Assessment of development form and its impact on the modal split and trip generation for low-income commercial developments

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(BTHMAR037)

MEng Transport Studies

A minor dissertation submitted in fulfilment of the requirement of the degree of

MASTER OF ENGINEERING
Department of Civil Engineering
Centre of Transport Studies
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University of Cape Town

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August 2017

SUBMISSION DETAILS

	Date submitted	Revision
Compiled by: M Botha (BTHMAR037)	28– 07 – 2016	Draft 1
	16 – 09 – 2016	Final Draft
	23 – 12 – 2016	Final Report
	05 – 04 - 2017	Reviewers Feedback
	12 – 07 – 2017	Reviewers Amendments
	21 – 08 - 2017	Final Report
Supervisor: A/Prof.Mark Zuidgeest		

ABSTRACT

This topic of research was motivated through my extensive interaction in the development field and a key element which was recognized with numerous development assessments within the City of Cape Town, was the fact that our current legislation or standards applied in South Africa do not accurately inform commercial developments within low-income areas. It was observed that the South African standards and policies rely heavily on international standards which focus on private vehicle movement and networks planning which is geared for mobility, whereas South Africa and in particular metropolitan Cape Town has unique characteristic due to the City Planning Structure which was shaped by a flawed political system. The objective of this dissertation is therefore firstly to assess the impact which the built environment (TOD and TND) has on the modal split and trip generation for low income commercial developments, secondary to draw a comparison between the actual operation of low income developments and the accepted trip generation rates used in South Africa, thirdly, to assess the unique characteristics of low income developments within a local context.

With this problem statement in mind the aim of this dissertation is therefore to, firstly, to establish a better understanding of the modal split and trip generation for low income commercial developments, secondly, to establish a trip generation rate which is more compatible with developments within low-income communities; and lastly to establish the benefits which can be attained through appropriate development form implementation within the low-income.

The literature review section of this dissertation will review academic literature as well as recent policy documents which investigate the relationship between the development form and the impact on traffic patterns, trip generation and modal splits of development. The literature review also establishes common trends and understandings when investigating/reviewing complex data of this nature. It is also the aim of the literature review to set a foundation for the site investigation and analysis process which will be undertaken as part of this dissertation.

A critical aspect of this research was the site selection process as this has a direct bearing on the outcomes of the analysis and the accuracy of the results. It is therefore critical to note that the three sites selected for this research were selected based on stringent criteria. With the site selection approach it was a key aspect to keep as many of externalities or external factors constant (*Ceteris Paribus*) and in this way the results would emphasize the impact of the development form on the trip generation, traffic patterns and the modal split of these developments (if any).

The data collection process was done using two distinct survey methods based on the level of technology available at the sites investigated. The first method used was data collection using recorded camera surveillance footage obtained from the centre management. The second method was a manual survey method done by individuals employed at the sites and this was used where electronic data was not available. The survey/data collection process was also broken up into 4 phases, of which the first of these processes was a pilot survey which was undertaken at one of the sites earmarked for the investigation. The aim of this pilot survey was to identify the any shortcoming in the data collection process and it was at this point where all adjustments could be made to eliminate any future errors in the data set. The pilot survey also indicated whether or not the relevant data could be extracted from the camera angles available.

The second critical phase of the survey process was that a full week survey was done, this was done to establish the critical peak day which would eventually be used to calculate the critical peak hour for the centres analysed as well as the peak hour factors. The aim of establishing a peak day for the various centres was to eliminate unnecessary data collection and cost, also to focus the study on peak data which will later be compared against prescribed peak rates for these types of developments. Once the peak day was established, phase three was to undertake the final surveys for each individual site and phase four was implemented in order to strengthen the outcomes of the data set, the approach of a repetitive assessment approach (three separate surveys at each site) was used.

Based on the weekly peak analysis done, it is evident that the Saturday peak is to be considered the critical/maximum peak for the week. A further conclusion of the weekly peak analysis is that the weekend (Saturday and Sunday) traffic pattern differs from the weekday pattern as it is structured around a single critical morning to midday peak, with the no secondary peaks encountered as with the weekday traffic patterns.

The analysis done indicates that TND development principals have a greater impact on the modal split (or preferred mode choice) than TOD as the number of pedestrian trips far exceeds the number of public transport trips generated. This trend was conclusive for all 3 sites used as part of the investigation.

A firm conclusion can be drawn from modal split analysis when assessing these developments. When the development form is adequately structured around a pedestrian movement and accessibility (TND type developments), one of the main benefits are increased pedestrian traffic. The outcomes of the modal split analysis also show a positive trend when using the TOD design approach, with the benefits of increased public transport trips.

When assessing all the results achieved in the trip generation comparative analysis, it can be concluded that the COTO rate is an accurate prediction for low income shopping centre developments which are built along a transport corridor (TOD design element) and which are pedestrian friendly developments (TND design element). The NDoT calculated rates are not considered appropriate for these developments as they are way in excess of the actual rates recorded.

DECLARATION

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1. CHAPTER 1: INTRODUCTION

1.1 Background and motivation

This topic of research was motivated through my extensive interaction in the development field and a key element which was recognised with numerous development assessments within the City of Cape Town, was the fact that our current legislation or standards applied (i.e. National Department of Transport (NDoT), South African Trip Generation Rates and COTO, TMH 17, South African Trip Data Manual) in South Africa do not accurately inform commercial developments within low-income areas.

It was observed that the South African standards and policies rely heavily on international standards which focus on private vehicle movement and networks which are geared for mobility, whereas South Africa and in particular metropolitan Cape Town has unique characteristic due to the City Planning Structure which was shaped by a flawed political system.

The motivation for this dissertation is therefore to investigate and unpack the dynamics of low-income commercial developments and an effort will be made to understand the impact which neighbourhood structure or development form has ontraffic patterns, modal split and traffic generation ofthese developments.

In comparison to the international development influences and standards, it is the expectation that developments within these low-income areas are more prone to generate a mixed modal split with a high percentage of pedestrian traffic, public transport trips and to a lesser extend private vehicle trips. The aim of this dissertation is therefore to firstly assess the development or neighbourhood form and then secondly to measure the actual modal split for these commercial sites located in and around low-income communities. Once the modal split has been assessed and quantified, a third aim of this dissertation is to draw a comparison between the prescribed trip generation rates and the actual operation (e.g. traffic patterns, traffic peaks and traffic fluctuations) of these developments.This process is aimed at establishing whether or not these standards are appropriate in the South African context but more specifically whether it is appropriate for developing within low-income communities.

The research will be focused on recognised development forms such as Traditional Neighbourhood Development (TND) and Transit Oriented Development (TOD) as these development forms are seen to have a significant influence on the revolving and modern neighbourhood, road network and City planning.

This research is expected to addsignificant value and understanding to the current gap in the knowledge base surrounding commercial development in low-income areas and it is expected to show a positive trend or impacts which can be attributed to the appropriate use of urban planning or development forms.This dissertation can be utilised as a base to support a positive change in the design approach for community based shopping centres.The current design approach is considered to bea ridge and outdated approach which is focused on private vehicles, compared to a more modern approach which is focused on integration and which has a strong emphasis on pedestrian movement and safety,also public transport focused. This change in approach is vital to creating sustainable developments which meet the criteria of its patrons which in the long term it will have a positive impact on negative aspects such as congestion, air and noise pollution, network failure and urban sprawl experienced in metropolitan Cities.

To establish change it will have to be start at the foundation and in terms of City planning, the development form can be seen as one of the critical building blocks to create a sustainable City.

In order to set a base for this research topic it is important to understand the inter-relationships between the four key components of this research, these components being:-

- Development form impacts;
- Income Level impact (focused on low-income);
- Modal choice or split; and
- Trip generation

The figure 1.1 below shows graphically the inter-relationship between the key components and this relationship is further discussed in detailed. The aim here is to give a full perspective of the research topic.

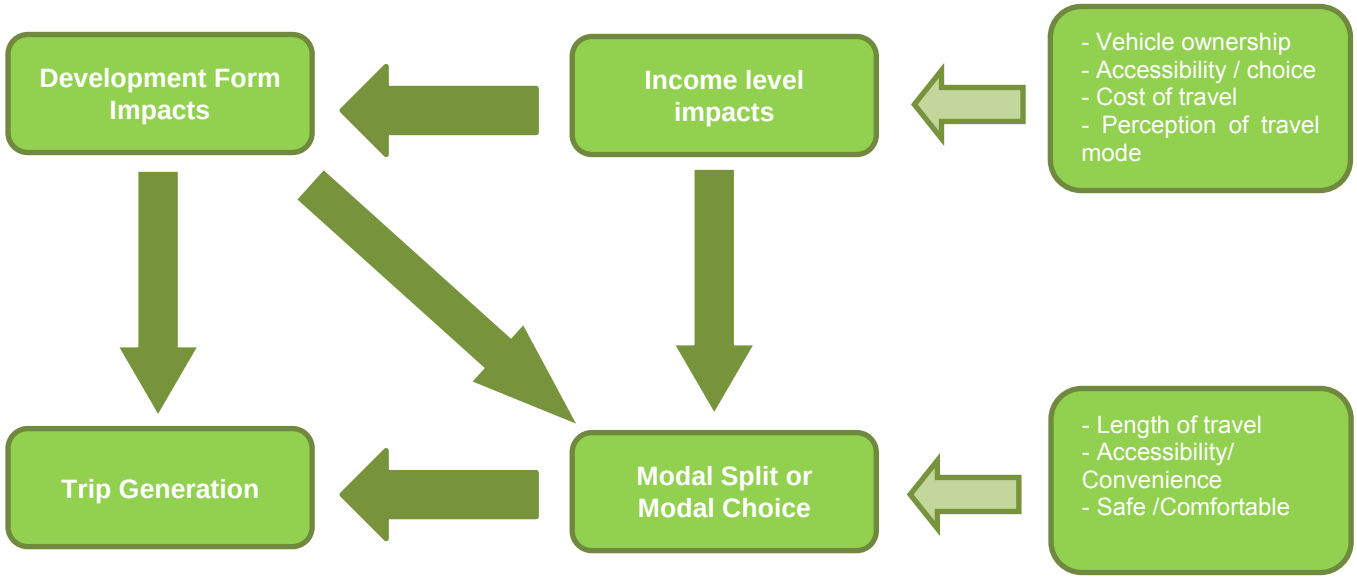


Figure 1.1: Inter-relationship of key components

Relationship 1: Income group – Modal Split:

There is a strong link between these two core elements as the income group has a rigid bearing on the modal choice of end users. Focusing on the low income group in this instance, their modal choice is largely determined by the accessibility to other modes of transport. In this income group private vehicle ownership is relatively low and the cost of travel is a fundamental consideration. The users within a low income group are therefore considered to be captive users and not choice users due to aspects of accessibility and cost. These users tend to be dependent on mass public transport (train, bus or taxi) and if facilities are accessible (within acceptable walking distance) on foot a high percentage of these users will opt to use NMT modes (walking and cycling).

Relationship 2: Income group – Development form:

The link between the income group and the development form is established at high level planning stage where the relevant authority will design a community based on the desired outcome or target market. If the community is geared for the low income group the emphasis of the development form will be placed on public transport and/or pedestrian accessibility as this is seen as the predominate modes of transport. On the other side of the spectrum, if a development is geared at the higher income group a greater emphasis will be placed on road infrastructure and mobility/accessibility for private car users. A key aspect of the design approach will be that the development form will have to respond to the expected demand generated, which differs depending on the income level. If an incorrect choice is made at the concept planning stage it will result in either, the overcapitalisation in infrastructure costs or developing a community that is not compatible for the residents which will result in high travel costs and which then will then need to be subsidised by the government.

Relationship 3: Development form – Modal split:

The development form is a key consideration when designing a community or city at a larger scale and this has a direct impact on the modal split of that specific community. If the intent is to promote public transport as with TOD developments, the stops are strategically positioned in order to maximise the accessibility and convenience for public transport users, in this way the attractiveness of public transport is increased and end user will consider public transport as a suitable alternative to a private vehicle. Also, by implementing a mixed use development with a variety of uses been accessible within one location, this will have a direct impact of the modal split of a community. The development form can also be used to give a particular mode of transport preference over other modes, such as allowing pedestrian a higher level of accessibility and more direct links compared to road transport (private car and public transport) as promulgated with TND development, this then has a direct impact on the modal choice and therefore the modal split of a particular community. This relationship is seen to be directly proportionate as the modal split is likely to increase as the mode is promoted using the development form (i.e. more pedestrian traffic with higher level of pedestrian facilities).

Relationship 4: Development form – Trip generation

There is a strong link between the development form and the trips that will be generated, this can be seen if a community is designed to be self-sustainable it is expected to generate a higher number of local trips, whereas if a community development form is geared to promote interaction with other communities there will be a higher volume of trips generated on road links.

1.2 Dissertation research problem statement

The research problem statement for this dissertation is briefly unpacked below and helps to give some insight into further investigation done:-

- The current trip generation standards used are based on international standards which is not necessarily compatible with the South African context, more specifically within low-income communities;
- Incorrect interpretation or understanding of the local context has a direct impact on the development form implemented within low-income communities and on City Planning in general;
- Lack of understanding in developing low-income commercial developments leads to incorrect capital investment (i.e. road upgrades for private vehicles instead of pedestrian and public transport facilities); and
- The development strategy focused on private vehicles is not sustainable within the South African context and therefore this approach needs to be adapted to a more sustainable approach which is focused around non-motorised transport and public transport.

1.3 Dissertation objective and scope

Based on the information discussed above, the objectives of this dissertation are as follows:-

- To assess the impact which the development form or built environment (TOD or TND) has on commercial developments within a low-income area;
- To establish the modal split and trip generation rates for low-income commercial developments;
- To assess the traffic patterns (vehicular and pedestrian) for low-income commercial developments;
- To draw a comparison between the actual trip generationrates of low-income developments and the accepted trip generation rates (NDoT and COTO standards); and
- To establish a benchmark for the modal split or modal choice for commercial developments within low-income areas.

For the data collection process to be consistent and for the outcomes to be acceptable from a comparison point of view it is imperative that the external factors be kept as consistent as possible.

For this purpose three community based shopping centres were earmarked for the assessment, the sites were strategically selected in terms of the patrons attracted (mode choice or accessibility etc.) as this will have an impact on the modal split, all of the developments selected are on a major public transport corridor. A further criteria for the assessment was that the assessment at all three sites will take place simultaneously so that the conditions (weather, time of the month, etc.) can be kept constant. A repetitive assessment was done over a prolonged period to assess fluctuationsin traffic patterns and to see if the trends remain unchanged over a period of time.

1.4 Dissertation aim

The research aim for this dissertation is briefly unpacked below and helps to give some insight into further investigation done:-

- To establish the actual impact and benefits of various developments forms implemented within the context of a low-income area;
- To establish a better understanding or benchmark for the modal split and trip generation rates for low-income commercial developments;
- To establish a trip generation rate which is more applicable to developments within low-income communities;
- To establish a benchmark for the modal splits for low-income commercial developments; and
- To establish the benefits which can be attained through appropriate development form implementation within the low-income communities.

1.5 Structure of the dissertation

The dissertation will take the following form as described below:-

- Chapter 2: Literature review: This section of the dissertation will review academic literature as well as recent policy documents which investigate the relationship between the development form and the impact on traffic patterns, trip generation and modal splits of development. The literature review also establishes common trends and understandings when investigating/reviewing complex data of this nature.
- Chapter 3: Research site details: This section of the dissertation will focus on the site selection process (why, where and how regarding the sites selected), the development form analysis and the survey methodology used to analysis the site in Chapter 4.
- Chapter 4: Data analysis and data review: This section will focus on the data captured on the various sites, an in depth analysis was done and a detailed review was concluded.
- Chapter 5: Conclusion and recommendation: Based on the findings in the data analysis and review process a firm conclusion was drawn to prove or disapprove the hypothesis set out in this dissertation.

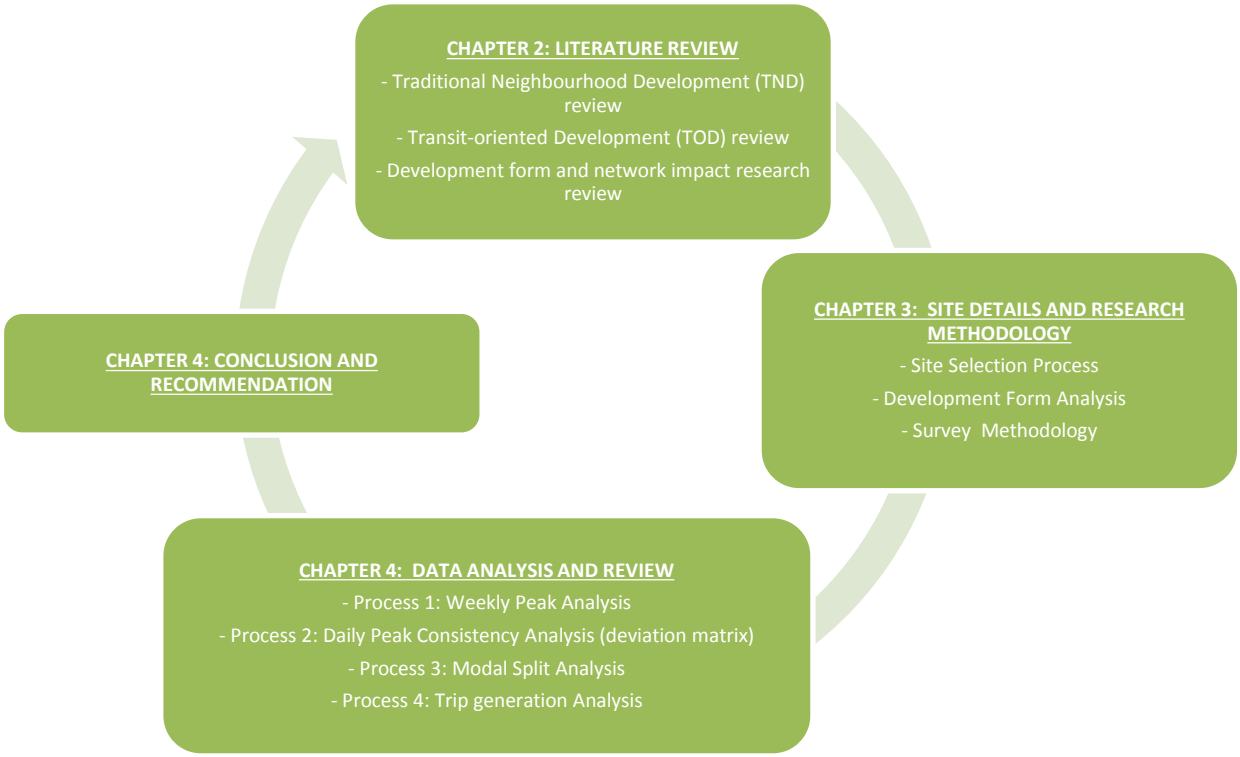


Figure 1.2: Research flow chart

2. CHAPTER 2: LITERATURE REVIEW

2.1 Literature review structure

The structure of this literature review will be divided into four sections and these sections will be briefly discussed below in order to give a better understanding or clarity into the research methodology or research process:-

Section 1: Introduction

This section of the literature review would introduce one of the key components of this dissertation which is the development form and it will look at the principles which are applied for various development forms. This section is geared at laying an important foundation for further research which would unpack the impact of various development forms.

Section 2: Development form assessment research

This section of the literature review will discuss two distinct development forms known as Traditional Network Development (TND) and Transit-oriented Development (TOD). These two development forms were specifically selected as the design principles of these two design approaches have clearly been implemented at the communities which will be discussed in Section 3 of this dissertation.

It is the aim of this section is therefore to discuss in detail the development form principles which are utilised when developing a community using the TND and TOD design approaches. Various literature sources were used to unpack these two development forms in order to give an in depth understanding.

It is critical to note at this point that although the sites selected will not necessarily comply with all the principles of a TND and TOD design (densities or mixed uses etc.), due to the fact that low income communities are captive users to either public transport or NMT modes, it is important to know how effective the TND and TOD design forms are in promoting these modes of transport.

Lastly, as the pedestrian mode is a critical element for low income communities and also the fact that it is a common thread in both the TND and TOD design forms, this section will also discuss the design principles for creating a Pedestrian Friendly Environment (PFE).

