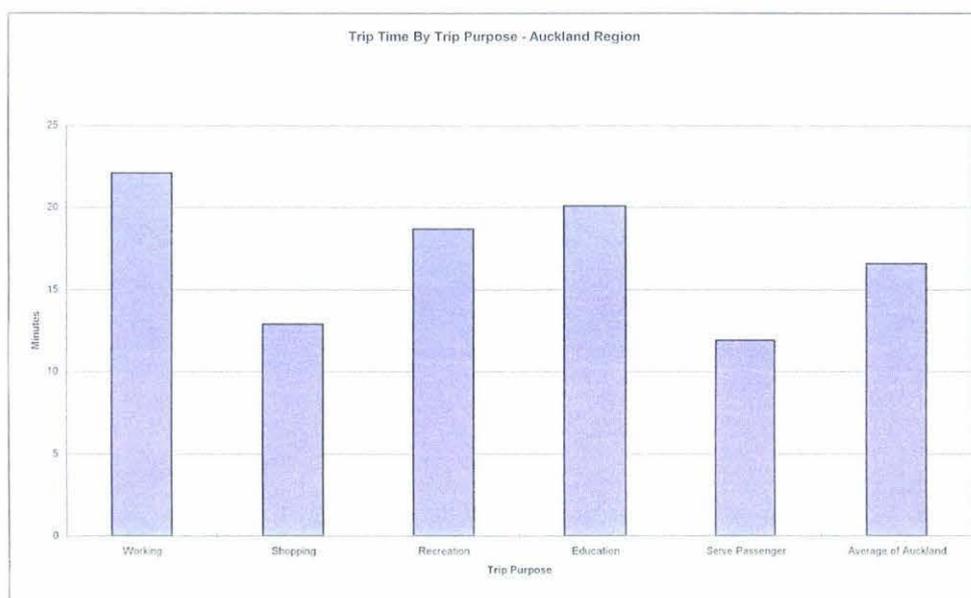


6.2.4.2 Figure 39 shows that overall passengers on public transport trips travel for the longest amount of time (38.6 mins) of all the travel modes. The average trip time for a car driver (16.2 mins), car passenger (16.6 mins) and walk/cycle trips (15.2 mins) is significantly less than the average for public transport. The results here suggest that average trip time may be one of the factors that induces the low level of public transport use. Of note is that the average walk/cycle travel times are similar to that for car driver and car passenger modes.

## 6.2.5 Trip Time By Trip Purpose

6.2.5.1 Figure 40 shows the average trip time for different trip purposes within the Auckland region.

Figure 40: Trip Time By Trip Purpose



6.2.5.2 Figure 40 indicates that on average working trips tend to be longer (22 mins) than the other types of trip purposes. Education trips (20 mins) recreation trips (19 mins) are on average slightly shorter than working trips. Both the shopping (13 mins) and serve passenger (12 mins) trips are on average shorter than the other trip purposes. Work destinations tend to be set for most people, therefore people are required to travel to and from the work site at set times of the day which contribute in part to peak period travel congestion. The result for working trips tends may in part be explained by this difference in travel times between working and other types of trip purposes.

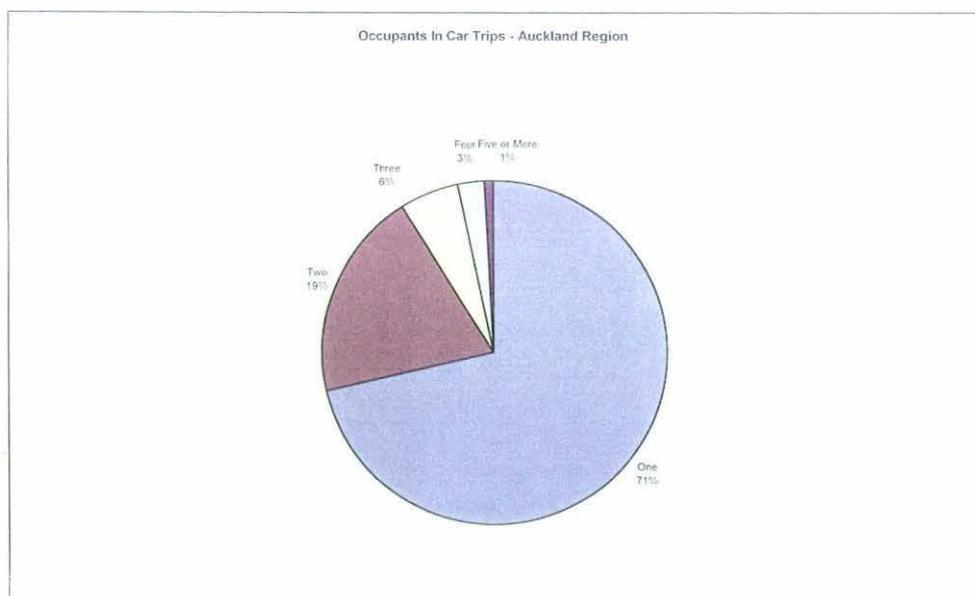
6.2.5.3 The result for education trips may suggest the same or that a higher proportion of these trips are made by public transport or walk/cycle modes

(refer Figure 39). This may lengthen the average trip time. People tend to be more able to choose when, where and how often they wish to shop. The result for shopping trips tends to suggest that people may shop more in local areas, or at times when congestion levels are lower. Of note is the average trip time for serve passenger trips which is also lower than the average for all the trips. This result suggests that these trips are only short trips to and from a destination which may for example, be close to home such as driving children to school or a spouse to work.

### 6.2.6 Number of Occupants in Car Trips

6.2.6.1 Figure 41 shows the number of occupants in car trips made by respondents within the Auckland region.

Figure 41: Number of Occupants in Car Trips



6.2.6.2 The results show that the majority (71.0%) of car trips have one occupant. The remainder of car trips mainly have two (19.7%) occupants. The results show that a small proportion of car trips have three (5.6%), four (2.5%) and five or more (0.7%) occupants.

6.2.6.3 Travel within Auckland can be summarised as being for:

- mainly non-work purposes;
- mainly made by car;
- with a single occupant or driver.

6.2.6.4 The trip time results suggest a reason why car travel may be a more favoured form of travel compared to modes such as public transport. The trip times suggest that trips with a fixed location or at set peak times of the day could lengthen average trip times. The results in this section indicate that overall Auckland exhibits predominately automobile based travel patterns.

## 6.3 SECTION TWO: TRAVEL BEHAVIOUR OF AUCKLAND STRATEGIC PLANNING ZONES

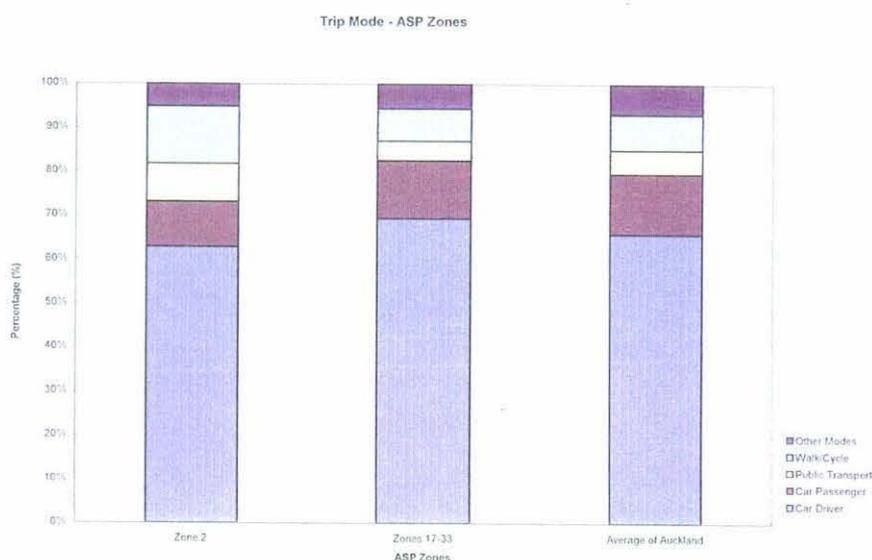
6.3.1 The results in Section Two compares the travel behaviour of all respondents that reside in Zone 2 with the travel behaviour of the all respondents that reside in Zones 17 to 33. The purpose of this Section is to identify whether Zone 2 which is characterised as containing a NTD urban form is less automobile reliant than Zones 17 to 33, or the zones that do not exhibit these characteristics.

6.3.2 The travel behaviour data from respondents that reside in the Zones 17-33 has been aggregated together because these zones have similar urban form characteristics and do not contain the degree or combination of NTD qualities exhibited by Zone 2 (refer Section 5.15.6). The travel behaviour data in Zones 17 to 33 has also been aggregated to provide a more statistically significant sample.

### 6.3.3 Trip Mode

6.3.3.1 Figure 42 shows the travel mode taken for all trips made by respondents in the ASP Zones.

Figure 42: Trip Mode



6.3.3.2 The results in Figure 42 show that the majority of travel in Zone 2 (73.0%) is made by car. This value is lower than Zones 17-33 (82.6%) and the average for Auckland (79.6%). The proportion of car passenger trips made in Zone 2 (10.2%) is slightly lower than Zones 17-33 (13.3%) and the average (13.7%). Zone 2 has a slightly greater proportion of walk/cycle (13.1%) and public transport (8.7%) travel than Zones 17 to 33 (6.9% and 4.5% respectively) and the average for Auckland (8.2% and 5.5% respectively).

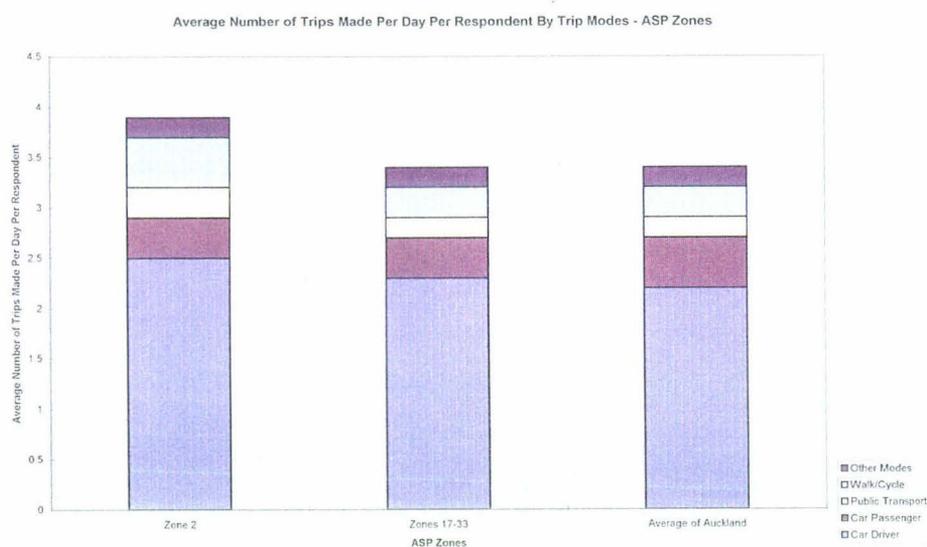
6.3.3.4 The results in Figure 42 show that the respondents that reside in Zone 2 have a lower proportion of automobile travel and a higher proportion of non-vehicular travel than Zones 17-33 and the average for Auckland. This result provides some support for the claim that urban areas with NTD characteristics exhibit a lower proportion of automobile travel than urban

areas without these NTD qualities (Cervero and Gorham 1995, Cervero and Radisch 1996, Handy 1995).

#### 6.3.4 Average Number of Trips Made By Trip Modes - ASP Zones

6.3.4.1 Figure 43 shows the average number of trips made per day per respondent by trip mode within the ASP Zones.

Figure 43: Average Number of Trips Made by Trip Modes



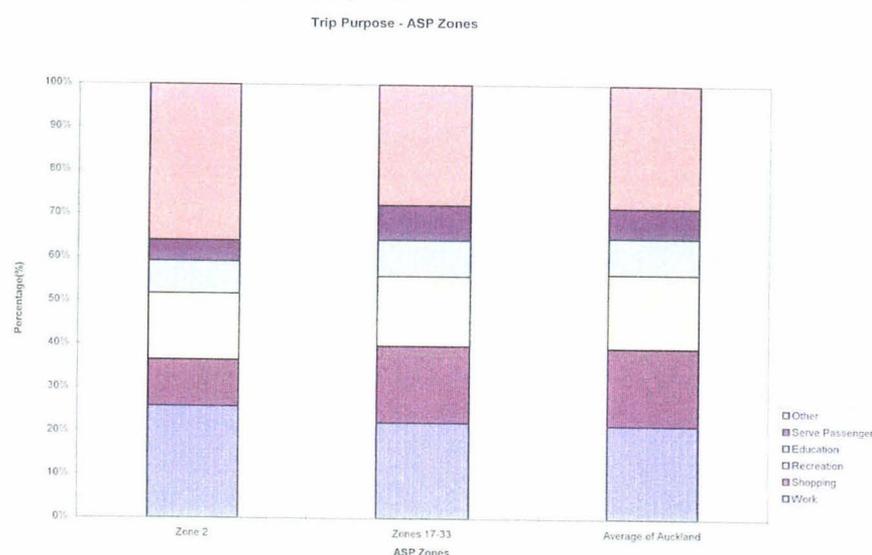
6.3.4.2 Figure 43 shows that the average number of trips made per day per respondent is greater in Zone 2 (4.0 trips) than Zones 17 to 33 (3.4 trips) and the average for Auckland (3.5 trips). This result seems to contradict the findings made in Cervero and Gorham (1995) research, that while both the different neighbourhoods ('transit neighbourhoods' and 'automobile neighbourhoods') had similar levels of trips out of home per day, the mean non-work trip rates (per person) for walking compared with automobile trips were notably different.

- 6.3.4.3 The results show that the average number of car trips made in Zone 2 is slightly higher (2.9 trips) than Zones 17 to 33 (2.7 trips) and the average for Auckland (2.7 trips). Essentially the respondents in Zone 2 average the same number of automobile trips as Zones 17-33 and the average. The average number of walking/cycling (0.5 trips) and public transport (0.3 trips) is also slightly higher in Zone 2 than Zones 17 to 33 (walk/cycle 0.3 trips and public transport 0.2 trips) and the average for Auckland (walk/cycle 0.3 trips and public transport 0.2 trips).
- 6.3.4.5 Research conducted by Cervero and Gorham (1995) found that more public transport trips were likely in transit neighbourhoods than in automobile neighbourhoods. The results in Figure 43 seem to concur with this finding as the average number of public transport trips made per day per respondent in Zone 2 is greater than in Zones 17-33 and the average. Handy (1995) found that more strolling trips and walks to a destination were made around the traditional neighbourhood than late modern neighbourhoods. Cervero and Radisch (1996) also showed that more walk trips and fewer automobile trips were made per day in the traditional neighbourhoods compared to the automobile orientated neighbourhoods. The results in Figure 43 also appear to be consistent with these findings made by Handy (1995) and Cervero and Radisch (1996).

### 6.3.5 Trip Purpose

6.3.5.1 Figure 44 shows the percentage of trips made for different purposes by respondents within ASP Zones.

Figure 44: Trip Purpose



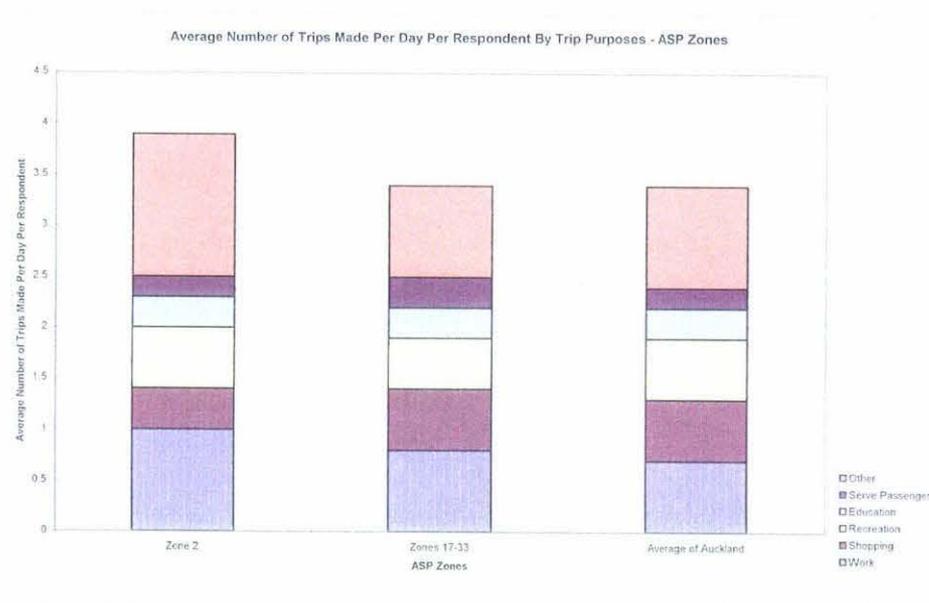
6.3.5.2 The results show that the residents in Zone 2 make more working trips (25.8%) than Zones 17-33 (22.1%) and the average for Auckland (21.6%). A lower proportion of shopping trips is made by respondents in Zone 2 (10.6%) than those in Zones 17-33 (17.6%) and the average for Auckland (17.8%). The proportion of recreation (15.3%) and education trips (7.4%) in Zone 2 is relatively similar to that for Zones 17-33 (16.0% and 8.4% respectively) and the average (17.0% and 8.3% respectively). The proportion of serve passenger trips is slightly higher in Zones 17-33 (8.0%) than the average (6.9%) and Zone 2 (4.8%). The proportion of 'other' trips including the employer's business trips and/or trips that do not have a home destination or origin, is significantly higher in Zone 2 (36.1%) than Zones 17-33 (27.8%) and the average for Auckland (28.5%).

- 6.3.5.3 The socio-demographic characteristics of Zone 2 and Zones 17-33 show that Zone 2 has a similar proportion of working age population (Zone 2 - 68.6% and Zones 17-33 - 67.0%), full time employed (Zone 2 - 55.2% and Zones 17-33 - 53.8%), non labour force (Zone 2 - 34.5% and Zones 17-33 - 35.0%) and similar income levels. This may in part explain the similarities in percentage of work trips made by the two sets of zones.
- 6.3.5.4 The lower level of shopping trips made by Zone 2 respondents compared to Zones 17-33 seems an unexpected results for the reason that Figure 21 and 22 shows that Zone 2 has a significantly greater number and variety of commercial establishments than any of the other ASP zones. Figures 19 and 20 show that Zone 2 has a greater proportion of commercially zoned land (25.7%) compared to Zones 17-33 (1.7%); and distribution of commercial/industrial land (15.0%) compared to (4.4%) in Zones 17-33. The results in Figure 40 also show that the average trip time for shopping trips in Zone 2 (12.0 mins) is slightly lower than Zones 17-33 (13.0 mins). One theory is that Zone 2 may have more complex travel patterns that involve more multi-purpose trip making by respondents. This conclusion is supported by the higher proportion of 'other' trip types that include trips not made to or from a home destination, which include a proportion of work to shops trips. However, the results from Figure 44 do not seem to support the claim that a more mixed use zone will encourage a greater level of shopping trips.

### 6.3.6 Average Number of Trips Made By Trip Purpose

6.3.6.1 Figure 45 shows the average number of trips made per day per respondent by trip purpose within the ASP Zones.

Figure 45: Average Number of Trips Made By Trip Purpose



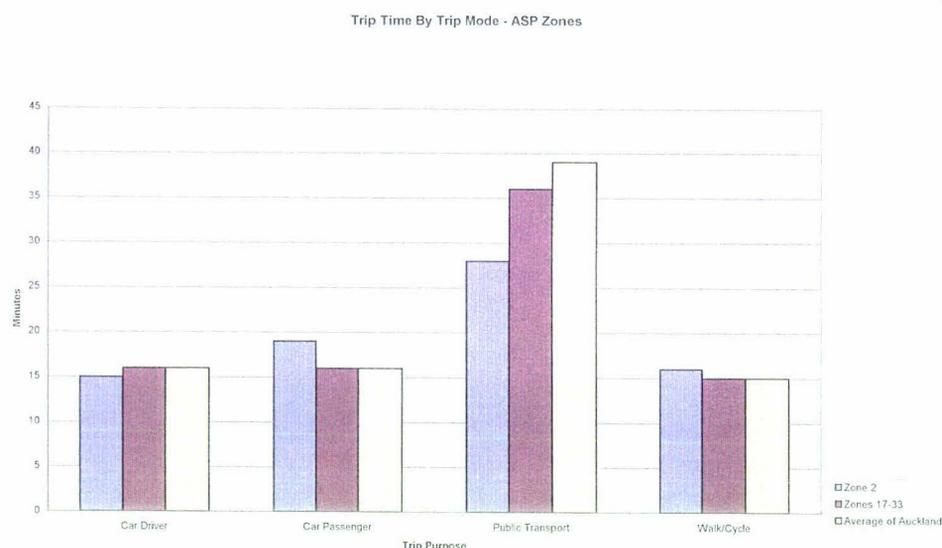
6.3.6.2 The average number of trips made per day per respondent as in Figure 45 is slightly higher for Zone 2, than Zones 17-33 and the average for Auckland. As in Figure 44 the average number of work trips is slightly higher in Zone 2 (1.0 trips) than Zones 17-33 (0.8 trips) and the average for Auckland (0.7 trips). The proportion of shopping trips made is again lower in Zone 2 (0.4 trips), than Zones 17-33 (0.6 trips) and the average for Auckland (0.6 trips). The trip rates for education, recreation and serve passenger trips are similar for Zone 2, Zones 17-33 and the average for Auckland, with only a difference +/- 0.1. As in Figure 44 the proportion of 'other' trips is higher for Zone 2 (1.4 trips) than Zones 17-33 (0.9 trips) and the average (1.0 trips). The research conducted by Cervero and Radisch (1996) found that for non-work related travel both the traditional and auto-orientated neighbourhoods made similar amounts of trips out of the home each day. The results show

that respondents in Zone 2 make slightly fewer trips (1.5 trips) for shopping, recreational, education, serve passenger purposes per day compared to Zones 17-33 (1.7 trips) and the average (1.7 trips). The greatest difference exists however with the proportion of 'other' trips.

### 6.3.7 Trip Time By Trip Mode

6.3.7.1 Figure 46 shows the average trip time by trip mode within ASP Zones.

Figure 46: Trip Time By Trip Mode



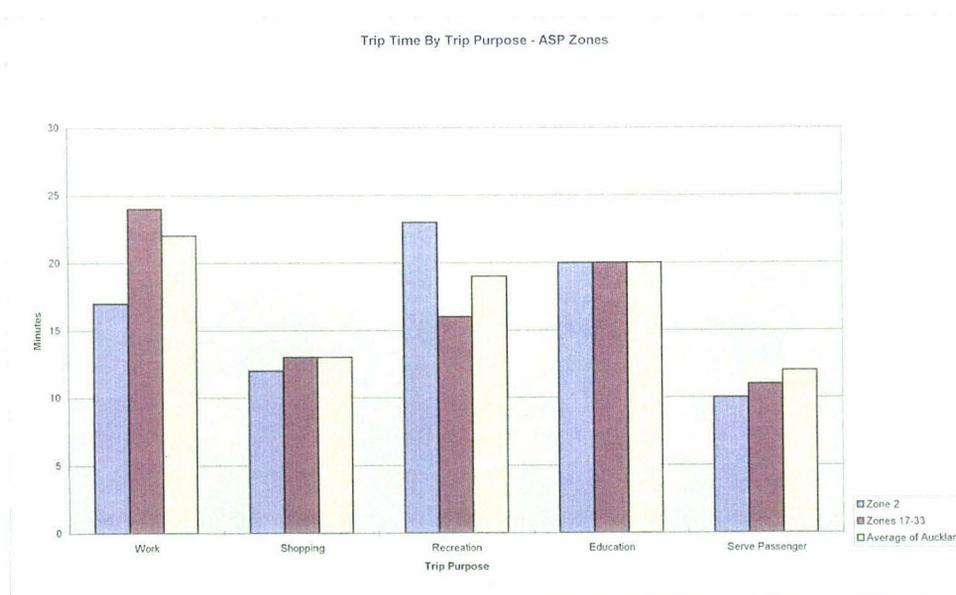
6.3.7.2 The results show that overall public transport is the most time consuming form of travel. The average trip time of public transport trips in Zone 2 (28 mins) is significantly shorter than Zones 17-33 (36.0 mins) and the average for Auckland (38.6 mins). The car driver, car passenger, and walk/cycle modes of travel have significantly lower average trip times at approximately 15 minutes per trip for Zone 2, Zones 17-33 and the average for Auckland. The average trip time for the car passenger mode in Zone 2 is the exception at an average of 19 minutes per trip. The results suggest that one reason why public transport is only used for a greater proportion of trips in Zone 2

(8.7%) than in Zones 17-33 (4.5%) may be due to the shorter trip times for public transport in this zone. Newman and Kenworthy's (1989) research on the average vehicle speeds of cars, buses and rail, and found that the average traffic speed of rail was strongly positively correlated with gasoline consumption use per capita. This implied that rail maybe more able to compete with car travel or be substituted for car travel. It was also found that average bus travel speed was not able to compete with car travel. However, while this relationship between trip time and the number of public transport trips made is important the degree to which rail or buses can compete with car travel will also depend on other factors including access to the route system, timetables and price of alternatives.

### 6.3.8 Trip Time By Trip Purpose

6.3.8.1 Figure 47 shows the average trip time by trip purpose within the ASP Zones.

Figure 47: Trip Time By Trip Purpose



6.3.8.2 The results in Figure 47 show that the average trip time for working trips in Zones 2 (17.0 mins) is significantly shorter than Zones 17-33 (24.0 mins)

and the average (22.0 mins). To interpret this result more clearly, other travel variables such as trip mode must be examined.

6.3.8.3 Figure 48 shows that the majority (68.8%) of all work trips in Zone 2 are made by car driver mode. While the result for Zones 17-33 (79.5%) is higher than Zone 2, the average for Auckland value (65.7%) is similar to Zone 2. The similarity between the percentage of car journeys to work between Zone 2 and the average suggests that mode may not be the most influential factor that determines trip time for the journey to work variable. This result may be compared with the research conducted by Brunton's (1996) on distance of journey to work. Brunton concluded that areas with a mixture of homes and worksites tend to produce shorter journey to work distances. This research tends to provide some support for Brunton's claim that a greater mix and density of employment can reduce the travel distance for work trips.

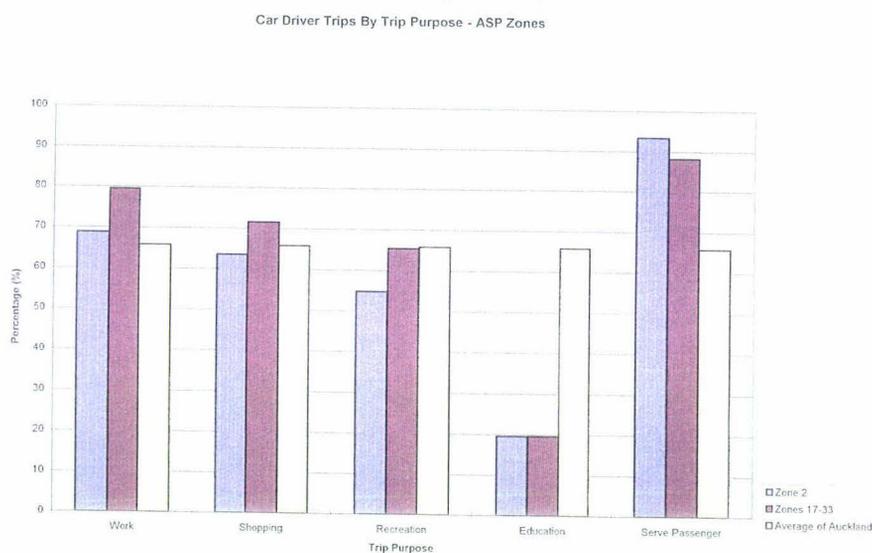
6.3.8.4 The average trip time for education trips is the same for Zone 2 (20.0 mins), Zones 17-33 (20.0 mins) and the average for Auckland (20.0 mins). The average trip time for recreation trips in Zone 2 (23.0 mins) is significantly longer than Zones 17-33 (16.0 mins) and slightly longer than the average (19.0 mins). This result may in part be explained by Figures 49 which show that the proportion of public transport (14.9%) trips made for recreation purposes is greater than Zones 17-33 (2.1%) and the average (5.5%). The shortest average trip times are for shopping and serve passenger trips. For both these trip purposes, Zone 2 has a similar average trip time (12.0 mins and 10.0 mins) compared to Zones 17-33 (13.0 mins and 11.0 mins) and the average (13.0 mins and 12.0 mins). The shorter average trip times for shopping and serve passenger trips could in part be explained by the low level of public transport use for these trip purposes (refer Figure 49). The shorter average trip time for shopping trips may also partly be explained by the ability of respondents to organise shopping behaviour outside peak congestion periods and choice of shopping locations. As Zone 2 has a greater proportion and distribution of commercial activity within the zone it would be expected that the average trip time for respondents in Zone 2 would be shorter than Zones 17-33 and the average. This suggests that Zone 2

respondents are still prepared to travel the same distance as their counterparts in Zones 17-33 for their shopping needs.

