Shaping Hamilton with Complete Streets

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EXECUTIVE SUMMARY

Hamilton's Complete Streets Context

Increasingly the City of Hamilton is facing new challenges related to mobility, accessibility, and urban growth. More people live in Hamilton than ever before and these numbers will continue to grow. But much of this growth will need to be accommodated within the existing built boundary through infill development and intensification if the city is to develop in a manner that is both economically efficient and environmentally sustainable and meets the mandated growth targets of the Province of Ontario's regional planning policies.

Furthermore, while not at the levels of the Greater Toronto Area, congestion is increasingly a problem and new types of stresses are emerging on the transportation network as the economy of Hamilton diversifies from a past largely oriented to large-scale employment in heavy industry. At the same time, as our understanding of the linkage between urban transportation networks and patterns of local development improves, more is being asked of these networks. In decades past, in a time of rising automobile ownership, the main emphasis was on maximizing vehicle flows and in many cases viewing higher speeds as a sign of efficiency. Nowadays the focus is on developing the urban corridors that host these transportation networks to their full potential. Taken together, these pressures of urban growth have brought more emphasis on the urban built environment in an effort to ensure that people can live, work and play more locally than before in their pursuit of a high-quality urban lifestyle.

Over recent years in Hamilton, there has been much debate about how to achieve such outcomes, especially in the Lower City and the Main/King corridor in particular. To that end, light rail transit (LRT) has received a great deal of attention as a potential catalyst for economic uplift. Here, Complete Streets stand as an important element in implementing transit-oriented development within LRT station areas. With the project now funded, Complete Streets should be viewed as an important element for achieving the greatest possible return on investment for LRT. Furthermore, while the inauguration of LRT service is several years into the future, in the interim it seems prudent to examine some immediate and cost effective options that have the potential to develop important city corridors as 'Rapid Ready' in advance of LRT by making them safer, more economically vibrant, and even better places to live. Moreover, from a planning perspective, many streets in Hamilton will be in need of renewal in the coming years, presenting a crucial opportunity to revisit how they function.

This report seeks to assess complete streets from a dispassionate point of view, which stands to move past some of the agenda-driven discourse that can often be found on the topic. We believe it to be one of the most comprehensive reviews of the core concepts available. This information is designed to help citizens, planners, and policymakers to reflect on the balance of particular neighbourhoods and whether complete street initiatives can help to capitalize on these opportunities and maximize the potential of an area.

To help define the scope of this report, it should be noted that there are a wide range of small-scale design elements associated with complete streets. This is a large topic in its own right and one which is generally beyond the scope of the current document. This report focuses on the core concepts of complete streets and their significance for the City of Hamilton.

What is a Complete Street

But what precisely *is* a complete street? The first use of the term complete streets is fairly recent while many of the concepts it unites are much older. It is a useful marketing term that bundles together some broadly relevant built environment concepts in a coherent package, but the term can be quite problematic for planning as in some cases it can promote "black and white"/ either-or thinking (e.g. a street is complete or it is not).

At its most basic, a complete street is a concept. Generally speaking, a complete street is one that aims to make streets safer, more appealing, vibrant, and accessible for all users of the built environment, from children to the elderly. How are such goals achieved? As opposed to promoting one strict type of built form, the term complete streets refers to a broad package of elements, and the degree of 'completeness' of a street is determined not by the number or type of complete street elements in place but by the overall *balance* that is achieved between the users of an area and the activities that they engage in on one hand, and the built form that supports these activities or, in some cases, suppresses these activities from taking place on the other.

As such, it is important to stress that there is no "one-size fits all" prescription for making a street complete. Instead, achieving completeness depends on an assessment of the balance between mobility and accessibility, and safety in a particular area, and whether elements of complete streets can be employed to re-balance these characteristics to optimize social, environmental, and economic outcomes. This re-balancing depends on interactions with the built environment, which is one of the primary mediums through which people understand and interact with the city. The configuration of the built environment can add life and vitality to a place, or potentially prevent or stifle such vitality. Fundamentally, the concept of complete streets seeks to harness the power of the built environment and complete streets themselves are part of the built environment.

In pursuing complete street implementations, attention must be paid to the realities of demand for the modes. There is no point in developing tailored infrastructure if it is to be mostly unused. At the same time, planning has to be done with a longer term horizon that recognizes the possibilities that could emerge as land uses and behaviour change over time. This latter point ties into the concept of "latent demand" or the idea that there is (or will be) unrealized demand for certain modes of travel lurking in the background and waiting to be unleashed in the right set of circumstances.

The Elements of Complete Streets

Regulation of Driver Behaviour

Among other elements, complete streets feature a package of approaches that seeks to regulate traffic speeds and enhance safety. Research indicates that just about anything that reduces vehicle speeds is likely to improve safety. In the urban context it is very important to remember that a vehicle speed increase from 30 to 50 km/h is associated with five times the level of pedestrian fatalities in the event of a pedestrian/vehicle collision. Increases in kinetic energy over this speed range are dramatic and people seem to underestimate the implications. Increases in noise are also apparent and have their own undesirable impacts.

Central to the idea of complete streets is that visual cues associated with the design of the road and the side of the road can cause drivers to be more cautious, vigilant and wary of their surroundings. It is a counter-intuitive finding that the more "unforgiving" the road is to drivers, the safer the outcome. Many roads and highways are designed, on the other hand, to be forgiving and accommodative of driver error and to give drivers a protective "buffer" to shield them from their errors. This approach works well on limited access freeways but appears to be problematic on many urban arterials. The busiest of urban arterials can be the worst of all worlds in that they handle large numbers of vehicles at fairly high speeds while accommodating extensive access activities, especially if there are long commercial strips. This is a natural recipe for conflicts and accidents.

Some research contends that poor or incompatible road design can systematically cause drivers to underestimate risk. They may, for example, find themselves going faster than the speed limit without really realizing it. One local example is Kenilworth Avenue near the escarpment in a mostly residential area. While the speed limit is 50km/h, the wide-open thoroughfare gives the sense that higher speeds are acceptable. In terms of another example, albeit in a non-urban context, analysis of accident data revealed that rural roads within the boundaries of the City of Hamilton are some of the most dangerous in the City based on risk of fatality per incident. Such roads tend to generate high speeds mixed with numerous access points. Drivers appear to be underestimating risk levels and many judge their speed based on visual cues and "feel" rather than posted speed limits.

There are a variety of means that can be used to regulate urban traffic flows more effectively without unduly slowing traffic down. These include road diets which reduce lanes while providing space for bicycles and vehicle turns. Road diets tend not to work with 24 hour volumes well in excess of 20,000 vehicles per day. Narrower lanes can have a calming effect as well as green landscaping such as rows of trees close to a road. Improved landscaping by the road side can have a calming effect while also improving aesthetics that can boost real estate values. Roundabouts can help to maintain a smooth flow of vehicles while reducing conflict points and improving safety. Not only do these measures help to curtail the average levels of speeds, they also help to reduce variability of speeds which is also a factor in accidents. These measures can also cater to varied road users. For example, the antics of aggressive drivers are better contained while the driving environment is improved for older motorists.

The conventional wisdom seems to be that the biggest emphasis of complete streets is the pursuit of multi-modal trip making. This is certainly significant but we believe the most important avenue through which complete streets have an impact is in the improved regulation of driving behaviour. When this is accomplished, there is enhanced potential for other modes to thrive if the built environment/local context are in sync.

Connectivity and Access Versus Throughput

Another important element of complete streets is that they tend to emphasize connectivity over vehicle throughput. Clearly this links to the debate about one-way versus two-way travel. Trips on one-way networks are longer and this can be significant for shorter average trip lengths. When Hamilton converted to a one-way network in 1956, cab drivers were quick to note improved revenues for the same origin/destination pairings. Recent research is revealing that it may be more important to maximize the rate at which destinations are reached as opposed to maximizing vehicle flows on key links and secondly, that it is very important to do evaluations in a network-aware manner. Two-way networks with pockets for left turns fare better in simulations than was previously thought and there is little doubt that two-way networks improve connectivity. With fewer lanes of travel per direction and more refined rights-of-way, two-way networks better align with the traffic calming principles of complete streets. This is not to say that one-way streets are inappropriate in all contexts – they are a viable tool in the complete streets “toolbox.”

Automobility and Fears About Congestion

One reality that seems unlikely to change in the foreseeable future is that travel by automobile is ubiquitous and by far it is the most important mode in Hamilton as with almost all North American cities. Although not mentioned by many, the second most important “mode” in Hamilton is not public transit or walking or cycling. It is travelling by automobile as a passenger. For most of the street cases studied in this report, it has been observed that auto-passenger travel is generally 2 to 3 times more important than public transit in terms of moving large numbers of people. Perhaps this is indicative of untapped future potential for transit. Nevertheless, providing adequate, well-functioning road infrastructure for the automobile and also commercial vehicles in Hamilton is critical. But it is also important to consider the numerous cases where there is an over-supply of automobile oriented infrastructure.

With complete streets implementations there are often fears of traffic chaos from truncated supply of lane infrastructure and that demand will overwhelm the newly limited supply. As it turns out, people and road networks are quite adaptable. In the case of the 2007 Interstate 35 bridge collapse over the Mississippi River, the City of Minneapolis coped surprisingly well despite the worst fears. Overall, 1/3 of diverted traffic shifted to arterials, 1/3 used other freeway crossings and 1/3 of the former trips simply disappeared in the form of altered destinations, consolidated trips or changes in mode. The latter 1/3 reflects the phenomenon that Cairns et al. (2002) refer to as "disappearing traffic." The shift to public transit in the Minneapolis case was minor though. People much preferred to leave earlier and/or change their travelling route. The main message of the Minneapolis example and the concept of disappearing traffic is that road networks and the people who use them are adaptable. This does not mean that road diets and related complete streets concepts can be imposed with wild abandon. Disappearing traffic is the converse of “induced traffic” that takes place when new, perhaps excess, road infrastructure may spur an increase in automobile trips.

It is very important to note that complete streets are not about declaring “war” on the automobile or motorists. If that were the case, such streets would not be “complete” anyway. Consider that there are many documented cases where pedestrian malls, which ban automobiles entirely on the street, have reverted back to allowing vehicle travel.

Cycling

With respect to cycling, there are some places where demand is relatively high and other places where it is negligible and will be difficult to induce. Utilitarian cycling, as opposed to recreational cycling, has the potential to remove some vehicular traffic from the roads. Where possible, it is a good idea to attempt to aggregate cycling flows so that “safety in numbers” effects are achieved. Too much cycling activity close to heavy traffic results in the inhalation of harmful emissions – this reminds us that there are environmental considerations and that there is an argument for segregated infrastructure (e.g. trails) in some instances.

Cycling demand is also heavily influenced by the presence of adequate infrastructure along routes. Good cycling parking infrastructure is highly valued by cyclists and needs to be given high priority as part of how we view complete streets. Research in Vancouver has shown that cycling demand is much more sensitive to weather than more sheltered modes of travel and this is another factor to consider.

For cycling in Hamilton, a strategic, network-wide approach seems best so that the needs of cyclists are well-served whatever their origin or destination. In some cases this could mean building separated cycling infrastructure on busy urban arterials. For some arterials it could mean achieving a separation effect with paint. In other cases, the network might rely on bicycle boulevards which make strategic use of side streets that are less heavily used by automobiles. There will also be paved paths that are separate from streets that will be appropriate in many circumstances. Research has shown that cyclists will consider travelling a somewhat longer distance for a safer route.

The type of high-end dedicated cycling infrastructure that is seen on King Street approaching Westdale and on Cannon Street should be developed where appropriate and where justified in the context of the overall cycling network. Typically, painted bike lanes are useful and where vehicular traffic is lighter still, sharrows can be employed. Recreational-type trails such as the CP Rail trail are superb components of the overall cycling network and the bicycle boulevard concept is a useful one also where arterial cycling is less attractive. The over-arching concept is that Hamilton's cycling network should be considered as a whole.

Barriers and Complications

Relationship to the Built Environment

In balancing the supply and demand equation for each mode and location, the nature of the nearby built environment is really the dominating aspect. The components of complete streets constitute a relatively small share of what defines the overall built environment. The nature of the built environment really determines the potential modes and demand for travel in the area. There seems little doubt though that a poorly conceptualized street can stifle this potential and cause the "storage" of latent demand.

One of the more useful ways of thinking about the built environment and urban vitality comes from the work of Cervero and Kockelman (1997) and focuses on the role of density, diversity and design. Achieving high levels/standards for each is best for increased vitality. Complete streets can contribute over time to higher levels of population and employment density and to more diversity of activity and of travel modes and road users. In that complete streets tend to be more aesthetically pleasing, they are very much about improved design. It has to be very clear though that complete streets alone cannot create high levels of density or diverse/mixed land uses.

The study of complete streets has not been helped by its lack of stature within conceptualizations of the built environment. The extensive body of literature on the interaction between the built environment and travel behaviour is not a literature that deals specifically with the impacts of complete streets implementations. There has been practically no comprehensive and rigorous research that has focused on the social, economic and environmental impacts of complete streets. Some of the most detailed research that has been done on a “street-by-street”/”link-by-link” basis has focused on the safety benefits of more “livable” streets.

Related to context and the built environment is the matter of “self-selection” or the neighbourhoods into which people sort themselves. As it turns out, many people live in neighbourhoods that do not suit their preferences. For example, there are some people who would like to live in a walkable neighbourhood but do not and others who live in walkable environments but do not walk. Similar dynamics will be at play for cycling and use of public transit. There is thus a significant risk that efforts put into improved street design are essentially going to be without impact on a significant share of the population even if the built environment is well suited to an extensive complete streets treatment. On the other hand, it is possible that people will move into a neighbourhood that has received a significant complete streets makeover because it will suit their desired, active lifestyle. Of course, such transitions take time.

Auto Dependence

Perhaps the most imposing challenge of all is automobile dependence which has at least indirectly given rise to many modern built environments. Zhang (2006) found a 31% chance that the average Bostonian will not even consider an active mode or transit for a trip. In the retail context, use of the automobile means that consumers are free to consider a wider range of options when shopping and this can often mean travelling further than the nearest store. Local shopping areas of the type that can co-exist well with a complete street face severe competition from auto-oriented alternatives that feature diversity of selection and better prices from huge scale economies. Large segments of the population, including those who live in denser areas, will often drive further afield to pursue these retail opportunities. The automobile also helps with transporting purchased goods. Certainly a complete street can help a local neighbourhood strip capitalize on its strengths from a retailing perspective but there are many more challenges than there were 100 years ago.

Complete Street Outcomes

Taken together, the evidence supports the conclusion that among social, economic and environmental outcomes, complete streets are most impressive in the social realm. Complete streets are safer and reduce the chances of serious injury or fatalities. Such streets are also likely a contributor to improved local economic circumstances as they help to create the pre-conditions for more livable neighbourhoods.

However, while it can be disappointing for those looking for that one catalyst that can change everything in terms of neighbourhood revitalization, it is very unlikely that complete streets alone is that catalyst. Clearly, there are a host of other factors that affect rebirth of an area and there can be frustrating time lags involved. We see complete streets as one among many important ingredients that will incrementally move the City of Hamilton along the correct path to a prosperous future.

With regard to streets as economic enablers, it is probably fair to say that the existence of the street and its linkage to a road network accounts for perhaps 80% of the benefit. The other 20% derives from appropriate design elements, ability to handle trips of different modes and degree of connectivity. It is not hard to imagine that a doubling or tripling of fuel prices, for example, might have more impact on encouraging other modes of travel than a typical complete streets implementation. However, such a statement should not be seen as minimizing the importance of what complete streets have to offer.

Hamilton Street Cases

Complete streets concepts can apply most anywhere in Hamilton because they are sound concepts. At the minimum they improve safety and at the maximum they enhance the chances of improved economic outcomes and enhanced local vitality. Having said that, it is clear that certain of these concepts are best applied selectively depending on context (nearby built environment).

Before proceeding, it is important to note that complete streets will do a lot to address the needs of Hamilton's vulnerable citizens. Many do not own a car and complete streets are very helpful in facilitating travel by the active modes and by transit. Employment and social services become more accessible for all and travel becomes safer.

As part of this research, 15 street cases selected almost entirely by the City of Hamilton were examined. The analytical work relied on important third party data sets like the 2011 Transportation for Tomorrow survey and the Census of Canada as well information on individual traffic accidents as provided by the Public Works Department of the City. The analytical work was also supported by field study through which each of the 15 cases were visited in person. The 15 selections have been classified into five street types to assist in how to think about the cases.

Among the 15 cases and others within the City, the concept of the road diet could be more widely used. Research suggests that road diets can typically be implemented with 24 hour traffic volumes of less than 20,000 vehicles per day. There are several of the street cases that met this criterion. As such they are good candidates for road diets and other complementary measures associated with complete streets. There are several four lane arterials running in the north-south direction in lower Hamilton that have very light traffic volumes.

Overall, this research has suggested the greatest optimism for **Neighbourhood Commercial Strips** as candidates for a complete streets "makeover." This category includes the cases of Locke Street, James Street North and Concession Street (which faces more challenges). The research suggests that these cases provide the best potential for simultaneous boosts in vitality and in improved safety. The cases are highly visible and this means that they can promote the case for further application of complete streets concepts. There is potential to tame automobile speeds which were observed in field work to be excessive and to further improve the environment of these strips for pedestrians. These neighbourhood commercial strips should really be treated as precious entities. Everything that can be done should be to develop these cases to their full potential. Much has been done and this has created forward momentum but there is more that can be done.

In many ways, the most challenging of the cases are the two **Major Commercial Arterials** which are Upper James Street and Queenston Road. Of the two the former has higher traffic volumes and more intense commercial development. Economic vitality is not really the issue for these cases, especially along the more suburban locales. The problem is that these commercial strips are more like highways and indeed have higher traffic volumes than many provincial highways. They are highly oriented to the automobile and in fact are somewhat hostile to the active modes in particular. Pedestrians are few and far between despite reasonable pedestrian infrastructure and cyclists are rarely to be seen. Without significant investments that might seek to tame these stretches by using "collectors" lanes for access and "express" lanes for throughput, it would seem that regulation of speeds and the discouragement of dangerous behaviours such as cycling on sidewalks are possibly the best approaches for these challenging cases.

The **Major Arterial Thoroughfares** are cases where there is a current emphasis on moving significant volumes of traffic but there is less intensity of commercial development. Cases include Longwood Road, Kenilworth Avenue, Main Street, King Street, and Cannon Street.

For Main, King and Cannon Streets the historical interdependency is noted which was somewhat reduced with the conversion to one-way travel. At the time of conversion, volumes on King and Main surged and those on Cannon lagged – trip flows became more unbalanced. In retrospect, the conversions were likely a mistake but one that is easily explained by the trends of the time. Automobile ownership was rising rapidly and there was a focus on rapid vehicle flow as a worthy objective.

Outcomes from this report suggest that two-way travel is generally to be preferred as connectivity and access are the most important considerations for improving local vitality. It is part of what reshaping a city is all about. The ultimate conversion of Main and King Streets back to two-way travel could well prove beneficial but due to 1960's infrastructure investments where Hwy 403 meets King and Main, this possible conversion might be cost prohibitive. Nevertheless, Main and King are important gateways to the downtown and this needs to be taken into account in evaluations.

Even so, complete streets concepts can be applied to one-way arterials to achieve beneficial effects. High traffic levels are accommodated elsewhere in the city with many fewer than the five lanes of traffic we see on stretches of Main Street. There should be room to be more accommodative towards pedestrians, transit access and cyclists potentially while seeking out calming effects.

For a comparison, consider Wilson Street in Ancaster, extending to Main Street in West Hamilton and then to the intersection with Osler Drive in Dundas. This stretch is an interesting model that could be applied more widely in Hamilton. It features up to 19,000 vehicles per day of automobile traffic moving in a single lane per direction with left-turn pockets where appropriate and road diet implementations toward the east. The route is cycling friendly and there is good and safe access to public transit. In the higher density areas of this route, the pedestrian infrastructure is high-quality and inviting. Clearly Main St. near downtown Hamilton is much busier but Wilson Street is an interesting example indicating that quite a bit can be accomplished with few lanes of traffic.

The one-way stretches of Main and King Streets east of the downtown are less busy with vehicular traffic and thus all options seem viable for those stretches. However, while more intangible and difficult to quantify, Main Street's status as an important and highly visible gateway to the core of Hamilton could encourage a costly, large-scale conversion based on considerations of the city's image and perception to residents and visitors.

The development of high end, dedicated cycling infrastructure on Cannon is seen as good for Hamilton and an important east-west component of a comprehensive and well-functioning cycling network.

For the Longwood Road case, the biggest problem that is identified is the intersection of Main and Longwood. The intersection combines an awkward configuration with high traffic levels and an important regional role. A speculative proposal is made in Section 5.3.3 that could help to relieve peak period congestion at this important intersection and maximize the chances that a road diet approach could work on Longwood Road. Kenilworth Avenue has the highest traffic volumes of the north-south arterials in the lower east of Hamilton but could benefit from the traffic calming virtues of a road diet.

The **Central Arterials** covered include Dundurn Street, Bay Street and Queen Street. Traffic volumes on all of these are fairly modest by the standards of urban arterials which increases flexibility. Bay and Queen could be more extensively converted to two-way travel but there are challenges. For example, about 10,000 vehicles per day make a right turn on to Queen, and its two mountain-bound lanes, from Main and there are a lack of realistic alternatives for this flow if Queen were to convert to two-way. Further study would be needed on this specific case.

With respect to Dundurn, it is noted that along much of its length, this street has already made significant progress in its development as a complete street. Dundurn features an extremely busy section near the Fortinos plaza and there are large numbers of pedestrians in the vicinity. This section appears to be well-managed given the large volumes of activity, the constrained space and the fact that King and Main have one-way travel.

The **Suburban Arterials** include Gage Avenue, Melvin Avenue and Britannia Avenue. These are older suburban cases with their lower surrounding population densities confirming their status. They are largely residentially-oriented with Gage having more industrial and commercial. Traffic volumes are low. While measures can be taken to improve these streets they seem to be lower priority cases, especially Melvin and Britannia. Still, it is costly to maintain multi-lane road infrastructure, particularly when it is not being extensively used, and reductions in infrastructure to reduce these costs could be considered.

1

Introduction and Background

The central premise of this report is that streets play a significant and underappreciated role in shaping places. Depending on how they are configured they can potentially add life and vitality to a place or, in extreme cases, take the vitality right out of a place. It can be hard for people to believe that how lines are painted on the road, where concrete curbs have been poured and whether attractive landscaping is present can have such an impact. But this report will seek to show that these types of impacts are real and along with other factors, can play a significant role in shaping the future of places. The findings will be shown to be quite relevant for the City of Hamilton.

The built environment exists as one of the primary mediums through which people understand and interact with the city. At a tangible level, a city's built environment can provide links for travel between origins and destinations or create places to meet and socialize. But the built environment also has an intangible effect. Lynch (1960) noted long ago that the built environment can have a profound effect on a city's image, which at its simplest refers to the ways in which people encounter, interact, and evaluate the city in their minds. At a basic level, complete streets are about both the tangible and intangible properties of the built environment. The term is reflective of a broader effort to acknowledge and capitalize on the relationship between how we design our urban places and how these designs in turn affect the ways that people perceive these places and how they behave when using them.

From narrow, tree-lined lanes to multi-lane arterials, we are all familiar with various types of street design, but what exactly is a 'Complete Street'? While we explore this topic in more depth in Chapter 2, the basic sketch of how this is thought to play out is as follows. The concept of a complete street is somewhat subtle and nuanced but at a basic level the intent is to design multi-modal road-oriented transport corridors that influence the way people behave. At a minimum, non-residents are influenced by road design and immediate environment to slow down, pay more attention to their surroundings and to what an area has to offer. This outcome alone tends to increase safety.

At the maximum, current residents and businesses benefit from an urban environment that has the potential to better facilitate social and economic interactions. Non-residents may also perceive such an improvement in an immediate environment, at least partially due to complete streets measures, such that they may consider the area as a destination in and of itself rather than simply a path to another part of the city. This may result in them stopping to visit a store or ultimately choose to relocate and become residents themselves.

Clearly there are many interesting benefits to consider as part of a Complete Streets program, but how has the concept been received? The past several decades have seen a rapid adoption of Complete Streets policies in the United States and increasingly in Canada. In the US, more than 200 communities have adopted complete street policies as part of their land use and planning programs (Burden & Litman, 2011).

Following that interest, several municipalities in Canada started to officially adopt complete street policies. The City of Calgary, for example, included the policies on its official and transportation plan in 2009 and released complete street guidelines in 2011. Waterloo also adopted complete street policies in 2011. On May 2013, the city of Edmonton approved complete streets policies as the fourth city in Canada to do so. In 2009, the Toronto Centre for Active Transportation (TCAT) and Toronto Cyclists Union (TCI) started collaboration to bring complete streets policy to Toronto and as of 2013 city councilors passed a motion to scope the creation of complete streets planning guidelines. Finally in Hamilton, a number of important initiatives have taken place over the past several years that are related to complete streets, such as traffic calming and the provision of pedestrian and cyclist infrastructure, though at present no formal complete streets planning policies exist.

Many cities have engaged in complete streets planning or expressed interest in the idea. However, for the most part the actual implementations of complete streets concepts, as opposed to statements of policy, are at their early stages in North America and many municipalities, in their own unique contexts, are grappling with the potential for the concept. In response, planning for complete streets, both in Hamilton and elsewhere, stands to benefit from greater knowledge and evidence of complete street inputs and their social, environmental, and economic outcomes.

1.1 Purpose and Objectives

The purpose of this report is to assess the extent to which Complete Street concepts and practices can be effective in shaping the development of Hamilton in the years to come and to arrive at a sense of how all the parts fit together, how important the concept is, and how to think about it in Hamilton.

To accomplish this overall goal, the report is structured according to three main components. The first is a review of the elements or 'inputs' that make up complete streets. This consists of an assessment of the most important research that has been done on topics that are directly relevant to complete streets or on complete streets themselves. This important step is really the foundation of the whole report. The second is an evaluation of the outcomes associated with complete street elements, organized according to their effects on a number of social, environmental, and economic indicators. This stage is assisted by a review of outcomes from prominent North American implementations of complete streets. Finally, the third component is to evaluate some specific Hamilton street cases in light of what has been learned in the first two components and on the basis of available data which helps us to characterize the local cases. A concluding section will tie the material together and develop some insights on the topic which hopefully will be useful for Hamilton.

Elements of complete streets have been analyzed in specific contexts but there has been little done to unite all of this evidence in one place and comment on its implications for the concept as a whole. This report makes a contribution in that sense among others and helps to draw conclusions about how sound the basis for complete streets is and whether it is a comprehensive solution in its own right that generates significant social, economic and environmental benefits for cities.

1.2 Scope

Complete streets and all the issues that are tied into it is an enormous topic. To properly address the concept, many different literatures and lines of thinking ideally ought to be incorporated. It is quite possible that there are many other areas of inquiry that could be pursued outside of what has been done in this report to fully assess the concept. Nevertheless, we believe that this report has made progress in assessing complete streets from an objective and dispassionate point of view which moves past some of the agenda-driven discourse that is prevalent on the topic.

An important chapter of this report deals with an examination of selected Hamilton cases to judge the applicability of complete streets concepts. From a scope perspective note that these are not highly detailed case studies – the primary focus is on the locational context associated with each. While each case has been physically visited by the research team, for the most part many of the conclusions drawn about the cases are based on comparisons of available data such as census variables, the Transportation for Tomorrow survey and others. Combining these analytics with insights from the literature is allowing us to develop a prioritization of the cases for amenability/potential to benefit from complete streets.

With regard to complete streets, context is everything. It may be in some cases that an area's urban design was holding it back in one or more ways. But in others, any benefits from complete streets may be outweighed by additional challenges that cannot be overcome by urban design alone. While we are not likely to be able to determine a causal relationship between complete streets and particular outcomes, the emphasis in this report is on distinguishing those elements of context from case to case which essentially determine whether a complete streets implementation has a chance to make a difference or not. People have high hopes for complete streets as an economic revitalization tool in its own right and in fact there may be something to that line of thinking. While this report will attempt to address the importance of complete streets in this regard, the report will by no means carry out a detailed review of the urban revitalization literature.

Furthermore, this is not a report about the small-scale implementation details within those cases. For example, we will not be commenting on whether a curb extension, for example, should be implemented at some specific location or the specific design features of particular areas within the cases. We do hope to comment on the relative ability of the different cases to support multiple modes of travel in a meaningful manner or to perhaps support an improved, pedestrian-oriented retail landscape, for example, which would enhance vitality.

What is a Complete Street?

The term "complete streets" is a relatively new one, having been coined in 2003 (Clifton et al., 2012). Certainly, many of the concepts that are tied to complete streets are not new and have been around for decades, if not centuries. But what precisely *is* a complete street? At its most basic, a complete street is a concept. As opposed to one strict type of built form, the term complete streets refers to a broad package of elements, and the degree of 'completeness' of a street is determined not by the number or type of complete street elements in place but by the overall *balance* that its achieved between the users of an area and the activities that they engage in and the built form that supports these activities or, in some cases, suppresses these activities from taking place.

Working from this idea, the National Complete Streets Coalition defines complete streets as those designed and operated to balance the competing needs of all road users by enabling safe access for pedestrians, bicyclists, motorists, and public transportation users of all ages and abilities. Key elements are clearly multimodalism and accessibility for all road users. In a report focused on California, McCann et al. (2012) strongly emphasize the safety benefits of complete streets. Complete streets appear to complement and be complemented by other transportation and planning themes including sustainable development, smart growth, New

Urbanism, context oriented planning, traffic calming and transportation demand management (Litman, 2013). It can even be argued that the complete streets philosophy represents an attempt to revisit what was really already known about the vitality of urban places (Jacobs, 1961) but to do so in a way that accommodates the prominent role of the automobile in modern society.

But to return to the idea of balance, one way to understand the balance of a place is in the difference between 'mobility' and 'accessibility'. Mobility refers to the capability or potential to move people and goods between origins and destinations. Accessibility on the other hand refers to ease of access, such as the availability and effectiveness of different modes for facilitating travel. Mobility can provide accessibility, but it is itself not accessibility. Cities with low travel times can be high in mobility, but if there are no destinations that individuals value travelling to then accessibility is low. Likewise, a city with high levels of congestion may lack mobility, but if it features a high number of amenities within a short travel time then accessibility can be high.

Planning for mobility generally means attempting to reduce the frictions involved in travel, which can be improved by increasing speeds or widening roads for automobile users, or by providing alternative modes. In contrast, planning for accessibility means focusing on the end users of a transportation system by ensuring they can reach the destinations they value. Increasing accessibility can be accomplished through transportation strategies such as those that broaden the appeal and effectiveness of different travel options for individuals as well as land use policies that provide more destinations within a shorter travel time.

In many contexts, arguments can be made that planning for mobility has taken precedence over accessibility. However, Marshall (2004) is of the opinion that such a history of planning roads solely on the basis of prioritizing mobility has done a great disservice to society. Complete streets initiatives can help to rebalance the tension between mobility and accessibility to provide urban areas that maintain high levels of mobility but ensure access for all users of the road.

But if a street is in fact determined to be out of balance, how can it become *complete*? Fundamentally, there is no one-size fits all prescription for making a street complete. As Chapter 3 will show, the complete streets concept is made up of many individual elements. Furthermore, their applicability depends greatly on local context. As such, achieving 'completeness' depends on an assessment of the balance between mobility and accessibility, safety, and vitality in a particular area, and then a determination of which elements of complete streets can be employed to re-balance these characteristics and optimize social, environmental, and economic outcomes.

2.1 Why Complete Streets?

Ultimately, complete streets have a strong normative element in that they seek to achieve better urban outcomes. "Better" in the Complete Streets context typically means that roads and immediate surroundings will be safer, more inclusive for a diverse population and range of mode types, and conducive to greater overall vitality. The theme of equality and fairness to all users of the road is a dominant theme, but if complete streets are to succeed in these goals, there are three main types of users for which they ought to have an impact:

1. For the person who lives in the vicinity, a complete street could help to make the neighbourhood a better place to live;
2. For the person who lives elsewhere, a complete street may increase the chances that he or she will visit the area to work, shop or for some other purpose;
3. For the person passing through, a complete street may increase the likelihood that they will do so safely and responsibly and perhaps even consider taking up residence near that location in the future.

At a more general level, it is wise also to consider Dumbaugh's (2005) note that "the central purpose of cities – and thus the streets that serve them – is to agglomerate compatible developments together and encourage a great deal of access between them." Many would argue that the relative low densities of many cities are at odds with this most fundamental of urban objectives. Relative to the generally prevailing status quo of sprawled and segregated development and auto dependence, Complete Streets represent an attempt to "put the genie back in the bottle" to some extent through the use of thoughtfully designed urban corridors and roadways of the type that are associated with mixed use, more locally oriented development.

Streets in general, with complete streets being no exception, can be understood as being part of the built environment. After Handy et al. (2002), the built environment "comprises urban design, land use and the transportation system, and encompasses patterns of human activity within the physical environment." The transportation system, to be more specific, includes physical infrastructure such as roads, sidewalks and bike paths, among other elements. As well as potentially influencing travel behaviour, there is the additional possibility that the use of complete streets principles may influence other elements of the built environment.

2.1.1 Beneficial Trends Shaping Demand for Complete Streets

Litman (2013) argues that there is significant latent demand for complete streets in many communities as a response to current change in demographic and economic trends; such as aging population, rising fuel prices, increasing health and environmental concerns and changing travelers' behaviour. Below we outline several beneficial trends that are presently shaping the demand for urbanization, and by extension, a desire for more livable urban neighbourhoods through complete streets. Such trends are being felt across North America generally, but are unquestionably also affecting Hamilton specifically.

Reduction in Auto-based Trips

As of 2013, per-capita vehicle-miles travelled have declined for nine consecutive years in the United States according to data from the Federal Highway Administration. In contrast, the American Public Transit Association reported that Americans took 10.7 billion trips on public transit in 2013, the highest number of trips seen in 57 years. In concert with higher transit use is a general trend towards higher levels of growth in US central cities at rates that have outpaced those seen in more suburban areas according to data from the US Census Bureau.

There is some evidence that auto use may have peaked. Davis et al. (2012) argue that the trend towards lower VMT is particularly strong among younger individuals. Between 2001 and 2009, VMT for those between the ages of 16 to 34 decreased by 23%. While high gas prices and the global economic recession have no doubt played some role, the Davis et al. argue that the decline in VMT is occurring outside of just these factors and is helped by improvements in alternative transportation and changes in preferences. As such, they conclude that traditional transportation policies that have favoured road construction need to respond to the fact that less travel is taking place by car than before.

Population and Demographics: Empty Nesters

As the baby-boomer generation ages, its housing needs have started to shift. As parents age and children leave home, families that typically once required a single-family home in a suburban neighbourhood are increasingly finding this lifestyle choice impractical or even burdensome. In response, many of these individuals are choosing to downsize their home and own fewer vehicles, and a subset of this cohort has been found to value locations in dense, transit-accessible, and amenity-rich neighbourhoods (Dittmar, Belzer, & Autler, 2004). Such neighbourhoods provide a sound option for those in later stages of their lives, as access to amenities within walking distance or via transit can challenge the notion that increasing age means decreasing mobility. In Toronto, individuals aged 45-64 make up a significant and growing proportion of the population in the central city, a trend that correlates with this area's increase in new condominium construction.

Population and Demographics: Echo Boomers

The children of the baby-boom generation, the 'echo' boomers presently aged between 20-34, are also a significant determinant of the market for transit and transit-oriented living. Young individuals have consistently made up a disproportionate share of the populations of the densest areas in cities across the United States. The benefits of agglomeration to the young are based on the density of amenities, social contact, and opportunities to find and change jobs as their careers advance (Glaeser, Kolko, & Saiz, 2000).

Aside from these broadly influential economic factors, demographic shifts in the size of this cohort over time can have a large impact on the demand for housing of different types and in locations. Foot (1998) argues that the coming of age of the baby boom generation was responsible for a large increase in demand for inner city living in urban areas across Canada and the United States throughout much of the 1970s. For the echo-boomers, Ehrenhalt (2012) has detailed how a new generation of young people is increasingly exercising similar preferences to locate in the inner areas of US cities.

Data from the most recent Canadian census reveals similar trends in Canada, and the sheer size of this cohort no doubt helps to partially explain the new construction of condominiums in the inner city. In Toronto for example, the age distribution of areas with new high-rise construction is heavily skewed towards the echo-boom generation (Higgins & Kanaroglou, 2012). Nevertheless, it is unclear how the aging of the echo-boomers will impact the urban market. Foot argues that preferences for central city living are temporary, and will shift to suburban locations as these individuals get married and have children. On the other hand, Ehrenhalt believes the preference for central city living among this generation is more permanent and will not result in mass-migration out of the inner city.

Non-Traditional Households

Research in the United States has shown that non-traditional households are an important driver of the market for urban housing (Dittmar, Belzer, & Autler, 2004), and the Canadian census shows similar trends are occurring in Canada. Over time, the number of married couples has declined and common-law and lone-parent families have increased. Similarly, the size of average families has decreased from 3.9 in 1961 to 2.9 in 2011 and the average number of children per family has fallen from 2.7 to 1.9 over the same period. The number of single- and double-person households has greatly increased from approximately 31% in 1961 to more than 60% of all households in Canada in 2011. Such households are much more likely to be located in an urban area, and along with the other trends noted in this section, constitutes an important area for housing and transportation demand.

Immigration

Cities have traditionally been magnets for immigration. Statistics Canada's most recent census data shows that this trend continues. There is a particularly strong link between newcomers and Canada's largest cities, where 63% of the 1.2 million immigrants arriving between 2006 and 2011 settled in Toronto, Montréal, or Vancouver. While many choose to settle in more suburban locations, lower income levels typically mean many will settle in more central areas, own fewer automobiles, and utilize transit and walking for travel (Dittmar, Belzer, & Autler, 2004). Evidence in Canada suggests that new immigrants are much more likely to settle in higher-density locations and utilize transit, though as time passes the levels of transit use among these individuals gradually approaches the same levels as those that were born in Canada, suggesting an 'integration' effect (Heisz & Schellenberg, 2004; Turcotte, 2008). Nevertheless, this group is an important driver urban growth, transit ridership, and the value of highly amenable and accessible locations.

Local and Regional Urban Planning

Demand for urbanization is also being driven by policy and planning at the local and regional levels in Hamilton. Several important policy frameworks are in place to ensure that the GTHA, Greater Golden Horseshoe (GGH) area, and other municipalities across the province grow in a manner that is both economically efficient and environmentally responsible. Within the GGH, the foundation of this integration is the interplay between the provincial *Greenbelt Act,* the *Places to Grow Act,* and *Growth Plan for the Greater Golden Horseshoe*, all of which aim to shape how our cities accommodate growth through mandated population and employment density targets. Complementary to the land use planning side is the *Big Move* regional transportation plan that aims to both facilitate this higher density growth and improve mobility in the GTHA and wider GGH region.

Municipalities in the GGH region are required to bring their Official Plans in line with these regional directives through their review by the Ministry of Municipal Affairs and Housing. In Hamilton, the city will soon be required to achieve 40% of its new growth within the existing urban boundary. This has resulted in an Urban Official Plan that places a heavy emphasis on accommodating urban growth through infill development concentrated around designated growth nodes and along high capacity transit corridors. Should these targets be met, the City of Hamilton will see a growing concentration of residents in urban areas and will likely increase the demand for these areas to become more 'complete'.

Taken together these trends stand to increase the demand for urban growth. However, there is clearly potential endogeneity in this relationship, as it may be that some urban areas will only become more attractive to new infill growth if they are made more complete prior to an influx of new development and redevelopment. It may very well be that pre-emptive action in some areas may be required to enable these trends to fully take hold.

2.2 The Historical Context

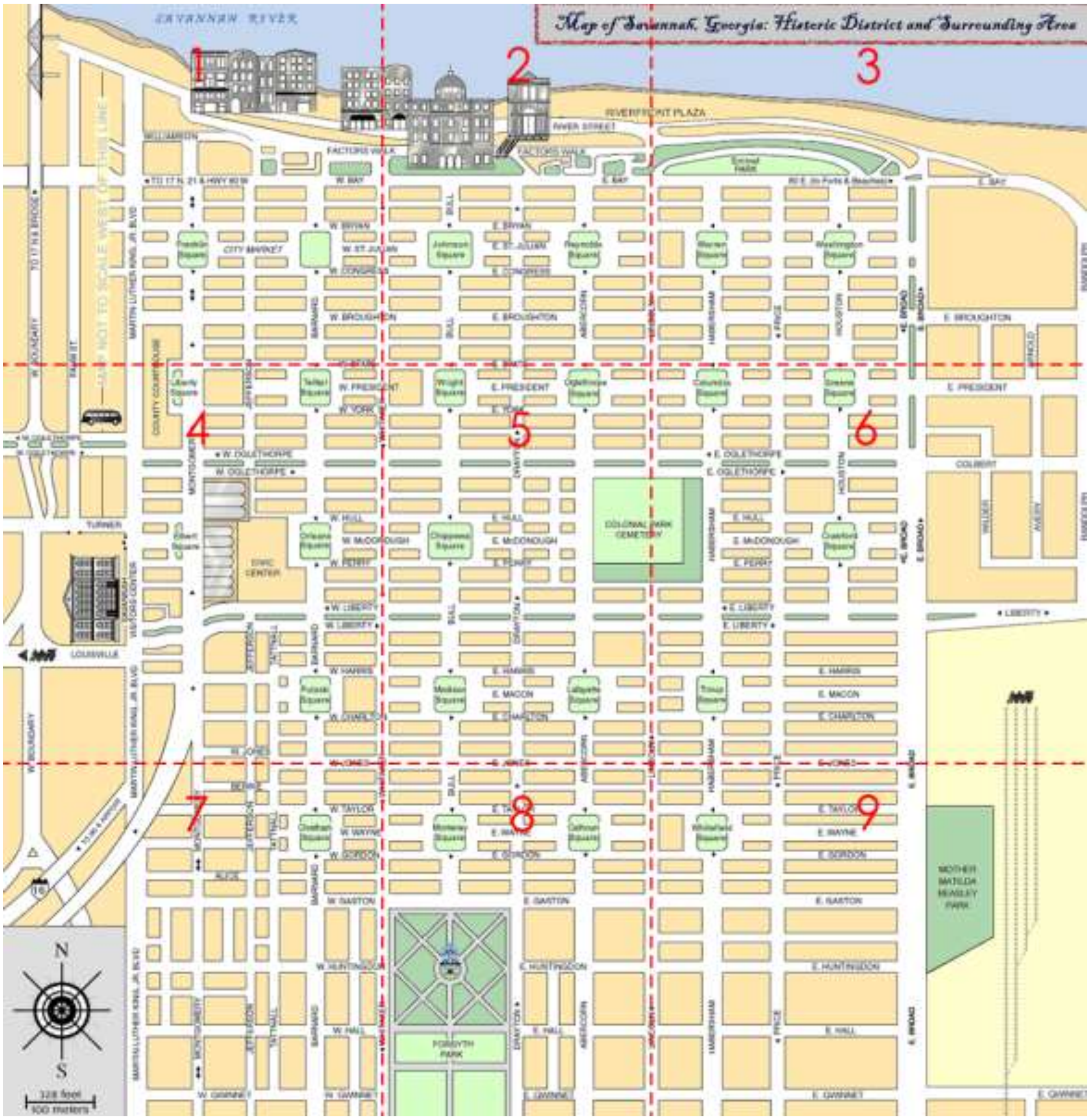
At a high level, there is no doubt that transportation generates various types of development - economic and otherwise. Great cities of the world have developed directly as a result of their location relative to key transportation routes. At the level of the city or metropolitan area, road networks (along with automobiles) have facilitated all types of developments that would have seemed far-fetched not much more than a century ago. Prior to the automobile, cities were noted for more intense development near to railways and public transit lines and many of these similar outcomes are being sought today in an effort to reduce automobile dependence.

Overall, transportation routes and networks have been a great enabler of development over time and it follows naturally that they have had large impacts on human behaviour. Some of these types of development have been planned and others have not or there have been unintended consequences. For example, traffic congestion and its unpleasant effects have come about largely as an unintended consequence of sprawled development and its associated road networks and automobile dependency. Fast-moving urban arterials have generated their own set of consequences as will be discussed later.

Since this report deals with the fundamental nature of streets, it is worth describing some “street history” from the past century or so. Dumbaugh and Rae (2009) provide an interesting historical account. The urban grid, which seems particularly familiar in Hamilton’s lower city, was popular in the 19th century in North America as it helped to promote rapid land development. The grids tended to feature blocks with uniform widths and equal intervals and maximized the number of premium corner lots. There was nothing too fancy about grid-based development and there was little in the way of variation. Savannah, Georgia is an interesting early example of a more advanced grid where public spaces or “squares” were actively incorporated into the street layouts (Figure 2.1) resulting in what many would consider to be a more “livable” environment.

In the early 20th century there was concern about the safety of grids as the automobile was rising to prominence. At the time there were two main safety ideas: 1) widen and straighten streets so that drivers are able to see far in advance and 2) reduce the number of intersections to minimize the chances for conflicts. Perry (1939) contributed work that marked the advent of modern community design. He promoted the idea of the neighbourhood unit of a few thousand people that could populate an elementary school and he also advocated the use of functionally-designed streets. The main premises were that there would be wide and straight arterial roadways to permit the efficient movement of motorists and that the overall network would be designed to prevent general traffic from entering residential areas. Land uses would be designed to reinforce functional separations. These were the seeds of modern (many would say sprawled) suburban development which tended to discourage mixed uses and was residentially premised on large lots with abundant space.

Figure 2.1: The Use of Streets and Squares in Savannah, Georgia



Source: Savannah Getaways and PRN Solutions

It has been becoming increasingly clear that streets and their layouts play a formative role in structuring the setting for urban design (Marshall, 2004) and that there is a strong need to aim for better “placemaking” without compromising the pillars of circulation and access. This line of thinking extends back to Jane Jacobs (1961) who was outlining these central tenets of streets as the lifeblood of cities at a time when many of her contemporaries were embracing concepts of Modernism. Marshall colorfully points out that Modernism “filleted” the city by stripping out the spine and ribs from the urban flesh and setting up the road network as a separate system where the most important traffic routes were no longer streets. In many ways, Complete Streets seek a return to the more human-scale urban development patterns seen in many cities throughout history.

3

A Review of the Complete Streets Concept

The concept of Complete Streets purports to offer many benefits to host cities, from safer environments and healthier lifestyles to new residential and commercial development and economic growth. But what does the evidence say as to the effects of complete streets on outcomes such as these? The truth of the matter is that there is little in the way of high quality research that *directly* attributes such outcomes to complete streets measures. This does not mean that complete streets are not important, it simply means that the concept has not been the main focus of research. The lack of work on the impacts of complete streets may also reflect a shortage of the data required to do such analysis. Data on census areas is easier to come by than data on the urban street links that tend to form the boundaries of these census areas.

Nevertheless, the concept of complete streets is really a package constructed of many individual but complementary elements or 'inputs' that go into making a complete street what it is, and there is a large body of research offering insight into each input individually. It thus seems logical that taken together, the effects of these individual parts can shape the outcomes of the concept as a whole. To arrive at an evaluation of complete streets as a concept in Chapter 4, this section first analyzes the research associated with each particular characteristic of the complete streets concept. As mentioned in the scope definition, many of these elements will be higher level considerations as opposed to highly specific design details.

There are certain key questions that we seek to keep in mind about each of the elements:

- Are the elements well-aligned with what complete streets seek to achieve or are there some inherent contradictions?
- How effective are the elements in achieving the goals of complete streets and is their sufficient evidence to really say?
- Are there certain elements that are overrated in what they can achieve versus others that are underrated?
- Are their important obstacles that hinder the ability of the elements to contribute to the goals of complete streets?

3.1 Traffic Speed and Safety

One of the primary goals of complete streets is to increase safety for all users of the road, both for those utilizing alternative modes to the personal automobile, and for road users of all age groups. To achieve this goal, the literature is quite clear: if eliminating deaths or permanent injury is one of the primary objectives of a road transport system, then speed is the most important element to regulate (Frith, 2012).

Indeed, the traffic safety literature suggests that, especially in the urban context, just about anything that reduces speeds is likely to improve safety (Aarts & Schagen, 2006; Anderson et al., 1997). There are some points that are of particular importance for the urban context. For one, it has been found that crash rates increase faster for a given increase in speed on minor/urban roads than is the case on major/rural roads (Aarts & Schagen, 2006). Also of relevance for the urban context is that the risk for pedestrian fatality ramps up rapidly in the range of 30 to 50 km/h with the latter being associated with five times the level of fatalities in the event of an accident (Rosèn & Sander, 2009). In the event of large commercial vehicles, of course, risk levels rise to another level entirely. Figure 3.1 illustrates the energy that is involved with different speeds and vehicle types. The non-linear relationship suggests that even small reductions in speed can reduce kinetic energy at an increasing rate.

Because speed is a primary determinant of safety for urban streets, complete streets programs often make use of a suite of measures designed to calm traffic (Table 3.1 and Figure 3.2). Such measures are designed to increase the 'cognitive load' on drivers by making the roadway more 'unforgiving' to drivers (Godley et al., 2004). To explain this, consider the design of highway systems and their influence on the design of many urban arterials: according to Dumbaugh

(2006), the North American approach of using "forgiving" designs for urban arterials, that offered drivers a safety buffer, emerged from the observation that the newly developed Interstate system in the U.S. was leading to lower rates of crashes and injuries than other roadway types despite the very high speeds of freeways. Interstates are designed to be forgiving of driver error by providing a safety buffer for drivers through wide lanes, wide shoulders, guardrails and separated traffic flows, and other design features. In particular, interstates eliminate sharp, high speed turns in favour of controlled access ramps which permit gradual merging and acceleration/deceleration of traffic.

Figure 3.1: Kinetic Energy by Speed and Vehicle Type

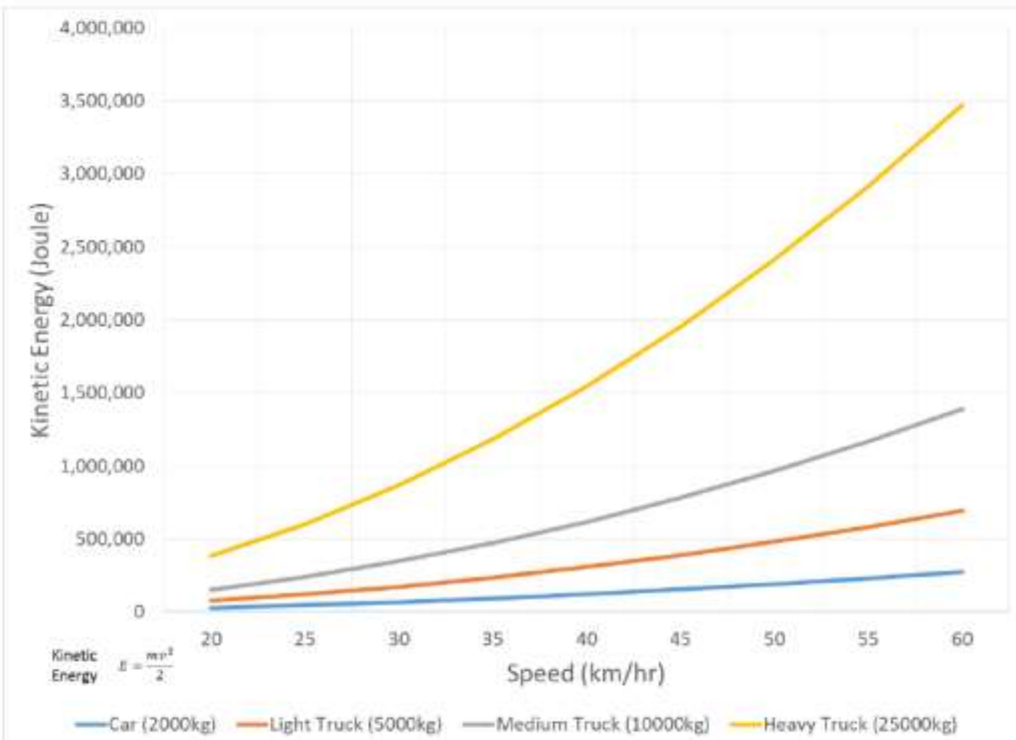


Table 3.1 The Range of Speed and Safety Measures

Broad Physical Changes	Vertical Deflection	Horizontal Deflection	Restricted Access	Enforcement
• Narrow lanes • Reduced turning radii • Lane reductions / road diets • Pedestrian refuges • 2-way conversions • Road markings • Road-side landscaping	• Speed bumps • Speed humps • Speed cushions • Speed tables • Road material changes	• Chicanes • Curb extensions • Chokers	• Pedestrian mall	• Speed limits • Speed cameras

Figure 3.2: Common Traffic Calming Measures

Dumbaugh (2006) contends that there are inherent problems in applying the “forgiving” approach in the context of urban arterials. Because an arterial has to handle a fairly large number of access locations, he suggests that there are two possible safe approaches: either minimize or eliminate turning maneuvers, which is essentially the "Interstate" approach, or reduce operating speeds through the tactics of complete streets. Interestingly, Dumbaugh notes that there are isolated cases where option one is being pursued and the principles of access management that are used for highways are being applied to certain high-volume arterials. No matter which solution is pursued, the dominant message from Dumbaugh is that accidents are often not simply a result of random human driver error. Instead, he contends that in many cases there are systematic design errors where the roadway design is poorly matched to the actual use of the road.