Therefore, this section is aimed at investigating core design elements to this dissertation such as public transport and pedestrians accessibility which are critical to developing in low income communities, which is a third core element.

Section 3: Network impact research

This section of the literature review is aimed at discussing the inter-relationship between the development form (a key component discussed in Section 1 and 2 above) and two other key components of this dissertation being the modal splits of patrons and trip generation impacts experienced when using the TND and TOD design approaches.

Various extracts of research are utilised in order to better understand the dynamic relationship between the development form and the impact it has on the modal splits and

trip generation rates of developments. This section also tries to quantify the impact which the development forms have, in order to create a benchmark for further research.

It is noteworthy that although this section does not specifically investigate commercial developments in low-income areas, the aim is to understand the impact/benefits of the development form in a general context. It should also be noted that although this topic is specific in terms of context and also the target market, the impact of the development form is expected to yield results which can inform this research.

Lastly, as this topic is considered a gap in the current knowledge base, this research can be seen as setting a benchmark for further research.

Section 4: Literature review conclusions

Based on the information in section 1 – 3 of the literature review, this section is aimed at drawing certain conclusions which will be reviewed against the data which is derived from the actual site investigations done in Chapter 4 of this dissertation.

2.2 Section 1: Introduction

In academic literature as well as recent policy documents in various countries (eg. Netherlands, Finland, USA, Japan) it is stated as a crucial fact that integration of land-use planning and transport planning be realised to obtain a more resilient and sustainable planning outcomes. However, it is noted that such development integration is scarcely present in practise (Bertolini 2009, Heeres et al 2012b).

Although this research topic is context specific and looks at how the development form has an impact on the trip generation and modal splits of these specific developments, this chapter is geared to unpack evidence which confirms this relationship between particular development forms, network planning practices and the travel patterns (trip generation, peak data etc.) or modal splits.

According to Behrens (2002), local network configuration is defined as, the arrangement of footways, roadways, pathways and cycleways in a development area to form street blocks and open spaces. It is further indicated that the formation of these development areas should facilitate local travel by various modes between the different land use activities they accommodate.

Behrens research indicates that there has been an evolution of local area movement network configuration, development forms and management practices between the 1900's and 2000's. The various forms are discussed briefly below:-

Garden City: This type of design form made use of radial road patterns which were built around a central node such as a central park to create a town centre. Travel speeds and through traffic were limited in these developments with the use of curved roads, open courts, narrow internal roads and cul-de-sacs. Another feature of this development style was that pedestrian movement was encouraged by allowing various through connections.

Neighbourhood Units: A key design element for this type of development form is that the development unit was defined by higher order peripheral arterial routes. As with the garden city design forms, these neighbourhood unit encouraged pedestrian moment by

allowing various through connections. To discourage high speeds and excessive through traffic, design elements such as, narrow internal road widths, curved roads and cul-de-sacs were used with this design form.

Radburn Superblock:The designfeature of this type of design form is to allow for a high level of pedestrian safety and this is done by segregation of pedestrian and vehicles onto physically separate roadways and paths in order to remove the conflict. The separation is done using overpasses and bridges to ensure that pedestrians never require crossing a roadway at grade.In order to prevent through traffic from entering the superblock design aspects such as cul-de-sacs, collector roads and limited access arterial routes get implemented.

Woonerf Design: With this approach the aim is to integrate roadways and footways, in this approach it is geared to safely integrate the movement of pedestrian and vehicles but making a pedestrian safe environment with the use of road design (narrow roads, chicanes, surface changes etc) and also the use of street furniture and planting.

Precinct Planning: This design approach makes use of a hierarchical classification of roads in arterials, sub-arterials and local routes. It also makes use of design elements such as road closure, and cul-de-sacs to create a precinct free of through traffic and in this way allow for a high level of pedestrian safety.

Pedestrian Pocket: This design approach differs from the radburn superblock design approach in that it promulgates a partial separation of pedestrians and vehicles onto separate movement systems in order to minimize the conflict and to create a pedestrian safe environment. This design approach is structured around a maximum walking distance for pedestrians and uses elements such as rectilinear and radial networks which originate from a central point.

This research topic focused on two distinct network and development planning forms which are known as Traditional Network Development (TND) and Transit-oriented Development (TOD). These two design approaches will be discussed in detail below:-

2.3 Section 2: Development form assessment research

2.3.1 Traditional Neighbourhood Development (TND)

The Traditional Neighbourhood Development (TND) was the concept of village-style developments which originated in the United States in the early 1990's and was first developed by Andres Duany and Elizabeth Plater-Zyberk (1991). The concept of TND falls under the banner of new urbanism or neo-traditional planning. (Bookout 1992, Katz 1994, Leccese and McCormick 2000).

The new urbanism or neo-traditional planningis based on the development principals of compact developments, areas which are made up of a variety of housing types, mixed land uses and walkable neighbourhoods which are similar to the traditional American towns of the 19th and early 20th centuries.It is argued that this system is geared at creating neighbourhoods which promote neighbourliness, another result of this type of development form is that travel modes such as walking and cycling are seen as preferred modes of travel and it is also expected that the use of public transport will increase. These benefits are all a result of bringing homes, jobs, shops and recreational amenities closer together. A major positive externality of this development design is that the dependence

on private vehicle use will be reduced as other modes become more viable from an end user perspective.

The sustainable cities guide which promotes the TND design approach indicates that TND development principals seek to remedy the problems which are associated with urban sprawl, these are aspects such as low-density developments, private vehicle oriented developments, single-use developments lacking context and distinctiveness. A critical problem such as private vehicle dependence results from the fragmentation of residential, commercial and industrial uses as is often required in modern zoning. This design practice makes neighbourhoods unwelcoming to pedestrians and bicyclists (NMT modes) and thus reduces community vitality. It also increases traffic. Area planning which are structured around TND and which are focused on mixes uses and developing in a compact area, on the other hand, can create high quality neighbourhoods.(Martin and Kasza 2013)

To qualify as TND the street pattern within the proposed network must be part of a dense,interconnected pattern. TND streets should connect with adjacent street networks as muchas possible. The degree of interconnectivity should be assessed by its ability to permitmultiple routes, to diffuse traffic and to shorten walking distances. Most TND street networks aredesigned to minimize through traffic. Streets are relatively narrow and often shaded by rowsof trees. Alleys may be used to provide site access. Larger vehicular corridors are usually,although not exclusively, found within the core area and near the perimeter of the proposeddevelopment. (McCoy, Sanderson and Goins 2000)

Figure 2.1: Typical Traditional Neighbourhood Development Layout *(Ref: McCoy, Sanderson and Goins 2000)*

2.3.2 Transit-oriented Development (TOD)

As with the TND design, Transport-oriented Development (TOD) originated in the United States, in the early 1990's and was first developed by Peter Calthorpe (1993). The concept of TOD was also noted to be the transit villages.

The major difference between the TOD design option and the TND design option is the focus on public transport stops or interchanges. The TOD design option involves the development of compact, mixed use and pedestrian-friendly neighbourhoods within a 10 minute (or 800m) walking distance of a public transport stop or interchange. One of the key elements to the TOD design which sets it apart from the TND design is the fact that it is not designed to be a self-sufficient or self-contained neighbourhood and therefore all people living in a particular neighbourhood are not expected to work, shop or partake in social activities within that specific neighbourhood.The TOD system is designed to promote interaction between various neighbourhoods or community and this is to be done by providing an adequate road network or rail service which includes a high level of public transport.

The TOD road network is generally characterised by interconnected streets, with typically direct radial links to the core which will be a public transport stop or interchange. Part of the argument for TOD would be that, by allowing a high level of through connections within a network, this provides for a more direct pedestrian link to local destinations and it is also aimed at reducing the walking distance to the public transport stops. It is further argued that these design elements encourage mode switching from private car to public transport.(Bernick and Cervero 1997)

Researchers identified transit-oriented development as a strategy used for regions and localities to implement livable community. It was noted that as promoting compact mixed-use development around public transport services (i.e. commuter rail stations or road based public transport), neighbourhoods benefit from elements such as affordable transportation and access to a wide range of amenities. (Kochera, Straight and Guterbock (2005)).

Zimbabwe and Anderson (2007) concluded that there are secondary externalities of a transit-oriented development, these been aspects such as increased revenue for transport agencies, increased land and property values, improved access to jobs, reduced cost of building new infrastructure, improved public health and the creation of public places with a sense of place. Furthermore they concluded that transit-oriented development can reduce transportation costs for working families and it can mitigate the negative impacts of private car on the environment and also the economy.

Evans and Pratt (2007) expanded the expected impact of transit-oriented development to aspects such as, increased interaction among neighbours and workers, this is gained while walking to and riding on the transit. Modal shift of end-user due to the improved accessibility and convenience of the system and reduced parking requirements.

Figure 2.2below show a typical layout of a Transit-oriented Development (TOD) design.

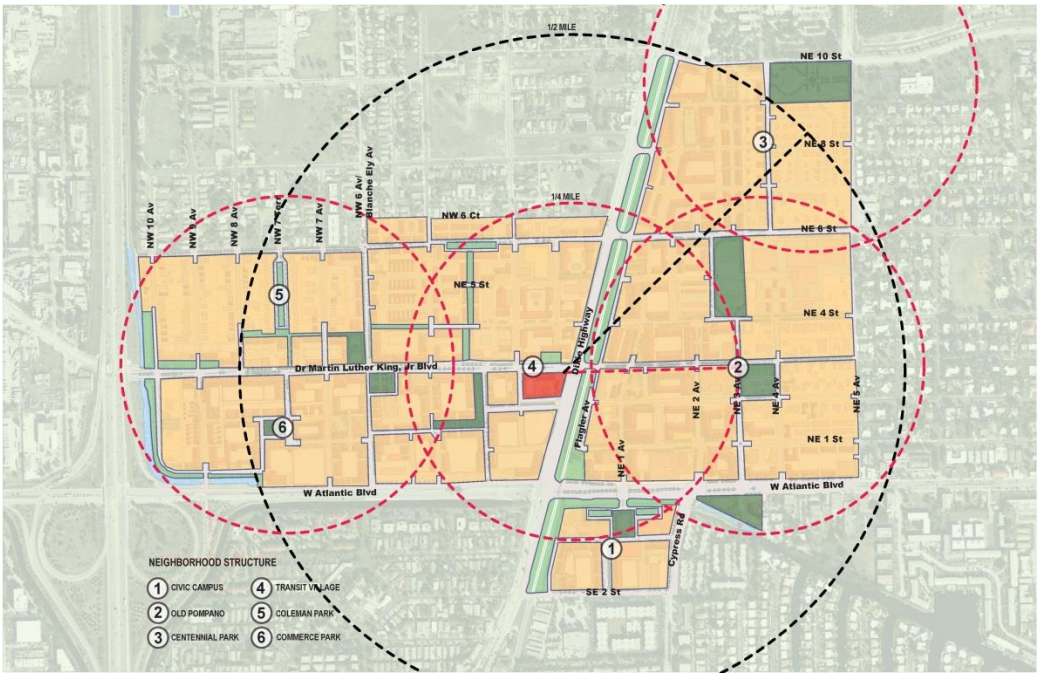


Figure 2.2: Typical Transit-oriented Development Layout *(Ref: https://www.asla.org)*

City of Cape Town TOD Strategic Framework

According to the City of Cape Town's TOD Strategic Framework document, it indicates that TOD in the context of a Strategic Framework is seen as a planning, design and implementation approach that can be used to rectify or improve inefficiencies in the urban form of a City. In this light TOD must not be seen as an element belonging to one specific discipline but it should be seen as a key element in addressing urbanisation, urban growth and service delivery with transport merely being the catalyst, the end product being to achieve operational efficiencies in the urban environment for both the City and its citizens.

The TOD Standard which was developed by the Institute for Transportation and Development Policy (ITDP) is aimed at establishing a common understanding of best practise and this based on international expertise. This standard promotes sustainable urban transport while trying to discourage the use of private vehicles and reducing the greenhouse gas (GHG) emissions.

The TOD Standard is based on ITDP's Principles of Urban Development for Transport in Urban Life as follows:

- Develop neighbourhoods that promote walking [WALK]
- Prioritize non-motorized transport networks [CYCLE]
- Create dense networks of streets and paths [CONNECT]
- Locate development near high-quality public transport [TRANSIT]
- Plan for mixed use [PLAN]
- Match density and transit capacity [DENSIFY]
- Create compact regions with short commutes [COMPACT]
- Increase mobility by regulating parking and road use [SHIFT]

In lieu of the aspects stated above it can be concluded that the purpose of the TOD Standard is an assessment, recognition and policy guidance tool focused on the integration of land use and transport practices. This standard can be seen to be aimed at a broad range of urban development stakeholders, including governments, developers

and investors, planners and designers, sustainable development advocates and interested citizens. It can be used to:

- Evaluate the transit orientation of completed urban development projects,
- Evaluate projects at the planning or design phases to identify gaps and opportunities for improvement,
- Guide policy and regulations relevant to urban planning, transportation planning, land use, urban design and parking.

The CoCT Strategic Framework states that there is a unique inter-relationship between transport and urban development, for this relationship to be effective TOD requires a City's transport system to respond to urban development in a way that caters for the needs of the passengers while remaining affordable to the City and its residents. It is said that this relationship follows a virtuous cycle which is shown in Figure 2.3.

The TOD strategy is based on core elements such as, addressing spatial inequality, improving public transport affordability, and arresting sprawl, which is driven by the integration of sustainable public transport and strategic land use intervention and built on the principles of affordability, accessibility, efficiency, intensification and densification.

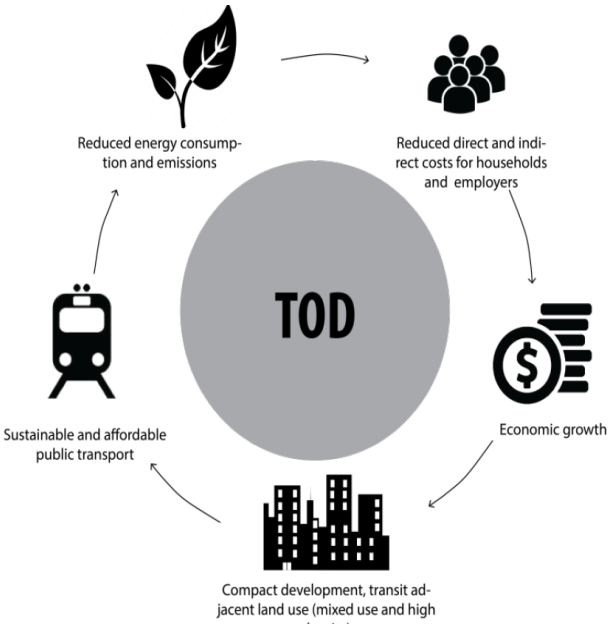


Figure 2.3: Virtuous Cycle of TOD

Section 4.3.6 of the City of Cape Town TOD Strategy indicates that TOD can be implemented as various levels and in order to have an effective/sustainable outcome the implementation of TOD principles must be implemented at all level, from a metropolitan scale to right down to project specific implementation. It is also critical to consolidate all public investment at all levels towards a common action plan for implementation to ensure alignment between land use and transport planning. See figure 2.4 for details.

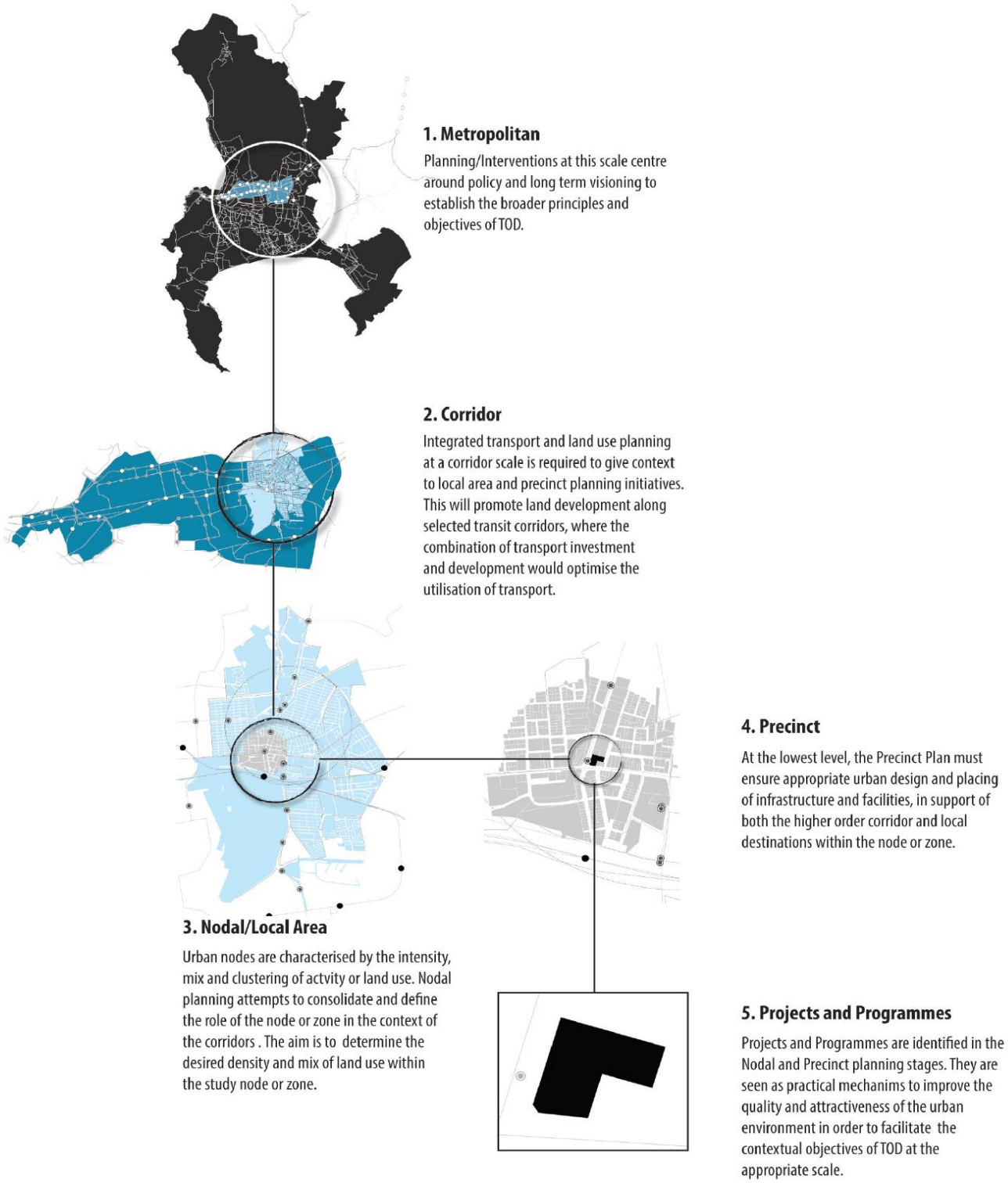
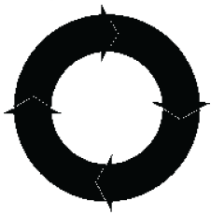


Figure 2.4: Scales of TOD Planning*(City of Cape Town TOD Strategic Framework)*

In order for a TOD strategy to be successful there needs to be a collective buy-in from all stakeholders involved, the stakeholder core is made up of the user (patron), developer, investor and the government. However, due to the vast range of objectives of the stakeholders it is important that the implementation plan be multi-dimensional to appeal to all ends of the spectrum. Table 2.1 below indicates certain tools that have been earmarked by the City of Cape Town in order to promote TOD developments.