### 6.3.9 Trip Purpose By Car Driver Mode

6.3.9.1 Figure 48 shows the percentage of car driver trips made for different trip purposes within ASP Zones.

Figure 48: Trip Purpose By Car Driver Mode

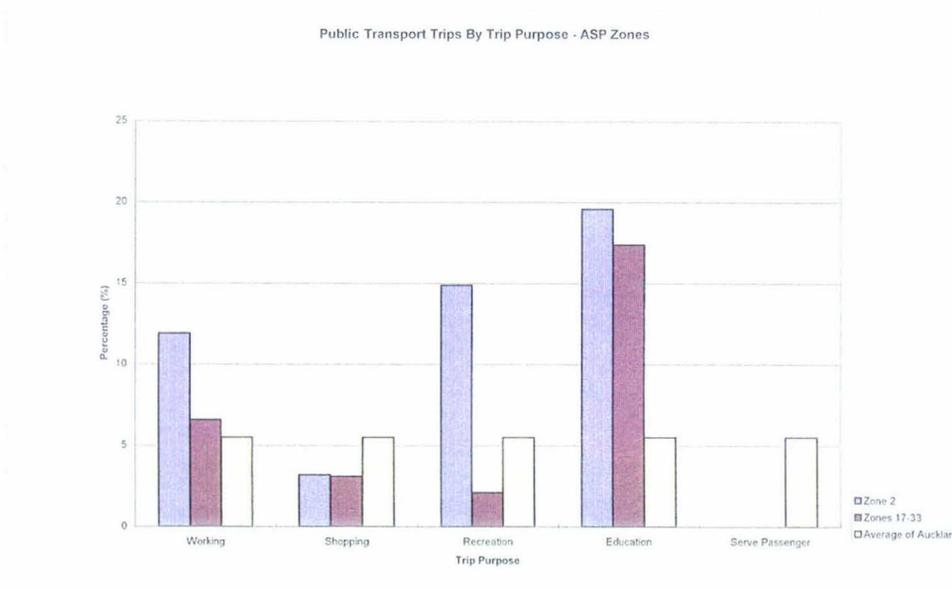


6.3.9.2 The results in Figure 48 show that most of the serve passenger trips made in Zone 2 (93.4%) and Zone 17-33 (88.2%) are car driver trips. This suggests that the car is the most favoured mode for serve passenger trip for example, driving children to school. Zone 2, has a lower proportion of car driver trips for working trips (68.8%) than Zones 17-33 (79.5%); however both these values are above the average (65.7). The proportion of car driver mode taken for shopping (54.8%) and recreation purposes (63.6%) in Zone 2 is lower than Zones 17-33 (65.4% and 71.5% respectively). The proportion of car driver trips is the same for education trips for Zone 2 (19.6%) and Zones 17-33 (19.6%).

### 6.3.10 Trip Purpose By Public Transport Mode

6.3.10.1 Figure 49 shows the percentage of public transport trips made for different trip purposes within ASP Zones.

Figure 49: Trip Purpose by Public Transport Mode



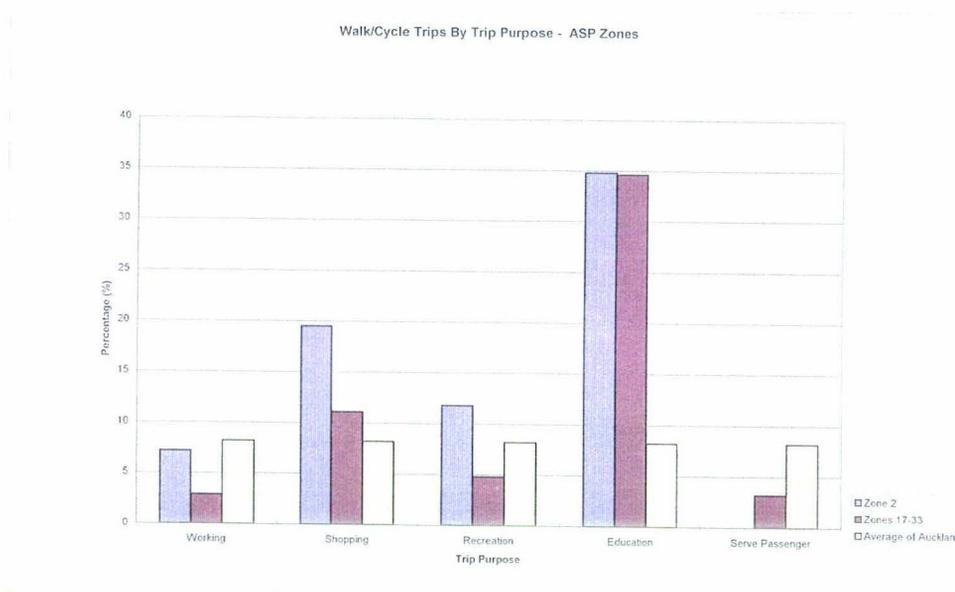
6.3.10.2 The results in Figure 49, shows that public transport is used more often overall in Zone 2 than Zones 17-33. The greatest proportion of public transport trips are made for education purposes in both Zone 2 (19.6%) and Zones 17-33 (17.4%). This suggests that one of main users of public transport is the younger population that may not access to a private car or hold a drivers license. Trips made for recreation purposes have the next highest proportion of public transport use in Zone 2 (14.9%). This is higher than the value for Zones 17-33 (3.8%) and the average (5.5%). The proportion of working trips made by public transport is also higher in Zone 2 (11.9%) than Zones 17-33 (6.6%) and the average (5.5%). The proportion of public transport use for shopping trips is relatively similar for Zone 2 (3.2%) and Zones 17-33 (3.1%) and is lower than the average (5.5%). This suggests

that modes such as walk/cycle and car driver modes are favoured more for shopping trips.

### 6.3.11 Trip Purpose By Walk/Cycle Mode

6.3.11.1 Figure 50 shows the proportion of walk/cycle trips made for each of the different trip purposes within ASP Zones.

Figure 50: Trip Purpose by Walk/Cycle Mode



6.3.11.2 The results in Figure 50 show that the proportion of walk/cycle trips is greater overall in Zone 2 than Zones 17-33, with the exception of the serve passenger trips as no serve passenger trips were recorded that used walk/cycle modes. The proportion of walk/cycle modes used for education trips is significantly higher in Zone 2 (34.8%) and Zones 17-33 (34.6%) than the average for Auckland (8.2%). This suggests that students are more likely to use other modes like public transport and walk/cycle modes as their transport choice is often restricted by factors such as age (drivers licence) and income (car ownership). Shopping trips have the next highest proportion of walk/cycle trips in Zone 2 (19.5%) and Zones 17-33 (11.1%). The

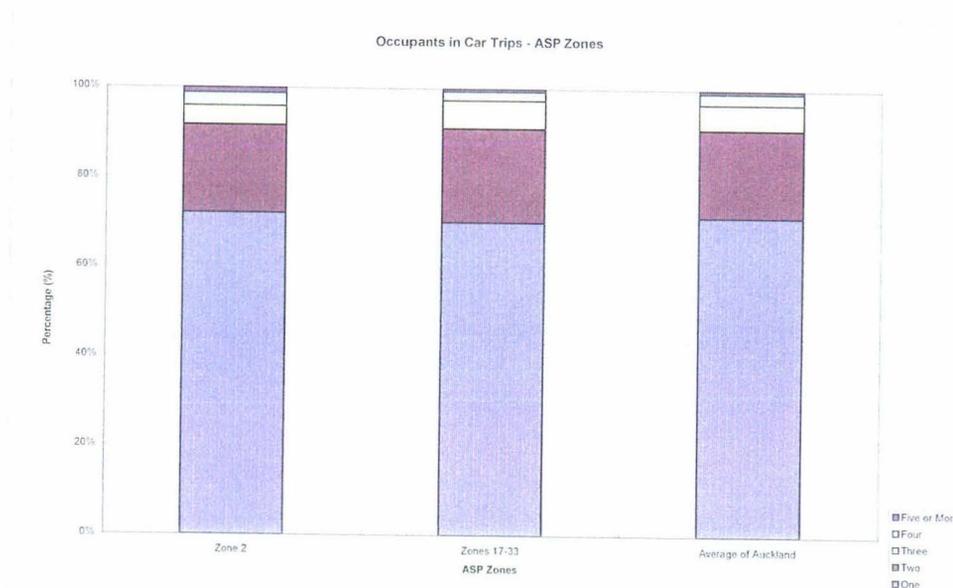
proportion of recreation trips made by walk/cycle mode is higher in Zone 2 (11.8%) than Zones 17-33 (4.8%) and the average (8.2%). Working trips and serve passenger trips have the lowest proportion of walk/cycle modes of all trip types within Zone 2 (7.2% and 0.0% respectively) and Zone 17-33 (2.9% and 3.2% respectively).

6.3.11.3 The results in Figures 48 to 50 show that overall Zone 2 has a lower proportion of car driver travel for working, and higher proportion of public transport and walk/cycle trips than Zones 17-33. The research conducted by Cervero and Gorham (1995) on work based travel supports these findings as their research concluded that public transport and pedestrian and cycling modal shares were in all cases higher in transit neighbourhoods than in automobile neighbourhoods. The proportion of shopping trips that are car driver trips is also lower in Zone 2 than Zones 17-33. The proportion of public transport trips for shopping purposes is similar in Zone 2 to that in Zones 17-33. However the proportion of walk/cycle trips for shopping purposes is higher in Zone 2 than Zones 17-33. This result is also supported by studies conducted by Cervero and Radisch (1996) that conclude that the non-motorised modal split for non-work trips was significantly higher in the traditional neighbourhoods compared to auto-orientated neighbourhoods. Research by Handy (1995) also found that the frequency of strolling and walks to a destination were overall greater in traditional neighbourhoods than in the late modern neighbourhoods.

### 6.3.12 Number of Occupants in Car Trips

6.3.12.1 Figure 51 shows the number of occupants in car trips for ASP Zones and the average for Auckland.

Figure 51: Number of Occupants in Car Trips



6.3.12.2 The results in Figure 51 show that the majority of car trips made in Zone 2 (72.0%) and Zones 17-33 (70.1%) have only one occupant. This result for Zone 2 and Zones 17-33 is similar to the average for Auckland value (71.5%). The remainder of car trips have mainly two occupants in both Zone 2 (19.6%) and Zones 17-33 (21.1%). This is again similar to the average (19.7%). The proportion of car trips with three occupants is slightly higher in Zones 17-33 (6.2%) than the average (5.6%) and Zone 2 (4.2%). However the proportion of car trips with four and five or more occupants in Zone 2 (2.9% and 1.2% respectively) is also slightly higher than Zones 17-33 (2.0% and 0.6% respectively) and the average (2.5% and 0.7% respectively).

6.3.12.3 This result is contrary to the findings of Cervero and Gorham's (1995) research which shows that transit neighbourhoods were found to have lower

automobile drive alone modal shares than the automobile neighbourhoods. The Survey and Census results show that the percentage of people in Zone 2 (42.2%) that own a car is less than those in Zones 17-33 (50.0%) and the average (47.7%) (census data only). The percentage of households that own more than one car is also significantly lower in Zone 2 (36.4%) than Zones 17-33 (49.1%) and the average (42.9%). This shows that despite significantly lower levels of car ownership in Zone 2 compared to Zones 17-33 and the average, the proportion of single occupant trips in Zone 2 (72.0%) is comparable to Zones 17-33 (70.1%) and the average (71.5%). The results in this Figure suggest that within Auckland, urban form characteristics tend to not alter the proportion of drive alone modal shares.

### 6.3.13 Summary

6.3.13.1 The travel behaviour patterns of respondents that live in Zone 2 differs from the travel behaviour patterns of respondents residing in Zones 17-33. The claims that urban areas that have Neo-Traditional characteristics induce less automobile travel and greater levels walking, cycling and public transport seem to be supported to some degree by the findings made in this research.

## 6.4 TRAVEL BEHAVIOUR FOR AGE GROUPS

### 6.4.1 INTRODUCTION

6.4.1.1 The results in Section 6.3 suggest that the urban form characteristics in Zone 2 (Neo-Traditional characteristics) may induce less automobile based travel behaviour than Zones 17-33 without these characteristics. The purpose of this section of results is therefore to identify whether the travel behaviour patterns of the respondents (by age group) that reside in Zone 2 exhibit less automobile based travel behaviour than those that reside in Zones 17-33. This section therefore aims to expand on the research conducted so far, to determine whether urban form features still influence travel behaviour patterns despite differing socio-demographic characteristics.

6.4.1.2 The research discussed in the literature review suggest that travel behaviour patterns vary according to age (Kitamura 1988, Principio and Pas 1996, Morris, McPherson and Richardson 1996 and Dodds 1997). This section of the results will show the current travel behaviour patterns of four different age groups. This section also identifies whether differences and/or similarities exist in travel behaviour patterns between the four age groups; and to establish whether the patterns and trends discussed in the literature review are apparent in the travel behaviour of these age groups in the Auckland region. Age as a socio-demographic measure was selected for study for the following reasons:

- The research discussed in the literature review identified that ‘age’ is an important variable that determines in part the travel behaviour patterns of an individual;
- The Home Interview Survey (1992) records the respondents age group which allows travel behaviour of age groups to be examined;
- The data could be categorised to provide statistically significant samples.

6.4.1.3 The results in this section show the travel behaviour of respondents in four different age groups (ages 5 to 24 years, 25 to 44 years, 45 to 64 years and 65 over years) within ASP Zone 2 and Zones 17-33. The results for the age group travel behaviour analysis is organized and presented according to the format used for Section One and Two of the results.

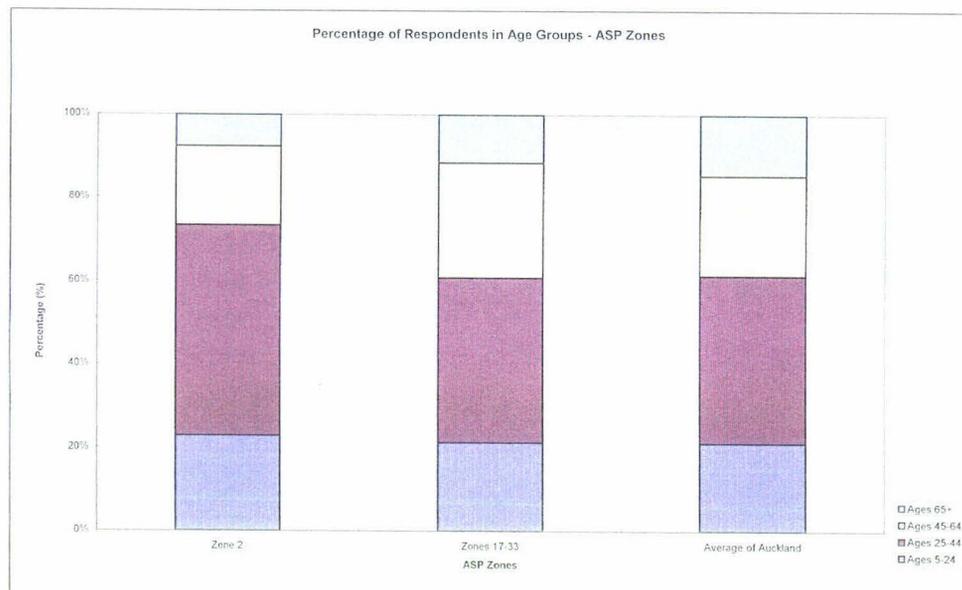
6.4.1.4 A statistical test such as t-tests is used to detect deviations from the null hypothesis. This type of statistical testing is designed to assess the strength of the evidence against the null hypothesis. Usually the null hypothesis is a statement of “no effect” or “no difference”. In practice the test is used to show that the null hypothesis is false, so high power is important. The t-test has been used in this research to determine the degree of confidence we can place in mean value between relatively small samples of data. The t-statistics have been shown for some of smaller samples in order to determine the degree of confidence in the results. These are indicated in the Tables 20

to 40 in the Results Chapter. The t-statistics have not been shown for the larger samples as these are statistically significant at 0.05 probability level.

#### 6.4.2 Percentage of Respondents In Age Groups

6.4.2.1 Figure 52 shows the percentage of respondents within each age group within the ASP Zones.

Figure 52: Percentage of Respondents in Age Groups



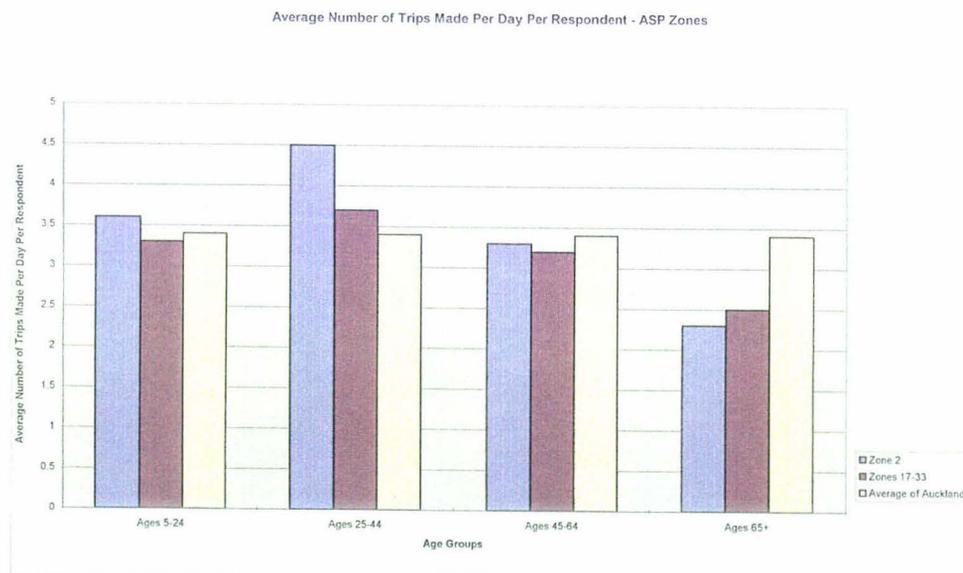
6.4.2.2 The results in Figure 52 show that the largest proportion of respondents are aged between 25 to 44 years for Zone 2 (50.3%) and Zones 17-33 (43.5%). This proportion is higher than the average for Auckland (40.1%). The socio-demographic data from the New Zealand Census confirms that the proportion of people aged between 25 to 44 years (40.2%) in Zone 2, is above the average for Auckland (31.9%). The proportion of respondents aged 5 to 24 years in the both Zone 2 (22.9%) and Zones 17-33 (21.3%) is relatively similar to the average for Auckland (21.1%). However the proportion respondents aged 45 to 64 years (19.1%) in Zone 2, is lower than Zones 17 - 33 (27.6%) and the average of Auckland (24.0%). The proportion

of respondents aged between 45 and 64 years (15.9%) in Zone 2 in the New Zealand census data, is slightly higher than the survey results and is similar to the average for Auckland (17.9%). The proportion of respondents in the over 65 years age group in Zone 2 is also slightly lower (7.6%) than Zones 17 - 33 (11.6%) and the average for Auckland (14.6%). The New Zealand census results show that the proportion of people aged over 65 years (8.5%) in Zone 2 is slightly higher than the survey results (7.6%).

### 6.4.3 Average Number of Trips Made By Age Groups

6.4.3.1 Figure 53 shows the average number of trips made per day per respondent by the age group in the ASP zones.

Figure 53: Average Number of Trips Made by Age Groups



6.4.3.2 The results in Figure 53 show that the respondents aged 25 to 44 years in both Zone 2 (4.5 trips) and Zones 17-33 (3.7 trips) make more trips overall than the other age groups. The results show that the respondents in this age group from Zone 2, tend to make significantly more trips overall than those in Zones 17-33. The respondents in the age group 5 to 24 years (3.6 trips)

and 45 to 64 years (3.3 trips) also make slightly more trips overall than their counterparts in Zones 17-33 (3.3 trips and 3.2 trips). Figure 53 shows that the over 65 years age group tend to make the least amount of trips of all the age groups in both Zone 2 (2.3 trips) and Zones 17-33 (2.5 trips).

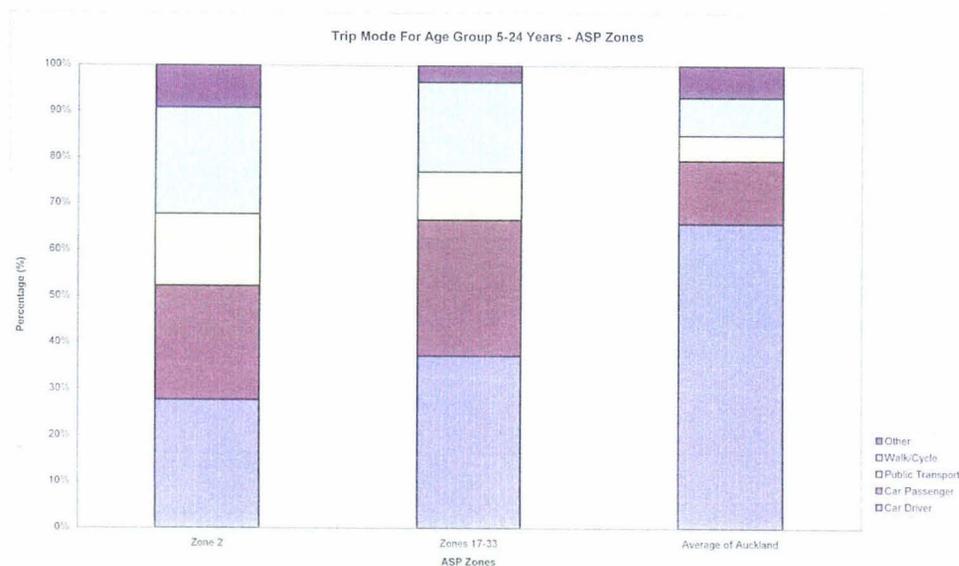
6.4.3.3 These results tend to concur with the studies conducted by Kitamura (1988), Principio and Pas (1996) and Morris, Richardson and McPherson (1996). Kitamura (1988) identified that mobility peaks in thirties and forties. Kitamura (1988) also suggested that travel behaviour patterns are partly influenced by income and car ownership in that income was strongly correlated with car ownership indicating a households propensity to travel. Kitamura's (1988) research concluded that income and transport expenditure peaked at the 45 to 54 years age group while the elderly (over 65 years) age group had the lowest trip generation rate of all the age groups. Kitamura (1988) suggested that one reason for the lower trip rate by elderly is absence of work related trip making.

6.4.3.4 Principio and Pas (1996) identified that the 'domestic caretakers' group which has an above average proportion of elderly respondents, made a fewer number of trips and tours than the average for the sample taken. The research conducted by Morris, Richardson and McPherson (1996) also concluded that the elderly are the least mobile of all the age groups. Kitamura (1988) research found that this age group had the second to lowest income level after the under 25 years age group and the lowest level of expenditure on transportation. Morris, Richardson and McPherson (1996) suggested that the cost of transport financial burdens may be a factor that limits the amount of travel by elderly. Morris, Richardson and McPherson (1996) found that the trip rates for young children are generally low, however once children reach school age they become more active participants in travel. Kitamura (1988) found that the under 25 years age group had the lowest level of income and the second lowest transport expenditure of all age groups. These findings tend to concur with the results shown in Figure 53.

#### 6.4.4 Trip Mode For Age Group 5 - 24 Years

6.4.4.1 Figure 54 shows the proportion of trips made by trip mode by the respondents in the age group 5 to 24 years within the ASP zones.

Figure 54: Trip Mode For Age Group 5 - 24 Years



6.4.4.2 The results in Figure 54 shows that nearly half (52.3%) of all travel by Zone 2 respondents is by car. The proportion of car trips made by Zones 17-33 (66.5%) is significantly higher than Zone 2, however both these results are significantly lower than the average for Auckland (79.5%). A major proportion of all car trips made by this age group in both Zone 2 (24.6%) and Zones 17-33 (29.3%) are car passenger trips. This is significantly higher than the average for Auckland (13.7%). Over a third of all (38.5%) travel in Zone 2 by the 5 to 24 years age group is by public transport (15.4%) and walk/cycle (23.1%) modes. The result for Zones 17-33 (10.5% and 19.4% respectively) is slightly lower than Zone 2. However the results for both these two sets of zones are significantly higher than the average for Auckland (5.5% and 8.2% respectively). The proportion of trips made by

Zone 2 (9.2%) respondents using 'other' modes is slightly higher than the average (6.9%), and Zones 17-33 (3.6%).

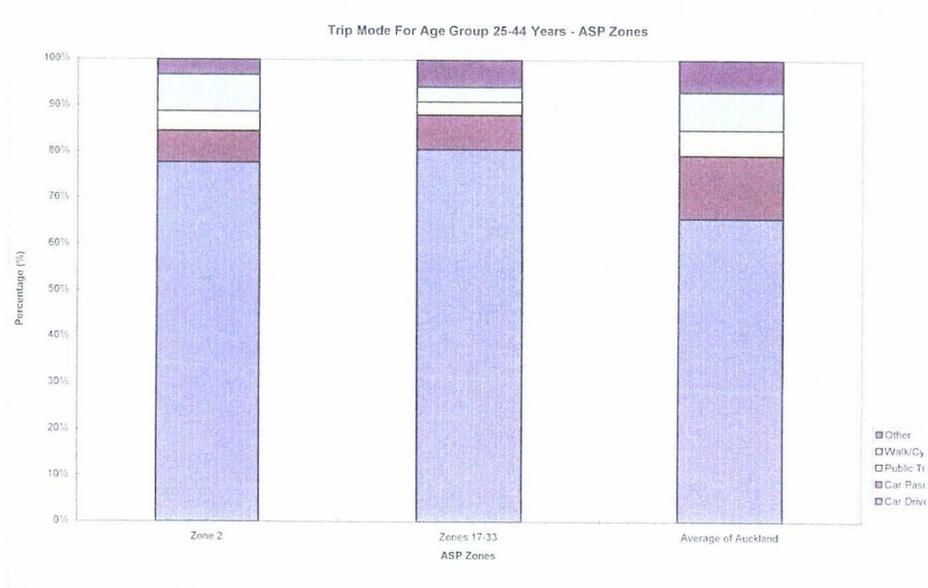
6.4.4.3 The results for this age group is supported by the studies conducted by Morris, Richardson and McPherson (1996) which found that the majority of young children have fewer independent travel needs and generally travel as a car passenger or walk. Morris, Richardson and McPherson (1996) further found that older children tend to use other modes of travel for example, public transport, cycle and walking. Kitamura (1988) concluded that the under 25 years age group have the lowest level of income of all the age groups and the second to lowest transportation expenditure after the over 65 years age group. This suggests that this age group is may be limited in transport choice because of income constraints. Age is also a significant determinant in the low level of car driver trips and higher level of car passenger trips because the restriction on the age to obtain a drivers license and access to private vehicles.

6.4.4.4 The results show that overall Zone 2 exhibits a significantly higher proportion of walk/cycle (38.5%) travel than Zones 17-33 (29.9%). These results suggest that urban form characteristics may have a greater influence on the travel choice for the 5 to 24 years age.