Such road design can have unintended consequences for other users of the road. If the design of highways influences drivers to feel comfortable at higher speeds, the adoption of such designs on urban arterials may subconsciously influence drivers to exceed legal limits and potentially adopt speeds that are higher than what might be desirable for the local context. Traffic calming measures on urban arterials such as those in Figure 3.2 seek to overcome these design issues by influencing drivers to adopt lower speeds both directly through interventions in the layout of the road itself, and indirectly through psychological cues, and such tools have had a proven effect on reducing the speed of automobile travel and increasing safety.

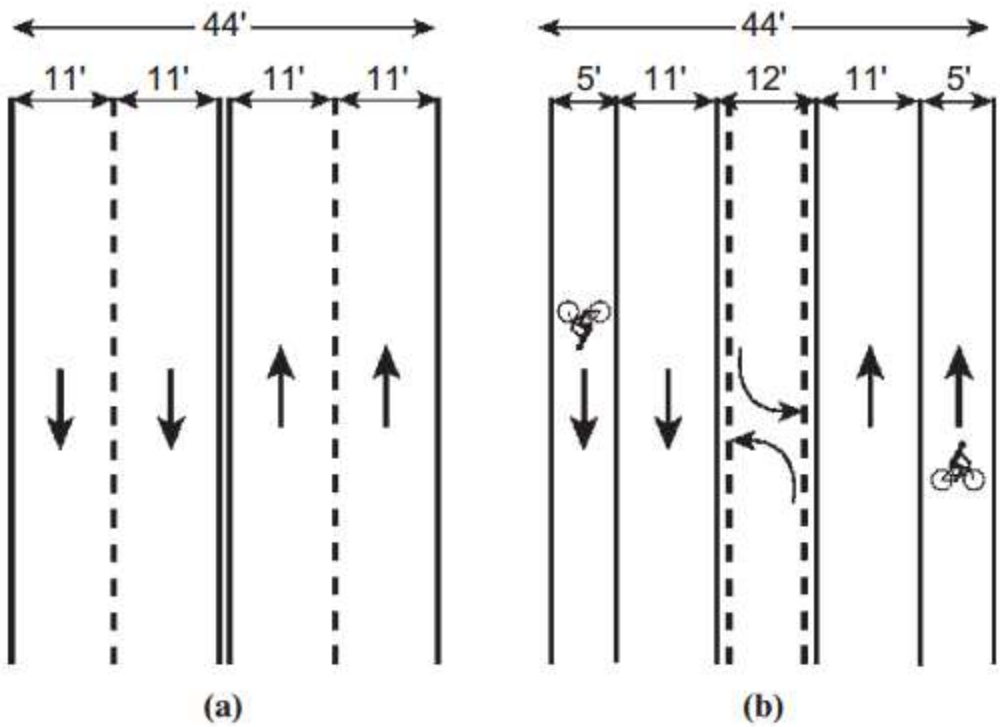
3.1.2 'Road Diets' and Balanced Provision of Space for Private Automobiles

The retrofitting of a complete street is primarily achieved by reducing excess space for the automobile through the use of alternative road layouts that re-allocate lanes and lane spacing. Road congestion is by no means viewed as a desirable outcome. Instead the objective is to achieve an appropriate and balanced allocation of space in accordance with transportation needs and local context.

The idea of managing the space for the automobile is sound from the point of view that research has shown that 75% of drivers tend to exceed posted speed limits (Dumbaugh, 2006). Many suspect that this type of behaviour is not consciously being pursued by drivers but that the visual cues of the road and the roadside communicate that it is okay to travel faster. Some contend that even "safe" drivers can find it hard to comply with posted speed limits in certain road design contexts. We explore the research on many of these initiatives in greater detail below,

The most common type of space reduction for the automobile on urban arterials is known as the "road diet" where four lanes of traffic for automobiles are reduced to three with the middle lane accommodating turns in both directions (shown conceptually in Figure 3.3 and in practice in Figure 3.4). The freed up space is most typically used to accommodate separate space for cycling, on-street parking, and wider sidewalks. A road diet is a fairly basic form of a complete street where in some cases the only changes have to do with lane markings but it is a useful lens through which to view the effects of regulating space for the automobile. Some of the best candidates for road diets appear to be arterials with four or more lanes in total but relatively modest traffic volumes. A number of largely public sector sources have offered discussion on road diets (Burden & Lagerwey, 1999; CDOT, 2012; McCann et al. 2012; MDOT, 2012; Welch, 2001) although there has been less discussion in the academic literature.

Figure 3.3: Layout of (a) Standard Arterial versus (b) Road Diet



Source: Pawlovich et al. (2006)

Tan (2011) provides an overview of how road diets can be useful. It is noted that road diets are most effective on arterials that have a significant number of left turns and short blocks. Under those circumstances a road diet can be effective with traffic volumes of up to 25,000 vehicles per day. On freer flowing stretches, road diets are seen as most effective with lower traffic volumes (up to 18,000 vehicles per day). Road diets with volumes of up to 30,000 vehicles per day have been tried. Knaap et al. (2003) explore road diet implementations through a simulation approach and suggest that there begin to be operational concerns at and above 875 vehicles per hour per direction which is consistent with the daily totals for both directions mentioned above.

Much of the academic research on the concept of the road diet is focused on safety outcomes. At its most basic, a road diet that reduces the number of lanes from four to three lanes reduces the number of lanes a pedestrian must cross, and Zegeer et al. (2001) have found fewer automobile-pedestrian collisions after road diets have been implemented. Other studies reached similar conclusions: Huang et al. (2002) undertook controlled experiments at a dozen road diet sites and about 25 comparison sites in California and estimated accident reductions of

6% despite a general increase in traffic at all sites of between 6-10%. Pawlovich et al. (2006) undertook similar work for a large number of cases in Iowa with a temporally more extensive data set and found a 25.2% reduction in crash frequency per mile and an 18.8% reduction in crash rate. The general consensus among practitioners is that road diets have significant safety impacts that are more in the range of this latter study. Pawlovich et al. actually spend time discussing the relatively muted safety improvements of Huang et al. and suggest that perhaps the earlier set of results were based on insufficient data in terms of the time period covered.

It stands to reason that removing or altering the layout of a road's lane orientation can offer additional benefits such as cost reductions for maintenance by subjecting less area to heavy traffic, improved driveway access for residents and businesses, increased parking, and more space for cycling or rapid transit lanes.

Figure 3.4: Road Diet on Delaware Avenue in Buffalo, NY

Lane Widths

While reducing the total number of lanes for automobile traffic is most common, reduction of urban arterial lane widths can also be used as a tool in addition to or as an alternative to removing lanes. The technique seems counter-intuitive in that less space could be seen as translating into more vehicle conflicts but the work of Potts et al. (2007) suggests that there is substantial scope to consider lane width options of less than 3.6 metres (10 feet) and that 3 metre lanes are quite workable in most circumstances. On four lane divided arterials, it is suggested that lane widths as little as 2.7 metres (9 feet) are possible.

Manuel et al. (2014) suggest for daily traffic volumes above 4,000 that standard sized roads are much safer than oversized roads. Similarly, Fitzpatrick et al. (2001) studied design factors that affect driver speed on suburban streets and found that as lanes got wider, speeds tended to increase. However, posted speed limit was found to have a stronger relationship with observed speeds than lane width alone.

Whether the approach is fewer lanes for cars or narrower lanes or both, the evidence suggests that there is a regulating effect on the behaviour of traffic and that one of the important by-products of better managing space for the automobile is improved safety. There is evidence that fewer lanes help to reduce speeds and also to reduce the variability of speeds which is another important safety element (Aarts & Schagen, 2006; Welch, 2001). With reduced lanes there is less potential for vehicle interactions in the form of vehicles passing one another (Navon, 2003). Essentially, alternative lane designs can help to reduce the potential for aggressive driving.

3.1.3 “Unforgiving” Road Sides

Our review of the literature suggests that arguably the most important element of what makes a street "complete" may not even be so much the road itself as it is the nature of the road side. This line of thinking is relatively new or at least not well known, especially in the North American context, and is somewhat counterintuitive in the outcomes that emerge. The main idea is that an effective complete street is one where road sides are "unforgiving" towards drivers (Dumbaugh, 2006; Dumbaugh & Gattis, 2005). The details of how this line of reasoning comes about are explained below.

Road Safety and Urban Context

In New Hampshire, Ossenbruggen et al. (2001) examined 87 road sites of varying contexts in a study that yielded surprises to the researchers and local officials. Police accident reports for 892 crashes at the sites over a five year period were collected and a detailed analysis of the characteristics of the 87 sites was developed and used in a statistical model to explain the accidents. The 87 sites, none of which were in any large metropolitan areas, were classified into three main land use types (45 were residential, 29 were shopping and 13 were described as village).

There were hypotheses amongst the researchers and pre-conceived notions among local officials that the village sites would prove to be most hazardous given concerns about much higher pedestrian density and vehicles speeding through the areas at a rate too fast for the surroundings. This is not what happened. The expected number of crashes (and injury crashes) were found to be almost two times more likely at a shopping site relative to a village site. The researchers concluded that at the village sites the infrastructure and circumstances (high pedestrian traffic, vehicles parked on the street and traffic control devices) systematically "warn" drivers to slow down. They further concluded that these elements were not encoded into the immediate environment at residential sites and especially less so at shopping sites.

What these researchers were latching onto, in the context of urban arterials, was related to an important trend that had already emerged in Europe in the 1970's (Kjemtrup & Herrstedt, 1992). The concept called "Woonerf", which translates to "living yard" or "living street", used visual cues about the immediate environment to calm traffic in residential areas so that children could safely play in neighbourhoods (Figure 3.5).

Figure 3.5: A 'Woonerf' or Living Street

The core idea of the concept was that it was not necessary to segregate vehicles and people but to design the immediate environment so that they could co-exist without people feeling threatened by the vehicles. As it turns out, this idea that people and vehicles can co-exist, under the right set of circumstances, translates reasonably well to the context of many urban arterials although speeds are significantly and unavoidably higher than in Woonerf contexts.

Application to the North American Arterial

Hamilton-Baillie (2004) provides an interesting overview of European thinking on the topic of using urban design to regulate traffic behaviour and how urban design and traffic engineering might work together to achieve complimentary goals. The emphasis of this work is that intelligent urban design can be used to clarify for drivers whether a given route is in the "traffic zone" or the "public realm." In the latter case, the visual cues of the built environment are used to regulate driving behaviour to a greater extent than traffic signals. This type of thinking is consistent with the Complete Streets philosophy and can actually enhance flow in many cases without sacrificing connectivity.

However, in the realm of the North American arterial, the vision of using the road side as a tool to regulate driver behaviour has been slow to take shape. Of particular interest is the use of an area that forms the road side and is referred to as the "clear zone." Naderi (2003) defines the clear zone as the area of the roadside where pedestrian activity intersects with driver perception. For many North American arterials, the idea of the clear zone has been to have it live up to its name by keeping it as clear of obstacles as possible and give drivers as much of a safety buffer as possible. The focus was on the drivers, not the pedestrians, who in many cases were not provided sidewalks anyway.

The first phase of Naderi's study examined stretches of some busy arterials in Toronto such as Yonge Street, Steeles Avenue and Ellesmere Road among others. The work sought to evaluate the effect of "Green Street" landscaping improvements that had taken place at certain locations between 1992 and 1995. Results suggested that in general these stretches were safer in terms of mid-block traffic incidents and that the economic value realized from reducing accidents at these locations paid for the landscaping improvements in short order.

3.1.4 Traffic Calming and Attractive Design

In the process of making road sides more unforgiving (and safer), they can also be made more attractive. Dumbaugh and Gattis (2005) studied stretches of Colonial Drive in Orlando, Florida and found that this busy arterial had improved safety outcomes at its most “livable” sections. In particular, over the time frame of the study, the most livable sections had zero fatalities and significantly reduced injuries

Part of what makes a roadside attractive is the positioning of trees close to the road. Trees have been highlighted as an often important element of what makes a complete street. There is evidence that strategic positioning of trees can actually have a calming effect on drivers which helps to keep driver frustration in check (Cackowski & Nasar, 2003) but more importantly these same trees have a traffic calming effect as the perceived threat of large roadside obstacles causes drivers to be much more wary of the implications of possible collisions with immovable objects (Dumbaugh, 2006).

Figure 3.6: Urban Arterial and Fixed Object Risk (A) and Safe Urban Roadside Treatment (B)

Source: Dumbaugh (2006)

However, Dumbaugh (2006) argues that some design elements can greatly increase the potential for conflicts between vehicles or with road side structures if not done correctly. Dumbaugh presents visuals that highlight his points(Figure 3.6).

In panel A, a visually “wide-open” major four lane arterial joins to a side road and there is a utility pole at one corner that could easily be hit if drivers’ turn onto the side road at high speed. The visual cues are such that high speeds are implicitly encouraged, but the placement of such obstacles increases the risks of road side collisions. But in panel B, mature trees are spaced every twenty yards or so very close to a three lane roadway. The road itself is shaded by all the foliage and it is quite clear to the driver that there are large, immovable objects near the road that would stop forward movement abruptly and violently if struck. Since the second case looks “more dangerous” Dumbaugh contends that drivers are far less aggressive in their driving behaviour and thus safer. Apparently the safety statistics for these respective stretches of road back up the hypotheses.

Trees have also been linked to positive economic impacts in urban contexts. Laverne and Winson-Geideman (2003) investigated the effect of trees and landscaping on the vitality of office buildings and found that they increased real estate values. Likewise, Gorman (2004) finds that urban residents value the presence of street trees. The use of trees to landscape a roadside has also been found to raise residential property values. Using hedonic models, Donovan and Butry (2010) found that street trees added $8,870 to the sales price of a house while also reducing its time on the market. In a later study, Donovan and Butry (2011) estimated that street trees were about four times more effective than lot trees for increasing rent. The former increased rents by $21 per tree. On this basis, they suggest that investments in urban forestry by the public sector are likely to more than justify the costs. They also note that only about 1/3 of the houses in their Portland sample had street trees which suggest some untapped potential to increase real estate values. However, according to Sullivan and Daly (2005) though, trees must be used more cautiously in the context of the medians of urban arterial highways where they apparently reduce safety rather than improving it.

The use of street trees appears to be the most predominant research topic in the literature. But in general, streetscape improvements in addition to trees such as light poles, improved lighting, hanging banners and baskets, street furniture, and median landscaping are often the focus of local improvement programs funded through tax-increment financing (TIF). Such programs have become popular in cities across the United States, and research by Smith (2009) has shown that price appreciation does indeed occur faster at such TIF sites compared to others without any improvements in Chicago, suggesting that the benefits of such investments are priced into the real estate market.

In conclusion, on a complete street it is a desirable thing for the road side to be unforgiving of drivers. They are stimulated by the road side environment to remain alert and vigilant as opposed to being relaxed and complacent. Fortunately, in the context of making a road side less forgiving, it is possible to also make it more attractive and functional for pedestrians and thereby accommodate the potential to generate more pedestrian activity.

3.1.5 Vertical and Horizontal Deflection Measures

Traffic calming as part of Complete Streets can also include a number of additional vertical and horizontal deflection measures, such as speed bumps, speed humps, speed tables, chicanes, bump-outs, or rumble strips. In general, such measures have been proven to reduce speeds and thus increase safety. For example, Cottrell et al. (2006) investigated the effectiveness of speed humps and speed tables installed at 18 different locations throughout Salt Lake City, UT. The researchers found overwhelmingly that the changes reduced speeds and increased speed limit compliance. The changes also produced a slight reduction in automobile collisions, however the overall reduction in speed meant that there was a large reduction in injuries in these collisions. Opinions of local residents were split, with 30% positive and 25% negative feelings to the changes.

However, these types of traffic calming measures are not well suited to all urban arterials. This is especially the case for those serving commuters and commercial and emergency vehicles, though many calming measures are designed to permit large emergency vehicles to pass through them relatively unencumbered. Elvik (2001) provides a meta-analysis of a series of research papers that have been published on the safety implications of area-wide traffic calming and finds that from a safety perspective such schemes are especially effective on local streets and less so on main roads. And as Archer et al. (2008) explain, there is also the potential for traffic calming measures to result in unwanted migration of traffic to less suited nearby streets. On the other hand, Topp (1990) notes that the tendency to focus so much traffic on main arterial streets is socially unjust, and Garrod et al. (2002) find that nearby residents who live near such main routes are "willing to pay" for traffic calming to improve their immediate vicinities.

3.2 Emphasis on Connectivity and Access over Throughput

With the rise of the automobile as the dominant form of transportation in Canadian and US cities, accommodation of large traffic flows in and of itself was thought to be an important element in ensuring a well-functioning urban area. Complete Streets de-emphasize this element to some extent. While they are aimed at funneling significant volumes of vehicular traffic, this is not done at the expense of connectivity and access. Handy et al. (2002) define connectivity as the "directness and availability of alternative routes from one point to another within a street network." Of course in many complete streets contexts, the road network is already there so the degree of connectivity becomes a question of how traffic flows are directed and controlled.

3.2.1 One-Way and Two-Way Streets

One of the interesting topics in this context of connectivity and access vs. throughput is the use of one-way versus two-way streets. In the post-war period, many North American cities converted important arterials to travel in one direction, consistent with a traffic engineering mindset that the most important objective was maximization of vehicular traffic flow. Indeed, Cunneen and O’Toole (2005) provide an overview of this viewpoint and suggest that there are other benefits such as improvements to safety. Even most complete street advocates have been willing to concede that one-way networks likely handled large volumes of traffic better. But they argued that maximizing flow is not the most important objective anyway.

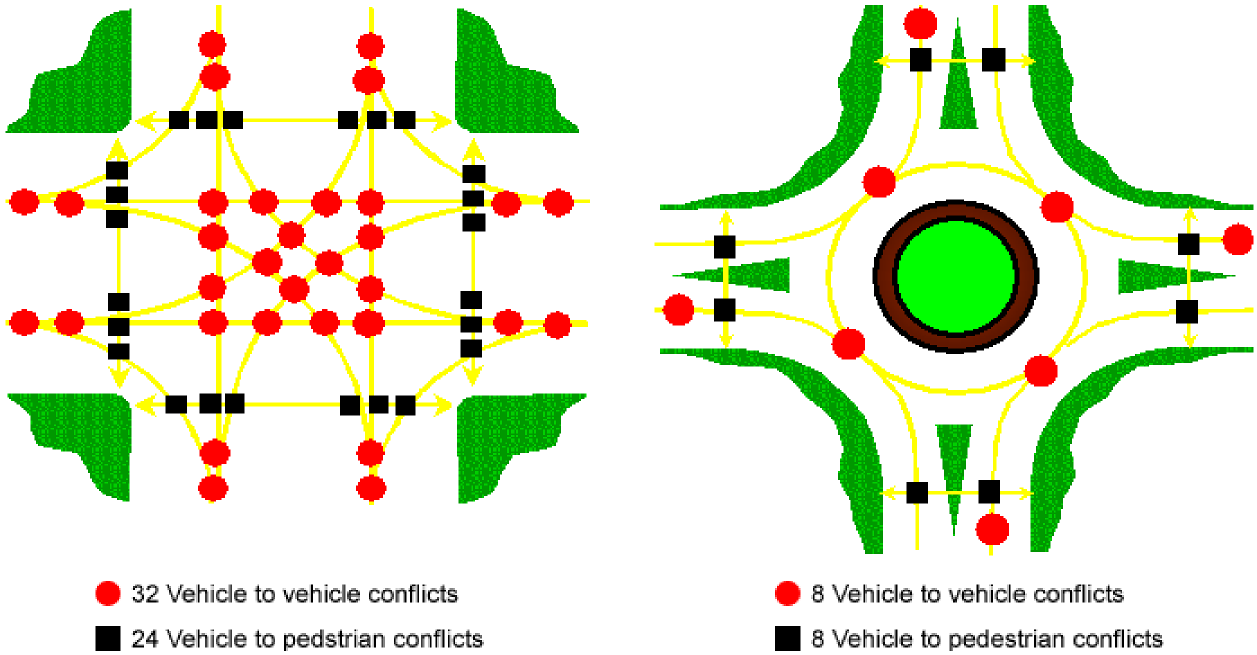
New work based on traffic simulation models suggests that two-way networks might be more efficient than previously thought. Gayah (2012) and Gayah and Daganzo (2012) point out that much of the work that attributes superior vehicle flow characteristics to one-way networks has in fact been site-specific and has not been sufficiently network-oriented. They contend that the ultimate efficiency objective is not to move many vehicles (an emphasis on mobility), but to maximize overall accessibility, or the rate at which large numbers of people reach their destinations. In the sense that one-way networks often cause drivers to take less direct routes, they reduce the rate at which destinations are reached. This problem is especially acute for shorter average trip lengths. The one critical advantage of one-way streets is that they eliminate conflicting left-turn situations at intersections. Gayah (2012) notes that two-way networks can compete reasonably well in this regard through left turn "pocket" lanes (as long as there is not too much dedicated traffic signal time for the left turns) or by doing away with left turns altogether in the case of larger cities. Roundabouts may also help in this regard, and we discuss them further below.

There is no doubt that the complete streets philosophy is more oriented to two-way travel and that many cities have been making conversions from one direction of travel. For example, Hart (1998) provides an overview of the conversion that took place in Lubbock, Texas and the generally favourable outcome. Most observers link two-way travel, and its improved connectivity, to a more livable street environment. Song and Knaap (2003) find that some of the street connectivity elements of New Urbanist design are important contributors to capitalization in housing values. In contrast, multiple lane one-way streets are in many ways associated with the traffic symptoms that road diets and other traffic calming measures explored above seek to address: excessive speeds, more potential for aggressive driving behaviour, greater risk of pedestrian injury, and an unwelcoming pedestrian environment (Burden & Lagerwey, 1999).

3.2.2 Roundabouts

Another potential measure for improving safety and traffic flow is that of the roundabout. Environmentally, there is no doubt that roundabouts reduce emissions as they reduce accelerations from a standing start (Mandavilli, Rhys, & Russell, 2008). In terms of safety, roundabouts reduce potential interactions among and between automobiles and pedestrians (Figure 3.7). However, the major exception is for cyclists as roundabouts appear to be worse (Daniels et al., 2008; Daniels et al., 2010). This is primarily a result of drivers not being able to see cyclists as well as they do at controlled intersections or cyclists may not yield properly (Mandavilli, Rhys, & Russell, 2008). Some contend that if properly designed, roundabouts can be safer for cyclists as well. Recent work by Gross et al. (2013) suggests overall significant safety benefits from converting signalized intersections to roundabouts. McCann et al. (2012) report on a San Diego example where the installation of roundabouts was the main change in an area where retail sales were boosted. Overall, roundabouts are less commonly mentioned as an element of complete streets but seem consistent with the philosophy. The potentially negative safety outcome with regard to cyclists shows that there can be tradeoffs to consider with any change.

Figure 3.7: Conflict Points at a Four-Way and Roundabout Intersection



Source: FHWA (2007)

3.3 Emphasis on Active Travel: Cycling

Most written pieces on Complete Streets place a strong emphasis on the role of cycling. If pictures are included in such pieces, they will typically show bicycling lanes as an integral part of what makes a complete street. The purpose of this section is to assess whether this strong apparent tie between cycling and complete streets has merit. For example, can a street be "complete" if it does not have cycling lanes?

3.3.1 Cycling and Health and Safety

From the perspective of health impacts, it is not easy to argue against cycling and the possible inclusion of cycling infrastructure in a complete street. de Hartog et al. (2010) determine that "without a doubt" the health benefits of cycling outweigh the risks. Some research has gone so far as saying that cycling seems to produce positive spillover effects by encouraging healthier behaviour in nearby residents, not just the relative few who commute by bike (Brown et al., 2013). Gotschi (2011) implements a framework that involves elements such as savings on health care costs that are facilitated by healthy cyclists and applies the framework in Portland. The results are positive for cycling. One of the potential health-based arguments against special accommodations for cyclists, at least in some circumstances, has to with cyclists being present on streets that are heavily travelled by pollutant-emitting vehicles. All things being equal, there are few cyclists who would prefer to cycle in such an environment if they could possibly avoid it, not to mention the physical dangers of nearby large and fast-moving vehicles.

A significant point in cycling’s favour is that its very presence appears to generate safety benefits. In general this is known as the “safety in numbers” hypothesis. Jacobsen (2003), using aggregate level data, showed that places with large numbers of cyclists and walkers have lower collision rates involving conflicts between vehicles and active travelers. He notes that fatality rates for incidents involving cyclists and pedestrians are quite similar in the Netherlands and the United States even though cycling is several times more prominent in the former. According to the work of Marshall and Garrick (2011) in California, cycling serves to protect all road users and not just cyclists. Most safety benefits seem to stem from a traffic calming effect generated by the presence of cyclists and the more the better. Recent research in New York City by Chen et al. (2012; 2013) supports the notion that even as bicycle lanes are added and the number of cyclists increase, the number of crashes involving cyclists seems to decline. Beyond a certain city size though, as in the case of New York and Chicago, Pucher et al. (2011) note that cycling is nevertheless more dangerous than in smaller centres, presumably in accordance with the risks involved with much higher traffic levels. One other interesting note about cycling and safety is that cycling injuries are often derived from “single vehicle” accidents (Eilert-Petersson & Schelp, 1997).

In some ways the “safety in numbers” argument argues for more selective use of cycling road infrastructure so as to concentrate cycling flows rather than dispersing them across many roads. In too many North American contexts, unlike in Europe, the traffic calming effect of safety in numbers is hampered by a shortage of cyclists. The bike share of commuters in Canada is only about 1.3% (Pucher et al., 2011) which is nevertheless about twice the overall levels observed in the United States. Furthermore, as Section 3.1 discussed, complete streets are partly about affecting safety and automobile speeds through the psychological cues of reduced road widths and other design elements. But it remains unclear whether an unused bike lane increases the perceived road width for drivers, thus having an inadvertent effect on the speed and safety goals that a complete streets program aims for. It is likely that different types of road markings offer alternative impacts for drivers, with fully separated lanes or lanes that are fully coloured (panel A of Figure 3.8) offering a larger speed deterrent than a lane that is not segregated, completely delineated, or coloured (panel B of Figure 3.8).

Figure 3.8: Common Cycling Markings

3.3.2 Cycling and Local Geography

The need for large amounts of cycling infrastructure can also be evaluated through the lens of intra-urban geography. North American studies have highlighted that cycling activity is quite oriented to central cities and much less so to the suburbs. Pucher et al. (2011) note that the central city share for bikes relative to the overall metropolitan area ranges from 4-to-1 in Washington and Minneapolis, to 3-to-1 in Portland and 2-to-1 in many other cities. Even within central cities, empirical evidence suggests that older, gentrifying neighbourhoods near city centres and jobs and university campuses have the highest shares of all. Bike mode shares exceed 10% in several of the central neighbourhoods of Toronto and Vancouver (Pucher et al., 2011). And as Chapter 4 will show, this is somewhat true in Hamilton though shares are not as high. These cycling-oriented types of places are also the most amenable to comprehensive complete street treatments.

3.3.3 The Need for Separate Cycling Facilities

Separate cycling facilities, of the type common on complete streets, are viewed very favourably (Hamann & Peek-Asa, 2013; Pucher et al., 2010). Dill (2009) notes the important role that infrastructure played in a survey of 166 regular cyclists in Portland and finds that a disproportionate share of the measured cycling activity occurred where there was bicycle infrastructure such as bicycling lanes, separate paths or bicycle boulevards. Variations to basic bike lanes include adding a buffer between the bike lane and the vehicle lanes (e.g. a line of parked cars, which can reduce the potential for collisions between car doors and cyclists), achieving a more overt physical separation of the lane (e.g. using a curb or some other concrete separation) or adding colourful paint to better clarify the presence of the lane to drivers.

Results suggest that every little bit helps. For example, Hamann and Peek-Asa (2013) indicate that the use of cycling-oriented pavement markings and signage not only reduce the number of incidents between cyclists and motor vehicles but also are beneficial to traffic flow. The results of Winters et al. (2011), based on a survey carried out in Vancouver, are fairly emphatic in suggesting that being well-separated from traffic is an important consideration for cyclists. Overall, research suggests that separate bike facilities induce more cycling and, in this respect, the more miles of it the better (Buehler & Pucher, 2012; Lawlor et al., 2003) and the more continuous it is the better (Krizek & Roland, 2005).

If there is a grey area, it is in relation to the *type* of separate cycling facility that is most highly valued. Studies show conflicting results. It appears that off-road or trail facilities may be most attractive for recreational cyclists and women and that separated facilities on busy roads may be more acceptable to experienced utilitarian cyclists seeking the fastest route to their destination. Analysis of incident data has revealed that cycling on roads is not necessarily unsafe and in fact cycling on paths has its own problems as well (Aultman-Hall & Kaltenecker, 1999; Garrard, Rose, & Lo, 2008). Cyclists themselves are not necessarily focused on complete streets solutions per se but simply on what route offers the best combination of efficiency and safety. In some cases, the outcome may be a less direct route that is perceived to be safer (Tilahun, Levinson, & Krizek, 2007). Certainly, complete streets help to reduce the need for behaviours such as cycling on sidewalks which has been shown to be quite unsafe (Aultman-Hall & Kaltenecker, 1999).

High traffic levels are one of the elements that appears to greatly reduce the attractiveness of cycling for women (in North America more so than Europe) (Pucher & Buehler, 2008). This is problematic from the complete streets viewpoint which emphasizes access for all. Some cyclists, especially less experienced ones, feel most secure by staying entirely away from busy arterials and using a "bicycle boulevard" instead. These often involve a less direct route but involve travel on streets with lower car volumes and a variety of modifications (pavements markings, signage) designed specifically to accommodate cyclists (Pucher, Dill, & Handy, 2010). The fact that so many cyclists are interested in alternatives to cycling on busy roads may suggest that cycling-oriented implementations on busy complete streets ought to be evaluated carefully. Many cyclists might prefer to be on a different right-of-way altogether.

3.3.4 Cycling and the Importance of “Non-street” Factors

A street may be considered "complete" but that is only part of the battle where cycling is concerned: at the end of a trip, there needs to be a place to park the bike. Hunt and Abraham (2007), in a study of Edmonton cyclists, found that excellent bike parking facilities were valued equivalently to an extraordinary 27 minutes of cycling time. Improvements such as showers at workplaces have also been shown to help in terms of making a cycling destination more attractive.

At a higher level, the success of complete streets implementations of cycling infrastructure are also dependent on coordinated policy action on a number of fronts such as educating about the health benefits of active transportation, promotions such as "cycle to work" days, policy prescriptions for competing modes and other elements. The bottom line, according to Pucher et al. (2010), is that some very large cities around the world have been successful in doubling, tripling or quadrupling their levels of cycling in fairly short time spans while improving safety but it has required concerted and coordinated action. Ultimate success has required much more than just complete streets as Pucher and Buehler (2008) show for the cases of the Netherlands, Denmark, and Germany.

One challenge for cycling, certainly in relation to driving, is that it is affected by weather. Gallop et al. (2012) have shown for Vancouver that the prevailing weather conditions have a massive impact on bicycle counts. Interestingly, other research has suggested that cycling is *not* particularly sensitive to weather. For example, Pucher et al. (2011) note that the highest cycling rates in North American are observed in the Yukon (2.6% of work trips) and the Northwest Territories (2.1% of work trips). However, these high observed rates are likely confounded by the smaller average trip lengths associated with smaller urban centres.

Beenackers et al. (2012) carry out a study that focuses on built environment factors and the extent to which they may impact cycling activity. The study was carried out in Perth, Australia and is notable for its longitudinal element where people who relocated their place of residence were monitored for their uptake of cycling behaviour. After relocation, 5% of the non-cyclists took up transport-related cycling and 7% took up recreational cycling. New recreational cycling was mostly associated with relocation to places with more street connectivity while transport cycling was associated with high residential densities near the place of residence and perceived access to parks.

Cervero and Duncan (2003), in a cross-sectional study in San Francisco, pay attention to factors such as the slope of terrain in specifying their models. It is not so common to include detailed information of this type in mode choice models but cycling is far more influenced by such variables. They find cycling to be equally influenced by density, diversity and design variables near the residential origins of cycling trips. They find the built environment to be of more significance near the origin than the destination in influencing cycling activity.

Overall, to the extent that complete streets cause more cycling infrastructure to be developed, it is likely a good thing. However, there are certain elements relating to the behaviour of cyclists that suggest some discretion in determining which roads ought to receive the “full cycling treatment.”

3.4 Emphasis on Walking and the "Local"

An important element of complete streets is that they are aligned with having people live more simply and locally. There is no doubt that large amounts are written on topics such as urban sprawl, low density development that lacks identity or any sense of place, and automobile dependence. Movements such as New Urbanism or Smart Growth (see for example Ewing, 1999) champion living in a more local, less auto-dependent way. Complete streets are very much aligned with these themes. Complete streets are also very much aligned with walking as a viable mode of transportation and as the mode that is most associated with an emphasis on the local. Accordingly, this section focuses on walking and its interaction with complete streets.

3.4.1 The Nature of Walking and What Influences It

Walking is integral to most conceptualizations of complete streets. It is hard to contest the virtues of walking as an activity to improve health (Handy et al., 2002; Shephard, 2008) and as a means to promote a vibrant neighbourhood atmosphere and local vitality. It is possibly somewhat easier to contest whether a complete street in and of itself is a big motivator of increased walking. Also, consider that good pedestrian infrastructure is a feature of many, if not most, traffic arteries and local streets and in many cases this infrastructure goes lightly used and does not seem particularly associated with high levels of local vibrancy.

In general, walking is a complex behaviour to understand and model or simulate. Ishaque and Noland (2008) highlight that pedestrian movements are very intricate and involved compared to vehicular patterns. One of the reasons for such complexity is that walking has a significant recreational component in that the movement may be for its own sake as opposed to having some utilitarian purpose. According to Handy et al. (2002) walking is fundamentally not so well understood as other forms of urban travel activity for this reason among others. Since so many walking trips take place for recreational purposes, there is concern that its importance is underestimated in surveys (Litman, 2013). Still it is fairly well understood that having pedestrians in an area, regardless of the purpose (if any), is a good thing for the vibrancy of that area (EPA, 2010).

It seems straightforward to conclude that sidewalks are an important aspect of generating pedestrian travel, and thus are an important part of complete streets. The presence of four-way stops has also been shown to promote walking, though the length of a city block does not appear to matter much (Boer et al., 2007). Sidewalks, and the pedestrians that are on them, are also integral to calming traffic movements. The results of Ossenbruggen et al. (2001), for example, show that the probability of a crash is two times higher at a site without a sidewalk. According to Loukaitou-Sideris and Ehrenfeucht (2010) many of the policies that emphasized flow and efficiency for roadways were also in effect in relation to sidewalks and with unfortunate results.

In terms of generating local vitality, it seems clear that many walkers will need to travel between origins and destinations within a short distance. Millward et al. (2013), based on Halifax travel diaries, find that most walks are shorter than 600 metres and few exceed 1,200 metres. Interestingly, this research also shows that the origin for the majority of these short walking trips is a place other than home and that shopping and work trips are the leading trip purposes. It is quite likely then that walkers will have taken some other mode to get to the general vicinity where they walk.

Nevertheless, the local nature of walking means that the built environment is a significant factor influencing walking trips. Of the “three D’s” of urban areas – density, diversity, and design, Cervero and Duncan (2003) found that neighbourhood land use diversity near the residential origin of a walking trip was the most important predictor of walking. The density and design families of variables were less important. Song and Knaap (2004) reached a similar conclusion, finding that the diversity associated with mixed land uses may play a larger role than the design associated with complete streets. Likewise, Boer et al. (2007) found that greater mixing of commercial businesses was a strong predictor of walking in their study of 10 US metropolitan areas.

However, an important issue to consider is that of “self-selection”. This can confound research into whether it is the diversity of the built environment or the provision of sidewalks that promotes walking, or simply the fact that people who maintain preferences for walkable neighbourhoods are more likely to walk and enjoy them. Handy et al. (2006) have carried out one of the most significant studies on untangling the complex relationships between self-selection, the built environment and walking behaviour. They have longitudinal elements to their study (similar to Beenackers et al., 2012) and also control for travel attitudes and neighbourhood preferences. Their results show that the built environment matters with respect to influencing walking behaviour but even the best studies available do little to estimate the specific impacts of complete streets implementations. In terms of the built environment, their results suggest that close proximity to potential destinations is the most important element. Other dimensions of the built environment that they see as playing a role include physical activity options, elements of safety, attractiveness and measures of socializing.

For Atlanta, Frank et al. (2007) carried out an important assessment in determining how important the built environment is to walking. Recall that complete streets are one element of the built environment. One of the things that makes the study significant is that it separates out the fact that people self-select to choose neighbourhoods based on their preferences. It is found that a significant proportion of the population is “mismatched” in that they do not live in their preferred neighbourhood type. People who preferred and lived in a walkable neighbourhood walked the most (about 1/3 of the people) and drove less than other people. For people that did not prefer a walkable environment, it made no difference where they lived.

If this conclusion is extended to the complete streets context, it suggests that modifications of street design would likely have no impact on a significant share of the population as these individuals did not have any underlying demand for the changes that were made. Nevertheless, this study does conclude that the construction of walkable environments will generate more physical activity and result also in less driving.

According to Forsyth et al. (2009) the social environment could be a more significant determinant of walking than the built environment. The social environment mostly refers to how neighbours, for example, interact with each other. More social environments can lead to more walking.

3.4.2 Complete Streets and Pedestrian Safety

Safety for pedestrians is paramount and there is good evidence that complete streets improves matters in this respect. In a study that utilized data from 1983-1986 (coincidentally for Hamilton, Ontario itself) visiting scholar Lars Leden studied pedestrian risk at 300 signalized intersections (Leden, 2002). The results of the analysis provided some confirmation of the "safety in numbers" hypothesis that is thought to apply for pedestrians and cyclists. In particular the risks of vehicle-pedestrian collisions were decreased with increasing pedestrian flows and increased with higher vehicle flows.

Retting et al. (2003) carry out a detailed review on how engineering measures can reduce pedestrian-motor vehicle crashes. They note that in the U.S., approximately 100,000 pedestrians are injured every year and nearly 5,000 die every year from such collisions. Their review of the literature suggests that there are three broad classes of countermeasures: speed control, separation of pedestrians from vehicles and measures that increase the visibility of pedestrians. They note that control of speeds is particularly important in the context of child pedestrians because the child is typically the party that makes the error resulting in the collision. Complete street measures of the type already discussed are well-suited to reducing the threat of high vehicle speeds. Retting et al. also stress the effectiveness of roundabouts (especially single lane ones) as replacements for conventional intersections. Countermeasures such as exclusive pedestrian signal phasing, pedestrian refuge islands and increased intensity of roadway lighting are characterized as "highly effective."

DiMaggio and Li (2012) focus on the issue of whether changes in the built environment, particularly those associated with roadway characteristics, can reduce the risk of pedestrian child injuries from incidents with vehicles. The study was a meta-analysis which assessed results from a range of specific studies on the topic. The results suggested that even relatively minor interventions such as changes in signage can have significant effects.

Jensen (1999) offers a good overview of pedestrian safety with an emphasis on Denmark. He notes that pedestrian injuries peaked in Denmark around 1965 and have been on a steady decline since. Nevertheless, particular groups at risk in terms of fatalities include the elderly, drunk pedestrians and pedestrians in darkness. The relationship with speed is noted as it is pointed out that there were zero Danish pedestrian fatalities from the period 1985-1995 on roads with speed limits less than 20 km/h.

Table 3.2: Pedestrian Safety Interventions and Resulting Safety Effects

Safety Measure	Types of Pedestrian Crash under Influence	Attained/Estimated Safety Effect
Speed reduction of 0.5-18km/h	All pedestrian crashes	-17% to -92%
Sidewalk	All pedestrian crashes	Crash reducing
Combined, two-way foot- and cycle path	All pedestrian crashes	-37%
Pedestrianization of street	All pedestrian crashes	-82% to -100%
From two-way to one-way street	All pedestrian crashes	-34% to -62%
Zebra crossing on road link	Crashes with crossing pedestrians	+50% to -50%
Zebra crossing at non-signalized junction	Crashes with crossing pedestrians	+127% to -35%
Footbridge	Crashes with crossing pedestrians	-85%
Side road pedestrian refuge with curb	All pedestrian crashes	+50% to -27%
Other pedestrian refuge with curb	All pedestrian crashes	+27% to -81%
Central reserve – marked or with curb	Crashes with crossing pedestrians	-57% to -82%
Guard rails on central reserve or at sidewalk	All pedestrian crashes	-20% to -48%
Signalization of a zebra crossing on a road link	Crashes with crossing pedestrians	-20% to -35%
Roundabout	All pedestrian crashes	-46% to -89%
Signalization of junction	All pedestrian crashes	0% to -70%
Exclusive pedestrian signal phase, scramble	All pedestrian crashes	-7% to -63%
Road lighting	Pedestrian crashes in dark	-35% to -45%
Improved lighting at pedestrian crossing	Pedestrian crashes in dark	-30% to -62%
Reflector, reflective strip	Pedestrian crashes in dark	-89%

Source: Reproduced from Jensen (1999)

The best contribution of this paper is that it carries out a review of approximately 50 studies on how design and engineering measures can reduce incidents with pedestrians. Table 3.2 is reproduced from the article and is interesting from the perspective that a whole range of interventions of possible and the review of the studies suggest that many of them have very dramatic impacts in reducing the potential for collisions, injuries and fatalities. It is also true that many of the measures are consistent with principles of complete streets.

Baltes and Chu (2002) developed a statistical model that explains the factors contributing to perceived level of service for pedestrians crossing at midblock locations. The level of perceived crossing difficulty tended to increase with a higher share of senior citizens and far side traffic volume and in areas with more turning movements nearby. Pedestrians preferred the presence of pedestrian signals.

One dimension to local pedestrian safety is the distribution of trips in an area. Previous research has shown an interesting correlation between rates of suburbanization and pedestrian injuries in cities, with the most suburban cities exhibiting the highest rates of injuries. However, the location of these injuries is heavily skewed towards collisions in the city's older, central, and higher density areas, with comparatively fewer collisions in suburban areas (Yiannakoulias et al., 2002). One immediate reason for this is higher population densities, as well as a general trend towards higher rates of alternative mode use in higher density areas that increases exposure to such injuries.

A second factor highlighted by Yiannakoulias and Scott (2013) concerns the origin and destination of the driver of the automobile. Using travel origins and destinations from the 2006 Canadian Census and information on collisions between children and motor vehicles, their research in the City of Toronto found that low-income central city neighbourhoods feature the highest levels of non-local traffic, and that this through-traffic was associated with higher levels of local child pedestrian injury. In contrast, high levels of local traffic were associated with lower risks of collisions between children and motor vehicles. One reason given for this is that drivers that are non-local and are using a neighbourhood's streets to reach a destination may lack the same degree of moral and practical responsibility for their behaviour than someone who resides locally. This greatly increases the spatial distribution of responsibility and can reduce the effectiveness of measures designed to increase safety among residents of a neighbourhood, such as awareness campaigns. One solution mentioned by Yiannakoulias and Scott (2013) is to utilize traffic calming measures instead. Aside from children, senior citizens are also at greater risk of injury or death as a result of pedestrian-motor vehicle collisions.

3.5 Emphasis on Varied Road User Types

Most definitions for complete streets stress the philosophy of accommodating all types of users on a street whether they be walkers, cyclists, motorists or transit users or combinations of these. As previous sections have shown, there are a lot of nuances to complete streets and differing contexts in a city influence the extent to which each of these modes will be utilized. Below we conclude this chapter by discussing several secondary dimensions concerning the mixing of different uses on the same road.

3.5.1 Vulnerable Users: Children and the Elderly

One of the central tenets of complete streets as a concept is a desire to increase safety and improve mobility for the most vulnerable users of the road, particularly the young and elderly. A street with low speeds and a welcoming built form presents an environment that is safe and welcoming for children, their parents, and their grandparents. For seniors especially, complete streets present an important option for maintaining mobility and quality of life, and with a rapidly aging population in Hamilton and across North America, this aspect of complete streets will only increase in importance over the next several decades. For example, reductions in the number of road lanes stand to make the driving environment less complex as fewer variables need to be considered and improvements to the pedestrian environment can lead to safer trip making, such as larger buffers between the sidewalk and road and additional mid-block pedestrian crossings that create shorter paths for seniors to reach destinations.

A great deal of recent research has been dedicated to the issue of senior mobility, including recent papers on Hamilton specifically (e.g. Mercado & Páez, 2009; Páez et al., 2007). The general consensus in this research is that many seniors located in more suburban areas stand to see their mobility decline dramatically as their use of a car is reduced or prohibited (Rosenbloom, 2001). In response, the two most popular solutions are to increase transit service to senior populations in a way that can replace trips that were previously taken by automobile, and to promote changes in neighbourhood design to increase livability and alternative mode use. Highly walkable neighbourhoods with many amenities provide the greatest flexibility in terms of maintaining senior mobility, and complete streets measures certainly help to achieve these goals.

However, the ability of a complete street to fundamentally alter senior mobility should not be overstated. While it may increase walkability, changes to the streetscape alone cannot transform a suburban location into an amenity-rich neighbourhood. For example, while wide sidewalks, improved landscaping, and better transit service can increase the safety and enjoyment of a trip, by themselves they do not decrease the distance an individual has to travel to reach a pharmacy, bank, or grocery store. To truly affect senior mobility, complete streets measures should be adopted in tandem with broader planning tools to promote a variety of urban housing options and higher-density areas that can support more localized amenities. Furthermore, the sooner this can be accomplished, the better. As Section 2.1.1 has shown, one of the biggest markets for new condominiums in Toronto has been the empty-nesters of the baby-boom generation. It may be that such individuals have become cognizant of future changes in their mobility at earlier stages of their life and are choosing to take the opportunity afforded by downsizing from a family home to prepare for retirement in areas with greater amenities and transportation options.

3.5.2 Mixing Pedestrians and Cyclists

In the complete streets literature there tends to be a focus on the automobile as the primary road user to be regulated, but it is important to note that from the perspective of pedestrians the presence of cycling can reduce the quality of the pedestrian experience. Kang et al. (2013) emphasize the perceived pedestrian level of service in the presence of bicycles and suggest that cyclists need regulating also in the eyes of pedestrians. However, the research was carried out in China where having pedestrians and cyclists occupy the same right-of-way is more common than in North America.

3.5.3 Traffic Calming, Driver Stress, and Aggressive Behaviour

One detriment to safety for all users of the road is aggressive driving. However, the relationship between complete streets and aggressive driving is unclear. Krahe and Fenske (2002) confirm that the stereotypes of aggressive drivers being young, male and exhibiting traits of "macho" personality are actually true although the work of Lajunen and Parker (2001) does indicate that aggressive driving is a very complex phenomenon indeed. Shinar (1998) notes however that women are as likely as men to engage in "mild" forms of aggressive driving.

To some extent, aggressive driving can be managed through the built environment. The matter of how complete streets moderate driving speeds (a classic aggressive behaviour) has been covered in Section 3.1. This research does suggest that modifications to the driving environment, referred to as "ergonomics-oriented" approaches, are a good way to moderate this type of aggressive behaviour. Certainly complete streets remove some of the avenues (e.g. multiple lanes and lane switching) by which drivers can pursue aggressive behaviours.

On the other hand, some complete streets measures may potentially increase aggressive driving. Shinar (1998) and Shinar and Compton (2004) find that aggressive behaviours are most likely to surface when traffic congestion is combined with stress in the form of time constraints (i.e. rush hours). There has not been rigorous work done on how complete streets affect driver stress but it does seem best, from the driver aggression point of view, that complete streets implementations ideally should not create excess congestion. In the end it is likely that a tradeoff will need to be made in complete streets target areas between the safety of local residents and vulnerable populations and the ease at which drivers, both local and otherwise, can move throughout these areas.

3.5.4 Users of Transit

Another important aspect of complete streets is the promotion of transit use. While increasing walking and cycling is in and of itself a worthy goal, both can benefit transit use as outside of park-and-ride lots, most transit trips begin and end on foot or on bicycle. In this sense, the provision of pedestrian-friendly streetscape designs can make transit use more accessible and more enjoyable, thereby increasing transit ridership and farebox returns. Indeed, Schlossberg and Brown (2004) find that the presence and location of pedestrian-hostile streets have a significant negative influence on the pedestrian environment surrounding transit stops. Likewise, Hess et al. (2004) suggest that safe pedestrian access to transit on busy urban arterials is a real issue.

This focus on walking and cycling has much in common with the literature on transit-oriented development (TOD), which is based on research showing that higher-densities, mixed land uses, and pedestrian and cyclist friendly design come together to create the right conditions for increased transit use (Cervero et al., 2004). Complete Streets and TOD should be seen as complimentary. Planning for TOD generally occurs at a higher level, ensuring proper zoning is in place and that incentive programs exist to promote streetscape improvements. Complete streets programs are more design-oriented, providing the guidelines that turn these aspects of TOD into reality.

3.5.5 Commercial Vehicles / Goods Movement

While in general complete streets are more sensitive to varied road user types the one important category where this perhaps is not the case relates to accommodation of commercial vehicles. There does seem to be a bias in what is written about complete streets to focus on key elements of people movement over goods movement. It is understandable that movements by heavy and perhaps medium commercial vehicles are not compatible with complete streets but light vehicles account for a large share of commercial vehicle movements and are important to accommodate for the sake of local economic efficiency and competitiveness. In this sense, any complete streets measures will need to be cognizant of issues related to commercial vehicles such as mail delivery, waste and recycling services, and provisions for loading and unloading goods for local retail establishments. While it may be difficult to accommodate such uses within the context of complete streets, they constitute important functions for any urban area and are likely to be a source of conflict in mixing users of the road.

4

Complete Streets Outcomes and Barriers

The purpose of this section is to evaluate complete streets in terms of their potential to generate significant social, economic and environmental benefits for society. Compared to Chapter 3, this chapter is focused on these outcomes or the "outputs" and seeks to examine Complete Streets vis a vis the yardsticks of sustainability and economic development. Chapter 4 also examines a number of factors that complicate the achievement of beneficial complete street outcomes and discusses barriers associated with implementation.

4.1 Overview of Outcomes

Generally speaking, our review has revealed that complete streets initiatives stand to have a positive impact across all three outcomes dimensions: social, environmental, and economic and there are interdependencies among the three classes. However, the availability and quality of information used to develop such conclusions varies. Little research has been done that directly links complete streets as a packaged concept to such outcomes. Instead, we draw conclusions from a body of evidence that considers the outcomes of complete street elements individually.

Still, there are a number of complicating factors associated with drawing such conclusions, a topic we discuss further in Section **Error! Reference source not found.**.

4.1.1 Social

Implementations of Complete Streets have been linked with a number of important social outcomes. But of these, perhaps the most unequivocal is the ability to improve safety. In as much as traffic calming measures are adopted, there appears to be great potential to reduce the speed of traffic and therefore help to prevent injuries and deaths for pedestrians, cyclists, and drivers. In terms of improved social outcomes, it is hard to imagine a better goal than that.

How have some Complete Streets cases fared in achieving these goals? In a wide-ranging study, Smart Growth America examined outcomes associated with 37 different complete streets projects across the United States. Of these, results suggest that

- 70% experienced a reduction in collisions, some significantly so, and 56% experienced a reduction in injuries while alternative mode use increased. This is estimated to have reduced costs associated with collisions by $18 million per year across the sample.
- In the case of Edgewater Drive in Orlando, FL, a road diet resulted in a 40% reduction in collisions and injuries fell by 71%. Automobile traffic fell by 12%, but cycling and walking increased by 30% and 23% respectively.
- For alternative mode use, results indicate more walking trips in 12 of 13 projects that collected pedestrian counts, more cycling trips in 22 of 23 projects that collected bicycle counts, and an increase in transit usage in 6 of 7 projects that collected ridership counts.
- Finally, these outcomes were cost-effective, with projects costing considerably less than a typical lane mile for automobile traffic.

The safety and well-being of a city's citizens should be the number one priority, particularly for the most vulnerable users. Work by Noland et al. (2013) suggests that the safety impacts of complete streets could be most needed in lower income areas as their work shows that both pedestrian and motor vehicle casualties occur at higher rates in these areas. In the context of a limited budget to implement complete streets, this finding could be one to consider in terms of where money could be allocated in a city.