Table 2.1: TOD Programme, Levers and Action Plans

TOD PROGRAMME	LEVERS	ACTIONS
Civil Society Participation 	*Public Incentives*	Investigate and consider the implementation of Government Housing Subsidies aligned to TAPs
		Investigate and consider the implementation of Lower Development Contributions in TAPs
		Investigate and consider the implementation of potential rates discounts in TAPs
	Marketing Tools: Improve political and public palatability of TOD	Establish a Marketing Campaign for TOD management
	Travel Demand Management	Develop a Travel Demand Strategy
	Non-Motorised Transport	Develop (update) Non-motorised Transport Strategy and design toolkit.
Institutional Alignment 	*Institutional and Policy Alignment: Align existing land use regulations and City-policy directives with TOD principles and objectives.*	Incorporate TOD principles and objectives into the IDP
		Align Cape Town Spatial Development Framework to TOD principles, objectives and vision.
		Align grant conditions in BEPP with TOD Comprehensive Indicators
		Investigate and include alternate housing typologies and locations conducive to higher densities and integrated land uses in the IHSF (Integrated Human Settlement Framework)
		Determine the impact of TOD Comp on the Densification Policy
		Incorporate TOD principle, objectives and vision into corporate strategies
		Amend road classification standards/requirements which impede incremental densification and undermine the use of public transport services.
	Change Management	Finalise the WCG and CoCT Game Changer Model
		Develop a TOD Manual
	Strategic Planning Frameworks. New (and changes to existing) development frameworks aligned to TOD principles and objectives.	Corridor plans
		District Spatial Plans
		Local Area Development Frameworks
		Urban design frameworks
	Catalytic Projects and Programmes	Identify and implement key catalytic projects and programmes

Integrated Business Model 	*Value Capture: tools to ensure the City recovers some or all of the value that public infrastructure generates for private landowners, to offset high operational costs*	Establish Special Assessment Districts aligned to existing and new public investment/infrastructure projects.
		Amend the Development Contributions Policy in line with TAPs
		Investigate and implement Land value increment taxes
		Establish congestion tax
		Establish appropriate parking levies
		Develop a Commercialization Strategy
		Investigate and consider the implementation of maximum parking requirements in areas where there is an imbalance between development and parking.
	Development Controls: regulatory tools to manage urban development processes in support of transit investment	Investigate the possibility of incorporating a monthly operational levy into the City's Development Contributions Policy.
		Streamline land use application process for development proposals in line with TOD and located in TAPs.
Private Sector Collaboration 	*Development Incentives: mechanisms to stimulate private sector development and leverage public investment.*	Extend Urban Development Zones
		Investigate and consider the implementation of Private Sector Subsidies and Loans
	Public land development programmes to leverage and expropriate land in support of transit investment	Establish an appropriate Property Acquisition and Disposal Policy aligned to TOD (including the acquisition, lease and disposal of air rights)
		Streamline lease and disposal of land for TOD type development
	Proactive planning: anticipatory planning mechanisms to fast-track development in TOD precincts	Covert TAPs into an Incentive Overlay zone using Section 19 of the City of Cape Town Municipal Planning By-Law. 2015.

2.3.3 Pedestrian friendly environments

The planning and design of the pedestrian friendly or walkable environment is receiving more and more attention for its various benefits related to public health, sustainability, economy, or social life. Therefore, there is a growing need for knowledge about the walkability of the built environment. While urban planning, design, and transportation research have also examined walking in urban environments, a recently growing field of research usually referred to as walkability research have been actively investigating the relation between the built environment and walking behaviour through correlation analysis (Gehl, 1980; Hillier, 1996; Kockelman, 1997).

According to Ewing, 1999 the urban design features for pedestrian friendly environments are categorised into three distinct categories being, Essential features, highly desirable features and nice additional features. These elements are indicated in Table 2.2 below:-

Table 2.2: urban design features for pedestrian friendly environments

Essential Features	#1 Medium-to-High Densities #2 Mix of Land Uses #3 Short to Medium Length Blocks #4 Transit Routes Every Half-Mile #5 Two- or Four-Lane Streets (with Rare Exceptions) #6 Continuous Sidewalks Wide Enough for Couples #7 Safe Crossings #8 Appropriate Buffering from Traffic #9 Street-Oriented Buildings #10 Comfortable and Safe Places to Wait
Highly Desirable Features	#11 Supportive Commercial Uses #12 Gridlike Street Networks #13 Traffic Calming along Access Routes #14 Closely Spaced Shade Trees along Access Routes #15 Little Dead Space, or Visible Parking #16 Nearby Parks and Other Public Spaces #17 Small-Scale Buildings (or Articulated Larger Ones) #18 Classy Looking Transit Facilities
Nice Additional Features	#19 Streetwalls #20 Functional Street Furniture #21 Coherent, Small-Scale Signage #22 Special Pavement #23 Lovable Objects, Especially Public Art

Reid and Susan, 2009 go a step further and bisects pedestrian friendly environments into three distinct components being the, direct physical considerations, indirect physical considerations and non-physical considerations. These different considerations are unpacked below:-

Direct Physical considerations: This element is linked to the physical design of the pedestrian corridor or space and this is seen as the foundation for an effective pedestrian friendly corridor. As these are physical elements which can be implemented to increase

pedestrian movement it must be considered early in the design stage. These elements are things such as:-

- Sidewalk widths
- Crossings
- Corner treatments
- Shelter (trees, awnings, arcades etc.)

Indirect Physical considerations: This element is linked to the placement of pedestrian facilities and how well the surrounding interacts with the facility rather than the actual physical design of the pedestrian infrastructure. It is therefore critical that the developer allow for synergy between the development and pedestrian corridor, this relationship would have a direct impact on the effectiveness of a pedestrian space. These elements are things such as:-

- Blank walls
- Doors or access to sidewalk
- Adjacent lanes (parking, travel, bike etc.)
- Treatment of difficult conditions
- Connections

Non-physical considerations: This element differs from the physical considerations as it has got to do with the individual feelings or perceptions of the end user (the pedestrian). Therefore, this is seen as the most difficult element to control but if the foundation of the physical elements are correctly laid it is bound to have a positive effect on the perception that pedestrians will have when using the pedestrian space. These elements are things such as:-

- Visual interest
- Feeling of safety
- Convenience factor
- Ownership of space
- Developer support

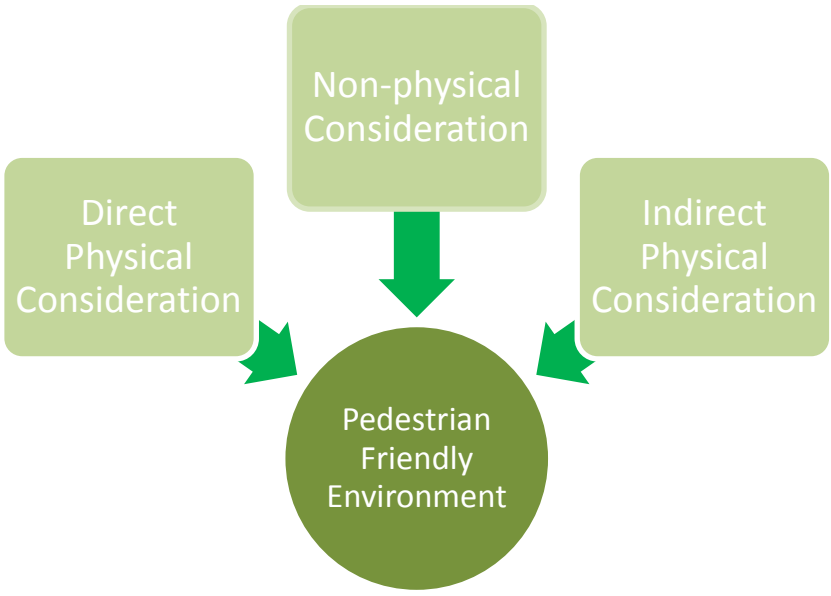


Figure 2.5: Pedestrian Environment Consideration *(Reid and Susan, 2009).*

2.4 Section 3: Network impact research

There has been a considerable amount of research done to address the question of improved local travel conditions following the emergence of design configuration such a TOD and TND design approaches. As previously indicated these design options are oriented to the needs of non-motorised and public transport modes and it is claimed in essence that a combination of mixed land uses, open or connected street networks, higher residential densities and narrower calmed roadways, would lead to, amongst other things the following external benefits, Behrens (2002):-

- Less kilometres travelled as a result of mixed land uses and more direct network connections;

- A shift from car use to walking and public transport use as a result of closer destinations, pedestrian-scaled streets and higher passenger thresholds;

- Reduced congestion as a result of alternative network connections and dispersed travel patterns; and

- Safer roadways as a result of reduced travel speeds by means of appropriate traffic calming measures implemented.

The benefits of this positive relationship between the development form and the improved travel behaviour has been the focus of numerous studies since 1990. The aim of these studies was to prove or test this hypothesis and this was done by various means, i.e. through either traffic simulation modelling, primary empirical observations or secondary datasets. Behrens (2002)

The evidence of the relationship between the network configuration and the travel behaviour can be tested by using two specific parameters being, the demand for travel (measured in trip length, kilometres travelled, vehicle hours travelled and trip generation rates) and then the utilisation of different travel modes (measured in modal split).

Most studies done to try and understand the relationship between the neighbourhood design or development form and the travel demand are done on a local scale. However, it is argued by numerous authors that the impact can generally only be determined at a larger sub-metropolitian scale and it is therefore said that it is at this scale that these comparative studies must be done to effectively establish the impact of urban form on trip making decisions and then also to establish the effectiveness of aspects such as public transport. (Cervero1993, McNally 1993)

Kulash*et al* (1990) argued based on a simulation study that, as a result of more direct traffic routing and mixed land uses, traditional neighbourhood developments produce 43% less vehicle kilometres travelled than conventional planned developments. It was however indicated that the study only focused on local internal trips and assumed a constant trip generation rate for both development scenarios. The study also concluded that neo-traditional networks generate less travel (shorter distances) than suburban network.

McNally and Ryan (1993) argued based on a further simulation undertaken that, due to the fact that drivers have the flexibility to choose from a variety of routes the traditional network design produces 11% less vehicle kilometres travelled and 15% shorter average trip lengths than the conventional network designs. It should be noted that with the

simulation done by McNally and Ryan, all aspects of the modelled neighbourhood were held constant except the road network.

Handy (1992) argued based on empirical studies done in California (San Francisco Bay area) that as a result of greater convenience and accessibility with the neo-traditional development design typology, the trip generation (vehicle and pedestrian) is 20% more than the planned unit development and this is when considering local shopping trips. It is said that this increase in trips generated is a result of ease of access to local facilities and thus people living in these self-contained neighbourhoods tends to be willing to make numerous short trips to local activities. These empirical studies further concluded that due to the short travel distance to local activities, this has a positive impact on the number of walking trips generated within the local neighbourhood. Based on these studies it has yet to be confirmed whether or not these walking trips replace private vehicle trips or whether these trips are in addition to normal vehicular trips.

Crane (1996a) argued on the bases of the empirical studies done by Susan Handy, that due to the increased accessibility and convenience, also the increase in shorter trips made by people, this design approach would tend to increase the total vehicles kilometres travelled. This outcome is however contrary to the desired outcome of this design approach which is fundamentally to reduce vehicle trips and vehicle kilometres, to increase pedestrian movement within local neighbourhoods and to reduce congestion.

Ewing *et al* (1994) argues that households within a suburban area tend to generate only two-thirds more vehicle travel hours per person, despite enjoying ten times less accessibility to the various amenities. This is attributed to the fact that these households tend to have better travel planning and often do multi-purpose trips or linking of individual trips of household members into a chain (e.g. home, school, work – work, shop, school home).

Later empirical research undertaken by Susan Handy (1996b) indicates that although the design approach of a community has an impact on the stimulation of pedestrian activity, it is said that the development form is unlikely to significantly increase the pedestrian volume and it is even more unlikely to reduce the vehicle km's by creating a significant shift between modes (from private car to walking or public transport).

Cervero and Kockelman (1996) concluded in an analysis of secondary data that although aspects such as residential density, mixed land uses and pedestrian or public transport oriented developments reduce vehicle kilometres and encourage modal shifts, it is said that based on the secondary analysis that the influence tends to be marginal in most cases. It was further concluded that the end-users attitude towards a specific mode has a greater impact on the mode choice than the actual development form or neighbourhood design characteristics.

Studies have generally concluded, when assessing the relationship between the development form and the impact on the modal split or modal choice of the end-user, that the impact is evident for local shopping trips more so than for other non-work trips where there is said to be less of an impact. These studies focus on three different modes being, private car, pedestrian or walking trips and then public transport trips. When investigating the impact on walking trips, the empirical studies done in the USA and The Netherlands have concluded that, as a result of more direct connections to more dispersed local destinations, the neo-traditional design form encourages a greater walking share for shorter distances than conventional suburban neighbourhoods. (Friedman et al 1994, Handy 1992 and Snellen 1999)

Cervero and Radisch (1995) concluded based on empirical studies, that in both pedestrian and car-oriented development forms, residents tend to see walking as a more viable mode as the travel distance decreases and therefore as the distance increases, regardless of the environment walking will not be seen as a viable alternate. The studies show that even in a pedestrian-oriented neighbourhood that trips exceeding 5 kilometres, 92% of these trips are done via car. The use of private car decreases to 65% when considering a distance of 2 kilometres. When assessing car-oriented development formstrips exceeding 5 kilometres, 100% of these trips are done via car and this decreases to 81% when considering a distance of 2 kilometres. Based on the empirical studies it was concluded that there is a difference of about 10% between pedestrian-oriented neighbourhoods and car-oriented neighbourhoods when considering walking as a viable travel mode, this was attributed the greater level of accessibility within pedestrian-oriented networks.

Cervero (1993, 1994) states that although there is a tendency for a higher public transport modal split in neo-traditional or transit-oriented developments, it is said that the reasoning for this increase is in most cases unclear. Based on various empirical studies Cervero has concluded three main elements which have a bearing on the effectiveness of transit oriented modes.

- The first conclusion derived is that for the transport-oriented developments to function effectively and for it to attract choice users, the origin (residential homes) and destination (work or retail facility) need to be clustered around a public transport stop or interchange. Research shows that if either one of the stops don't allow for ease access to and from the public transport system, the system does not function effectively.

- The second conclusion derived is that the city form has a greater impact on the modal split than the local area development plans and therefore for transport-oriented design forms to function to its maximum potential, it needs to be developed at a city level and not only at a local planning level.

- The third conclusion drawn it that there are many externalities which have a bearing on the effectiveness of a transport-oriented system and these range from aspects such as universal parking charges, employee paid public transport allowances or elements such as tolling and network congestion. A critical point noted in the studies undertaken is that elements such as car ownership levels, settlement densities and cost difference between public transport and car commuting, are elements which have a much stronger impact on the effective of a transport-oriented system.

Ma et al (2015) states that many empirical studies that have been done to investigate the relationship between the development form and the travel behaviour are fundamentally flawed as these studies rely on cross sectional data. It is said that using cross sectional data as a base for these empirical studies limit the ability to draw concrete conclusions based on the reliability or consistency of the data set been used. Mulley's model and research suggests that the built environment has an immediate effect on increasing walking as a mode but it may not be as effective in reducing car trips or increasing bus trips within a neighbourhood area. It is said that the built environment has a longer term effect and specifically when evaluating reduction in private car use. (Ma L, Mulley C and Liu Wen, 2015)

Ewing and Cervero (2010) state that the association between the built environment and travel behaviour is well established and the recent meta-analysis found that there were over 200 studies done to evaluate this relationship. Ewing concludes that the main element of the built environment which affects the travel behaviour is by affecting the generalised cost of travel to various destinations. This research goes on to conclude that by designing areas with higher densities, mixed land uses and pedestrian-friendly networks, this can improve the time cost of travelling from one location to various other locations. Ewing states that by designing a development form which is based on concentrating trip origins closer to the destinations as with the neo-traditional design principal, this will result in the reduction in time cost which in turn results in the change in the modal splits.

Research done by Cao *et al* (2009) concluded that it is difficult to make a general conclusion when assessing the relationship between built environment and travel behaviour, one of the main obstacles noted is self-selection issue. The element of self-selection shows that residents who prefer to walk will tend to live in walkable neighbourhoods and those that prefer to use private cars as their mode of travel will opt to live in more drivable neighbours. Based on this type of thought process, the relationship between built environment and the travel behaviour becomes fixed as the end-users preference is predetermined. Further studies done concluded that the neighbourhood characteristics retained a significant effect on travel behaviour after controlling the effect of self-selection, with the subjective factors playing an equally important role than objective physical environment in explaining the variation of travel mode choice.

Cao et al (2007) took the research a step further by conducting a quasi-longitudinal survey. Using this assessment approach, individuals were asked to recall their travel behaviour over the past year prior to moving to a new neighbourhood and the aim of this approach was to evaluate any changes in personal travel behaviour. This study concluded that there is a casual relationship between the built environment linking to driver and walking tendency or behaviour. Even though this approach was considered an improvement to previous studies when considering the quality of the data set, it was noted that a flaw in this process was that the study did not consider the changes of individual's attitude over an extended period of time nor have the changes in travel behaviour been investigated.

Krizek (2003) concluded using a longitudinal assessment that, there is a definitive change in household travel behaviour when exposed to different urban forms. The study specifically stated that when relocating to an area with high accessibility, this has a positive result in reducing the vehicle kilometres travelled in the area. It was however noted in this study that although the data set was longitudinal, it was highlighted that the study couldn't fully resolve the aspect of self-selection and therefore the change in mode could be attributed to external factors such as, change in preference towards travel or residential location rather than simply changes in the built environment.

Cao (2010) did a further investigation using the propensity scoring method, a benefit of this study which sets it apart from other research done is the fact that it helped to control the selection bias factor. The outcome of this study was that it showed that the influence of the built environment on the travel behaviour played a more important role in affecting walking behaviour than residential self-selection. However, due to the cross-sectional nature of the study sample it was not possible to draw a strong enough conclusion.

Rodier,(2015) concluded that studies indicated that compact developments which are supportive of public transit investment (i.e. Transit-oriented developments) will have a relatively low impact on the vehicle kilometres travelled. The notion of transit-oriented

development is to reduce the spatial distribution of trip origins and destination and thus to increase the probability of ridership. The study concluded The Transit-Oriented Developments have an impact in the order of 1.3% to 3.2% less private vehicle trips compared to developments which are not supportive of transit investment.

Wegener and Furst (2004) explain the different impacts which different sectors can have on the Land-use Transport Feedback cycle. He goes on to explain how the transport system affects the accessibility of a region, which affects the land-use in that region and also the activities which will take place in that region. This will in turn affect mobility which finally has an impact of the modal choice within the region. This then concludes one full cycle of the Land-use Transport Feedback system. Wegener concludes that for this system to function efficiently there must be a high level of integration at all spheres within the process and the system needs to be studied intensely to achieve an effective traffic/transport model.

Wegener and Furst concluded that the interaction between infrastructure planning, development form, land use planning, mobility and modal choice is a complex model to understand but Figure 2.6 attempts to set up a visual representation of this interactive process.

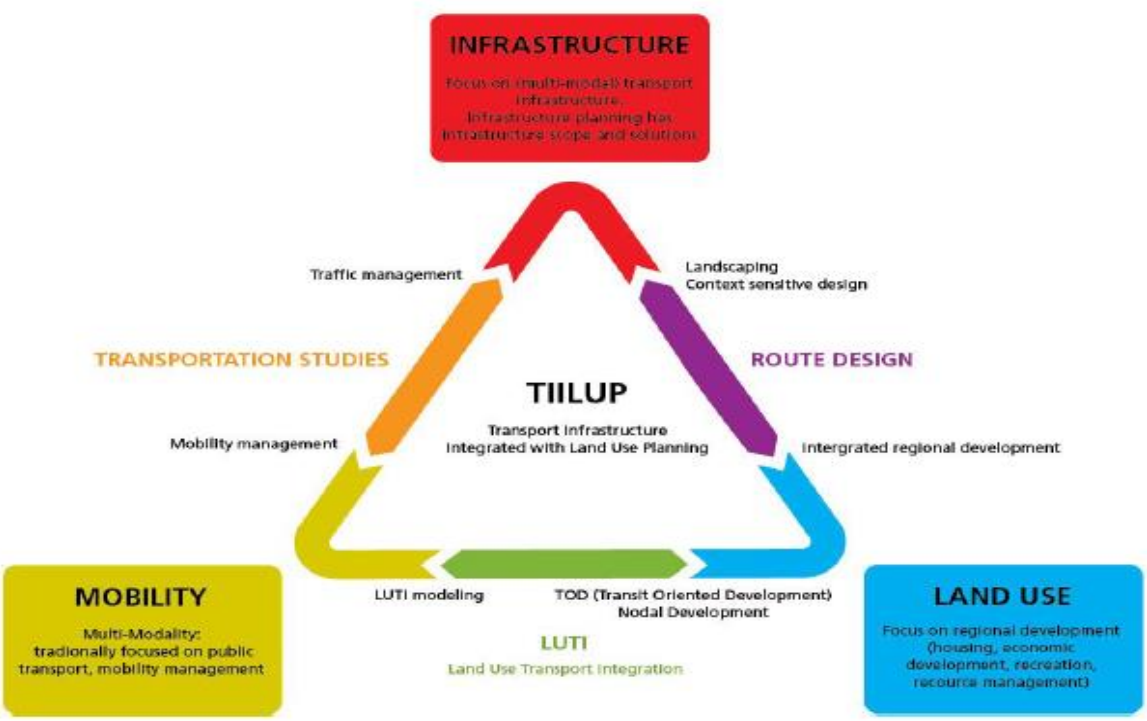


Figure 2.6: Infrastructure, land use, mobility and modal choice interaction (Wegener,Furst (2004)

Heeres et al (2012a) concludes when investigating this interaction that, from an aspect of land-use and transportation infrastructure the interaction is considered externally oriented and requires collaboration at various levels. Whereas the interaction between mobility and infrastructure planning seems to be more internally oriented within the transport sector.