## 6.4.5 Trip Mode For Age Group 25 - 44 Years

6.4.5.1 Figure 55 shows the trip mode by the respondents in the age group 25 to 44 years within the ASP zones.

Figure 55: Trip Mode For Age Group 25 - 44 Years



6.4.5.2 The results in Figure 55 show that overall most of the travel made by respondents in the 25 to 44 year age group is by car in Zones 2 (84.6%) and Zones 17-33 (88.2%). The majority of these trips are car driver trips in Zone 2 (77.8%) and Zones 17-33 (80.7%) which is significantly higher than the average (65.8%). The proportion of public transport use and walk/cycle modes is therefore lower in Zone 2 (4.2% and 7.9% respectively) and Zones 17-33 (2.8% and 3.2% respectively) than the average for Auckland figures (5.5% and 8.2% respectively). Of note is that the proportion of public transport and walk/cycle travel is slightly greater for Zone 2 than for Zones 17-33. The proportion of trips made by 'other' modes in Zone 2 (3.3%) is slightly lower than Zones 17-33 (5.8%) and the average (6.9%).

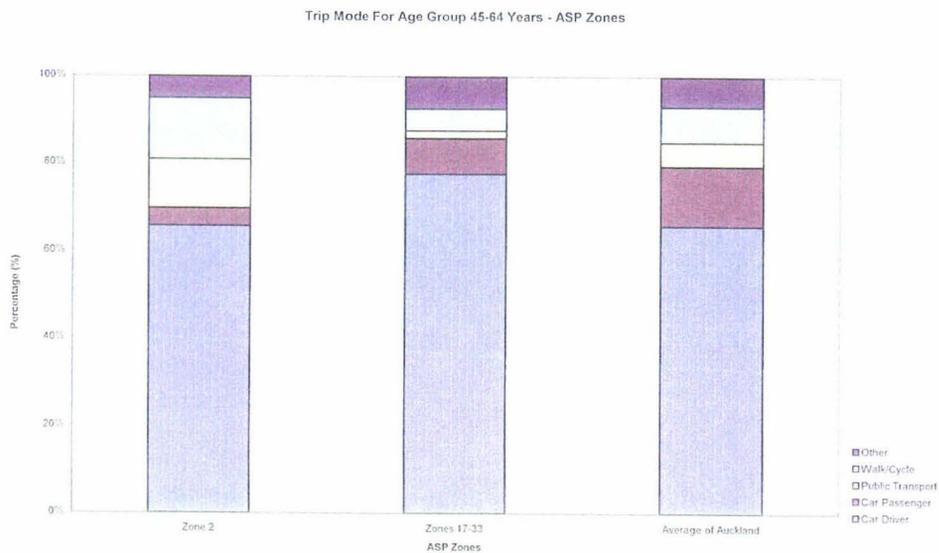
6.4.5.3 Kitamura (1988) research concluded that annual expenditure on transportation peaks in the 45 to 54 years age group then the 35 to 44 years, followed by 25 to 34 and the 54 to 64 years age group. Annual expenditure on gasoline consumption and motor oil peaks in the 45 to 54 years age group, then in the 35 to 44 years age group. Expenditure on cars and trucks (net outlay and finance charges) is highest in the 35 to 44 years age group followed by the 45 to 54 years age group. These findings suggest that the 25 to 44 years age group and the 45 to 64 years age group spend more overall on transportation, gasoline and motor oil, and vehicle net outlay than the under 25 years and over 65 years age group. This provides some support for the higher proportion of car trips and lower levels of public transport use and walk/cycle than the average figures.

6.4.5.4 The results show that the proportion of public transport and walk / cycle travel in Zone 2 (12.1%) is again slightly higher than Zones 17-33 (6.0%). This result suggest that the urban form characteristics may if at all have only a slight influence on travel choice within the 25 to 44 years age group.

## 6.4.6 Trip Mode For Age Group 45 - 64 Years

6.4.6.1 Figure 56 shows the trip mode by the respondents in the age group 45 to 64 years within the ASP zones.

Figure 56: Trip Mode For Age Group 45 - 64 Years



6.4.6.2 The results show that overall the majority of the travel made by respondents in the 45 to 64 year age group in Zone 2 (69.7%) and Zones 17-33 (85.9%) is by car. The proportion of trips made by car for Zone 2 (69.7%) is notably lower than the average for Auckland (79.5%), however the proportion of car trips made in Zones 17-33 is above the average (85.9%). The majority of car trips have the respondent as the car driver in Zone 2 (65.7%) and Zones 17-33 (71.0%). The proportion of public transport (11.1%) and walk/cycle travel (14.1%) in Zone 2 is significantly higher than Zones 17-33 (1.8% and 5.0% respectively) and the average for Auckland figures (5.5% and 8.2% respectively). The proportion of travel made by 'other' modes in Zone 2 (5.1%) and Zones 17-33 (7.4%) is similar to the average (6.9%). The result for Zone 2 (69.7%) suggests that there is a significant difference in travel

modes which can not be attributed to the socio-demographic characteristics of age.

#### 6.4.7 Trip Mode For Age Group Over 65 Years

6.4.7.1 Figure 57 shows the trip mode by the respondents in the age group over 65 years within the ASP zones.

Figure 57: Trip Mode For Age Group Over 65 Years

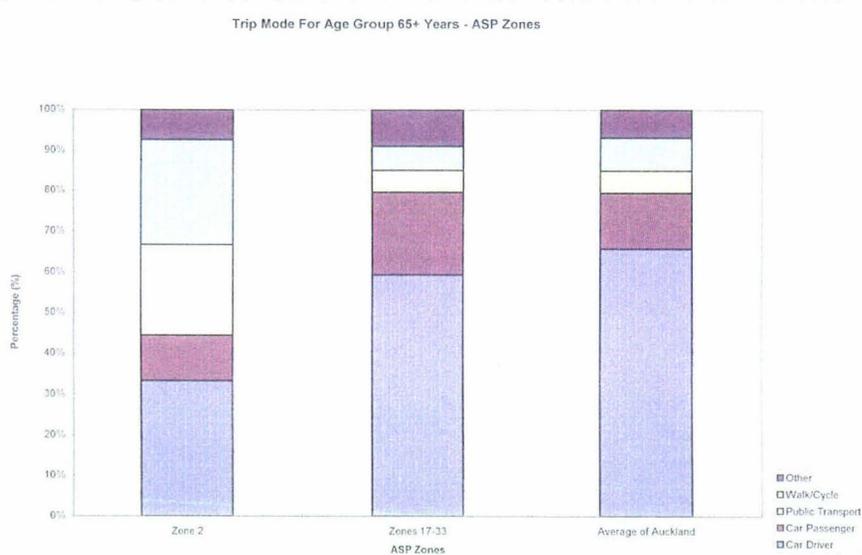


Table 20: T-test Results for the Over 65 Years Age Group

TRIP MODE VARIABLE	t STAT	t CRITICAL ONE TAIL	P (T <=t) ONE TAIL
CAR DRIVER	1.83	1.77	0.05
CAR PASSENGER	0.44	1.78	0.34
PUBLIC TRANSPORT	1.58	1.81	0.07
WALK/CYCLE	1.10	1.80	0.30
OTHER MODES	N/A	N/A	N/A

6.4.7.2 The results in Figure 57 shows that under half (44.4%) of all travel by the age group over 65 years in Zone 2 is by car. This is significantly lower than Zones 17-33 (77.7%) and the average for Auckland (79.5%). The majority

of car travel is made by car drivers (33.3%), the proportion of car passenger travel in Zone 2 (11.1%) is slightly lower than Zones 17-33 (16.0%) and the average for Auckland (13.7%). The proportion of public transport (22.2%) and walk/cycle travel (25.9%) in Zone 2 by this age group is higher than Zones 17-33 (5.4% and 6.0% respectively) and the average (5.5% and 8.2% respectively). Zone 2 therefore exhibits less automobile reliant travel behaviour compared to Zones 17-33 and the average for Auckland. The proportion of 'other' modes (9.0%) used for travel in Zones 17-33 is slightly greater than Zone 2 (7.4%) and the average (6.9%).

6.4.7.3 The results in Figure 57 suggest that the proportion of car and walk/cycle travel in Zones 17-33 for the over 65 years age group is similar to the average for Auckland values. The number of respondents in the over 65 years age group Zone 2 is 12. A t-test is therefore necessary to determine whether there is a statistically significant difference between the results for Zone 2 and 17-33. The t-test results shown in Table 20 show that a statistically significant difference exists in the travel behaviour results for Zone 2 Zones 17-33 for the car driver modes. However the t-test results show that a statistically significant difference does not occur for car passenger, public transport, walk/cycle and other modes.

6.4.7.4 Research conducted by Principio and Pas (1996) indicates that the 'domestic caretakers' group (mostly comprised of elderly respondents) utilize the car and physical modes to an average extent and use public transport (or bus) more frequently than most. The low score for public transport trips suggests that the proportion of public transport travel made by the elderly in Zones 17-33 is not as frequent as the Principio and Pas (1996) suggest.

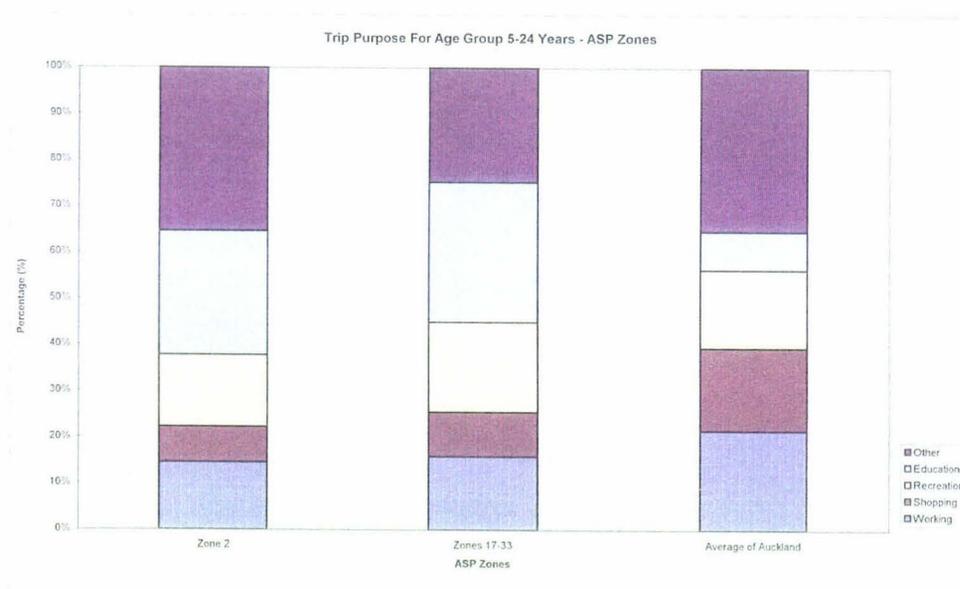
6.4.7.5 Morris, Richardson and McPherson (1996) state that for the elderly age group, driving is limited to their ability, financial resources which may be limited due to higher user charges and increased privatization of community services. Kitamura (1988) research shows that the elderly or over 65 years age group have the second to lowest income level and expenditure on transportation of all age groups after the under 25 years age group. Principio and Pas (1996) research confirms that the elderly generally have a low

number of vehicles. These findings however do not concur with the findings of this research which suggests that the elderly mainly use the car to travel.

#### 6.4.8 Trip Purpose For Age Group 5 - 24 Years

6.4.8.1 Figure 58 shows the proportion of trips made for different purposes by respondents aged 5 to 24 years in ASP Zones.

Figure 58: Trip Purpose For Age Group 5 - 24 Years



6.4.8.2 The results in Figure 58 show that respondents aged 5 to 24 years in Zone 2 and Zones 17-33 make the greatest proportion of education and recreation trips. The proportion of education (26.9%) and recreation trips (15.4%) made in Zone 2, is slightly lower than the proportion for Zones 17-33 (30.3% and 19.4% respectively). The proportion of education trips made in Zone 2 and Zones 17-33 is however, significantly higher than the average (8.3%). The proportion of recreation trips is slightly lower in Zone 2 (15.4%) than the average (17.0%) and slightly higher in Zones 17-33 (19.4%). The proportion of shopping and working trips in Zone 2 (7.7% and 14.6%

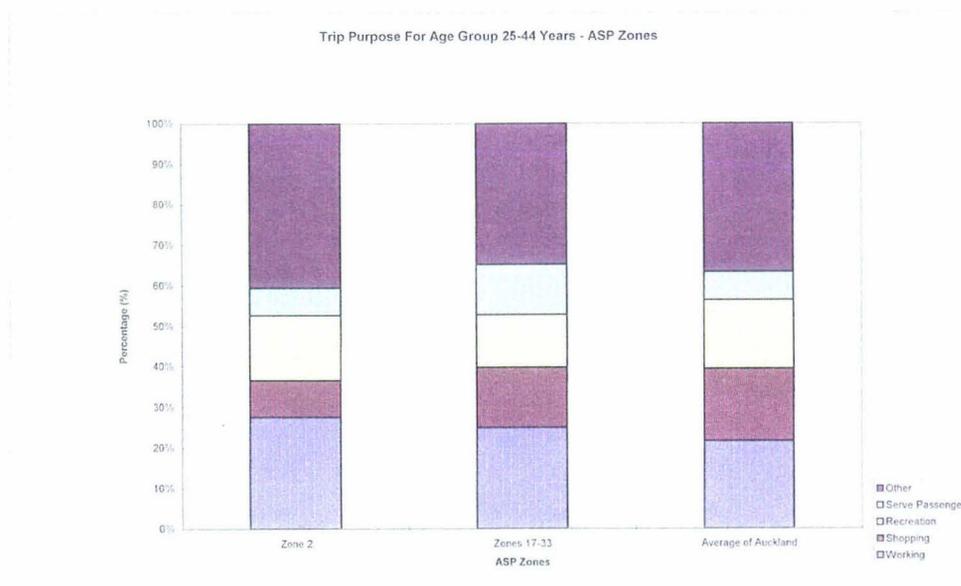
respectively) and Zones 17-33 (9.6% and 15.9% respectively) is significantly lower than the average (17.8% and 21.6% respectively). The proportion of 'other' trip purposes in Zone 2 (35.4%) is the same as the average (35.4%), while the proportion of 'other' trips in Zones 17-33 is significantly lower (24.8%).

6.4.8.3 The research conducted by Kitamura (1988) examined the influence certain lifestyle variables had on household income and expenditure and therefore activities. As part of this research Kitamura concluded that the under 25 years age group had similar household expenditure levels as the over 65 years age group. However the budget allocations of their income was different in that the under 25 years age group spent more on eating out, alcohol, transportation and entertainment. The findings of Kitamura (1988) research corresponds to the results in this section in that both Zone 2 and Zones 17-33 have an average proportion travel for recreational purposes and the below average proportion of working and shopping travel. The high proportion of travel for education purposes suggests that a large proportion of the respondents in this age group attend an educational institution.

#### 6.4.9 Trip Purpose For Age Group 25 - 44 Years

6.4.9.1 Figure 59 shows the proportion of trips made for different purposes by respondents aged 25 to 44 years in ASP Zones.

Figure 59: Trip Purpose For Age Group 25 - 44 Years



6.4.9.2 The results in Figure 59 show that a higher proportion of working trips and 'other' trips are made by the age group 25 to 44 years in both Zone 2 (27.6%) and Zones 17-33 (25.0%) compared to the average for Auckland result (21.6%). It is therefore assumed that this age group has a large proportion of workers. The proportion of 'other' trips in Zone 2 (40.6%) and Zones 17-33 (38.0%) is similar and again above the average (35.4%). This indicates that the age group makes more trips for 'other' purposes for example, business related travel and/or multi-purpose trips. The proportion of recreation trips in Zone 2 (16.1%) is similar to the average (17.0%), however the proportion in Zones 17-33 (13.0%) for this age group is below the average. The research conducted by Kitamura (1988) found that expenditure on housing and entertainment peaked in the 35 to 44 years age

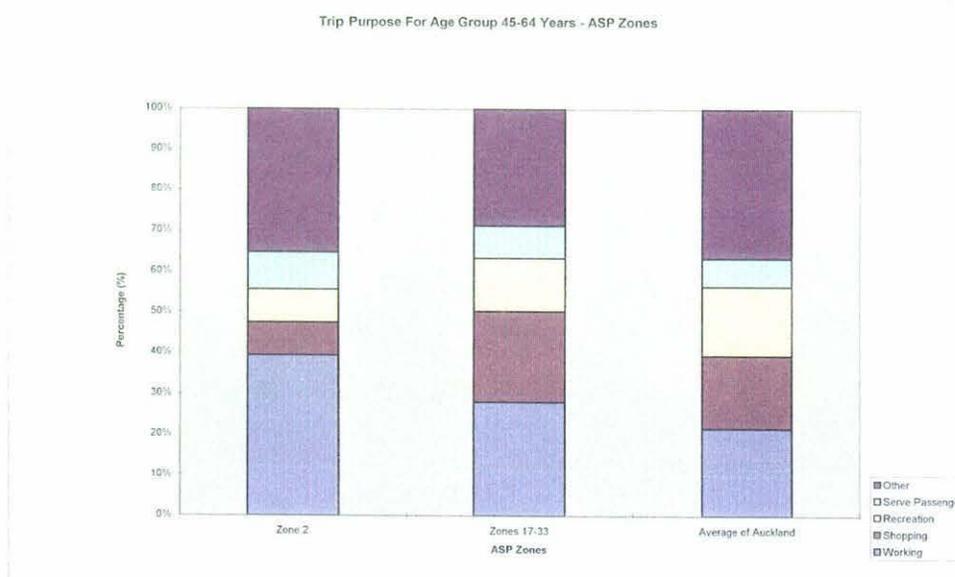
group. However these findings are not reflected by a higher proportion of recreation trips made in Zone 2 and Zones 17-33 for this age group.

6.9.4.3 The proportion of shopping trips made in Zone 2 (9.0%) is significantly lower than the average (17.8%), while the proportion of shopping trips made in Zones 17-33 (14.8%) is only slightly lower than the average. The low proportion of shopping trips in Zone 2, seems an unusual result as Zone 2 has a greater proportion and distribution of commercial land and more commercial establishments than Zones 17-33. This result may be explained in part by the higher proportion of 'other' trips such as multi-purpose trips that may includes trips made to and from the shops. The proportion of serve passenger trips in Zone 2 (6.8%) is similar to the average for Auckland (6.9%), however the proportion for Zones 17-33 (12.4%) is nearly double the average value.

#### 6.4.10 Trip Purpose For Age Group 45 - 64 Years

6.4.10.1 Figure 60 shows the proportion of trips made for different purposes by respondents aged 45 to 64 years in ASP Zones.

Figure 60: Trip Purpose For Age Group 45 - 64 Years



6.4.10.2 The results in Figure 60 show that the respondents in this age group in Zone 2 (39.4%) and Zones 17-33 (27.9%) make an above average proportion of working trips compared to the average (21.6%). It is assumed from this result that there is a significant working population component in this age group in Zone 2 and Zones 17-33. The proportion of 'other' trips in Zone 2 (35.4%) is the same as the average (35.4%), however the result for Zones 17-33 (28.8%) is below this value. The proportion of shopping (8.1%), recreation trips (8.1%) Zone 2 is lower than Zones 17-33 (22.3% and 13.0%) and the average (17.8% and 17.0% respectively). The proportion of serve passenger trips for Zone 2 (9.1%) and Zones 17-33 (7.9%) is similar and is slightly above the average figure (6.9%).

6.4.10.3 Research conducted by Kitamura (1988) concluded that the higher the income, (highest income and expenditure in the 45-54 years age group) the more social trips and more multi-stop trip chains. Zones 17-33 have a higher proportion of recreation trips than the average which therefore provides some support for Kitamura's findings. However the proportion of recreation trips in Zone 2 is below the result for Zones 17-33 and the average, and therefore does not concur with these findings.

#### 6.4.11 Trip Purpose For Age Group Over 65 Years

6.4.11.1 Figure 61 shows the proportion of trips made for different purposes by respondents aged over 65 years in ASP Zones.

Figure 61: Trip Purpose For Age Group Over 65 Years

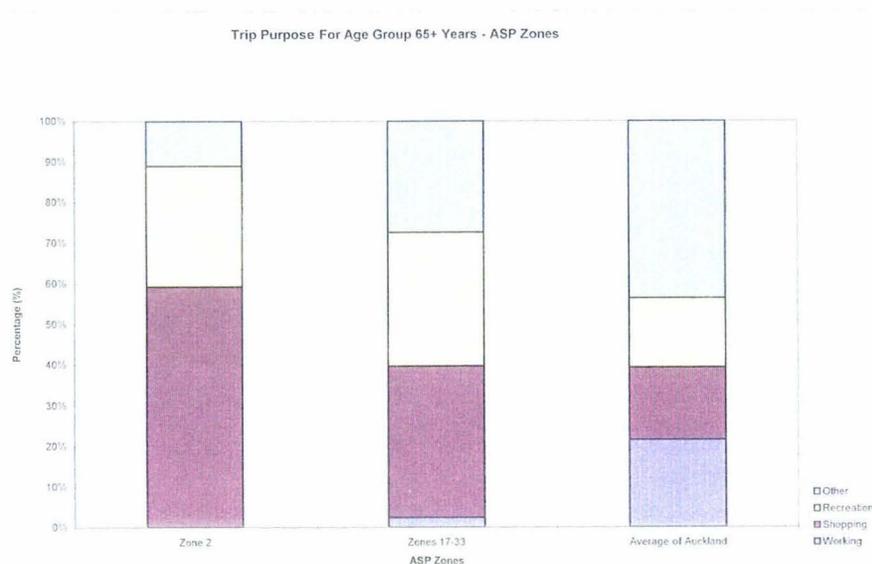


Table 21: T-test Results for Over 65 Years Age Group

TRIP PURPOSE VARIABLE	t STAT	t CRITICAL ONE TAIL	P (T<=t) ONE TAIL
WORKING	1.98	1.66	0.02
SHOPPING	1.50	1.78	0.08
RECREATION	0.20	1.77	0.42
OTHER	3.34	1.68	0.001 (3dp)

6.4.11.2 The results in Figure 61 show that the proportion of shopping and recreation trips by the over 65 years age group in Zones 2 and Zones 17-33 is significantly higher than the average figures. Over half (59.3%) of all the trips made by respondents in Zone 2 are for shopping purposes. This is significantly higher than the proportion in Zones 17-33 (37.0%) and the average figure (17.8%). The proportion of recreation trips in Zone 2 (29.6%)

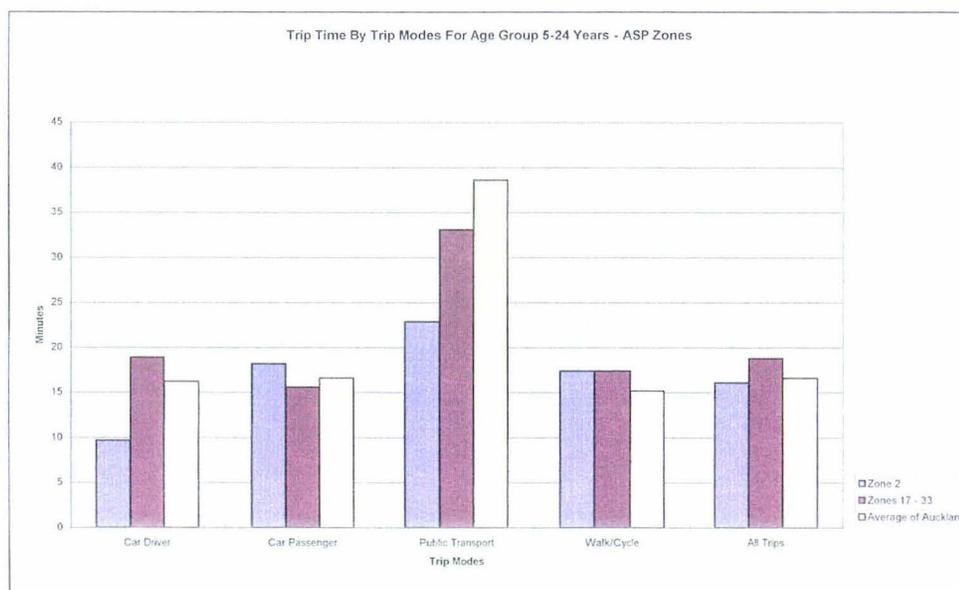
and Zones 17-33 (32.8%) for this age group is significantly higher than the average (17.0%). The proportion of trips made for working purposes in Zone 2 (0.0%) and Zones 17-33 (2.4%) is significantly lower than the average figure (21.6%) suggesting a smaller working population base in this age group compared to the average. The proportion of trips for 'other' purposes is also significantly lower in Zone 2 (11.1%) than the average (35.4%) and Zones 17-33 (27.5%). The t-test results found that a statistically significant difference exists in the results for 'working' and 'other' trip purposes between Zone 2 and Zones 17-33. The t-test however concluded that there the difference in the 'shopping' and 'recreation' trip purposes is not statistically different between the two zones.

6.4.11.3 The low level of working trips made by this age group in Zone 2 and Zones 17-33 is supported by research conducted by Principio and Pas (1996). They identified that the 'domestic caretakers' life cycle group (mainly comprised of elderly people) generally do not participate in work or educational activities.

#### 6.4.12 Trip Time By Trip Mode For Age Group 5 - 24 Years

6.4.12.1 Figure 62 shows the average trip time by trip mode made by respondents aged 5 to 24 years in the ASP Zones.

Figure 62: Trip Time By Trip Mode For Age Group 5 - 24 Years



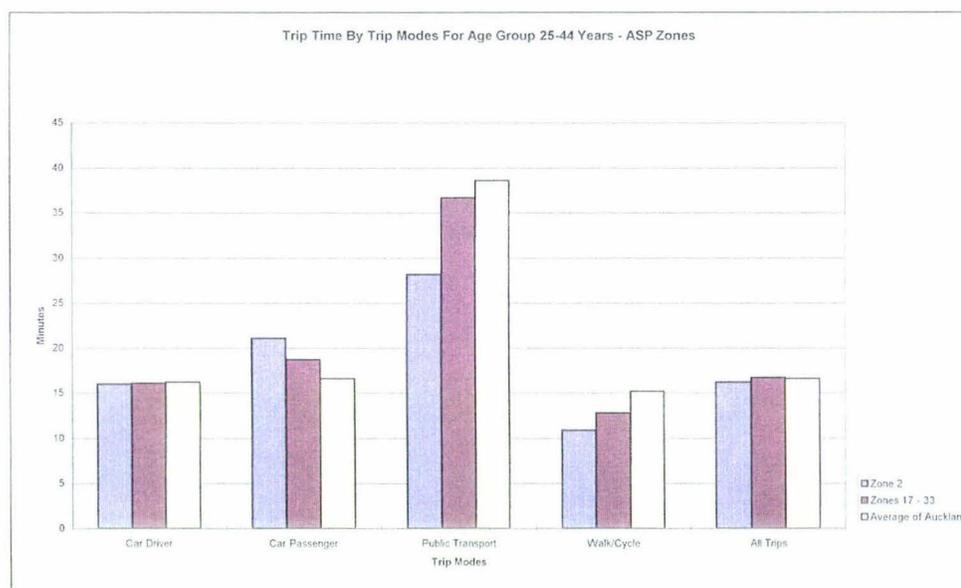
6.4.12.2 The results in Figure 62 show that public transport trips are significantly longer in trip time than the other modes for both Zone 2 and Zones 17-33. The average trip time for public transport trips in Zone 2 (22.9 mins) and Zones 17-33 (33.1 mins) is below the average for Auckland (38.6 mins). This result suggests that the 5 to 24 years age group in Zone 2 do not travel as long on public transport as their counterparts in Zones 17-33. The average trip time of car driver trips in Zone 2 (9.7 mins) is shorter than the average for Auckland (16.2 mins), however the average trip time for car driver trips in Zones 17-33 (18.9 mins) is above the average. This indicates that the average trip length in Zone 2 may be shorter in distance than in Zones 17-33. The average trip time for car passenger trips in Zone 2 (21.1 mins) is above the average for Auckland (16.6 mins) and Zones 17-33 (15.6 mins). The

average trip time for walk/cycle modes is similar for Zone 2 (17.4 mins) and Zones 17-33 (17.4 mins) and the average for Auckland (15.2 mins).