There are other ways where complete streets appear to have social benefits but the linkages are perhaps not as direct. The review in Chapter 3 suggests that there are certainly health benefits from cycling and also there is evidence that complete streets typically possess the types of high-quality cycling infrastructure (e.g. separated bike lanes) that induces more cycling.

Pedestrian improvements that promote walking can also lead to improved heath outcomes associated with more active travel.

Of course, such improved health conditions also have clear economic implications as well and it appears likely that complete streets induce such social benefits in a number of ways. One recent study of cycling infrastructure for example applies the World Health Organization's Health Economic Assessment Tool (HEAT) to the case of a proposed 60km segregated cycleway in Ireland. Using survey data, Deenihan and Caulfield (2014) employ HEAT to estimate that the cycleway would produce health benefits valued between €27 million and €141 million over 10 years, depending on modal switch to cycling and uptake rates. With an estimated cost of €12 million, the health benefits of the cycleway offer a benefit-cost ratio of between 2.22:1 and 11.77:1, indicating that it would be a worthwhile investment from a health economic perspective.

Built environment factors can also improve health outcomes. Frank et al. (2004) found that increases in land use mix reduced chances of obesity in their study of Atlanta. Likewise, each additional hour spent in a car per day was associated with a 6% increase in the likelihood of obesity, while each kilometre walked was associated with reductions of 4.8%. Although not translated into dollar terms, Morrison et al. (2004) find that there were direct health benefits associated with the implementation of a local traffic calming scheme on a main road in Glasgow.

Studies of rapid transit have also found associations between transit use and health outcomes. Stokes et al. (2008) carried out work to assess the public health benefits of a new light rail system in Charlotte, NC. The estimated health cost savings over nine years were positive, but estimated at a modest $12.6 million which the authors point out is rather small compared to the large investments that light rail requires to build. Regardless, from rapid transit to traffic calming and improved streetscapes, any initiatives that promote more walking and help individuals lead more active lives can produce better health outcomes.

Other research has examined the concept of "social capital" as a means to evaluate social impacts. Wood et al. (2012) find that linking social capital to neighbourhood design and the built environment is rather difficult. They suggest that there is evidence that aspects like street connectivity influence social well-being but there are other elements of the environment that come into play like unkempt gardens or broken windows.

Still, it is important to consider that some behaviours like social contacts and obesity change very slowly. While the availability of data can help to evaluate the effectiveness of such initiatives and provide a justification for further investments, planners and policymakers should continue to measure outcomes for long periods of time after a complete streets project is implemented (Lusher, Seaman, & Tsay, 2008).

4.1.2 Environmental

Greenhouse gas emissions (GHGs) and toxic criteria air contaminants that result from human activities have serious environmental and social consequences. By far the largest user of energy, and by extension GHGs, in North America is the transportation sector. In addition to the obesity effects noted above, vehicular travel also produces harmful emissions that are associated with respiratory problems and contribute to global warming.

It stands to reason then, that if complete streets measures are able to promote the use of alternative modes to the personal automobile, there should be a corresponding decline in associated GHG emissions. Likewise, street design programs that feature street trees and planted medians can also help to absorb carbon dioxide.

On the other hand, traffic congestion increases fuel consumption and GHG emissions. Similarly, if measuring emissions according to GHGs per kilometre of travel, slower speeds involve high levels of fuel consumption per distance travelled. If traffic calming measures slow traffic or create congestion, there is likely to be a tradeoff between greater levels of safety and increased levels of emissions.

Furthermore, a complete streets approach does mean that active modes and motorized modes are operating in closer proximity to one another. From the point of view that motorized travel emits harmful emissions there are health implications to consider. Busy arterials with newly designed cycling infrastructure will expose cyclists to increased levels of harmful emissions. In the cases of cycling routes that involve pedalling up steep hills, there is greater exposure to emissions because vehicle engines work harder to negotiate the change in grade.

The largest potential for environmental improvement associated with complete streets continues to be an increase in the share of alternative modes. If complete streets measures improve economic development and produce land use change and a greater number of neighbourhood amenities, it can result in individuals making shorter trips by foot, bicycle, and even car, which can also reduce GHG emissions.

4.1.3 Economic

Social, environmental, and economic benefits are to some degree intertwined. For example, the health impacts noted earlier can lead to significant economic benefits through cost savings. However, the narrower question of whether or not investments in complete streets produce value for money in terms of measurable economic development is of particular interest to planners and policymakers interested in crafting a business case for implementation.

Certainly the evidence suggests little doubt that complete streets concepts influence small-scale decisions about how people (often as drivers) will behave as they traverse a neighbourhood, but can these concepts be capable of generating the economic revitalization and growth of these neighbourhoods? Furthermore, as Chapter 3 has shown, there are many inputs that make up complete streets, but which measures offer the greatest return on investment? An important part of evidence-driven planning and policymaking is the use of 'yardsticks' to measure outcomes against. Furthermore, in as much as complete streets cause positive economic impacts such as a rise property values, there exists a rationale for the public sector to recapture some of this value to pay for complete streets projects through land value capture tools such as Tax Increment Financing.

Clearly there are some important rationales for understanding the economic impacts of complete streets. However, our review has revealed that there are real challenges in *directly* linking complete streets and their implementations to economic impacts. Minimal credible work has been done to establish a direct effect between complete streets and economic outcomes, and as such, answers to the types of questions posed above are difficult to provide.

Still, some research has occurred. Below we briefly review high-level trends and consider three separate approaches to complete street cases where more detailed performance measurement has been attempted. The first and third, from New York City and Denver, CO respectively, offer perhaps the best evidence that complete streets can lead to improved economic outcomes. However, the second, from San Diego, highlights the difficulties in attributing outcomes to complete streets. Finally, following the case studies, we also attempt to link economic outcomes from individual Complete Street elements to the concept as a whole.

General Trends

Smart Growth America (Cox, et al., 2015) provides a high level overview of several case studies. For economic outcomes, the authors argue that Complete Streets implementations have led to greater numbers of new businesses compared to unimproved streets and higher sales within them. In terms of property values, 10 cases collected data before and after complete streets implementations, and 8 revealed increases in property values. However, when controlling for trends in a parallel corridor or citywide averages, only 4 of these demonstrated increases that outpaced control areas. In the case of Edgewater Drive in Orlando, FL mentioned above, the road diet was associated with an increase of 77 new businesses and 560 new jobs.

However, the Smart Growth America report does not go into sufficient detail to examine research design, modeling assumptions, and any confounding factors and their effects on study outcomes. In contrast, we offer a more detailed discussion of three studies below.

Case Study 1: New York City

Complete Streets philosophies are at play in the massive developments occurring in lower Manhattan (Lethco et al., 2009). This paper gives an overview of some of the planning that is taking place there and the opportunity for creating more livable places in the wake of 9/11. The New York City Department of Transportation has focused on three key strategies: designing safer streets, designing for all users, and building great public places. The city's proposed street management framework classifies roads into: 1) Through 2) Access 3) Activity 4) Support and 5) residential, with the first two elements in the list being associated with the largest amounts of traffic.

From this, one of the best studies has been done using a semblance of a controlled experiment has been carried out recently by the City of New York (NYCDOT, 2013). This study has treatment cases of complete street implementations and comparison sites and has followed their progression in terms of retail sales over time. This has been done for a multitude of sites both inside and outside Manhattan. While many of the sites have done well in rebounding from the Great Recession, the results suggest that treated sites have rebounded more strongly on the whole, thereby offering some evidence of a positive economic development effect associated with complete streets initiatives.

This particular research design is important for helping to draw out causal conclusions. Some of the case studies that we have encountered for this time period where complete streets concepts have been implemented are a bit sensationalistic in the sense that any increases in sales get attributed to the improvements when instead it is likely that a huge bounce-back in the economy actually drives much of the improvement. The New York studies show the importance of having comparison sites to help net out effects of the general economy.

Case Study 2: La Jolla Boulevard, San Diego

In contrast to the research from New York City, consider the case of La Jolla Boulevard in San Diego. In 2008, the city implemented a complete street project in the Bird Rock community to create safer environment for pedestrians and cyclists and to increase business revenues along La Jolla Boulevard business district. Measures included installing a number of roundabouts along the length of the street and reducing the number of vehicular lanes from four to two (**Error! Reference source not found.**).

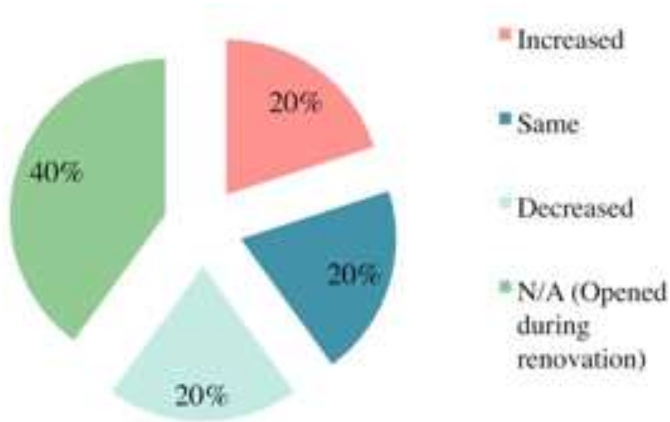
Figure 4.1: La Jolla Boulevard, Before & After treatment

Source: McCann, 2012

After implementation, a survey of tax receipts was completed among 95 businesses along the corridor, and the results showed a 20 percent increase in sales (McCann et al., 2012). However, another study by Masukawa (2012), revealed significant ambiguity in economic outcomes along the boulevard and that many businesses have in fact not seen a great increase in economic activity compared to their those before the complete streets implementation, with some reporting a decline in business of approximately 20% (**Error! Reference source not found.**). In response, it is difficult to conclude that in this case economic outcomes have been ambiguous at best.

Such a study illustrates the difficulty of properly measuring the economic effects of complete streets. For example, it seems likely that a complete street will not benefit all businesses equally. Those more oriented to pedestrian-friendly activities such as walkable amenities may see an improvement in business attributed to an improved walking environment compared to others more oriented to the automobile, such as a gas station, which may see a decline in business due to lane reductions or other traffic calming initiatives. Measures of business activity may also be too coarse to capture the total economic effects of complete streets, as improvements to the local neighbourhood can also be capitalized into the local real estate market rather than just sales receipts.

Figure 4.2 Comparison of La Jolla Business Activity Before and After the Renovation



Source: Masukawa, 2012

Case Study 3: Larimer and 15th Streets, Denver

A recent case study of three complete streets elements in Denver has shown promise in the concept in terms of economic outcomes. Similar to the discussion of Hamilton in Chapter 5 below, the City of Denver had a history of prioritizing expedient automobile commuting to and from the city's downtown core through the use of an extensive network of one-way streets. Recently, the city has shifted priorities to promote Complete Streets as part of a plan for downtown growth and development and alternative mode use. Such programs have been hailed as successful; more people now live and work downtown and as of 2014 approximately 60% of the city's downtown commuters utilize LRT and other transit, bike, walk, or carpool to work (City of Denver, 2014).

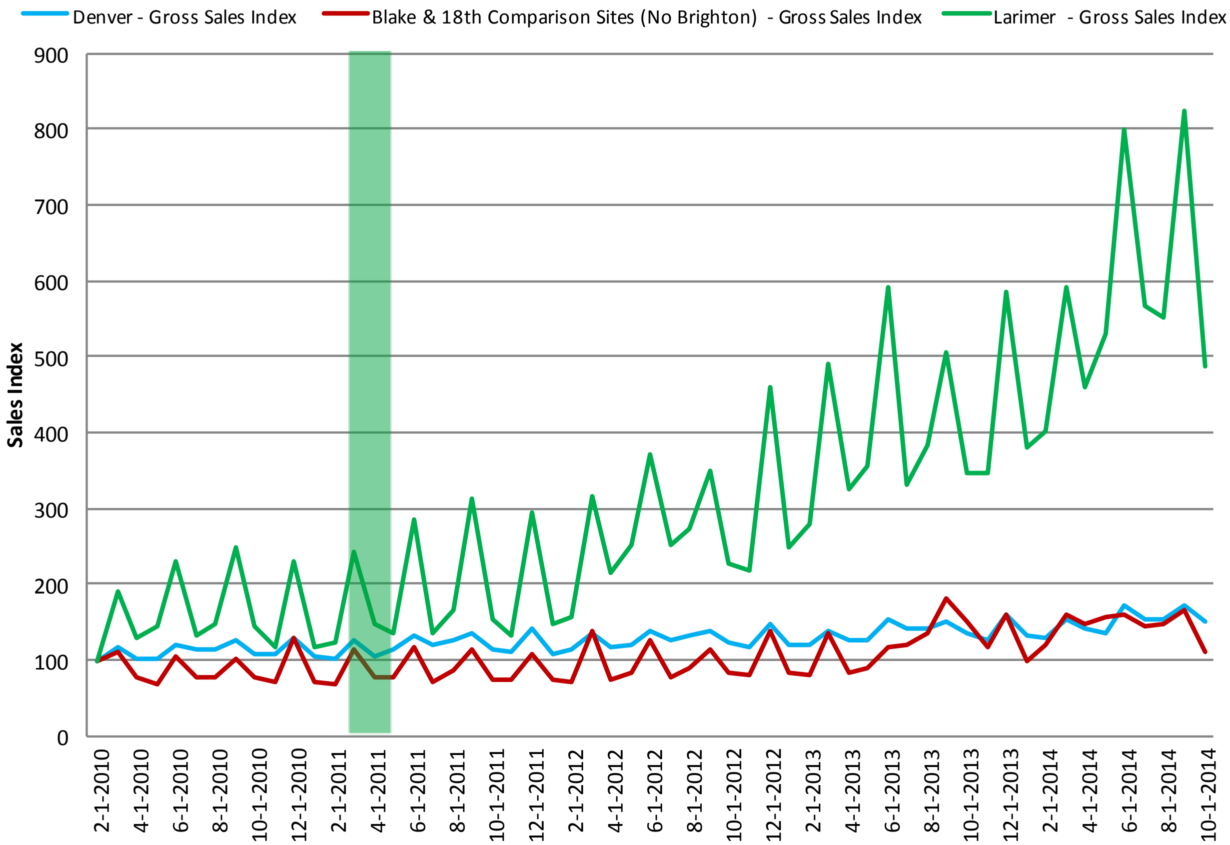
But aside from such changes, have complete streets measures led to any direct economic impacts? In a presentation at the 2015 Annual Meeting of the Association of American Geographers, Rijo (2015) examined sales tax receipts along several corridors, one that received protected bike lanes and another a road diet, as well as a number of parallel control streets that saw no changes over the study period.

Figure 4.3. Larimer Street Road Diet

In the case of Larimer Street, the City of Denver implemented a two-way street conversion and road diet along a one-mile section of the street in 2011. From 5 lanes of one-way traffic, the end result was a redesigned street with two lanes of bidirectional traffic, two bike lanes, and parking on either side of the street (Figure 4.3).

These changes have had a positive economic impact. Since conversion, Rijo has shown that growth in sales tax receipts along this section of street has consistently outpaced that along two comparison sites and throughout Denver as a whole (Figure 4.4). Still, while the study is commendable for adopting a quasi-experimental approach, it remains unclear what factors resulted in the increase in tax receipts. In terms of complete street elements such as bike lanes, two-way traffic, and greater on-street parking, it is unclear whether and to what degree the each of these elements contributed to greater sales. Furthermore, the author does not control for growth in any new businesses that may have opened up on the street, which would also increase sales tax receipts. Nevertheless, the study does suggest that this two-way street conversion and road diet did not have a negative economic impact.

Figure 4.4. Increase in Sales Tax Receipts in Treatment and Control Areas



A second case study completed by Rijo (2015) considers the mode choice and economic impacts of shared and protected bike lanes implemented in a segment of 15th Street in Denver. Here roughly ¾ of the study area features separated bike lanes on a wide one-way street implemented in 2014 as in Figure 4.5, with the remainder adopting a shared right-of-way implemented in 2013. Results for this segment suggest a slight increase in sales tax receipts, though the limited amount of time that has passed since implementation means no distinct trends can be identified. Still, the implementation of the bike lanes has resulted in other transportation benefits including a funneling of bike traffic to the lanes from other parallel streets, a 37% increase in the number of cyclists and a wider assortment of users, a 33% decrease in traffic violations, and a 54% decrease in sidewalk riding.

Figure 4.5. 15th Street Protected Bike Lane

Economic Impacts of Individual Complete Street Elements

While the number of studies that have attempted to isolate the economic impacts of complete streets as a standalone concept are limited, as with Chapter 3 there are a number of studies that have examined the impacts of complete street elements in isolation.

There is a substantial literature on whether elements of the built environment such as transit infrastructure can increase land values, with more than 60 studies completed in North America alone over the past 40 years (Higgins & Kanaroglou, 2014). Furthermore, there is a more recent literature that has looked specifically at the land value impacts of transit- and pedestrian-oriented developments. See Bartholomew and Ewing (2011) for an excellent review of this topic. Briefly, the authors note that several studies have found significant positive land value spillover effects associated with urban design factors such as mixed-use zoning, open and public spaces, and pedestrian-oriented street design.

Of the studies oriented to complete streets specifically, Bagby (1980) provides an interesting case study of two adjacent nearly identical neighbourhoods in Grand Rapids, Michigan. One neighbourhood implemented significant calming measures at three key intersections that had the effect of diverting through traffic. The reduction in traffic volumes was very significant with over ¾ of traffic disappearing. In the subsequent years, residential real estate appreciated substantially more in the calmed neighbourhood.

By calming traffic and moving traffic somewhat further away from dwellings (in the event of more extensive sidewalks or bike lanes for example) it is probable that complete streets can reduce the noise from traffic. Results from the work carried out by Wilhelmsson (2000) in Stockholm suggest that these types of noise reductions can create real economic value. In comparing a noisy location to a quieter one, he estimates a difference of as much as 30% in the price of a single detached dwelling. These results are echoed to some extent by Kim et al. (2007) who suggest that traffic noise has a direct and measurable effect on property values. In a study of condominiums in Hamburg, Brandt and Maennig (2011) find that the impact of road noise exposure on condominium values is more muted and they note that most work up the point of their research has focused on single family dwellings.

Possibly the boldest experiments in evolving a place to behave more locally, a process Cervero et al. (2009) term “urban reprioritization”, have come about from natural disasters or freeway demolitions. This has occurred in Boston as an outcome of the “Big Dig” and it has occurred in San Francisco after the Embarcadero Freeway and the Central Freeway were heavily damaged by the famous 1989 earthquake. In both cases, elevated expressways were replaced by surface boulevards. In Cervero et al.’s (2009) paper, the resulting freeway-to-boulevard conversions in San Francisco were found to have enhanced livability along these corridors and maximized the chances that urban professionals live centrally rather than commuting along a former expressway. Contrary to what might be expected, the authors note that the traffic-moving capabilities of the replacement boulevards remain significant. These appear to be cases where significant changes to the flow characteristics of roadways have helped to develop the local and down weight the importance of serving regional needs. Although these are not complete streets examples per se, they illustrate the spirit of what can potentially be accomplished.

Finally, there is more general evidence of general economic benefits. Making a vibrant place is no small task, and a main challenge is the misconception of costs. Some agencies says that complete streets cost more to be built than a regular streets projects, however previous experiences have proven that complete street often costs similar and in some cases cost even less. But even if a complete street costs more, there is some evidence of an increased willingness to pay from individuals to obtain complete street benefits. Research from New Zealand estimated that individuals would be willing to pay for up to $2 million in safety improvements to avoid the loss of one life ($3.7 million in today's terms) (Frith, 2012). While more general, these findings can be added to the economic ledger at it relates to complete streets.

Economic Case Study Conclusions

Taken together, such findings support the idea that elements of complete streets can produce positive economic benefits. However, it is exceedingly difficult to generalize past studies to delineate the precise nature of which elements actually caused land values to increase and in what context such findings are most likely to be repeated. As well, in considering the issue of economic impacts, it is important to note the difference between a spatial reallocation of economic activity that would have tended to occur anyway versus net new economic growth. Economic growth is typically associated with increases in output or GDP and with new forms of increased productivity. A relationship has long been found in the rapid transit literature, where the economic impacts associated with a new transit project are redistributed to the transit corridor from growth that would have occurred anyhow elsewhere in the region (Higgins et al., 2014). Similarly, our review has found no evidence that assesses the extent of new economic growth associated with complete streets.

4.2 Complicating Factors: Untangling the Influence of the Street Itself

Although we have attempted to draw some conclusions regarding complete street outcomes, there are several complicating factors at work related to the complexity of the relationship between individuals and urban environments, and such factors limit the ability to draw confident causal inferences from the literature. Quite simply, it is difficult to untangle the influence of the street itself on social, environmental, and economic outcomes and little has been done in this research direction anyway.

From a research perspective, findings for complete streets as a whole have been hindered because the specific impacts of complete streets tend to be 'lost in the shuffle' in the maze of measureable elements that researchers use to quantitatively define what the built environment actually is. One specific example is that many of these types of studies work with census units (polygons) as the observational units because that is how most data tends to be made available. To the extent that "street" variables are used, they are mapped over to polygons using some aggregation or conversion technique. Meanwhile, to the extent that road links (or streets) are used in statistical studies, it appears to be tied mostly to the traffic safety literature as opposed to travel behaviour and trip-making. Quite simply, research that attempts to quantify the effects of complete streets must be conducted at a very micro scale, and data at this level of geography is still hard to come by and work with.

One critical element in the evaluation of complete streets themselves is determining causality: whether beneficial interactions are in fact stimulated by complete streets or whether they would tend to happen anyway. There has been little if any direct research into this question. Furthermore, in terms of complete streets, they are more complex than traditional, auto-oriented streets and are thus thought to stimulate more complex interactions with the nearby urban and built environment, again creating issues for research.

There has been a very large amount of research that has attempted to link the built environment to travel behaviour more broadly, and there is particular interest in how modifications to the former can affect the latter. In particular, there is a great deal of interest in whether the built environment can be modified to trigger more active trips and transit trips and less dependence on the automobile (i.e. help make areas more local). The presumption is that places that are more locally oriented and defined by a smaller spatial scale will also tend to be more vital and more sustainable.

But here again academics have had trouble, for a variety of reasons, properly assessing fundamental issues such as the importance of the built environment on people's travel choices (Cervero, 2002) and how influential these components are in influencing individual behaviour. Availability of proper data has been a big issue and in this context, it is easy to understand why there is little understood about the true impact of complete streets.

Nevertheless, a wide range of studies have examined the link between the built environment and travel behaviour and they offer some clues about the impact of complete streets. One of the leading early studies in this regard is by Cervero and Kockelman (1997) who show that some of the main desirable, urbanized elements such as density, diversity of land uses (coined at that time as the 3D's) and pedestrian-oriented designs are associated with reduced auto trips and are more conducive to use of other modes. In a finding which tends to be echoed in other studies, there were no single dimensions that were dominant in influencing travel behaviour but several together were shown to have an impact. In other words, they concluded that the built environment in aggregate (of which complete streets would be a part) matters.

Ewing and Cervero (2010) have carried out a "meta-analysis" of 200 studies to follow up their own similar earlier study (Ewing & Cervero, 2001) which related vehicle miles travelled (VMT), which can be understood as a surrogate for automobile dependence, to travel behaviour. A meta-analysis is a data-oriented review and compilation of the numeric and analytical results of prior studies on a topic. With regard to VMT, there is a huge focus on whether estimates of VMT per capita vary over the city and accordingly whether some places are essentially better at "behaving locally" than others. They find that VMT is most strongly related to measures of accessibility to destinations and secondarily to street network design variables. The likelihood to walk is improved by elements like land use diversity, density of intersections and number of nearby destinations within walking distance. Bus and train use depend on proximity to transit primarily and secondarily to land use diversity. Cervero and Murakami (2010) reconfirm the finding that certain types of urban form can reduce VMT in a nationwide analysis of the U.S. While such studies do not directly evaluate complete streets, they illustrate how elements of complete streets are aligned with variables that do seem to influence travel behaviour.

There has also been a considerable literature that has developed on whether the built environment determines how people behave or whether this behaviour is more intrinsic to the people themselves. For example, if you put an auto-oriented, non-walking type of person in a walking-oriented neighborhood would they start behaving like others in the neighhbourhood or would they stick to their previously established patterns of behaviour? In a way, such a hypothetical question can be rendered moot by the fact that the auto-oriented person may be likely to only consider living in an auto-oriented neighbourhood that suits their lifestyle. Cao et al. (2006) suggest that the ability to manage travel behaviour and encourage open mindedness to non-auto modes through the built environment may be limited and that a large share of the population may simply be highly auto-oriented. Handy et al. (2005) were less definitive in their appraisal of the question producing one set of statistical results that showed attitudes are by far more important and another that showed more of a causal impact of the built environment.

To summarize, while it may be true that complete streets themselves are aiming to enhance the local, little has been done to isolate the specific effects of complete streets as a packaged concept. Typically the previous literature linking the built environment to travel behaviour is premised on surveys of individual choices and various measures of the built environment followed by a statistical analysis. But in such work the concepts of complete streets are never fully captured and if they are at all it is rather indirectly. As such, while there is a clear need for better insight into the social, environmental, and economic outcomes of complete streets than those outlined above, the state of research on complete streets means that the ability to draw such conclusions remain elusive.

4.3 Barriers and Contradictions

Finally, there are a number of important barriers and contradictions to be considered when designing and implementing complete streets initiatives. A first issue concerns resistance to speed reductions. Significant speed reductions in a localized area can be difficult to achieve though because often it is not evaluated by the wider public to be an important issue and also because of institutional barriers and communication issues that make this type of change challenging (Delepierre, 2008). Nevertheless, as Chapter 3 has shown, beyond regulating speed through changes in posted limits, speed can also be reduced through road design factors.

4.3.1 Road Changes and Perceptions of Congestion

By far the biggest challenge/obstacle related to the implementation of complete streets is the perception that less space for the automobile is going to translate into hardship for drivers in the form of greatly increased travel times. Welch (2001) notes that it is difficult for many, including traffic engineers, to believe that arterial lanes for roads handling up to 20,000 vehicles per day can be reduced or narrowed while at the same time managing to maintain an adequate level of service. In practice, the worst fears are almost never realized. Probably the most extensive study of this issue took place in the United Kingdom. Cairns et al. (2002) conducted an extensive accounting of the before and after circumstances of a large number of road conversions in the U.K. and found that affected areas coped surprisingly well. This does not mean that a lot of stakeholder engagement is not advisable. For example, Taylor and Tight (1997) describe in detail a consultation process that was used in implementing a traffic conversion scheme in the U.K. In the U.S. there have been numerous examples where implemented road diets have led to improved safety outcomes without any significant increase in traffic congestion problems (see Appendix 7.1).

Consider the case of a natural disaster. Traffic conversions and road diets are moderate interventions in comparison to what happens when there is a natural or some other form of disaster which affects regular functioning of a transportation route. Even in such cases the perceptions of impending traffic chaos are much worse than what actually happens. In 2007, for example, the I-35 corridor through the heart of Minneapolis was disabled due to the collapse of an interstate bridge over the Mississippi. With some revised highway lane markings on other freeways and the ability of nearby roads to absorb capacity, the system quite easily adapted to the missing bridge for the approximate full year it took to build a replacement (Zhu et al., 2010). Overall, it is estimated that 1/3 of diverted traffic shifted to arterials, 1/3 used other freeway crossings and 1/3 of the former trips simply disappeared in the form of altered destinations, consolidated trips or changes in mode. The latter 1/3 reflects the phenomenon that Cairns et al. (2002) refer to as "disappearing traffic." Their work in the U.K. strongly suggests that fewer automobile trips get made in the event of a road conversion and that this helps to moderate any incremental congestion effects. One interesting note from the experience in Minneapolis was that the change induced a minor shift to public transit. People much preferred to leave earlier and/or change their travelling route rather than shift mode to transit.

Related to the question of congestion impacts is the issue of whether it is necessarily a bad thing for trip times to be increased a small amount. Typically, even if speeds are reduced somewhat due to less space for vehicles, the results are not dire (Archer et al., 2008) given that trips times by automobile will typically still be much less than for alternative modes of travel. Often aggressive drivers seek to minimize their total trip times by weaving in and out of traffic but there is evidence that due to traffic control devices, this approach is not too effective for reducing travel times in any case (Archer et al., 2008).

4.3.2 Automobile Prohibition

While many are against any space reductions for automobiles, there are those at the other extreme who advocate complete elimination of automobiles access on many streets. An important component of what makes a street complete, however, is that it pays considerable attention to the needs of all road users including drivers. As an example consider that the concept of pedestrian malls was attempted frequently in the 1960's and 1970's in the U.S. but low sales volumes typically caused such streets to be opened again to cars (Pucher et al., 2010). This has recently been the case in Buffalo, where the city's downtown pedestrian mall, which was supported by a fare-free zone for the city's light rail transit line, was recently converted back to mixed automobile traffic (Higgins & Ferguson, 2012). Such a case highlights the fact that even a neighbourhood that is complete in the sense of a pedestrian-friendly environment supported by alternative modes of transportation cannot overcome more fundamental factors affecting the urban market.

Still, some pedestrian malls have seen success. Pojani (2005) offers an interesting discussion on the unique set of circumstances that have made the Santa Monica pedestrian mall quite successful. Unfortunately, it is a fairly unique set of circumstances not easily replicated in many other places. Robertson (1990) provides an overview of cases that for the most part have led to the failure or underperformance of many pedestrian malls. However, for the sake of street festivals, or for days that promote alternative modes of travel, there are times when restricting automobile access can be a sound strategy for promoting active travel modes.

4.3.3 Traffic Bypasses and Neighbourhood Vitality

One step removed from the concept of the pedestrian mall is the use of traffic bypasses to help keep through traffic off streets that are viewed as being more local in character. However, there is concern that such an approach can reduce local vitality. Leden et al. (2006), using a case study from Sweden, find that traffic calming is an effective way to avoid the need for bypasses. In many cases, it appears that one thing that is worse for local vitality than high levels of auto traffic are levels of auto traffic that are too low. Despite the focus on other modes, road traffic remains a critical part of what makes a street complete.

4.3.4 Auto Dependence and Its Implications

The multi-modal aspirations of complete streets are made much more challenging by the phenomenon of automobile dependence. This is defined by Zhang (2006) as the probability that driving is the only element in travelers' feasible choice set of travel modes. He estimates this probability for the average Bostonian to be 31%. There is little doubt that actually owning an automobile has a lot to do with whether driving is in a person's choice set but Kenworthy and Laube (1999) stress that auto dependence also hinges on how much an owned vehicle gets used. Americans actually *use* their vehicles far and away more than people in other countries. As Zhang (2006) notes, some people rely on their automobiles for attitudinal reasons and will drive no matter where they live and whether other travel options exist while others drive because of work constraints and household responsibilities. He stresses that being auto dependent is not necessarily indicative of wealth. He finds in Boston that higher income jobs are often well-situated with respect to rapid transit while many suburban, lower income and part-time jobs were quite reliant on access by automobile.

There are various complicating elements that relate to auto dependence and which work against the ability of complete streets to make a difference in affecting choice of travel modes. For example, there is the phenomenon of undirected travel (Mokhtarian & Saloman, 1999) which suggests that people like travelling further afield for the sake of it. A bigger complication is time. Some of the objectives of complete streets, encouraging the use of active modes in particular, are at odds with the time constraints that people have in modern day society (Bopp et al., 2012). This reduces the time for active recreational trips and the odds of choosing an active mode for a utilitarian trip.

An interesting and prominent trip purpose that links to auto dependence and sprawled land uses and yet can also support local areas in certain contexts is shopping. There are many retail concepts, particularly "big box" retailing and shopping malls, that are essentially designed for access by automobile and are not easy at all to access by other modes. Movements even within the same general retailing complex often require an automobile in the eyes of most people. A large proportion of retail sales are associated with automobile movements.

In a more localized, possibly non-suburban shopping context, it is a very challenging thing for local retail to compete with big box alternatives that feature vast selections and better price and yet local retail can be a very important element of local vibrancy. Apart from the significant issue of selection and price, Teller (2008) analyzes shopper perceptions in the context of street versus mall shopping and finds that in both cases, shoppers are judging locations based on retail mix and atmosphere. The former is far easier to control in the case of a shopping mall whereas local street retail mix is an ad hoc process. Atmosphere is a less tangible thing and is more subjective but there is little doubt that there is a higher level of variability in street atmospheres than more standardized mall atmospheres. The overall result is that it can be hard, but certainly not impossible, for local streets to compete in these respects.

The work of Handy and Clifton (2001), in a study of how effective local shopping options are in reducing automobile travel, suggests that it can be a very challenging thing to get people to think and shop locally. For many, local options may not even be perceived in their choice sets and it is common to drive to far off locations that that offer better perceived value. It is quite common for people to drive somewhere other than their closest option. The results of Handy and Clifton suggest that those who are interesting in living more locally tend to sort themselves into neighbourhoods where this type of living is possible -- and certainly there are many places where it is not.

The magnitude of the problem in having locally oriented commercial areas compete better becomes even more apparent when it is considered that there are many commercially-oriented, auto-dependent retail strips that are having trouble competing with more modern retailing alternatives. These were places that were premised on the automobile but that has not prevented serious declines in some instances. The long and linear commercial developments associated with these strips came about in the post-war period, especially in the U.S. context but were undermined by massive retailing and entertainment developments that tended to unfold near the intersections of major interstates and freeways. The EPA (2010) has proposed an approach for dealing with these deteriorating urban commercial strips suggesting that complete streets concepts will play a significant role. These suburban locales may never approach the charm of town or village centres but complete streets may be able to play a role achieving better localization of activities and more cycling and pedestrian activity.

4.3.5 Urban Context

The range of situations outlined above are indicative of the fact that complete streets concepts are widely applicable. Certainly, complete streets have been characterized as being applicable anywhere in the urban context but the range of elements is most relevant when the number of modes of travel that could work in a certain setting are maximized. In a low density context, walking is not going to be highly viable and there may be other cases, for example, where a street is not on a public transit route. For these types of situations the term “Context Sensitive Solutions” (CSS) has been coined to help apply complete streets concepts in a wider range of circumstances. The basic classes are: commercial streets, mixed use streets, main streets, residential streets, and industrial streets.

The existence of CSS though does not alter the fact that the potential for having the “most complete” of streets is probably in a higher density, central area with lots of potential for walking, cycling and with good public transit access. But there is a significant role for context-sensitive solutions in other places and the extent of the sprawled strip development that has taken place suggests that there may be ample demand for these solutions in the future. As will become clear in Chapter 5, areas that are effectively rural formally fall within many a city boundary. There are real safety concerns in many of these rural contexts and most discourse on complete streets does not take this context into account.

5

Assessing Complete Streets for Hamilton

The prior chapters of this report and the North American cases of Appendix 7.1 have laid the groundwork to comment on complete streets in the context of Hamilton. Complete streets at present are largely unimplemented in Hamilton and there is much more that could be done. To that end, the City of Hamilton has suggested a series of street cases to consider with a view to refurbishing these using complete street concepts. To be fair, the Main/King corridor was not one of the cases suggested but there are stakeholders in Hamilton who consider the future treatment of this corridor as critical to the future of the lower city. As such, the corridor has been added as a case.

This report offers an overview of each case and considers each case through the lens of the literature review that has been completed for this study. Important data sets such as the 2011 Transportation Tomorrow Survey data have been employed to assist in the analysis. An attempt is made to generally prioritize the cases. The current chapter provides the compiled results of this material, focusing on the most important points and also contains a thematic review of the key yardsticks which we believe can be used to assess each case. It is very important to note that these are high-level reviews of each case. More work would be required on each one to assess the specifics of implementation.

A full-scale implementation of complete streets in Hamilton would be a significant and major undertaking. It would require commitment and strong political will, especially if these concepts were to be applied in the most controversial of cases. In light of what may be required for the future, it is useful to examine the events of 1956 and the impacts that were perceived in 1957 when a one-way road network was implemented overnight in the core of the City. This is done in Section 5.1 below.

At the time, civic leaders were of the opinion that they were doing the right thing for Hamilton but in retrospect the conversion to a one-way system violated some essential tenets of the complete streets philosophy. No doubt it is easy to make such a statement with the benefit of hindsight. No one had heard of the term “complete streets” in 1956 and the rise of the automobile was prominent in the minds of most. While it is doubtful that Hamilton is better off from the road network changes that took place, other more powerful factors explained most of the subsequent decline of the central city.

5.1 The Case of Downtown Hamilton (1956-57)

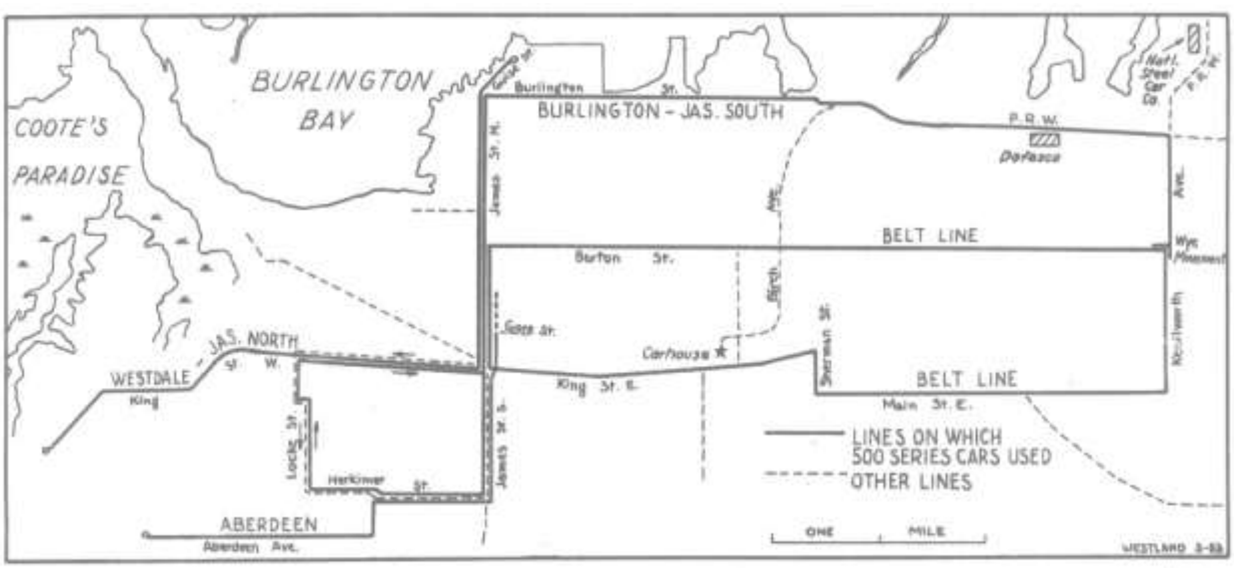
Our own city offers us a unique glimpse into how the design/configuration of streets can shape human travel behaviour. In the early hours of the morning on October 28th, 1956 the rules governing movements on Hamilton’s downtown streets were changed overnight. In an instant the network of two-way streets that had prevailed until that time were replaced with a one-way network. MITL has reviewed micro-film issues of the Hamilton Spectator from that time which covered the events as they unfolded. In particular, we focused on newspaper articles that were featured in October 1956, May and June of 1957 and October of 1957. What we found in this review of the Spectator archives is the focus of this section of the report.

The switch to a one-way system was a continuation of the shift toward a more automobile-oriented Hamilton. Earlier in that decade, in 1951, the tracks for the rail-based streetcar system that had prevailed in the early part of the 20th century were ripped up (Figure 5.1) to help clear the way for the expected further rise of the automobile. This included the “loops” of the old Belt Line which had moved people between downtown, the industrial core and residential areas (Figure 5.2). Automobile ownership was rising rapidly in the 1950’s and a one-way system seemed like a reasonable measure at the time.

Figure 5.1: Removal of Streetcar Tracks at King and James Streets, 1951

There were some sobering aspects to the review process that became evident in reviewing the Spectator day by day. In each issue, a daily small table was found on the upper left corner of the local news page. The table featured the total number of local people killed and injured through automobile accidents to that point in the year. Certainly it is worth reflecting on the fact that automobile-related safety has improved dramatically in the past half century. While automobiles themselves are much safer than they used to be, it is also true that sound road design and traffic control principles of the type relevant to complete streets have played a significant role.

Figure 5.2: Hamilton's Streetcar and Electric Rail Network



We found that the leading local news stories of the day tended to appear on Page 8 of the Spectator and there was little doubt that the conversion of the road network ranked highly on the list of local stories. The initial reaction to the conversion was muted but six months after, a storm of protest was raging among negatively impacted groups. In October 1956, just before the conversion, there was surprisingly little apparent discussion on the topic. On October 2nd the Spectator featured a map of the north-south changes to the road network so that readers might prepare. Apparently the east-west changes had been featured at an earlier date and then on October 6th a full system map was printed. Other than this type of information, the Spectator did not seem to feature much in the way of anticipatory news on the conversion.

In the initial two of three days after the conversion the tone was one of cautious optimism. Cab drivers were noted to be enjoying the change in the October 29th Spectator. It was being experienced by drivers and customers alike that fares were higher because routes were less direct. Of course elsewhere in this report, in Section 3.2.1, Gayah (2012) describes how this exact characteristic of one-way systems is one of their primary disadvantages. Other observations at the time were that drivers were going too fast in left lanes that had an important function to support left turns. Signal control devices had not been fully installed at King and James by the opening date so there was considerable concern for a police officer standing on a box in the middle of four fast flowing lanes of traffic on King Street. The Downtown Businessmen's Association was stated on October 31 as being in favour of the conversion although this position would reverse in the months ahead.

At the release of the May 10, 1957 issue, all was not well. There were complaints about a "horn-honking serpant" of traffic going up James Street to the mountain during the prior day dinner hour. Although it is not clear, some of this problem may have been due to construction work and issues caused by not keeping York Street (as it was known at the time) as a two-way route. Regardless James Street North is portrayed as something of a "parking lot" with it taking 15 minutes to "move past Eaton's" with worse to come as the commuter makes their way up the access. Alderman Ramsey Evans describes the new streets as "race tracks by day and hopelessly crippled arteries in the rush hours." In an observation that seems quite relevant in view of some reverse conversions that have taken place in Hamilton in recent years, Evans notes that Hamilton is not really laid out for a one-way system running north-south although it is conceded that a moderate east-west program might work.

It appears that the first major venting of frustration about the new system was described on May 22, 1957 under the headline: "Business Groups attack one-way plan: roads become race tracks traffic committee told." The article describes a meeting of the City's Transportation and Traffic Committee where the room was apparently packed with local business people. Retailers were particularly upset. One describes losing 150 customers the first week that the new system operated. There are statements that old customers are no longer to be seen and that many are sending in final payments to settle their accounts. Customers have apparently noted that there is now less opportunity to park and that traffic is too heavy. Retailers note that they have invested money into new, visually appealing storefronts but that nobody has time to stop and look. Much of the representation seems to come from downtown King Street East retailers who seem particularly affected by a reduction in business from the west end of Hamilton. One retailer states that he knows of newer west end residents who had never even seen his store and suggests that the reduced accessibility from the change has something to do with it. In response to thoughts that the main problem is one of parking, one participant responded: “there’s no parking problem on an artery that is made into a through highway – people simply shoot on through!” Meanwhile, Alderman Ramsey Evans, who stands out as a prominent local critic of the conversion, states that in his view the problem is one of inaccessibility under the new system.

On May 23, 1957 the Spectator describes a 33 page report put together by the consulting firm Wilbur Smith and Associates based in New Haven, Connecticut. This American firm, which had advised many other cities, had played a leading role in Hamilton’s conversion. Apparently the firm had originally advised an incremental approach in carrying out the conversion but the City had decided to do it all at once. The report from May 1957 describes how the system is functioning six months later. The story that is told is an interesting reflection of the times. The report states that the flow of traffic has improved, that more traffic is passing through the Central Business District and that speed increases of up to 65% have been observed. These are all portrayed as being unambiguously good things. Main and King Streets are noted to be carrying between 12 and 53% more traffic than before. This appears to be one of the interesting side effects of the change: traffic is less evenly distributed before with more being concentrated on the two primary arterials.

Many of letters to the editor at that time were of the anonymous variety. One amusing and yet insightful letter was printed with the tag line: “The Forgotten Shopper” on June 11, 1957. The writer notes that her “high hopes” for the new system had been dashed. She states that one would be “hard pressed to design a better system for making it inconvenient for shoppers to get to the downtown stores.” Echoing other sentiments about Main and King Streets being turned into “expressways”, she notes that you are “swept along with the tide and are probably pretty well out toward Stoney Creek before you can get off Main Street.”

While the statement is tongue and cheek, the implication is that access to the downtown has been reduced in her eyes. Having made the turn onto King and travelling on the reverse direction from Main to reach the King Street store, she observes that “you may get a fleeting glimpse of the store you wanted to go to as you are whirled along but that is as near it as you will get.” She rhetorically asks about the streets: “are they intended as a means of access from the homes to the stores and places of business”? Carrying on with the expressway theme she is of the opinion that the “only people who benefit from the one-way street system are those who want to go straight through the city without stopping.” Overall, she views accessibility as more important than traffic flow.

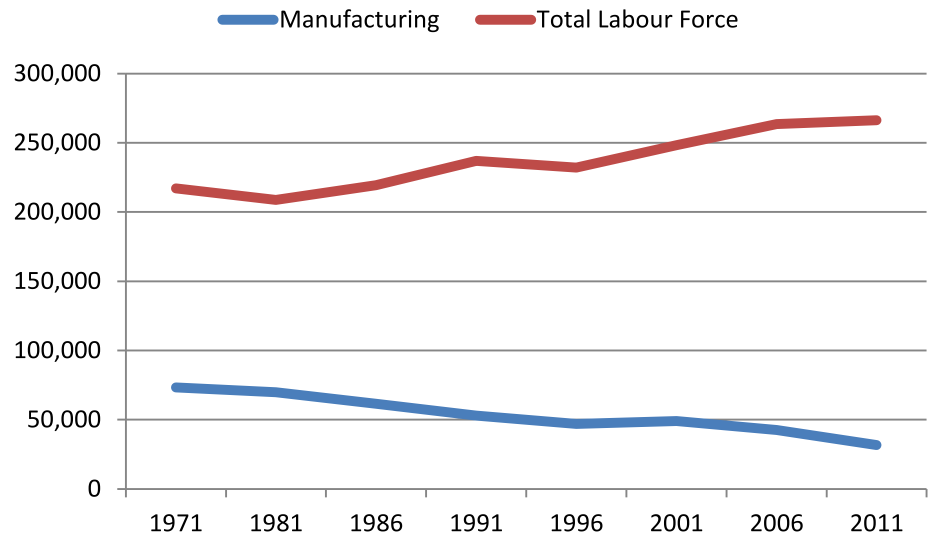
Around the one-year anniversary of the switch there were none of the types of headlines that one might expect to see today such as "Hamilton's One-Way Network: One Year Later." In fact, there was little mention of the topic at all. It appears that by this point one year later the conversion had been accepted as a part of Hamilton's landscape as similar changes had been in many other North American cities. The only mention of the conversion came on October 16, 1957 where the outcome of the City's Transportation and Traffic Committee meeting was that the system was "here to stay" with the main question under consideration being the extent to which modifications would take place to iron out “kinks”.

Legacy

The ultimate lack of an enduring outcry in the local media may be a product of the one-way network serving its intended purpose at the time. Early in the 20th century, Hamilton was known as the ‘Electric City’ as cheap hydroelectricity helped to fuel a boom in manufacturing employment and population growth. By the 1950s, large employers located in Hamilton’s lower city east-end industrial core such as Westinghouse and Stelco employed tens of thousands. Every day these employees would travel to the industrial core to start a shift, just as thousands more finished theirs and travelled home. The commuting demands of such a large concentration of employment created a need for high capacity transportation not only between the east and west, but also for employees crossing the Niagara escarpment on their commutes between the upper and lower city. In this context, the city’s expansive one-way road network and the construction of several mountain access points such as the Kenilworth Access would have greatly expedited such commuting flows.

However, as time has passed and the nature of employment in Hamilton has changed, an argument can be made that much of the city’s extensive one-way network has outlived its original purpose. Though employment in Hamilton’s industrial core remains an important economic engine for the city, the total number of individuals commuting to this area has fallen dramatically. Manufacturing employment as of 2011 stands at just over 31,000 jobs, a number that is less than half of what it was in 1971 according to the Canadian Census (Figure 5.3). For steel manufacturing specifically, total employment in this sector has fallen from its highs of more than 20,000 workers in the 1980s to approximately 7,000 at Dofasco and less than 1,000 at Stelco, the latter of which has recently ended its history of steel manufacturing in the city.

Figure 5.3: Manufacturing Employment and Labour Force Totals for Hamilton, 1971-2011



Over this time period the city has greatly diversified its employment base into post-industrial sectors such as healthcare, education, and services. But this employment is also spatially diversified across many areas throughout the city, creating new hubs of economic activity beyond those in the traditional industrial core. As our analysis of traffic volume data will show, the legacy of job losses at Hamilton's once large manufacturing centres has left the city with several corridors of overbuilt infrastructure, particularly in the eastern lower city. Given that the broader pressures of demographic changes and the re-urbanization of people and jobs are presently shaping the nature of growth in Hamilton, a case can be made for the re-allocation of excess road space away from automobile-oriented uses in an attempt to rebalance social, environmental, and economic outcomes in affected areas.

5.2 A Thematic Review of Hamilton Street Cases

5.2.1 Approach

Table 5.1: Hamilton Complete Street Cases

Western Lower City	Central Lower City	Eastern Lower City	Mountain
Longwood Road	Main/King Corridor	Gage Avenue	Upper James Street
Dundurn Street	James Street North	Britannia Street	Concession Street
Locke Street	Cannon Street	Melvin Avenue	
Queen Street	Bay Street	Queenston Road	
		Kenilworth Avenue	

In consultation with the City of Hamilton, Table 5.1 above lists 15 cases that have been identified as street cases of interest for further examination as complete streets. This list is too extensive to do detailed case-study examinations within the constraints of this report but nevertheless, we present substantial material to characterize each case along the most meaningful dimensions that we have identified through the extensive process in the earlier chapters.

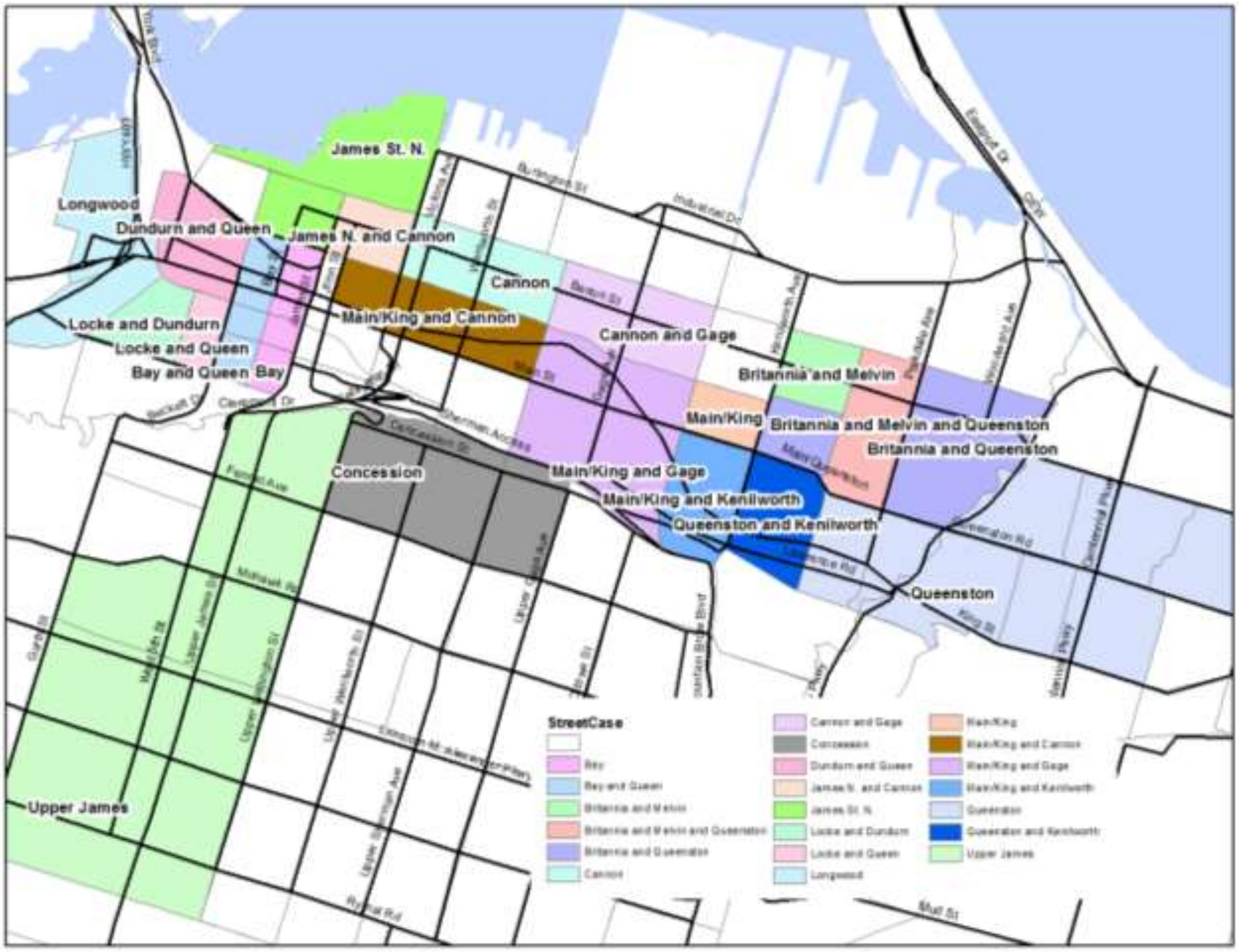
The various identified street cases in Hamilton are discussed below on a theme-by-theme basis. There are two main categories of available data to consider:

- Traffic volume (Link-based)
- Zone-based

Traffic volumes have been collected through empirical observation, largely at intersections, whereas zone based criteria have been collected through census/survey work.