Cervero (2004) concluded using travel dairies assessment method which was based on residents in California, the assessment conclude that nearly 20% of residents living within a half-mile (800m) of a transit facility make use of this mode of transport to travel to work, this

is compared to less than 9% of residents who use the facility when living more than a 800m of a transit facility. The study therefore concluded that the development forms is critical to establish a decent level of ridership within a specific area and that if the area is not designed correctly it will not function as an effective and sustainable community for all residents.

Cervero and Arrington (2008) found when investigating 17 transit-oriented developments areas that, 44% fewer trips were generated than was initially estimated using accepted trip generation rates published in the Institute of Transportation Engineers manual. It was further concluded that vehicle trip generation rates were particularly low in Washington and Portland, where regional and corridor planning has been adopted and it is said that the trip generation is inversely proportionate to the densities in these areas (as the density increase the trip generation decreases). Cervero and Arrington also concluded in their studies that residents living near transit facility (i.e. within 800m walking distance) were 5 – 6 times more likely to commute via transit modes than residents who live outside the 800m walking distance.

Bartholomew and Ewing (2010) stated based on research done that the increase in proximity and convenience allowed residents with a transit-oriented area to complete their daily activities within a smaller area. It was concluded that this will result in shorter travel distances, lower average vehicle trip rates and lower vehicle kilometres travelled.

Zhang (2010)applied the four-step travel demand model to simulate traffic outcomes for three different TOD scenarios in the Austin TX area. The purpose of the study was to investigate the impact on the trip generation and also to predict the shiftin modal split with these various scenarios. The options were, the scenario with no TOD facilities, rail only and a scenario with rail and bus-feeder facilities. The model simulated increasing losses in private car use and single occupancy travel and also predicted an increase in transit trips which was directly proportionate to the level of TOD. Furthermore, Zhang was also able to estimate a significant drop in person kilometres travelled by private car and an increase in person kilometres travelled by the various transit modes.

Zhang also concluded an overall reduction in congestion due to the implementation of TOD and this was regardless of the fact if drivers were persuaded to abandon their private vehicles or not. He attributed the reduction in congestion to the fact that the distance between origins and destinations were now shortened but also concluded that the reduction in congestion were more significant as one travels further away from the centroid of the TOD. Therefore, bearing this fact in mind the impact of the TOD was less significant within the local context.

2.5 Section 4: Literature review conclusions

It can be concluded from the literature that the main aim behind the development forms researched is to reduce the kilometres travelled, to promote a modal shift, to reduce congestion, to reduce the impact on the environment and to create safer road spaces for all road users.

The research shows a direct relationship between the development form, the traffic patterns and modal splits generated. It was concluded that this relationship can be measured at a local scale but it can be measured more effectively on a sub-metropolitan scale.

The literature shows that various methods of assessment are used to test this hypothesis, it can either be done through traffic simulation modelling, primary empirical observations or secondary datasets.

The results of the various studies show a level of inconsistency as some studies reveal a reduction in vehicle kilometres travelled and shorter average trip lengths. Other studies argue based on their results that these development forms will increase the trips generated (vehicle and pedestrian) as a result of the ease of access to local activities.

Some empirical studies further concluded that due to the short travel distance to local activities, this has a significant positive impact on the number of walking trips generated within the local neighbourhood.

The research indicated that in both pedestrian and car-oriented development forms, residents tend to see walking as a more viable mode as the travel distance decreases and therefore as the distance increases, regardless of the environment walking will not be seen as a viable alternate.

Research shows that the element of self-selection shows that residents who prefer to walk will tend to live in walkable neighbourhoods and those that prefer to use private cars as their mode of travel will opt to live in more drivable neighbours.

Some studies concluded that certain households tend to have better travel planning and often do multi-purpose trips or linking of individual trips of household members into a chain (e.g. home, school, work – work, shop, school home) and this has a direct impact on the household trips generated.

Based on the fluidity of the result in this section it is clear that the relationship between development form and transport is a dynamic relationship and this will be taken into consideration in the analysis section of this dissertation.

3. CHAPTER 3: RESEARCH SITE DETAILS

3.1 Site selection criteria

A critical aspect of this research was the site selection as this has a direct bearing on the outcomes of the analysis and the accuracy of the results. It is therefore critical to note that the three sites selected for this research were selected based on stringent criteria. These criteria are as follows:-

- The three sites were specifically selected based on the built form being either Transit Oriented Development (TOD) or a Traditional Neighbourhood Development (TND) or a combination of the two development options.
- The site had to serve the same demographic group as well as the same income level as this aspect will have a direct bearing on the acceptable/predominant travel mode (private vehicle, pedestrian or public transport).
- The sites had to serve a community with the same or similar vehicle ownership levels as this has a direct impact on the accessibility factor and whether or not patrons are choice users or captive users to a particular mode of transport.
- The developments had to give patrons the aspect of modal choice and therefore needed to cater effectively for the various modes of transport. By catering for different modes the level of accessibility increases and it is expected that modes other than private vehicles will become prevalent.
- The development must consist of at least one major anchor tenant (shopping centre) and can have a limited secondary use to minimize the volume of traffic generated to the secondary uses.

A total of eight sites were investigated as part of the initial review process and besides the three sites which were used as part of the research these other sites were excluded based on the following factors:-

Table 3.1: Additional sites and excluded

Site	Location	Exclusion factors
Lansdowne Mall	C/O Jan Smuts and Lansdowne Road	- This site has a larger catchment area and it not considered to be a local community based facility. - This site is expected to generate a high volume of passer-by trips and this will affect the result of the analysis. - This site is not consistent with the scale of the selected site and has many other land uses. - It would be extremely costly to survey this site due to the multiple accesses on different roads.
Ottery Hyper Market	Ottery Road	- This site has a larger catchment area and it not considered to be a local community

		based facility. - This area is considered to be a middle income area and therefore the results are expected to be different for a commercial development in a low income area.
Grassy Park Pick n Pay Local	5th Avenue Grassy Park	- Although this site fits most of the criteria, due to the context and operation of this site it would be difficult to survey as patrons tend to park informally in the surrounding public streets.
Grassy Park Woolworth	Prince George Drive (M5)	- Due to the tenant this site has a larger catchment area and it not considered to be a local community based facility. - These sites generally generate a higher volume of traffic as it tends to attract a certain patron (middle to high income) due to the price disparity with stores of a similar nature and this is not consistent with the research objectives.
Shoprite Steenberg	Military Road	- This site functions as a wholesaler and also has a range of other land uses, therefore, the makeup of the development is not considered to be compatible with the other sites selected.

Note: With the site selection approach it was a key aspect to keep as many of externalities constant (*Ceteris Paribus*) and in this way the results would emphasize the impact of the development form on the trip generation as well as the modal split of these developments (if any).

3.2 Development form details

Having discussed the various site selection criteria in Section 3.1 above, the different aspects of the three sites selected are discussed in detail below:-

3.2.1 Retreat Shopping Centre:

Retreat Shopping centre (Erf 174390, Retreat) is a 8,177m2 site and it is located on the corner of Retreat Road and 8th Avenue with Retreat Road been a significant east-west connection between Main Road (M4) and Prince George Drive (M5).

The current development is considered a mixed use development with a shopping centre (Shoprite) being the major tenant with smaller line shops being the secondary feeders. The entire length of Retreat Road has been earmarked as a business corridor and therefore there is a wide spectrum in land uses (office, commercial, industrial, residential and community facilities) along this corridor.

This centre is expected to cater for the wider Retreat area as it is centrally located and the next closest shopping centre would be Blue Route Mall which is approximately 3km away. The site is located on an extremely busy public transport corridor and it is approximately 1km from the Retreat public transport interchange which serves all public transport modes (i.e. bus, taxi and train). There is also a local public transport stop right in front of the pedestrian entrance on Retreat Road which improves the level of accessibility for all modes.

Due to the context of this site it qualifies as a Transit Oriented Development (TOD) and therefore it is expected that the analysis will show a high demand/usage of the public transport service provided.

Besides the qualifying elements of TOD discussed above, the surrounding built form of this development also lends itself to qualify as a Traditional Neighbourhood Development (TND) with a standard grid-like neighbourhood structure with high accessibility, local amenities serving an enclosed community which are cut off from the external communities with the use of a high order/high volume road (i.e. Prince George Drive (M5) in the east and Main Road (M4) to the west.

The community served by the development spans approximately 1km radius and is divided by the local east-west collector (Retreat Road) which links onto the higher order Main Roads. The main commercial node where the centre is located falls on the east-west collector and it falls at the centroid of the node. See Figures 3.1 -3.3 for locality plans.

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Figure 3.2: Retreat Centre –Site Layout

Figure 3.2: Retreat Centre -Development form

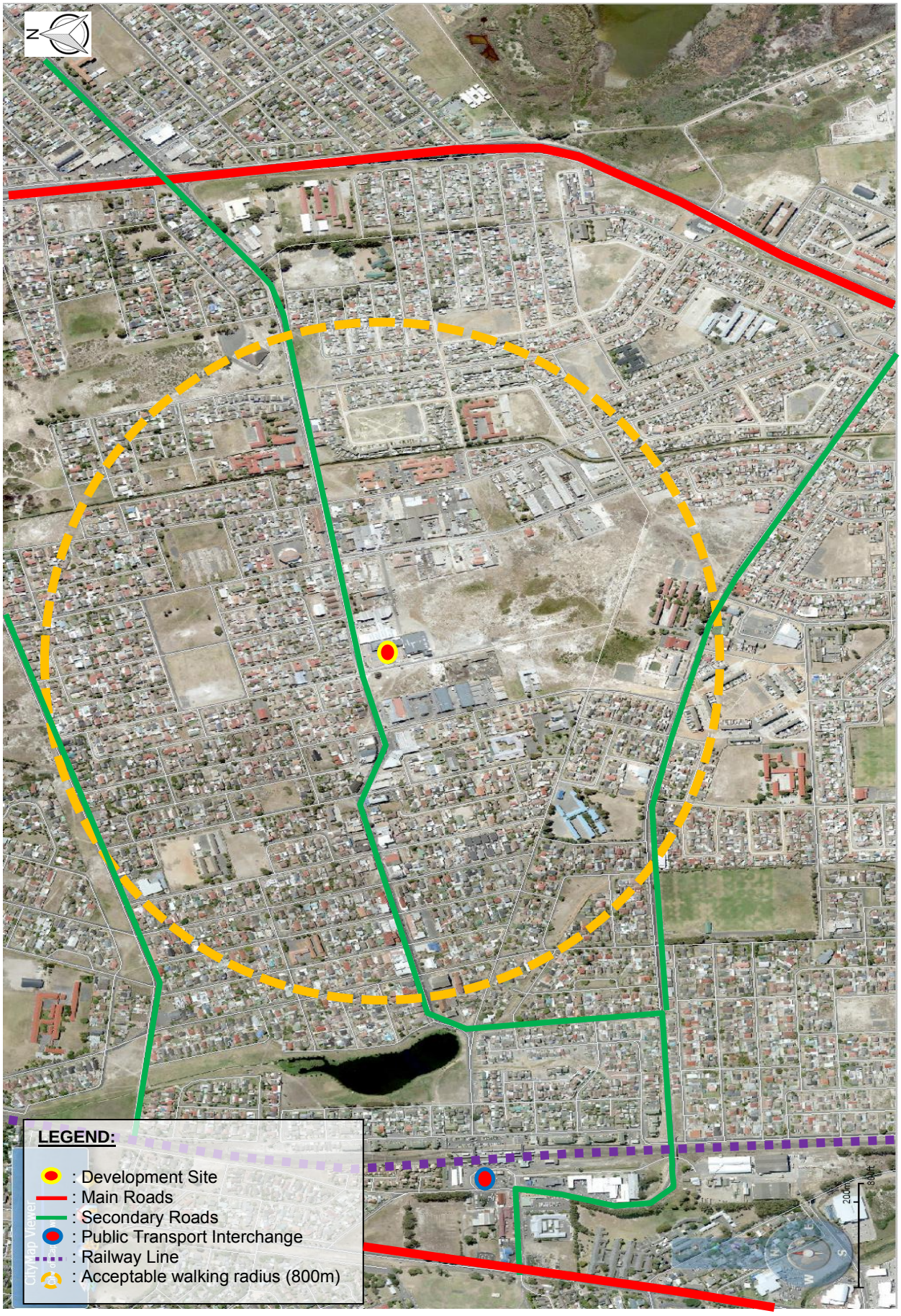

Figure 3.3: Retreat Centre- Wider area development form and road network

3.2.2 Pelican Park Shopping Centre:

The Pelican Park Shopping Centre (Erf 2706, Pelican Park) is a 20,619m2 plot and it is located on the corner of Strandfontein Road and 15th Avenue. Strandfontein Road (M17) is a major north-south Class 3 road linking between Baden Powell Drive in the south and ending at the intersection with Govan Mbeki Road (M9) to the north. This link then becomes Jan Smuts Drive (M17) which links on the N2.

This development was recently built in 2014 and it is considered a mixed use development with a shopping centre (Shoprite) being the major tenant with smaller line shops being the secondary feeders.

This commercial development is considered as a node to cater for the needs of the newly established residential community (Eagle Park) which is approximately 3,500 units and the housing typology ranges from government subsidy houses to market related houses.

This section of Strandfontein Road has also been earmarked as a development node in accordance with the Spatial Development Framework (SDF). This is relevant to the selection criteria as nodal development promote both mixed use development and densification which are both important TOD design elements.

When assessing the development form surrounding the facility it is evident that the development has been structured as a TOD as it abuts a major public transport corridor with local stops right at the facility (80m walking distance). In accordance with the Integrated Public Transport Network (IPTN) Plan 2032, Strandfontein Road serves as part of phase three of the MyCiti rollout and it is expected that have a trunk service (Route T15: Strandfontein-Pelican Park-Athlone-Pinelands-Maitland-CBD) will run along this corridor. It is therefore expected that the analysis will show a high demand/usage of the public transport services.

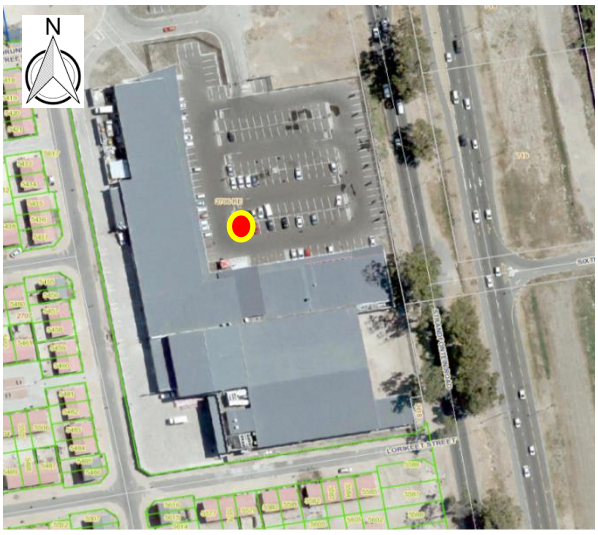

Figure 3.4: Pelican Park Centre –Site Layout

As with the Retreat Centre, the surrounding built form of this development also lends itself to qualify as a Traditional Neighbourhood Development (TND) with a neighbourhood structure geared around high accessibility and a high level of safety for pedestrians. The development form is structured around a superblock design which allows for protected and also separated pedestrians corridors. The design of the surrounding built form also uses elements such as narrowing of the road reserves and traffic calming measures (i.e. speedhumps and roundabouts) to reduce the travel speeds and this to increase the pedestrian safety within the surrounding community. It is therefore expected that the analysis will show a high percentage of pedestrian trips been generated to this commercial development.

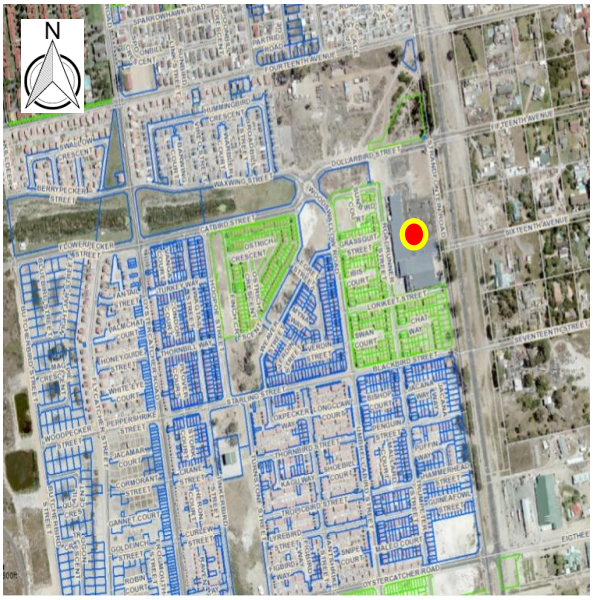

Figure 3.5: Pelican Park Centre - Development form

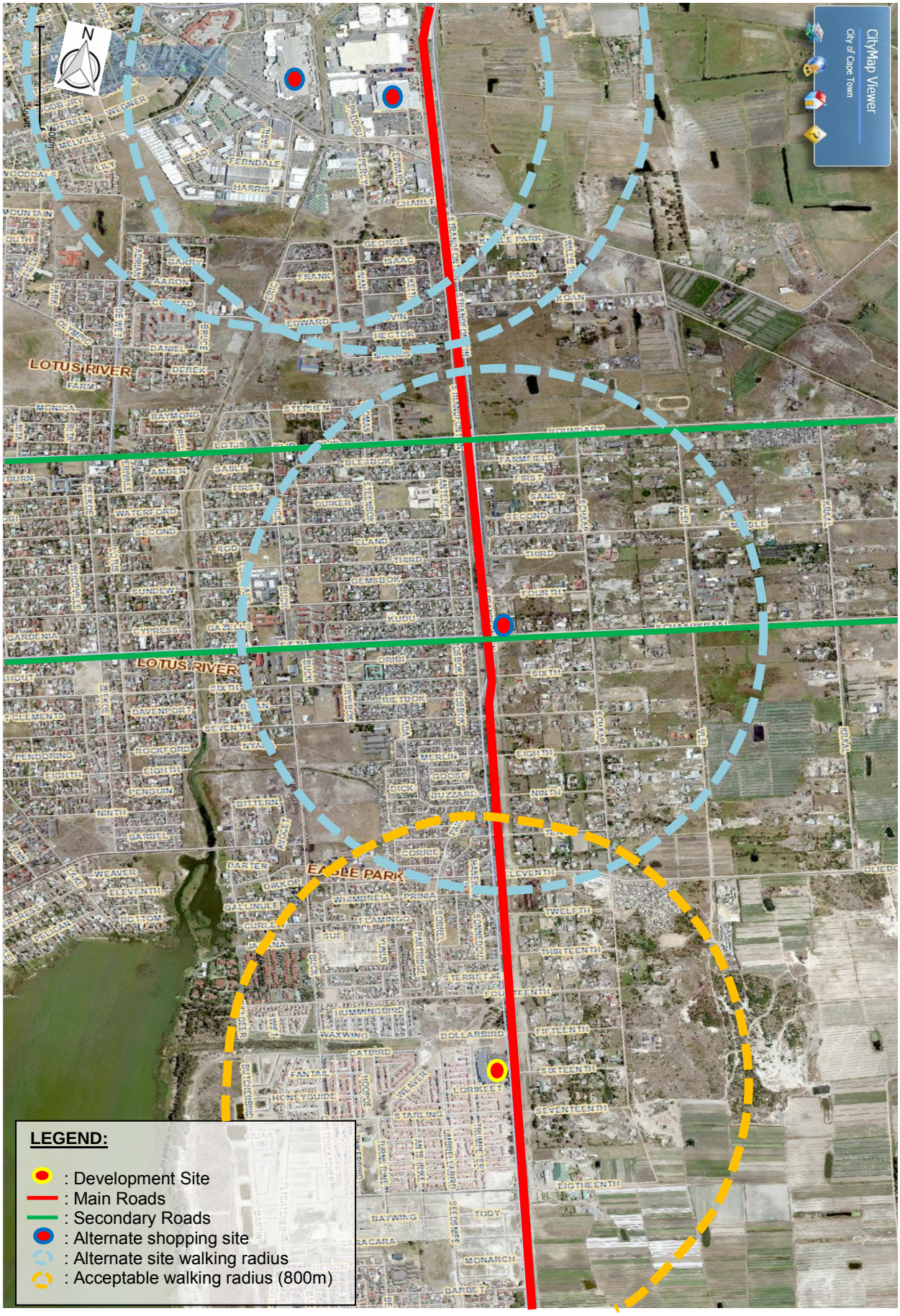

Figure 3.6: Pelican Park Centre - Wider area development form and road network

3.2.3 Schaapkraal Shopping Centre:

The Schaapkraal Shopping Centre (Erf 14, Schaapkraal) is situated on a 4,100m2 site and is located on the corner of Strandfontein Road and Schaapkraal Road. Strandfontein Road (M17) is a major north-south connection (Class 3) linking between Baden Powell Drive in the south and ending at the intersection with Govan Mbeki Road (M9) to the north. This link then becomes Jan Smuts Drive (M17) which links on the N2.