#### 6.4.13 Trip Time By Trip Mode For Age Group 25 - 44 Years

6.4.13.1 Figure 63 shows the average trip time by trip mode made by respondents aged 25 to 44 years in the ASP Zones.

Figure 63: Trip Time By Trip Mode For Age Group 25 - 44 Years



6.14.3.2 The results in Figure 63 show that, the average trip time for public transport trips is significantly longer than the average times for all the other modes in both Zone 2 and Zones 17-33 for the 25-44 years age group. The results show that the average public transport trip time for Zone 2 respondents (28.2 mins) is significantly shorter than for Zones 17-33 (36.7 mins) and the average (38.6 mins). The average trip time for car passenger trips in Zone 2 (21.1 mins) and Zones 17-33 (18.7 mins) is above the average for Auckland (16.6 mins). The average trip time for car driver trips is similar for Zone 2 (16.0 mins), Zone 17-33 (16.1 mins) and the average (16.2 mins). The average trip time for walk/cycle trips is slightly shorter in Zone 2 (10.9 mins)

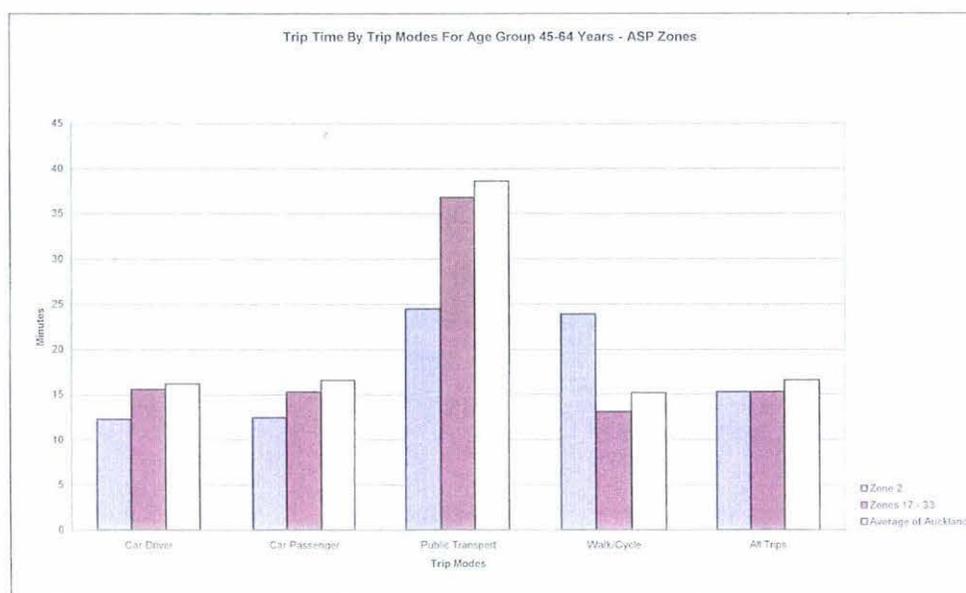
than Zone 17-33 (12.8 mins) and the average (15.2 mins). Overall in the 'all trips' variable Zone 2 (16.2 mins), Zones 17-33 (16.7 mins) is similar to the average (16.6 mins).

6.14.3.3 The results here indicate that on average shorter trip times are experienced in Zone 2 for this age group for walk/cycle and public transport trips. This may provide some support for the claim that NTD urban form may have an impact on the length of trips (excluding automobile travel) in terms of the origins and destinations being in closer proximity.

#### 6.4.14 Trip Time By Trip Mode For Age Group 45 - 64 Years

6.4.14.1 Figure 64 shows the average trip time by trip mode made by respondents aged 45 to 64 years in the ASP Zones.

Figure 64: Trip Time By Trip Mode For Age Group 45 - 64 Years



6.4.14.2 The results in Figure 64 show that the average trip time for public transport trips made by respondents aged 45 to 64 years in Zone 2 (24.5 mins) is significantly shorter than Zones 17-33 (36.8 mins) and the average for Auckland (38.6 mins). The average trip time for walk/cycle modes in Zone 2 (23.9 mins) is longer than Zones 17-33 (13.1 mins) and the average (15.2 mins). The average trip times for car driver (12.3 mins) and car passenger (12.5 mins) is slightly shorter than Zones 17-33 (15.6 mins and 15.3 mins respectively) and the average (16.2 mins and 16.6 mins respectively). The 'all trip' variable shows that the average trip time for all the modes is the same for Zone 2 (15.3 mins) and Zones 17-33 (15.3 mins), and this is similar to the average (16.6 mins).

#### 6.4.15 Trip Time By Trip Mode For Over 65 Years Age Group

6.4.15.1 Figure 65 shows the average trip time by trip mode made by respondents aged over 65 years in the ASP Zones.

Figure 65: Trip Time By Trip Mode For Over 65 Years Age Group

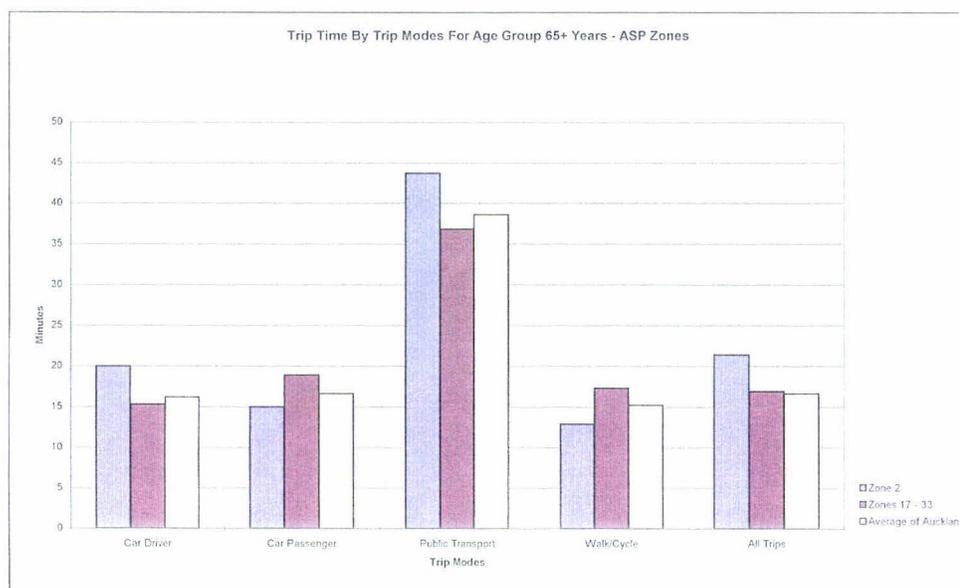


Table 22 - T-test Results for the Over 65 Years Age Group

TRIP TIME TRIP PURPOSE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
CAR DRIVER	1.26	1.81	0.12
CAR PASSENGER	1.74	1.67	0.04
PUBLIC TRANSPORT	0.33	1.80	0.37
WALK/CYCLE	2.30	1.71	0.02
ALL TRIP MODES	1.37	1.70	0.09

6.4.15.2 The results in Figure 65 show that the average trip time for public transport trips in Zone 2 (43.7 mins) is longer than Zones 17-33 (36.8 mins) and the average (38.6 mins) for the over 65 years age group. The average trip time for car driver trips is also longer in Zone 2 (20.0 mins) than Zones 17-33 (15.3 mins) and the average (16.2 mins). The average trip time of the

walk/cycle (12.9 mins) and car passenger (15.0 mins) modes is slightly shorter than Zones 17-33 (17.3 mins and 18.9 mins respectively) and the average for Auckland (15.2 mins and 16.6 mins respectively). The 'all trips' variable shows that overall the average trip time is longer in Zone 2 (21.4 mins) than Zones 17-33 (16.9 mins) and the average (16.6 mins). The t-test results conclude that the difference in car passenger and walk/cycle trip times between Zone 2 and Zones 17-33 are statistically significant. However the difference in car driver, public transport modes is not statistically different between Zone 2 and Zones 17-33. This suggests that the trip times for walk/cycle and car passenger trips vary between Zone 2 and Zones 17-33.

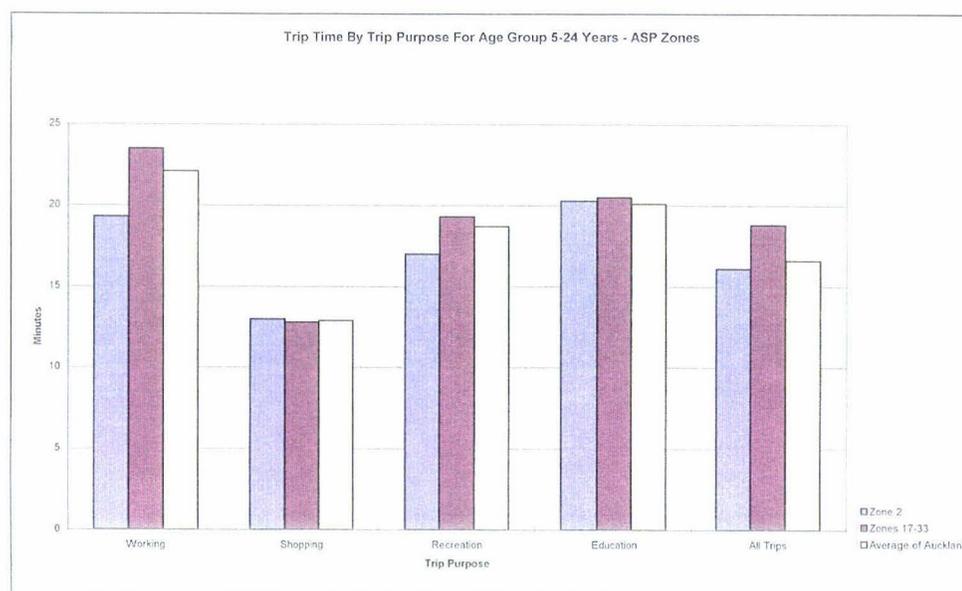
6.4.15.3 The significant trends in average trip times by comparing the four age groups is as follows:

- That public transport trips in Zone 2 are generally shorter than Zones 17-33 and the average (with the exception of the over 65 years age group);
- The average trip length for public transport trips in Zone 2 and Zones 17-33 is longer than the other modes;
- That the average trip time for car driver trips in Zone 2 are shorter compared to Zones 17-33 (with the exception of the over 65 years age group);
- Walk/cycle trips tend to be longest overall in the 5 to 24 years age group.

#### 6.4.16 Trip Time By Trip Purpose For Age Group 5 - 24 Years

6.4.16.1 Figure 66 shows the average trip time by trip purpose by respondents aged 5 to 24 years in the ASP Zone.

Figure 66: Trip Time By Trip Purpose For Age Group 5 - 24 Years

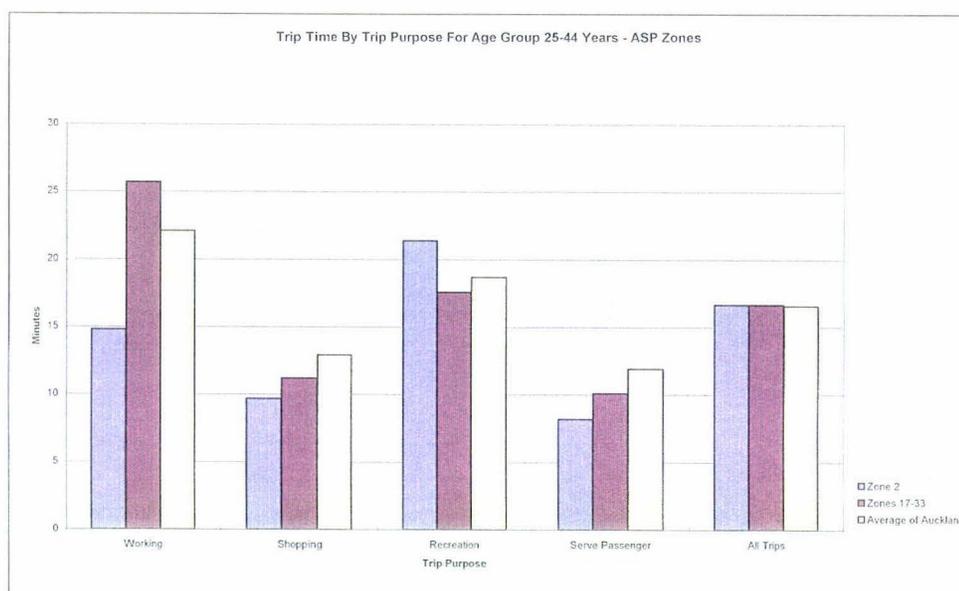


6.4.16.2 The results in Figure 66 show that respondents in the 5 to 24 years age group in Zone 2 have slightly shorter working trips (19.3 mins) than Zones 17-33 (23.5 mins) and the average (22.1 mins). The average trip time for education/school trips in Zone 2 (20.3 mins) is similar to the Zones 17-33 (20.5 mins) and the average (20.1 mins). The average trip time for recreation trips in Zone 2 (17.0 mins) and Zones 17-33 (19.3 mins) is similar to the average (18.7 mins) in this age group. The average trip time for shopping trips for Zone 2 (13.0 mins) and Zones 17-33 (12.8 mins) is also similar to the average (12.9 mins). The 'all trips' variable shows that the average trip time for all modes in Zone 2 (16.1 mins) is similar to the average (16.6 mins), however the time for Zones 17-33 (18.8 mins) is slightly longer than Zone 2 and the average. Overall the results show that the average trip time is slightly shorter in Zone 2 than Zones 17-33.

#### 6.4.17 Trip Time By Trip Purpose For Age Group 25 - 44 Years

6.4.17.1 Figure 67 shows the average trip time by trip purpose by respondents aged 25 to 44 years in the ASP Zone.

Figure 67: Trip Time By Trip Purpose For Age Group 25 - 44 Years



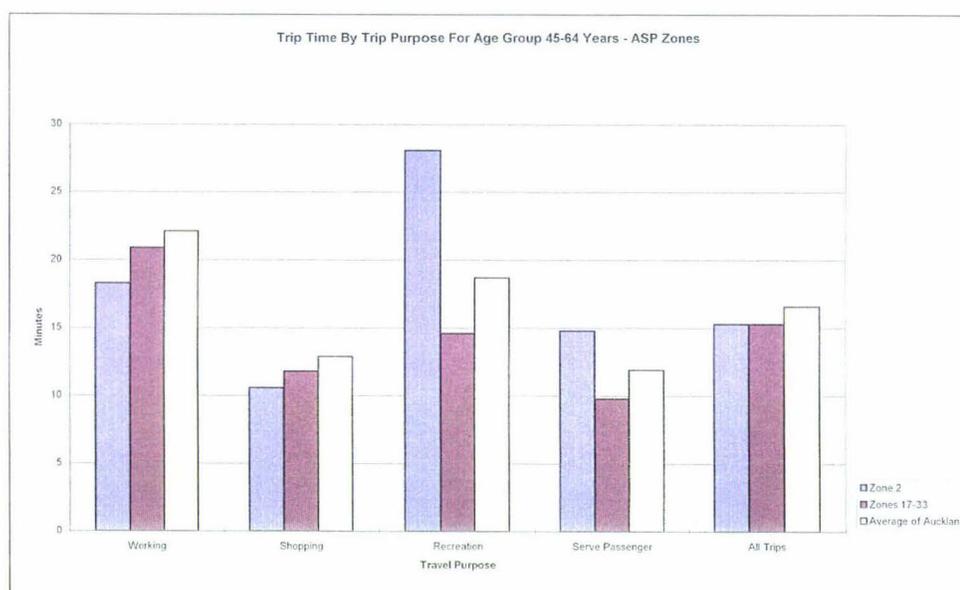
6.4.17.2 The results in Figure 67 show that the average trip time for working trips in Zone 2 (14.8 mins) for the 25 to 44 years age group is significantly shorter than Zones 17-33 (25.7 mins) and the average (22.1 mins). The average trip time for recreation trips in Zone 2 (21.4 mins) is longer than Zones 17-33 (17.6 mins) and the average (18.7 mins). The average trip time for shopping trips in Zone 2 (9.7 mins) is similar to the result for Zones 17-33 (11.2 mins). These two values are also similar to the average for Auckland (12.9 mins). The average trip time for serve passenger trips in Zone 2 (8.2 mins) and Zones 17-33 (10.1 mins) are also similar to the average (11.9 mins). The 'all trip' variable shows that the average trip time for all modes is similar for Zone 2 (16.7 mins), Zones 17-33 (16.7 mins) and the average (16.6 mins).

Overall the average trip times in Zone 2 is slightly shorter than Zones 17-33 except for recreation trips.

#### 6.4.18 Trip Time By Trip Purpose For Age Group 45 - 64 Years

6.4.18.1 Figure 68 shows the average trip time by trip purpose by respondents aged 45 to 64 years in the ASP Zones.

Figure 68: Trip Time By Trip Purpose For Age Group 45 - 64 Years



6.4.18.2 The results in Figure 68 show that the average trip time by the age group 45 to 64 years for recreation trips in Zone 2 (28.1 mins) is longer than Zones 17-33 (14.6 mins) and the average (18.7 mins). The average trip time for working trips in Zone 2 (18.3 mins) is shorter than Zones 17-33 (20.9 mins) and the average (22.1 mins). The average trip times for shopping trips in Zone 2 (10.6 mins) is similar to Zones 17-33 (11.8 mins) and the average (12.9 mins). However the average trip time for serve passenger trips in Zone 2 (14.8 mins) is longer than for Zones 17-33 (9.8 mins) and the average (11.9 mins) for this age group. The average trip time for the 'all trip' variable is the same for Zone 2 (15.3 mins) and Zones 17-33 (15.3 mins) which is also

similar to the average (16.6 mins). Overall the average trip times are slightly shorter for working and shopping trips for Zone 2 and longer for recreation and serve passenger trips than in Zones 17-33.

#### 6.4.19 Trip Time By Trip Purpose For Over 65 Age Group

6.4.19.1 Figure 69 shows the average trip time by trip purpose by respondents aged over 65 years in the ASP Zones.

Figure 69: Trip Time By Trip Purpose For Over 65 Age Group

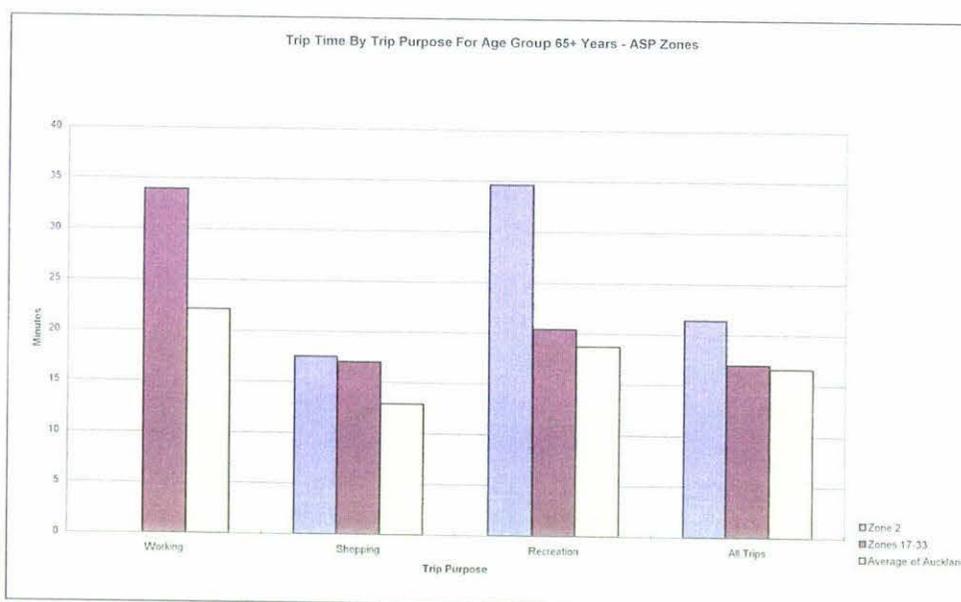


Table 23: T-test Results for the Over 65 Years Age Group

TRIP TIME BY TRIP PURPOSE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE TAIL
WORKING	N/A*	N/A*	N/A*
SHOPPING	0.66	1.69	0.26
RECREATION	1.59	1.86	0.08
ALL TRIP MODES	1.37	1.70	0.09

\* t-Test could not be calculated as no trips were made by respondents for working purposes in Zone 2.

6.4.19.2 The results in Figure 68 show that the average trip length for recreation trips in Zone 2 (34.6 mins), is significantly longer than Zones 17-33 (20.4 mins) and the average (18.7 mins) for the over 65 years age group. The absence of a result for working trips in Zone 2, in Figure 68 has occurred as no trips recorded for working purposes by the over 65 years age group. The result for working trips in Zones 17-33 (33.9 mins) shows however that this is longer than the average (22.1 mins). Zone 2, has a similar average trip time for shopping trips (17.5 mins) compared with Zones 17-33 (17.0 mins) which are longer than the average (12.9 mins). The average trip time for 'all trips' variable is longer in Zone 2 (21.4 mins) than for Zones 17-33 (17.0 mins) and the average (16.6 mins). The t-test results indicated that the difference between the average trip times in Zone 2 and Zones 17-33 are statistically significant.

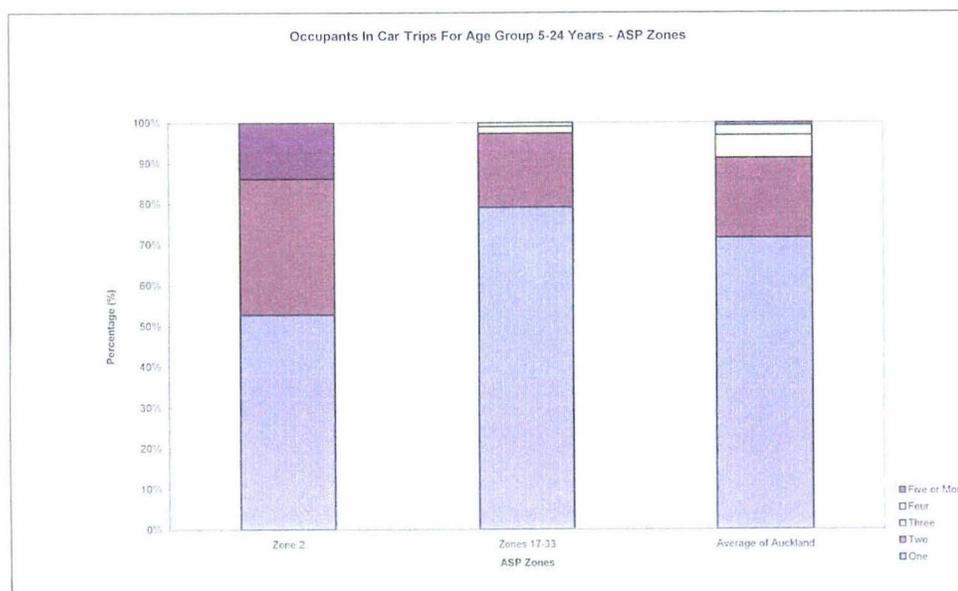
6.4.19.3 Overall the main trends in the results for the average trip times for different trip purposes can be summarised below:

- That in all the age groups and zones, working trips tend to be the longest overall of all the different trip purposes.
- The average trip time for education/school trips in the age group 5 to 24 years tends to have long average trip times.
- Recreation trips overall tend to have the next longest trip times after working trips for the age groups and zones.
- The average trip time for shopping and serve passenger trips in all the age groups and zones tends to be shorter than for the other trip purposes.

#### 6.4.20 Occupants In Car Trips For Age Group 5 - 24 Years

6.4.20.1 Figure 70 shows the number of occupants in car trips for respondents in the age group 5 to 24 years in the ASP Zones.

Figure 70: Occupants In Car Trips For Age Group 5 - 24 Years



6.4.20.2 The results in Figure 70 show that nearly half (52.8%) of all the car trips made by respondents aged 5 to 24 years in Zone 2, have only one occupant. In comparison, the majority (76.9%) of car trips made in Zones 17-33 have only one occupant. The result for Zones 17-33 is slightly higher than the average for Auckland (71.5%) while the result for Zone 2 is significantly lower than the average. One third (33.3%) of all the car trips made in Zone 2 have two occupants; this is significantly higher than Zones 17-33 (18.2%) and the average (19.7%). The remainder (13.9%) of car trips in Zone 2 have five or more occupants.

6.4.20.3 Overall the result suggests that a significantly greater proportion of car journeys have more than one occupant for Zone 2 than Zones 17-33. This result when compared to results in Figure 54 shows that the proportion of car

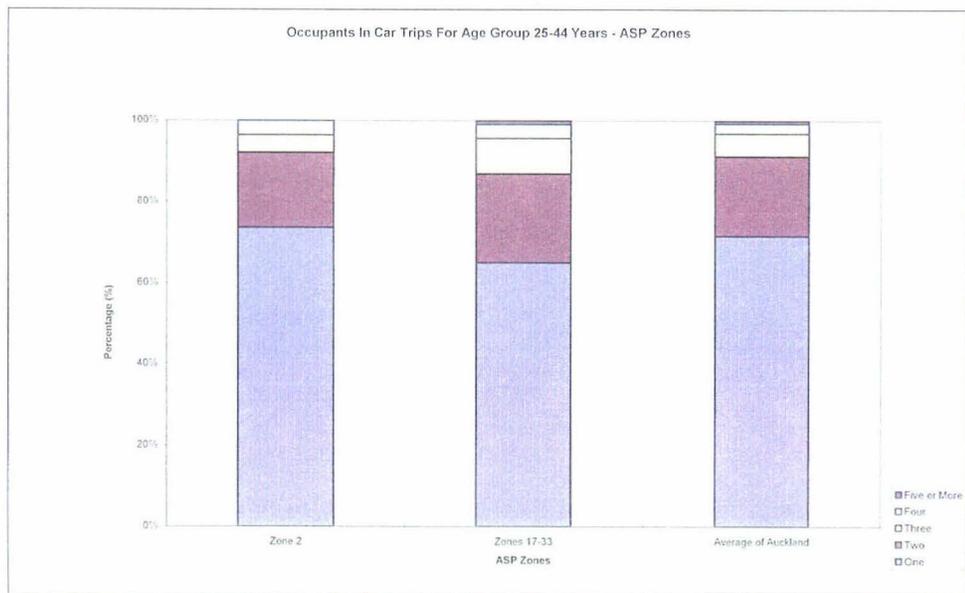
passenger trips made in Zone 2 (24.6%) is slightly lower than Zones 17-33 (29.3%). It would be expected that the proportion of car passenger trips made by this age group for Zone 2 would be greater in Figure 54 given the occupancy rate for car trips for Zone 2.

6.4.20.4 Morris, McPherson and Richardson (1996) found that young children have very few independent needs and the majority of journeys for children are made as car passengers. Chen (1994) found that fewer than 10% of all trips made by children of primary school age were independent of other household members, whereas some 25% of trips made by children older than primary school age were made independently (Morris, McPherson and Richardson 1996). This research confirms the results for Zone 2, however the result for Zones 17-33 does not indicate the same conclusions. It is difficult to speculate as to the reasons for the marked gap in the proportion of single occupant trips between the two sets of zones particularly compared to the results for car passengers in Zone 2 in Figure 54.

#### 6.4.21 Number of Occupants In Car Trips For Age Group 25 - 44 Years

6.4.21.1 Figure 71 shows the number of occupants in car trips for respondents in the age group 25 to 44 years in the ASP Zones.