The link-based traffic volumes can be joined directly to particular streets. By definition, zone-based metrics are directly associated only with zones, therefore a translation/walk over process is required to associate the quantities (e.g. census results or survey results) to streets. For the purposes of the streets cases, the solution was to assign zones to street cases based on proximity. The result of the process that was used for 2011 Transportation for Tomorrow Survey (TTS) zones is shown in Figure 5.4. It is important to note that some TTS zones were assigned to more than one street case. This outcome is simply a reflection of the fact that some street cases are quite close together and also that TTS zones are quite large relative to small census areas. This can be seen in Figure 5.2.1 in that some of the colours in the legend are associated with multiple street cases.

Figure 5.4: Defining Areas Associated with Street Cases

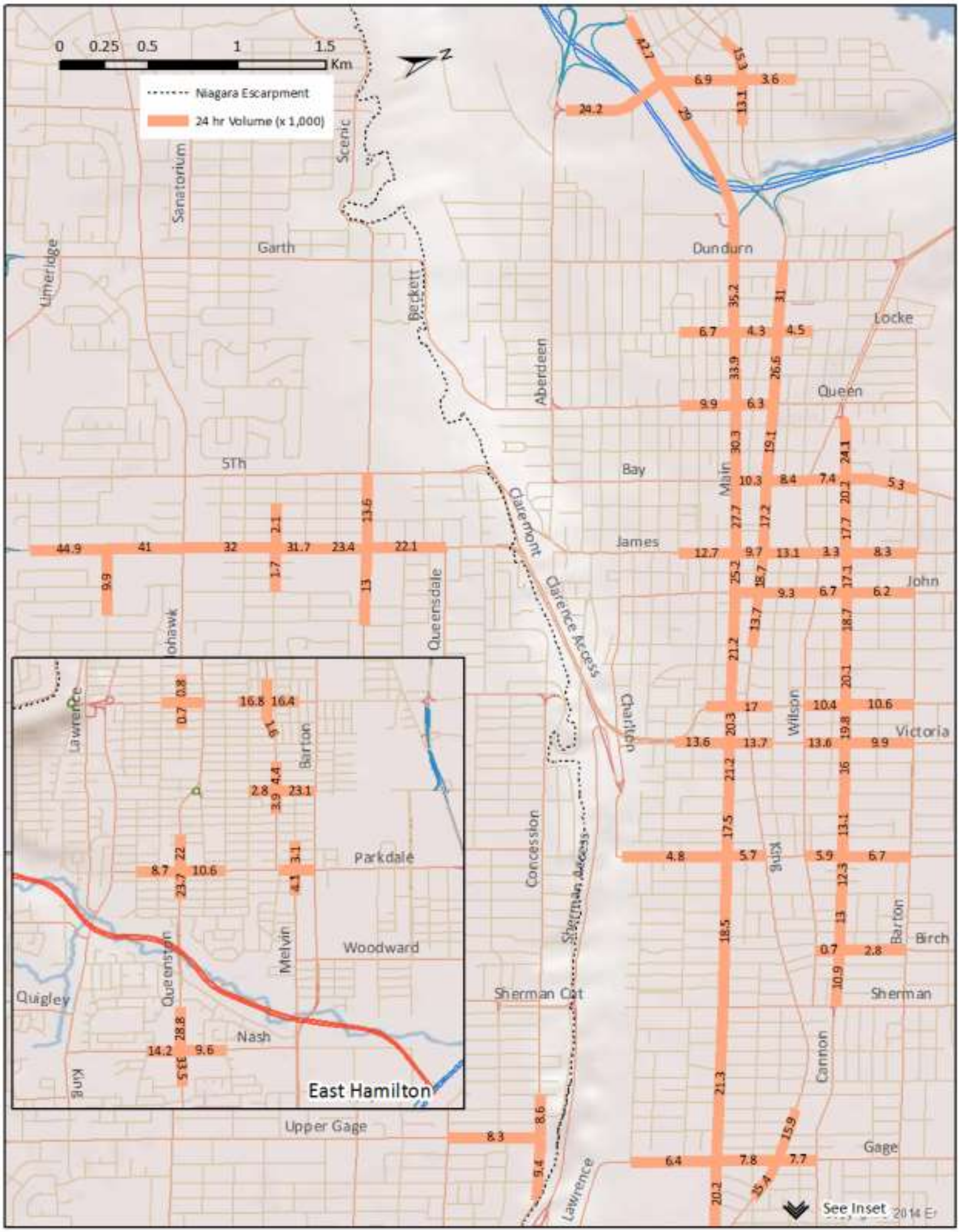


5.2.2 Traffic Volumes

One of the most fundamental metrics for a complete street is traffic volume. The relationship of traffic volumes to complete streets is not complex: where there is excessive road space given prevailing traffic volumes, there is more flexibility to implement a wider range of complete streets concepts. Where traffic volumes are relatively high, for example well in excess of 20,000 vehicles per day, the risks of congestion are higher if space for the automobile is reduced to one lane per direction. If there are several lanes per direction that are under-utilized, the potential for reallocating space for other uses is likely enhanced.

Figure 5.5 below provides selected traffic volume information that has been collected by the City of Hamilton at certain key intersections. For the most part these data overlap with the street cases that we are considering. It has to be noted that these are snippets of intersection data have been collected at different points in time over the past few years. As such, this is not an accurate snapshot for a given point in time.

Figure 5.5: Selected 24hr Traffic Volume Information for the City of Hamilton



In the Lower City, the major volume flows are east-west while North-South volumes are generally light. From this figure alone it seems clear that traffic volumes and worries about congestion should not be a limiting factor for complete streets measures on most if not all north-south links in lower Hamilton. Road diets could be implemented in certain cases. The east-west flows on the Main/King corridor appear lightest between John St. and the Red Hill Valley Parkway. For large stretches of Main Street between these points, the traffic volumes are really not that high, especially given the number of lanes that are allocated for vehicles. Main Street funnels into Queenston Road and the latter has higher volumes near the Parkway. On the mountain, the traffic volumes we have received are less comprehensive but the major arterial flow is north-south along Upper James and in particular for stretches close to the Linc. Along with Main St. from McMaster to the downtown, this section of Upper James is among the busiest of urban arterials in Hamilton and has more than twice the levels seen on major stretches of Main Street.

The following set of figures from Figure 5.6 to Figure 5.13 are dramatic depictions of excess capacity for certain Hamilton cases. Based on data received from the City, traffic volume is shown over the course of the day in 15 minute intervals. The grey horizontal lines represent the capacity of a road link over each interval depending on the number of lanes. For example, one lane of traffic can handle 200 vehicles in a 15 minute interval whereas three lanes can handle 600 vehicles in the same span of time. Keep in mind that these are rules of thumb as there are other factors which influence traffic flow and capacity.

The results for Longwood Road show that a reduction to one vehicle travel lane in each direction could be problematic during peak periods as traffic flow in theory is likely to exceed capacity. The similar illustrations for Melvin Avenue and Locke Street show that one-lane of traffic per direction can and does work quite well in the case of the latter. The depictions for King Street suggest that there is more flexibility at John Street than there is at Bay Street. As few as two lanes could be possible at John Street but the case for same is borderline at Bay Street. Of course, King Street west of Wellington is already two lanes for a significant stretch. Consider as well that people may reallocate trips, and change routes or modes in response to these types of changes in road configuration.

Figure 5.6: Longwood Road South of Main – Northbound Lanes (Mar 24, 2010)

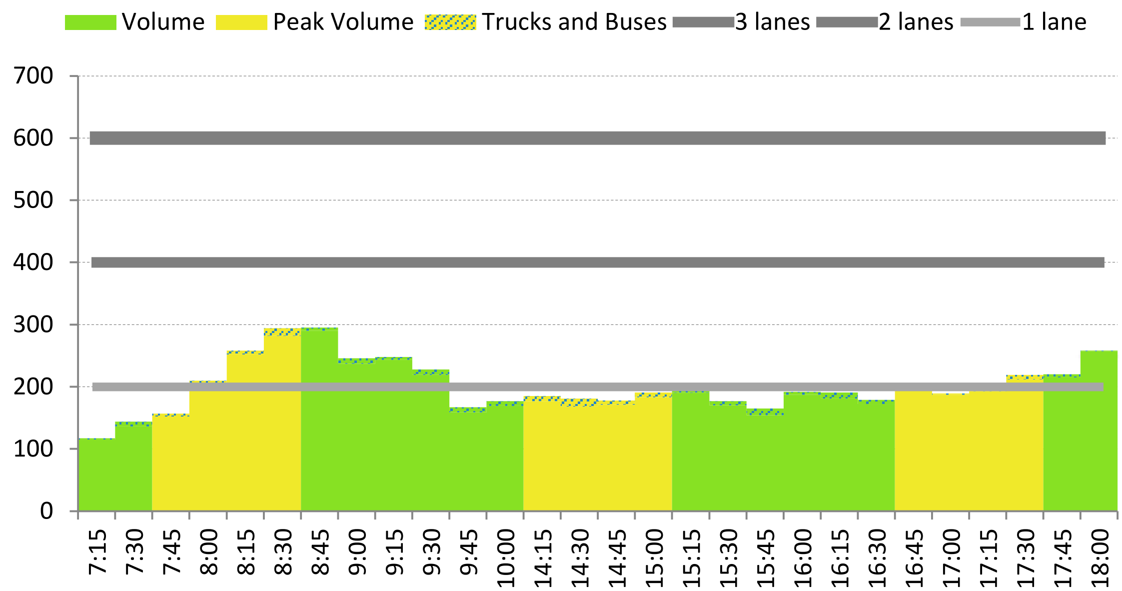


Figure 5.7: Longwood Road South of Main – Southbound Lanes (Mar 24, 2010)

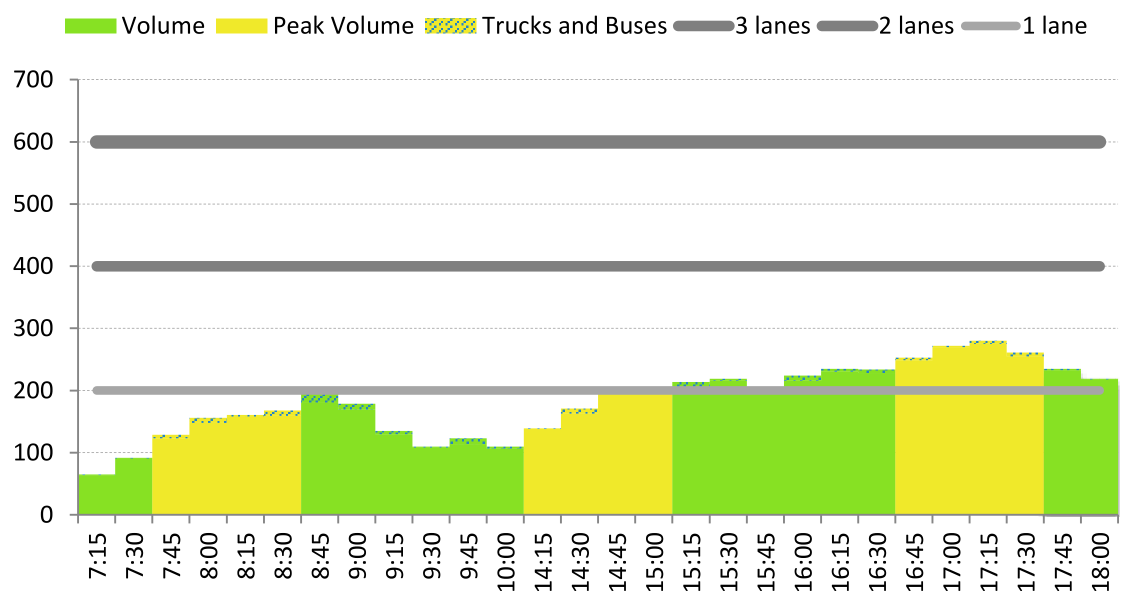


Figure 5.8: Melvin West of Parkdale – Westbound Lanes (Oct 17, 2009)

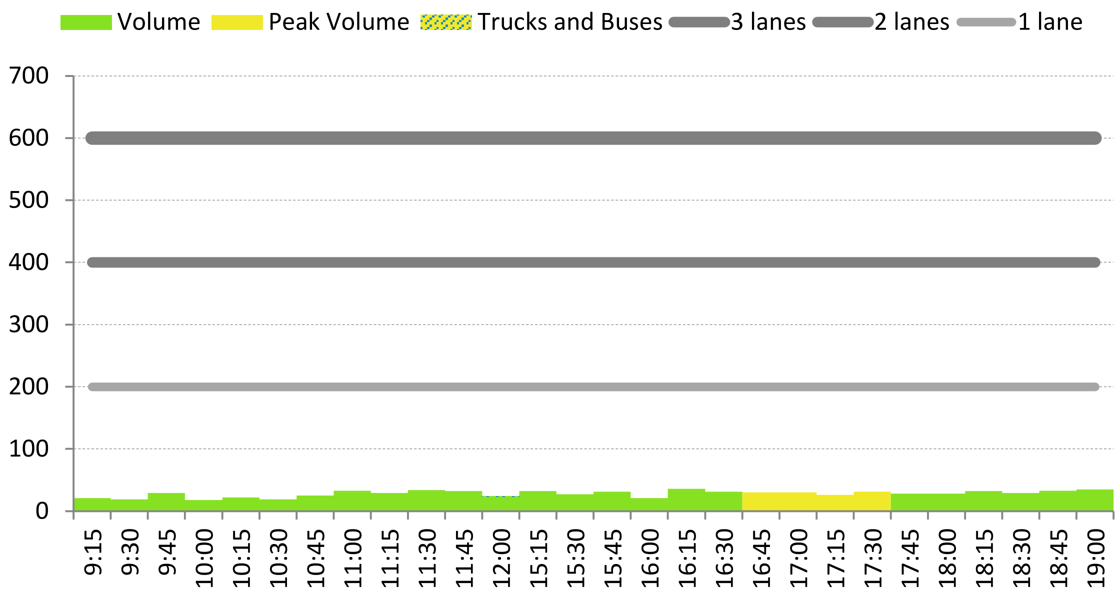


Figure 5.9: Melvin West of Parkdale – Eastbound Lanes (Oct 17, 2009)

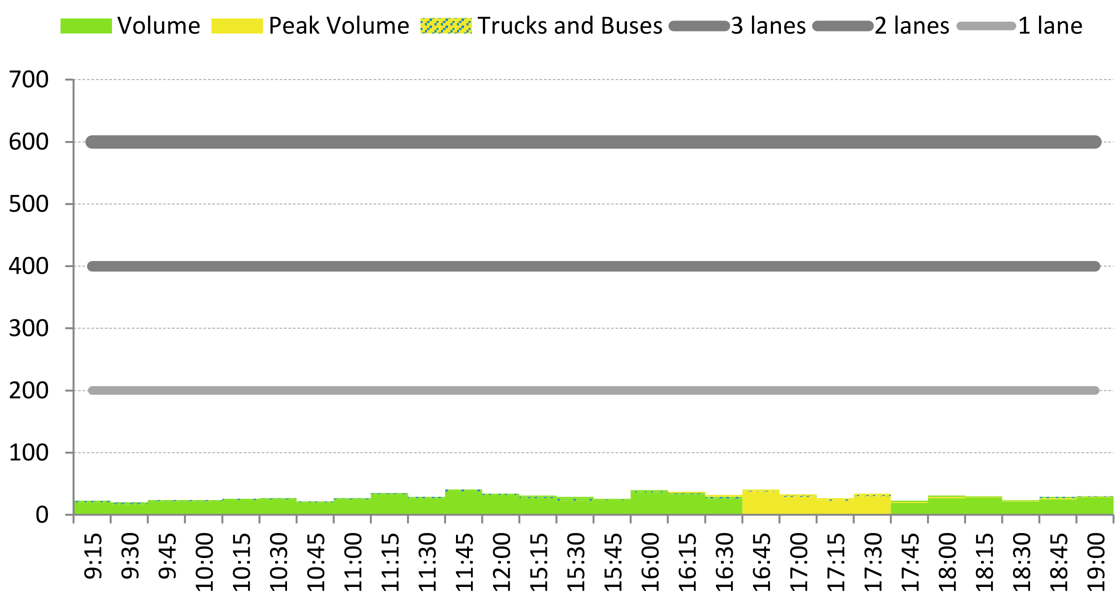


Figure 5.10: Locke North of Stanley – Northbound Lanes (May 28, 2013)

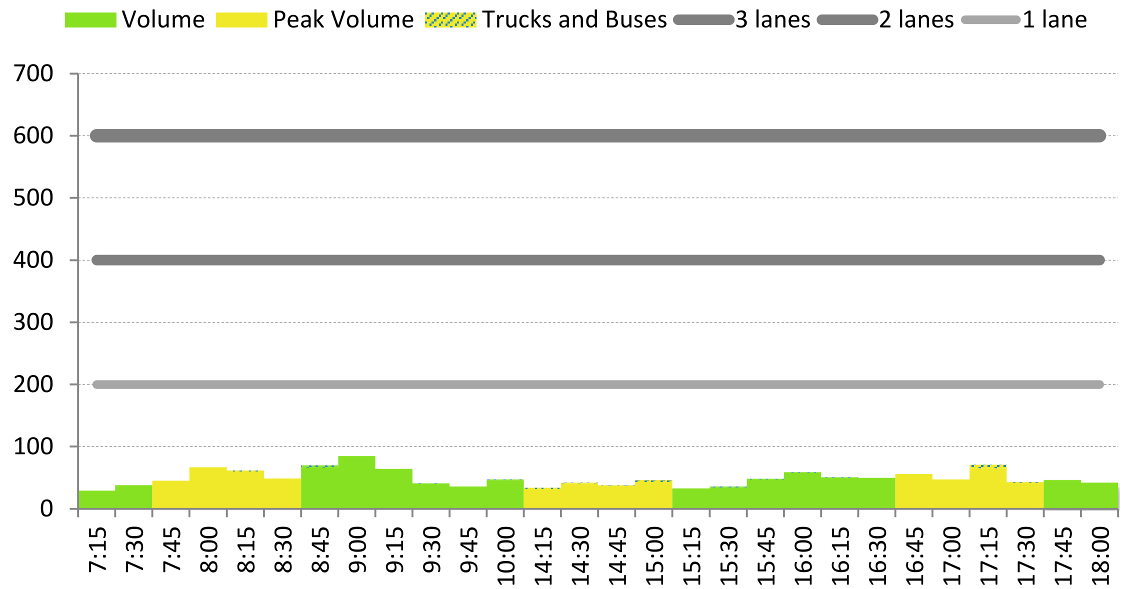


Figure 5.11: Locke North of Stanley – Southbound Lanes (May 28, 2013)

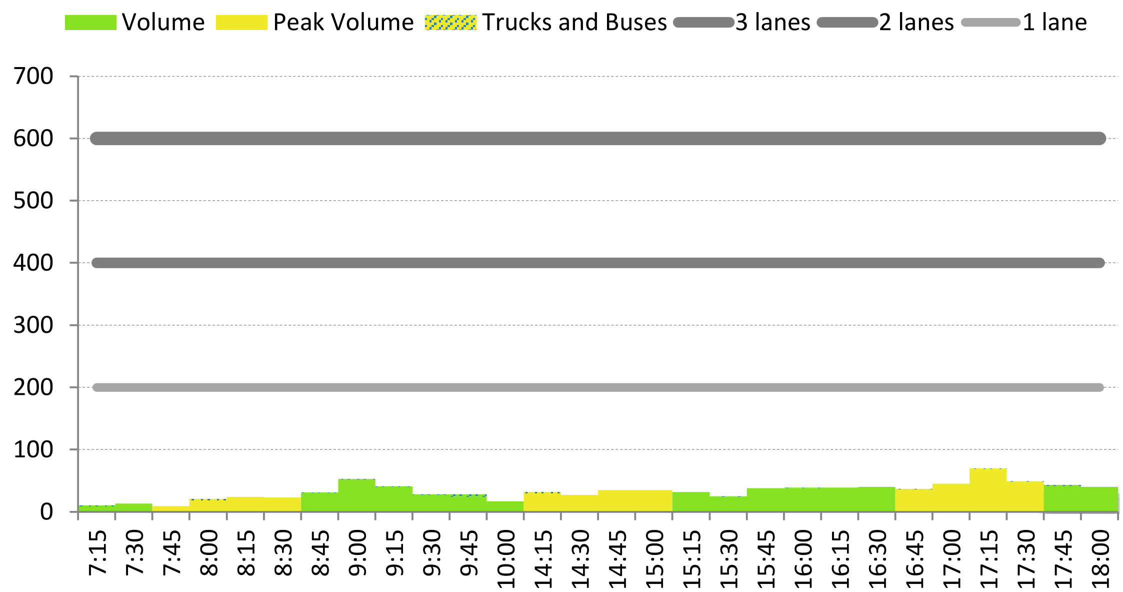


Figure 5.12: King East of John – Westbound Travel (May 13, 2013)

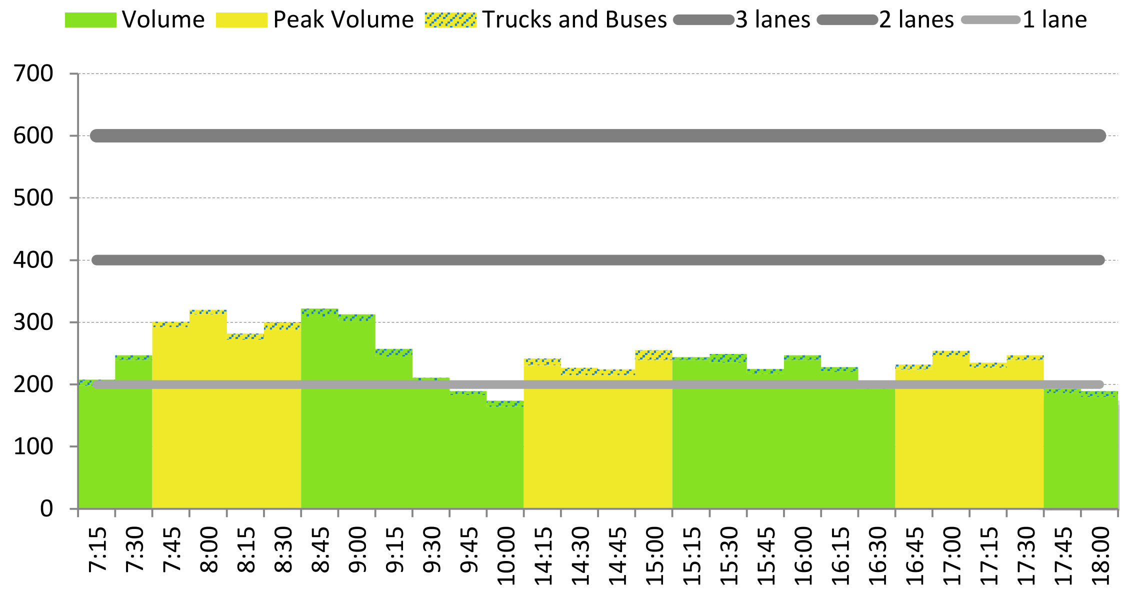
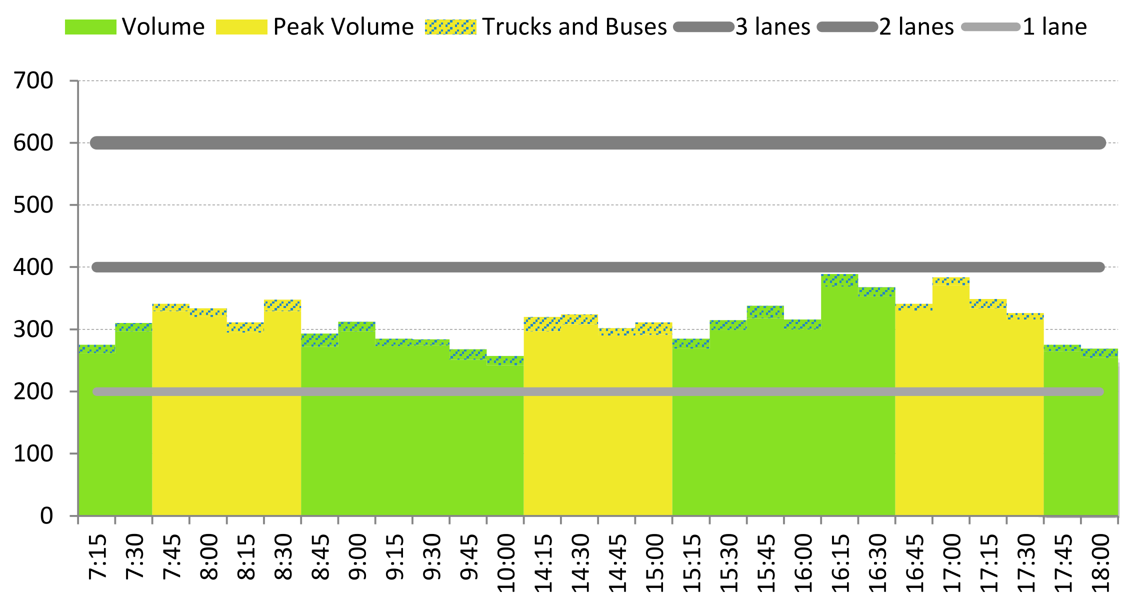


Figure 5.13: King East of Bay – Westbound Travel (May 14, 2013)



5.2.3 Modal Splits and Trip-making

Ultimately, for a complete street to have a significant impact beyond improved safety, it will likely have to influence trip making behaviour. In understanding what could happen with a complete street implementation, it is helpful to assess trip making patterns associated with the Hamilton Street cases. To this end, data from the 2011 Transportation for Tomorrow Survey, which was released at the end of 2013, is the best available source. This work is based on case-specific zones as outlined in Section 5.2.1.

Trip Generation per Population and Street Case

From Table 5.2 below, there is clear evidence of a wide range of travel behaviours across the street cases. The cases are ranked in descending order of originating auto driver daily trips per thousand people from within the catchment areas defined in Figure 5.4. Generally, the cases that generate a lot of automobile trips are also the places that generate a lot of trips in general. The Longwood case is interesting in that a large number of auto trips are generated (perhaps based on its ideal location for highway access) but at the same time there are very high rates of walking trips. The latter is likely associated with the university and a large number of schools in the area. Another trend that seems apparent is that places that generate the most transit trips per thousand people also tend to generate fewer trips overall.

Cycling trips appear as the least prominent of all but what is noticeable is that it is the western cases within Hamilton, those within cycling distance of McMaster University, which lead the way in cycling. Cycling is much less prominent in the eastern part of the lower city where many of the street cases of interest are situated. There are street cases that show up as zero for cycling and to some extent this is likely due to sampling variability. If not zero, it is clear that the cycling rates in those cases are very low.

Walking trips are generally comparable to transit trips – sometimes the walking total is higher and sometimes it is not[1]. One interesting note is that James Street is captured as three cases in the table. Upper James North is on the Mountain close to the brow and Upper James is farther from the brow on the mountain. Meanwhile the third case is referred to as James Street and passes through the city core. Walking rates increase by about 2.5 times as one moves from the southern reaches of Upper James to the northern reaches of James Street near the core.

Similar data for some comparison cases is presented in Table 5.3 and for the most part there is nothing remarkable to be derived from those results given the discussion outlined above. What

[1] Walking trips are generally considered to be under-reported. Most transit trips begin and end with walking trips, for example.

is worth noting is that many of the comparison cases are more auto-oriented than the average street case of Table 5.2. This probably indicates that the City has largely chosen street cases that are naturally less oriented to the automobile than average. There is thus probably a pre-conceived notion that complete streets concepts are most applicable in locations that feature other modes of travel more.

Table 5.2: AM Peak Originating Trips per Thousand People by Mode and Street Case

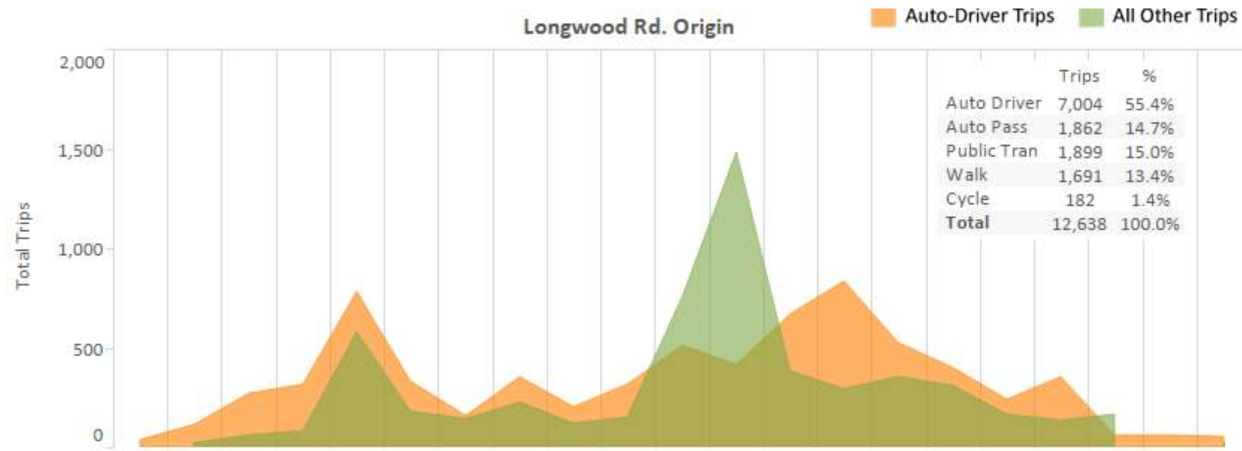
	Auto Driver	Auto Passenger	Public Transit	Walk	Cycle	Total
Longwood	386.2	45.1	26.5	118.7	13.3	589.8
Upper James	299.7	70.3	47.4	28.8	0.0	446.1
Concession	266.8	53.0	48.8	31.5	1.7	401.8
Locke	266.8	50.4	40.4	73.9	11.9	443.5
Upper James N.	260.3	59.8	24.6	49.0	7.1	400.9
Kenilworth	253.7	59.0	58.8	17.9	0.0	389.3
Dundurn	251.4	58.4	21.0	58.0	10.9	399.7
Melvin	251.0	39.0	31.8	44.9	0.0	366.8
Britannia	240.8	31.9	49.5	51.8	0.0	373.9
Queenston	236.1	39.0	51.6	40.7	1.7	369.1
Gage	213.2	61.5	59.2	40.2	2.7	376.9
Main/King	212.2	55.7	69.9	46.2	2.5	386.6
Bay	204.0	43.3	41.1	58.0	1.8	348.1
James N.	203.5	38.4	63.3	71.7	1.8	378.7
Cannon	185.6	42.9	71.9	58.5	3.0	361.9
Queen	172.5	44.7	47.2	58.6	0.0	323.1

Table 5.3: AM Peak Originating Trips per Thousand People by Mode and Comparison Case

	Auto Driver	Auto Passenger	Public Transit	Walk	Cycle	Total
Wilson	327.8	48.1	12.7	16.5	0.0	405.1
Mud	317.7	46.7	16.3	19.4	0.0	400.2
Main W.	298.5	59.1	47.8	63.5	15.9	484.8
Governors	298.2	45.5	25.5	23.6	2.6	395.5
Upper Wentworth	283.7	90.1	69.2	37.0	0.5	480.6
Mohawk	281.7	76.1	51.6	46.3	2.4	458.1
Upper Gage	272.6	72.0	40.3	38.8	2.7	426.5
York	213.9	36.1	34.5	53.2	10.1	347.9

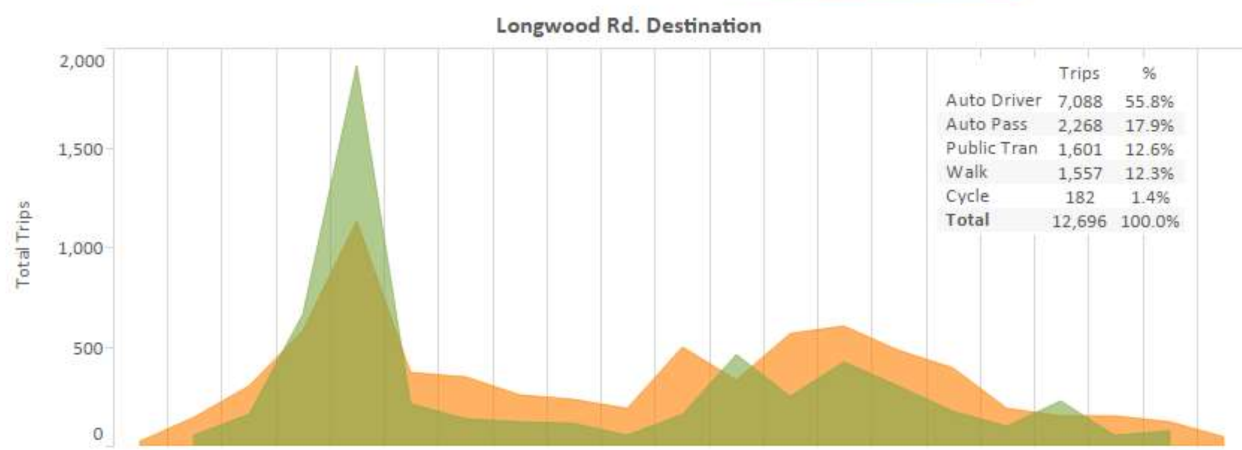
21 Hour Trip Profiles

Figure 5.14: 21 Hour Trip Count Profile by Primary Mode – Longwood Rd.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	37	111	272	319	779	328	159	353	204	318	513	417	670	837	530	398	241	354	57	57	50
Auto Pass		20	21	41	98	16		79	44	130	204	200	156	43	232	257	126	134	61		
Public Tran			42		52	68	71	52	50	20	371	592	166	170	69	31	42		74		29
Walk				41	380	67	52	72	16		184	689	62	56	50	22					
Cycle					47	26	21	26	12					21					29		
Total	37	131	335	401	1,356	505	303	582	326	468	1,272	1,898	1,054	1,127	881	708	409	488	221	57	79

Hourly % of Daily Trips for Given Mode 0.29% – 40.75%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	25	146	303	579	1,129	368	345	257	236	188	493	333	566	599	484	393	185	150	148	119	42
Auto Pass		19	42	228	619	17	94	80	89	28	85	60	47	228	165	82	98	186	26	75	
Public Tran		31	115	349	493	134	39			26	29	68	42	95	91	68		21			
Walk				60	801	56		28	26		41	282	158	43	20			16	26		
Cycle				21				12				50		52	21	26					
Total	25	196	460	1,237	3,042	575	478	377	351	242	648	793	813	1,017	781	569	283	373	200	194	42

Hourly % of Daily Trips for Given Mode 0.20% – 51.45%

For each of the individual cases in Table 5.2, a 21 hour figure has been created that provides much more detail about the modes and counts of arriving and departing trips in the local vicinity during a typical day. An example is shown in Figure 5.14 for the Longwood Road area. A collection of nearby traffic study zones associated with the TTS survey have been grouped using the process described in Section 5.2.1.

Note that this figure does not capture traffic volumes on Longwood Road but rather trip totals associated with the catchment area of Longwood Road. With respect to Figure 5.14, the area under the orange curve captures auto-driver trips while the area under the green curve captures all other trips (including auto-passenger). The results suggest that zones associated with Longwood Road are important destinations during AM Peak and important origins during PM peak. One notable result is that there is a very sharp transit/walking spike during the two peak periods. The PM transit/walking spike seems to lead the auto driver spike by about two hours. Auto driver trips appear to me more evenly distributed. There appear to be certain times of the day where there is more pressure on Longwood Road and other streets in the catchment area to handle a large number of trips from different modes simultaneously. Complete Streets can be particularly important during such periods.

Appendix 7.3 has been devoted to figures of this type for the other Hamilton cases as well as a range of comparison cases that are of interest. These can be studied in detail by the interested reader as they shed light on the trip dynamics of each street case. Some of the salient points that can be derived from the figures as a group are as follows:

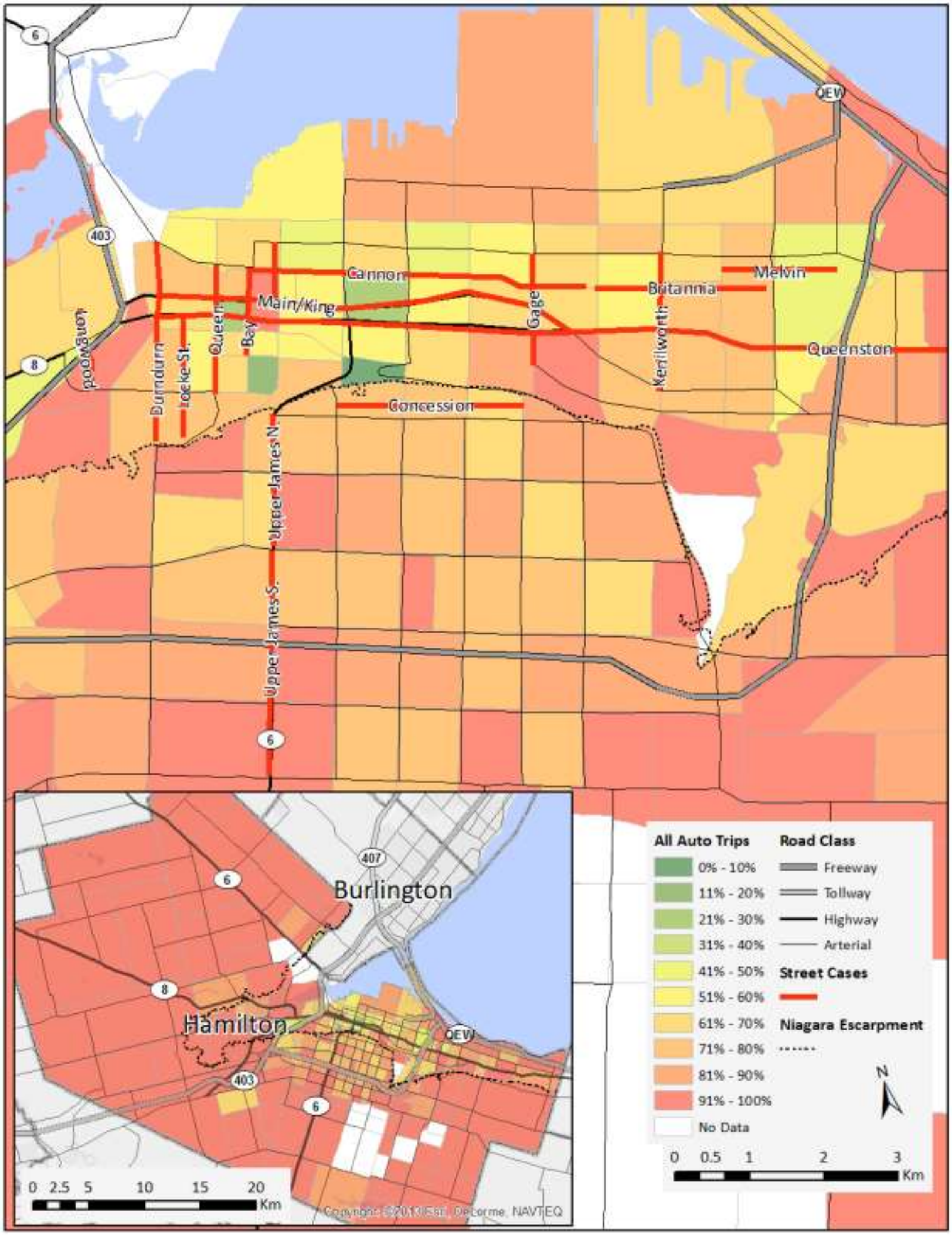
- It is important to pay attention to the trip scale vertical axes as it differs quite a bit from figure to figure

- It is interesting to compare the auto-driver (orange) curve to the other trips (green) curve across the figures. The most clearly auto-oriented catchment areas are associated with:
    1. Wilson Street (Ancaster)
    2. Mud Street
    3. Dundurn Street
    4. Concession Street
    5. Upper James

- For most of the street cases, the total for "all other trips" exceeds auto-driver trips for at least one or more hours per day

- James Street North and Cannon Street show up as being least auto-oriented but it is important to note that even the least auto-oriented places in Hamilton are nevertheless quite auto-oriented.

Figure 5.15: 8AM Auto Driver/Passenger Share of Trips (2011)



- Transit/Walking spikes are more pronounced/jagged than auto-driver peaks
- Among trips originating or arriving in areas that are adjacent to Main Street, note that auto-driver trips are almost matched by other trip types. This is true of Main Street to an extent greater than other street cases. The degree to which non-auto driver trips predominate is one measure of how complete a street is.

Maps of Modal Split in Hamilton

While the prior section has highlighted the temporal patterns of trip making in Hamilton the series of maps from Figure 5.15 to Figure 5.20 illustrate some of the spatial patterns of trip making at important times of the day.

As Figure 5.15 and Figure 5.16 vividly illustrate, much of the backdrop for complete streets in Hamilton, as with most medium cities in North America, begins and ends with a heavy reliance on the automobile. These figures sum the originating auto-driver and auto-passenger trips as auto trips for individual TTS zones and express the figures as a share of all originating trips. This is done for 8AM and 5PM with the latter zooming in more on the lower city. For 8AM the green colour shows that there are pockets of central locations in Hamilton where auto trips are not the majority. But for most of Hamilton they are the majority and in many areas, particularly outlying ones, they are a strong majority. The central city pattern for 5PM shows that auto use is event more dominant at that time. The interested reader is referred to Appendix 7.6 which shows TTS auto share maps for key areas of Toronto. This gives a frame of reference, especially in downtown Toronto, where transit is much more dominant than is the case in Hamilton.

Figure 5.17 and Figure 5.18 focus on share of originating trips done by transit. Note in the legends that the shares covered range from 0 to 50% while the scale went from 0 to 100% for the prior auto maps. At 8AM in particular there are some prominent transit shares in Hamilton. There are a handful of zones at this time where shares are even in excess of 50% and there are quite a few zones, even on the Mountain, which are solidly over 20 and 30%. Of course, as the 21 hour profiles in the Appendix show, the 8AM hour in Hamilton represents transit at its peak in terms of moving a large share of trips. Transit shares have faded by 5PM relative to 8AM and this seems more noticeable on the Mountain where there are higher levels of auto ownership. Overall it seems fair to say that even without comprehensive complete streets implementations in Hamilton and without an advanced light rail transit system, there is evidence of a significant and important east-west transit corridor in the lower city as well as other secondary transit corridors.

Figure 5.19 illustrates 8AM walking shares on a 0 to 25% share basis. The pattern really seems to mimic the 8AM transit share pattern to a significant extent. Many of the places that have a high share of transit trips also have a fairly high share of walking trips. Walking does seem to be relatively more important in the area of Westdale and less important in areas where walking distances are likely too large. The lower City definitely shows up as being more prominent for walking than the Mountain although the latter has a handful of prominent zones for walking trips. Figure 5.20, which is about three pages below, illustrates that cycling is the least prominent of the travel modes in handling a large share of 8AM trips. The categories range from 0 to 8% but even at those low levels most of the map is coloured red. This means that the TTS survey was essentially unable to pick up cycling trips for large swaths of Hamilton. To the extent that cycling trips are showing up, it is mostly in the west and in other areas of the lower city in particular that would be expected.

Figure 5.16: 5PM Auto Driver/Passenger Share of Trips (2011)

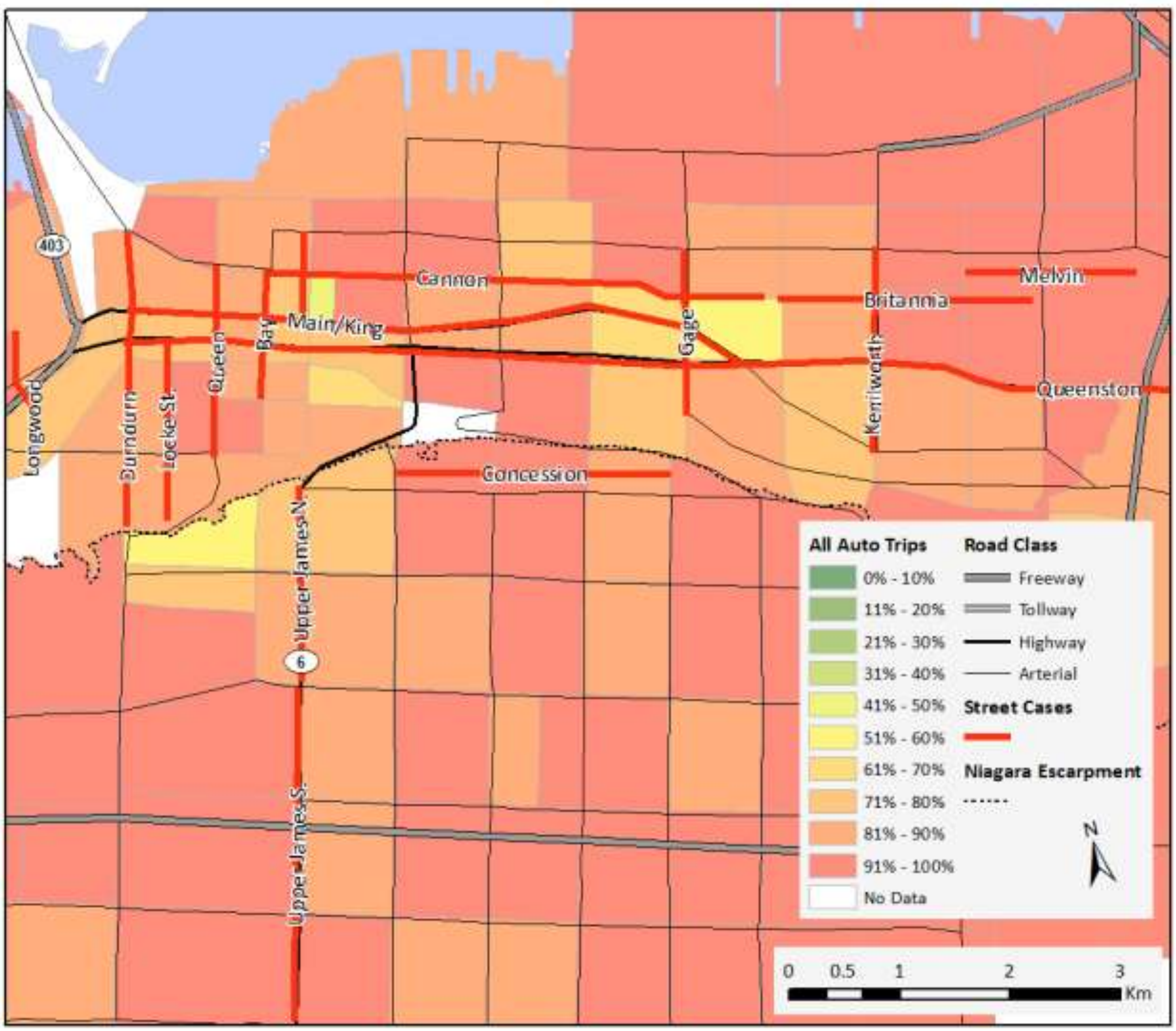


Figure 5.17: 8AM Transit Share of Trips by Zone of Origin (2011)

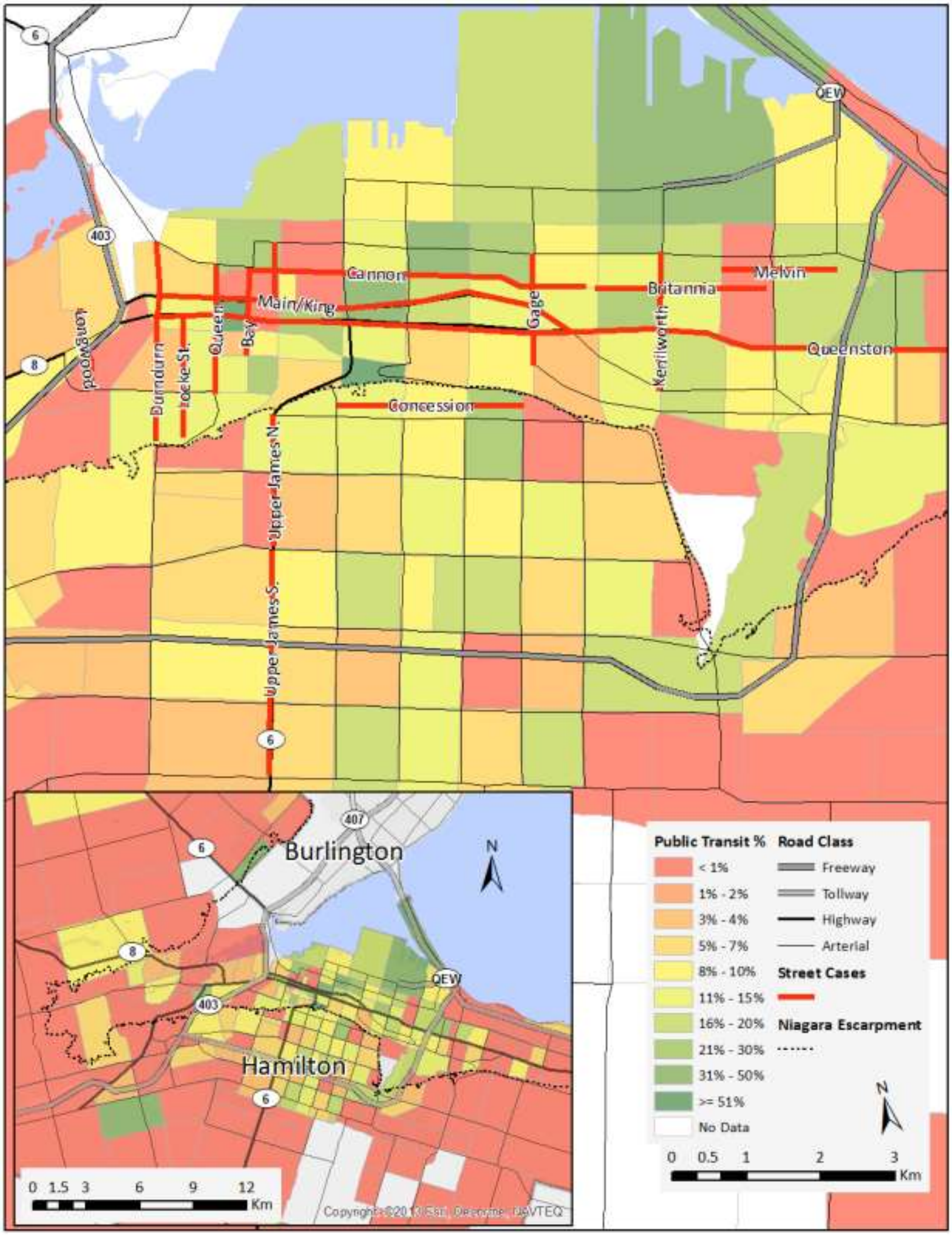


Figure 5.18: 5PM Transit Share of Trips by Zone of Origin (2011)