This site was redeveloped in 2014 and was converted from line shops in a small scale shopping centre (Pick n Pay). Similar to the other two sites selected, this site has a shopping centre as the major tenant with smaller line shops being the secondary feeders.

This site is also located centrally within a proposed development node but the surrounding business properties are undeveloped at this stage.

Similar to the Pelican Park site, this site is also located on Stranfontein Road but it is 1.8km in a northern direction. Therefore, this development has also been structured as a TOD as it abuts this major public transport corridor with local stops right at the facility (120m walking distance).

Figure 3.7: Schaapkraal Centre –Site Layout

According to the 2032 IPTN Network Plan Report, the MyCiTi trunk service which is planned for Stranfontein Road (Route T15r) is characterised by a system that operate in the median dedicated bus ways with central, high floor, closed stations. The service has an AM Peak supplied capacity of 6,600 passengers and headway of one minute.

Where this site differs significantly from the two sites discussed above, is that Strandfontein Road in this instance is seen as barrier between the development and the residential community to the west which it is intended to serve. As a result of this development form it is expected that the volume of pedestrian traffic generated will be significantly affected as this development will not be seen as a pedestrian friendly development.

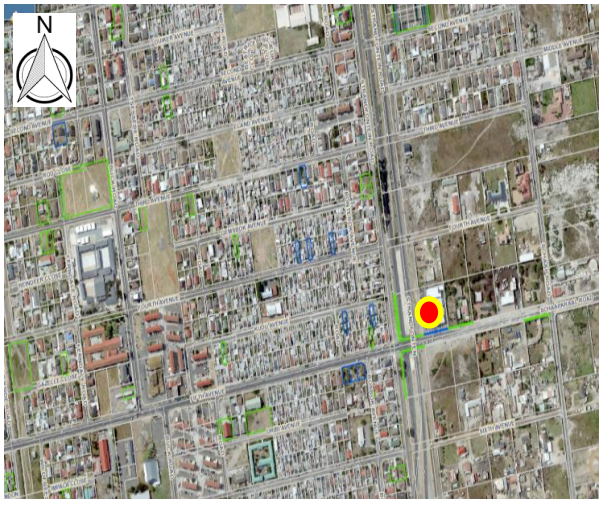

Figure 3.8: Schaapkraal Centre - Development form

Besides the barrier described above, a further barrier to pedestrian movement in this context will be the fact there are limited or no pedestrian facilities (sidewalks, dropped kerbs or marked pedestrian crossings) provided to the properties to the west of the site and this coupled with the fact that Schaapkraal Road carries high volumes of traffic at high speeds is expected to have a significant impact on the volume of pedestrian trips generated.

Due to the context and the restrictions, this site is expected to be a development which is geared towards attracting patrons using private cars and to a lesser extent users of public transport/pedestrians.

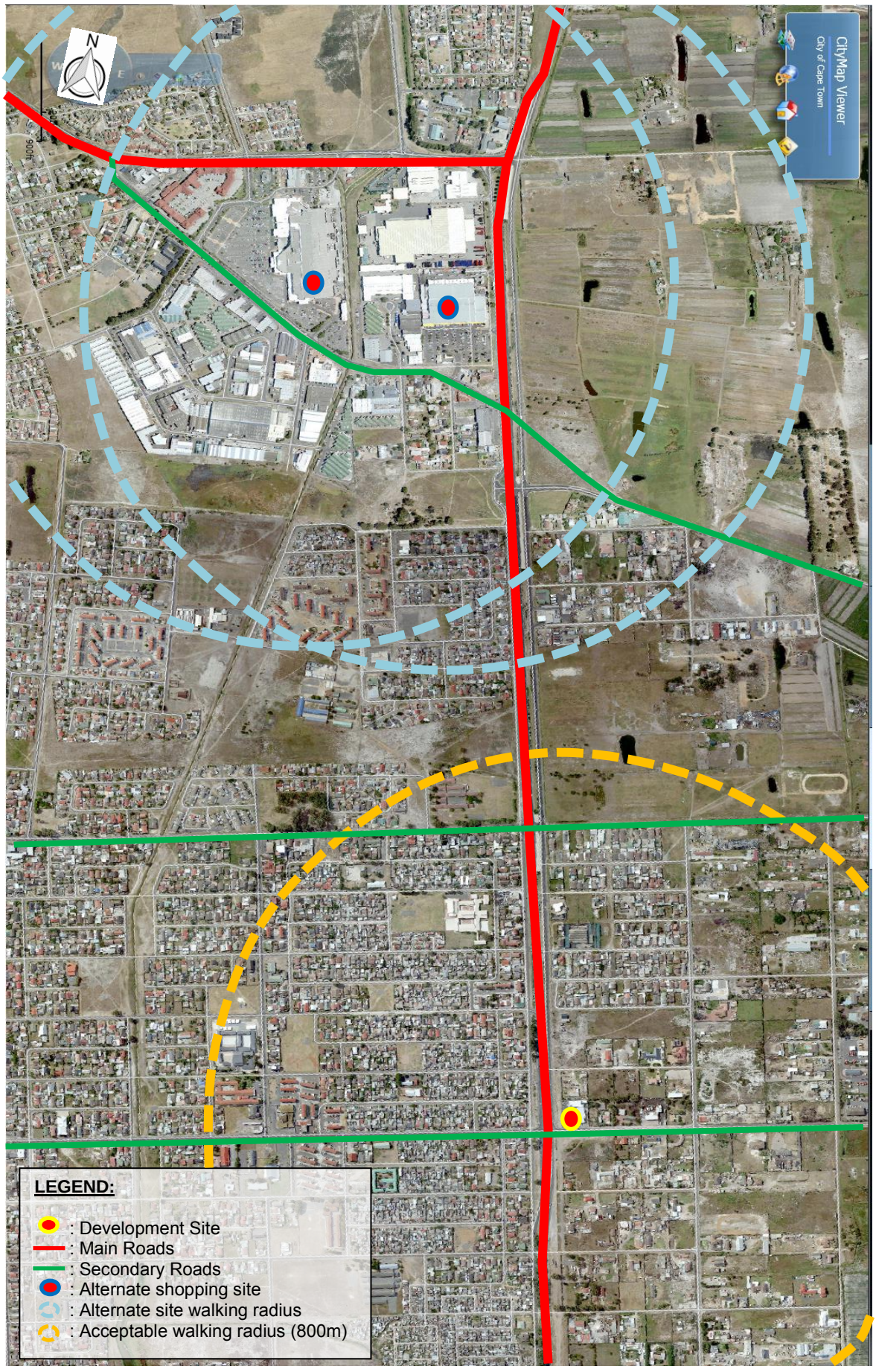

Figure 3.9: Schaapkraal Centre - Wider area development form and road network

3.3 Income level details

One of the key components of this research was to establish whether or not the income level of patrons has a direct bearing on the mode of travel and also the traffic patterns generated. In order to validate the income levels in the direct vicinity of the three sites selected, information was extracted from the City of Cape Town 2011 Census, this information is summarised in Table 3.1 and discussed below:-

Table 3.1: Income summary

Monthly household income	Pelican Park	Philippi	Retreat
	%	%	%
No income	12.8%	14.2%	10.9%
R 1 - R 1 600	13.1%	21.8%	13.7%
R 1 601 - R 3 200	13.8%	22.7%	14.5%
R 3 201 - R 6 400	15.4%	19.2%	18.1%
R 6 401 - R 12 800	15.7%	10.2%	18.3%
R 12 801 - R 25 600	15.6%	6.8%	14.4%
R 25 601 - R 51 200	10.1%	3.8%	7.7%
R 51 201 - R 102 400	2.7%	0.7%	1.8%
R 102 401 or more	0.7%	0.7%	0.5%
Unspecified	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%

City classification:

Very Low Income – income of R0 to R3 200 per month
Low Income – income of R3 201 to R6 400 per month
LowerMiddle Income – income of R6 401 to R12 800 per month
Higher Middle Income –income of R12 801 to R25 600 per month
High Income –income of R25 601 or more per month

According to the summary table a total of 56% and 58% of households in the Pelican Park and Retreat areas respectively earn less than R6 400.00/household/month which is classified as very low to low income and this percentage is increased to 77% for the Philippi area.

Based on the information above is can be concluded that all three area can be classified as lower income areas as the majority of households fall within the lower income bracket compared to middle and high income bracket, this is in accordance with the City of Cape Town's classification standard.

3.4 Site summary

Table 3.2 below is a summary of the sites selected when considering aspects such as the surrounding development form, the element of public transport and then also the pedestrian facilities.

Table 3.2: Site parameters summary

Site	Development Form			Public Transport			Pedestrian	
	TOD	TND	Environment *1	Type *2	Service *3	Distance to Stop (m)	Facilities	Barriers
Retreat	Y	Y	R, I, B	B, T	S, U	25	Y	N
Pelican Park	Y	Y	R, C, B	I, B, T	S, TR, U	80	Y	N
Schaapkraal	Y	N	R, A, B	I, B, T	S, TR, U	115	N	Y

*1 – R = Residential, C = Community facilities, B = Business/retail, A = Agricultural, I = Industrial
*2 – I = Integrated Rapid Transport (IRT), B = Bus service, T = Taxi Service
*3 – S = Scheduled service, U = Unscheduled service, TR = Trunk service

Based on the table above it can be seen that the Pelican Park site and the Schaapkraal site are practically identical besides for the environment and pedestrian parameters. This was strategically done in order to draw a direct comparison between these two developments and also eliminating all other externalities which could have a bearing on the travel patterns and modal splits achieved. The outcome of the research should then show the impact which the development form has on the travel patterns and modal splits achieved in this specific context.

The third site being the Retreat site was chosen as a control or validation point to check the results achieved in the base research points being the Pelican Park site and the Schaapkraal site. The Retreat site was also strategically selected in order to match as far as possible the development parameters of the Pelican Park site and in this way a comparison can be drawn between the two pedestrian-friendly sites (i.e. Pelican Park and Retreat sites) and a development which is designed to attract private vehicle users (i.e. Schaapkraal site).

The aim of this investigation is to test various development scenarios and as a result a conclusion will be drawn linking the development form to changes in travel behaviour.

3.5 Survey methodology

The data collection process was done using two distinct survey methods based on the level of technology available at the sites investigated. The first method used at both the Pelican Park Centre and Schaapkraal Centre was data collection using recorded camera surveillance footage obtained from the centre management. The second method was a manual survey method, where two surveyors were employed at the Retreat Centre and manual counts were done to capture the data required. The manual count method was also used at the Schaapkraal site to count the number of public transport users. Table 3.3 indicates the detail of the survey.

Table 3.3: Survey Details per site

Site	Pedestrian Survey Method	Vehicle Survey Method	Public Transport Survey Method	Time period
Pelican Park	CS	CS	CS	06:00 – 18:00
Schaapkraal	CS	CS	MC	06:00 – 20:00
Retreat	MC	MC	MC	06:00 – 18:00

CS = Camera Surveillance

MC = Manual Count

Pelican Park survey:-

The camera surveillance for the Pelican Park was done using three separate camera footage, one which cover the only public vehicle entrance, another which was located at the only pedestrian access and the third camera was a security camera which covered the public transport facility. It is noteworthy that a high volume of pedestrians used the vehicle only entrance and this information was recorded and added to the pedestrian count.

Schaapkraal survey:-

The camera surveillance for the Schaapkraal site was done using footage from one camera as this covered the only access to the development (shared pedestrian and vehicle access). The public transport count was done manually by one surveyor who was stationed at the facility.

Retreat survey:-

Although there was surveillance footage available at the site and the owner committed to assisting with this information, this information was not forthcoming and therefore a full manual count was done at this site. The count was done using two surveyors, the first surveyor was placed at the main entrance off 8th Avenue and recorded both vehicle and pedestrian data. The second surveyor was placed at the pedestrian access off Retreat Main Road and recorded both pedestrian and public transport data.

Survey data collection process:-

The survey/data collection process was also broken up into 4 phases, of which the first of these processes was a pilot survey which was undertaken at one of the sites earmarked for the investigation. The aim of this pilot survey was to identify the any shortcoming in the data collection process and it was at this point where all adjustments could be made to eliminate any future errors in the data set. The pilot survey also indicated whether or not the relevant data could be extracted from the camera angles available.

The pilot survey was done on (27th February) and it was done using the camera surveillance at the Pelican Park Shopping Centre and the hours were between 06:00 – 18:00 (operation hours 08:00 – 18:00) to capture a full business day at this particular centre. After this survey the process was adjusted to improve the final data set and the final survey process was set.

The second critical phase of the survey process was that a full week survey (Monday to Sunday, 27th March to 01st April) was done, this was done to establish the critical peak day which would eventually be used to calculate the critical peak hour for the centre as well as the peak hour factors. The aim of establishing a peak day for the various centres was to eliminate unnecessary data collection and also to focus the study on peak data which will later be compared against prescribed peak rates for these types of developments.

Once the peak day was established, phase 3 was to undertake the final surveys for each site and phase four was implemented in order to strengthen the outcomes of the data set, the approach of a repetitive assessment approach (three separate surveys at each site) was used. The final survey parameters therefore included the following:-

- The surveys done at the various sites must be done on the same day and during the same timeframe in order to have consistency in the external factors (weather conditions, monthly peak fluctuation, monthly special events etc.)
- The survey process must be repeated three times in order to strengthen the data set and also to strength the argument presented.
- The final survey must capture the various modes such as private vehicles, pedestrians and public transport been generated by these developments.

Note: As with the site selection, in the survey approach it was a key aspect to keep as many of externalities constant and in this way the results would emphasize the impact of the development form on the trip generation as well as the modal split of these developments (if any).

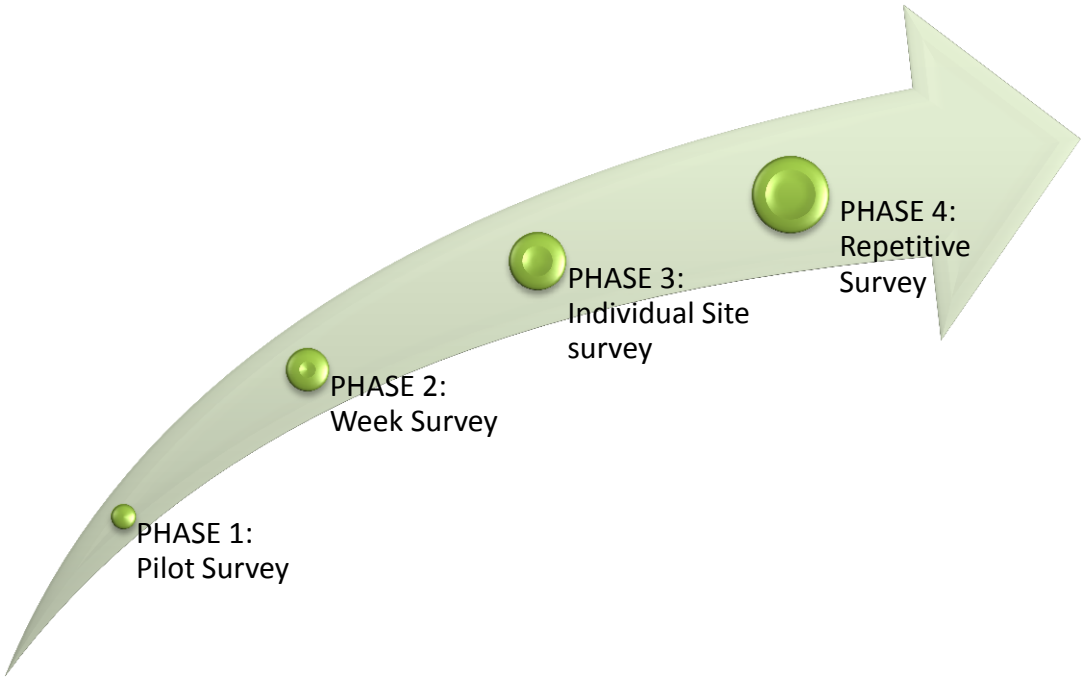

Figure 3.10: Full Survey Process Diagram

4. CHAPTER 4: DATA ANALYSIS AND REVIEW

4.1 Process 1: Weekly peak analysis

A weeklong(business hours, Monday to Sunday) trip generation study was undertaken at one of the target sites in order to establish the critical peak within the week and this was then used as the base for all the other surveys and analysis done at all the other target sites. Based on the principal of "*ceteris paribus*" it is considered an acceptable conclusion that the traffic peak analysis for the different sites will be generally consistent and therefore the assumption that the Saturday peak will be the critical peak for all the sites is valid in this instance.

From the trip generation study, it was concluded that Saturday can be seen as the peak day for a development of this nature, this is based on the vehicle trip data recorded. The detailed analysis can be seen in Figure 4.1 below.