Figure 71: Number Of Occupants In Car Trips For Age Group 25 - 44 Years

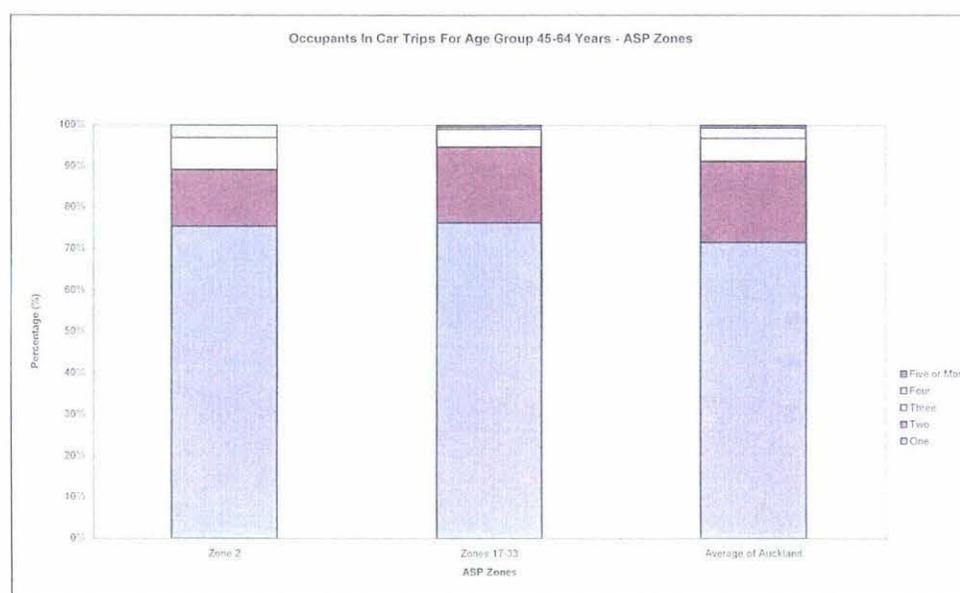


6.4.21.2 The results in Figure 71 show that Zone 2 (73.6%) has a higher proportion of single occupant trips in comparison to Zones 17-33 (65.1%) and the average (71.5) for the 25 to 44 years age group. The remainder of car trips in Zone 2, predominantly have two occupants (18.5%). In comparison the proportion of car trips with two occupants in Zones 17-33 (21.9%) is slightly higher than the result for Zone 2 and the average (19.7%).

#### 6.4.22 Number Of Occupants In Car Trips For Age Group 45 - 64 Years

6.4.22.1 Figure 72 shows the number of occupants in car trips for respondents in the age group 45 to 64 years in the ASP Zones.

Figure 72: Number of Occupants In Car Trips For Age Group 45 - 64 Years



6.4.22.2 The results in Figure 72 show that the majority of car trips made by the 45-46 years age group in Zones 2 (75.4%) and Zones 17-33 (76.2%) are single occupant trips. This is slightly higher than the average (71.5%). The proportion of two occupant car trips in Zone 2 (13.8%) and in Zones 17-33 (14.6%) are consequently lower than the average (19.7%). However the proportion of three (7.7%) and four (3.1%) trips is slightly higher in Zone 2, than Zones 17-33 (6.9% and 0.7% respectively), and the average (5.6% and 2.5% respectively).

### 6.4.23 Number Of Occupants In Car Trips For Over 65 Years Age Group

6.4.23.1 Figure 73 shows the number of occupants in car trips for respondents in the age group over 65 years in the ASP Zones.

Figure 73: Number Of Occupants In Car Trips For Over 65 Years Age Group

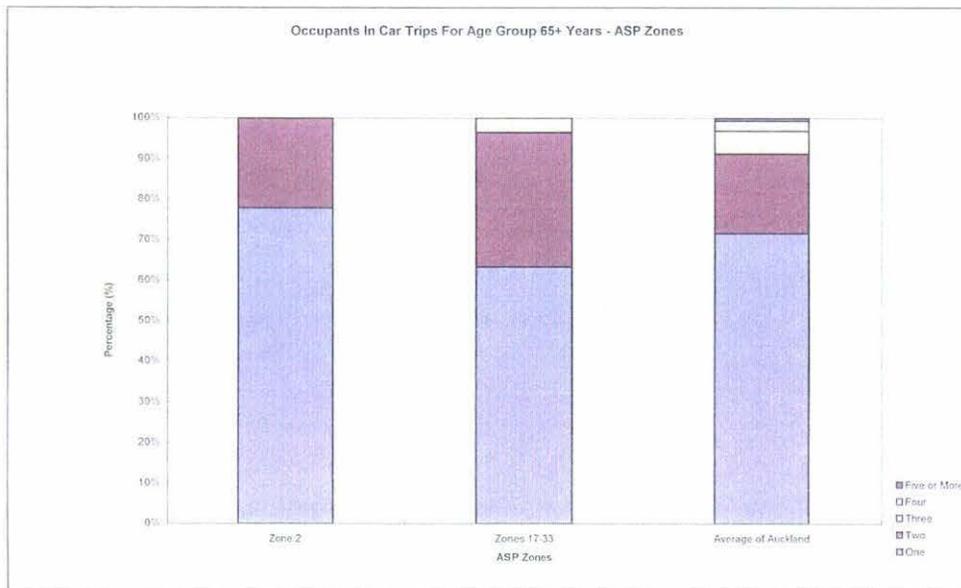


Table 24: T- test Results for the Over 65 Years Age Group

TRIP VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
OCCUPANTS	1.18	1.83	0.13

6.4.23.2 The results in Figure 73 show that the majority (77.7%) of car trips made by the over 65 years age group in Zone 2 have only one occupant. However the results for Zones 17-33 show that the proportion of single occupant car trips (63.3%) is significantly lower than the result for Zone 2 and the average for Auckland (71.5%). The remainder of car trips in Zone 2 have two occupants (22.2%), which is slightly higher than the average (19.7%) One third (33.2%) of all car trips in Zones 17-33 have two occupants, this is also higher than the average. The remainder (3.5%) of car trips in Zones 17-33

have three occupants. The t-test results revealed that the difference between Zone 2 and Zones 17-33 is not statistically significant.

#### 6.4.24 Is the Travel Behaviour In Zone 2 Less Automobile Reliant Than Zones 17-33 Across The Age Groups?

6.4.24.1 The results from this Section conclude that overall trip generation rates are higher in Zone 2 than Zones 17-33 and the Auckland regional average in all age groups. The results also found that the proportion of public transport and walk/cycle modes is greater overall in Zone 2 than Zones 17-33 for all age groups. It is identified that this is more notable for the 5 to 24 years and the 45 to 64 years age groups. This result is consistent with the claims of NTD researchers that indicate that factors such as a more mixed land use zone, higher residential density and more connective street patterns are associated with more non-vehicular modes of transport. The results further indicated that the trip purposes were relatively similar between the two zones. However there is an exception in that more shopping were proportionally made in Zones 17-33 age group 45 -64 years than Zone 2. The average trip times tended to vary across age groups and zones. The results for the average trip times did however indicate that public transport trips are generally longer than other modes for all the age groups. The average trip times for working and recreation generally also tended to be longer overall than shopping and serve passenger trips. The results across the various age groups tended to give some support claim that less automobile reliant behaviour does occur in Zone 2 compared to Zones 17-33 across age groups. However this seemed to be more prominently shown in the 5 to 24 years age group and the 45 to 64 years age group.

### 6.5 TRAVEL BEHAVIOUR OF HOUSEHOLD GROUPS

#### 6.5.1 INTRODUCTION

6.5.1.1 The research discussed in the literature review (Chapter 3) suggests that travel behaviour patterns vary according to the socio-demographic status of an individual or household, in terms of lifestyle (Principio and Pas 1996 and

Kitamura 1988), life cycle stage (Kitamura 1988 Morris, McPherson and Richardson 1996) and role of the household member (Vadarevu and Stopher 1996, Morris, McPherson, Richardson 1996). The purpose of this section of results is to identify whether the travel behaviour patterns of the respondents (by household member group) that reside in Zone 2 exhibit less automobile reliant travel behaviour than those that reside in Zones 17-33. This section of results expands on the research conducted so far on travel behaviour patterns by identifying the travel behaviour of different household groups to establish whether the patterns and trends observed in the literature review are apparent in the travel behaviour of household groups in Auckland region.

6.5.1.2 The travel behaviour patterns of household member group were selected for research for the following reasons:

- The research discussed in the literature review identified the role of the household member as an important variable determining in part travel behaviour patterns of the individual;
- The Home Interview Survey (1992) categorised respondents records according to the role of the household member, rather than by lifestyle or lifecycle variables used by researchers such as Principio and Pas (1996).

6.5.1.3 The four household member groups that have been selected for study include:

1. Main Income Earners: This group includes those respondents that earn the majority of the income for the household. Respondents in this group can be of any age and gender.
2. Wife/Partner/Defacto: This group includes women respondents that are not the Main Income Earners of the household and are in either a married, partner or defacto relationship.
3. Single Retired: This group includes those respondents that are both single and retired. Respondents in this group can be of any age and gender, however it is noted that this group is mostly comprised of older people.

4. Unrelated Flatmates: This group includes those respondents that are single, not related and living in a flatting situation. Respondents in this age group are of any age and gender.

6.5.1.4 The research discussed in the literature review (Chapter 3) can be applied to the results and conclusions made on the travel behaviour of the household member groups in this research. Principio and Pas (1996) found that travel behaviour can vary according to the 'lifestyle' group an individual belongs to. Principio and Pas (1996) research identified seven different lifestyle groups by examining the socio-demographic characteristics and daily activities of groups. These included: workaholics, active workers, socializers, leisure enthusiasts, domestic caretakers, diverse participants and scholars.

6.5.1.5 The study of the travel behaviour of the Main Income Earner household group was based on the 'workaholics and active workers' lifestyle groups examined in Principio and Pas (1996) research. The 'workaholics' group are comprised of adults that spend on average 85% of activity classified as work therefore spend most of time on work related activities. This group has the highest number of full time workers and the lowest number of retired individuals. The 'active workers' group spends a the majority of available time on work related activities (63.1%). The remainder of available time is spread over other activities for example, social and recreational activities. This group has similar demographics and employment characteristics to the workaholics group.

6.5.1.6 The 'domestic caretakers' and 'leisure enthusiasts' lifestyle groups examined in Principio and Pas (1996) research is similar to the 'single retired' household group used in this research. The 'domestic caretakers group' spend 81.4% of time on maintenance activities and generally do not participate in school or work. The group is comprised of mostly adults with few or no children. The pattern of time use examined, indicated that the people in this household groups are generally retired and elderly. The 'leisure enthusiasts' group spend 57.3% of time on recreational activities and minimally participate in work and school activities. This group is characterised as including mainly retired people i.e. an average of one retired

person per household, few workers present, small household size and very few children. The research conducted by Kitamura (1988) identified that certain lifestyle and life cycle variables for example, income, age, gender and employment status and socio-demographic change induced certain patterns of travel behaviour. These variables examined by Kitamura can be applied to the household groups used in this research to give insight into the socio-demographic influences on travel behaviour.

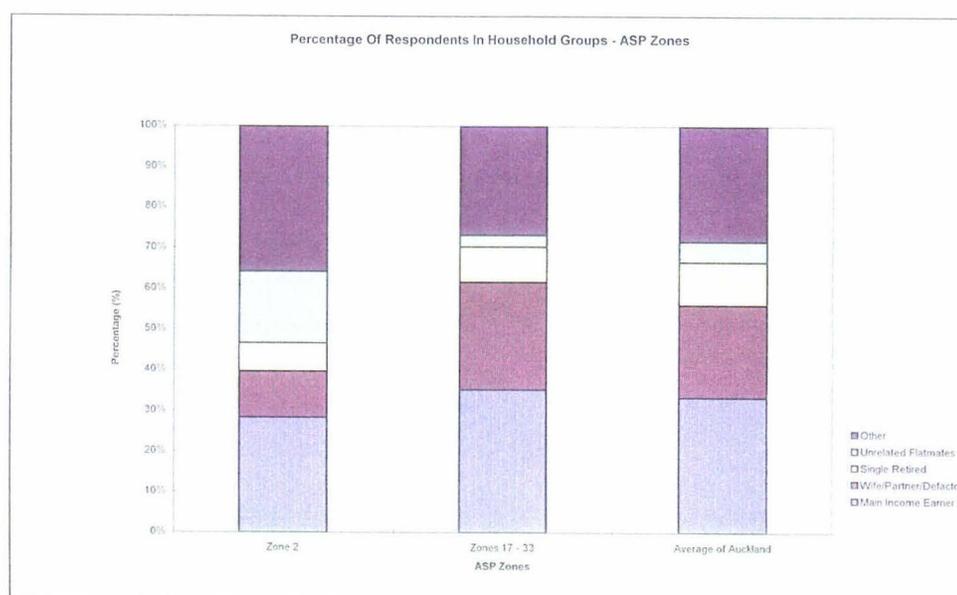
6.5.1.7 Morris, Richardson and McPherson (1996) examined the travel behaviour of women, the elderly and children. The research on women however does not differentiate between married and single women as in the household groups used in this research. The research made by Morris, Richardson and McPherson (1996) further differs from the household group variables used in this research in that this research differentiates between women that are Main Income Earners those that are not and includes these in one group with all male Main Income Earners. The research made by Morris, Richardson and McPherson (1996) research however provides information about the general travel patterns of women which can be used to contrast with travel behaviour patterns of Wife/Partner/Defacto group used in this research.

6.5.1.8 The 'unrelated flatmates' household group used in this research differs from the lifestyle, life cycle or socio-demographic variables used in the research made by Kitamura, Principio and Pas, Morris, McPherson and Richardson as discussed in the literature review. The results derived from this research can however be compared with the socio-demographic characteristics examined by researchers such as Kitamura.

## 6.5.2 Percentage of Respondents in Household Groups

6.5.2.1 Figure 74 show the percentage of respondents in each household group in the ASP Zones.

Figure 74: Percentage of Respondents in Household Groups



6.5.2.2 The results in Figure 74 show that Zone 2 (28.3%) has a lower proportion of respondents as Main Income Earners than Zones 17-33 (35.2%) and the average for Auckland (33.3%). The proportion of respondents in Zone 2 (11.3%) that are in the Wife/Partner/Defacto group is also lower than Zones 17-33 (23.7%) and the average (22.8%). The proportion of respondents in the Single Retired group in Zone 2 (6.9%) is similar to the proportion in Zones 17-33 (8.6%). The results for Zone 2 and Zones 17-33 are however slightly lower than the average (10.5%). The proportion of respondents that are in the Unrelated Flatmates group in Zone 2 (17.6%) is significantly greater than Zones 17-33 (2.9%) and the average (5.0%). The proportion of respondents in the 'other' household group (those not classified into one of the four categories) is also higher in Zone 2 (35.8%) than Zones 17-33 (26.9%) and the average for Auckland (28.5%).

6.5.2.3 The census data in Figure 28 shows that the proportion of family households in Zone 2 (51.3%) is significantly lower than the proportion in Zones 17-33 (79.7%) and the average for Auckland (73.8%). This could in part explain the higher proportion of respondents in the Wife/Partner/Defacto group in Zones 17-33 compared to Zone 2. The Census data shows that the proportion of non-family households in Zone 2 (20.1%) is higher than Zones 17-33 (4.7%) and the average (6.5%). This could also be in part explained by the greater proportion of respondents in the Unrelated Flatmates household group in Zone 2 compared to Zones 17-33. The proportion of single person households in Zone 2 (27.4%) from the Census data is again greater than Zones 17-33 (15.1%) and the average (6.5%). This result does not concur with the results show in Figure 74, as the proportion of respondents in the Single Retired is slightly lower in Zone 2 than Zones 17-33.

### 6.5.3 Average Number of Trips Made By Household Member

6.5.3.1 Figure 75 shows the average number of trips made per day per respondent by all the household groups in the ASP Zones.

Figure 75: Average Number of Trips Made By Household Member

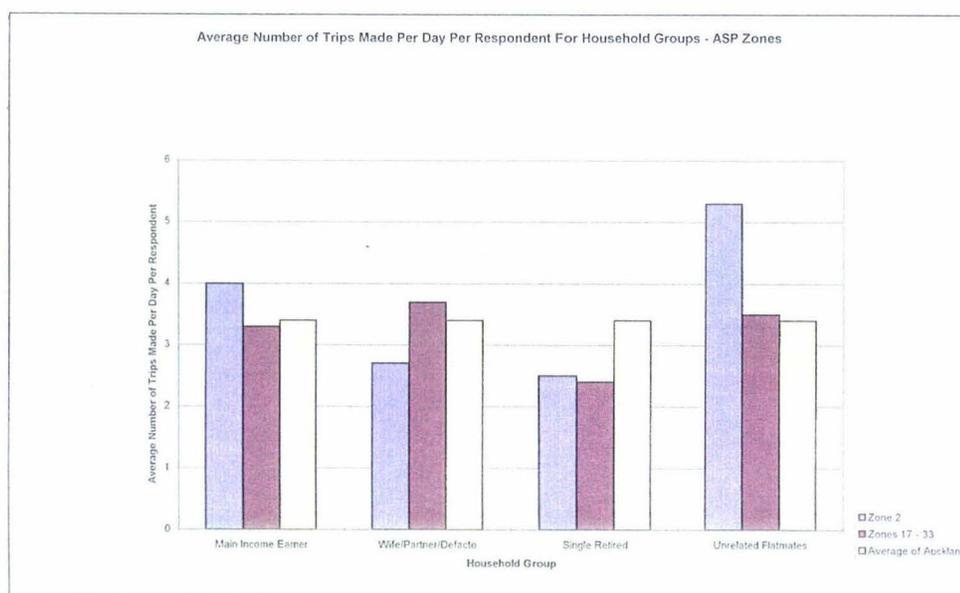


Table 25: T-test Results for the Average Number of Trips Made for all the Household Groups

AVERAGE NUMBER OF TRIPS MADE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
WIFE/PARTNER/DEFACTO	2.27	1.67	0.01
SINGLE RETIRED	0.08	1.76	0.47
UNRELATED FLATMATES	1.82	1.67	0.04

6.5.3.2 The results in Figure 75 show that overall the respondents in the Unrelated Flatmates group (5.3 trips) in Zone 2 make the greatest number of trips per day. This result is significantly higher than Zones 17-33 (3.5 trips) and the average (3.4 trips). The t-test results showed that the difference in the result for the Unrelated Flatmates group between Zone 2 and Zones 17-33 is statistically significant. The average number of trips made by the Main

Income Earners in Zone 2 (4.0 trips) is also higher than Zones 17-33 (3.3 trips) and the average (3.4 trips). However the average number of trips for the Wife/Partner/Defacto group in Zones 17-33 (3.7 trips) and the average (3.4 trips) is higher than the result for Zone 2 (2.7 trips). The t-test results showed that the difference in results for Zone 2 and Zones 17-33 is also statistically significant. The average number of trips made by the Single Retired group in Zones 2 (2.5 trips) and Zones 17-33 (2.4 trips) is similar, and below the average for Auckland (3.4 trips). The t-test results showed that in this case the difference between Zone 2 and Zones 17-33 is not statistically significant.

6.5.3.3 Principio and Pas (1996) research concluded that those respondents in the 'workaholics' group make fewer trips than the average of the sample. They suggest that this is due to the coordinating of trips more efficiently and the high level of trips per tour. The 'active workers' were found by Principio and Pas (1996) to have a high number of trips and tours and the highest level of travel for a two day period. This group was also found to be highly efficient at linking trips. The result for the Main Income Earner Group for both Zone 2 and Zones 17-33 is similar to the average which could suggest that this group is consistent with the "active workers" group results.

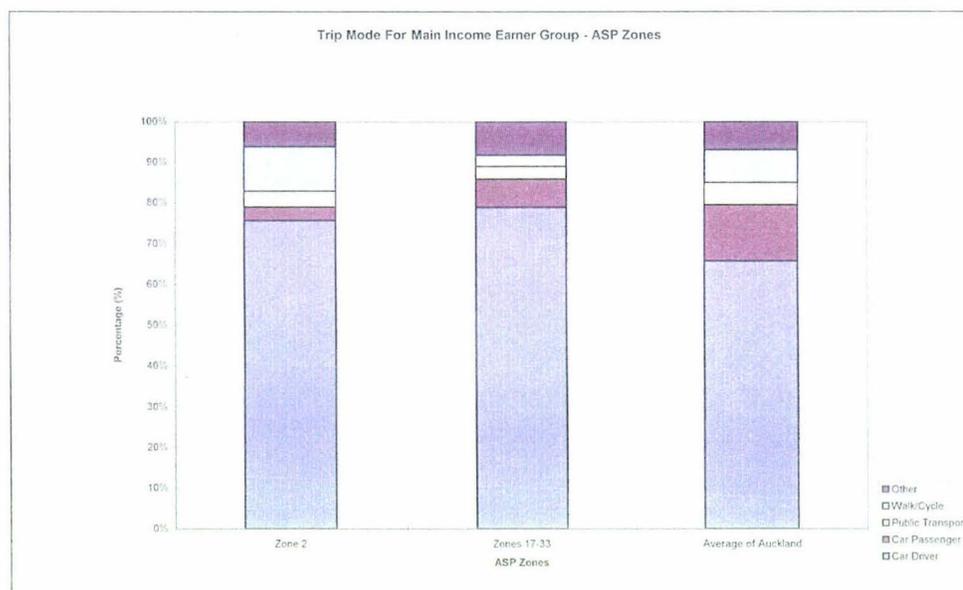
6.5.3.4 Kitamura (1988) found that women make trips less frequently than men even when employment status is accounted for. This finding concurs with the result shown for the Wife/Partner/Defacto group in Zone 2. The Wife/Partner/Defacto group in Zone 2 has a below average number of trips which does concur with Kitamura's conclusions. However, it should be recognised that in some cases women often have more complex trip making patterns in that they often link trips together i.e. running errands, picking up children from school. Principio and Pas (1996) concluded that the 'domestic caretakers' and 'leisure enthusiasts' group make a below average number of trips and tours of the sample. Kitamura (1988) also suggested that the elderly group have a lower trip rate which is in part due to the absence of work related travel. These findings concur with the results for the Single Retired and over 65 years (in Figure 53) for both Zone 2 and Zones 17-33 made by this research. Kitamura (1988) further found that the 'single

individuals' group are more mobile than their married individuals of the same age group. This result provides some support for the higher rates of travel in Zone 2 and Zones 17-33.

#### 6.5.4 Trip Mode For Main Income Earner Household Group

6.5.4.1 Figure 76 shows the percentage of trips made by trip mode by the Main Income Earner household group in the ASP Zones.

Figure 76: Trip Mode For Main Income Earner Household Group



6.5.4.2 The results in Figure 76 show that most of the travel in Zone 2 (79.0%) and Zones 17-33 (85.9%) is by car. The result for Zone 2 is similar to the average (79.5%), however the result for Zones 17-33 is slightly above the average. The proportion of trips that are car passenger trips in Zone 2 (3.3%) and Zones 17-33 (7.0%) is below the average for Auckland (13.7%). While the proportion of public transport travel in Zone 2 (3.9%) and Zones 17-33 (3.1%) is similar, this is slightly lower than the average (5.5%). There is a marked difference in the proportion of walk/cycle trips in Zone 2 (11.0%) compared with Zones 17-33 (2.8%). The average for Auckland (8.2%) is

mid way between these two results. The proportion of trips made by ‘other’ modes in Zone 2 (6.2%) is similar to the average (6.9%), the proportion in Zones 17-33 is slightly above the average (8.3%).

6.5.4.3 Principio and Pas (1996) research concluded that the respondents classified as ‘workaholics’ relied heavily on the private vehicle for travel while the ‘active workers’ group mainly relied on the private vehicle. Based on the findings of Principio and Pas, this indicates that the above average proportion of walk/cycle trips in Zone 2, is unexpected result for this household member group. This result may provides some support for the claim that NTD urban form characteristics may induce greater levels of walk/cycle travel for the Main Income Earners

#### 6.5.5 Trip Mode For Wife/Partner/Defacto Household Group

6.5.5.1 Figure 77 shows the percentage of trips made by trip mode by the Wife/Partner/Defacto household group in the ASP Zones.

Figure 77: Trip Mode For Wife/Partner/Defacto Household Group

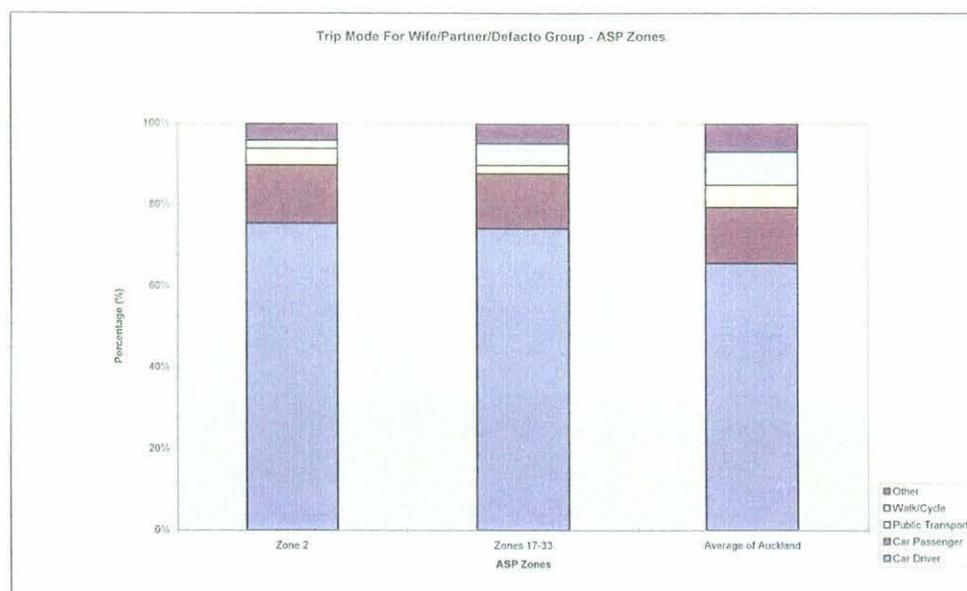


Table 26: T-test Results for the Wife/Partner/Defacto Household Group

TRIP MODE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
CAR DRIVER	0.16	1.73	0.44
CAR PASSENGER	0.43	1.73	0.34
PUBLIC TRANSPORT	0.51	1.73	0.31
WALK/CYCLE	0.04	1.73	0.48
OTHER	2.10	1.65	0.02

6.5.5.2 The results in Figure 77 show that most of the travel by respondents in the Wife/Partner/Defacto household group in Zone 2 (89.8%) and Zones 17-33 (87.7%) is by car. Both these result are above the average for Auckland (79.5%). The proportion of car passenger trips made in Zone 2 (14.3%) and Zones 17-33 (13.5%) is similar to the average for Auckland (13.7%). Reliance on the automobile for travel is much higher for the Wife/Partner/Defacto household group than for the Main Income Earner household group. The proportion of public transport trips in Zone 2 (4.1%) and Zones 17-33 (2.1%) is slightly below the average (5.5%). The t-test results showed that this difference was not statistically significant for public transport trips between the two sets of zones. The proportion of walk/cycle trips made in Zone 2 (2.0%) and Zones 17-33 (5.3%) is also below the average (8.2%). The t-test results concluded that the difference in walk/cycle modes in Zone 2 and Zones 17-33 is not statistically significant. The proportion of 'other' trips made by this group in Zone 2 (4.1%) and Zones 17-33 (4.9%) is also slightly below the average (6.9%). The results show that there is little difference in the proportion of automobile travel made by this group between Zone 2 and Zones 17-33.

6.5.5.3 Kitamura (1988) research concludes that women (both Single or Married/Defacto/Partner) on average make more public transport and walking trips than men. This conclusion is not supported by the results in this Figure 77. This could be explained in part by census data that shows that 40.7% of the population in Zone 2 and 46.0% of the population in Zones 17-33 own a car. This high level of car ownership may in part explain the high rate of car trips made by the Wife/Defacto/Partner group and other groups such as the Main Income Earners.

6.5.5.4 Morris, Richardson and McPherson's (1996) research found that concerns about public safety on public transport and walk/cycle can limit the amount of travel made during night hours and at times during the day. This may provide some explanation to the lower level of non-vehicular travel. Morris, Richardson and McPherson's (1996) research further found that women tend to be passengers rather than drivers however the tendency does vary with age. These findings are reflected by the higher proportion of car passenger trips made by both respondents in the Wife/Partner/Defacto group in Zone 2 and Zones 17-33 compared to other groups such as the Main Income Earners Group.

#### 6.5.6 Trip Mode For Single Retired Household Group

6.5.6.1 Figure 78 shows the percentage of trips made by trip mode by the Single Retired household group in the ASP Zones.