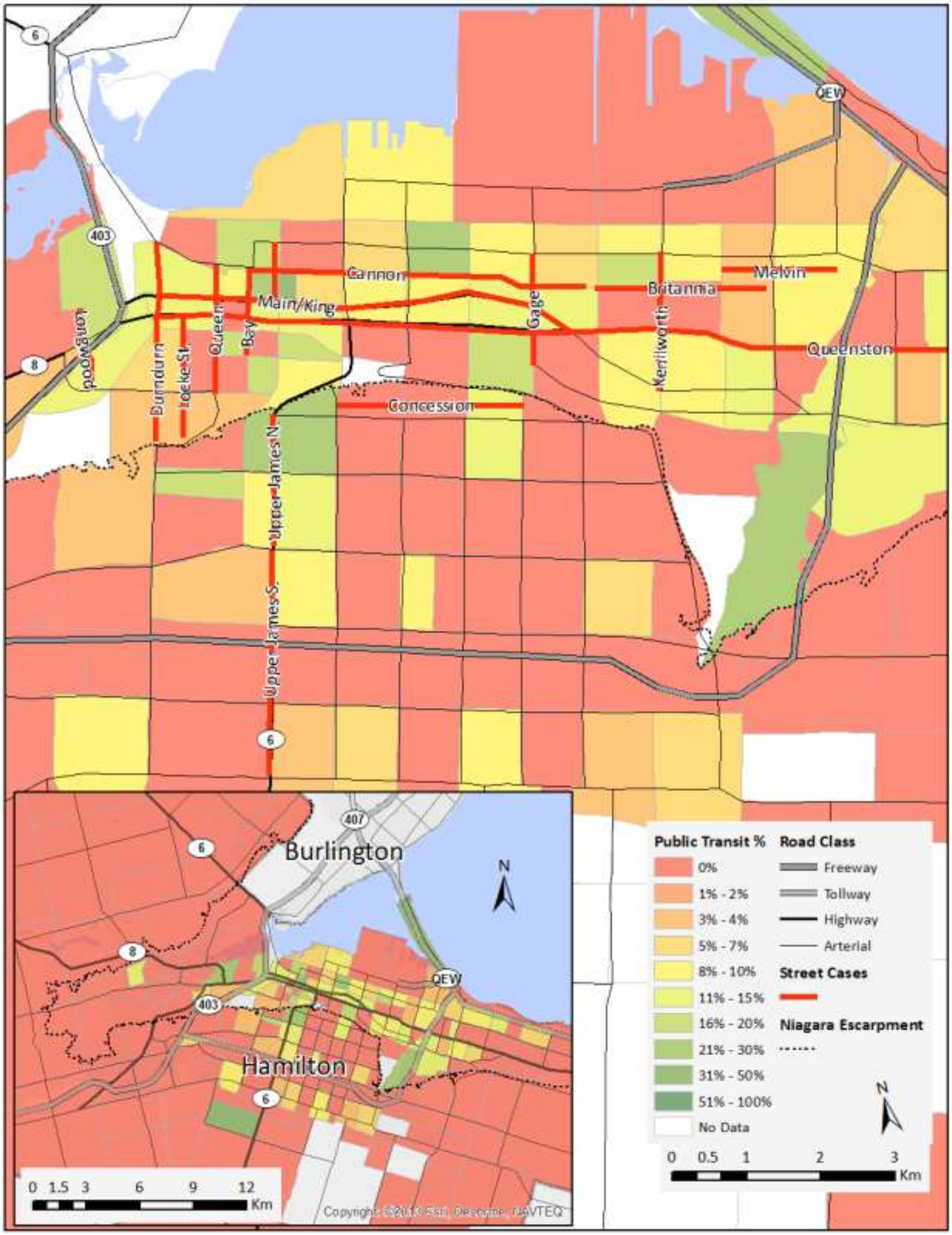


Figure 5.19: 8AM Walking Share of Trips by Zone of Origin (2011)

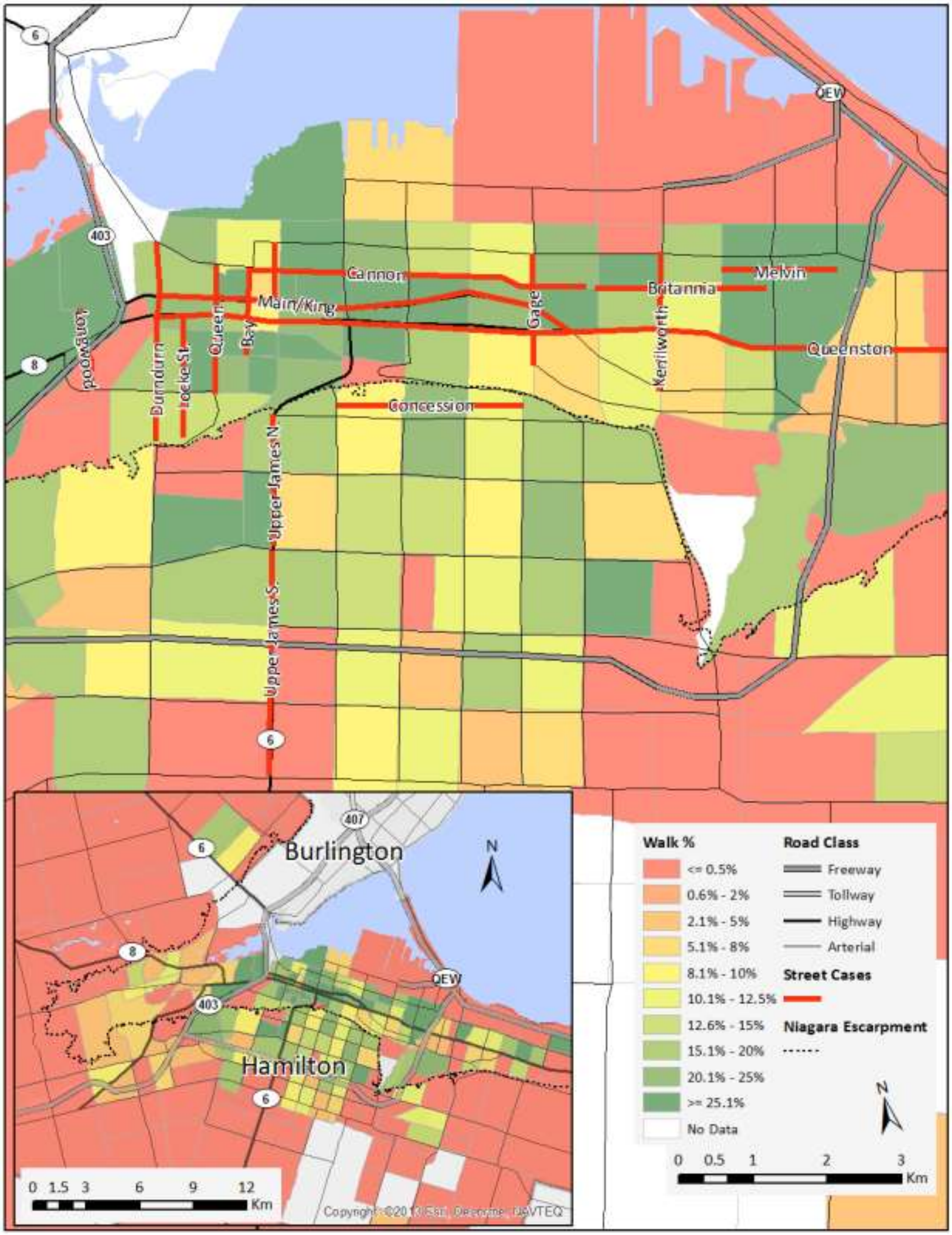


Figure 5.20: 8AM Cycling Share of Trips by Zone of Origin (2011)

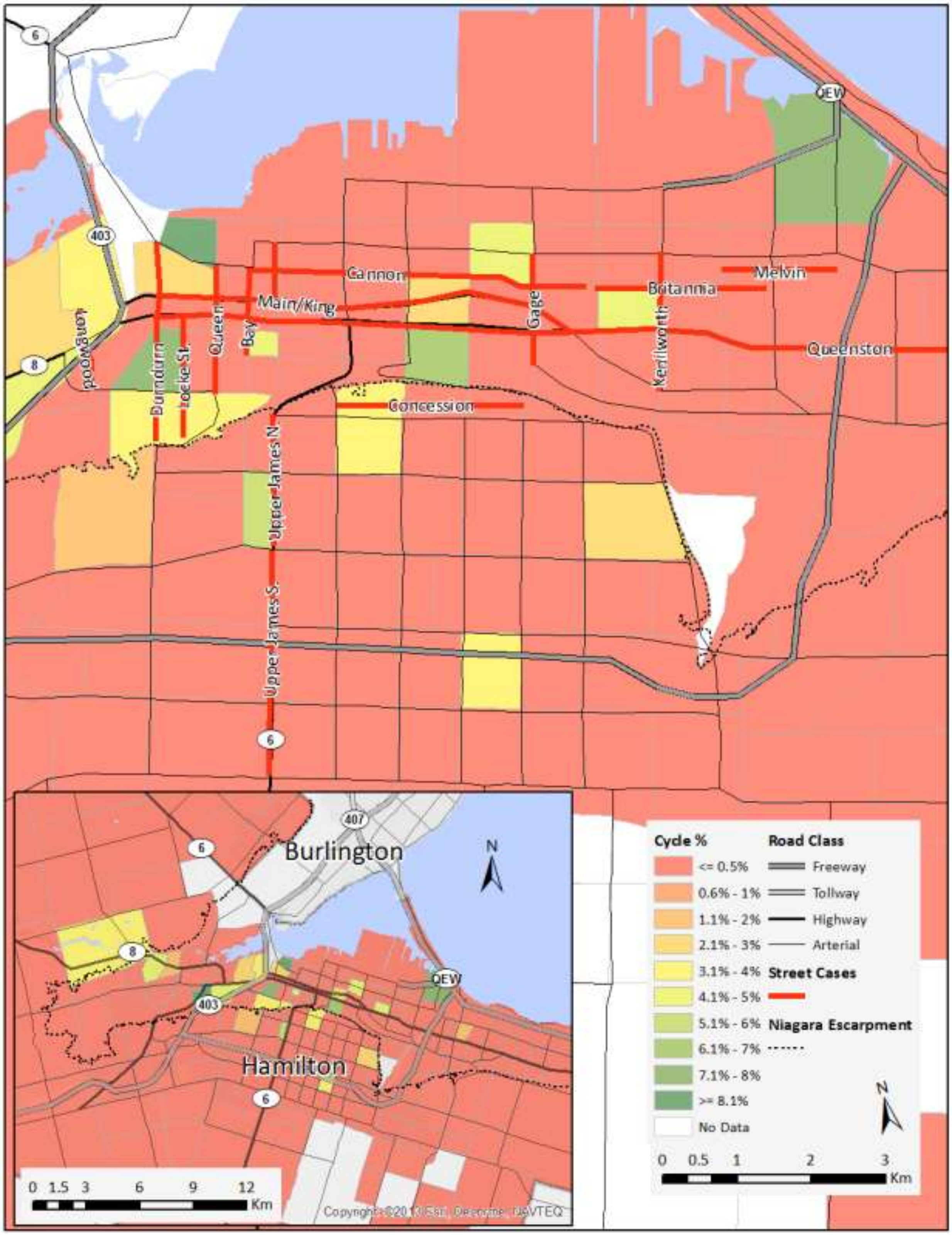
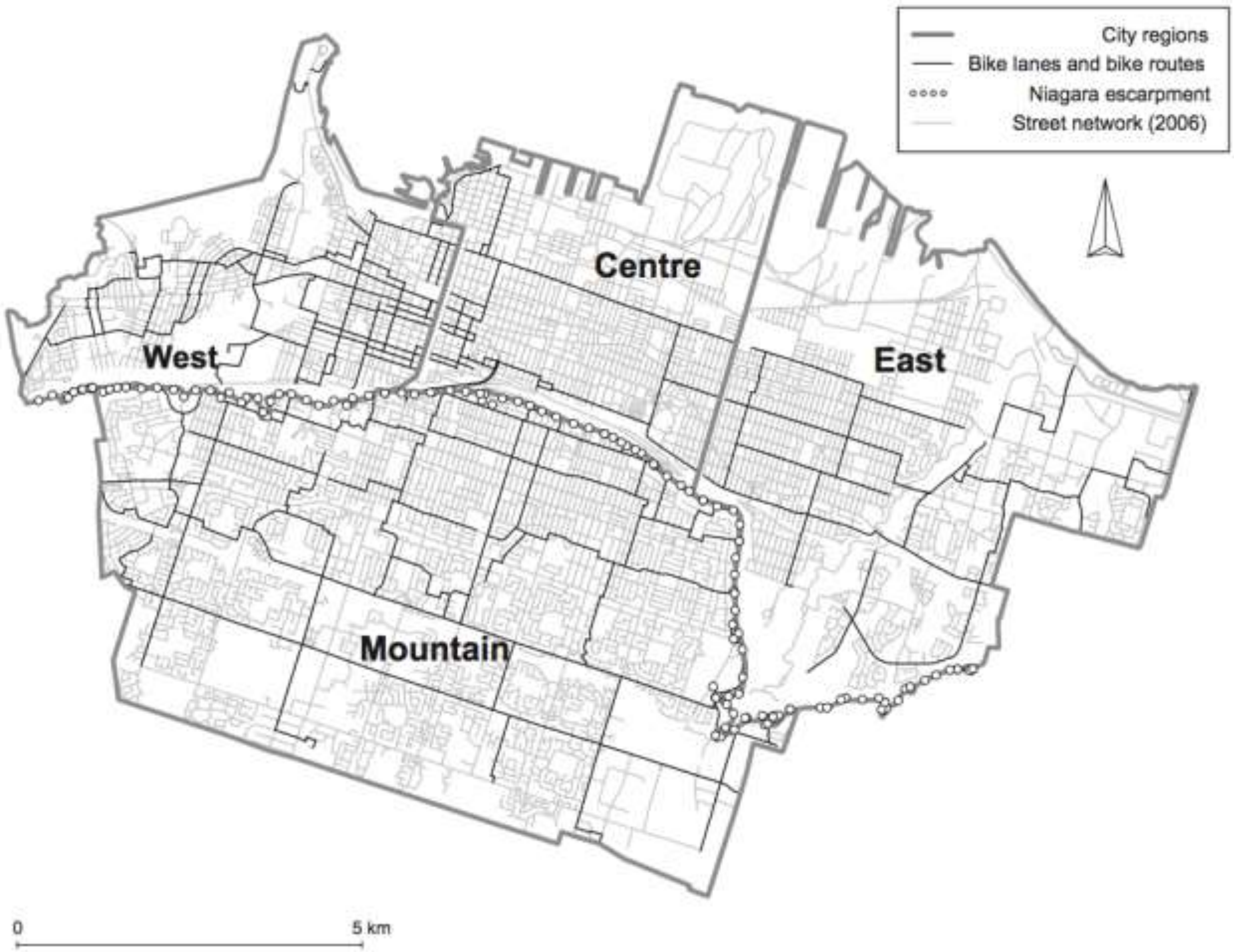


Figure 5.21: Cycling Infrastructure in the City of Hamilton



With regard to the predominant location of cycling trips, consider Figure 5.21 above which shows the layout of cycling infrastructure in Hamilton. There is a fairly close correspondence between where most trips are and where the infrastructure is. Presently those looking to travel between the eastern and western lower city by bicycle must do so at elevated personal risk by riding on un-separated, unprotected, and unmarked routes, such as Barton Street, that carry high levels of automobile and truck traffic. The new, high-end cycling infrastructure on Cannon Street has helped in this regard.

5.2.4 Density

As Chapter 3 has demonstrated, one of the most important preconditions for vibrant areas that accommodate travel over multiple modes is density, both in terms of population and employment. Businesses serving a local population in an urban neighbourhood invariably rely on a large customer base to survive. Likewise, the walking, transit and cycling modes are critically dependent on high densities and a diversity of uses to generate meaningful activity. A complete street can enable many of these activities -- if the nature of the street was a factor holding them back from being realized. But it also can be the case that even if a complete street is built, densities may be insufficient to support greater vitality. An unattractive built environment can also hinder densities from occurring. In general, higher density places will tend to offer more potential for complete streets to have an impact.

With that in mind Figure 5.22, which captures residential population density from the 2011 Census at the spatially fine dissemination area level is important. This detailed map shows that the majority of Hamilton is essentially suburban and low density in character. There are many areas of the Hamilton Mountain and east of Gage and Kenilworth in particular that are in the range of 2,000-5,000 people per square kilometre. The eastern reaches of the lower city, which is also the area of many of the street cases, is essentially suburban in character. It is an older suburb than its counterparts on the Mountain, but it is suburban nevertheless. Centre Mall or “The Centre” as it was known starting in the 1950’s was perceived as a suburban mall at the time which threatened to undermine the vibrancy of retailing in the downtown. This suburban shopping area is at the core of the eastern lower city.

Since some of the street cases we are considering, especially those east of Gage, are surrounded by those fairly low levels of densities, there is likely a natural upper limit on the amount of economic activity that can be induced through complete streets measures. Likewise, Figure 5.22, shows that the eastern lower city is quite similar in density terms to much of the Hamilton Mountain and thus is likely to share many of the challenges associated with intensification. It is no small thing to generate increased residential densities when low density housing infrastructure is already in place -- it takes massive investment. Likewise, the potential for small businesses oriented to walkable or transit-oriented neighbourhoods is also diminished. Preemptive complete street measures can increase the attractiveness of an area for development and larger planning measures to add population and employment densities in the long-run to overcome the density issue. In the short run though economic development benefits are likely to be marginal.

It has been said that for Hamilton’s lower city to really thrive, it must become much denser in terms of population and jobs. This is probably true. For another frame of reference showing where things are in terms of population density in Hamilton, consider Figure 5.23 which compares Hamilton and the core of Toronto. The latter has large areas, mostly east of Yonge Street (see inset), that achieve very high levels exceeding 30,000 people per square kilometre. Hamilton has a handful of dissemination areas that reach those levels and they are all near the downtown. Perhaps more significantly, Toronto has huge areas that range between 7,500 and

12,500 people per square km. Hamilton’s spatial extent within these classes is much smaller and is bounded mostly by the downtown, Gage Street, Main Street and Cannon Street.

Figure 5.22: Population Densities in Hamilton and Near Street Cases (2011)

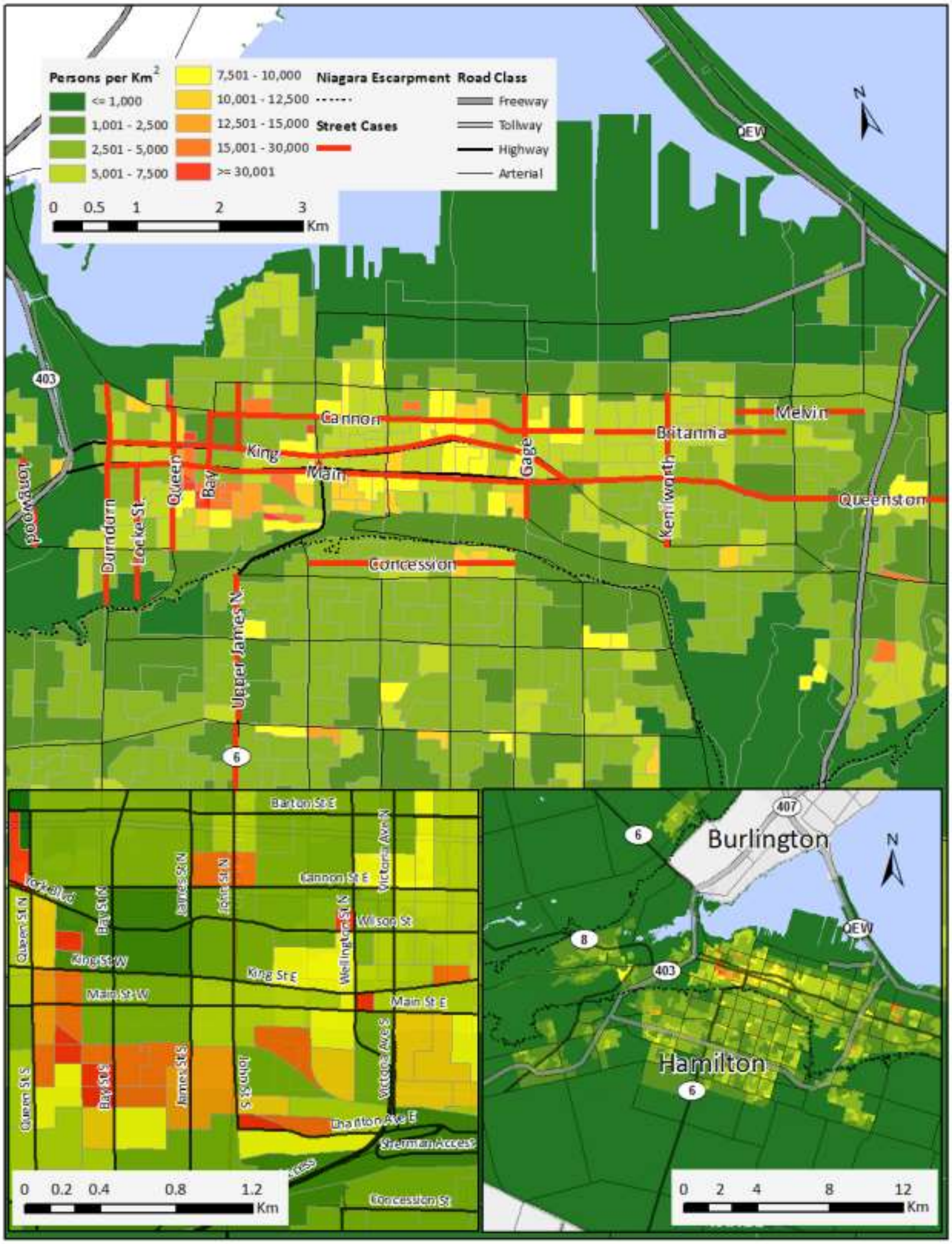
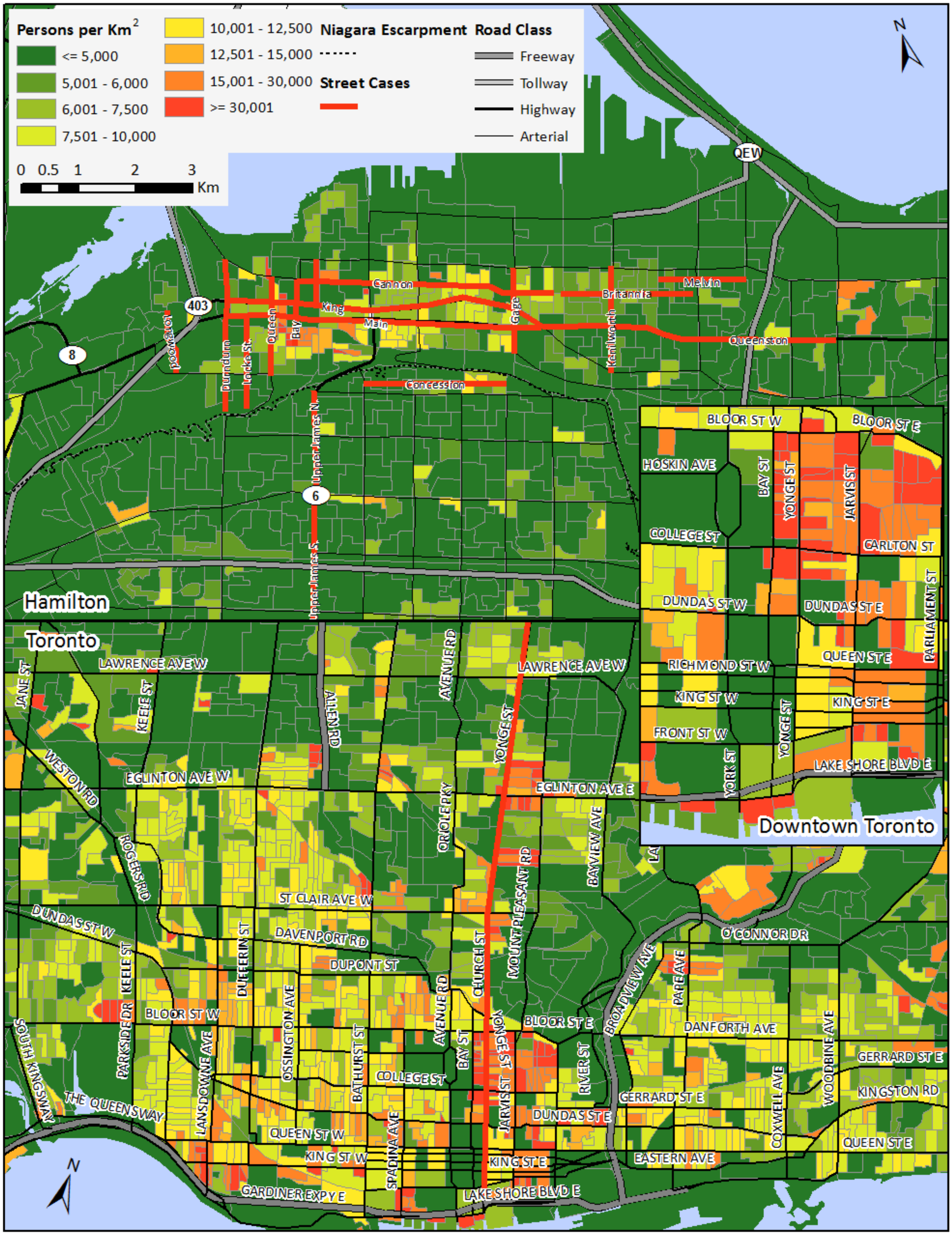


Figure 5.23: Population Densities in Hamilton and Toronto



The difference in patterns reflects that Toronto's older core of higher density residential, which to a large degree has been and is getting gentrified, is much larger than Hamilton's old core.

The net result of this comparison is that, in Toronto, there are many more places where a complete street implementation will have large and modally varied flows to actually manage and funnel. If the flows are smaller and less varied to start with, partly because of lower densities, it suggests less grounds for an extensive complete streets development in an area. In such a context there is less urgency to do something elaborate and even the status quo may suffice if economic criteria are the main consideration.

While Figure 5.22 focuses on population densities, employment densities also matter, as the greatest alternative mode use synergies are unlocked by connecting origins and destinations through a network of complete streets. In view of the street cases considered, the greatest employment densities are to be found in the vicinity of the central core and vicinity and in the areas near McMaster. There are certainly other employment clusters but they are less relevant in relation to the set of specific street cases.

Considering concentrations of both population and employment, it appears that the central lower city, particularly the area bounded by Dundurn Street and Gage Avenue represents the strongest case for the largest immediate benefits from complete streets. The downtown core in particular is home to Hamilton's greatest concentrations of employment, and recent office and condominium construction projects highlight growing demand for urbanized locations.

5.2.5 Socioeconomic Factors

The socioeconomics of the areas which host the street cases are very relevant. As Chapter 3 has shown, there are links between safety issues and vulnerable populations and this may affect the urgency to apply complete streets. As Yiannakoulias & Scott (2013) have pointed out:

"Socioeconomic disadvantage has a strong and nearly ubiquitous association with pedestrian injury risk at various scales (Durkin, Davidson, Kuhn, O'Connor, & Barlow, 1994; Oliver & Kohen, 2009; Roberts & Power, 1996), and declines in incidence and mortality are not the same across income strata (Nantulya & Reich, 2003). There are social inequalities in the effectiveness of prevention programs (Collins & Kearns, 2005) as well as income-specific differences in pedestrian injury associated with urban development."

As an example, children in lower income families are more likely to walk to school which increases exposure to traffic risk. From the perspective of using complete streets to induce improved vitality in an area, it is an unfortunate truth that vulnerable populations typically do not have the resources to support a diverse array of local commercial and related activity.

From Figure 5.24 to Figure 5.26 three maps, based on results of the 2011 Census, highlight key elements of socioeconomics across the street cases are provided. The first of these illustrates the percentage of the adult population with a post-secondary degree. The spatial pattern is rather stark with their being strong differences between the west and the east of the city. The differences are especially pronounced in the lower city where many of the street cases are located. On the Mountain, there is more of a blended patterns between higher and lower levels of educational progress.

The second map of the three deals with the unemployment rate by dissemination area and it provides a less stark picture. There is no doubt that the highest levels and largest clusters of unemployment are found in the lower city in the areas between Gage and Wellington but the overall pattern is more nuanced across the city. The third map, which is one of median household income, presents a pattern that looks more like the map of education than the one of unemployment rates. While unemployment rates may be relatively low in some of the lower income areas, it is clear that many vulnerable households are nevertheless struggling to generate a good living. The locations of the struggling areas in the lower city overlap very well with a large number of the street cases that are being considered and by the same token, there are a number of cases near the downtown and to the west that are located in better-off areas.

As a note for Figure 5.26, Bhat and Guo (2007) consider it very important to take income variations into account in this context. Their models show that household income is a dominant factor in where people choose to live and it is a key element of sensitivity to built environment elements (such as complete streets). Their research in the US suggests that low income households tend to sort themselves into neighbourhoods with low commute costs, long commute times and high employment density and they also own fewer cars. The findings offer further support for the idea that more vulnerable populations stand to benefit from complete streets because they may align well with travel behaviours and use of alternative modes.

Overall, there is certainly a rationale for an investment in improvements to the built environment in areas of vulnerable populations, though expectations for greatly improved economic vitality should be moderate. The aspects of complete streets that champion safety and alternative mode use stand to have the largest immediate impact for populations within these areas. The provision of cycling lanes and improved transit infrastructure can enable higher levels of mobility and potentially better health outcomes for affected populations. Furthermore, while the personal automobile may still offer the highest levels of overall mobility across the city, such investments stand to reduce a household's overall level of auto ownership. If improved transit service or a network of cycling lanes can provide a lower-cost option, a household may not feel compelled to purchase a second or third automobile to achieve an acceptable level of mobility, thus presenting an opportunity for significant savings.

Figure 5.24: Percentage of Population with Post-Secondary Degree (2011 Census of Canada)

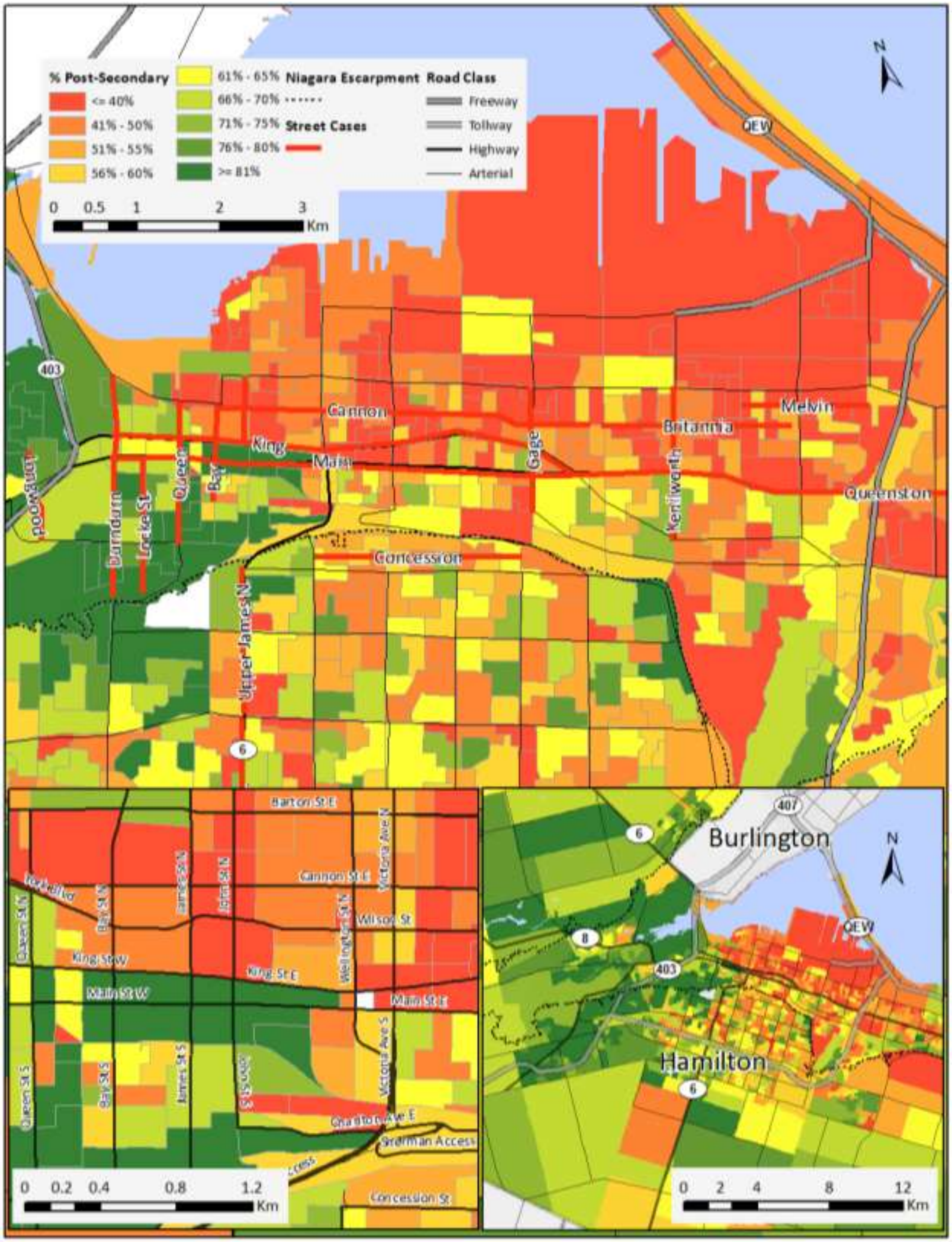


Figure 5.25: Unemployment Rate (2011 Census of Canada)

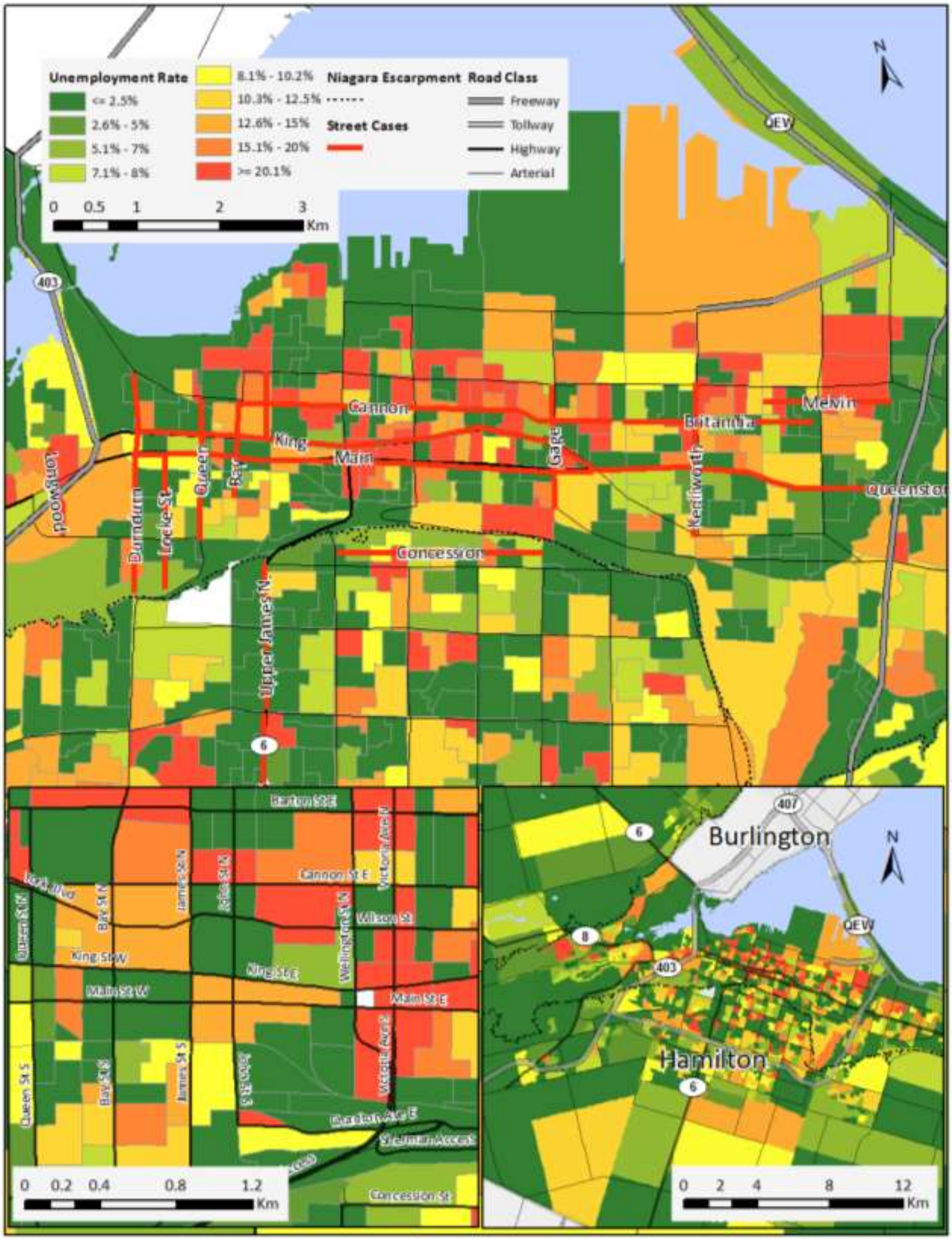
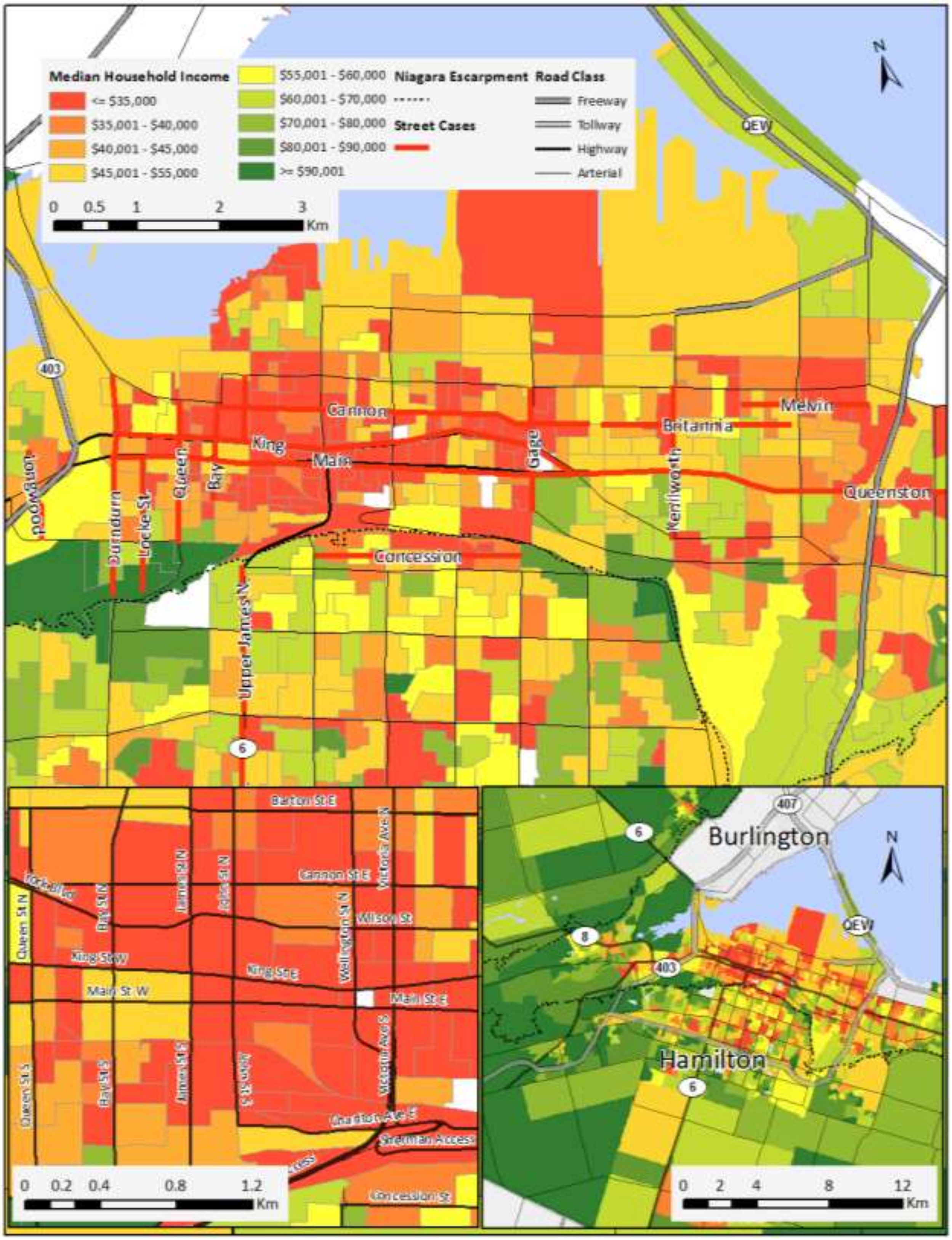


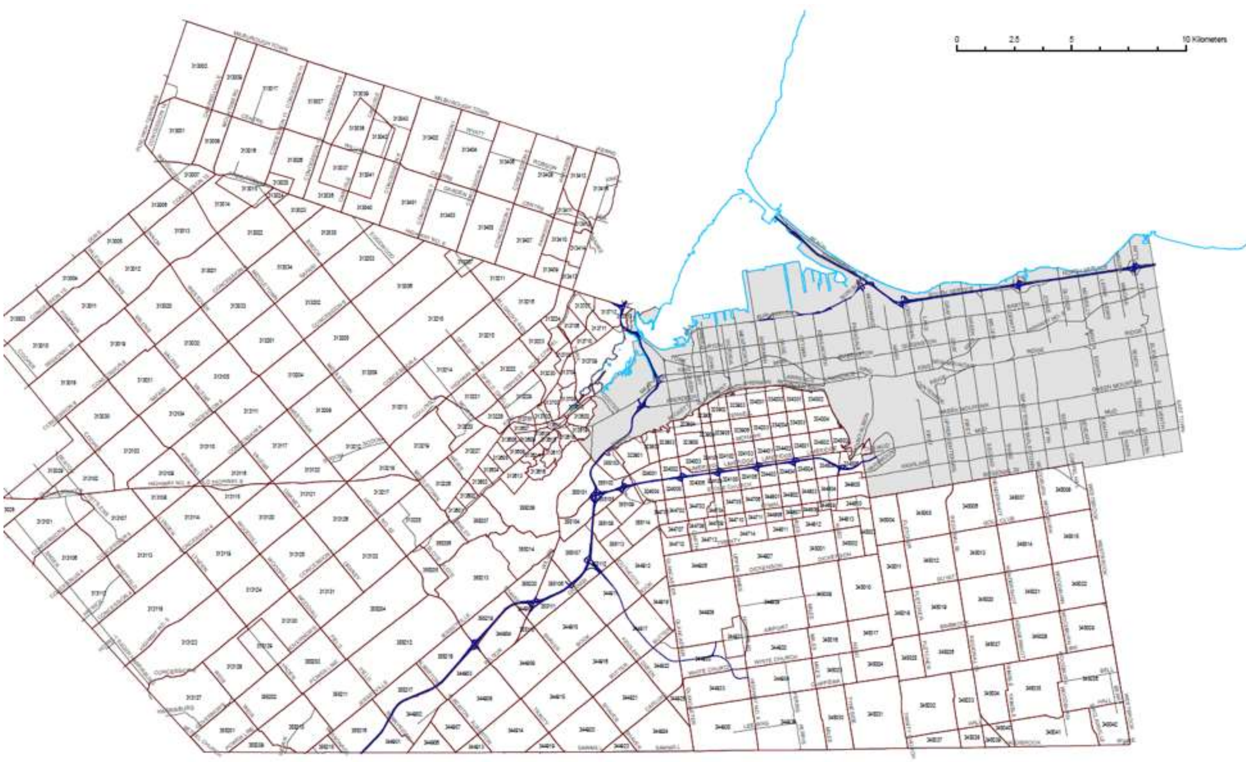
Figure 5.26: Median Household Income (2011 Census of Canada)



5.2.6 Safety

The detailed review in Chapter 3 has made it clear that safety is a dominant theme as it relates to complete streets and that there is significant reason to believe that widespread implementation of complete streets concepts could result in enhanced safety outcomes such as lower fatality rates and less serious injuries. The purpose of this section is to review accident data provided by the Public Works Department of the City of Hamilton for the period 2009-2013 to assess implications for complete streets cases in Hamilton. Note that the database of incidents that has been used does not include those that occur on the provincial highways such as Hwy 403 but does include the Lincoln Alexander Parkway and the Red Hill Valley Parkway.

Figure 5.27: Overview of Zoning System Used to Report Accidents



The data provided by the City are micro-data in the sense that some specifics for every incident that occurred over the five years are provided; but there were some very important specifics that were not provided. In particular, the data lacks location specificity, which eliminates the possibility of specific analysis on the street cases. Each incident is assigned to one of approximately 560 zones over the City with each zone averaging a size of about 2 km^2. The zones are somewhat smaller than this average in more densely populated areas and larger in the rural areas of the City. The zonal system is used for policing purposes and the incidents captured are those for which police reports were filled out at the scene. Based on the information provided, there is no obvious way to tell exactly where the incident took place or to assess, for example, whether it occurred on a local, residential street or a busy arterial. Figure 5.27 provides a reasonable overview of the nature of the zoning system (although not for the lower city) and highlights the difficulties in linking a zonal concept to specific streets.

After a data cleaning exercise and removal of some apparent duplicate records, a total of 17,851 incidents are captured over the five year period and 15,840 of these involved motorists only, with no involvement of pedestrians or cyclists. Incidents are fairly evenly distributed over the five years although it is interesting to note a smaller share of incidents in 2009 which was a year of serious recession. Reduced economic activity will have translated into reduced traffic and therefore fewer accidents. Over the five years there is an average of about 300 incidents per month and 1.42 fatalities per month within the boundaries of the City.

Severity of incident is certainly an important theme and the data show that thankfully, the majority are not serious. For the City as a whole across all incident types, the fatality rate is 0.48% (half of one percent). This is broken down into 2.11% for incidents involving pedestrians, 0.77% for incidents involving cyclists and 0.33% for incidents involving motorists only.

One dimension that is well-covered in the provided data is the nature of the impact during an accident. Such information could have implications for the design of complete streets. Figure 5.28 has been provided by the City and shows the wide range of collision types that are possible. The collision types can be considered in relation to Figure 5.29 which breaks down all the collisions that have occurred in the City by the nature of the impact and how severe the outcome was. Absolute totals of incidents are shown for the severity class and then the same three classes are shown as a percentage distribution to enable comparisons. Some points of clarification are that:

- “PD only” means that there was property damage but no injuries
- “Non Fatal” means that injuries were sustained that could range from minor to very serious
- “SMV” refers to single motor vehicle

It becomes immediately obvious that pedestrian/vehicle impacts are by far the most serious. Such impacts account for only 1.1% of incidents that involve only property damage but 30.6% of fatal incidents. Such impacts also account for a significant percentage of incidents that produce injuries. Given the severity of pedestrian/vehicle impacts, it is interesting to note that the data do not capture the circumstances of such impacts in nearly as much detail as for purely vehicular impacts. For example, was a pedestrian hit as a result of a left or right turn? These details are not reflected in the data.

Figure 5.28: Collision Types

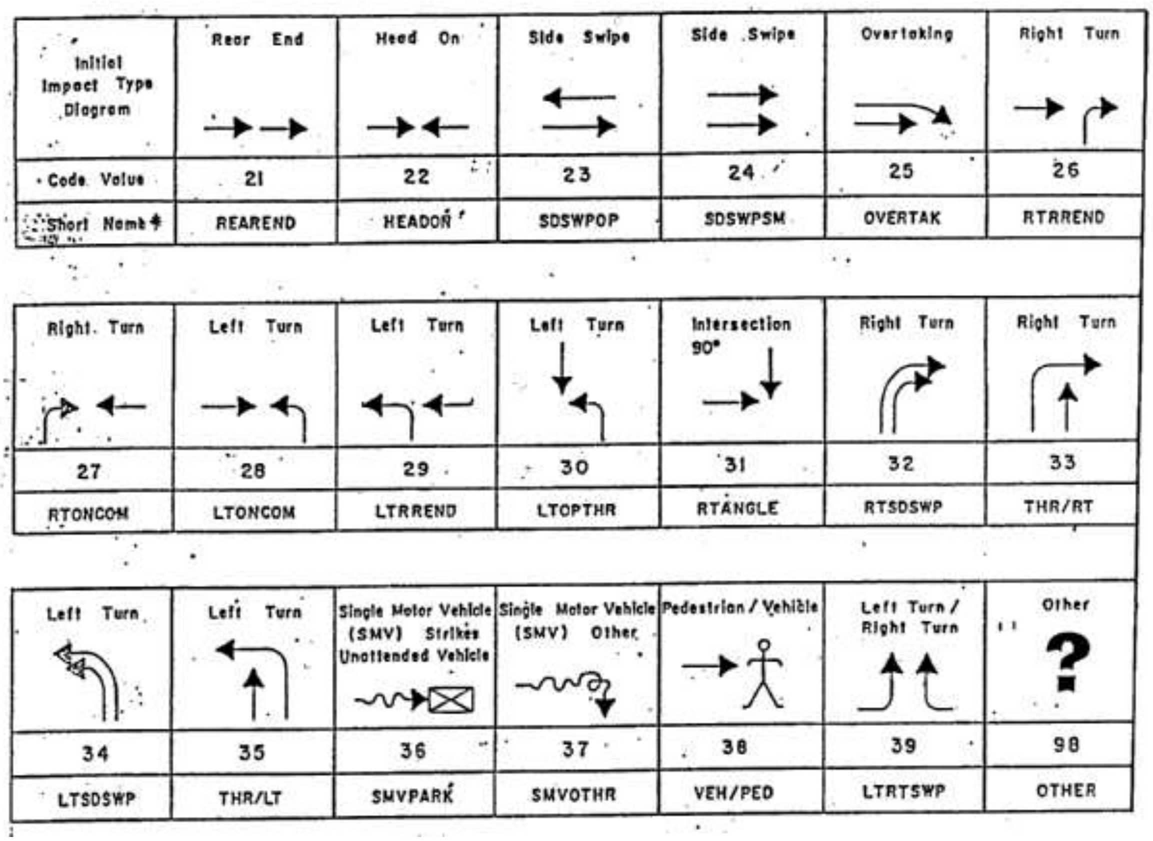


Figure 5.29: Collision Types in City of Hamilton by Severity of Incident (2009-2013)

Impact	PD only	Non Fatal	Fatal	PD only %	Non Fatal %	Fatal %
Rear end	1659	2574	5	18.6	29.1	5.9
Intersection 90 degrees	801	1398	6	9.0	15.8	7.1
Ped/Vehicle	101	1108	26	1.1	12.5	30.6
SMV other	2503	1032	20	28.0	11.7	23.5
Left turn (opposite thru)	467	823	6	5.2	9.3	7.1
Left turn (oncoming)	290	422	0	3.2	4.8	0.0
Side swipe (same dir)	689	260	3	7.7	2.9	3.5
Head on	124	197	14	1.4	2.2	16.5
Left turn (thru-right)	185	181	1	2.1	2.0	1.2
SMV strikes unattended	1029	151	1	11.5	1.7	1.2
Other	1081	691	3	12.1	7.8	3.5
Total	**8929**	**8837**	**85**	**100.0**	**100.0**	**100.0**

There are some interesting patterns among the collision types. Rear end collisions are very frequent and result in proportionally a large number of injuries but they are less prominent in terms of fatalities. Head on collisions are comparatively rare but are quite deadly. The number of collisions that involve only a single motor vehicle is surprisingly high and many of these collisions are apparently very dangerous. Apart from rear end and SMV collisions, it is probably fair to say that turning vehicles are a factor in most collisions. The side swipe collision where both vehicles are moving in the same direction is an interesting exception but in a relative sense is not particularly dangerous.

Because impact types for incidents involving cyclists have been captured in the data, it is possible in Figure 5.30 to develop a similar figure as above that is focused on cyclists. Only about 15% of cyclist impacts involve no injury whereas for impacts in general, 50% of incidents do not involve injury. Six cyclist fatalities occurred over the five year period in comparison to 26 pedestrian fatalities as was seen in the prior figure. Cycling trips are less prevalent then pedestrian trips though.