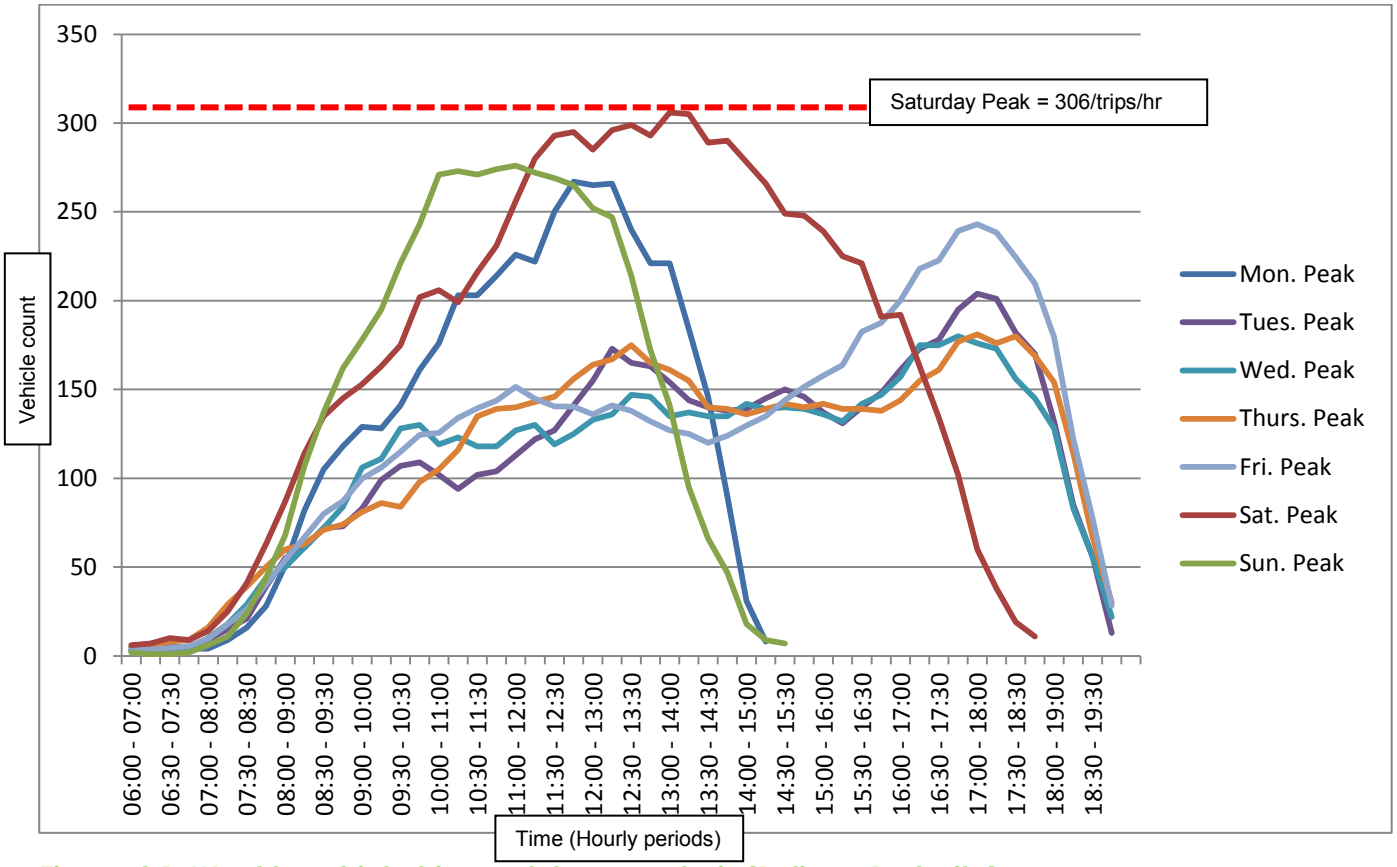

Figure 4.1: Weekly vehicle trip peak hour analysis (Pelican Park site)

Note: (1) It must be noted that an assumption was made at this point, based on the week peak analysis done at the Pelican Park site. The assumption was that the operations at the other two sites (Schaapkraal and Retreat) will be similar if not identical in terms of the peak patterns, thus also peaking on the Saturday. Also due to the approach of *ceteris paribus used, it was considered an acceptable approach as the final surveys would have to be done on the same days at the same times. (2) If the cost constraint was not a factor, the week peak analysis should be done at all the research sites and this would confirm whether or not the assumption that the peaks of the sites will be consistent. (3) As part of the initial assessment done, a visual observation was also undertaken and it was concluded that the pedestrian trips generated mirror the vehicle traffic pattern.*

Table 4.1: Weekly peak analysis summary

Day	Peak volume	Peak Hour Factor (PHF)*	Peak time	Daily Volume	Peak %
Monday	267	0.89	11:45 - 12:45	1108	24.1
Tuesday	204	0.93	17:00 – 18:00	1447	14.1
Wednesday	180	0.94	16:45 - 17:45	1422	12.7
Thursday	181	0.94	17:00 – 18:00	1489	12.2
Friday	243	0.92	17:00 - 18:00	1618	15.0
Saturday	**306**	**0.90**	**13:00 - 14:00**	**2082**	**14.7**
Sunday	274	0.95	10:45 - 11:45	1212	22.6

* Peak Hour Factor (PHF): The peak hour factor (PHF) is the hourly volume during the maximum-volume hour of the day divided by the peak 15-minute flow rate within the peak hour; this factor can be seen as the measurement of traffic demand fluctuations within the peak hour.The PHF measures the relationship between the peak 15-minute interval of traffic compared to the total vehicle traffic measured within the total hour.

Analysis Review Pelican Park:

- Based on the weekly peak analysis it is clear that the Saturday peak is to be considered the critical peak for the week with a total peak trips 306(14.7% of total trips) and a total daily trip of 2,082 trips.
- It can also be seen from the analysis that the weekend (Saturday and Sunday) traffic patterns is structured around a single critical morning to midday peak, with the Saturday peak occurring between 13:00 – 14:00 and Sunday peak between 10:45 – 11:45. No secondary peaks as with the weekday traffic patterns.
- The weekday traffic pattern would take the form of a commuter traffic pattern with a lower AM peak and the critical peak occurring in the PM between 16:00 – 18:00. This pattern will indicate that patrons tend to shop outside normal working hours.
- The total weekday trips of about 1400 vehicles per day is considerably less (35% less trips) than the weekend trips and the peak accounts for about 12% - 14% of the total trips.
- There would seem to be an anomaly with the Monday traffic pattern which is similar to the weekend traffic pattern, however, this can be explained by the fact that the Monday of the weekly assessment was a public holiday. The trading hours for a public holiday was between 08:00 and 14:00 so the peak of 1108 trips (24.1% of the total trips) was generated between 11:45 – 12:45.
- The Friday traffic pattern is similar to the other week days although there is a fluctuation between 12:00 and 14:00. The reason for this fluctuation can be attributed to the fact that certain shops closed during this time period and the number of patrons also reduced due to religious reason (Muslim prayer time). It can also be seen that Friday has a higher peak than a normal week day, which could be attributed to the fact that the following day the weekend begins or it could be that patrons get paid on a fortnight (every two weeks).

Conclusion:

- The weekly peak analysis can be concluded with the Saturday traffic pattern having the maximum hourly peak volume.
- The Saturday traffic volumes will be taken forward into process 2 of this assessment.
- The assessment done on Monday must be omitted as this traffic profile is not a true reflection of a normal Monday.

4.2 Process 2: Daily peak consistency analysis (deviation matrix)

In order to strength the argument and the finalfindings of this study, a daily peak consistency analysis was done at all of the target sites. The aim of this analysis was to validate the data set using a repetitive or longitudinal sample method instead of using a spot or cross section survey as the base of the argument.

From the data analysis shown below in Figure 4.2 to 4.4 it is clear the strength of the argument will be strength by this repetitive survey as the results show limited deviation from the initial analysis sample set used for the modal split analysis.

It is important to note that this analysis was purely based on the vehicle traffic flow patterns and that the other modes (i.e. pedestrian trips and public transport trips) were excluded for this part of the analysis. The justification for this decision is that it is expected that the vehicle trips were less likely to be affected by external elements such as weather, availability and accessibility which could have a significant impact on pedestrian trips and public transport trips, this approach is therefore considered to strengthen the consistency analysis done. Therefore in terms of the "*ceteris paribus*" principal the consistency analysis was further strengthened by eliminating pedestrian trips and public transport trips which are perceptible to significantly change if affected by external factors.

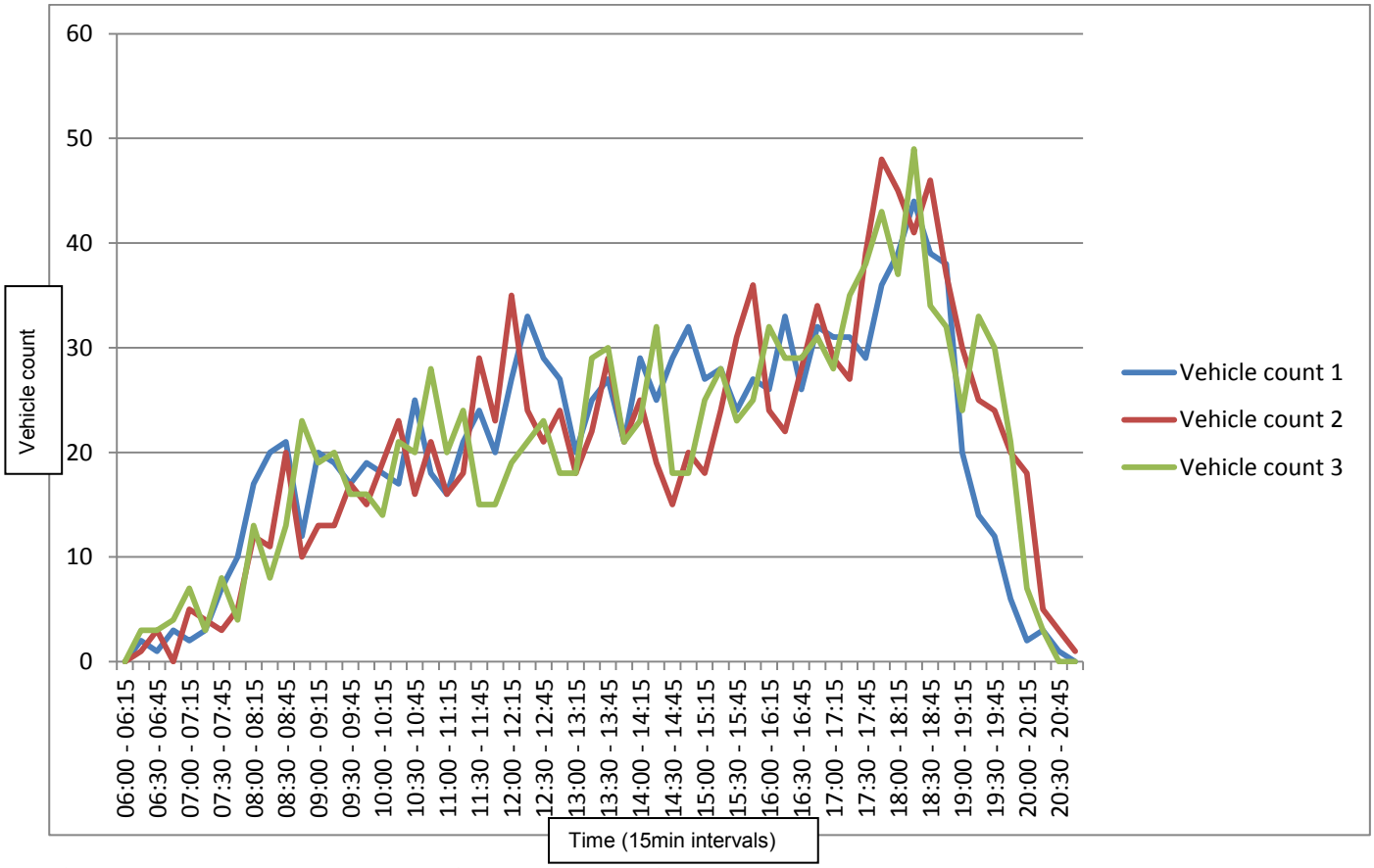

Figure 4.2: Schaapkraal Consistency Analysis

Note: Each line on the graph above represents a full day of Saturday count data and this is to represent the consistency of the traffic pattern over time.

Table 4.2: Standard deviation assessment (Schaapkraal site)

Time Period	06:00 - 06:15	06:15 - 06:30	06:30 - 06:45	06:45 - 07:00	07:00 - 07:15	07:15 - 07:30	07:30 - 07:45	07:45 - 08:00	08:00 - 08:15	08:15 - 08:30	08:30 - 08:45	08:45 - 09:00	09:00 - 09:15	09:15 - 09:30	09:30 - 09:45
Count 1	0	2	1	3	2	3	7	10	17	20	21	12	20	19	17
Count 2	0	1	3	0	5	4	3	5	12	11	20	10	13	13	17
Count 3	0	3	3	4	7	3	8	4	13	8	13	23	19	20	16
Mean	0.00	2.00	2.33	2.33	4.67	3.33	6.00	6.33	14.00	13.00	18.00	15.00	17.33	17.33	16.67
Standard Deviation	0	1.00	1.155	2.082	2.517	0.577	2.646	3.215	2.646	6.245	4.359	7.00	3.786	3.786	0.577

Time Period	09:45 - 10:00	10:00 - 10:15	10:15 - 10:30	10:30 - 10:45	10:45 - 11:00	11:00 - 11:15	11:15 - 11:30	11:30 - 11:45	11:45 - 12:00	12:00 - 12:15	12:15 - 12:30	12:30 - 12:45	12:45 - 13:00	13:00 - 13:15	13:15 - 13:30
Count 1	19	18	17	25	18	16	21	24	20	27	33	29	27	20	25
Count 2	15	19	23	16	21	16	18	29	23	35	24	21	24	18	22
Count 3	16	14	21	20	28	20	24	15	15	19	21	23	18	18	29
Mean	16.67	17.00	20.33	20.33	22.33	17.33	21.00	22.67	19.33	27.00	26.00	24.33	23.00	18.67	25.33
Standard Deviation	2.082	2.646	3.055	4.509	5.132	2.309	3.00	7.095	4.041	8.00	6.245	4.163	4.583	1.155	3.512

Time Period	13:30 - 13:45	13:45 - 14:00	14:00 - 14:15	14:15 - 14:30	14:30 - 14:45	14:45 - 15:00	15:00 - 15:15	15:15 - 15:30	15:30 - 15:45	15:45 - 16:00	16:00 - 16:15	16:15 - 16:30	16:30 - 16:45	16:45 - 17:00	17:00 - 17:15
Count 1	27	21	29	25	29	32	27	28	24	27	26	33	26	32	31
Count 2	29	21	25	19	15	20	18	24	31	36	24	22	28	34	29
Count 3	30	21	23	32	18	18	25	28	23	25	32	29	29	31	28
Mean	28.67	21.00	25.67	25.33	20.67	23.33	23.33	26.67	26.00	29.33	27.33	28.00	27.67	32.33	29.33
Standard Deviation	1.528	0	3.055	6.506	7.371	7.572	4.726	2.309	4.359	5.859	4.163	5.568	1.528	1.528	1.528

Time Period	17:15 - 17:30	17:30 - 17:45	17:45 - 18:00	18:00 - 18:15	18:15 - 18:30	18:30 - 18:45	18:45 - 19:00	19:00 - 19:15	19:15 - 19:30	19:30 - 19:45	19:45 - 20:00	20:00 - 20:15	20:15 - 20:30	20:30 - 20:45	20:45 - 21:00
Count 1	31	29	36	39	44	39	38	20	25	27	18	7	5	1	0
Count 2	27	39	48	45	41	46	37	30	25	24	20	10	5	3	1
Count 3	35	38	43	37	49	34	32	24	33	30	21	7	3	0	0
Mean	31.00	35.33	42.33	40.33	44.67	39.67	35.67	24.67	27.67	27.00	19.67	8.00	4.33	1.33	0.33
Standard Deviation	4.00	5.508	6.028	4.163	4.041	6.028	3.215	5.033	4.619	3.00	1.528	1.732	1.155	1.528	0.577

Table 4.3: Standard deviation summary table (Schaapkraal site)

Range	Frequency	Percentage
0 - 1	5	8.47%
1 – 2	11	18.64%
2 – 3	8	13.56%
3 – 4	9	15.25%
4 – 5	12	20.34%
>5	14	23.73%
TOTAL	**59**	**100%**

Analysis ReviewSchaapkraal:

- The aim of the repetitive survey was to establish 3 data points at each 15minute period and this is expected to strengthen the argument or the accuracy of the data set. From the summary table above it can be concluded that more than 85% of the 59 data sets (177 data points) analysed had a standard deviation which was less than 5 trips.
- With the comparison achieved in the repetitive assessment (more than 85% below 5 trips), the assessment process going forward which will look at a detailed analysis of 1 specific Saturday can be viewed as a general trend and not a once off occurrence.

Conclusion:

- With this assessment done for the Schaapkraal site it can be concluded with a high level of accuracy that the traffic profile for a Saturday is relevantly constant.

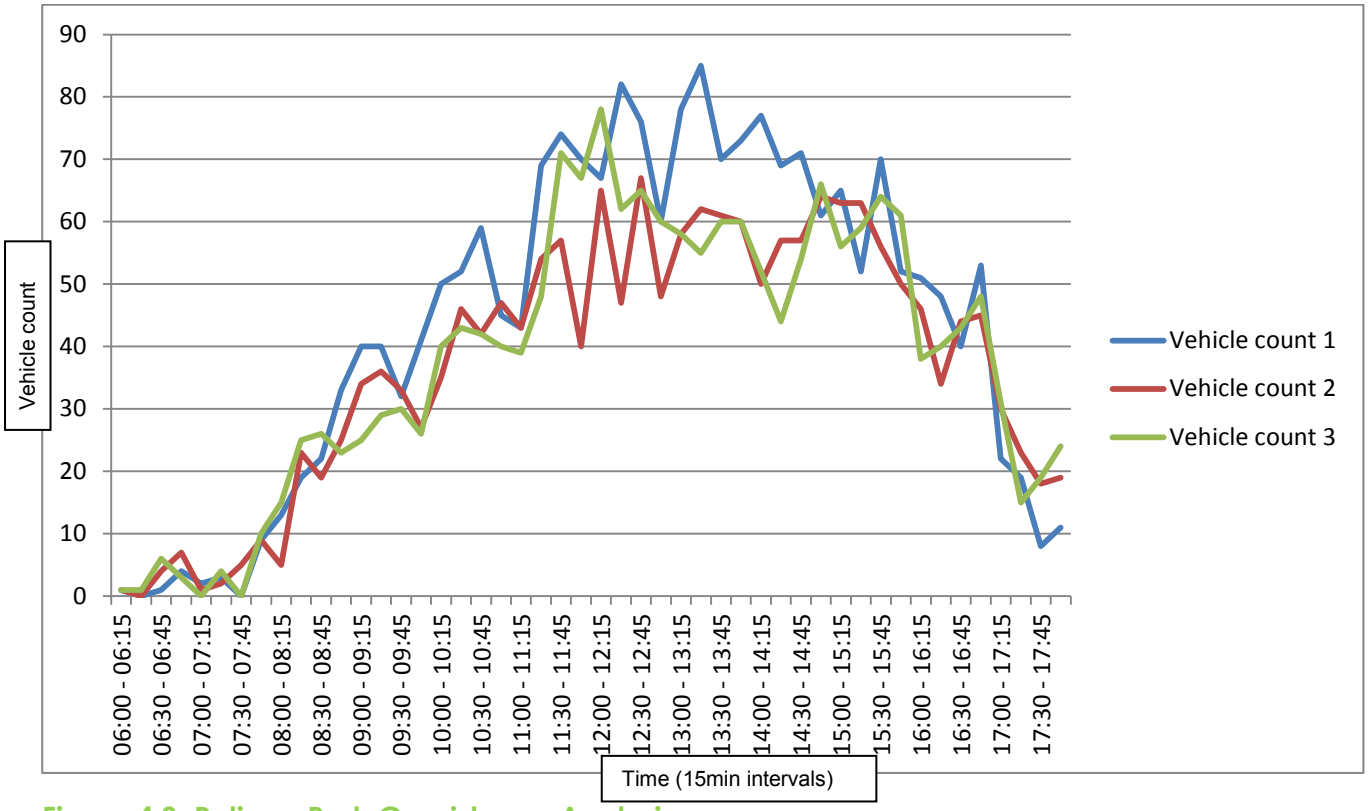

Figure 4.3: Pelican Park Consistency Analysis

Note: Each line on the graph above represents a full day of Saturday count data and this is to represent the consistency of the traffic pattern over time.