Figure 78: Trip Mode For Single Retired Household Group

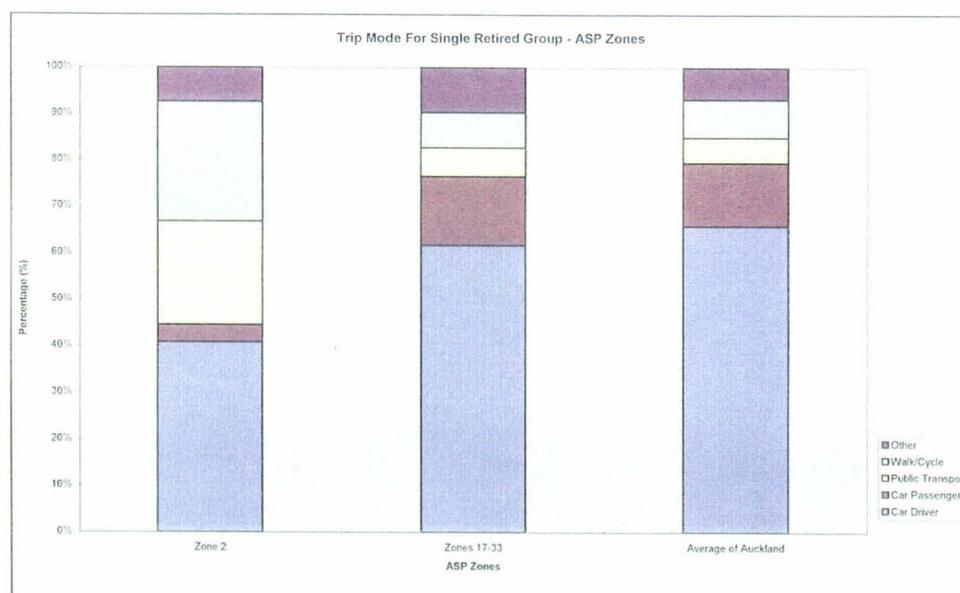


Table 27: T-test Results for the Single Retired Household Group

TRIP MODE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE TAIL
CAR DRIVER	1.86	1.76	0.04
CAR PASSENGER	1.55	1.71	0.07
PUBLIC TRANSPORT	1.47	1.80	0.08
WALK/CYCLE	1.53	1.80	0.08
OTHER	N/A	N/A	N/A

6.5.6.2 The results in Figure 78 show that under half (44.4%) of all travel made in Zone 2 by the Single Retired household group is by car. This is significantly lower than Zones 17-33 (76.4%) and the average (79.5%). The t-test results show that the difference between Zone 2 and Zones 17-33 is a statistically significant result. The proportion of car passenger trips in Zone 2 (3.7%) is significantly lower than the proportion in Zones 17-33 (14.8%) and the average (13.7%). The t-test results showed that this is not a statistically significant difference. The proportion of respondents in the Single Retired group in Zone 2 that made public transport (22.2%) and walk/cycle (25.9%) trips is significantly higher than in Zones 17-33 (6.3% and 7.6% respectively) and the average (5.5% and 8.2% respectively). The t-test results showed that this is not a statistically significant different for public transport and walk/cycle trips. The proportion of walk/cycle trips and public transport trips in Zone 17-33 are similar to the average figures. The proportion of 'other' trips in Zone 2 (7.4%) and Zone 17-33 (9.7%) are similar to the average figure (6.9%). The results in Figure 78 suggest that the level of automobile reliance is less in Zone 2 than Zones 17-33 therefore providing support to the claim that NTD urban forms induce less vehicular travel.

6.5.6.3 Principio and Pas (1996) research on the 'domestic caretakers' group concluded that this group utilizes the car and non-motorised modes to an average extent, and uses the bus more frequently than most. The 'leisure enthusiasts' lifestyle group were found to have the least number of vehicles per households of all the groups. These findings concur with the results that the car is used to an average extent. The t-test results significant at the 10% confidence level, for public transport show that Zone 2 does exhibit less car

use and more public transport use at this 10% significance level and therefore providing some support for this claim.

### 6.5.7 Trip Mode For Unrelated Flatmates Household Group

6.5.7.1 Figure 79 shows the percentage of trips made by trip mode by the Unrelated Flatmates household group in the ASP Zones.

Figure 79: Trip Mode For Unrelated Flatmates Household Group

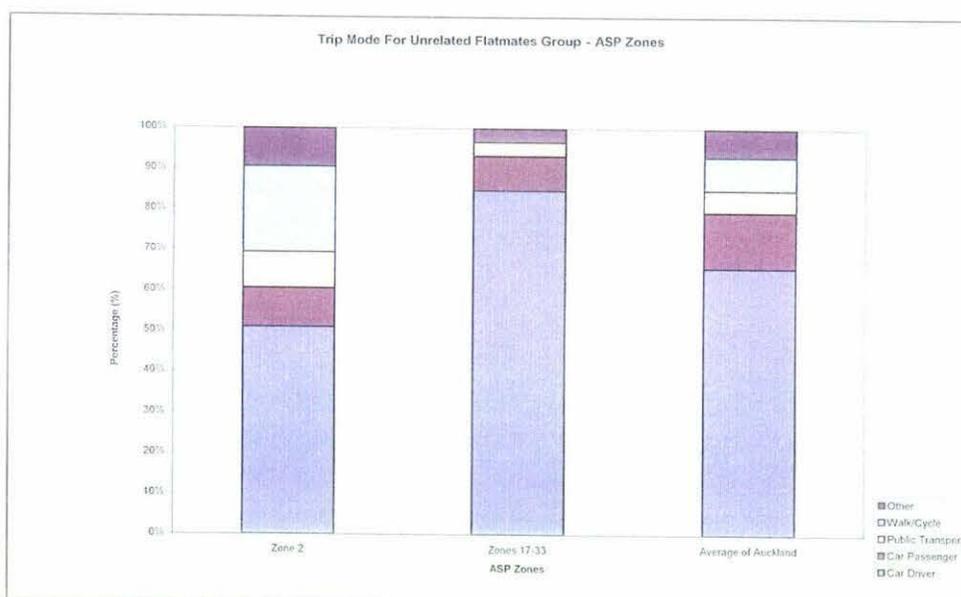


Table 28: T-test Results for the Unrelated Flatmates Household Group

TRIP MODE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
CAR DRIVER	2.07	1.68	0.04
CAR PASSENGER	1.29	1.69	0.21
PUBLIC TRANSPORT	1.47	1.68	0.15
WALK/CYCLE	2.97	1.70	0.003 (3dp)
OTHER MODES	1.43	1.68	0.08

6.5.7.2 The results in Figure 79 show that over half (60.6%) of all the travel made by the Unrelated Flatmates group in Zone 2 is by car. This result is significantly

lower than Zones 17-33 (93.1%) and the average for Auckland (79.5%). The t-test results concluded that the difference in car driver travel made by Zone 2 and Zones 17-33 is statistically significant. The proportion of car passenger trips for Zone 2 (9.6%) and Zones 17-33 (8.5%) is similar, however these figures are slightly below the average (13.7%). The proportion of public transport trips made in Zone 2 (8.8%) is slightly higher than the average (5.5%), while the proportion of public transport trips in Zones 17-33 is slightly lower (3.4%) than the average. The t-test results showed that the result for Zone 2 is not a statistically significant difference result from Zones 17-33. The proportion of walk/cycle trips in Zone 2 (21.1%) is significantly higher than that of Zone 17-33 (0.0%) and the average (8.2%). The t-test results conclude that the difference is statistically significant. The proportion of 'other' modes used by the this household group in Zone 2 (9.5%) is slightly higher than the average (6.9%), while the result for Zones 17-33 (3.4%) is lower than the average. The results show that the travel behaviour by respondents in the Unrelated Flatmates group is less automobile reliant patterns in Zone 2 than those in Zones 17-33.

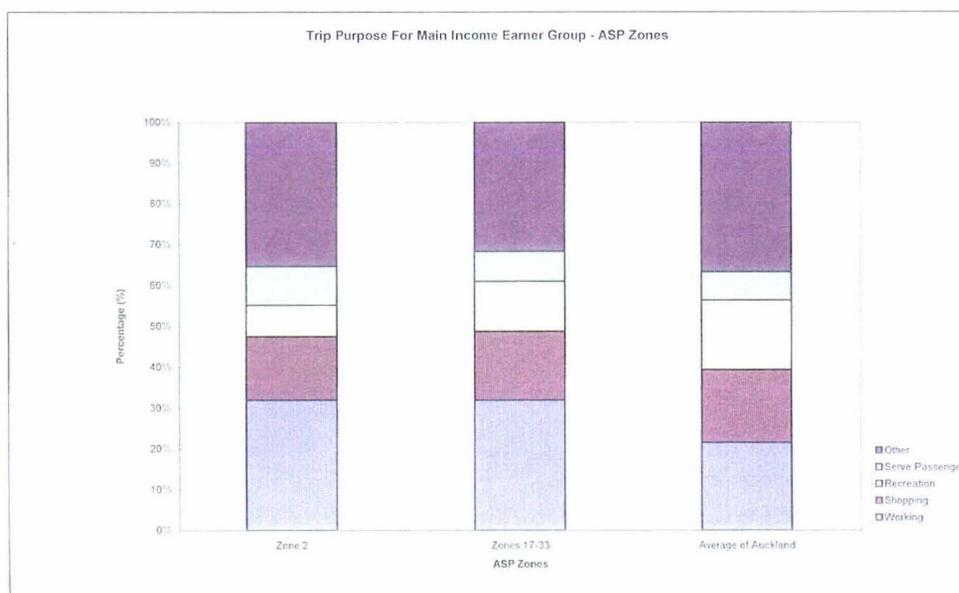
The main trends identified in the results for trip mode across the various household groups are summarised below:

- That majority of travel made by the Main Income Earner and the Wife/Partner/Defacto household groups is by car. This proportion of car travel is not notably different between Zone 2 and Zones 17-33.
- The proportion of car driver travel for the Single Retired group is lower in Zone 2 compared to Zones 17-33 and that this group for Zone 2 exhibits proportionately less automobile travel than the other household groups.
- The proportion of car travel for the Unrelated Flatmates group in Zone 2 is notable lower than that for Zones 17-33, while the proportion of walk/cycle travel is notably greater.

## 6.5.8 Trip Purpose For Main Income Earner Household Group

6.5.8.1 Figure 80 shows the percentage of trips made by trip purpose by respondents in the Main Income Earner household group in the ASP Zones.

Figure 80: Trip Purpose For Main Income Earner Household Group



6.5.8.2 The results in Figure 80 show that the proportion of working trips made by respondents in the Main Income Earner group is similar for Zone 2 (32.0%) and Zones 17-33 (31.9%). These results are higher than the average for Auckland value (21.6%). The proportion of 'other' trips made by respondents in Zone 2 (35.4%) and Zones 17-33 (31.7%) is slightly lower than the average (36.8%). The proportion of shopping trips made by respondents in this household group in Zone 2 (15.5%) and Zones 17-33 (16.8%) is similar to the average (17.8%). The proportion of recreation trips made in Zone 2 (7.7%) by this group is lower than Zones 17-33 (12.3%). Both of these results however are lower than the average (17.0%). The proportion of serve passenger trips made by respondents in Zone 2 (9.4%) and Zones 17-33 (7.3%) is similar to the average (6.9%).

6.5.8.3 Principio and Pas (1996) identified that the ‘workaholics’ group spend 85% of their daily activity in work related activities and that the ‘active workers’ also spend the majority of their daily hours in work related activities (63.1%). The conclusions of Principio and Pas (1996) research concurs with the results shown in this Figure 80 in terms of work related travel patterns. The respondents in the Main Income Earner group make a greater proportion of travel for work and ‘other’ related travel in Zone 2 and Zones 17-33 compared to the average for Auckland. This group also makes a lower proportion of recreation travel than the average.

#### 6.5.9 Trip Purpose For Wife/Partner/Defacto Household Group

6.5.9.1 Figure 81 shows the percentage of trips made by trip purpose by respondents in the Wife/Partner/Defacto household group in the ASP Zones.

Figure 81: Trip Purpose For Wife/Partner/Defacto Household Group

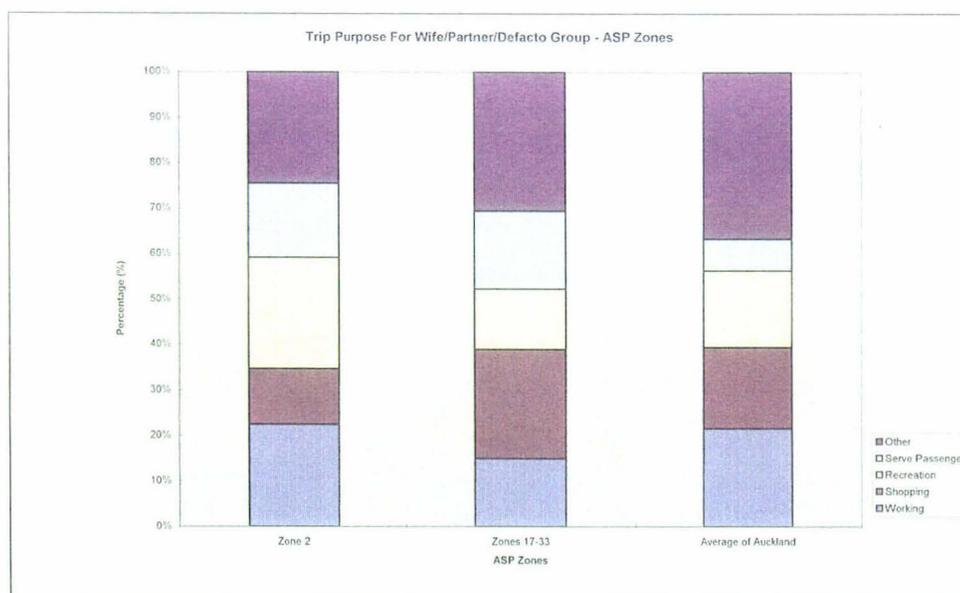


Table 29: T-test Results for the Wife/Partner/Defacto Household Group

TRIP PURPOSE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
WORKING	0.55	1.72	0.29
SHOPPING	2.37	1.71	0.01
RECREATION	1.85	1.73	0.04
SERVE PASSENGER	0.66	1.69	0.26

6.5.9.2 The results in Figure 81 show that the proportion of working trips made by respondents in the Wife/Partner/Defacto group in Zone 2 (22.4%) is slightly above the average for Auckland (21.6%). However the proportion of working trips made by the same group in Zones 17-33 (14.9%) is below the average (21.6%). The t-test results concluded that this difference between Zone 2 and Zones 17-33 is not highly statistically significant. The proportion of recreation trips made by respondents in Zone 2 (24.5%) for this group is also above the figure for Zones 17-33 (13.4%) and the average (17.0%). The t-test found that difference between Zone 2 and Zones 17-33 is statistically significant. The proportion of shopping trips made in Zones 17-33 (24.0%) is significantly above that for Zone 2 (12.2%) and the average (17.8%). The t-test results show that this difference is statistically significant. The proportion of serve passenger trips made by respondents in the Wife/Partner/Defacto group in Zone 2 (16.3%) and Zones 17-33 (17.1%) is significantly above the average for Auckland (6.9%). The proportion of 'other' trips however in Zone 2 (24.5%) and Zones 17-33 (30.6%) is below the average (36.8%).

6.5.9.3 Kitamura (1988) research found that women have a higher shopping and personal business trip rate than men of similar life cycle stages. This finding is supported by research conducted by Vadarevu and Stopher (1996). Vadarevu and Stopher (1996) concluded that females tend to spend more time on shopping and personal business than males, while males spend more time in recreational activities than females. Vadarevu and Stopher (1996) also concluded that households containing both working and non-working adults, the non-working adults spend more time on shopping and personal business than the working adults do in all life-cycle groups. The level of shopping trips made in Zones 17-33 is higher than for Zone 2 and the

average. This is also supported by the t-test results. Kitamura's (1988) research found that the highest percentage of shopping trips are associated with suburban homemakers, followed next by the urban employed home makers. This could suggest that the women in suburban areas that are not employed make more shopping trips of all life cycle groups examined by Kitamura.

6.5.9.4 Kitamura (1988) found that the daily travel-activity patterns of adult females is affected by the presence and absence of young children in the household, but maintains the effect of employment supersedes this. McGinnis (1986) found that households with children have lower work trip rates, but higher total trip rates and non-work trip rates. McGinnis (1986) further concluded that the presence of children has little affect on the transportation of the husband and wife in household. Employment figures from the census show that the proportion of women in the workforce is similar between Zone 2 (25.1%) and Zones 17-33 (23.0%). These similarities in employment rates for women do not explain the higher proportion of work trips made by respondents in Zone 2. One explanation to the lower proportion of 'working trips' in Zones 17-33 is the higher proportion of 'other' trips which may include multi-purpose trip chains, part of which may include a working trip.

6.5.9.5 Morris, Richardson and McPherson (1996) note that having children at home has an influence on the number of serve passenger trips made by women. Morris, Richardson and McPherson (1996) state that children travel needs can influence the timing and modes for travel and the level of independent trip making by parents. The proportion of serve passenger trips made in Zone 2 and Zones 17-33 is significantly higher than the average which may suggest that a large proportion of respondents in this group could be making serve passenger trips to transport children.

### 6.5.10 Trip Purpose For Single Retired Household Group

6.5.10.1 Figure 82 shows the percentage of trips made by trip purpose by respondents in the Single Retired household group in the ASP Zones.

Figure 82: Trip Purpose For Single Retired Household Group



Table 30: T-test Results for the Single Retired Household Group

TRIP PURPOSE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
WORKING	N/A*	N/A*	N/A*
SHOPPING	1.25	1.77	0.23
RECREATION	0.19	1.77	0.49
OTHER	0.63	1.76	0.27

\*N/A Absence of trips made for working purposes in Zone 2

6.5.10.2 The results in Figure 82 show that the proportion of working trips made by respondents in the Single Retired Household Group in Zone 2 (0.0%) and Zones 17-33 (5.5%) is significantly lower than the average for Auckland (21.6%). This result concurs with Figure 61 which shows that the proportion of working trips for the over 65 years age group in Zone 2 (0.0%) and Zones 17-33 (2.4%). The proportion of shopping trips made by this group in Zone

2 (44.4%) and Zones 17-33 (32.1%) is however significantly higher than the average (17.8%). The proportion of recreation trips made by respondents in Zone 2 (29.6%) and Zones 17-33 (30.0%) is again significantly above the average for Auckland value (17.8%). The proportion of serve passenger trips made by this group in Zone 2 (7.4%) is similar to the average (6.9%), however this proportion is below Zones 17-33 (3.4%). The proportion of 'other' trips made in Zone 2 (18.5%) is significantly lower than Zones 17-33 (29.5%) and the average (36.8%). The t-test results showed that none of the results in Zone 2 were statistically different from the results in Zones 17-33. This suggests that urban form has little or any effect on trip purposes of respondents in the Single Retired household group.

6.5.10.3 Principio and Pas (1996) research shows that the 'domestic caretakers' group spend 81.4% of their time on maintenance activities, they generally do not participate in education or work related activities. The 'leisure enthusiasts' group spend 57.3% of their time on recreational activities and also participate minimally in work and school activities. This confirms the results shown in Figure 82 where the majority of travel in Zone 2 and Zones 17-33 is for shopping and recreation purposes rather than work related travel.

6.5.11 Trip Purpose For Unrelated Flatmates Household Group

6.5.11.1 Figure 83 shows the percentage of trips made by trip purpose by respondents in the Unrelated Flatmates household group in the ASP Zones.

Figure 83: Trip Purpose For Unrelated Flatmates Household Group

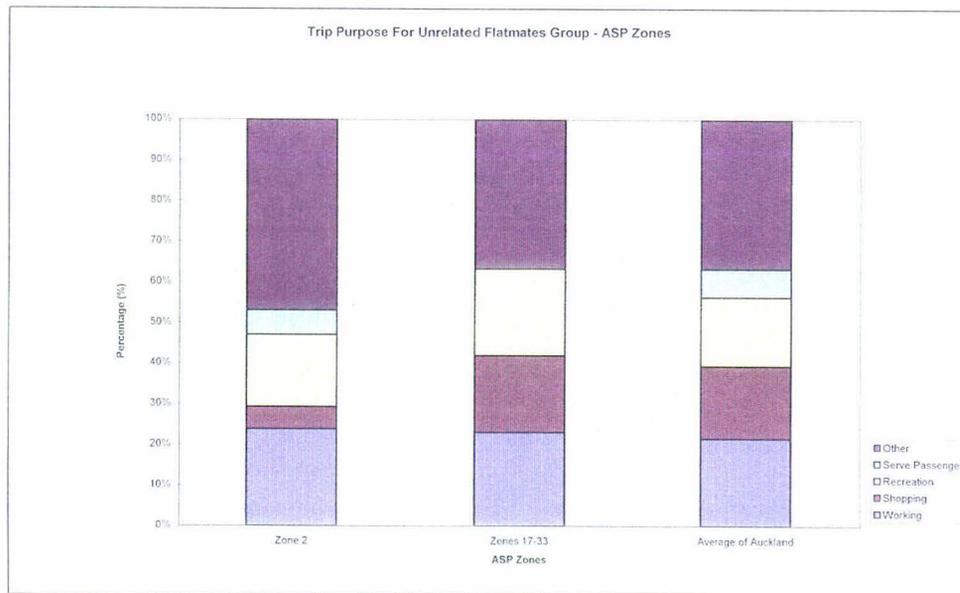


Table 31: T-test Results for the Unrelated Flatmates Group

TRIP PURPOSE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
WORKING	0.15	1.68	0.44
SHOPPING	1.80	1.69	0.04
RECREATION	0.07	1.68	0.47
SERVE PASSENGER	1.22	1.70	0.12
OTHER	3.28	1.68	0.002 (3dp)

6.5.11.2 The results in Figure 83 show that the proportion of working trips made by respondents in the Unrelated Flatmates group in Zone 2 (23.8%) and Zones 17-33 (23.1%) is similar and slightly above the average (21.6%). The proportion of recreation trips made in Zone 2 (17.7%) is also similar to the average (17.0%), while the proportion made by Zones 17-33 (21.4%) is

slightly above the average. The t-test results showed that the difference between the result for Zone 2 and Zones 17-33 is statistically significant. The proportion of shopping trips made in Zone 2 (5.4%) is significantly lower than for Zones 17-33 (18.8%) and the average (17.8%). The t-test results showed that the difference between Zone 2 and Zones 17-33 for shopping trips is statistically significant. The proportion of serve passenger trips in Zone 2 (6.1%) is similar to the average (6.9%) however there is an absence of serve passenger trips made by respondents in Zones 17-33 (0.0%). Nearly half (46.9%) of all the travel made by this group in Zone 2 is for 'other' purposes. This result is higher than the average (36.8%) and for Zones 17-33 (36.8%). The t-test results show that the difference in the proportion of 'other' trips made in Zone 2 compared to Zones 17-33 is statistically significant.

6.5.11.3 Overall nearly half of all the trips made are for 'other' purposes (46.9%) in Zone 2. The remaining proportion of travel is mainly made for working (23.8%) and recreation (17.7%) purposes. Only a small proportion of travel is made for serve passenger (6.1%) and shopping purposes (5.4%) in Zone 2. The greatest proportion of travel made in Zones 17-33 is also for 'other' (36.8%) trip purposes. The proportion of working (21.6%) travel is slightly higher than that for recreation (21.4%) and shopping (23.1%).

6.5.11.4 The main trends identified in the results for trip purpose across the various household groups are summarised below:

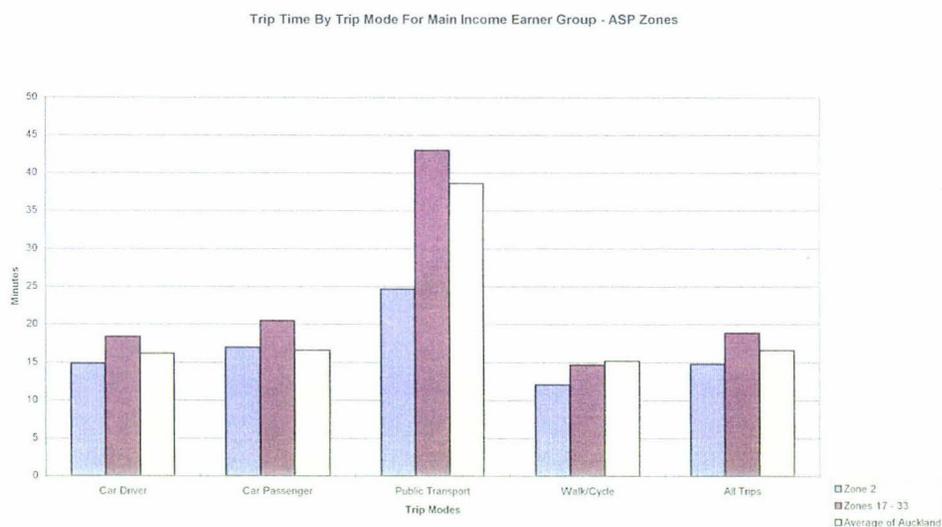
- The Main Income Earners have the greatest level of work related trips and a lower level of shopping trips compared to the average for Auckland.
- The Wife/Defacto/Partner household group have a low proportion work related travel and an above average proportion of shopping related travel for Zones 17-33 and greater than average proportion of recreation trips for Zone 2.
- The Single Retired household group have the highest proportion of all the household groups for shopping and recreation related travel and the lowest of all the household groups for work-related travel.

- The Unrelated Flatmates household group have only above average shopping related travel for respondents in Zones 17-33 and not in Zones 2, work related travel is similar to the average for Auckland.

#### 6.5.12 Trip Time By Trip Mode For Main Income Earner Household Group

6.5.12.1 Figure 84 shows the average trip time for the different modes by the Main Income Earner household group in the ASP Zones

Figure 84: Trip Time By Trip Mode For Main Income Earner Household Group



6.5.12.2 The results in Figure 84 show that overall the average trip time for public transport trips in Zone 2 (24.7 mins) and Zones 17-33 (27.6 mins) is below the average for Auckland (38.6 mins). The average time for car driver mode in Zone 2 (14.9 mins) is below the average (16.2 mins), the result for Zones 17-33 (18.4 mins) is above this average. The average time for car passenger trips in Zone 2 (17.0 mins) and Zones 17-33 (20.5 mins) are both above the average (16.6 mins). The average time for walk/cycle trips in Zone 2 (12.1 mins) and Zones 17-33 are both below the average (15.2 mins). The 'all trip'

result shows that overall Zones 17-33 (18.9 mins) have a longer average trip time than Zone 2 (14.8 mins) and the average (16.6 mins).

6.5.12.3 The results suggest that overall the average trip times for the Main Income Earner group in Zone 2 are shorter than in Zones 17-33. This result supports claim that areas with NTD characteristics are more likely to have shorter travel times as the mixture of land uses results in shorter distances between destinations.

6.5.12.4 Principio and Pas (1996) research suggests that the 'active workers' lifestyle group have the highest total travel time for the survey period. Figure 76 shows that most of the travel made by the 'active workers' (in this research) approximated by the Main Income Earners is by private car. The results in this Figure 84 show that the average trip time for car driver and car passenger trips is slightly shorter in Zone 2 than the average and slightly longer in Zones 17-33. The result for Zones 17-33 confirms the findings made by Principio and Pas but does not confirm the result for Zone 2. This does however provide support for the claim that areas NTD urban form patterns may reduce travel times.

### 6.5.13 Trip Time By Trip Mode For Wife/Partner/Defacto Household Group

6.5.13.1 Figure 85 shows the average trip time for the different modes by the Wife/Partner/Defacto household groups in the ASP Zones.

Figure 85: Trip Time By Trip Mode For Wife/Partner/Defacto Household Group

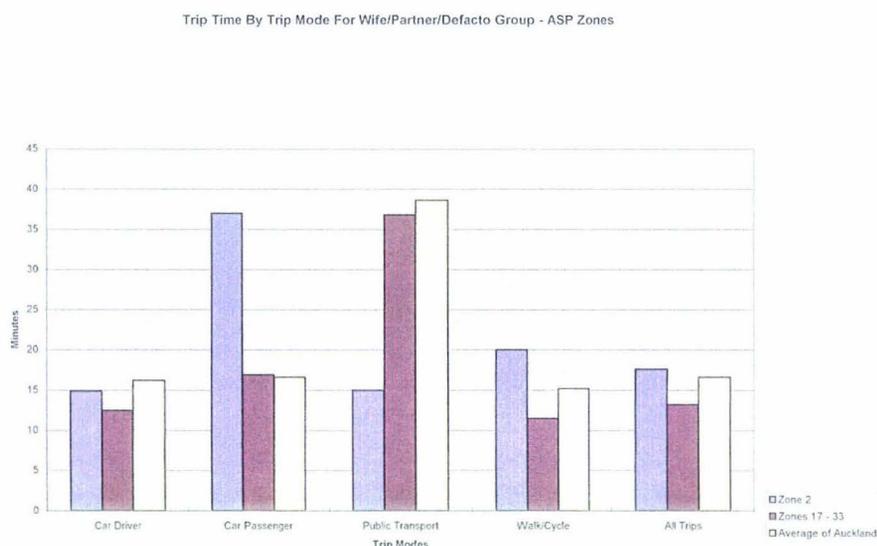


Table 32: T-test Results for the Wife/Partner/Defacto Household Group

TRIP TIME BY TRIP MODE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
CAR DRIVER	1.10	1.69	0.14
CAR PASSENGER	0.95	1.94	0.19
PUBLIC TRANSPORT	N/A*	N/A*	N/A*
WALK/CYCLE	N/A*	N/A*	N/A*
ALL MODES	1.25	1.68	0.11

\*N/A A t-test was unable to be conducted on the following results due to low level of trips made in Zone 2 by the mode.