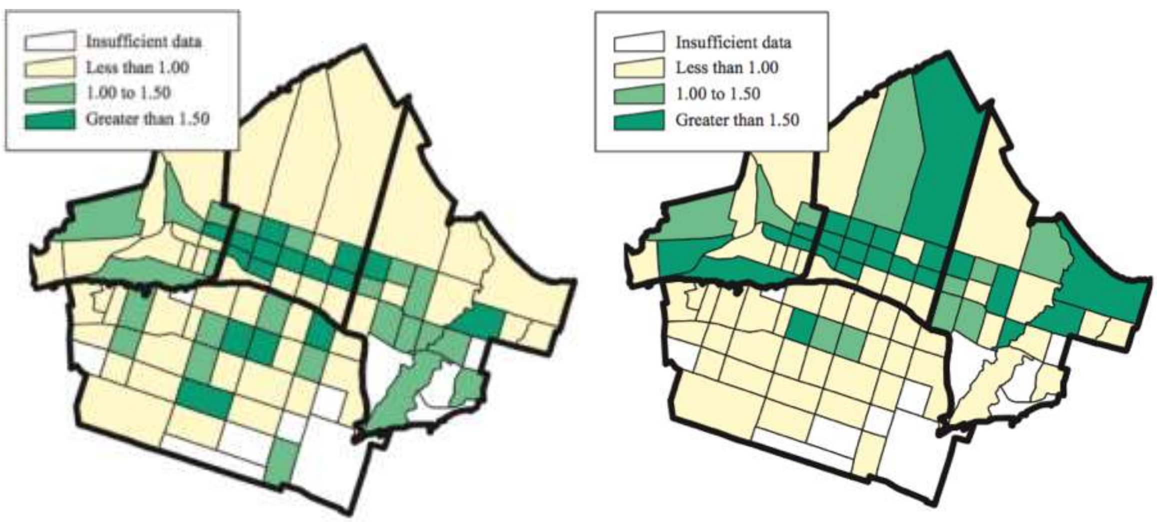
One interesting note is that the “Intersection 90 degrees” impact is much more prominent if cyclists are involved. This impact type accounts for 36% of incidents involving cyclists but only 12% of incidents in general. The result seems to suggest that intersections are particularly hazardous for cyclists and this in turn could suggest roundabouts as a solution. The fact that roundabouts have been highlighted as more dangerous for cyclists than other roundabout users (see Chapter 3) raises the question of which is the lesser of two evils for cyclists.

Figure 5.30: Collisions Types Involving Cyclists by Severity of Incident (2009-2013)

Impact	PD only	Non Fatal	Fatal	PD only %	Non Fatal %	Fatal %
Intersection 90 degrees	45	237	1	37.5	36.2	16.7
Right turn (oncoming)	16	77	1	13.3	11.8	16.7
Left turn (opposite thru)	10	73	1	8.3	11.2	16.7
Side swipe (same dir)	11	43	1	9.2	6.6	16.7
Rear end	6	37	1	5.0	5.7	16.7
Right turn (thru-right)	4	36	0	3.3	5.5	0.0
Left turn (oncoming)	7	28	0	5.8	4.3	0.0
SMV strikes unattended	5	23	0	4.2	3.5	0.0
Left turn (thru-right)	5	20	0	4.2	3.1	0.0
Right turn (rear end)	2	19	0	1.7	2.9	0.0
SMV other	0	15	1	0.0	2.3	16.7
Other initial impact	2	12	0	1.7	1.8	0.0
Overtaking	1	11	0	0.8	1.7	0.0
Other	6	23	0	5.0	3.5	0.0
Total	**120**	**654**	**6**	**100**	**100**	**100**

Using data on cyclist commuting origins and destinations from the 2006 census and rates of cyclist-motor vehicle collisions from the City of Hamilton, Yiannakoulias and Scott (2012) determine that the highest levels of cycling commuting risk are found within the lower city. Given the existing network of cycling facilities, the future Cannon Street bi-directional bike lanes stand to have a large improvement in facilitating east-west cycle commuting. In terms of how cycling fares in Hamilton, the absolute numbers of cycling commuters has increased from 1,785 in 1996 to a high of 2,470 in 2001, but fell to 2,355 in 2006 and 1,810 in 2011 according to the Canadian Census. Collision risk may be a reason why cycle commuting declined over the past decade.

Figure 5.31: Cycling Risk per Trip Kilometre (A) and per Capita (B)



In Figure 5.32 some attention is paid to the geographical aspect of collisions. There is clearly a pattern that more population, more density and presumably more traffic lead to more incidents. This is not surprising. There are few in the way of stark differences between the allocations of incidents with no injuries versus those with non-fatal injuries. The one aspect that really stands out is the high share of rural incidents that are fatal. Clearly there is an issue in the rural parts of the City of Hamilton based on a combination of higher speeds, numerous access points and possibly other factors that leads to a greater likelihood of severe outcomes when an incident does occur. On the other hand, the East Mountain stands out for a lower share of fatalities than might be expected. It is true that the East Mountain features a lower share of heavily travelled commercial arterials, which the literature suggests can be more dangerous, than the West Mountain. Upper James Street, for example, is classified as West Mountain for this analysis.

In terms of other geographical notes, consider that an incident is far more likely to involve a pedestrian or a cyclist in the lower city and more so in the lower west of the city. Over the five years, 73% of fatal incidents in the lower city involved pedestrians and cyclists. When incidents as a whole are considered the four core areas of the city (LW, LE, ME, MW) are safest in terms of severe outcomes. The overall incident fatality rate for these location is 0.28%.

Figure 5.32: Collisions by Severity and Region of City (2009-2013)

Region	PD Only	Non Fatal	Fatal	PD Only %	Non Fatal %	Fatal %
Lower West	2261	2199	11	25.3	24.9	12.9
Lower East	1919	1819	11	21.5	20.6	12.9
Mountain East	1056	1285	5	11.8	14.5	5.9
Mountain West	990	1271	9	11.1	14.4	10.6
Ancaster-Dundas-Waterdown	1097	873	11	12.3	9.9	12.9
Stoney Creek	628	734	13	7.0	8.3	15.3
Rural	978	656	25	11.0	7.4	29.4
Total	**8929**	**8837**	**85**	**100**	**100**	**100**

Detailed time of day for the occurrence of each incident has been tabulated in Figure 5.33. The hour field runs from 4 to 27 with the former corresponding to 4AM at the start of a day and the latter corresponding to 3AM at the end of a day. For fatalities the results by hour show statistical variability. A possible result of interest in the 3-4 PM hour when students are going home from school and traffic levels on arterials and local streets can be quite high. This outcome conforms to the 3PM trip peaks associated with many of the 21 hour trip patterns shown in Appendix 7.3. There is no apparent similar pattern of more incidents in the morning though. There does appear to be a discernable patterns where incidents that happen throughout most parts of the work day are more likely to result in injuries as opposed to property damage only. The fact that there are more pedestrians and cyclists moving around at such times is likely to explain this outcome.

Implications for Complete Streets

While there are certainly interesting patterns in the incident data that have been assessed above the main matter of concern for this report is what the results imply for complete streets. Bear in mind that the ability to draw firm conclusions using the City of Hamilton data has been hampered by a lack of locational specificity in the data. Specific streets cannot be assessed with the data provided.

There is some evidence in the data that the busiest of arterials with numerous access points and turning cars feature elevated levels of danger. Some may argue that risk levels are not elevated when incidents are normalized by volume of traffic. This type of analysis is beyond the scope of what is provided here but we would argue that areas where accident counts are known to be high require extra vigilance regardless and are high priorities for complete street implementations.

Figure 5.33: Collisions by Severity and Time of Day (2009-2013)

Hour	Pd only	Non Fatal	Fatal	Pd only %	Non Fatal %	Fatal %
4	144	52	1	1.6	0.6	1.2
5	119	91	3	1.3	1.0	3.5
6	203	147	3	2.3	1.7	3.5
7	304	284	0	3.4	3.2	0.0
8	481	517	4	5.4	5.9	4.7
9	427	405	3	4.8	4.6	3.5
10	419	450	4	4.7	5.1	4.7
11	458	555	4	5.1	6.3	4.7
12	470	594	1	5.3	6.7	1.2
13	531	646	5	5.9	7.3	5.9
14	450	624	5	5.0	7.1	5.9
15	579	745	10	6.5	8.4	11.8
16	557	712	1	6.2	8.1	1.2
17	510	764	6	5.7	8.6	7.1
18	501	521	7	5.6	5.9	8.2
19	482	403	2	5.4	4.6	2.4
20	417	323	7	4.7	3.7	8.2
21	390	270	2	4.4	3.1	2.4
22	318	190	1	3.6	2.2	1.2
23	322	163	3	3.6	1.8	3.5
24	205	91	3	2.3	1.0	3.5
25	234	108	2	2.6	1.2	2.4
26	221	95	4	2.5	1.1	4.7
27	187	87	4	2.1	1.0	4.7
Total	**8929**	**8837**	**85**	**100**	**100**	**100**

In other areas of the city, such as the lower west, there are elevated levels of pedestrian and cyclist activity and pedestrians and cyclists are involved with the majority of fatal incidents. Intersections appear to be a particular issue for cyclist incidents. On the basis of safety, these areas would seem to be a logical place for the most advanced implementations of complete streets. There is a strong safety rationale for doing so given that the demand for multimodal travel is highest in such areas.

One other theme that has emerged is that of higher relative danger on rural thoroughfares within the boundaries of the City of Hamilton. Fatality rates are much higher in these contexts than in the rest of the city given that an incident occurs. A detailed analysis of rural circumstances is beyond the scope of this report but the results do suggest that there may be an opportunity for some of the principles of complete streets to be applied more aggressively on rural roads. Potentially there are ways to communicate to drivers through optimal road design that the dangers of the roads they travel on are more than they perceive.

5.3 Complete Streets Potential of Hamilton Street Cases

The purpose of this section is to integrate learnings from Chapter 3, the earlier parts of this Chapter and North American cases in the Appendix to offer thoughts on the Hamilton street cases. The street cases are classified in five different groups based on the nature and context of each case. The groupings are as follows:

- Neighbourhood Commercial Strip
- Major Commercial Arterial
- Major Arterial Thoroughfares
- Central Arterials
- Minor Suburban Arterials

As well as the analytical work of the prior sections, the review of the cases has been supported by field trips to each of the locations. The cases have also been reviewed via Google street view to reinforce or confirm perceptions from the field work. The photography below has resulted from the field trips.

5.3.1 Neighbourhood Commercial Strips

This subsection discusses the cases of Locke Street, James Street N. and Concession Street. As a group these are the cases which are most likely to experience some boost in vitality from a complete streets treatment.

Locke Street

We think that the section of Locke Street south of the rail tracks and north of Aberdeen Ave. is one of the most promising for a comprehensive complete streets treatment. The stretch of commercial activity currently in place there is a precious neighbourhood resource and a magnet of interest for many visitors. Everything possible should be done to develop this stretch to its maximum potential. Another advantage of an emphasis on Locke Street is that it is a prominent case that could generate momentum for the complete streets concept in the region.

We are concerned that to the extent that Locke Street acts as a thoroughfare, it reduces the attractiveness of the area to pedestrians. As Figure 5.34 illustrates the speed limit through this area is 50km/h. In our view this is excessive and a limit as low as 30km/h, as is the case in many European jurisdictions, should not be out of the question. In our field trips to Locke Street as pedestrians, the intimidating presence of fast-moving vehicles was quite evident. The pedestrian experience at Locke Street really needs to be emphasized and this could mean the construction of wider sidewalks so that there is more space to meet and congregate. Perhaps this means that there would be less space for parked vehicles on the street, which might concern merchants, but we would suggest that the improved pedestrian atmosphere would more than compensate. Other municipal parking options in the vicinity could be highlighted or expanded as required. Defined lanes for bikes could be considered.

Figure 5.34: Locke Street

James Street N.

The case of James St. N. (Figure 5.35) is quite similar to the case of Locke Street although the former is located in somewhat closer proximity to the downtown. The two photographs taken for this project reinforce the similarity between the cases. Many of the comments suggested for Locke Street can be echoed for James Street North. The latter has an even more impressive profile in terms of minimizing the number of automobile trips that are generated. Mainly this is because the use of public transit is much more prominent near the James case than it is in the Locke Street case. The differences in the two cases suggest that people with the means to drive will tend to own a car rather than taking transit and generally income levels are higher near

Locke Street. The fact that light rail is to be developed along this stretch is quite likely to reduce the prominence of the automobile here.

Figure 5.35: James St. N. Business District Facing North

Concession Street

In the sense that Concession Street is a neighbourhood commercial strip for a long stretch, it has quite a bit in common with James St. N. and Locke Street. The 21 hour trip profiles in Appendix 7.3 indicate that trip makers in the Concession St. area have more of an automobile orientation than the other two cases and meanwhile the level of public transit use is closer to the levels of Locke Street than James Street North. As Figure 5.36 illustrates, elements of a road diet are already present along Concession Street in that there are not excessive lanes of travel for automobiles. Sidewalks along the commercial strip are already quite wide (not shown) and there is ample room for separated bike lanes if that is deemed a priority. Despite these measures that have been implemented previously, the Concession commercial strip continues to lack vibrancy and pedestrian activity is typically not high. There are factors at play that are probably more significant than can be overcome by the tools of complete streets alone. Certainly, there is a strong automobile orientation in the area.

Figure 5.36: Concession St. at Upper Wentworth St. Facing West

As a supplement to this section, it is worth mentioning Ottawa Street between Main and Barton as a case that could benefit from increased attention to the concepts of complete streets. There are many similarities between Ottawa Street and Locke Street although traffic volumes are lighter on the former.

5.3.2 Major Commercial Arterials

Among the cases suggested by the City of Hamilton, those of the major commercial arterials are important ones to consider. Neighbourhood vitality is one point of interest but we are particularly concerned with issues of safety in terms of the cases of this street class.

Upper James Street

Upper James Street is a very important north-south artery in Hamilton and it handles high levels of traffic (Figure 5.37). Upper James has little in common with its namesake in the lower city and is highly auto-oriented. There are two distinct strips of intense commercial development along Upper James. The stretch between Fennell Avenue and the "Linc" is very developed but is more compact than the more modern and sprawling development between the Linc and Rymal Road. Traffic volumes are higher for the latter strip though and exceed 40,000 vehicles per day. These are very high levels of traffic and it is not an exaggeration to say that these levels are higher than most highways. Hwy 6 near Hwy 401, for example, is less than 30,000 vehicles per day. Few people would want to ride a bicycle on a highway and few do so on the busiest stretches of Upper James. That some may consider riding on a sidewalk as an alternative has to be a major concern. Drivers in the vicinity do not expect to see cyclists on sidewalks and pedestrians in the area are rare as well.

North of Fennell Ave. on Upper James there is more of a neighbourhood-oriented commercial strip that is not particularly vibrant. The area suffers partially because vehicles are moving far too fast. This commercial strip is not far from the Claremont Access, which itself is something of a highway, and this close proximity generates elevated speeds. If there is a stretch on Upper James that could benefit from complete street principles, it is probably this one as there is an opportunity to calm traffic and promote increased local vitality. Traffic volumes along this stretch are just under 20,000 vehicles per day.

Upper James as a whole is a very difficult case. It is probably the most prominent case in the city where high traffic volumes are combined with high numbers of commercial access points. This type of intense, automobile-oriented commercial strip is inherently less safe and there is not a great deal from a complete streets perspective that can undo what has been done.

Figure 5.37: Upper James St. near Stonechurch Road

Mall developments (such as Limeridge Mall on Upper Wentworth) are safer forms of commercial development in this regard in that access points are more controlled and limited even though the commercial activity is just as intense, if not more so. Relative to a shopping mall like Limeridge, Power Centres (such as the Meadowlands in Ancaster) are a step backwards from a complete streets perspective as vehicles need to move between the different sites and they often seem to do so quite urgently. Few people walk between these retail sites. Moreover, there are few locations where a pedestrian can feel as uneasy as they will in a busy Costco parking lot with vehicles moving in many directions.

Queenston Road

Figure 5.38: Queenston Rd. at Parkdale Ave. S. Facing East

We see Queenston Road as a more moderate case than Upper James but one that shares many similarities. Just as the “Linc” divides Upper James, the Red Hill Valley Parkway divides Queenston Road and the nature of the commercial activity on either side is demarcated in a similar manner as well. To the east the development is more scaled to the automobile and to the west the development is more like the traditional 1950’s commercial strip (Figure 5.38). The latter area has not had the same investment in a “retail retrofit” as has been in the case of Upper James near Fennell. Traffic levels along Queenston Road are across the board lighter than Upper James but the eastern stretches of Queenston Road feature levels that are comparable to Main Street near Hwy 403. Like Upper James, the options are somewhat limited as traffic levels are quite high and there is not much excess space. Low speed limits, enforcement and design cues that might moderate speeds seem like the best possibilities.

5.3.3 Major Arterial Thoroughfares

The cases covered in this section generally are more oriented to moving substantial numbers of vehicles than to intense forms of commercial activity. The downtown sections of Main, and especially King, are exceptions to some extent but taken as a whole the intensity of commercial activity along these streets is less than the cases of the prior section.

Longwood Road

Without a doubt the case of Longwood Road is one of the most challenging. This street features a complex interplay between vehicular traffic, public transit, and high levels of active travel. Volumes of traffic between Longwood South of Main and Main Street itself are relatively high at nearly 22,000 per day based on 2012 counts. The volumes passing through on Main Street are much higher. There are few north-south cycling options in the vicinity so a significant number of bicycles cross the bridge over Hwy 403 (see Figure 5.39). The intersection of Longwood and Main is one of the busiest in the city and is awkward to negotiate as Longwood north of Main is not perpendicular to the rest of the intersection. The intersection accommodates approximately 1800 pedestrians per day as Westdale High School is adjacent to the location.

Longwood Road is one of the best possibilities in Hamilton for a “complete intersection.” The issue of what can be done to Longwood Road is possibly secondary to whether everything has been done to improve Main and Longwood as an intersection. It seems prudent to answer this question properly before contemplating, for example, an expensive new bridge across Hwy 403.

One potential solution that would need more extensive study is the creation of what in essence would be a giant clockwise traffic roundabout using the roads that enclose Westdale High School and the Metro grocery store. This roundabout is already about 2/3 in place and would be completed by converting Longwood between Main and King into a route for northbound vehicles only. This would mirror the functioning of Paradise Street on the other side of the roundabout which caters to southbound vehicles only.

There are about 5200 vehicles per day travelling southbound on Longwood towards Main Street and these tend to hold up the higher volume northbound flow of left turns from Longwood onto Main. Also, a significant share of the 5200 vehicles has taken a neighbourhood shortcut from Westdale Village along Marion Ave and turns right onto Longwood on the way to Main Street. Marion Ave. is a local street that could do without a lot of through travel. It could be better to route these through trips onto King Street travelling east and feed them into the Paradise Road one-way circuit that is already in place.

For the scheme to work though, left turns from Main St. travelling west and onto Longwood travelling south would need to be enabled and traffic signals would need to be appropriately timed to properly handle the required flows and there would only be room for one left-turn pocket. While this approach would cause some inconvenience for some local drivers in the form of less direct travel, it may well improve local safety and will most likely improve the regional dynamics of this important intersection. The development of light rail in this vicinity could have a significant bearing on whether this approach could work.

The intersection does accommodate a lot of pedestrians and there is anecdotal evidence that high school students get dropped off at unsafe locations. Queuing of vehicles occurs due partly to high pedestrian activity. Access to Hwy 403 westbound from locations near McMaster is particularly convoluted and these flows put an extra burden on this intersection. All options to maximize safety for pedestrians and improve vehicle flow should be considered.

Figure 5.39: Longwood Road

Overall, the volume of traffic on Longwood south of Main, at 22,000 per day, is significant but perhaps not insurmountable in terms of implementing road diet concepts. A lot depends on the flow of traffic through the intersection. Left-turn infrastructure will need to be excellent.

The Longwood route is also very important for cyclists as north-south options for cyclists are quite limited in the area. Accordingly, the idea of a new crossing over Hwy 403 geared towards active travel is an interesting one and probably a safer option.

Main, King and Cannon

As the historical review earlier in Chapter 5 has shown, Main and King Streets have generated their share of controversy over the years. That conversions to one-way travel took place are perhaps not surprising as that was a trend of the times. Such conversions emerged in many North American cities in the 1950's. Soon after the conversion to one-way, the Burlington Skyway opened in 1958 and this helped to moderate some of the through traffic impacting central Hamilton. In retrospect, there seems little doubt that these streets could all have stayed as two-way arteries and the local areas in question might have been even better off than they are today. What can be done from this point in time is a challenging question.

Figure 5.40: Main St. near Queen St. Facing West

As Figure 5.40 shows clearly, there is something unsettling about the five lane convoys of oncoming traffic that make their way east down Main Street in periodic bursts. It means that the road surface is used less efficiently and it means that left and right turns may well require a lot of lane changing maneuvers. A car exiting Hwy 403 and turning right onto Locke Street will have to cross many lanes in a short period of time. Two-way travel less demanding for drivers in this respect. The wall of traffic is unsettling for drivers who feel they have to jockey around for position let alone for nearby pedestrians or cyclists. As Figure 5.41 shows, there are more eastbound lanes on Main Street than there are on Hwy 403. In fact, eastbound travel is reduced to only two lanes as the freeway passes the Hamilton Spectator building. Overall, the case is fairly convincing, and the literature suggests, that these walls of fast-moving traffic limit the vitality of the immediate surrounding areas. The section of Main Street shown will naturally tend to be busier during AM Peak and while its King Street counterpart will be busier at PM Peak.

One other consideration for Main Street is that it acts as the gateway to central Hamilton. As such it plays a role beyond the more basic logistics of moving vehicles. The initial picture of Hamilton, for many that arrive for the first time, is that of being swept along in a tide of fast-moving vehicles along a street that does not seem particularly vibrant. When such considerations are taken into account then perhaps the very significant investment that would be required for a conversion to two-way travel could be worthwhile.

Figure 5.41: Hwy 403 with Fewer Eastbound Lanes than Main Street

One of the dominant themes from the 1950's was a perception that King Street East merchants suffered and became more cut off from the west of the City. There is the possibility that a complete return to two way travel would restore or improve this connection but interestingly, King Street East in the downtown is one stretch that has received many design improvements. A lot of attention has been paid to widening the sidewalks and improving the pedestrian experience. There are two one-way lanes of traffic and not much room to implement two-way travel, especially if light rail ultimately follows this right-of-way.

Overall, there appears to be the most flexibility for two way travel in the areas east of the downtown where traffic volumes are much lighter and there is little interaction with important fixed infrastructure such as Hwy 403 access ramps that have been developed with one-way travel in mind[2]. This is not to say that two way travel might not be a desirable thing west of the downtown but it seems more difficult to achieve. In the event that one-way travel is retained there is probably capacity to devote more space to the non-auto modes depending on what is most appropriate in certain contexts.

Figure 5.42: Cannon Street near Gage Ave.

[2] The section of the Hwy 403 near Main and King was opened in 1963 and the configuration of ramps assumes the one-way travel on Main and King that had already emerged in 1956. Alterations to this infrastructure and to sewage overflow tanks under Cathedral Park in the vicinity would mean a very large investment associated with a conversion to two-way travel.

From the point of view that Cannon Street is another important east-west arterial it can naturally be grouped with Main and King Streets but it is generally less heavily travelled. Figure 5.42 has been taken at about 11AM on a typical weekday, near Gage Ave., and there are no moving vehicles to be seen. This two-way stretch of Cannon hosts about 10,000 vehicle trips per day and this number increases to the west, and especially on the one-way section of Cannon, to numbers approaching 20,000 vehicles per day.

One thing that became clear from looking back at the 1950’s is that the conversion to one-way travel had the effect of concentrating more traffic on Main and King Streets than had been the case. This meant less flows on other streets (e.g. Cannon Street). As it turns out, a significant share of Cannon Street real estate is being devoted to top-notch cycling infrastructure. This is a reasonable thing for the sake of east-west travelling cyclists in Hamilton but it does reduce the potential for Cannon Street to handle more traffic in a complete two-way travel scenario. The volumes on King and Cannon are actually comparable on some parallel sections. Having only two lanes on sections of King Street has likely diverted some vehicles to the Cannon route that were taken away from Cannon at the time of the mass one-way conversions.

Given the inter-dependencies between Main, King and Cannon, it makes sense to think of the three as a package. In all three cases there is more flexibility east of the downtown to implement complete streets concepts and with the new bike infrastructure developed on Cannon this is well underway. Two-way travel east of the downtown seems more likely than to the west. Direction of travel is not necessarily a constraint on the use of complete street principles as downtown King Street East has already shown.

Kenilworth Avenue

Of the north-south links in the lower east end of the city, Kenilworth Avenue (Figure 5.43) is the most prominent as a thoroughfare in that it connects industry to the mountain access. In doing so, traffic volumes are somewhat less than 20,000 vehicles per day. There is assorted commercial strip development along the road but mostly smaller independent businesses as opposed to larger retail chains. Kenilworth does border on the revised Centre Mall development. There are also large stretches of the street that are residential in character. Kenilworth would seem to be a good candidate for a road diet treatment as the volumes are within reason. It is important to bear in mind that Kenilworth is actually quite suburban in character and the trip patterns reflect that nearby residents are quite automobile-oriented in their travel behaviour. As such, measures to induce more use of other modes and active travel are likely to have limited impact.

One interesting note about the intersection of Kenilworth and Main is that accident totals at the intersection are high. It appears to be a case where relatively high traffic volumes in both directions are coming together at an intersection that is less spacious than many suburban intersections and this increases the potential for conflicts. Complete Street concepts could play a role to improve safety at this location.

Figure 5.43: Kenilworth Avenue near Main Street

5.3.4 Central Arterials

The central arterials among the street cases are significant conduits for vehicles but they are in higher-density urban contexts than the streets of the prior section and they generally handle less traffic. At the same time, they lack the neighbourhood-oriented commercial strips that characterize Locke Street, for example.

Bay Street

Of the three central arterials considered in this section, Bay Street (Figure 5.44) is certainly the most central. Bay Street stands out as a conduit for the large number of central city workers who arrive and depart predominately by automobile. This results in huge spikes of inflowing trips during AM peak and a similar spike of departing trips during the PM peak. Spikes in transit usage are also quite evident (see Appendix 7.3). The arrival and departure of work trips during the day does not result in massive traffic volumes of Bay Street with the totals being little in excess of 10,000 vehicles per day.

Apart from the prominent central city role, the vast majority of Bay Street is actually residential in character and this applies to a large extent in either direction from the downtown. North of Cannon Street, Bay is a two way road but otherwise it is generally two-lane, one-way travel. There is ample space north of Cannon to implement a road diet and possibly an argument could be made for one-way travel along the entirety of Bay Street. However, Bay Street does have sharp spikes in traffic during AM/PM Peak and because of events at the First Ontario Centre. These spikes are possibly better funneled with one-way travel.

Figure 5.44 Bay Street Facing South from Cannon Street

Dundurn Street

Dundurn Street has already received some attention as a complete street as Figure 5.45 illustrates and appears to be functioning fairly well. There is reasonable access to public transit and bicycle lanes are present. Traffic is calmed to some extent as there is only one lane per direction except in the vicinity of the Fortinos plaza. The southern reaches of Dundurn are more commercially-oriented and there is some strip development activity but not with the same level of charm as Locke Street. Compared to Queen and Bay, Dundurn does not generate or receive a high share of transit trips and is actually a fairly automobile-oriented area of the city despite its central location.

The biggest problem area on Dundurn is the short stretch defined by Main and King. Here there is intense commercial activity and meanwhile Main and King are conducting an important role in shuttling vehicles to and from Hwy 403 as well as to and from the western reaches of the city. Movements are fairly well controlled though, with a median along this stretch, but the cycling infrastructure does break down. Cycling trips to and from the west of Dundurn (e.g. McMaster-oriented trips), as opposed to along the entire length of Dundurn, are being encouraged given the location of infrastructure.

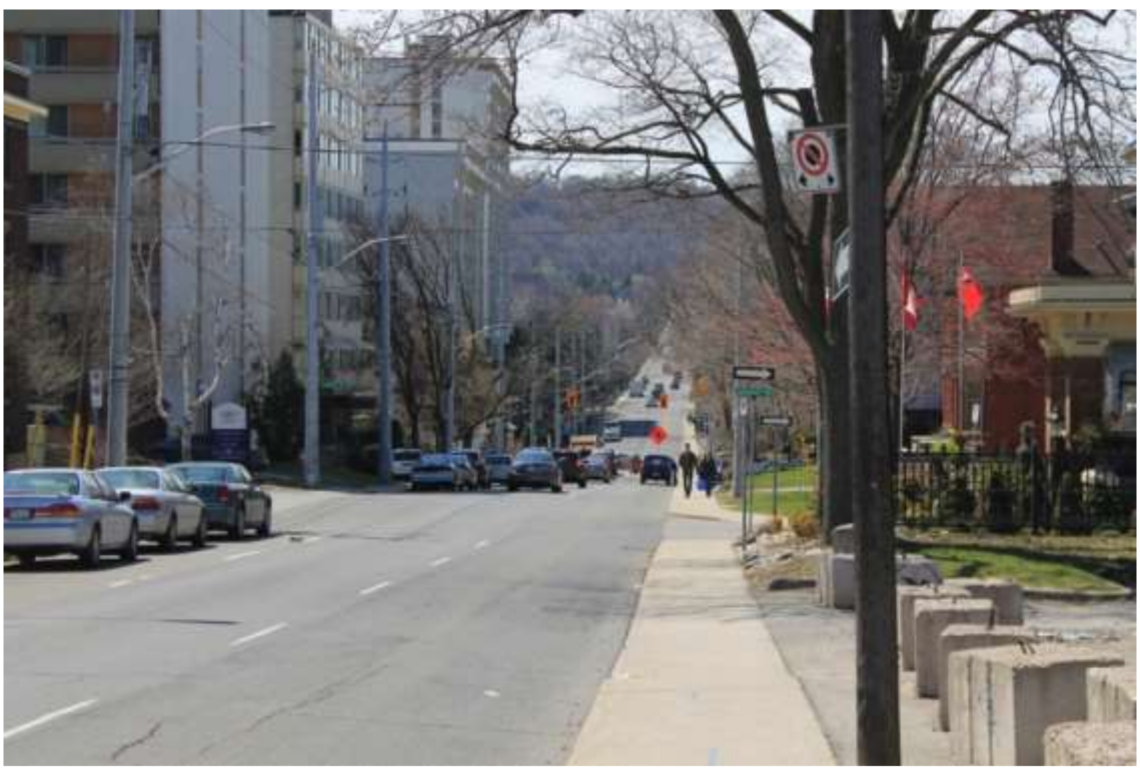
Figure 5.45: Dundurn Street Facing South Toward King Street

As appears to be the case now, the emphasis on Dundurn should be on safety and access and the efficient funneling of multi-modal trips. In general, the pedestrian experience will not require as much emphasis as on Locke Street but there are large counts of pedestrians crossing at both King and Main. Their safety is of paramount importance.

Queen Street

Queen Street (Figure 5.46) is largely residential in character but it does play an important role in moving vehicles and in providing one of the primary mountain access routes. It is a one-way street for most of its length except for a short stretch near the mountain access. Traffic volumes near Main Street are at about 10,000 vehicles per day moving in the direction of the mountain. As long as Main Street remains a one-way route the same should probably apply for Queen Street given the difficulties of handling that number of vehicles on one lane of traffic on Queen. Also, there is a lack of parallel alternatives that could play an increased arterial role to remove burden from Queen. In the shorter run, there is likely more flexibility to consider two-way travel on Queen north of King Street. Pedestrian infrastructure on Queen seems reasonable and while cycling on Queen is not being actively encouraged through infrastructure, it can be argued that Dundurn and Locke Streets, for example, are probably better alternatives anyway.

Figure 5.46: Queen St. at Main St. E. Facing South



5.3.5 Minor Suburban Arterials

Minor suburban arterials are defined here as running through areas that are suburban and lower density in character but with low traffic volumes. There are three cases identified by the City that fit these criteria and these are towards the east in the lower city.

Gage Avenue

Figure 5.47 shows Gage Avenue near King Street and also highlights the challenges in maintaining road infrastructure particularly after a harsh winter. Traffic volumes along Gage top out at about 8,000 vehicles per day which is light given the significant road infrastructure in place. Gage Avenue is a mix of industrial, commercial and residential activity with industrial predominating towards the north. Traffic volumes suggest that there would be no difficulty in implementing a road diet on Gage and from the point of view that Gage Park is nearby, cycling infrastructure could be featured as part of the package. Of course traffic volumes are low enough that it is hard to feel a strong sense of urgency for such a change relative to other cases in Hamilton that might be viewed as more pressing.

Figure 5.47: Intersection of Gage Avenue near King St. E.

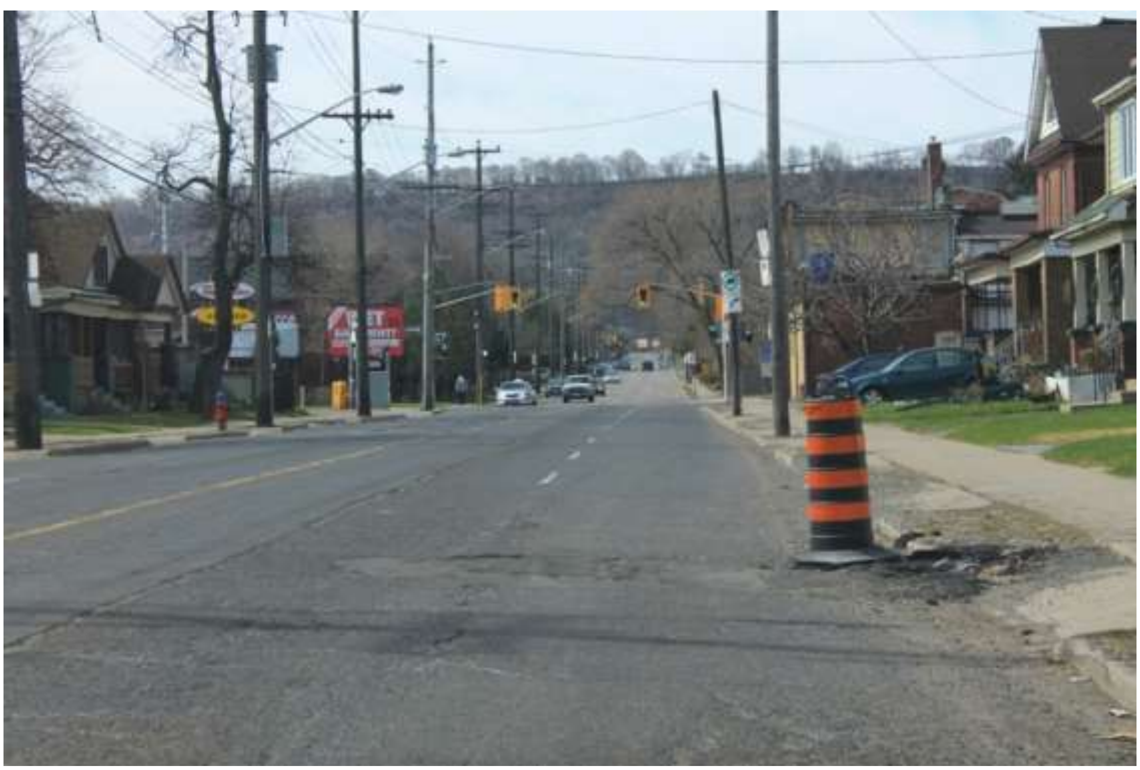
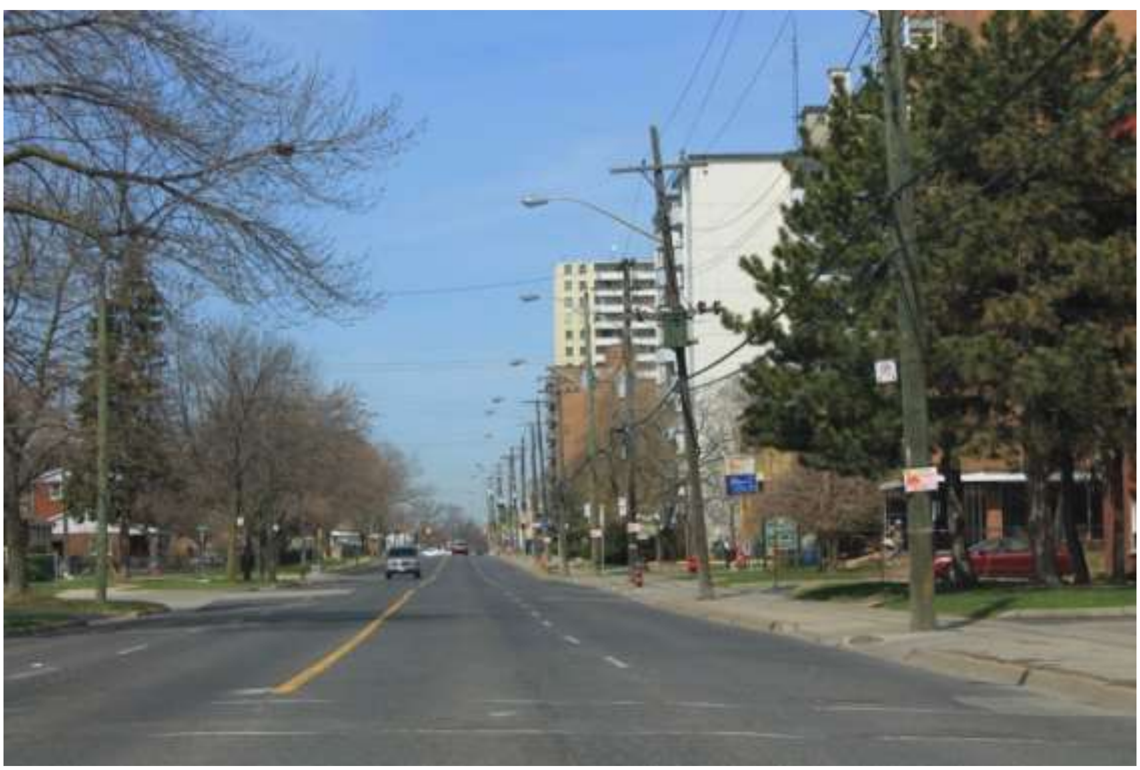


Figure 5.48: Britannia Avenue

Figure 5.49: Melvin Avenue



Also in the category of minor suburban arterials we are including the cases of Melvin Avenue and Britannia Avenue. These streets are located in close proximity to one another and run east-west. The eastern extents of both streets are near the Red Hill Valley Parkway. Britannia runs further than Melvin with the latter terminating just before Strathearne Avenue. At one point Britannia feeds into Cannon street for westbound travel and much of the traffic is diverted to Cannon. As a whole, both streets are quite residential in character, do not appear to be heavily travelled, and if anything provide more road infrastructure than is really required. Given the high cost over time to maintain this infrastructure, there could be an argument to reduce the paved area along certain of these stretches as opposed to carrying out elaborate complete streets treatments that attempt to make use of all the space. Given the suburban character of these areas, existing pedestrian infrastructure seems adequate.

5.3.6 Some Existing Complete Street Examples in Hamilton

In considering the future of complete streets in Hamilton it is important to note that a lot has been done already and some examples have been in place for a long time. The brief discussion below highlights a handful of cases and we note that there are other examples that could have been discussed.

Figure 5.50: Victoria Avenue near Hamilton General

Figure 5.50 illustrates a fairly recent treatment on Victoria Avenue outside Hamilton General hospital. There is a separated bike lane which also has a buffer between the bike lane and the vehicle lane. As is typical, no cyclists are visible and pedestrian traffic is light. Roadway space has been devoted to serving parked cars, which would be to the chagrin of some complete streets purists but seems like a practical approach in this context which also helps to calm traffic. The two lanes of traffic are fairly heavily travelled and the fact that travel is in one direction is not a significant handicap. Excessive speed did not seem to be an issue in the area at the time we visited. The crossing environment for pedestrians is reasonable without the need for pedestrian refuge islands or the like. The overall treatment seems to match well with the immediate environment.

Figure 5.51: Barton Village – Attractive Design Only Part of the Equation

The treatment at Barton Village (Figure 5.51) has been in place for some time. Considerable effort has been put into improving the design of the road and to create a more pleasant environment. Much of the effort is concentrated in the median and on its beautification. A full implementation of complete street principles would typically define separate space for cycling and perhaps use the median area as a third lane to accommodate turns. There would likely be more emphasis on treatments of the road side, possibly in terms of landscaping or wider sidewalks to accommodate pedestrians. The photo is from the middle of a weekday morning and probably the strongest theme that emerges is a lack of “hustle and bustle” or vitality in the area. A truck is being unloaded, some traffic is passing though, few vehicles are parked and a couple of isolated figures on the sidewalks are visible. Commercial activity appears light. One could quibble with the particular type of street treatment that has been applied here but it seems hard to deny that the forces governing activity in this area are larger than the configuration of this street. Nevertheless, the current design is there to serve this area as it further develops in the future. The overall good design is hardly a liability.

Figure 5.52: Wilson Street in Ancaster – Complete Street in Auto-Oriented Area

Figure 5.52 relates to Wilson Street in Ancaster. Here there are various complete street principles that are present. While the street functions well in governing the flow of traffic and in providing a pleasant environment for pedestrians and cyclists (for the latter, in other sections more than the one pictured) an important observation is that this is one of the most automobile-oriented areas in the City of Hamilton. Rates of auto ownership are quite high and auto-driver trips dwarfs all other trip types (see Wilson Street in Appendix 7.3). Clearly, the actual ability of the street to fundamentally influence modal choice patterns, despite sound design principles, is limited. Nevertheless, this right-of-way is successful in channeling significant traffic volumes while maintaining a high-quality environment for non-motorists.

6

Conclusions

This report has analyzed the complete streets concept from the ground up and has reviewed a wide range of literature to formulate insights on how to think about complete streets. These insights have been applied in high-level examinations of street cases in Hamilton. Accordingly, this concluding section summarizes the results of these efforts separated into the more general context and contexts which relate to Hamilton. An additional section considers future research.

While it has not been examined in-depth in this report, one important conclusion is that complete streets is about many small design elements coming together to achieve a significant overall effect. But even single elements, if well done, can make a significant difference in peoples' lives. A well-designed crosswalk can make things much better for an elderly person who frequently has to cross a busy road. A cyclist may take great pleasure in a small new stretch of bike lane that completes a route for them or a new place to park their bike. A pedestrian may enjoy a new cobblestoned sidewalk on a small retail strip. Finally, an older driver may feel less intimidated about traversing their daily route. These thoughts should not get lost in some of the more analytical findings outlined below.

6.1 General Conclusions

The Complete Streets Concept

- “Complete Streets” is an umbrella/marketing term that draws together a range of tools, elements and concepts in a package to help achieve better social, economic and environmental outcomes along urban road corridors. While the term is relatively new, many of its associated elements have been around for a long time.

  The concept of complete streets is one that is fully aware of the linkages between the built environment and the types of activities that take place within them, and complete street initiatives fundamentally seek to change urban environments to achieve a number of goals, such as increasing safety, economic vitality, and alternative mode use and the promotion of healthier and more environmentally sustainable lifestyle choices.

Regulating Driver Behaviour

- It has emerged that regulating driver behaviour is one of the core and most widely applicable elements of what defines complete streets. It is through the regulation of this behaviour, either in calming the antics of aggressive drivers or in better accommodating the needs of older drivers, that the best possible environment is presented for multimodal travel and vibrant neighbourhoods.

- The regulation of driving behaviour is partly accomplished through techniques such as: fewer and narrower lanes, unforgiving roadsides, vertical and horizontal deflection measures, wider sidewalks and street beautification. Such approaches have been shown to reduce average speeds and their variability, along with various forms of aggressive driving.

- Complete Streets emphasize connectivity and access over vehicle throughput. One-way streets are no doubt contrary to the first two and there is evidence that their importance to the latter has been over-estimated relative to what a well-conceived two-way network with left turn pockets can do. Having said that, it is quite possible to develop a one-way street that is essentially robust from a complete streets perspective. Roundabouts are sound from the safety, connectivity, traffic flow and other perspectives and should be discussed more in the complete streets conversation.

- From this, there are many who fear that excess traffic congestion will be an unfortunate by-product of these measures. In practice, the worst fears with regard to traffic congestion rarely materialize. In the short run, people shift modes, defer trips, take alternate routes or refrain from making a trip altogether. This phenomenon is known as "disappearing traffic" and it is the reverse of induced traffic that occurs in the presence of excess infrastructure for cars. In the long run, somewhat reducing the relative attractiveness of automobile travel in certain cases can literally "shape" the city by increasing population densities in desirable areas with extensive complete streets treatments. There is no doubt though that implementations in arterials with traffic flows in excess of 30,000 vehicles per day are much more difficult.

- Worries about congestion can also be addressed through approaches that are not under the complete streets umbrella but can work in concert with complete streets. Transportation Demand Management solutions can also influence the mode choices that people make. For example, employers can implement telecommuting or staggered work hours or sponsor programs and policies that encourage at least the occasional use of other modes. There are many other examples.

Complete Streets Outcomes

- Improved safety for all, but especially for vulnerable populations, is the most fundamental outcome that defines the basic rationale for complete streets. The safety benefits accrue to pedestrians of all ages, cyclists, drivers and passengers. Clearly, fewer accidents generates social and economic benefits in its own right but economic revitalization in the form of fewer vacancies, improved vibrancy and higher real estate values may take time to unfold even under the right circumstances. Improved safety can be seen as fulfilling important pre-conditions for advanced forms of economic improvement.

- It is important to note that if vulnerable populations, who may not have access to a vehicle, have improved access to employment opportunities and health care or schools through the use of alternative modes, that these are improved social and economic outcomes.

- Economic revitalization of an area can be aided by complete streets. But complete streets are most effective in the economic sense if other tailwinds are in place. Complete streets in and of themselves will not halt a serious decline due to factors such as high crime or pollution levels. Nevertheless, the safety benefits of complete streets will still apply.

- Furthermore, the nature of existing land use and the built environment in various contexts across a city is of enormous importance for realizing the full potential of complete streets implementations. There are large areas of many modern day cities where the built environment is essentially designed for the automobile; dispersed and segregated land uses prevail over concentrated, mixed uses. In such contexts it is probable that a full-scale complete streets implementation might lead to negligible improvements in multi-modal travel.

Achieving Balance and Context Sensitivity

- It is prudent to work from the perspective of *balance* in judging the efficacy of complete streets. Is the existing street design the one that best serves the needs of everyone in a neighbourhood, including automobile and transit commuters, homeowners and shop owners, and small children and seniors? Or has the flow of automobile and truck traffic been prioritized at the expense of pedestrian and cyclist safety and local economic vibrancy? If such an area is indeed deemed to be out of balance, complete street measures can potentially help a street or neighbourhood to reach a new equilibrium and achieve better social, environmental, and economic outcomes.

- With so many potential complete streets elements, there are many permutations for how a complete street can be set up. Implemented solutions will ideally be sensitive to context. Demand for each travel mode needs to be taken into account while considering the possibility that there is latent demand for modes of travel that could be "unlocked" with the right infrastructure and design. Excess emphasis on automobile travel may be prioritizing the needs of the region over the needs of the immediate vicinity, thereby suppressing latent demand for modes such as cycling or walking.

A Long Time Horizon

A focus on short-term impacts is not appropriate for judging complete streets as there is a long time horizon involved in responses in land use, travel behaviour, and economic development associated with changes in the built environment. Even if demand for particular changes does not yet exist in an area, complete streets initiatives that reconfigure a poorly conceptualized street can no doubt lead to greater appreciation and utilization of these changes as more individuals self-select to locate in these areas over time.

Research Limitations

- There is very little academic discourse using the term "complete streets" as a package concept. More has been done on some of the individual elements that make up a complete street. There has been considerable academic discourse on the interactions of the built environment with travel behaviour but little discourse on the interactions between complete streets per se and travel behaviour. Complete streets are only a minority of what defines the built environment.

- Research on the impacts of complete streets is complicated by the fact that it is hard to statistically separate built environment impacts from the attitudes of the people who occupy the built environment. For example, does suburban travel behaviour originate with the built environment or with the residents or both?

6.2 Hamilton-Specific

Our high-level case studies organized street cases according to five broad street types, each of which exhibit different roles within the organizational and functional context of the city against which their overall balance must be evaluated. As such, there is no one-size fits all prescription for complete streets in Hamilton and more study will need to be done beyond our high-level assessment to determine the most appropriate complete streets measures for each case. Some important points about our examination of the Hamilton context has yielded the following:

- The 1956 conversion of much of the street network of the lower city to one-way travel was a reflection of the times. Automobile ownership was increasing rapidly and there was considerable North American emphasis on moving large numbers of vehicles quickly. In the wake of the conversion to one-way travel in 1956 it was noted that traffic flows became more concentrated on Main and King and vehicle speeds went up significantly. The passage of time has shown that these were probably not the right goals to achieve.

- The ultimate conversion of Main and King Streets back to two-way travel could well prove beneficial but due to 1960's infrastructure investments where Hwy 403 meets King and Main, this possible conversion might be cost prohibitive. Traffic movements would be calmed, connectivity would be improved, and travel distances would decline. If driving times were to increase, it would not be by as much as many people fear. The backdrop to encourage other modes of travel and urban intensification would improve. In general, the results of this report suggest that fewer one-way streets in Hamilton would be better.

- Certain neighbourhood commercial strips (e.g. Locke St., James St. and Ottawa St.) offer the best potential for the prototypical multimodal complete streets treatment. Some neighbourhood commercial strips could benefit from slower traffic speeds (even as low as 30km/h) and an improved pedestrian environment, which can potentially lead to better economic outcomes.

- Hamilton has mostly low population densities. Even large parts of the lower city (e.g. east of Gage) are suburban. This increases the challenge for multimodal balance.

- The heavily travelled suburban commercial strip (e.g. stretches of Upper James especially and Queenston Road) are challenging cases which carry more vehicles than many provincial highways and yet host numerous access points to adjacent activities. A focus on safety is paramount in these cases which are functioning fundamentally as they were designed to function.
- For certain of the Hamilton cases considered, particularly near the historic industrial core, it can be argued that there is an excess of multi-lane road structure. It is costly to maintain such infrastructure, particularly when it is not being used extensively. Reductions in road infrastructure is a possible option for these cases. Overall there is a case for re-allocation of excess road space away from automobile-oriented uses in an attempt to improve social, environmental, and economic outcomes in many of these areas.
- There is potential for increased use of the road diet concept in Hamilton. This can calm traffic flows while providing some extra cycling and/or pedestrian infrastructure.
- Safe cycling infrastructure along the east-west spine of the lower city can lower risk and potentially increase cycling trips, though its ultimate success as a highly-utilized cycling network link depends on the degree to which it links important origins and destinations valued by cyclists.
- Light rail will work well with complete streets. The former will define a backbone for improved economic outcomes in the lower city and complete streets will further amplify the positive ripple effects across a wider area.
- In focusing our efforts here on select cases within Hamilton it is important to remember that other areas have needs from a complete streets perspective. There are numerous examples in the City where basic sidewalk infrastructure is not in place but is needed.
- Any changes to the built environment that make it safer, more accessible for all users of the road, and potentially more economically vibrant are worth considering. Hamilton has, and continues to play host to many changes in its population, demographic, and economic structure. Future infrastructure renewal needs across the city provide a perfect opportunity to consider the balance of the built environment. Such an exercise may reveal alternative street configurations that stand to offer a better return on investment in terms of social, economic, and environmental outcomes while potentially being more cost-effective. While short-term benefits will likely be hard to measure, in the end complete streets changes should be evaluated on the simple benchmark of whether or not they make the city a better place to live.

6.3 Future Research

- Fundamentally, this report found a lack of collective primary data collection on the elements and outcomes of complete streets and especially where these data were collected over a long period of time and considered treatment sites and control sites. While there is a lot of "piece meal" evidence that suggests the effectiveness of complete streets, studies such as NYCDOT (2013) are few and far between. Apart from this major consideration, here are a few other questions:What is the ROI of complete streets and/or its component elements?

- Are urban travel patterns more about the built environment or the people doing the travelling? For example, if you put an auto dependent person in a walkable neighbourhood, how much will they walk?

- How should complete streets implementations in Hamilton be prioritized and what are the proper metrics to measure progress for policy evaluation?

- From the large menu of items associated with complete streets, what are the best specific selections for the range of urban street contexts?

- In concert with intensification and infill development how can urban corridors be developed, in a cost-effective manner, to their full potential so that people can live, work and play more locally?

Appendix

7.1 North American Cases

1. The Blvd, City of Lancaster, CA
2. 1st and 2nd Avenue, Manhattan
3. 9th Avenue, Manhattan
4. East Boulevard, Charlotte, NC
5. Prospect Park West, NYC
6. Edgewater Drive, Orlando, FL
7. Bridgeport Way, University Place, WA
8. Seattle, WA
9. Stone Way North, Seattle, WA
10. Nickerson Street, Seattle, WA
11. Fourth Plain Boulevard, Vancouver, WA
12. Nebraska Avenue, Tampa, FL
13. Baxter Street, Athens, CA

7.1.1 The Blvd, City of Lancaster, CA

General Information
Street type: arterial
Land use context: commercial/ mixed use

Before treatment
Number of travel lanes: 4
Speed data: 40-50 mph (65 to 80 km/h)

After treatment
Number of travel lanes: 2
Speed data: 25 mph (40 km/h)

Problem

Lancaster Boulevard located in downtown Lancaster was primarily a four-lane road on which automobiles travelled at speeds of 65 to 80 km/h. It was an unsafe and unpleasant road for residents to walk and shop.