Table 4.4: Standard Deviation Assessment (Pelican Park Site)

Time Period	06:00 - 06:15	06:15 - 06:30	06:30 - 06:45	06:45 - 07:00	07:00 - 07:15	07:15 - 07:30	07:30 - 07:45	07:45 - 08:00	08:00 - 08:15	08:15 - 08:30	08:30 - 08:45	08:45 - 09:00	09:00 - 09:15	09:15 - 09:30	09:30 - 09:45
Count 1	1	0	1	4	2	3	0	9	13	19	22	33	40	40	32
Count 2	1	0	4	7	1	2	5	9	5	23	19	25	34	36	33
Count 3	1	1	6	3	0	4	0	10	15	25	26	23	25	29	30
Mean	1.00	0.33	3.67	4.67	1.00	3.00	1.67	9.33	11.00	22.33	22.33	27.00	33.00	35.00	31.67
Standard Deviation	0	0.577	2.517	2.082	1	1	2.887	0.577	5.292	3.055	3.512	5.292	7.55	5.568	1.528

Time Period	09:45 - 10:00	10:00 - 10:15	10:15 - 10:30	10:30 - 10:45	10:45 - 11:00	11:00 - 11:15	11:15 - 11:30	11:30 - 11:45	11:45 - 12:00	12:00 - 12:15	12:15 - 12:30	12:30 - 12:45	12:45 - 13:00	13:00 - 13:15	13:15 - 13:30
Count 1	41	50	52	59	45	43	69	74	70	67	82	76	60	78	85
Count 2	27	35	46	42	47	43	54	57	40	65	47	67	48	58	62
Count 3	26	40	43	42	40	39	48	71	67	78	62	65	60	58	55
Mean	31.33	41.67	47.00	47.67	44.00	41.67	57.00	67.33	59.00	70.00	63.67	69.33	56	64.67	67.33
Standard Deviation	8.386	7.638	4.583	9.815	3.606	2.309	10.82	9.074	16.52	7	17.56	5.859	.928	11.55	15.7

Time Period	13:30 - 13:45	13:45 - 14:00	14:00 - 14:15	14:15 - 14:30	14:30 - 14:45	14:45 - 15:00	15:00 - 15:15	15:15 - 15:30	15:30 - 15:45	15:45 - 16:00	16:00 - 16:15	16:15 - 16:30	16:30 - 16:45	16:45 - 17:00	17:00 - 17:15
Count 1	70	73	77	69	71	61	65	52	70	52	51	48	40	53	22
Count 2	61	60	50	57	57	64	63	63	56	50	46	34	44	45	30
Count 3	60	60	52	44	54	66	56	59	64	61	38	40	43	48	31
Mean	63.67	64.33	59.67	56.67	60.67	63.67	61.33	58.00	63.33	54.33	45.00	40.67	42.33	48.67	27.67
Standard Deviation	5.508	7.506	15.04	12.5	9.074	2.517	4.726	5.568	7.024	5.859	6.557	7.024	2.082	4.041	4.933

Time Period	17:15 - 17:30	17:30 - 17:45	17:45 - 18:00
Count 1	19	8	11
Count 2	23	18	19
Count 3	15	19	24
Mean	19.00	15.00	18.00
Standard Deviation	4.00	6.083	6.557

Table 4.5: Standard deviation summary table (Pelican Park)

Range	Frequency	Percentage
0 - 1	3	6.1%
1 – 2	3	6.1%
2 – 3	6	12.2%
3 – 4	3	6.1%
4 – 5	5	10.2%
>5	29	59.2%
TOTAL	**49**	**100%**

Analysis Review Pelican Park:

- Unlike the results from the Schaapkraal site above, the result from the standard deviation assessment done for the Pelican Park site is less conclusive with 59.2% of the data sets been 5 more trips difference.
- Although the result show a significant deviation between the 3 survey days, it must be noted that count 1 seems to be the count which sways the results as count 2 and 3 have a relatively low standard deviation value (80% with a standard deviation below 5 vehicular trips).
- The anomaly with count 1 could not be explained other than it could be something site specific (e.g. Local Sale) but the fact that count 2 and 3 have a low standard deviation it was concluded there is a high level of accuracy with the traffic profile for a Saturday and it is concluded that the pattern is relevantly constant (based on count 2 and 3).

Conclusion:

- With this assessment done for the Pelican Park site it can be concluded with a high level of accuracy that the traffic profile for a Saturday is relevantly constant, this conclusion is made when excluding count 1 in the analysis.

Figure 4.4: Retreat Consistency Analysis

Note: Each line on the graph above represents a full day of Saturday count data and this is to represent the consistency of the traffic pattern over time.

Table 4.6.: Standard Deviation Assessment (Retreat Site)

Time Period	06:00 - 06:15	06:15 - 06:30	06:30 - 06:45	06:45 - 07:00	07:00 - 07:15	07:15 - 07:30	07:30 - 07:45	07:45 - 08:00	08:00 - 08:15	08:15 - 08:30	08:30 - 08:45	08:45 - 09:00	09:00 - 09:15	09:15 - 09:30	09:30 - 09:45
Count 1	1	0	1	3	1	2	0	6	8	12	14	21	26	26	21
Count 2	0	0	3	2	2	2	4	8	6	7	12	17	20	28	29
Count 3	1	1	4	2	0	3	0	7	10	16	17	15	16	19	20
Mean	0.67	0.33	2.67	2.33	1.00	2.33	1.33	7.00	8.00	11.67	14.33	17.67	20.67	24.33	23.33
Standard Deviation	0.375	0.375	1.678	0.362	1.015	0.362	2.309	1.103	1.904	4.644	2.452	3.323	4.918	4.81	5.151

Time Period	09:45 - 10:00	10:00 - 10:15	10:15 - 10:30	10:30 - 10:45	10:45 - 11:00	11:00 - 11:15	11:15 - 11:30	11:30 - 11:45	11:45 - 12:00	12:00 - 12:15	12:15 - 12:30	12:30 - 12:45	12:45 - 13:00	13:00 - 13:15	13:15 - 13:30
Count 1	27	33	34	38	36	36	45	48	46	44	53	49	44	51	51
Count 2	32	27	37	37	40	36	49	50	51	53	47	48	48	47	47
Count 3	17	26	28	32	33	40	40	46	44	51	50	42	42	40	44
Mean	25.33	28.67	33.00	35.67	36.33	37.33	44.67	48.00	47.00	49.33	50.00	46.33	44.67	46.00	47.33
Standard Deviation	7.656	3.5	4.589	3.345	3.512	2.309	4.505	1.925	3.863	4.928	3.151	3.789	3.055	5.434	3.369

Time Period	13:30 - 13:45	13:45 - 14:00	14:00 - 14:15	14:15 - 14:30	14:30 - 14:45	14:45 - 15:00	15:00 - 15:15	15:15 - 15:30	15:30 - 15:45	15:45 - 16:00	16:00 - 16:15	16:15 - 16:30	16:30 - 16:45	16:45 - 17:00	17:00 - 17:15
Count 1	55	46	47	45	46	40	42	34	34	34	33	31	26	25	14
Count 2	45	39	38	38	43	43	44	45	39	37	36	27	28	28	24
Count 3	44	41	40	38	37	43	36	38	42	40	25	26	28	31	20
Mean	48.00	42.00	41.67	40.33	42.00	42.00	40.67	39.00	38.33	37.00	31.33	28.00	27.33	28.00	19.33
Standard Deviation	6.243	3.342	4.994	3.955	4.648	1.906	3.98	5.633	3.863	2.929	5.877	2.759	1.141	3.101	4.884

Time Period	17:15 - 17:30	17:30 - 17:45	17:45 - 18:00
Count 1	12	10	7
Count 2	20	17	12
Count 3	10	12	16
Mean	14.00	13.00	11.67
Standard Deviation	5.328	3.562	4.24

Table 4.7: Standard deviation summary table (Retreat Site)

Range	Frequency	Percentage
0 - 1	4	8.2%
1 – 2	7	14.3%
2 – 3	5	10.2%
3 – 4	14	28.6%
4 – 5	10	20.4%
>5	**7**	**14.3%**
TOTAL	47	

Analysis Review Retreat:

- It can be concluded that the Retreat site has lowest level of deviation with 85.7% of the readings (40 of 47 data sets) showing a deviation less than 5 trips.
- With the comparison achieved in the repetitive assessment (more than 85% below 5 trips), the assessment process going forward which will look at a detailed analysis of 1 specific Saturday can be viewed as a general trend and not a once off occurrence for this development.
- It is understood that as patrons of a development get familiar with the operations of a new development, a trend is formed in the behaviour of those patrons and this is clearly indicated with all 3 developments assessed.

Conclusion:

- With this assessment done for the Retreat site it can be concluded with a high level of accuracy that the traffic profile for a Saturday is relevantly constant.

4.3 Process 3: Modal split analysis

As discussed in Section 2 of this dissertation, the theory indicates that the development form surrounding a facility has a direct bearing on the modal choice of patrons using that facility. It is therefore the aim of this analysis to test this theory and to establish the extent of the relationship between the development form and travel behaviour

Based on the theory, a development designed on TOD and TND principals should generate significant public transport and pedestrian trips respectively.

Figure 4.5 shows the modal split recorded at the Pelican Park site over the typical Saturday and this information is analysed in Table 4.8.

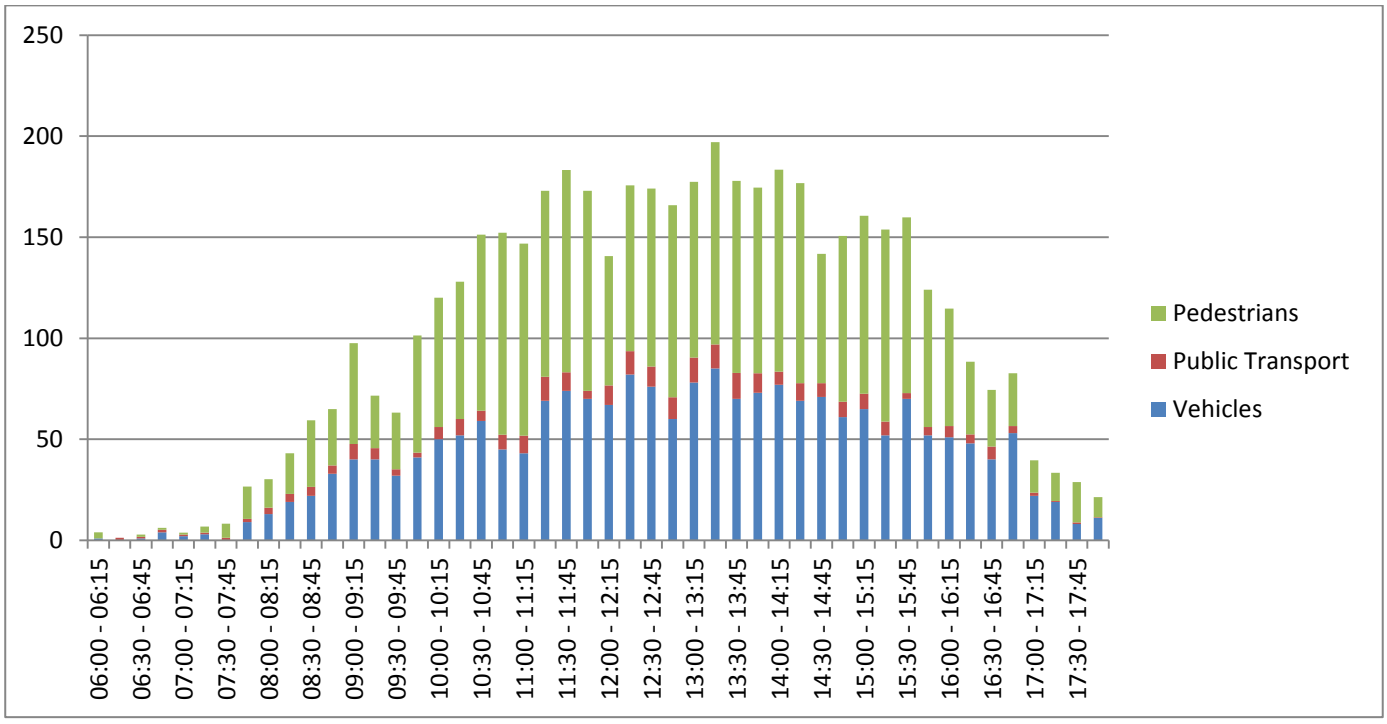

Figure 4.5: Pelican Park modal split analysis

Note: (1) Pedestrian and public transport trips indicate number of persons trips recorded.

(2) Vehicle trips indicate the number of vehicles recorded.

(3) See Section 3.5 for details of the survey methodology.

Table 4.8: Peak Trip generation per mode (Pelican Park Site)

No	Mode	GLA	Trips Actual (IN)	Rate Actual *	%mode trips
1	Vehicular	5813	306	10.5	36
2	Pedestrian	5813	491	16.9	58
3	Public Transport	5813	47	1.6	6
		Total	**844**	-	100

Notes:

(1) The unit for the trip rate is trips/100m2 of Gross Leasable Area (GLA)

(2) Gross leasable area (GLA): is the amount of floor space available to be rented in a commercial property. Specifically, gross leasable area is the total floor area designed for tenant occupancy and exclusive use, including any basements, mezzanines, or upper floors.

Analysis Review Pelican Park:

- Based on the analysis, the TND/TOD development form has a greater percentage of pedestrian trips than a development which is designed around private vehicle users, this is indicated in the analysis which shows the pedestrian trips accounts for 58% of the trips for this shopping centre and the vehicular trips accounts for 36% and to lesser extent the public transport trips accounts for 6% of the trips.
- The analysis also indicates that TND development principals has a greater impact on the modal split (or preferred mode choice) than TOD as the number of pedestrian trips far exceeds the number of public transport trips generated.
- In terms of the trips generation rate comparison between private vehicle usage and pedestrian trips, the vehicular trip generation rate is 38% lower (10.5trips/100m2 vs 16.9trips/100m2) than the pedestrian trips.
- For this development the pedestrian mode of transport is viewed as the preferredmode of transport and the private vehicle is seen as the secondary mode choice.

Conclusion:

- The analysis clearly indicates the relationship between the development form and the type of trips generate in this specific case, this is one of the key objectives set out in Section 1.3 of this dissertation.
- Based on the analysis results, it can be concluded that the TND/TOD development forms are compatible for low income shopping centre within the South African context and it can be seen as a sustainable approach to development.
- Despite many references from literature review chapter indicating that the link between development type and modal split is weak (at best) this modal split analysis indicates that a strong link exists.

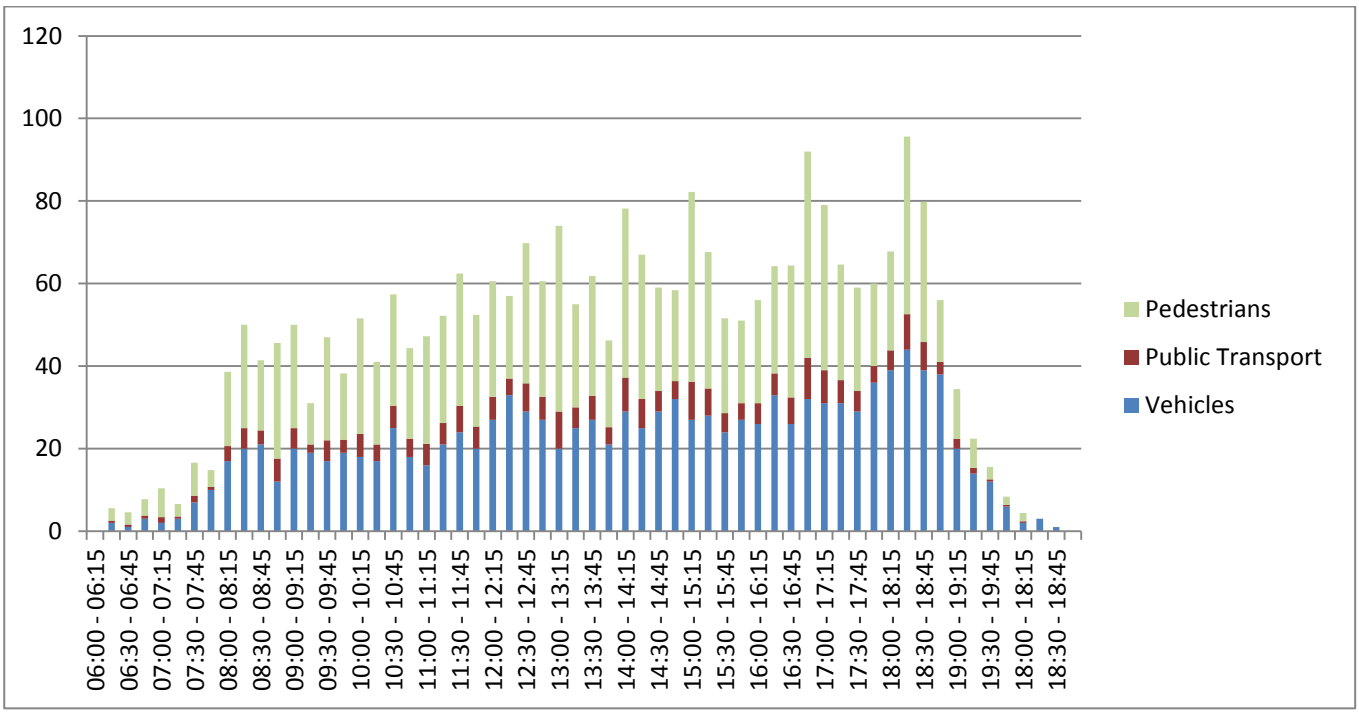

Figure 4.6: Schaapkraal modal split analysis

Note: (1) Pedestrian and public transport trips indicate number of persons trips recorded.

(2) Vehicle trips indicate the number of vehicles recorded.

(3) See Section 3.5 for details of the survey methodology.

Table 4.9: Peak Trip generation per mode (Schaapkraal Site)

No	Mode	GLA	Trips Actual (IN)	Rate * Actual	%mode trips
1	Vehicular	1601.4	160	20.0	47
2	Pedestrian	1601.4	151	18.7	44
3	Public Transport	1601.4	29	3.7	9
	Total		**340**	-	100

* Note: The unit for the trip rate is trips/100m2 of Gross Leasable Area (GLA)

Analysis Review Schaapkraal:

- Based on the analysis, this development form which is designed around private vehicle users has a greater percentage of vehicular trips which accounts for 47% of the trips for this shopping centre and the pedestrian trips accounts for 44% and to lesser extent the public transport trips accounts for 9% of the trips.
- Drawing a direct comparison with the results of the Pelican Park site, the vehicular mode increased by 11%, whereas the pedestrian mode decreased 14% and the public transport mode also increased by 3%.
- In terms of the trips generation rate comparison between private vehicle usage and pedestrian trips, the vehicular trip generation rate is 7% higher than the pedestrian trips (20.0trips/100m^2 vs 18.7trips/100m^2).
- Drawing a direct comparison with the results of the Pelican Park site, the vehicular trip generation rate increased from 10.5trips/100m^2 to 20.0trips/100m^2. Although the pedestrian trip generation rate remained more or less constant with a rate 16.9trips/100m2 compared to 18.7trips/100m2.
- Bearing in mind that most externalities of these two site were constant except for the development form, it can be concluded with a high level of certainty that the main reason behind the shift in modal choice is directly linked to the development form which differs in each scenario.

Conclusion:

- The analysis clearly indicates the relationship between the development form and the type of trips generate in this specific case, this is one of the key objectives set out in Section 1.3 of this dissertation.
- Based on the analysis results, it can be concluded that this type of development form which is geared around private vehicle users is not compatible nor sustainable for a low income community which are dependent on NMT and public transport to access these local/community based facilities.
- It can be concluded that, by designing a community or area effectively it can either discourage or encourage modal choices such as NMT and public transport, in this instance the incorrect design or neglect of pedestrian consideration has resulted in a negative response from NMT and public transport users.
- Despite many references from literature review chapter indicating that the link between development type and modal split is weak (at best) this modal split analysis indicates that a strong link exists.