6.5.13.2 The results in Figure 85 show that the average time for car driver trips in Zone 2 (14.9 mins) and Zones 17-33 (12.5 mins) are below the average for Auckland (16.2 mins). However the average time for car passenger trips in

Zone 2 (37.0 mins) is significantly higher than Zones 17-33 (16.9 mins) and the average (16.6 mins). The t-test results showed that the difference in the car passenger result in Zone 2 and Zones 17-33 is not statistically significant. The average time for public transport trips in Zone 2 (15.0) is significantly lower than Zones 17-33 (36.8 mins) and the average (38.6 mins). A t-test was unable to be carried out on this result due to the low levels of trips made in Zone 2 by the public transport mode. The average time for walk/cycle trips in Zone 2 (20.0 mins) is longer than for Zones 17-33 (11.5 mins) and the average (15.2 mins). The t-test results again were unable to be carried out because of the low level of trips made by walk/cycle modes in Zone 2. The 'all modes' variable shows that overall the average trip time in Zone 2 (17.6 mins) is slightly longer than Zones 17-33 (13.2 mins) and the average. The t-test on this result showed that this difference between Zone 2 and Zones 17-33 is not statistically significant.

6.5.13.3 Overall the results in Figure 85 suggest that the Wife/Partner/Defacto group in Zone 2 have longer average trip times than the Zones 17-33. The t-test results however identify that this difference is not statistical significant. This therefore does not disprove the claim that areas with NTD urban form attributes have shorter average trip lengths.

6.5.13.4 The average trip time by Main Income Earners in Zones 17-33 trends to be longer by all modes than Wife/Partner/Defacto group in Zones 17-33. Kitamura (1988) concluded that women's trips tend to be shorter compared to men's. The t-test confirm that the difference in average trip times by all the modes in Zone 2 for the Wife/Partner/Defacto group is not statistically significant from Zones 17-33. This suggests that the trip times for Zone 2 in the Wife/Partner/Defacto group is similar to that for Zones 17-33.

6.5.14 Trip Time By Trip Mode For Single Retired Household Group

6.5.14.1 Figure 86 shows the average trip time for the different modes by the Single Retired household groups in the ASP Zones.

Figure 86: Trip Time By Trip Mode For Single Retired Household Group

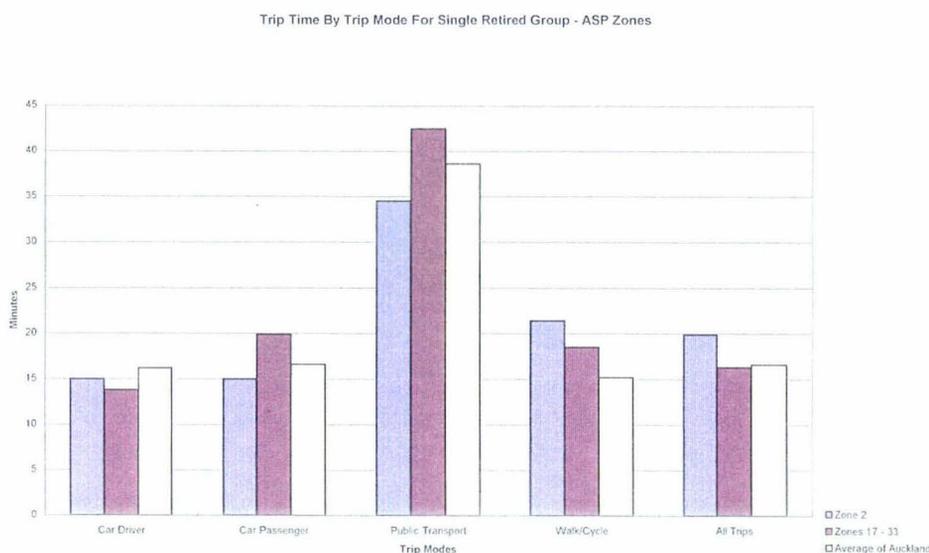


Table 33: T-test Results for Single Retired Household Group

TRIP TIME BY TRIP MODE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
CAR DRIVER	0.49	1.77	0.32
CAR PASSENGER	N/A*	N/A*	N/A*
PUBLIC TRANSPORT	1.14	1.78	0.14
WALK/CYCLE	0.73	1.83	0.24
ALL MODES	1.10	1.69	0.14

N/A\* A t-test was unable to be carried out on this result due to the low level of car passenger trips made in Zone 2.

6.5.14.2 The results in Figure 86 show that the average time of car driver trips in Zone 2 (15.0 mins) and Zones 17-33 (13.8 mins) is below the average for Auckland (16.2 mins). The average time for car passenger trips in Zone 2 (15.0 mins) is also below the average (16.6 mins) while the average time for

car passenger trips in Zones 17-33 (19.9 mins) is above the average. A t-test was unable to be undertaken because of the low number of car passenger trips made by respondents in Zone 2. The average time of public transport trips in Zone 2 (34.5 mins) is shorter than the average (38.6 mins) while the time for Zones 17-33 (42.5 mins) is longer than the average. The t-test results showed however, that the difference for Zone 2 and Zones 17-33 is not statistically significant. The average time for walk/cycle trips in Zone 2 (21.4 mins) is longer than Zones 17-33 (18.5 mins) and the average (15.2 mins). The t-test results showed that the difference in average time in Zone 2 and Zones 17-33 for walk/cycle trips was not statistically significant. The 'all modes' variables shows that the average trip time for Zone 2 (19.9 mins) is longer than Zones 17-33 (16.3 mins) and the average (16.6 mins). The t-test results show that the difference in average trip times between Zone 2 and Zones 17-33 is statistically significant.

6.5.14.3 Principio and Pas (1996) found that the average trip length for the 'domestic caretakers' group is shorter than the rest of the sample surveyed. The 'leisure enthusiasts' group were also found to spend the least amount of time traveling. The findings made in this research for Zone 2 in the "all trips" mode concurs with Pincipio's research. However, the "all trip" for Zones 17-33 is similar to the average which suggests that the Single Retired group in Zone 17-33 may have similar travel distances as the other household groups.

### 6.5.15 Trip Time By Trip Mode For Unrelated Flatmates Household Group

6.5.15.1 Figure 87 shows the average trip time for the different modes by the Unrelated Flatmates household groups in the ASP Zones.

Figure 87: Trip Time By Trip Mode For Unrelated Flatmates Household Group

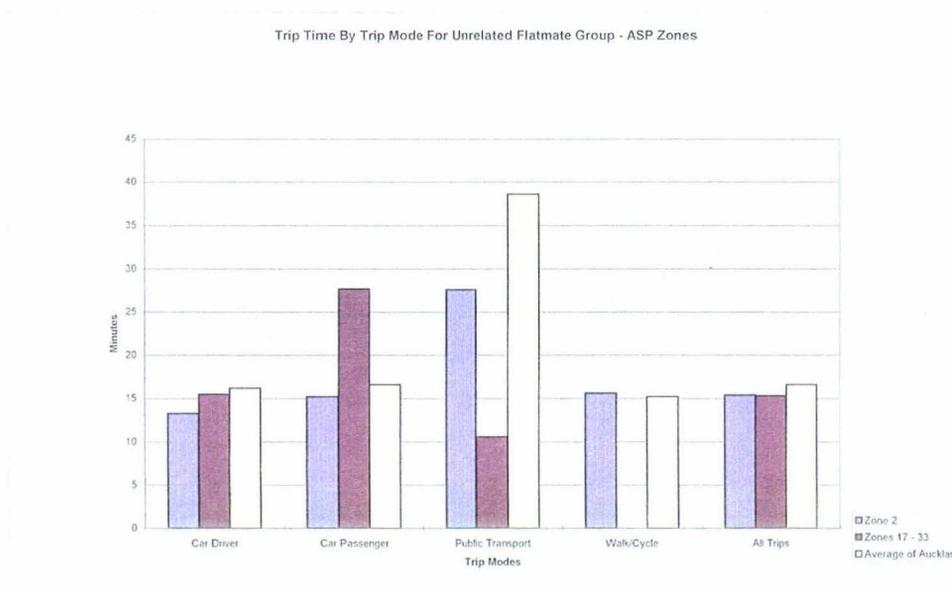


Table 34: T-test Results for Unrelated Flatmates Household Group

TRIP TIME BY TRIP MODE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
CAR DRIVER	1.30	1.65	0.10
CAR PASSENGER	1.13	1.80	0.14
PUBLIC TRANSPORT	0.20	2.35	0.43
WALK/CYCLE	N/A *	N/A *	N/A*
ALL MODES	0.10	1.65	0.46

N/A \* A t-test was unable to be carried out on this result because of the low level of walk/cycle trips made by respondents in Zones 17-33

6.5.15.2 The results in Figure 87 show that the average trip time for car driver trips in Zone 2 (13.3 mins) and Zones 17-33 (15.5 mins) is below the average (16.2

mins). The average trip time for car passenger trips in Zone 2 (15.2 mins) is also below the average while the trip time for Zones 17-33 (27.7 mins) is significantly longer than the average (16.6 mins). The t-test results show that the difference between average car passenger trip time result in Zone 2 and Zones 17-33 is not statistically significant. The average time for public transport trips in Zone 2 (27.6 mins) is significantly longer than Zones 17-33 (10.6 mins). The results for Zone 2 and Zones 17-33 is however shorter than the average (38.6 mins). The t-test results showed that the difference in average public transport trip times between Zone 2 and Zones 17-33 is not statistically significant. The average time for walk/cycle trips in Zone 2 (15.6 mins) is similar to the average result (15.2 mins). The average trip time for walk/cycle trips in Zones 17-33 was unable to be calculated due to the low number of walk/cycle trips made by Unrelated Flatmate respondents in Zones 17-33. The average time for 'all modes' variable in Zones 2 (15.4 mins) and Zones 17-33 (15.3 mins) is slightly below the average. The results and the t-tests suggest that the average trip time by the different trip modes for the Unrelated Flatmates household group in both Zone 2 and Zones 17-33 are not statistically different.

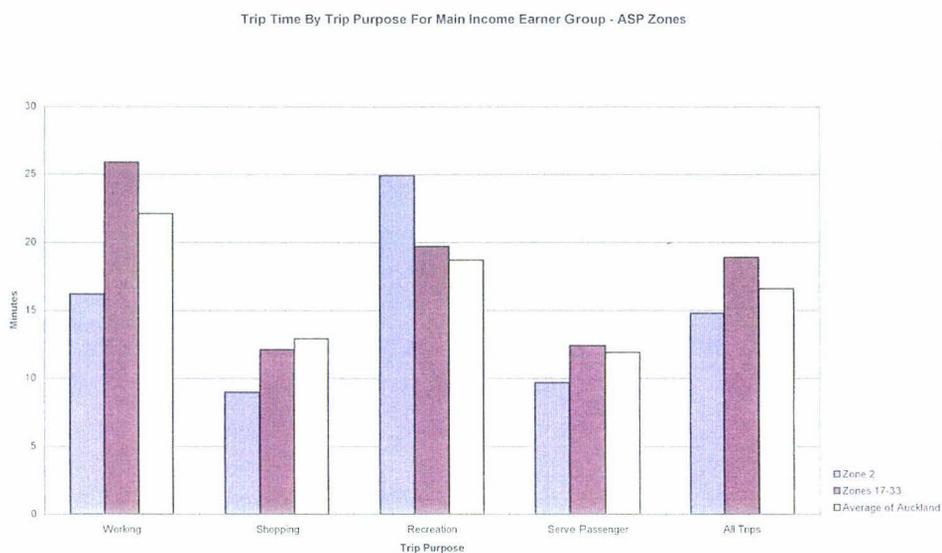
6.5.15.3 The main trends identified in the results for trip time by trip mode travel variable across the various household groups are summarised below:

- That the average trip time for all trip modes is shorter for Zone 2 respondents in the Main Income Earners household group than for respondents in Zones 17-33. This is not significantly noticeable for public transport trips.
- The impact of the results for the average trips times for the Wife/Defacto/Partner, Single Retired and Unrelated Flatmates household groups is difficult to determine as the t-test results were not always statistically significant for the variables.

### 6.5.16 Trip Time By Trip Purpose For Main Income Earner Household Group

6.5.16.1 Figure 88 shows the average trip time for the different purposes by the Main Income Earner household groups in the ASP Zones.

Figure 88: Trip Time By Trip Purpose For Main Income Earner Household Group



6.5.16.2 The results in Figure 88 show that the average time for working and shopping trips made by Main Income Earners in Zone 2 (16.2 mins and 9.0 mins respectively) is shorter than Zones 17-33 (25.9 mins and 12.1 mins) and the average (22.1 mins and 12.9 mins respectively). The average trip time for recreation trips (24.9 mins) is longer than Zones 17-33 (19.7 mins) and the average (18.7 mins). The average trip time for serve passenger trips in Zone 2 (9.7 mins) is slightly shorter than Zones 17-33 (12.4 mins) and the average (11.9 mins). The average trip time for 'all purpose' variable in Zone 2 (14.8 mins) is slightly shorter than Zones 17-33 (18.9 mins) and the average. Overall the results show that the average trip length in Zone 2 is shorter than Zones 17-33 (with the exception of public transport trips). This results for the Main Income Earners household group suggests that Zone 2

respondents have slightly shorter average trip times for working, shopping, serve passenger than they counterparts in Zones 17-33. This gives some support the claim that Zones with NTD characteristics have shorter trips than those urban areas without NTD characteristics.

6.5.17 Trip Time By Trip Purpose For Wife/Partner/Defacto Household Group

6.5.17.1 Figure 89 shows the average trip time for the different purposes by the Wife/Partner/Defacto household groups in the ASP Zones.

Figure 89: Trip Time By Trip Purpose For Wife/Partner/Defacto Household Group

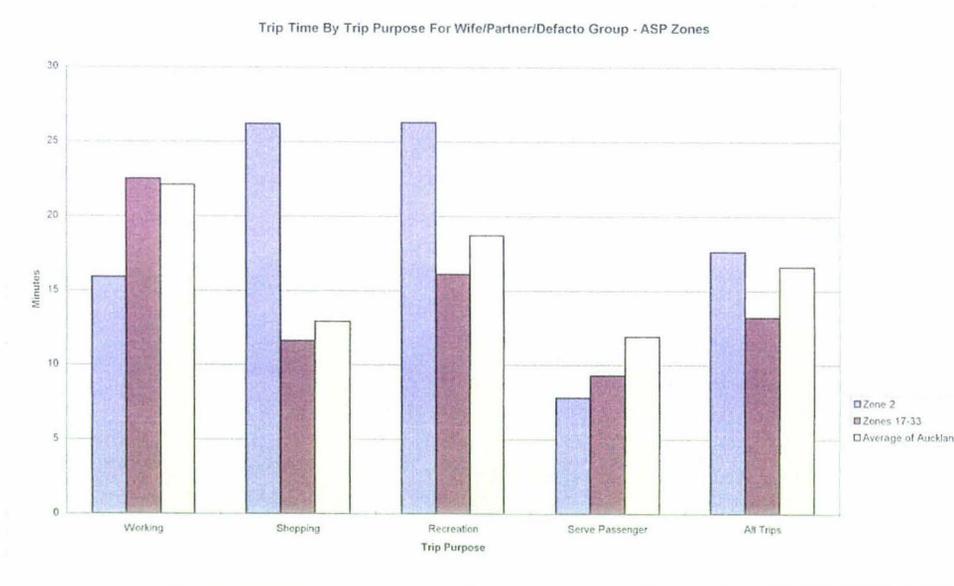


Table 35: T-test Results for Wife/Partner/Defacto Household Group

TRIP TIME BY TRIP PURPOSE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
WORKING	1.70	1.78	0.06
SHOPPING	1.29	2.13	0.13
RECREATION	0.80	1.80	0.22
SERVE PASSENGER	0.55	1.86	0.30
ALL PURPOSES	1.25	1.68	0.11

6.5.17.2 The results in Figure 89 show that the average time for working trips in Zone 2 (15.9 mins) is shorter than Zones 17-33 (22.5 mins) and the average for Auckland (22.1 mins). The t-test results showed that the difference in car driver trip times in Zone 2 and Zones 17-33 is not statistically significant. The average time for shopping and recreation trips in Zone 2 (26.3 mins and 26.3 mins respectively) is significantly longer than Zones 17-33 (11.6 mins and 16.1 mins respectively) and the average (12.9 mins and 18.7 mins respectively). The t-test results show that the difference between the two sets of zones is not statistically significant for both working and shopping trips. The average time for serve passenger trips in Zone 2 (7.8 mins) is slightly shorter than Zones 17-33 (9.3 mins) and the average (11.9 mins). The t-test result again showed that this difference is not statistically significant. The 'all purposes' variable showed that overall trip times in Zone 2 (17.6 mins) is longer than Zones 17-33 (13.2 mins) and the average (16.6 mins). The t-test result showed that this difference was not statistically significant. While the results in Figure 89 indicate that the difference in average trip times made by the Wife/Partner/Defacto group are longer overall in Zone 2 than Zones 17-33, the t-test results indicate that this difference is not statistically significant. This conclusion therefore does not support nor contradict the claim that urban areas with NTD characteristics have shorter average trip times for the Wife/Partner/Defacto household groups.

### 6.5.18 Trip Time By Trip Purpose For Single Retired Household Group

6.5.18.1 Figure 90 shows the average trip time for the different purposes by the Single Retired household groups in the ASP Zones.

Figure 90: Trip Time By Trip Purpose For Single Retired Household Group

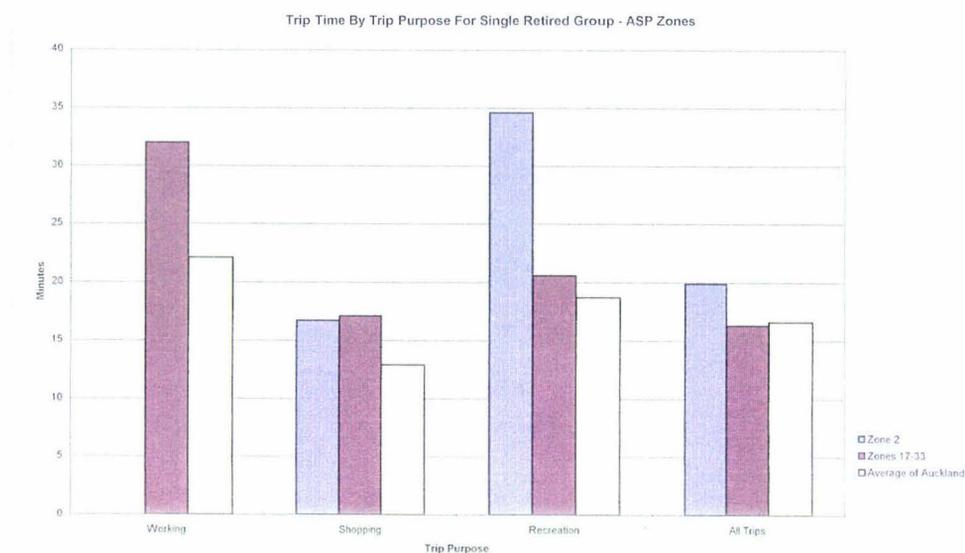


Table 36: T-test Results for Single Retired Household Group

TRIP TIME - TRIP PURPOSE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
WORKING	N/A*	N/A*	N/A*
SHOPPING	0.49	1.7	0.32
RECREATION	1.83	1.86	0.05
ALL TRIPS	1.10	1.69	0.14

N/A\* The result is unable to be calculated due to the low level of trips made for working purposes by Zone 2 by this group.

6.5.18.2 The results in Figure 90 show that the average trip time for working trips in Zones 17-33 (32.0 mins) is significantly higher than the average (22.1 mins). The average trip time for working trips in Zone 2 is not calculated due to the low number of working trips made by respondents in the Single Retired household group. The average trip time for shopping trips in Zone 2 (16.7

mins) is similar to Zones 17-33 (17.1 mins). These results are both longer than the average (12.9 mins). The average time for recreation trips (26.3 mins) is significantly longer than Zones 17-33 (16.1 mins) and the average (18.7 mins). The t-test results show that this difference is not statistically significant. The average trip time for the 'all purposes' variable is longer in Zone 2 (19.9 mins) than Zones 17-33 (16.3 mins) and the average (16.6 mins). The t-test results show that this difference is not statistically significant. While the results in Figure 90 indicate that the difference in average trip times made by the Single Retired household group are longer overall in Zone 2 than Zones 17-33, the t-test results indicate that the differences are not statistically significant. This conclusion therefore does not support nor contradict the claim that urban areas with NTD characteristics have shorter average trip times for the Single Retired household group.

### 6.5.19 Trip Time By Trip Purpose For Unrelated Flatmates Household Group

6.5.19.1 Figure 91 shows the average trip time for the different purposes by the Unrelated Flatmates household groups in the ASP Zones.

Figure 91: Trip Time By Trip Purpose For Unrelated Flatmates Household Group

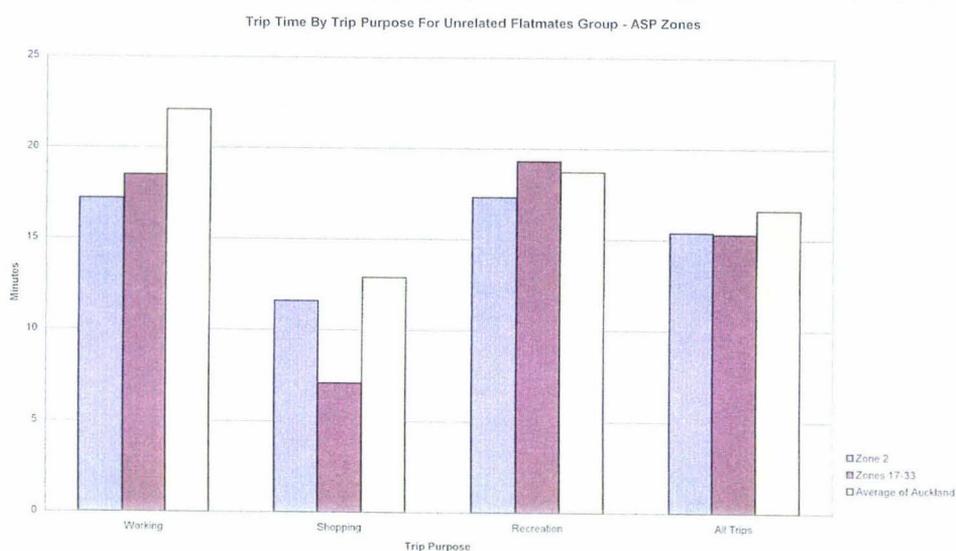


Table 37: T-test Results for Unrelated Flatmates Household Group

TRIP TIME - TRIP PURPOSE VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
WORKING	0.49	1.67	0.31
SHOPPING	1.01	1.80	0.18
RECREATION	0.45	1.69	0.33
ALL PURPOSES	0.1	1.69	0.33

6.5.19.2 The results in Figure 91 show that the average trip time for working trips made by the respondents in the Unrelated Flatmates in Zone 2 (15.4 mins) and Zones 17-33 (15.3 mins) is similar. These results are shorter than the average for Auckland trip time (22.1 mins). The t-test results show that this

difference is not statistically significant. The average time for shopping trips in Zone 2 (11.6 mins) is similar to the average (12.9 mins); the average time for Zones 17-33 (7.1 mins) however is significantly shorter than Zone 2 and the average. The t-test results show that this difference is not a statistically significant result. The average time for recreation trips in Zone 2 (17.3 mins) and Zones 17-33 (19.3 mins) is similar to the average (18.7 mins). The average trip time for the 'all purposes' variable in Zone 2 (15.4 mins) is similar to Zones 17-33 (15.3 mins). These results are slightly below the average for Auckland (16.6 mins). The results in Figure 91 suggest that overall trip times made by Unrelated Flatmates group in Zone 2 and Zones 17-33 have shorter average trip times for working, shopping, and all purposes variables. The difference between the results for Zone 2 and Zones 17-33 were found to not be statistically significant. This conclusion therefore does not support nor contradict the claim that urban areas with NTD characteristics have shorter average trip times for Unrelated Flatmates household group.

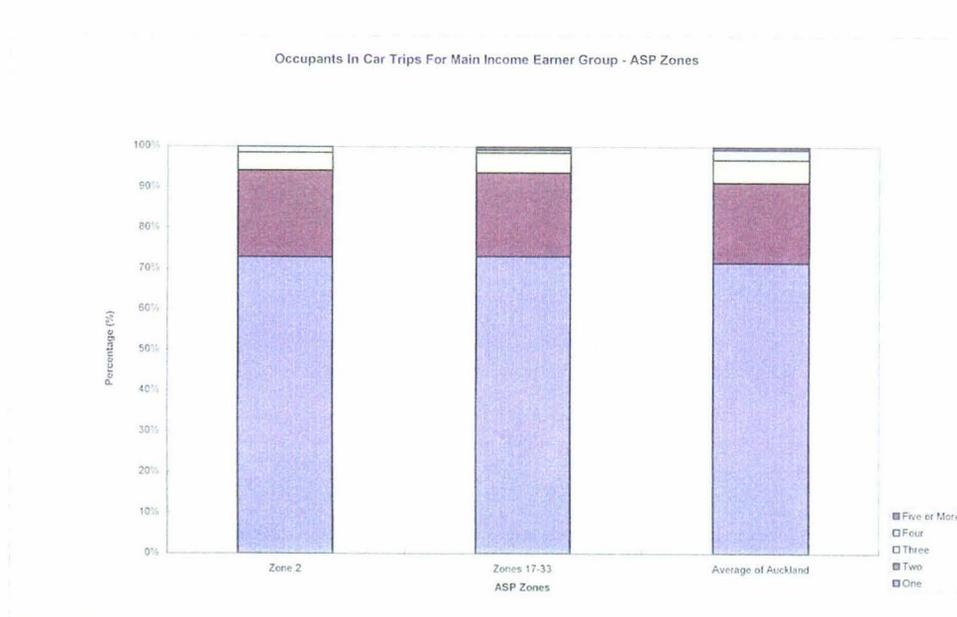
6.5.19.3 The main trends identified in the results for trip time by trip purpose across the various household groups is summarised below:

- The Main Income Earners household group respondents in Zone 2 have shorter average trips for all purposes except for recreation related travel than for their counterparts in Zones 17-33.
- The impact of the results for the average trips times for the Wife/Defacto/Partner, Single Retired and Unrelated Flatmates household groups is difficult to determine as the t-test results were not highly statistically significant for any of the variables.

### 6.5.20 Number Of Occupants In Car Trips For Main Income Earner Household Group

6.5.20.1 Figure 92 shows the number of occupants in car trips made by the Main Income Earner household group in the ASP Zones.

Figure 92: Number Of Occupants In Car Trips For Main Income Earner Household Group



6.5.20.2 The results in Figure 92 show that the majority of all car trips made by respondents in the Main Income Earner household group in Zone 2 (73.0%) and Zones 17-33 (73.2%) have one occupant. This result is slightly higher than the average (71.5%). The proportion of car trips made with two occupants in Zone 2 (21.2%) and Zones 17-33 (20.5%) is similar to the average (19.7%). The remainder of car trips made by this group in Zone 2 have three (4.4%) or four occupants (1.5%). The remainder in Zones 17-33 have slightly more three occupant trips (5.5%) than Zone 2, and slightly less four occupant (0.8) trips. The results suggest that urban form (NTD) characteristics do not influence the number of passenger in trips for the Main Income Earner household group.