Approach

In 2010, the City adopted a plan with "complete streets" design features to encourage economic investments in the city's downtown district along Lancaster Boulevard (rebranded as The BLVD). The new plan reduced the number of travel lanes from four to two, removed six traffic signals and created spaces for public events. The design features include, a plaza for public events, on-street parking, raised median, improved crosswalks, urban planting and lighting, and outdoor seating.

Figure 7.1: The Blvd, Before Complete Streets Design and After

Source: McCann et al., 2013

Results

The project has triggered dramatic economic growth and job creation as well as improved safety in the area. The City evaluates that a public investment of $10 million, primarily in new lighting, landscaping, and trees, has spurred $125 million in private investment in the downtown area, with 50 new businesses opening and 800 new jobs. Sales tax revenue grew by 26 percent (McCann et al., 2012) and injury-related collisions reduced by 85 percen (Gordon-Koven, 2013).

The BLVD is now a place where neighbors can interact on the street. The street is noted for its hosting of a holiday feast and other public events (such as farmers markets). This project was awarded the U.S. Environmental Protection Agency's 2012 Smart Growth award for Overall Excellence.

7.1.2 1st & 2nd Avenue, Manhattan

General Information

Street type: arterial
Land use context: commercial/ mixed use
Speed limit: 30 mph

Before treatment	**After treatment**
Number of travel lanes: 4	Number of travel lanes: 3
Traffic volume[3]: 1,652	

Problem

Safety, especially for bicyclists and pedestrians, along 1st and 2nd Avenues was a prominent concern for the city and residents. These two corridors ranked in the top 22% and 12% respectively of severe injuries to all users, compared to all other corridors in Manhattan Island (NYCDOT, 2011).

Approach

In 2010-2011 the city implemented a re-design plan to address safety issues in the two corridors. Some physical changes were made to create a safer environment for pedestrians and bicyclists. The City created dedicated lane for buses and bicycles, over 45 pedestrian safety islands, and mixing zones for bicycles and motor vehicles. The mixing zones better accommodate vehicle/bike turning conflicts, where bike traffic merges with turning vehicles. The new design has kept the same number of travel lanes but a protected bike path has been created by swapping the existing bike lane with a parking lane (NYCDOT, 2011). First Avenue is seen below at East 6th Street along with another graphic of the typical design used from East 96th Street to East 125th Street.

3 Peak Hour Vehicle Volumes: Average of three consecutive weekdays (Monday-Thursday) taken the week of 4/4/11. Between E. 96th St to E. 125th St

Figure 7.2: 1st Avenue, Before Complete Streets Design and After

Source: NYCDOT, 2011

Results

Results indicate an 18 percent increases in bus speeds and 12 percent increase in bus ridership. Changes in street design have led to a rise of 177 percent in people riding bikes along the street and 47 percent decline in commercial vacancies (Gordon-Koven, Nov 2012). The re-design has also cut pedestrian, bike and auto injuries by 37% and 11% on 1st and 2nd Avenues respectively (NYCDOT, 2011).

Figure 7.3: 1st Avenue Complete Streets Design Implementation

Source: NYCDOT, 2011

7.1.3 9th Avenue, Manhattan

General Information
Street type: arterial
Land use context: commercial/ mixed use

Before treatment
Number of travel lanes: 4
Traffic volume (peak hours)[4]: 1,800

After treatment
Number of travel lanes: 3

Problem

9th Avenue in Manhattan was an unsafe four-lane road with a long crossing distance (70') and no cycling space (NYCDOT, 2007). These characteristics created an unfriendly environment for pedestrians, bicyclists, people with disabilities as well as children and older adults.

Figure 7.4: 9TH Avenue Before Treatment

Source NYCDOT, 2007

Approach

In 2007, the city created the first protected bicycle lane in the US on 8th and 9th Avenue. These initiatives were followed by the introduction of other elements of complete streets such as refuge islands, visible crosswalk marking and street planting. The overall outcome was that the street was converted from a four-lane road to a three-lane road with pedestrian refuges in the middle and bicycle lanes.

4 Traffic volume during peak hours is no more than 1,800 vehicles per hour, whereas each lane can accommodate 600 vehicles per hour, the current four travel lanes excess capacity.

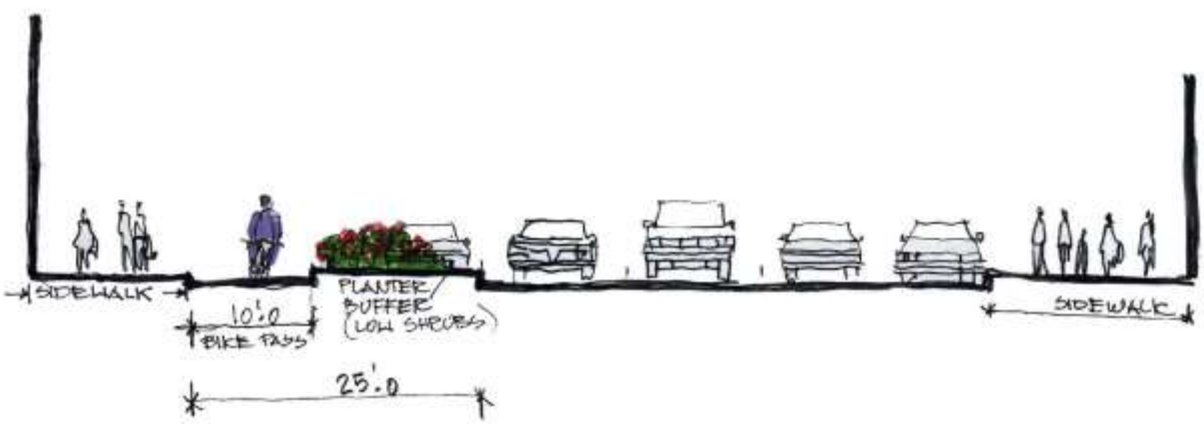
Figure 7.5: 9th Avenue Pedestrian Refuge

Source: NYCDOT, 2009

Results

The roadway, crosswalk and bicycle lane improvements have improved safety and provided more mobility options for all types of users. These positive changes have resulted in a 58% decrease in injuries to all street users and up to a 49% increase in retail sales (Locally-based businesses on 9th Ave from 23rd to 31st Streets, compared to 3% borough-wide) (NYCDOT, 2012).

Figure 7.6: 9th Avenue Cross Section Design Proposal



Source: NYCDOT, 2007

7.1.4 East Boulevard, Charlotte, NC

General Information
Street type: arterial
Land use context: Commercial/ mixed use

Before treatment
Number of travel lanes: 4
Traffic volume: 21,400 VPD[5]
Average Daily Traffic: 21,400
Speed data: 55 mph (90 km/h)

After treatment
Number of travel lanes: 2
Average Daily Traffic: 18,400
Speed data: 40 mph (65 km/h)

Problem

East Blvd is located in the heart of Dilworth, a historic neighborhood with a mix of residential, commercial and recreational land uses. The street was a four-lane, undivided road which did not favor all modes of transportation effectively. High speeds and an unfriendly environment for pedestrians and bicyclists were paramount issues on East Blvd. Numerous driveways and access points especially along commercial areas caused conflicts (CSS, 2012). East Blvd. emerged as a high accident corridor with high levels of bike/pedestrian accidents and left-turn collisions (CDOT, 2007).

Figure 7.7: East Blvd., before and after treatment

Sources: CSS, 2012; CDOT, 2013

5 Vehicle Per Day

Approach

To improve matters, the city converted East Blvd from four lanes to two lanes and included a center turn lane as well as a bike lane on both sides of street. The project was implemented in three phases starting in 2006 and was completed by summer 2011 (CDOT, 2013). The new design sought to maintain left-turn access to all driveways and businesses and improve intersection safety and visibility.

Figure 7.8: The Intersection of East Boulevard & Scott Avenue, Dilworth

Source: CSS, 2012

Results

After modification, the street better accommodates many users including pedestrian, bicyclists and motorists and driveway-related conflicts have been reduced. The road conversion has also moderated motor vehicle speeds while accommodating the same amount of traffic volume (20,000 vehicles per day) (CSS, 2012). Corridor travel times have not been impacted (CDOT, 2007). Traffic on East Blvd. now functions more efficiently and pedestrians can cross the street more safely via refuge islands.

Jones (2012) studied the behavioural impacts of East Blvd. modification and reported residents' points of view. One said: "Before the city changed East Blvd., it was difficult to cross at any point, even at crosswalks with a signal, because there was always a constant flow of traffic. We walk more now and definitely cross the street more."

7.1.5 Prospect Park West, NYC

General Information
Street type: arterial
Land use context: Recreational, residential
Speed limit: 30 mph

Before treatment
Number of travel lanes: 3
Traffic volume[6]: 1,055
Average Speed: 55 kmh
(NYCDOT, 2011)

After treatment
Number of travel lanes: 2
Traffic volume[7]: 1,109
Average Speed: 43 kmh

Problem

Prospect Park West is an important thoroughfare in the Park Slope neighborhood of Brooklyn, New York that borders Prospect Park. Unsafe pedestrian crossings, lack of access for cyclists and speeding vehicles were problems for this corridor (Murphy, 2011). A study done before the project implementation found that 3 out of 4 vehicles were breaking the speed limit.

Figure 7.9: Prospect Park West, Before & After

Source: Okafar, 2011

6 Carroll Street AM Peak Hour (8-9AM); Counts conducted April 2009 and May 2010.

7 Carroll Street AM Peak Hour (8-9AM); Counts conducted October 2010.

Approach

In 2007, the Community Board 6 approved the DOT study traffic-calming measures. These included the addition of a two-way bike path, new loading zones, and pedestrian islands as well as modification of signal timing for pedestrians and warning signs for cyclists (Murphy, 2011; Okafor, 2011).

Results

The street reconfiguration project has reduced the crashes down to 16% and there is a 21% decrease in injuries to all street users. Before the project, a crash was twice as likely to include an injury (18% vs. 8%), after the project, there is no pedestrian or cyclist injuries reported from pedestrian-bike only crashes (NYCDOT, 2011). The number of cyclists has been tripled on the weekdays since the implementation of the project (190% increase[8]) and doubled over the weekends (125% increase). Percentage of cyclists riding on the sidewalk fell to 3%* from 46%; 32% of these cyclists were children 12 years and younger and legally allowed to ride on the sidewalk.

Figure 7.10: Prospect Park West Bike Lanes

Source: NYC DOT, 2011

Prospect Park West now accommodates 13% & 9% more commuters during the AM & PM rushes, respectively, while travel times have remained stable after implementation (NYCDOT, 2011). The project has also created safer access to the park and shortened the crossing times

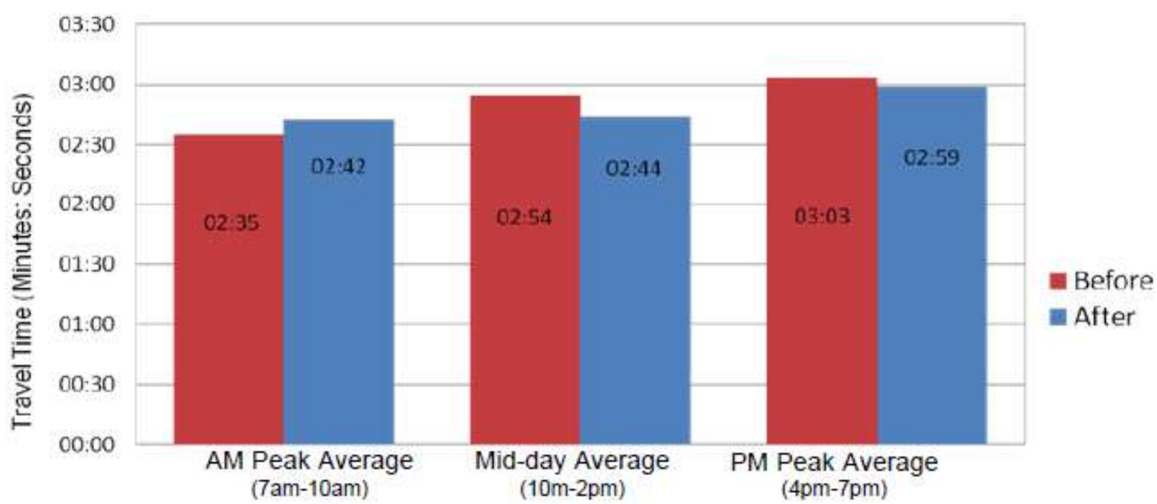
8 190% increase based on average of after counts compared to before count; data from a single weekday count.

for pedestrians. Although, cars now travel an average of 12 km/h slower, there is almost no change in automobile volume.

Figure 7.11 illustrates the impacts that Complete Street design had on the travel times along Prospect Park West, (Union St. to 15th St.) throughout the day. A small increase in travel times during the morning peak is offset by a small decrease during the afternoon peak. During non-peak times at mid-day, travel times also where reduced.

After the redesign only 1 out of 5 vehicles are now observed to break the speed limit (Okafor, 2011).

Figure 7.11: Prospect Park West Portion, Weekday Travel Times; Before & After



Source: NYCDOT, 2011

7.1.6 Edgewater Drive, Orlando, FL

General Information
Street type: arterial
Land use context: commercial

Before treatment
Number of travel lanes: 4
Average Daily Traffic: 20,500
Travel time (minutes)[9]: 3.25

After treatment
Number of travel lanes: 3
Average Daily Traffic: 18,100
Travel time: 4.15

Background

Edgewater Drive is a north-south roadway that serves as the main road of the College Park neighbourhood in Orlando, FL. The College Park Horizon Plan identified Edgewater as an important corridor to implement improvements such as new crosswalks, safer parking, bicycle lanes and enhanced sidewalks. The Horizon Plan vision was to reconfigure Edgewater Drive into an active livable commercial district with high level of safety and accessibility for pedestrians (City of Orlando, 2011).

Problem

The prior 4-lane road was an auto-oriented thoroughfare without sufficient room for bike paths, wider sidewalks, and other streetscape features.

Figure 7.12: Edgewater Drive, Before & After treatment

Source: City of Orlando, 2011

9 AM peak (7-9 AM)

Approach

The results of a review of other implemented CS cases were presented in two public meetings held April-June 2001. The public approved of the overall concept and the city started to evaluate some effectiveness metrics in before and after conditions (City of Orlando, 2011). Ultimately, Edgewater was converted to 3-lanes with two-way bike lanes and on-street parking.

Results

Table 7.1 shows a significant reduction in crash and injury rates presumably due to the four-to-three-lane conversion. Speeds have been reduced. Drivers are making better use of on-street parking as it is now easier for them to get into and out of parked vehicle along the road. Both pedestrian and cyclists counts have been increased due to the increased safety and comfort levels after the project implementation. Transit users have benefited from scheduled bus services available at walking distances from businesses along Edgewater Drive.

Table 7.1: Summary of Complete Street Design Impacts

Variables	Before[10]	After[11]	Difference %
Crash rate (per MVM)	12.6 1 crash every 2.5 days	8.4 1 crash every 4.2 days	34% reduction
Injury rate (per MVM[12])	3.6 1 injury every 9 days	1.2 1 injury every 30 days	68% reduction
Vehicles traveled over 36 mph (Average)	18.3%	12%	6.3% reduction
On-street parking utilization	29%	41%	12% increase
Pedestrian volumes	2,136	2,632	23% increase
Bicyclist volumes	375	486	30% increase

There is some evidence of a boost in residential and commercial property values. Annual growth[13] of 8-10 % and 1-2 % respectively have been reported (City of Orlando, 2011). Table 7.2 shows a summary of a survey that was conducted before and after the project among residents and merchants (City of Orlando, 2011). The results are generally very favourable.

10 Before represents an average of Years 1999, 2000 & 2001

11 After represents four months (annualized)

12 MVM = Million Vehicle Miles

13 Years of 2001-2002

Table 7.2: Measure of Effectiveness

Measure of Effectiveness	Did the Re-Striping Accomplish the Objective?
Avoid Increasing Traffic On Neighborhood Streets	YES
Reduce Speeding on Edgewater Dr	YES
Increase Bicyclist Volumes	YES
Increase Pedestrian Volumes	YES
Reduce Crashes	YES
Increase On-Street Parking Use Rates	YES
Increase Pedestrian Satisfaction (Residents)	YES
Increase Pedestrian Satisfaction (Merchants)	NO
Increase Parking Satisfaction (Residents)	YES

7.1.7 Bridgeport Way, University Place, WA

General Information
Street type: regional arterial
Land use context: commercial area

Before treatment
Number of travel lanes: 5
Average Daily Traffic: 25,000
Average Actual Speed: 37.6 mph (61 km/h)

After treatment
Number of travel lanes: 4
Average Actual Speed: 32.6 mph (52 km/h)

Problem

The following were the major problems of Bridgeport Way:

- High speed limit and over-speeding vehicles
- Absence of sidewalks and bicycle lanes
- Insufficient lighting
- Multiple uncontrolled access points
- High number of crashes many with injuries

Between 1995 and 1998, over 300 hundred crashes occurred in a one mile section of this corridor. This section consisted of five undivided lanes (two in each direction and a middle left-turn lane) without any sidewalk for pedestrians. Many pedestrian attempted dangerous mid-block crossings while cyclists had to share this high-speed road with automobiles. Bridgeport Way bisected the main commercial area of University Place but contributed little in terms of aesthetics and multi-modal functionality (Yazici & Sugg, n.d.).

Figure 7.13: Bridgeport Way, Before & After treatment

Source: (Yazici & Sugg, n.d.)

Approach

In 1996, the city decided to address the safety issues along the Bridgeport Way corridor and transform it into a more inviting main street. Goals were to provide safe access for pedestrians and cyclists but accommodate movements of vehicles and trucks. Also there were hopes to increase the vibrancy of downtown. The city held a series of neighborhood meetings and open houses to identify a vision from residents and businesses. From 1998 to 2002 over three phases, a section of Bridgeport Way was transformed to a complete street with bike lanes, sidewalks, roundabouts and a lighted landscaped median. Flared intersections were designed in a way to accommodate wide-turning vehicles at signalized intersections. Mid-block crossings were installed to minimize pedestrian-car conflicts and provide better access to businesses on both sides of street (Yazici & Sugg, n.d.).

Results

Traffic calming features reduced vehicle speeds by 13%, in a 30 mph speed-limit zone. The crash total reduced 60% from 19 to 8 in the first year after the street reconfiguration. The number of pedestrians and visitors have increased and more than 100 pedestrians use mid-block crosswalks daily. Despite pedestrian count increases and more exposure to traffic flow, crashes involving pedestrians remained unchanged (Yazici & Sugg, n.d.).

The project has also improved business activity. A number of new businesses were observed to move to the corridor after project completion.

7.1.8 Seattle, WA

Since 1972, the Seattle Department of Transportation (SDOT) has implemented more than 30 road diets and is still determining the feasibility of other road candidates. In 2007, Seattle passed a Complete Street Ordinance to incorporate complete street principles into all transportation plans including, strategic plan and pedestrian or bicycle master plan. It required SDOT to (re)design city's streets to encourage walking, bicycling and transit use while promoting safe access for all road users. For a corridor to be selected as a candidate for street reconfiguration, SDOT suggests taking the following aspects of transportation system into consideration (Tan, 2011):

- Volume of traffic -- less than 25,000 vehicles per day
- Number of collisions -- all modes (motor vehicle, pedestrian, bicycle)
- Vehicle speed
- Number of lanes
- Freight usage
- Bus stops and routing
- Travel time
- Accessibility

As population density is increasing in Seattle, the city will increasingly rely on street rechannelization (often referred to as "road diet") to create more space for alternative modes of transport (walk, bike and transit), as opposed to widening roadways to accommodate more private vehicles. Seattle continues to use rechannelizations as a way to improve roads for all modes of transportation. As of March 2012, 36 road rechannelizations had occurred in the City.

7.1.9 Stone Way North, Seattle, WA

General Information
Street type: arterial
Land use context: Adjacent land use is mixed use residential, retail and commercial
Speed limit: 30 mph (50 km/h)

Before treatment
Number of travel lanes: 4
Average Daily Traffic: 13,000
Speed data[14]: 60 km/h

After treatment
Number of travel lanes: 3 + bike lanes
Average Daily Traffic: 6% reduction
Speed data: 58 km/h northbound, 55 km/h southbound

Problem

14 85th percentile speed

Stone Way north is a north-south roadway that connects two urban villages. Prior to reconfiguration, the street surface was in poor condition, with no bicycle path and less pedestrian facilities. There were several uncontrolled marked crosswalks, which were noncompliant under SDOT's 2004 revised crosswalk guidelines. The pedestrian had to make a long and dangerous crossing over four lanes of traffic (Tan, 2011). There are several pedestrian generators including eight schools, two libraries and five parks within five blocks of the street.

Figure 7.14: Stone Way North, Before & After treatment

Approach

To improve the safety and mobility of walkers and cyclists along the roadway, the city decided to undertake a lane reduction project. In 2008, SDOT implemented changes along a 1.9 kilometer segment of the corridor from N 34th street to N 50th street. The segment was reduced to two moving lanes plus a left-turn lane, bicycle lanes and parking on both sides. High-visibility pedestrian crossings were made compliant with federal guidelines (Tan, 2011).

Results

Overall, the street redesign resulted in improved safety, an increased number of cyclists, and only minor impacts to auto vehicle mobility. Speeding, collisions and injuries declined and the number of cyclists increased by 35 percent. Moreover, the project has spurred new development and a more livable environment. Vehicle traffic volumes remained consistent with the citywide trend and there was no apparent diversion to neighborhood streets or increases in congestion. These were both major concerns prior to the implementation and at one point the local chamber of commerce threatened to cancel a portion of the project. Table 7.3 shows a comparison of before and after the street re-channelization.

Table 7.3: Stone Way North, Before-After Analysis

Variables	Difference %
% vehicles traveled 40 mph (64 km/h) or faster	2% reduction
ADT	6% reduction
Peak hour volume	5% reduction
Off-peak volume[15]	2% increase
Bicycle volume	35% increase
Total crashes[16]	14% reduction
Injury crashes	33% reduction
Pedestrian crashes	80% reduction

15 South of 45th street

16 2 years before (2006-2007) and after (2008-2009) crash data

7.1.10 Nickerson Street, Seattle, WA

General Information
Street type: arterial

Land use context: commercial, light industrial, institutional, and some medium density residential

Transit service: 1 local bus route (15 min weekday headway)
Speed limit: 50 km/h

Before treatment
Number of travel lanes: 4
Average Daily Traffic: 18,560 (2009)
Speed data (Average): 68 km/h

After treatment
Number of travel lanes: 3
Average Daily Traffic[17]: 18,360 (2011)
Speed data: 52 km/h

Problem

Excessive speeds was a major problem on Nickerson Street in Seattle. Few pedestrian crosswalks and long crossing distances made it a difficult roadway for pedestrians to negotiate. Existing uncontrolled crosswalks did not comply with the guidelines (McGrane, Nickerson Street Road Diet, n.d.).

Figure 7.15: Nickerson Street, Before & After treatment

Source: SDOT, 2012

17 ADT also decreased on two potential diversion routes.

Prior to street rechannelization, there were two travel lanes in each direction exclusively designed for motorized vehicles. Top-end speeding[18] in some segments of the corridor was as high as 38%. A pedestrian struck at 40 miles per hour has only a 15 percent chance of survival.

Approach

To improve matters, the City of Seattle re-channelized over one mile of Nickerson Street, as the city's 28th road diet project. In 2010, the city added two new marked crosswalks and converted the four-lane roadway into two moving lanes, a two-way left-turn lane in the center, and bicycle facilities. Median islands were installed at the corridor and on-street parking was maintained on both sides of the street.

Figure 7.16: Pedestrian Refuge Islands

Results

The project has led to significant speed reduction. During the year after implementation, traffic collisions decreased by 23% compared to the previous five-year average. The share of top-end speeders dropped from 38% to 1.5% in the same segment. Average daily traffic has decreased very slightly (about 1 percent reduction) with little to no diversion to the neighborhood streets. Trucks continue to use Nickerson Street as a through route. The number of freight vehicles actually increased slightly after the project implementation and maintains a 5% share of vehicle

18 The percent of drivers traveling more than 10 miles per hour over the posted speed limit. For Nickerson Street, top-end speeding would be 40 miles per hour.

trips along the corridor. Overall, the project improved pedestrian safety by reducing problems associated with excessive lanes and consequently decreasing the level of speed on the corridor.

Table 7.4: Nickerson Street, before-after analysis

Variables	Before	After	Difference %
Speeders	Westbound 88%	Westbound 32%	64% to 63% Reduction
	Eastbound 91%	Eastbound 34%	
Top End Speeders	Westbound 17%	Westbound 1.4%	92% to 96% Reduction
	Eastbound 38%	Eastbound 1.5%	
Number of collisions	33.6[19]	26[20]	23% Reduction

7.1.11 Fourth Plain Boulevard, Vancouver, WA

General Information
Street type: principal arterial
Land use context: residential w/commercial
Speed limit: 50 km/h

Before treatment
Number of travel lanes: 4
Average Daily Traffic: 17,000
Speed data (Average): 50 km/h

After treatment
Number of travel lanes: 3
Speed data: 40 km/h

Problem

Before project implementation, the roadway consisted of four lanes with a width of 4 meters (12 feet). The number of lanes increased to five near major intersections (with a lane width of 2.7 to 3 meters (9-10 feet)). These circumstances created an unsafe environment for pedestrians and made it difficult for trucks and other vehicles to maneuver (Rosales, 2007).

19 Five year average
20 One year after completion

Figure 7.17: Before: Sidewalk dangerously close to traffic and, after redesign

Source: City of Vancouver, 2004

Approach

In 2001, a neighborhood planning grant initiated a discussion over the future of Fourth Plain Boulevard. A community dialogue began to highlight the notion that Fourth Plain should have better pedestrian circumstances and that travel lanes should be reduced from four to three (City of Vancouver, 2004). Fourth Plain had initially been designated as a state truck route. After conversion, a parallel road, Mill Plain Boulevard, was converted to a truck route bypass (Rosales, 2006). As planned, the number of travel lanes was reduced to three, while a centre turn lane was added in the middle. Sidewalk ramps, bike paths and underground utilities were also added to the roadway as part of the restriping project (City of Vancouver, 2004).

Figure 7.18: Fourth Plain Boulevard, Before & After treatment

Source: City of Vancouver, 2004

Results

After project implementation, the number of reported collisions was reduced by 52%. Pedestrian safety improved along the road with no reported pedestrian crash after the restriping project (Rosales, 2006). Traffic speeds decreased by 18%. No congestion or vehicle queuing along the roadway was reported after the project implementation. Pedestrian and cyclists are safer after road conversion as the bike lanes created a buffer zone between sidewalk and travel lanes, and cyclists themselves do not have to share the road with truck and other vehicles anymore. There is little evidence of traffic diversion and the retail sales analysis showed that the commercial areas on or near Fourth Plain have performed better compared to similar areas (Rosales, 2006).

7.1.12 Nebraska Avenue, Tampa, FL

General Information
Street type: Urban arterial
Land use context:

Before treatment
Number of travel lanes: 4
Average Daily Traffic: 21,500 (2006)

After treatment
Number of travel lanes: 2
Average Daily Traffic: 15,800 (2010)

Problem

Nebraska Avenue in Tampa, FL had among the highest bicycle and pedestrian crash frequency rates in the region. Nebraska was initially a 4-Lane Undivided Roadway with narrow, sub-standard lane widths (Chin, 2010). The roadway had few marked crosswalks and non-continuous sidewalks along the road. The corridor crash rate was 50 percent higher than comparable roadways and this was an indication of an unsafe environment for pedestrians and cyclists.

Approach

The Florida Department of Transportation converted the roadway to three lanes with a two-way turn lane and bike lanes in both directions. Pedestrian friendly features such as crosswalks, medians and sidewalks were also added. Midblock crossings and raised medians with visible markings were provided for pedestrian to cross the roadway safely. The medians have additional locations in the middle for the pedestrian to wait while crossing the road (McGrane, Nebraska Avenue Road Diet, n.d.).

Figure 7.19: Nebraska Avenue, Before & After treatment

Results

The road conversion resulted in a reduction of the overall crash frequency, crash rates, and crash severity. As pedestrian enhancement and bicycle lanes were included in the reconfiguration project, both pedestrian and bicycle crashes decreased significantly and fatal crashes per year were reduced by 61% (Chin, 2010). Truck and vehicle traffic continue to operate efficiently and overall the improvements have provided a safer and more accessible roadway for pedestrians and cyclists (McGrane, Nebraska Avenue Road Diet, n.d.).

Figure 7.20: Nebraska Avenue Redesign Elements

7.1.13 Baxter Street, Athens, GA

General Information
Street type: arterial
Land use context: Commercial with residential and university
Speed limit: 35 mph (55 km/h)

Before treatment
Number of travel lanes: 4
Average Daily Traffic: 20,000

After treatment
Number of travel lanes: 3

Problem

Baxter Street is an arterial near the University of Georgia, which connects the University on the east to a major shopping center on the west (Rosales, 2006). Like many other cases throughout North America, a decision was made to try and better accommodate the needs of all transportation users on its local streets. Baxter Street was a four-lane roadway, which was solely designed for automobile accommodation without any safety facility for pedestrians, cyclists or transit users (Clark, 2001).

Approach

In October 1999 an agreement for a conversion of Baxter Street was reached. Baxter Street was converted to three-lanes from four-lanes, with a two-way turn lane in the middle to separate through traffic from left-turning vehicles. Designated bus lanes on both sides of roadway were also added to create a safe environment for cyclists as well as separating vehicles from the sidewalk edge (Rosales, 2006).

Figure 7.21: Baxter Street, Before & After treatment

Source: Rosales, 2006

Results

After implementation, the total number of crashes was dramatically decreased. No significant change in traffic volume was observed but there is evidence of slight traffic increases in other streets around the project area (Clark, 2001). The success of the Baxter Street project caused the city of Athens to expand the road diet idea to the other roadways near the University of Georgia.

7.2 Complete street elements

Safety elements

- Signalized intersections
- Pedestrian refuge islands
- Protected bike paths
- Dedicated left/right/through lanes
- Mid-block pedestrian crosswalk
- Lower traffic speeds
- Speed humps and slow zones
- Roundabouts
- Pavement treatments/painting/striping
- Protective devices for pedestrian and cyclists
- Shorten crossing length in order to reduce pedestrian exposure to moving vehicles
- On-street parking; to provide buffer between sidewalk and traveling lane

Inclusiveness elements

- Pedestrian/cyclists/transit signal priorities
- Mixing zones for bicycles and left-turn vehicles
- Bicycle facilities
- On-level curb extension
- ADA sidewalk and universal design features
- Multi-space parking
- Raised, visible crosswalk
- Bus pullouts, bus shelter and dedicated bus lane
- Safe pedestrian connections to transit stations

Vitality elements

- Create pedestrian/public plazas
- Street furniture
- Landscaping features such as trees, flower box and ground cover
- Storefront seating area

- Sidewalk amenities for pedestrians such as benches and public arts
- Continuous and active storefront
- Fewer driveways
- Adequate street lighting in pedestrian scale

Complete street goals
Safety
Economic growth
Sustainability
Mobility and accessibility
Community health
How reachable are these goals?

7.2.1 Lessons Learned

The case studies in this chapter tell the story of how different municipalities in U.S. have applied complete street projects that resulted in improved pedestrian safety, fewer crashes, more vibrant communities, and increased number of pedestrians and cyclists in the urban streets. There are also successful examples addressing economic growth and business activities such as Lancaster, CA. As discussed in the first chapter there is no identical design that could fit to all streets, and each community must develop its own unique approach. However, case studies are useful in a way that provide us with weaknesses and strengths of each plan where the measure outcomes are available. As highlighted in most cases, safety is one of the fundamental reason for communities to adopt complete streets approach. Table 5 shows that several cases have been implemented in urban arterials in an attempt to slow down continuous flow traffic. Urban arterial is a conventional transportation strategy adopted during post-war period in an attempt to reduce neighborhood traffic volume by channeling traffic onto it and restricting private access (Dumbaugh & Rae, 2009). This strategy however has not shown much success, because over the time, number of retail, commercial parcels and big boxes gradually increased in many arterial roads. Since more people were exposed to these fast-paced thoroughfares, number of traffic conflicts and accident injuries raised (Dumbaugh & Rae, 2009). To slow traffic speed, several strategies were applied in different cases including; widened sidewalk, reduced crossing distance, added median and mid-block crosswalk among others.

Table 7.5: Complete Street Cases

CS/ location	street type	ADT	# travel lanes (lane width)	project length	posted speed	land use context	CS project elements	outcomes safety	other effects	project cost	project date/ time
The BLVD Lancaster, CA	Arterial		Four			Commercial, mixed use	converted to two lanes, added median, planting and lighting; added a plaza for public events	injury collisions decreased by 85%; improved pedestrian and cyclists safety	increased economic growth and created 800 new jobs; improved urban vibrancy	41M	2010
1st & 2nd Avenue NYC	arterial	1,600 (hourly-peak)	Four		30 mph	Commercial, mixed use	converted to three lanes, dedicated bus lane, swapped bike lane and parking lane;, added medians and mixing zones	reduced injuries by 37% (1st Ave) and 11% (2nd Ave);	increased bus speeds by 18%; increased bus ridership (12%) and # cyclists (177%); decreased commercial vacancies by 47%		2010-2011
9th Avenue, NYC	arterial	1,800 (hourly-peak)	Four; total pavement width 21-meter	N/A		Commercial, mixed use	converted to three lanes, added bike lane and left-turn lane, visible crosswalks, refuge islands and landscaping; reduced crossing distance by 7.6-meter	reduced injuries by 58%; improved pedestrian and cyclists safety	increased retail sales by 49%; bus service unchanged; Loss of about 20 metered parking spaces for left turn bays; new muni-Meters and loading zones		2007-2009

Prospect Park West, NYC	arterial	1,055 (hourly-peak)	Three	30 mph		converted to two lanes, added bike lanes, loading zone and refuge islands; signal modifications	reduced crash y 16% and injuries by 21%; improved pedestrian safety	increased # cyclists by 190% over weekdays; travel times remained stable	2007
East Blvd, Charlotte, NC	arterial	21,400	Four (undivided roadway)		residential, commercial, recreational	converted to two lanes, a center turn lane, bike lanes; added refuge islands	improved intersections' safety, safer access to driveways	improved traffic flow; no significant change to travel times	2006-2011 (three phases)
Edgewater Drive, Orlando, FL	arterial	20,500	Four		Commercial	converted to three lanes, added bike lanes and on-street parking; enhanced sidewalk	reduced crash by 34% and injuries by 68%; decreased speeding drivers by 6%	increased pedestrian volumes by 23% and cyclists by 30%; residential and commercial property values growth; economic development	
Bridgeport Way, University Place, WA	Regional arterial	25,000	Five	30 mph	Commercial	converted to four lanes, added bike lanes, and roundabouts; added landscaped median and mid-block crossings; enhanced intersections'	reduced crash by 60%; decreased vehicle speeds by 13%; improved pedestrian safety	increased # pedestrian and visitors; improved business activity	1996-2002

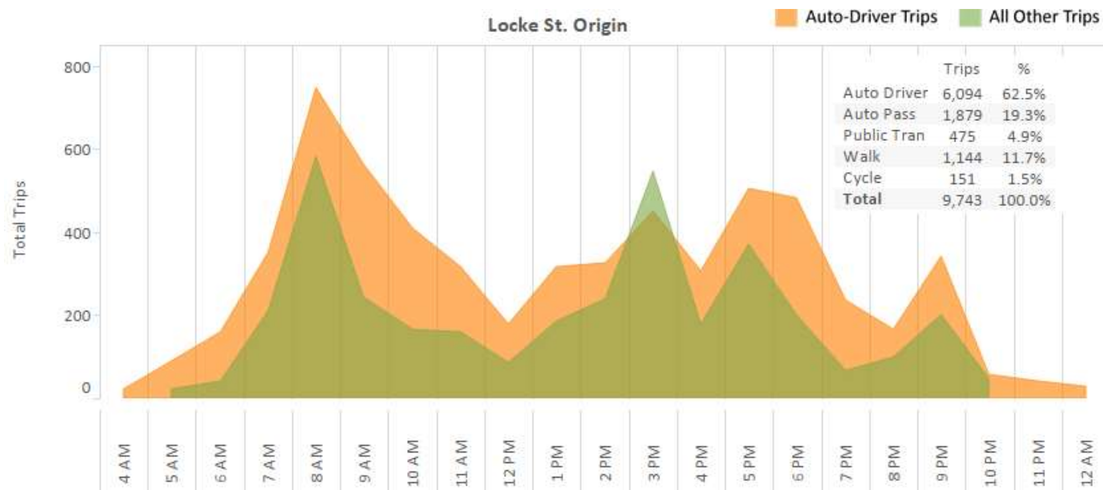
							elements				
Stone way north, Seattle, WA	arterial	13,000	Four	1.9 km	30 mph	residential, retail and commercial	converted to two lanes, a center turn lane, bike lanes, and parking	decreased speeding, collisions and injuries; improved pedestrian safety	increased # cyclists by 35%; no significant changes on traffic volume		
Nickerson Street, Seattle, WA		18,500	Four		30 mph	commercial, light industrial, institutional, medium density residential	converted to two lanes, two-way turn lane, bike lane, refuge islands, on-street parking	traffic collisions decreased by 23%; speeding drivers reduced by 64%	No significant changes to traffic volume; no traffic diversion; no impact on truck movement		2010
Fourth plain Blvd, Vancouver, WA	Principal arterial	17,000	Four (4-meter)	1-mile	30 mph (50 kph)	Residential w/ commercial, and light industrial	converted to two lanes, two-way turn lane, bike lanes	crashes decreased by 52%; speeds reduced by 18%; improved safety for pedestrian and cyclists	No queues blocking access; no traffic conversion; economic growth in adjacent businesses	1.26M	2002
Baxter street, Athens, GA	Arterial	20,000	Four (3-meter)	1.9-mile	35 mph (55 kph)	Commercial w/ residential and university	converted to two lanes, two-way turn lane, bike lanes, signal modifications	total crashes decreased by 53%; reduced speeding; safer pedestrian environment	No significant changes to traffic volume; business and home improvements	190K	1999

St. George street, Toronto, Canada	Minor arterial	7,400	total pavement width 14-meter	0.65-mile	25 mph	University	converted to two lanes, bike lanes, added median; improved sidewalk and pedestrian features, added planting	crashes decreased by 40%; improved pedestrian and cyclists safety	no traffic diversion and volume changes; good traffic operation and mobility; increased active transportatio n	4M (1996 CAD)	1993 & 1996 (two phases)
Grand Blvd, Vancouver, WA											
Valencia street, San Francisco, CA											
U.S. 18, Clear lake, IA	State Highway	12,000	Four (undivided roadway)	1.1-mile	45 mph (70 kph)	Commercial, residential	re-striped to two lanes, two-way turn lane, shoulders, temporary signal (interim project)	crashes decreased by 65%; speeding reduced by 52%	good traffic operation and mobility	105K	2003
Neberska, Tampa, FL	minor urban arterial	21,500 (2006)	Four								

7.3 21 Hour Trip Profiles for Selected Hamilton Cases

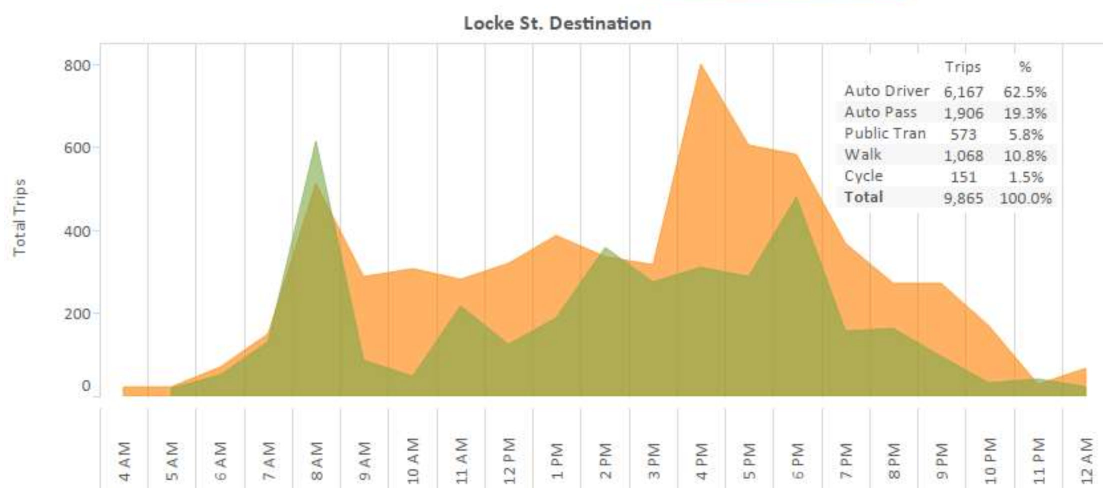
7.3.1 Neighbourhood Commercial Strips

Locke St.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	21	89	161	350	749	562	408	316	180	315	326	449	307	505	481	238	167	342	58	41	29
Auto Pass			20	67	151	81	104	89	87	151	112	241	35	291	152	44	59	177	18		
Public Tran		22	22	68	101	60	62			35			21	28				25	31		
Walk				75	274	101		72			127	256	94	51	50	22	22				
Cycle					56							48	28				19				
Total	21	111	203	560	1,331	804	574	477	267	501	565	994	485	875	683	304	267	544	107	41	29

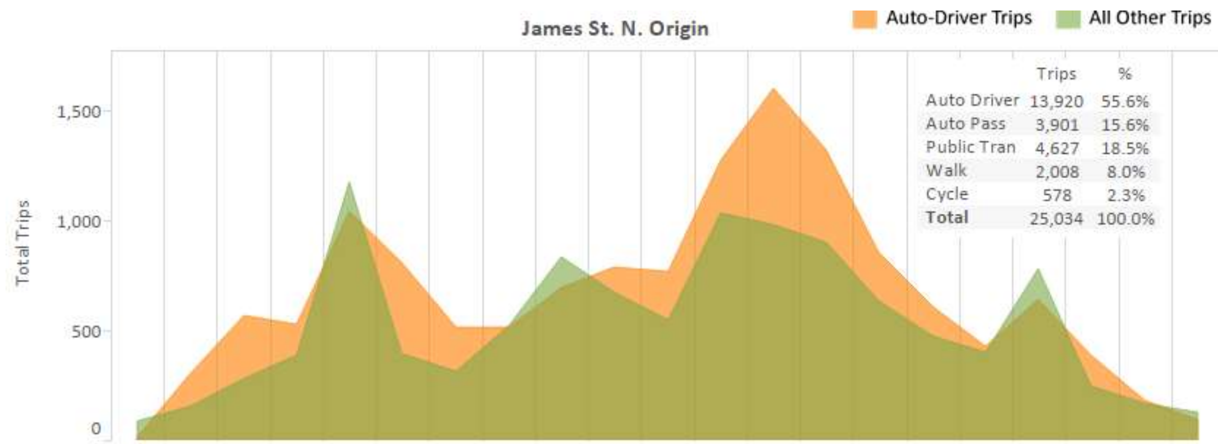
Hourly % of Daily Trips for Given Mode 0.22% – 37.09%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	22	21	71	150	510	289	307	281	320	386	334	317	798	605	583	366	271	271	169	28	68
Auto Pass		20	22	57	259	45	35	121	85	172	118	102	148	134	241	94	63	97	31	40	22
Public Tran			29		23			31		18	94	56	78	61	112	20	51				
Walk				74	310	40	13	66	39		145	88	84	93	50	44	22				
Cycle					20							28			75		28				
Total	22	41	122	281	1,122	374	355	499	444	576	691	591	1,108	893	1,061	524	435	368	200	68	90

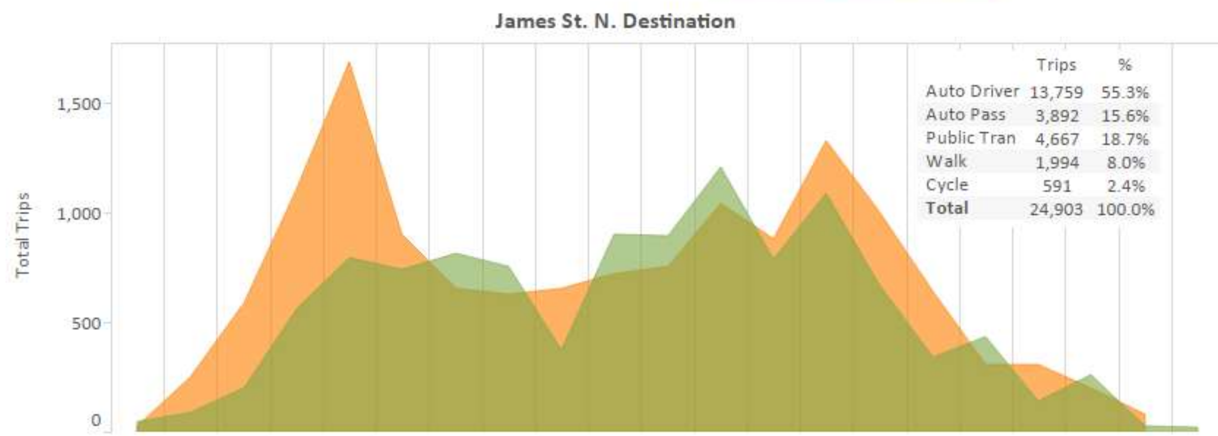
Hourly % of Daily Trips for Given Mode 0.22% – 49.67%

James St. N.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	14	297	569	529	1,044	810	513	513	696	785	766	1,277	1,599	1,320	853	610	425	641	386	179	94
Auto Pass	43	128	129	132	143	100	164	186	178	243	200	178	250	265	330	261	260	419	176	17	99
Public Tran		24	128	237	301	203	112	245	509	298	213	551	578	475	194	152	47	183	41	105	31
Walk	46		24		731	24	19	59	107	70	89	268	122	117	83	29	71	149			
Cycle				19		69	19	28	43	66	42	38	29	44	28	29	22	29	28	45	
Total	103	449	850	917	2,219	1,206	827	1,031	1,533	1,462	1,310	2,312	2,578	2,221	1,488	1,081	825	1,421	631	346	224

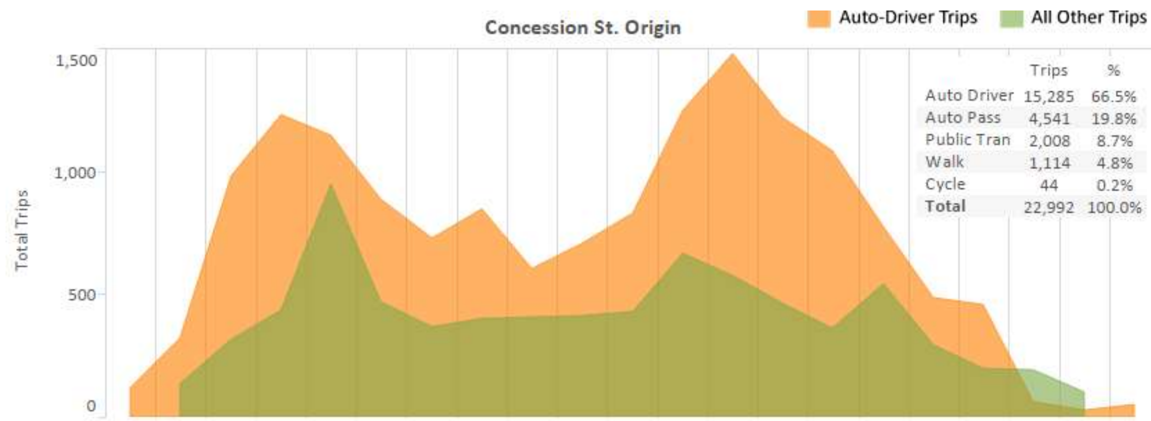
Hourly % of Daily Trips for Given Mode 0.10% – 36.40%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	24	246	585	1,111	1,688	903	653	630	653	723	754	1,041	884	1,329	1,007	638	308	306	198	78	
Auto Pass		20	89	92	234	152	121	229	119	207	230	308	263	614	497	225	271	89	89	24	19
Public Tran		70	99	396	316	413	536	282	202	495	534	356	199	346	101	112	73	23	114		
Walk	46		13	56	222	151	136	160	18	72	100	483	275	117	23		64	29	29		
Cycle				16	24	24	19	82	35	125	28	60	53	14	54		29		28		
Total	70	336	786	1,671	2,484	1,643	1,465	1,383	1,027	1,622	1,646	2,248	1,674	2,420	1,682	975	745	447	458	102	19

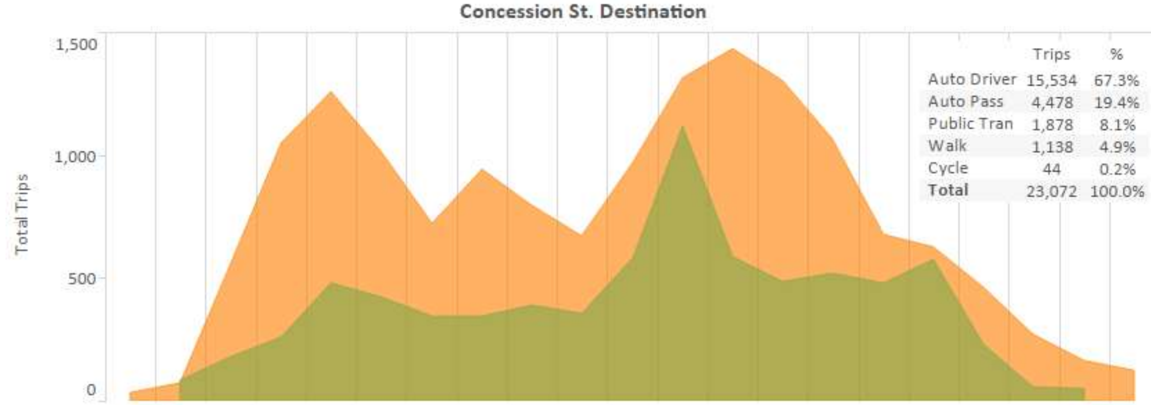
Hourly % of Daily Trips for Given Mode 0.08% – 24.22%

Concession St.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	117	320	982	1,231	1,143	886	730	848	605	706	831	1,248	1,477	1,220	1,082	775	487	456	60	28	53
Auto Pass		60	149	183	334	162	233	322	244	197	233	285	390	363	299	494	282	141	114	56	
Public Tran		46	98	224	292	179	98	46	162	217	179	84	141	47	61	22	13		52	47	
Walk		28	69	28	299	129	36	31			14	277	46	50		23		56	28		
Cycle					22							22									
Total	117	454	1,298	1,666	2,090	1,356	1,097	1,247	1,011	1,120	1,257	1,916	2,054	1,680	1,442	1,314	782	653	254	131	53

Hourly % of Daily Trips for Given Mode 0.18% – 50.00%

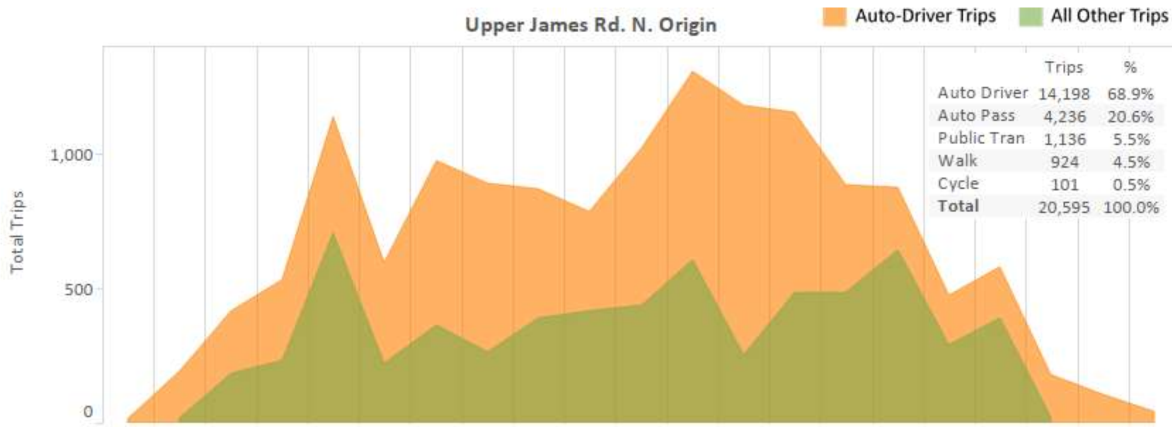


Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	36	76	562	1,051	1,259	1,017	724	939	793	670	968	1,312	1,430	1,304	1,067	676	628	464	270	163	125
Auto Pass		59	111	161	256	277	166	251	272	261	283	317	332	315	417	387	401	212			
Public Tran		23	16	55	60	95	142	41	89	69	227	425	180	102	101	69	85	22	28	49	
Walk			51	46	163	50	36	54	28	28	70	351	74	68		23	68		28		
Cycle												22					22				
Total	36	158	740	1,313	1,738	1,439	1,068	1,285	1,182	1,028	1,548	2,427	2,016	1,789	1,585	1,155	1,204	698	326	212	125