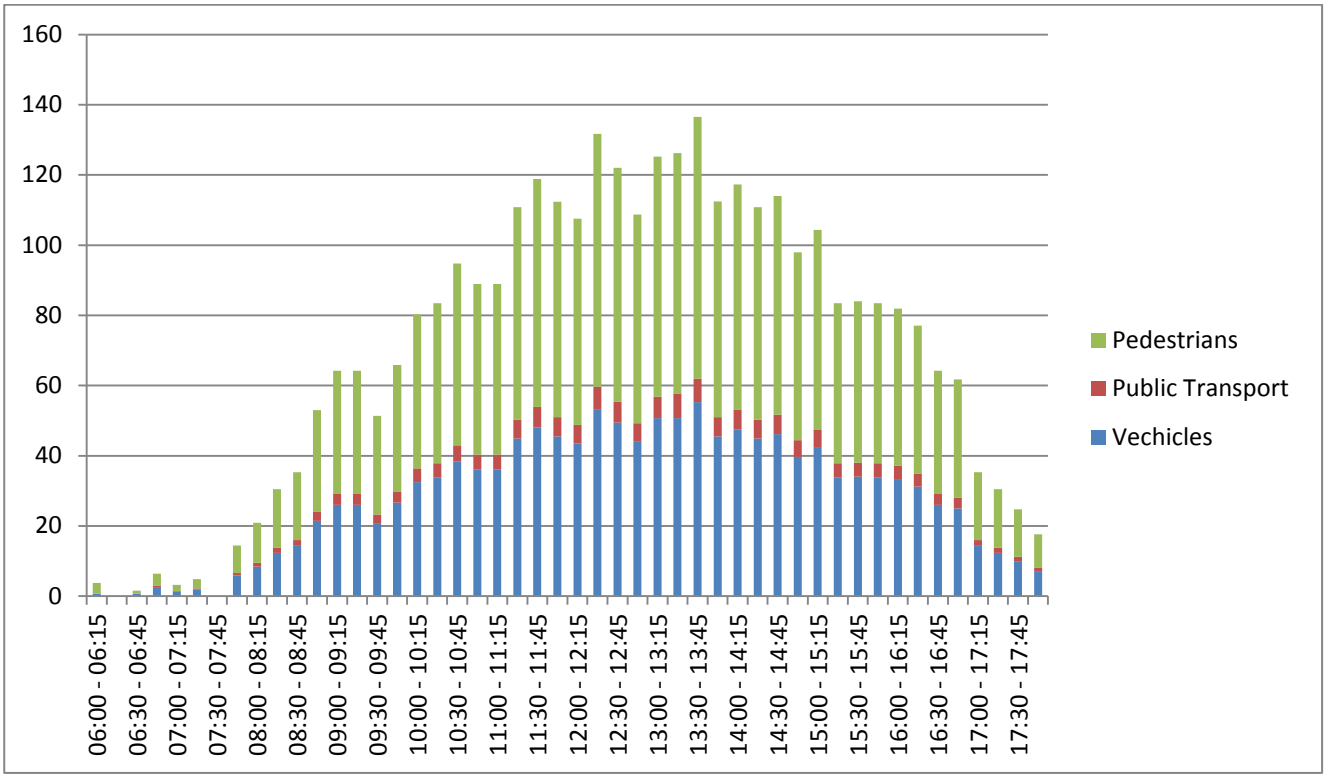

Figure 4.7: Retreat modal split analysis – Final graph to be added

Note: (1) Pedestrian and public transport trips indicate number of persons trips recorded.

(2) Vehicle trips indicate the number of vehicles recorded.

(3) See Section 3.5 for details of the survey methodology.

Table 4.10: Peak Trip generation per mode

No	Mode	GLA	Trips Actual (IN)	Rate Actual	%mode trips
1	Vehicular	3200	202	12.6	40
2	Pedestrian	3200	273	17.1	55
3	Public Transport	3200	25	1.6	5
	Total		**500**	-	100

* Note: The unit for the trip rate is trips/100m2 of Gross Leasable Area (GLA)

Analysis Review Retreat:

- As this site was utilised as the third site to prove or disprove the hypothesis, it can be concluded from the summary table above that these results are consistent with the results achieved for the Pelican Park site.
- The results indicate a high percentage of pedestrian trips (55% pedestrian trips, which amounts for 273 of 500 peak trips) been generated and this can be seen as the preferred mode of transport for this development. This is consistent with the result for the Pelican Park site and it can be concluded with a high level of certainty that the modal choice or split is significantly affected by the development form.
- Although this site is also well located in terms of public transport as with the other two sites, it can be concluded that the impact on the modal choice is minimal with 5% of the peak trips been generated by public transport.
- The results achieved for this site indicates that by developing your site in a pedestrian friendly environment with a high level of safety for pedestrians, where suitable pedestrian facilities are provided and also where the site is well located (within an acceptable walking distance), this will have an impact of increasing your pedestrian trips by 11% and reducing your private vehicle trips by 7%.
- Reviewing all the sites selected for this research it can be concluded that the development form has a high impact on the modal choice, whereas the impact from a TOD perspective is less substantial.

Conclusion:

- The analysis clearly indicates the relationship between the development form and the type of trips generate in this specific case, this is one of the key objectives set out in Section 1.3 of this dissertation.
- Based on the analysis results, it can be concluded that these results are consistent with the results achieved for the Pelican Park site and it therefore proves the hypothesis that the volume of pedestrian trip generated by a development is directly proportionate to the level of pedestrian facilities provided in and around the facility. Therefore it can be concluded that, poor provision of pedestrian facilities leads to a low generation of pedestrian trips and visa versa.
- Despite many references from literature review chapter indicating that the link between development type and modal split is weak (at best) this modal split analysis indicates that a strong link exists.

4.4 Process 4: Trip generation comparison

This section of the dissertation is aimed at establishing a comparison between the actual trip generation rates of the 3 sites evaluated, compared to rates generally used to estimate the trip generation for new developments. The two established trip generation manuals used is the COTO, TMH 17, South African Trip Data Manual, Version 1.01, September 2013 and the National Department of Transport (NDoT), South African Trip Generation Rates, Report No. RR 92/228, Pretoria, 1995.

The outcome of this section will establish whether or not the rates prescribed are appropriate for low income shopping centres within the South African context.

Table 4.11: Pelican Park Trip Generation Comparison

				NDoT				COTO			
Use	GLA	Trips Actual (IN)	Rate Actual	Trip Rate	Trips	IN	OUT	Trip Rate	Trips	IN	OUT
Shopping Centre	5813	306	**10.5**	**18.6 ***	1080	540	540	**11.4 ****	661	331	331

* NDoT Rate = $250.2*GLA^{-0.20}$
** CoTo Rate – 15% reduction for PT

Analysis Review and Conclusion:

- When comparing the actual trip generation figures recorded at the development, it can be seen from the table above that the recorded AM peak trip rate of 10.5trips/100m^2 is compatible with the rate of 11.4trips/100m^2 prescribed in the COTO standard trips. The difference between the actual rate and the COTO rate is 9% which is considered to be an acceptable degree of accuracy when estimating the trip generation for a new development.
- The base Saturday peak rate prescribed COTO is 13.4trips/100m^2, however, this standard allows for a reduction of 15% for developments within a public transport node or located along high level public transport corridor. By applying the 15% reduction, the rate was reduced to the 11.4trips/100m^{2}as indicated in the table above.
- The COTO standard allows for a further 30% reduction for developments that fall within areas with low vehicle ownership, this reduction will reduce the trip generation rate to 8.0trips/100m^2 which is 24% lower than the actual rate recorded and therefore this reduction was not applied as part of the comparison. It can therefore be concluded based on the actual trip rates, that this area does not fall into the category of a low vehicle ownership area, although the average income is relatively low.
- When calculating the trip generation rate based on the NDoTfigures, the calculated rate using the prescribed formula predicted a trip of 18.6trips/100m^2. This value is 77% higher than the actual trip rate of 10.5trips/100m2 and therefore the NDoT rate is not considered appropriate for this development.

Table 4.12: Schaapkraal Trip Generation Comparison

			NDoT					COTO			
Use	GLA	Trips Actual (IN)	Rate Actual	Trip Rate	Trips	IN	OUT	Trip Rate	Trips	IN	OUT
Shopping Centre (PM)	1601.36	160	**20.0**	**27.3**	438	219	219	**11.4**	182	91	91

* NDoT Rate = $250.2*GLA^{-0.20}$
** CoTo Rate – 15% reduction for PT

Analysis Review and Conclusion:

- When comparing the actual trip generation figures recorded at the development to the COTO standard, it can be seen from the table above that the recorded PM peak trip rate of 20.0trips/100m^2 is significantly higher than the COTOrate of 11.4trips/100m^2 (43% higher) and therefore the COTO rate is not considered appropriate for this development.
- This comparison between the actual rate and the COTO rate is significantly different to the figured recorded for the Pelican Park Site (8% vs 43%) and this allows one to draw a firm conclusion that the traffic generation for the two sites are significantly different.
- When calculating the trip generation rate based on the NDoT figures, the calculated rate using the prescribed formula predicted a trip of 27.3trips/100m^2. This value is 36% higher than the actual trip rate of 20.0trips/100m2 and therefore the NDoT rate is also not considered appropriate for this development.
- The rate of 20.0trips/100m^2 falls between the rates prescribed in COTO and NDoT standards (actual average 19.35trips/100m^2) and could be utilised as a more effective rate for estimating the trip generation for shopping centres within a low-income but with a poor level of pedestrian accessibility.

Table 4.13: Retreat Trip Generation Comparison

		Actual		NDoT				COTO			
Use	GLA	Trips Actual (IN)	Rate Actual	Trip Rate	Trips	IN	OUT	Trip Rate	Trips	IN	OUT
Shopping Centre (AM)	3200	202	**12.6**	**22.2 ***	711	356	356	**11.4 ****	364	182	182

* NDoT Rate = $250.2*GLA^{-0.20}$
** CoTo Rate – 15% reduction for PT

Analysis Review and Conclusion:

- When comparing the actual trip generation figures recorded at the development, it can be seen from the table above that the recorded AM peak trip rate of 12.6trips/100m^2 is compatible with the rate of 11.4trips/100m^2 prescribed in the COTO standard trips. The difference between the actual rate and the COTO rate is 10% which is considered to be an acceptable degree of accuracy when estimating the potential development trips.
- When calculating the trip generation rate based on the NDoT figures, the calculated rate using the prescribed formula predicted a trip of 22.2trips/100m^2. This value is 76% higher than the actual trip rate of 12.6trips/100m^2 and therefore the NDoT rate is not considered appropriate for this development.
- When assessing all the results achieved it can be concluded that the COTO rate is an accurate prediction for low income shopping centre developments which are built along a transport corridor (TOD design element) and which are pedestrian friendly developments (TND design element).
- It can also be concluded based on the results achieved that the development form has a significant impact on the trip generation, this more so than the provision of public transport.

5. CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions:

Based on the weekly peak analysis done in Section 4.1 (Figure 4.1) of this dissertation, it is evident that the Saturday peak is to be considered the critical/maximum peak for the week.

A further conclusion of the weekly peak analysis is that the weekend (Saturday and Sunday) traffic pattern differs from the weekday pattern as it is structured around a single critical morning to midday peak. No secondary peaks were encountered as with the weekday traffic patterns.

The weekday traffic pattern would take the form of typical shopping centre trip pattern, with a lower AM peak and the critical peak occurring in the PM. This pattern also indicates that patrons tend to shop outside normal working/business hours. The network would generally follow a commuter travel pattern with a distinct AM and PM peak.

The repetitive survey assessment it can be concluded that the results achieved can be utilised as a general assumption due to the high level of accuracy/consistency in the repetitive survey.

A further conclusion can be drawn using the outcomes of the standard deviation assessment done, it can be concluded with a high level of accuracy that the traffic profile for a Saturday is relevantly constant. This conclusion can be drawn when considering the result of all three sites assessed.

The analysis done in Section 3.3 of this dissertation indicates that TND development principals has a greater impact on the modal split (or preferred mode choice) than TOD as the number of pedestrian trips far exceeds the number of public transport trips generated. This trend was conclusive for all 3 sites used as part of the investigation.

Bearing in mind that most externalities (external factors) were constant except for the development form, it can be concluded with a high level of certainty that the main reason behind the shift in modal choice is directly linked to the development form which differs in each scenario. Despite many references from Chapter 2 indicating that the link between development type and modal split is weak (at best) the analysis done in this dissertation indicates that a strong link exists.

A firm conclusion can be drawn from modal split analysis (Section 3.3) when assessing these developments. When the development form is adequately structured around a pedestrian movement and accessibility (TND type developments), the benefits are increased pedestrian traffic in the region of 14%.

The test site (Retreat site) which was utilised to prove or disprove the hypothesis, firmly concludes the research topic that the development form has a significant impact on the travel behaviour and traffic patterns, The results from the pedestrian friendly sites (Pelican Park and Retreat sites) show the same trends which are different to the results from the non-pedestrian friendly site (Schaapkraal).

The outcomes of the modal split analysis also show a positive trend when using the TOD design approach, with the benefits of increased public transport trips in the region of between 4% - 9%. Although this is a positive result, the result is considered to be relatively low compared to the 15% trip reduction allowed for in the COTO standards.

The literature from the literature review concluded conflicting results when assessing the relationship between the development form and the modal splits but based on the results achieved it can be concluded that a strong link exists.

Reviewing the results of Section 3.3, it can be concluded that the development form structured around pedestrians has a high impact on the modal choice, whereas the impact from a TOD perspective is less substantial.

When assessing all the results achieved in Section 3.4, the difference between the actual trip rate recorded and the COTO rate is less than 10% which is considered to be an acceptable degree of accuracy when predicting the trip generation for a new development. The NDoT calculated rates are not considered appropriate for these developments as they are way in excess of the actual rates recorded.

It can be concluded that the COTO rate is an accurate prediction for low income shopping centre developments which are built along a transport corridor (TOD design form) and which are pedestrian friendly developments (TND design element).

When assessing the non-pedestrian friendly site, it can be seen from the figures that the recorded peak PM trip rate of 20.0trips/100m2 is significantly higher than the calculated rate of 11.4trips/100m2 prescribed in the COTO standard (43% higher) and therefore the COTO rate is not considered appropriate for this development.

The rate of 20.0trips/100m2 recorded at the non-pedestrian friendly site falls between the rates prescribed in COTO and NDoT standards (actual average 19.35trips/100m2) and rate could be utilised as a more accurate rate for estimating the trip generation for shopping centres within a low-income but with a poor level of pedestrian accessibility.

Comparing the actual rates of the Pelican Park site (pedestrian friendly) and the Schaapkraal site (non-pedestrian friendly) there is a significant different to the figures recorded (10.5trips/100m2 vs 20.0trips/100m2). This allows one to draw a firm conclusion that the traffic generation for the two sites are significantly different and can be directly linked to the difference in the development form of these two sites.

5.2 Recommendations:

Based on the assessments done in Section 4 of this dissertation it is recommended that the relationship between the development form, trip generation and modal split be further investigated in order to achieve a conclusive benchmark for developments of this nature. It is also recommended that this study is expanded to include a variety of land uses such as residential, industrial and offices etc.

It is clear from the study that the trip generation standards used are not always compatible within the South African context and more so within the low-income communities, therefore, it is recommended that the trip generation standards which can be seen as one dimensional needs to be a live, dynamic document which considers in depth aspects such as, income group of patrons, development forms aspects (TND and/or TOD), surrounding network connectivity, modal preferences (choice users or private vehicle captive users), vehicle ownership level/usage and availability of public transport. In this way the trip generation rates prescribed will be accurate when assessing development impact.

In order to achieve sustainable City Planning, it is imperative that Land Use Planning and Transport Planning be an integrate approach and it is recommended that this be established as a fundamental partnership in the City Planning process. The relationship

between the Spatial Development Framework (SDF) and the Local Area Plans, Integrated Transport Plans (ITP) and Integrated Public Transport Network (IPTN) must be emphasised at all levels as this is a critical link in sustainable and effective City Planning

For low-income communities, it is recommended that these communities be more self-sufficient and that all land uses (live, work, community and social) be accommodated within the local community or within an acceptable distance which can be accessed via NMT modes. This is consistent with the TND design approach and it is clear from the assessment that this type of design approach is sustainable and effective in this context.

It is recommended that measures be investigated to improve the benefits of the TOD design approach and it also critical to fully understand the dynamics behind public transport usage and attractiveness from an end-user perspective.

The final recommendation of this dissertation is that low income developments be developed using the correct development form principles in order to achieve an effective and sustainable development which adequately serve the patrons needs.

6. REFERENCES

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7. Annexure A – Assessment of Ethics Form

EBE Faculty: Assessment of Ethics in Research Projects

Any person planning to undertake research in the Faculty of Engineering and the Built Environment at the University of Cape Town is required to complete this form before collecting or analysing data. When completed it should be submitted to the supervisor (where applicable) and from there to the Head of Department. If any of the questions below have been answered YES, and the applicant is NOT a fourth year student, the Head should forward this form for approval by the Faculty EIR committee: submit to Ms Zakiya Chikte (Zakiya.chikte@uct.ac.za); New EBE Building, Ph 021 650 5739).

Please note – It is important to keep a signed copy of this form as students must include a copy of the completed form with the dissertation/thesis when it is submitted for examination.

Name of Principal Researcher/Student: Marlyn Lloyd Botha **Department:** Civil Engineering

If a Student: **Degree:** MEng Transport Studies **Supervisor:** A. Prof. Mark Zuidgeest

If a Research Contract indicate source of funding/sponsorship: N/A

Research Project Title: Assessment of development form and the impact it has on the modal split for low-income commercial developments

Overview of ethics issues in your research project:

Question 1: Is there a possibility that your research could cause harm to a third party (i.e. a person not involved in your project)?	YES	(NO)
Question 2: Is your research making use of human subjects as sources of data? If your answer is YES, please complete Addendum 2.	YES	(NO)
Question 3: Does your research involve the participation of or provision of services to communities? If your answer is YES, please complete Addendum 3.	YES	(NO)
Question 4: If your research is sponsored, is there any potential for conflicts of interest? If your answer is YES, please complete Addendum 4.	YES	(NO)

If you have answered YES to any of the above questions, please append a copy of your research proposal, as well as any interview schedules or questionnaires (Addendum 1) and please complete further addenda as appropriate.

I hereby undertake to carry out my research in such a way that

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

Signed by:

	Full name and signature	Date
Principal Researcher/Student:	Signature Removed	29 – 02 – 2016

This application is approved by:

Supervisor (if applicable):	Signature Removed	07-03-2016
HOD (or delegated nominee): Final authority for all assessments with NO to all questions and for all undergraduate research.	Signature Removed	02/3/16
Chair : Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the above questions.	Signature Removed	

ADDENDUM 1:
Please append a copy of the research proposal here, as well as any interview schedules or questionnaires:

ADDENDUM 2: To be completed if you answered YES to Question 2:

It is assumed that you have read the UCT Code for Research involving Human Subjects (available at http://web.uct.ac.za/depts/educate/download/uctcodeforresearchinvolvinghumansubjects.pdf) in order to be able to answer the questions in this addendum.

2.1 Does the research discriminate against participation by individuals, or differentiate between participants, on the grounds of gender, race or ethnic group, age range, religion, income, handicap, illness or any similar classification?	YES	NO
2.2 Does the research require the participation of socially or physically vulnerable people (children, aged, disabled, etc) or legally restricted groups?	YES	NO
2.3 Will you not be able to secure the informed consent of all participants in the research? (In the case of children, will you not be able to obtain the consent of their guardians or parents?)	YES	NO
2.4 Will any confidential data be collected or will identifiable records of individuals be kept?	YES	NO
2.5 In reporting on this research is there any possibility that you will not be able to keep the identities of the individuals involved anonymous?	YES	NO
2.6 Are there any foreseeable risks of physical, psychological or social harm to participants that might occur in the course of the research?	YES	NO
2.7 Does the research include making payments or giving gifts to any participants?	YES	NO

If you have answered YES to any of these questions, please describe how you plan to address these issues (append to form):

ADDENDUM 3: To be completed if you answered YES to Question 3:

3.1 Is the community expected to make decisions for, during or based on the research?	YES	NO
3.2 At the end of the research will any economic or social process be terminated or left unsupported, or equipment or facilities used in the research be recovered from the participants or community?	YES	NO
3.3 Will any service be provided at a level below the generally accepted standards?	YES	NO

If you have answered YES to any of these questions, please describe how you plan to address these issues (append to form)

ADDENDUM 4: To be completed if you answered YES to Question 4

4.1 Is there any existing or potential conflict of interest between a research sponsor, academic supervisor, other researchers or participants?	YES	NO
4.2 Will information that reveals the identity of participants be supplied to a research sponsor, other than with the permission of the individuals?	YES	NO
4.3 Does the proposed research potentially conflict with the research of any other individual or group within the University?	YES	NO

If you have answered YES to any of these questions, please describe how you plan to address these issues(append to form)