6.5.21 Number Of Occupants In Car Trips For Wife/Partner/Defacto Household Group

6.5.21.1 Figure 93 shows the number of occupants in car trips made by the Wife/Partner/Defacto household group in the ASP Zones.

Figure 93: Number Of Occupants In Car Trips For Wife/Partner/Defacto Household Group

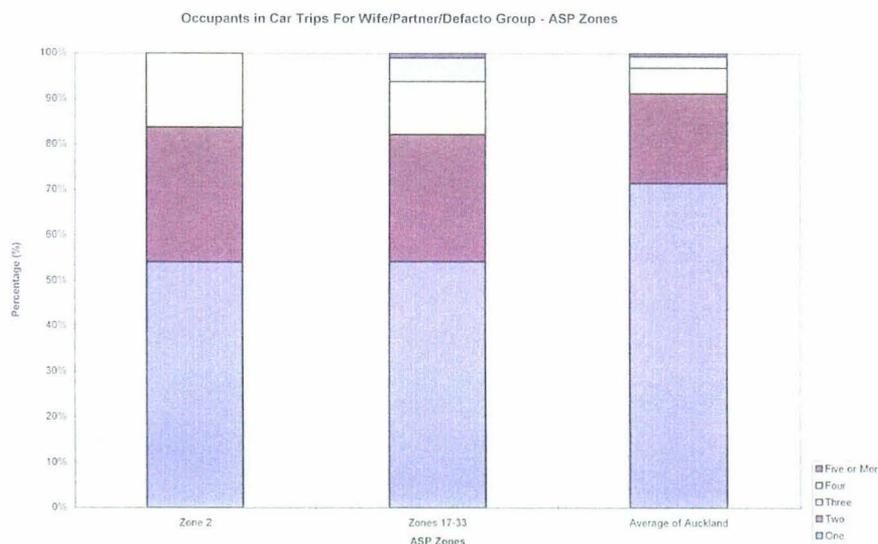


Table 38: T-test Results for Wife/Partner/Defacto Household Group

OCCUPANTS IN CAR TRIPS VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
OCCUPANTS	0.65	1.68	0.26

6.5.21.2 The results in Figure 93 show that nearly half of all the car trips made by the Wife/Partner/Defacto group in Zone 2 (54.1%) and Zones 17-33 (54.3%) have only one occupant. This result is significantly lower than the average for Auckland (71.5%). The remainder of car trips in Zone 2 have two (29.7%) or three (16.2%) occupants. The remainder of car trips in Zones 17-33 have

two (28.0%), three (11.8%) or four (4.9%) occupants. The t-test results and concluded that the difference in number of occupants in car trips made by Wife/Partner/Defacto household group in Zone 2 and Zones 17-33 is not statistically significant. These results support the observations in Figure 81 which shows the proportion of serve passenger trips is significantly higher than the average in both Zone 2 and Zones 17-33. This result does not support the claim that urban areas with NTD characteristics result in more complex trip making patterns.

#### 6.5.22 Number Of Occupants In Car Trips For Single Retired Household Group

6.5.22.1 Figure 94 shows the number of occupants in car trips made by the Single Retired household group in the ASP Zones.

Figure 94: Number Of Occupants In Car Trips For Single Retired Household Group

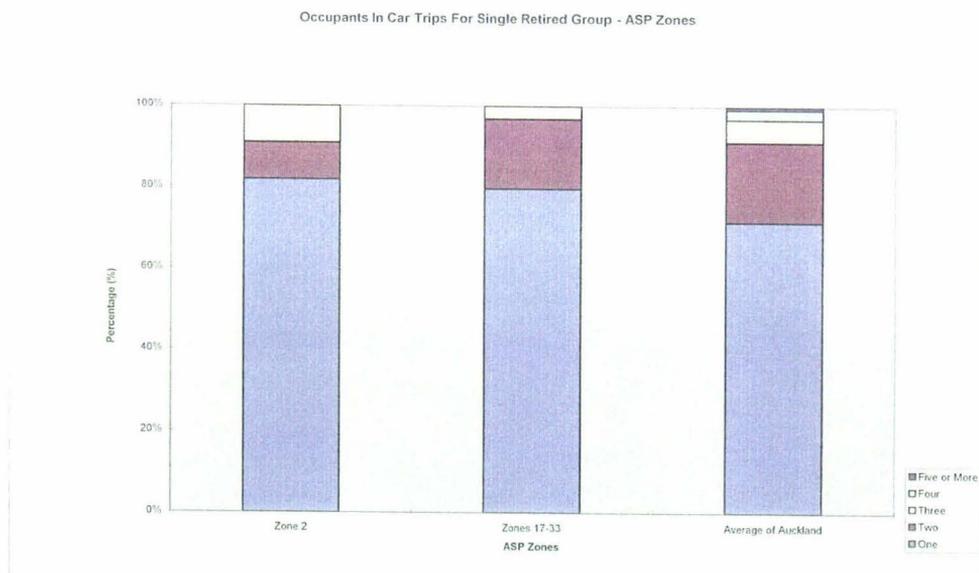


Table 39: T-test Results for Single Retired Household Group

OCCUPANTS IN CAR TRIPS VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
OCCUPANTS	0.20	1.80	0.42

6.5.22.2 The results in Figure 94 show that most of the car trips made by respondents in the Single Retired household group in Zone 2 (81.8%) and Zones 17-33 (79.6%) only have one occupant. This result is above the average for Auckland (71.5%). The remaining proportion of car trips in Zone 2 have either two (9.1%) or three (9.1%) occupants. The remaining proportion of car trips in Zones 17-33 have two (17.8%) occupants, while a small proportion have three (2.7%) occupants. The t-test on this result show that the difference in the number of occupants in car trips made by the Single Retired household group in Zone 2 and Zones 17-33 is not statistically significant. This result does not support the claim that urban areas with NTD characteristics result in more complex trip making patterns.

### 6.5.23 Number of Occupants In Car Trips For Unrelated Flatmates Household Group

6.5.23.1 Figure 95 shows the number of occupants in car trips made by the Unrelated Flatmates household group in the ASP Zones.

Figure 95: Number of Occupants In Car Trips For Unrelated Flatmates Household Group

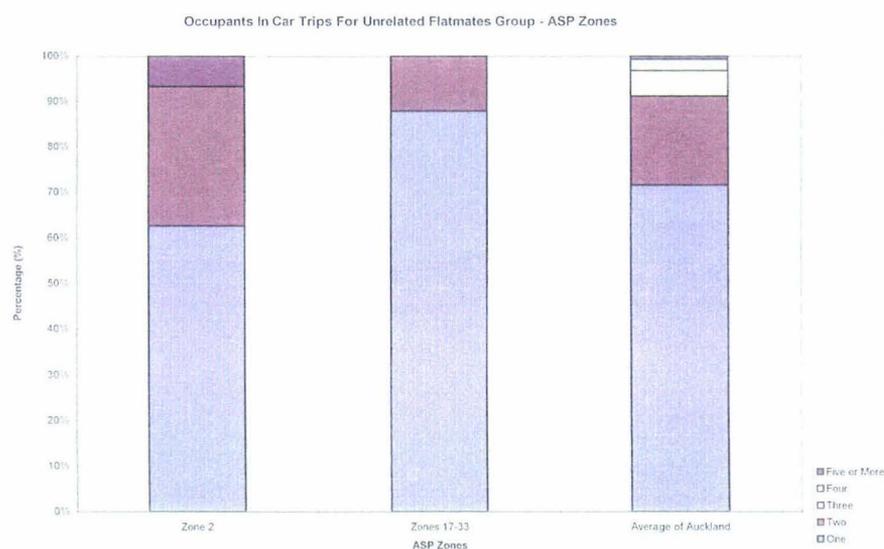


Table 40: T-test Results for Unrelated Flatmates Household Group

OCCUPANTS IN CAR TRIPS VARIABLE	t STAT	t CRITICAL ONE-TAIL	P (T<=t) ONE-TAIL
OCCUPANTS	3.07	1.66	0.001 (3dp)

6.5.23.2 The results in Figure 95 show that the majority of car trips made by respondents in the Unrelated Flatmates household group in Zone 2 (62.7%) have one occupant. This is below the average for Auckland (71.5%). In comparison most (87.8%) of the car trips for the same group in Zones 17-33 have only one occupant. The remaining proportion of car trips in Zone 2, by this group have two (30.7%) or five (6.7%) occupants. The remaining proportion of trips in Zones 17-33 have two occupants (12.1%). The t-test

results showed that the difference in the number of occupants in car trips made by the Unrelated Flatmates household group in Zone 2 and Zones 17-33 is statistically significant. This result does not support the claim that urban areas with NTD characteristics result in more complex trip making patterns.

6.5.23.3 The main trends identified in the results for the average number of occupants per car trip variable across the various household groups is summarised below:

- The Main Income Earner household groups have similar proportions of occupants in car trips for both Zone 2 and Zones 17-33 to the average for Auckland.
- The impact of the results for the average trips times for the Wife/Defacto/Partner and Single Retired household groups is difficult to determine as the t-test results were not highly statistically significant for any of the variables.
- The result for the Unrelated Flatmates household group were statistically significant and indicates that these respondents in Zone 2 are more likely to either be a car passenger or take car passengers than their counterparts in Zones 17-33.

## CHAPTER SEVEN - CONCLUSIONS

### 7.1 OVERALL TRAVEL BEHAVIOUR PATTERNS WITHIN AUCKLAND

- 7.1.1 The results within Chapter Six identify that Aucklanders rely majorly on the automobile as their main mode of travel. The results indicate that the automobile is used predominately for all types of travel and that the majority of car trips have only one occupant. These results concur with similar studies conducted by the Auckland Regional Council (1995) and follow similar travel behaviour trends exhibited in other western cities around the world.
- 7.1.2 Travel within Auckland occurs for a number of different reasons. The results in Chapter Six show that work related travel accounts for about a quarter of all travel. It should be noted that this does not include work-related travel that is part of a trip chain. Non-work related travel for example, for shopping or recreation purposes is also an important source of travel accounting for a quarter of all travel made. Aucklanders tend to travel by car for all types of trips including, shopping and recreation travel, not just for work related travel. The average trip times for car driver, car passenger, walk/cycle modes are similar in length. However the average trip time for public transport trips is significantly longer than for these modes. This result may in part suggest one reason why Aucklanders do not make greater use of public transport services as the results indicate that the average times from origin to destination are longer than for any other mode. The results show that overall non-vehicular modes of travel are not the preferred travel option for most Aucklanders. The high level of reliance on automobile travel supports this type of research into the potential influences on travel behaviour in order to effectively address this significant urban sustainability issue.

## 7.2 URBAN FORM AND TRAVEL BEHAVIOUR - THE SIGNIFICANCE OF THIS LINK

- 7.2.1 The results in Chapter Six indicate that urban form does have an influence on the travel behaviour patterns. The results showed that while the level of automobile use is the same in Zone 2 as in Zones 17-33, the proportion and average number of walk/cycle and public transport trips made by respondents in Zone 2, (the zone with NTD characteristics) is greater than the proportion of walk/cycle and public transport trips made in Zones 17-33 (or those zones without NTD characteristics). This therefore provides support to the claim that urban areas with NTD characteristics have a greater level of public transport and non-vehicular travel than urban areas without these NTD characteristics.
- 7.2.2 Neo Traditional Development advocates claim that an increase in residential density will make public transport a more viable option to provide. Zone 2 is characterised as having a significantly higher residential density level than Zones 17-33. The results clearly show that the average number and proportion of public transport trips in Zone 2, is greater than that for Zones 17-33. This may be partially attributed to the more frequent bus transport service dispersed throughout Zone 2 compared to Zones 17-33. The location of Zone 2 surrounding the CBD, means that a number of bus routes must travel through the Zone to get in and out of the central area. In summary, the results in Chapter Six do indicate that urban areas with NTD characteristics have a greater level of public transport use.
- 7.2.3 The advocates of Neo-Traditional Developments claim that urban form features such as a greater mix and balance of land uses and a more connective street system may reduce travel distance between destinations, and therefore induce more non-vehicular travel. The results show that slightly longer average walk/cycle trip times exist in Zone 2 than Zones 17-33. The longer average trip length and the greater average number and proportion walk/cycle trips made in Zone 2 compared with Zones 17-33, suggests that people living within areas with these urban form NTD

characteristics are more conducive to taking non-vehicular modes of transport than those in urban areas without these NTD characteristics.

- 7.2.4 The results in Chapter Six further show that the average trip times for working, shopping and serve passenger trips are shorter in Zone 2 (with a greater mix and distribution of land uses) compared to Zones 17-33. This provides some support for this claim that a greater mix of commercial/industrial activity with residential activity will reduce the length of time taken to travel to destination. The average trip times for recreation in Zone 2 are significantly longer than for Zones 17-33. The results in this sections show that a major proportion of all recreation trips made in Zone 2 are by public transport which may explain the increase in average trip times.
- 7.2.5 Overall, the results contained in Chapter Six clearly identify that the automobile is the favoured mode of transport for most Aucklanders. Its convenience and accessibility to areas within the City makes it difficult to coerce people from their automobiles to other more sustainable modes of travel. The scale of the transport problem within Auckland and the detrimental environmental, economic and social effects associated with the level of automobile reliance (outlined in Chapter Three) highlights the need to adopt strategies that address Auckland's growing transport issue in a integrated manner. The results in Chapter Six therefore provide support to pursue Neo-Traditional Development policies and strategies which seek to further integrate transport and urban form planning together in order to encourage greater walking/cycling and public transport use. The results indicate that the Neo-Traditional Development approach offers part of a solution to address Auckland's growing transport problem; however the results further identify that this approach alone will not be able to effectively deal with the current and increasing reliance on the automobile and significant impact this is placing on urban sustainability.
- 7.2.6 It is recognised that steps have been taken within the current legislative setting particularly though documents such as the draft Auckland Regional Growth Strategy and the draft Auckland Regional Land Transport Strategy to address Auckland's transportation issue in a wider context. It is noted that

both these documents include policies and objectives that promote the greater integration of transportation and urban form. This research therefore concludes that a strategic planning approach that integrates transportation and urban form objectives as included in these documents is essential in the management of Auckland's future growth.

### 7.3 SOCIO - DEMOGRAPHIC CHARACTERISTICS - THE RELATIONSHIP BETWEEN AGE AND TRAVEL BEHAVIOUR

7.3.1 The results within Chapter Six clearly identify that the travel behaviour patterns differ according to age. This can be demonstrated by the trends in travel behaviour exhibited by the four age groups studied. The results in Chapter Six show for example, that respondents within the 5 to 24 years age group make a greater proportion of walk/cycle and public transport trips than those respondents in the 25 - 44 years age group. The results also show that the 25 to 44 years age group make on the whole more trips per day per respondent than any of the other age groups. Most of these trips are made by car with the respondent being the car driver. The 25 to 44 years age group further exhibited a slightly greater proportion of working and serve passenger trips than the other age groups.

7.3.2 The results for the 45 to 64 years age group also differed from the other age groups in that the results were notably different between the two sets of zones. The results clearly identified that the respondents in this age group in Zone 2 made a greater proportion of walk/cycle trips and public transport trips than those in Zones 17-33 who mainly used the automobile for travel. The types of trip purposes and the average trip times also varied greatly between the two sets of zones. The travel behaviour of the over 65 years age group again exhibited different trends from the other age groups. Work related travel was minimal for this age group, while the proportion of shopping and recreation travel was significantly higher than for the other age groups. The results showed that proportion of travel by walk/cycle and public transport modes for the respondents in Zone 2 in the over 65 years age group was the greatest of all age groups. However the results for Zones 17-33 for this age group, indicated that the level of public transport use and

walk/cycle modes was significantly lower than Zone 2 but not dissimilar to the average for Auckland.

- 7.3.3 These results and many others provides support that socio-demographic characteristics such as age do influence travel behaviour. The overall significance of these results is that it provides greater knowledge about the relationships between age and travel behaviour and greater recognition of the complexity of travel patterns within Auckland. Knowledge of the main users of different travel modes can lead to improved provision and management of transport options to cater for differing transport needs. An example of this, that greater provision and maintenance of cycling and walking paths may improve travel options and accessibility for the 5 to 24 years and the over 65 years age groups as these two groups were shown in Chapter Six to make a greater proportion of walking and cycling trips than the 25 to 44 years age group. It can therefore be concluded that age is an important factor that influences travel behaviour and should be considered when designing strategies to improve Auckland's transport management and provision.

#### 7.4 SOCIO - DEMOGRAPHIC CHARACTERISTICS - THE RELATIONSHIP BETWEEN HOUSEHOLD GROUP AND TRAVEL BEHAVIOUR

- 7.4.1 The results within Chapter Six identify that a clear link exists between household group and travel behaviour. This can be demonstrated by the range of different travel patterns exhibited by the four different household groups. The Main Income Earner household group and the Wife/Defacto/Partner groups for example, make a high proportion of car driver trips compared to the Single Retired group and the Unrelated Flatmates group in Zone 2. The results also show that the Main Income Group makes the greatest proportion of work related trips of all the groups while the Single Retired group makes the highest proportion of shopping and recreation travel. Another interesting result was the higher proportion of multi occupants for car trips particularly for the Wife/Partner/Defacto age group compared to the high level of single occupant trips for the Main Income Earner, Single Retired household groups.

7.4.2 These results suggest that the activities undertaken during the day by a respondent will derive certain types of travel behaviour patterns. The Main Income Earners for example, are assumed to spend a significant proportion of the day at work and therefore derive a higher level of work related travel. This travel demand is met by using the automobile for travel and where more often than not the Main Income Earner is the single occupant for the trip. In comparison, the Wife/Partner/Defacto household group are assumed to make a significantly lower level of work-related travel and greater levels of shopping and recreational travel. While still mainly using the automobile, this group tend to have more than one occupant for the trip. These results and others also provides support that socio-demographic characteristics such as household group influence travel behaviour.

## 7.5 CONCLUDING REMARKS

7.5.1 This research has investigated a number of key factors that contribute to varying degrees to travel behaviour. The relationships that exist between travel behaviour and socio-demographic characteristics has been shown in this research and by other international studies thereby provides support for developing strategies that greater integrate transportation decisions with land use and socio-demographic considerations. Knowledge and understanding of travel behaviour and the factors that influence it has been confirmed as being a necessary focus to address Auckland's transportation issues in a sustainable manner.

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## APPENDICES

### APPENDIX 1:

District Plan Planning Maps used to determine Urban Form Variables.

Source: Waitakere Proposed District Plan October 1995, Human Environment Maps.

#### Zone 25

Swanson Map	1: 12 000
Birdwood Map	1: 15 000
Ranui Map	1: 8 000
Lincoln Map	1: 8 000
Royal Heights Map	1: 8 000
Massey North Map	1: 8 000
West Harbour South Map	1: 8 000
West Harbour Map	1: 8 000

#### Zone 22

New Lynn Map 1:	6 000
Green Bay Map 1:	10 000
Kelston Map 1:	8 000
Glen Eden Map 1:	8 000
Glendene Map 1:	10 000
Parrs Park Map 1:	8 000
Woodlands Map 1:	10 000
Sunnyvale Map 1:	8 000

Manukau City Proposed District Plan, Zoning Maps, Year 1995

#### Zone 28

Map 12	1: 7 500
Map 16	1: 7 500
Map 17	1: 7 500
Map 18	1: 7 500
Map 26	1: 7 500
Map 27	1: 7 500
Map 28	1: 7 500

#### Zone 30

Map 20	1: 7 500
Map 21	1: 7 500
Map 29	1: 7 500
Map 30	1: 7 500
Map 31	1: 7 500
Map 32	1: 7 500
Map 43	1: 7 500
Map 44	1: 7 500

Zone 33

Map 22	1: 7 500
Map 23	1: 7 500
Map 24	1: 7 500
Map 33	1: 7 500
Map 34	1: 7 500
Map 35	1: 7 500
Map 36	1: 7 500
Map 37	1: 7 500

## North Shore City Proposed District Plan, Zoning Maps 1994

Zone 17

Map 23	1: 10 000
Map 24	1: 10 000
Map 25	1: 10 000
Map 28	1: 10 000
Map 29	1: 10 000
Map 30	1: 10 000

Zone 18

Map 3	1: 10 000
Map 4	1: 10 000
Map 7	1: 10 000
Map 8	1: 10 000
Map 13	1: 10 000
Map 14	1: 10 000
Map 20	1: 10 000
Map 21	1: 10 000

## City of Auckland Proposed District Plan (Isthmus Section) 1993

## Planning Maps No.1 Zoning

Zone 2

Map A:07	1: 5 000
Map B:05	1: 5 000
Map B:06	1: 5 000
Map B:07	1: 5 000
Map B:09	1: 5 000
Map B:10	1: 5 000
Map C:06	1: 5 000
Map C:07	1: 5 000
Map C:08	1: 5 000
Map C:09	1: 5 000
Map C:10	1: 5 000
Map D:06	1: 5 000
Map D:07	1: 5 000
Map D:08	1: 5 000
Map D:09	1: 5 000

## APPENDIX 2:

## Structure and Coding of the Trip File

Field	Name	Type	Width	Description
1	NUMREC	Character	4	Identifying key relating HHIFLE.DBF, TRIPFILE.DBF and PERFILE.DBF (RECNO)
2	RESP	Character	6	Respondent's first name
3	TRIP	Character	2	Make any trips yesterday: 1- Yes, 2 - No
4	OPUR	Character	2	Doing at beginning of trip: 1 - Home, 2 - Work, 3 - School/Education, 4 - Shopping, 5 - Employer's business, 6 - Social/Recreational, 7 - Serve pax, 8 - Refuse
5	DPUR	Character	2	Doing at end of trip: 1 - Home, 2 - Work, 3 - School/Education, 4 - Shopping, 5 - Employer's business, 6 - Social/Recreational, 7 - Serve pax, 8 - Incidental pax, 9 - Other, 10 - Refuse
6	TPUR	Character	1	Overall purpose of trip: 1 - Home, 2 - Work, 3 - School/Education, 4 - Shopping, 5 - Employer's business, 6 - Social/Recreational, 7 - Other
7	AMODE	Character	2	Mode of travel for first leg of trip: 1 - Private car driver, 2 - Private car pax, 3 - Company car driver, 4 - Company car pax, 5 - Truck driver, 6 - Truck pax, 7 - Light com. driver, 8 - Light com. pax, 9 - Motorcycle/scooter, 10 - Taxi pax, 11 - Bus pax, 12 - Train Pax, 13 - Ferry pax, 14 - Walk only, 15 - Cycle, 16 - Duplicate Mode, 17 - Refuse
8	BMODE	Character	2	Mode of travel for second leg of trip (codes same as for field 7)
9	CMODE	Character	2	Mode of travel for third leg of trip (codes same as for field 7)
10	DMODE	Character	2	Mode of travel for fourth leg of trip (codes same as for field 7)
11	STIME	Character	4	Trip start time (24 hour)
12	FTIME	Character	4	Trip finish time (24 hour)
13	PTFARE	Character	1	Method of payment for public transport (excluding taxis): 1 - Cash, 2 - Weekly concession card, 3 - Monthly pass, 4 - Refused
14	PTPAY	Character	1	Method of payment (taxis): 1 - Paid it him/her self, 2- Employer paid it
15	PTCOST	Numeric	4.2	Fare amount \$\$cc
16	PTSWALK	Character	2	Minutes of walking at start of PT trip
17	PTWAIT	Character	2	Minutes of wait time for PT service
18	PTIVT	Character	2	Minutes of PT invehicle time
19	PTEWALK	Character	2	Minutes walking at end of PT trip

Field	Name	Type	Width	Description
20	PTCAR	Character	1	Car available to drive/travel as pax in: 1 - None available, 2 - Drive, 3 - Pax, 4 - Both, 5 - Refuse
21	PKTYPE	Character	1	Type of parking: 1 - On street free, 2 - On street meter, 3 - Off street private, 4 - Off street public, 5 - Refuse
22	PKPAY	Character	1	Who pays for parking: 1 - No charges, 2 - Employer pays all of it, 3 - Employer pays part of it, 4 - I pay all of it
23	PKFREQ	Character	1	How do you pay for parking: 1 Daily, 2 - Monthly, 3 - Annually, 4 - Don't know employer pays, 5 - Refuse
24	PKCOST	Numeric	4.2	How much are parking charges: \$\$cc
25	CDWALK	Character	2	Minutes walk at beginning of car trip
26	CDEWALK	Character	2	Minutes walk at end of car trip
27	CDOCCUP	Character	2	Number of occupants in car
28	CDWORK	Character	1	Was trip work related: 1 - Yes, 2 - No, 3 - Refuse
29	CDPT	Character	1	Has public transport been taken for trip: 1 - Yes, 2 - No, 3 - Refused
30	PSRELHH	Character	1	Car pax relationship with driver: 1 - Household member, 2 - Friend, 3 - Neighbour, 4 - Workmate, 5 - Other, 6 - Refused
31	PSHHM	Character	2	Which household member
32	PSPAY	Character	1	Did you contribute towards running costs: 1- Yes, 2 - No, 3 - owns the car, 4- Refused
33	PSTRCOST	Numeric	4.2	Running costs per trip \$\$cc
34	PSWRCOST	Numeric	2	Running cost per week \$\$
35	PSMRCOST	Numeric	2	Running costs per month \$\$
36	PSPARK	Character	1	Contribute towards parking costs: 1 - Yes, 2 - No, 3 - Refused
37	PSTPARK	Numeric	4.2	Parking cost per trip \$\$cc
38	PWWPARK	Numeric	2	Parking cost per week \$\$
39	PWMPARK	Numeric	2	Parking cost per month \$\$
40	PSCOM	Character	1	Is vehicle a company vehicle: 1 - Yes, 2 - No, 3 - Refused
41	PSPT	Character	1	Was public transport available for trip: 1 - Yes, 2 - No, 3 - Refused

Field	Name	Type	Width	Description
42	PSCD	Character	1	Was car available to drive in: 1 - Yes, 2 - No, 3 - Refused
43	PSSWALK	Character	2	Minutes walk time at beginning of car pax trip
44	PSEWALK	Character	2	Minutes of walk time at end of car pax trip
45	MORE	Character	1	Flag to indicate trip type: 1 - all trip except last, 2 - last trip for person, 8 - second leg of mixed mode trip, 9 - dummy record for household which made no trips
46	FROM	Character	7	Trip origin meshblock
47	TO	Character	7	Trip destination meshblock
48	TYPE	Character	2	ART household type (1 - 18)
49	ARTFROM	Character	3	ART zone at origin of trip
50	ARTTO	Character	3	ART zone at destination of trip
51	HOMEZONE	Character	7	Meshblock of respondent's home
52	RECID	Numeric	5	Record identifier
53	ARTHOME	Numeric	3	ART zone of respondent's home
54	FACTOR	Numeric	5.3	Trip expansion factor (appended after editing)
55	HHOD2	Character	7	Meshblock of respondent's workplace (1st job)
56	HHOD3	Character	7	Meshblock of respondent's workplace (2nd job)
57	HHOD4	Character	7	Meshblock of respondent's workplace (3rd job)

## APPENDIX 3:

## New Zealand Standard Industrial Classifications:

Group 62211 - Groceries and Dairies;

Group 62213 - Supermarkets;

Group 62214 - Butchers;

Group 62215 - Fish Shops;

Group 62216 - Delicatessens;

Group 62217 - Health Food Shops;

Group 62218 - Milk Vendors;

Group 62219 - Food n.e.c ( includes: Biscuit Retailers, Cake and Bread Shops, Bread Retailing and Home Delivery Service, Confectioners)

Group 62220 - Greengrocers and Fruiterers;

Group 62512 - Video Cassette Hire;

Group 62710 - Pharmaceutical Supplies, Cosmetics and Toiletries;

Group 63111, 63112, 63119 - Takeaways (includes Fish and Chips, Chicken Takeaways, Lunch Bars, Picnics etc)

Group 63120 - Tearooms, Coffee Lounges and Unlicensed Restaurants;

Group 63141 - Licensed and BYO Restaurants;

Group 63142 - Cabarets and Night Clubs;

Group 81130 - Savings Banks;

Group 94502 - Health and Fitness Centres;

Group 95810 - Dry Cleaning and Laundry Services;

Group 95910 - Hairdressers and Beauty Shops.