Hourly % of Daily Trips for Given Mode 0.16% – 50.00%

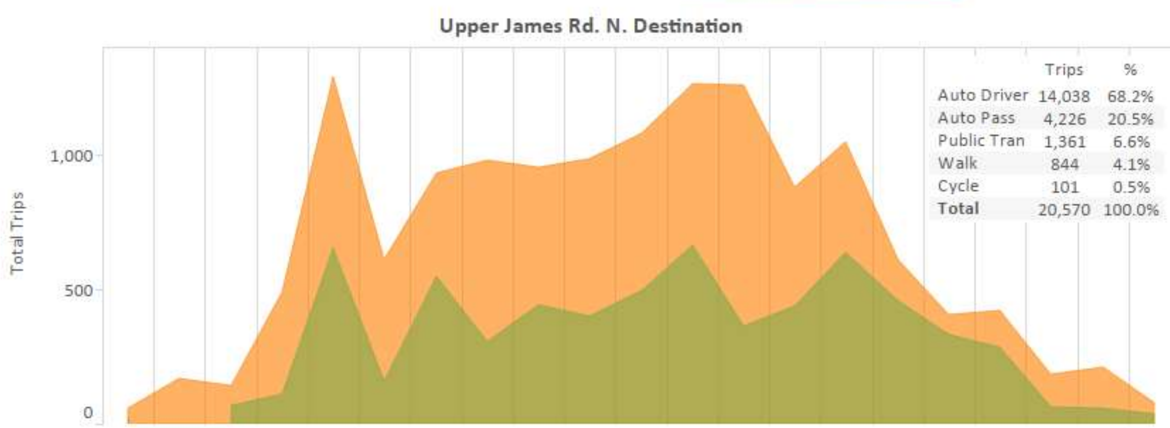
7.3.2 Major Commercial Arterials

Upper James Rd. N.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	18	192	418	531	1,135	597	976	887	868	783	1,020	1,303	1,180	1,150	884	874	473	581	181	103	44
Auto Pass			78	90	311	147	297	248	246	255	247	314	236	186	446	584	214	316	21		
Public Tran		17	47	48	102	17	47	13	144	133	22	112	18	250	17	18	59	72			
Walk			61	56	275	55	17			27	170	157		50		39	17				
Cycle				40	17							22			22						
Total	18	209	604	765	1,840	816	1,337	1,148	1,258	1,198	1,459	1,908	1,434	1,636	1,369	1,515	763	969	202	103	44

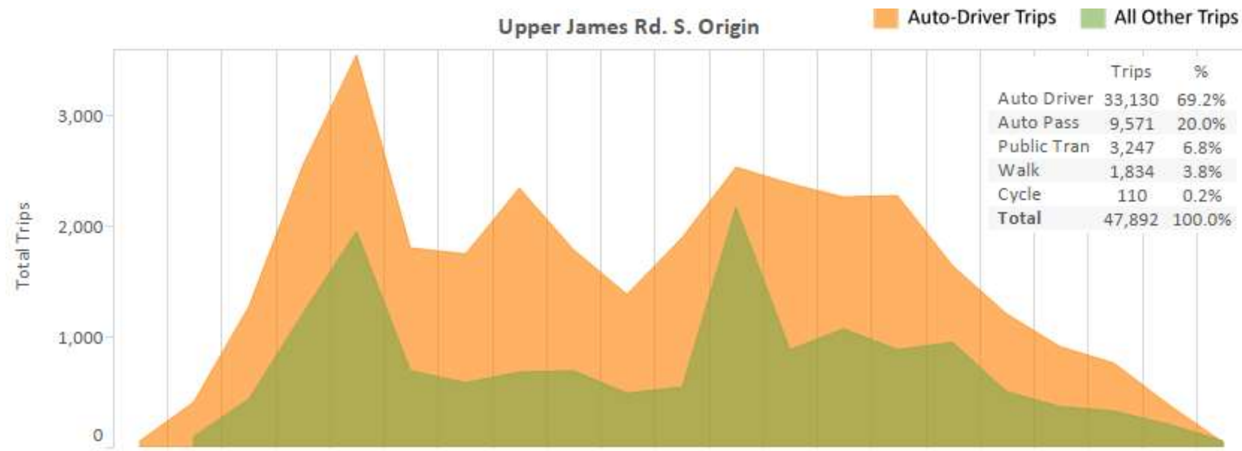
Hourly % of Daily Trips for Given Mode 0.09% – 39.60%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	56	169	140	489	1,287	611	931	981	955	985	1,080	1,262	1,256	878	1,047	613	403	421	184	210	80
Auto Pass	19		42	48	380	110	428	224	231	257	248	226	207	251	556	352	285	236	46	58	22
Public Tran			29	37	93	24	91	79	163	71	163	216	74	120	62	45	27	50			17
Walk				24	158	22	30		50	70	82	223	61	46		61	17				
Cycle					22								22	22	17				18		
Total	75	169	211	598	1,940	767	1,480	1,284	1,399	1,383	1,573	1,927	1,620	1,317	1,682	1,071	732	707	248	268	119

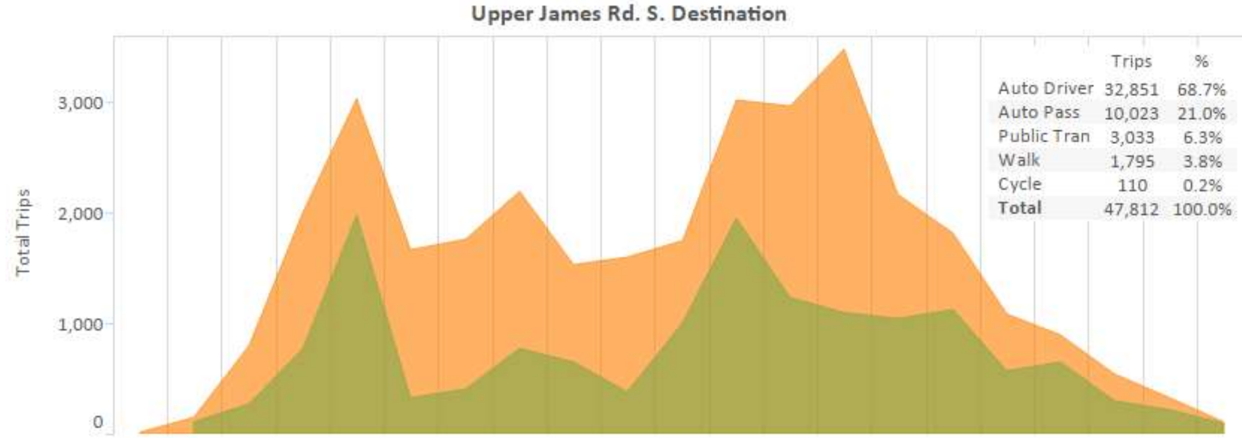
Hourly % of Daily Trips for Given Mode 0.36% – 26.42%

Upper James Rd. S.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	54	404	1,270	2,539	3,547	1,803	1,744	2,340	1,783	1,380	1,899	2,532	2,377	2,259	2,277	1,636	1,200	909	756	377	44
Auto Pass		95	288	400	1,037	380	426	546	495	348	315	945	518	870	788	858	444	343	250	176	49
Public Tran			115	689	359	242	142	64	108	101	72	689	264	113	73	89	59	17	22	29	
Walk			28	120	559	69	13	70	82	43	160	538	81	48	23						
Cycle													22	41					47		
Total	54	499	1,701	3,748	5,502	2,494	2,325	3,020	2,468	1,872	2,446	4,704	3,262	3,331	3,161	2,583	1,703	1,269	1,075	582	93

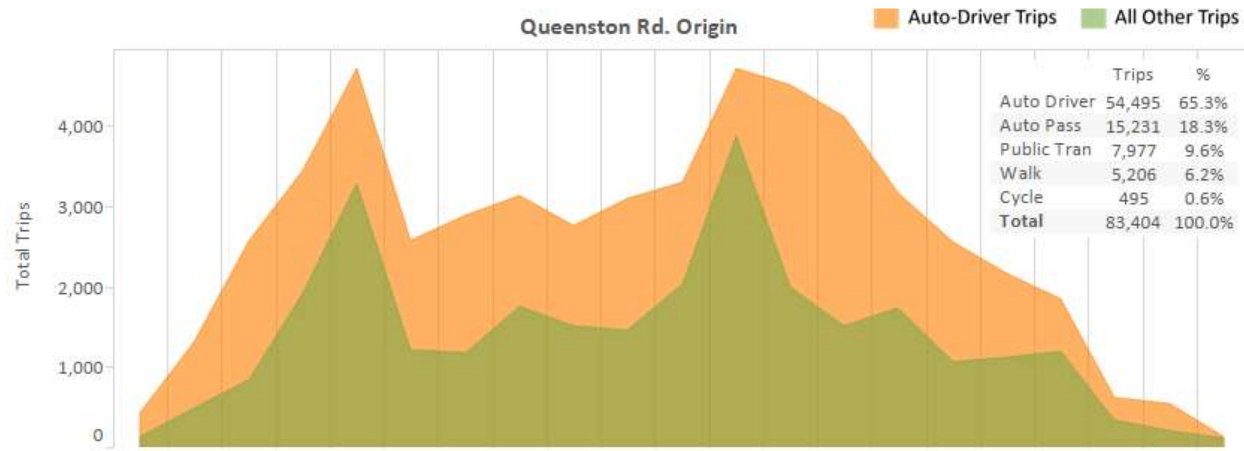
Hourly % of Daily Trips for Given Mode 0.11% – 42.73%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	19	150	801	2,002	3,027	1,667	1,756	2,190	1,523	1,597	1,748	3,014	2,968	3,479	2,160	1,810	1,084	887	537	327	105
Auto Pass		58	113	462	992	190	307	645	562	336	443	976	789	934	742	1,042	448	566	220	145	53
Public Tran		46	98	211	379	117	80	77	73	46	375	365	343	125	223	87	118	90	76	77	27
Walk			61	43	605	21	14	21	21		182	607	106	43	50						21
Cycle				59				29							22						
Total	19	254	1,073	2,777	5,003	1,995	2,157	2,962	2,179	1,979	2,748	4,962	4,206	4,581	3,197	2,939	1,650	1,543	833	549	206

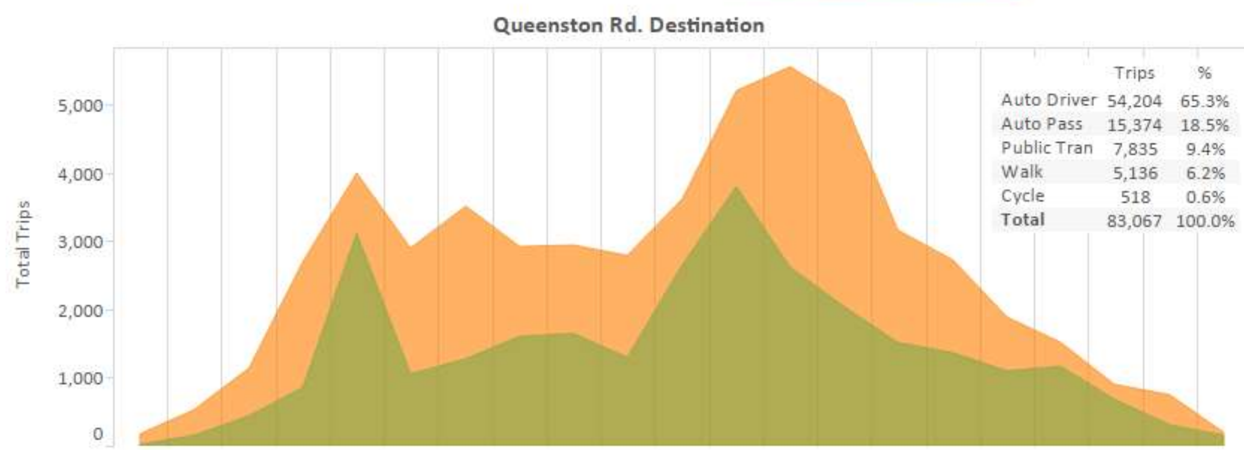
Hourly % of Daily Trips for Given Mode 0.04% – 53.64%

Queenston Rd.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	419	1,308	2,561	3,446	4,717	2,562	2,883	3,136	2,754	3,091	3,304	4,717	4,505	4,106	3,169	2,542	2,158	1,841	612	534	130
Auto Pass	102	263	379	593	799	504	613	820	955	1,008	1,018	1,453	1,219	1,052	1,328	876	896	873	260	167	53
Public Tran	24	164	359	987	998	436	335	711	379	376	567	829	416	380	299	163	169	239	82	39	25
Walk		30	109	275	1,464	258	162	181	171	74	407	1,527	296	47	45	19	23	87			31
Cycle		23		54	24	14	67	37			31	69	62	24	65		25				
Total	545	1,788	3,408	5,355	8,002	3,774	4,060	4,885	4,259	4,549	5,327	8,595	6,498	5,609	4,906	3,600	3,271	3,040	954	740	239

Hourly % of Daily Trips for Given Mode 0.24% – 29.33%

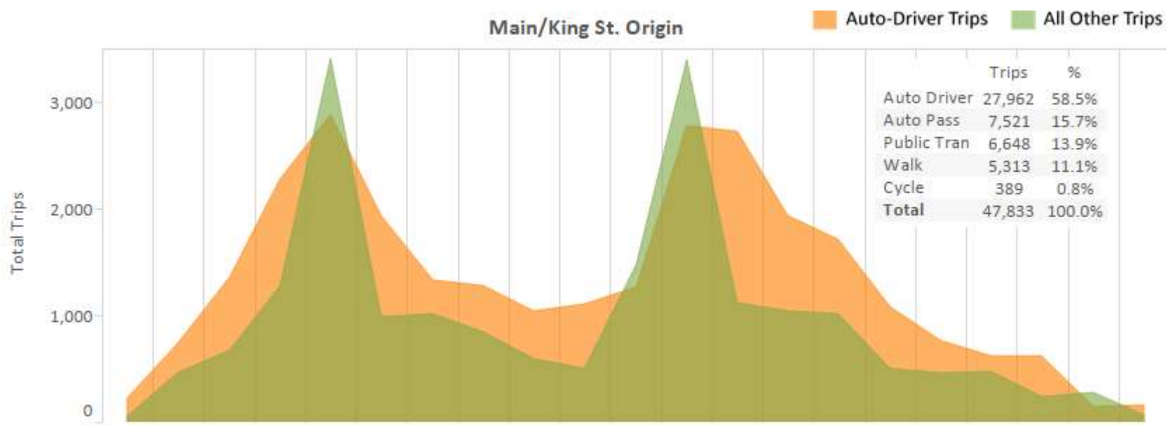


Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	183	516	1,140	2,692	3,998	2,895	3,502	2,924	2,938	2,785	3,632	5,211	5,562	5,079	3,155	2,727	1,889	1,524	907	745	200
Auto Pass	23	70	177	450	909	559	832	891	914	749	1,376	1,132	1,453	1,241	1,190	1,126	868	805	464	115	30
Public Tran		17	200	199	612	235	290	493	558	499	757	1,186	797	619	278	179	210	278	179	198	51
Walk		52	55	214	1,514	210	119	181	158	45	520	1,380	329	102	20	67	23	87	29		31
Cycle		23			76	57	24	37	24			93	38	79	36						31
Total	206	678	1,572	3,555	7,109	3,956	4,767	4,526	4,592	4,078	6,285	9,002	8,179	7,120	4,679	4,099	2,990	2,694	1,579	1,058	343

Hourly % of Daily Trips for Given Mode 0.15% – 29.48%

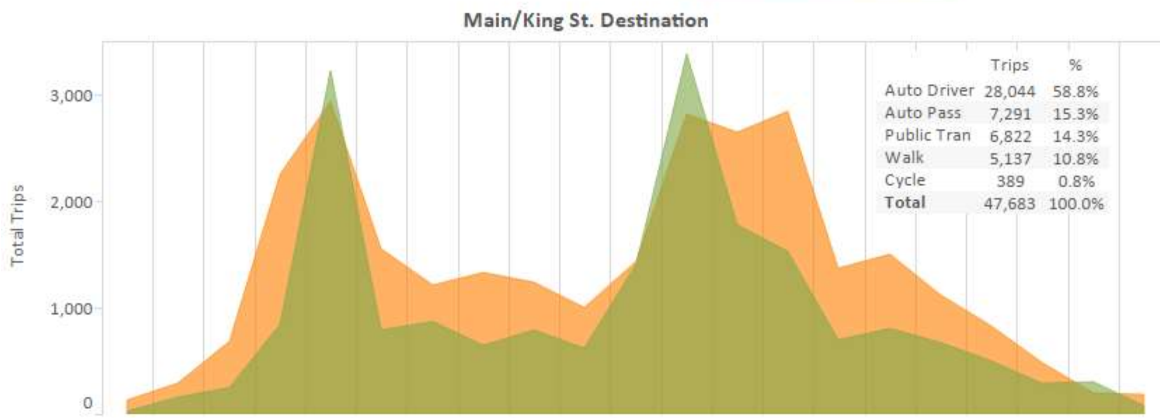
7.3.3 Major Arterial Thoroughfares

Main/King Corridor



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	229	743	1,353	2,277	2,886	1,933	1,330	1,272	1,038	1,109	1,267	2,774	2,728	1,931	1,717	1,081	758	622	613	147	154
Auto Pass	37	183	244	428	1,040	441	466	335	134	209	303	724	627	524	646	327	345	261	130	117	
Public Tran	18	255	340	774	1,034	351	446	340	320	210	615	723	234	226	298	71	97	119	90	51	36
Walk		24	58	80	1,281	154	95	173	110	79	543	1,873	240	206	75	105	25	96		96	
Cycle			24		54	35			24		14	72	14	89					14	18	31
Total	284	1,205	2,019	3,559	6,295	2,914	2,337	2,120	1,626	1,607	2,742	6,166	3,843	2,976	2,736	1,584	1,225	1,098	847	429	221

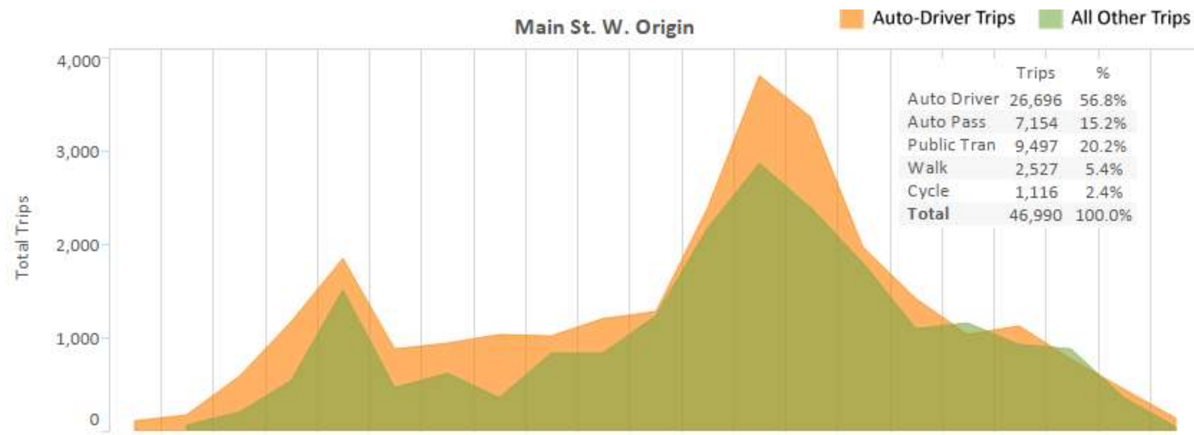
Hourly % of Daily Trips for Given Mode 0.27% – 35.25%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	131	289	681	2,253	2,928	1,555	1,217	1,333	1,231	997	1,437	2,811	2,646	2,838	1,372	1,504	1,118	835	487	202	179
Auto Pass		85	96	342	768	364	361	283	294	265	442	621	563	619	537	492	534	251	269	105	
Public Tran	32	43	99	463	523	231	263	219	296	228	603	1,495	860	681	129	229	66	199	24	77	62
Walk		24	58	23	1,858	201	229	138	193	57	333	1,169	327	225	29	45	49	54		125	
Cycle				16	70		19			62	31	92	24			32	25				18
Total	163	441	934	3,097	6,147	2,351	2,089	1,973	2,014	1,609	2,846	6,188	4,420	4,363	2,067	2,302	1,792	1,339	780	509	259

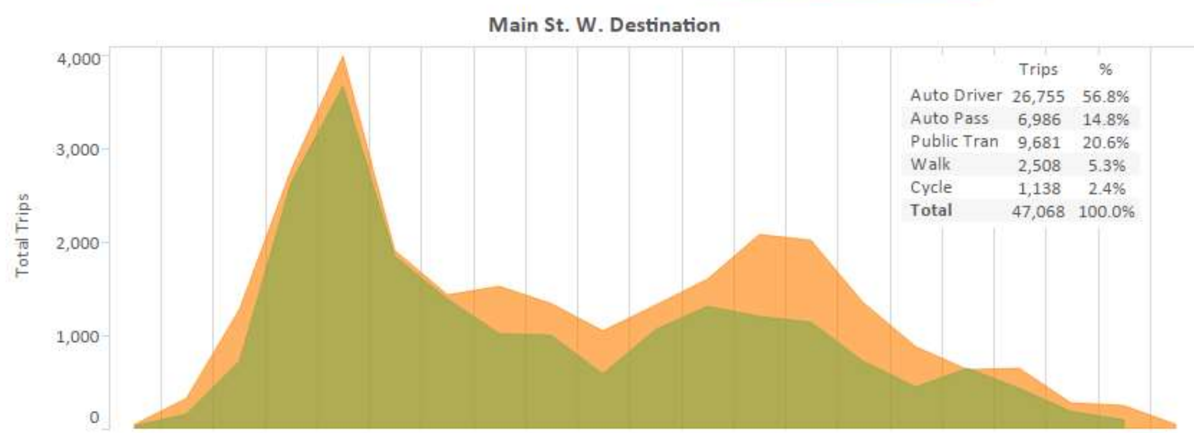
Hourly % of Daily Trips for Given Mode 0.34% – 36.17%

Main St. W.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	110	171	579	1,176	1,843	875	946	1,026	1,024	1,206	1,282	2,393	3,809	3,355	1,975	1,414	1,026	1,125	767	449	145
Auto Pass			140	237	335	143	134	189	315	386	331	650	825	738	727	459	599	343	405	153	45
Public Tran		54	16	230	330	168	331	112	255	282	706	1,219	1,578	1,241	817	502	526	525	408	197	
Walk			16	26	723	116	100	26	234	84	152	222	300	237	159	28	12	50	42		
Cycle			21	44	127	38	51	24	22	74	40	77	166	173	101	106	26		26		
Total	110	225	772	1,713	3,358	1,340	1,562	1,377	1,850	2,032	2,511	4,561	6,678	5,744	3,779	2,509	2,189	2,043	1,648	799	190

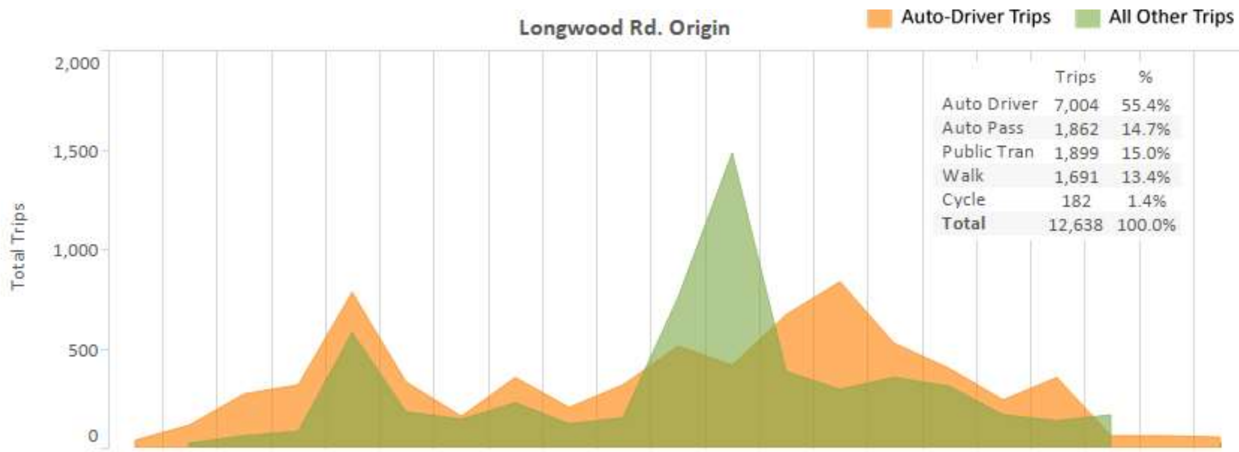
Hourly % of Daily Trips for Given Mode 0.17% – 28.61%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	40	320	1,273	2,777	3,993	1,904	1,436	1,524	1,336	1,048	1,325	1,608	2,077	2,015	1,355	877	632	647	273	246	49
Auto Pass		19	185	582	1,062	591	332	301	323	195	415	468	469	410	377	350	467	294	74	72	
Public Tran	24	129	507	1,888	1,786	991	839	660	432	228	464	409	362	484	144	45	150	95	44		
Walk			16	70	588	139	152	26	208	84	170	356	218	176	147	28	12	50	42	26	
Cycle			18	94	237	135	59	38	45	74	12	82	146	71	54	21	26		26		
Total	64	468	1,999	5,411	7,666	3,760	2,818	2,549	2,344	1,629	2,386	2,923	3,272	3,156	2,077	1,321	1,287	1,086	459	344	49

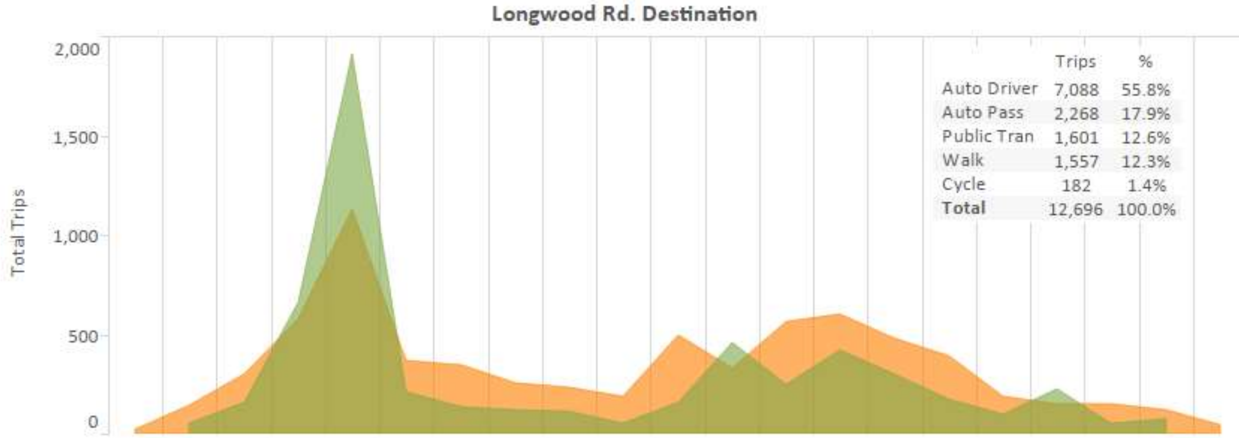
Hourly % of Daily Trips for Given Mode 0.10% – 23.44%

Longwood Ave.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	37	111	272	319	779	328	159	353	204	318	513	417	670	837	530	398	241	354	57	57	50
Auto Pass		20	21	41	98	16		79	44	130	204	200	156	43	232	257	126	134	61		
Public Tran			42		52	68	71	52	50	20	371	592	166	170	69	31	42		74		29
Walk				41	380	67	52	72	16		184	689	62	56	50	22					
Cycle					47	26	21	26	12					21					29		
Total	37	131	335	401	1,356	505	303	582	326	468	1,272	1,898	1,054	1,127	881	708	409	488	221	57	79

Hourly % of Daily Trips for Given Mode 0.29% – 40.75%

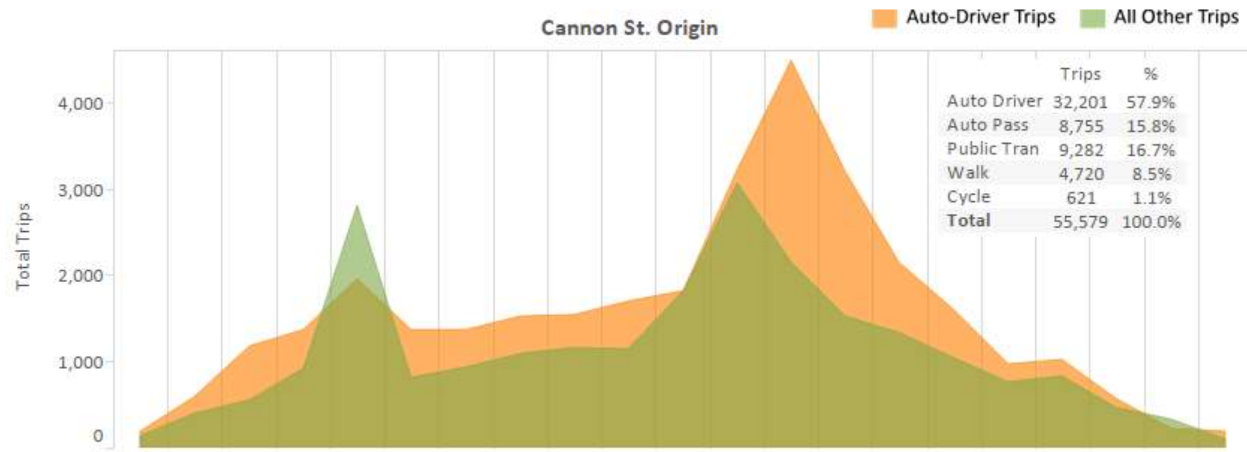


Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	25	146	303	579	1,129	368	345	257	236	188	493	333	566	599	484	393	185	150	148	119	42
Auto Pass		19	42	228	619	17	94	80	89	28	85	60	47	228	165	82	98	186	26	75	
Public Tran		31	115	349	493	134	39			26	29	68	42	95	91	68		21			
Walk				60	801	56		28	26		41	282	158	43	20			16	26		
Cycle				21				12				50		52	21	26					
Total	25	196	460	1,237	3,042	575	478	377	351	242	648	793	813	1,017	781	569	283	373	200	194	42

Hourly % of Daily Trips for Given Mode 0.20% – 51.45%

Cannon Street

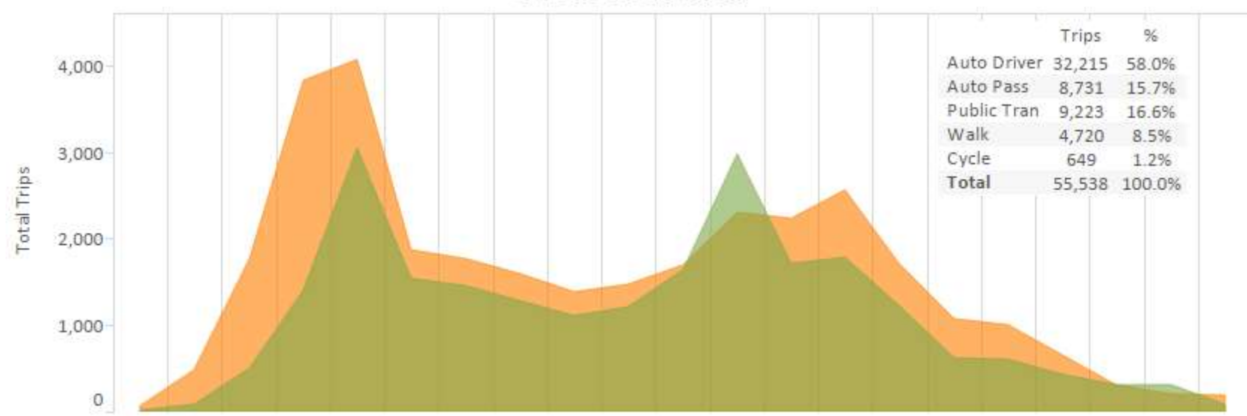
Cannon St. Origin



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	195	586	1,170	1,371	1,946	1,363	1,361	1,520	1,533	1,702	1,824	3,218	4,472	3,206	2,150	1,584	972	1,024	576	233	195
Auto Pass	86	220	343	195	500	289	476	344	388	415	468	801	914	619	681	680	492	449	287	58	50
Public Tran	48	183	182	632	925	323	391	488	652	514	761	1,186	843	678	493	214	181	206	141	188	53
Walk			24	71	1,319	90	72	185	99	110	561	1,011	366	182	129	135	92	178	29	67	
Cycle				21	52	104		80	24	101	33	62	30	40	28	14			14	18	
Total	329	989	1,719	2,290	4,742	2,169	2,300	2,617	2,696	2,842	3,647	6,278	6,625	4,725	3,481	2,627	1,737	1,857	1,047	564	298

Hourly % of Daily Trips for Given Mode 0.51% – 27.94%

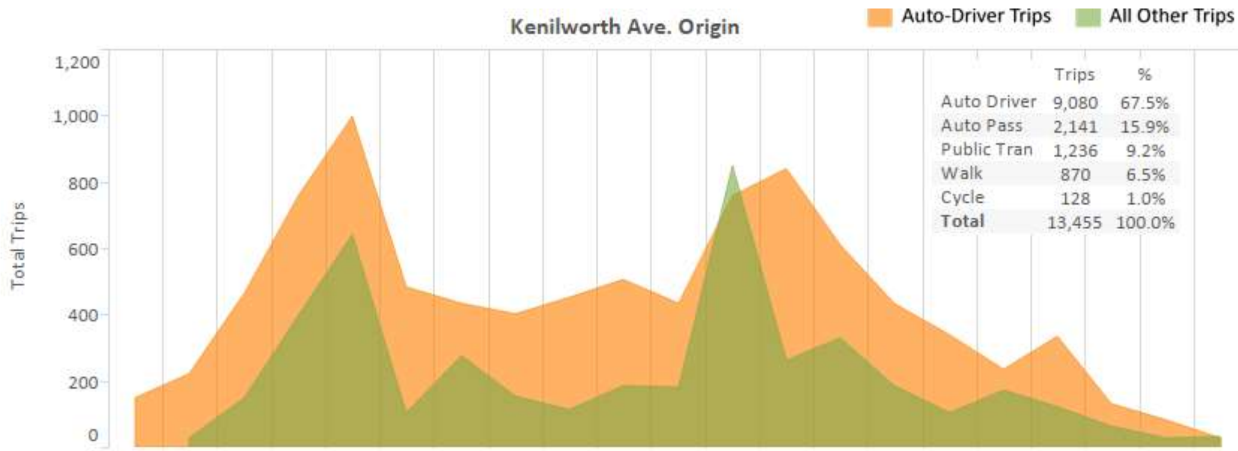
Cannon St. Destination



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	67	485	1,758	3,821	4,059	1,864	1,764	1,594	1,390	1,472	1,693	2,293	2,237	2,567	1,714	1,077	996	661	315	203	185
Auto Pass		51	276	434	892	505	511	468	321	412	397	786	631	907	766	339	480	289	102	116	48
Public Tran	18	31	192	881	877	707	662	539	559	642	840	1,124	620	637	352	167	28	90	109	105	43
Walk			42	56	1,236	300	245	205	181	66	370	1,034	406	210	46	82	69	48	58	66	
Cycle				32	40	24	43	61	40	87	33	37	52	21	57	32	29		42	19	
Total	85	567	2,268	5,224	7,104	3,400	3,225	2,867	2,491	2,679	3,333	5,274	3,946	4,342	2,935	1,697	1,602	1,088	626	509	276

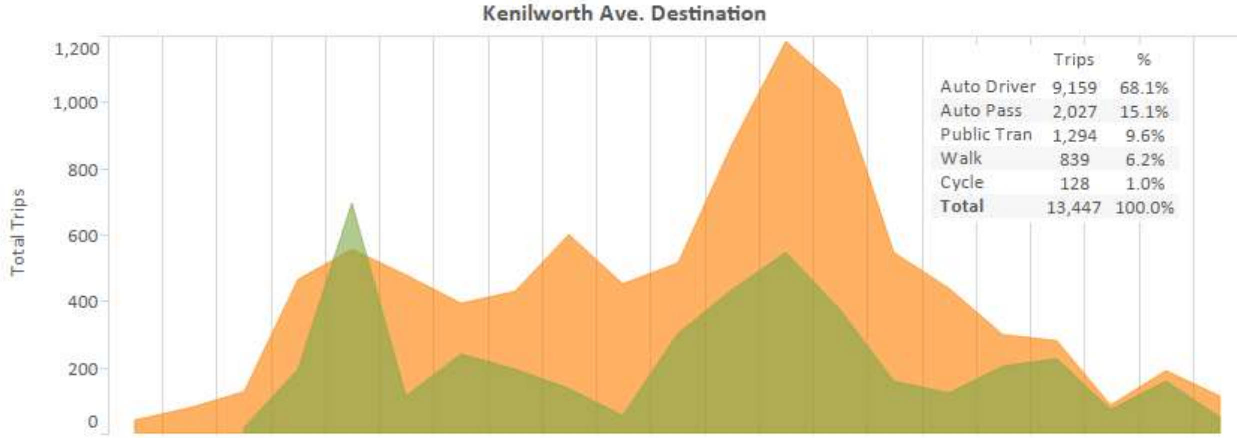
Hourly % of Daily Trips for Given Mode 0.15% – 26.19%

Kenilworth Avenue



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	149	220	463	757	995	481	434	400	450	506	433	760	840	609	434	339	234	336	130	82	28
Auto Pass		25	85	182	248	50	166	64	58	93	58	192	178	176	159	106	86	123	63	29	
Public Tran			62	213	238	25	83	91	31	91	68	161	31	81	25		36				
Walk					156	31	25		25		56	442	54	25			25				31
Cycle												54		49			25				
Total	149	245	610	1,152	1,637	587	708	555	564	690	615	1,609	1,103	940	618	445	406	459	193	111	59

Hourly % of Daily Trips for Given Mode 0.31% – 50.80%

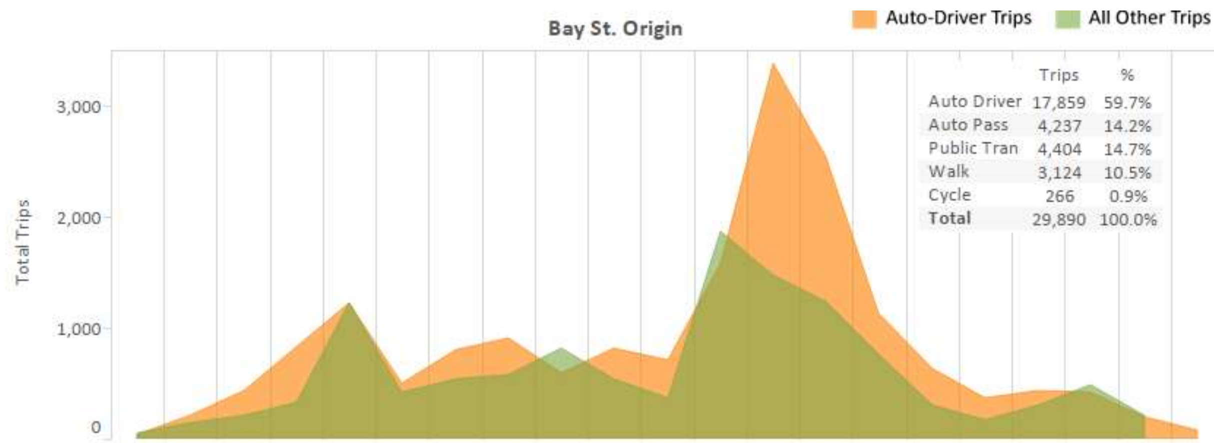


Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	41	76	125	463	557	477	394	430	602	449	514	869	1,180	1,036	544	437	297	281	84	189	114
Auto Pass			19	115	249	62	126	35	117	30	176	159	158	170	160	92	70	143	70	76	
Public Tran				52	54	28	86	134	20		125	126	299	126		31	81	56		56	20
Walk				29	338	25	25	23		25		150	87	31			25	25		25	31
Cycle					54									49			25				
Total	41	76	144	659	1,252	592	631	622	739	504	815	1,304	1,724	1,412	704	560	498	505	154	346	165

Hourly % of Daily Trips for Given Mode 0.30% – 42.19%

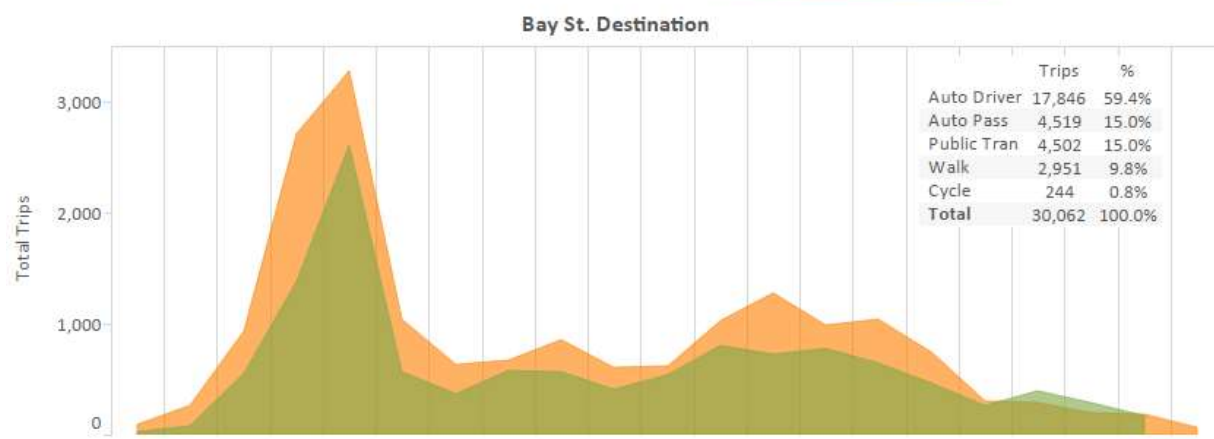
7.3.4 Central Arterials

Bay St.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	40	211	438	834	1,226	495	798	910	596	822	707	1,577	3,376	2,546	1,136	632	373	436	426	200	80
Auto Pass		28	111	92	327	48	176	231	191	262	136	343	578	393	404	160	76	180	296	205	
Public Tran	31	120	50	207	247	187	199	193	429	202	142	787	633	505	211	18	79	72	92		
Walk	18		46	31	633	132	161	116	152	78	92	739	259	327	115	51	22	57	95		
Cycle					22	50		41	40					17	28	68					
Total	89	359	645	1,164	2,455	912	1,334	1,491	1,408	1,364	1,077	3,446	4,846	3,788	1,894	929	550	745	909	405	80

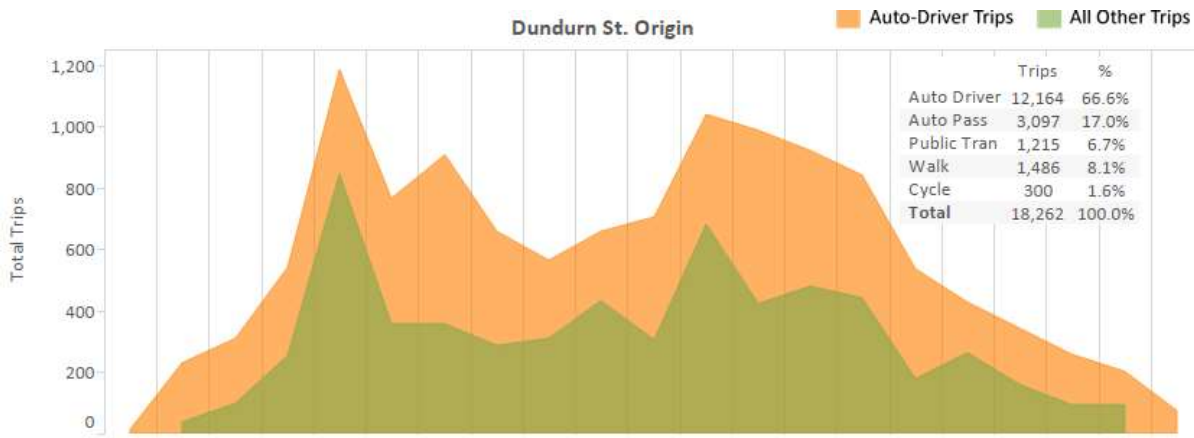
Hourly % of Daily Trips for Given Mode 0.22% 25.56%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	96	264	938	2,717	3,276	1,041	634	671	854	611	618	1,022	1,281	983	1,044	741	304	293	202	187	69
Auto Pass	17	43	259	340	737	89	157	178	281	169	207	243	262	309	285	369	140	187	170	77	
Public Tran	13	15	174	824	893	259	181	316	177	156	223	246	266	173	214	18	73	107	126	48	
Walk			118	197	974	179	29	86	114	80	107	316	133	300	90	40	55	105		28	
Cycle		24		17		40							67		50	28				18	
Total	126	346	1,489	4,095	5,880	1,608	1,001	1,251	1,426	1,016	1,155	1,827	2,009	1,765	1,683	1,196	572	692	498	358	69

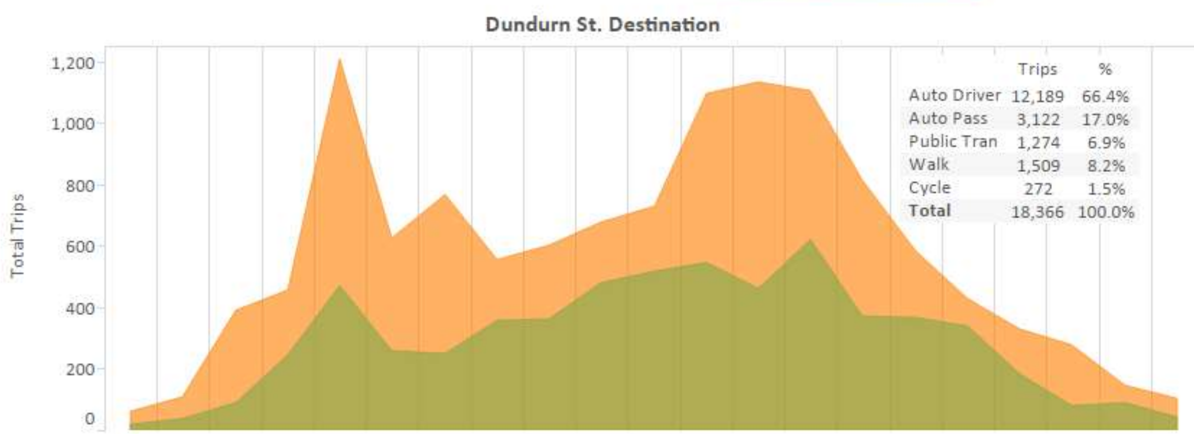
Hourly % of Daily Trips for Given Mode 0.23% 33.01%

Dundurn St.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	16	230	311	539	1,183	764	907	659	564	658	705	1,037	987	923	839	535	427	341	259	203	77
Auto Pass			36	162	274	88	147	174	156	249	237	297	154	232	270	158	214	118	50	81	
Public Tran		38	33		137	87	140	28	63	99	16	251	88	122	67		28		18		
Walk			29	77	363	172	69	62	69	55	54	104	126	123	78	22		44	26	13	
Cycle				16	72	12		22	21	28		28	56		26		19				
Total	16	268	409	794	2,029	1,123	1,263	945	873	1,089	1,012	1,717	1,411	1,400	1,280	715	688	503	353	297	77

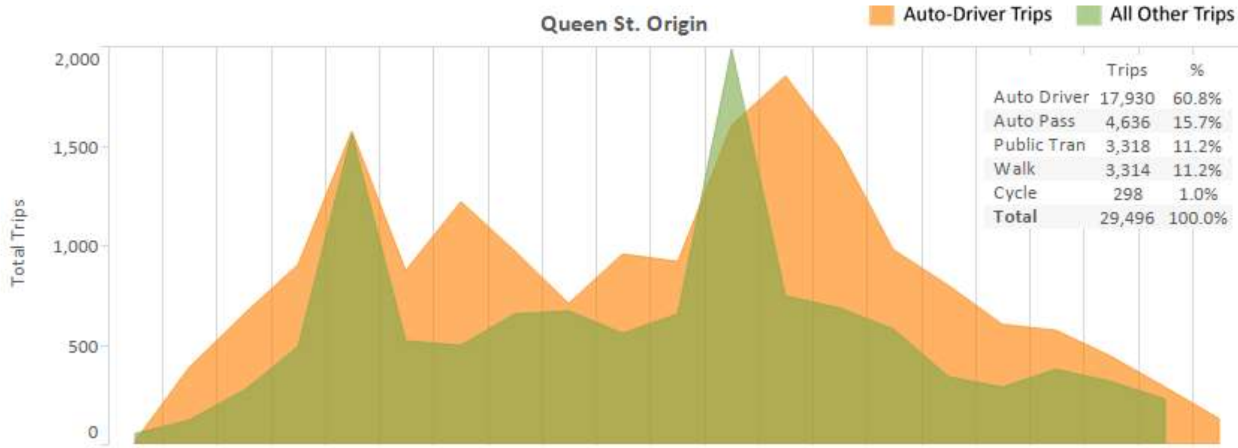
Hourly % of Daily Trips for Given Mode 0.09% 24.43%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	63	110	392	454	1,207	627	767	555	602	675	727	1,097	1,131	1,103	811	583	429	327	278	146	105
Auto Pass		20	45	112	183	129	127	143	190	268	241	285	177	293	167	320	161	117	53	48	43
Public Tran		18	29	72	47	14	59	45	66	99	111	119	178	139	85	20	105	68			
Walk	18		16	59	239	101	61	140	106	77	166	111	107	152	44	28	43		28	13	
Cycle						16		28		34		28		37	75		28			26	
Total	81	148	482	697	1,676	887	1,014	911	964	1,153	1,245	1,640	1,593	1,724	1,182	951	766	512	359	233	148

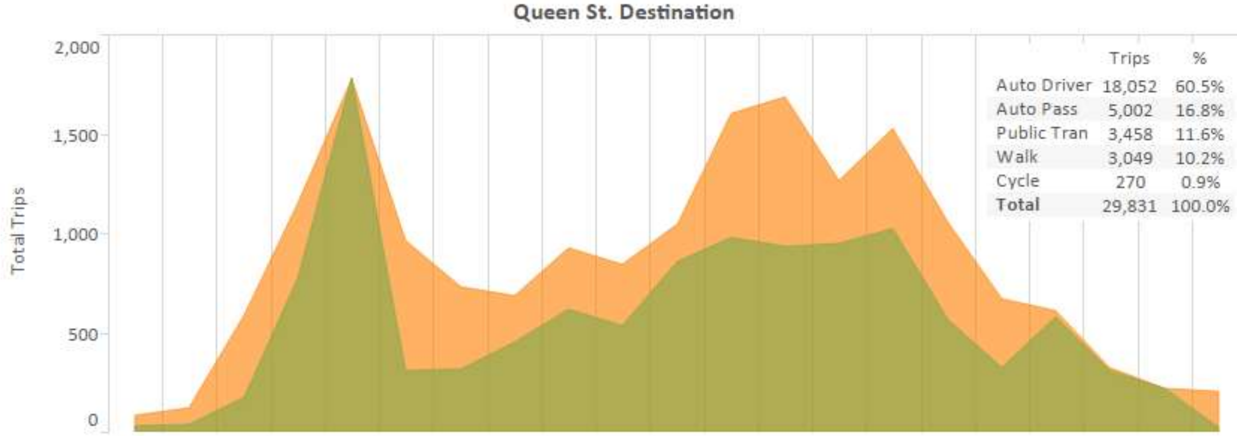
Hourly % of Daily Trips for Given Mode 0.44% 27.57%

Queen St.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	16	386	656	904	1,569	869	1,215	973	709	957	920	1,600	1,851	1,490	980	800	603	574	446	284	128
Auto Pass		28	109	139	432	117	176	264	230	234	281	517	278	374	347	205	235	281	176	213	
Public Tran	31	92	105	217	367	133	168	190	261	201	125	760	194	164	129	18	28	48	87		
Walk	18		57	113	741	232	152	136	156	95	251	691	245	149	50	95	22	44	54	13	
Cycle				16	16	34		63	21	28		20	28		54	18					
Total	65	506	927	1,389	3,125	1,385	1,711	1,626	1,377	1,515	1,577	3,588	2,596	2,177	1,560	1,136	888	947	763	510	128

Hourly % of Daily Trips for Given Mode 0.09% – 22.91%

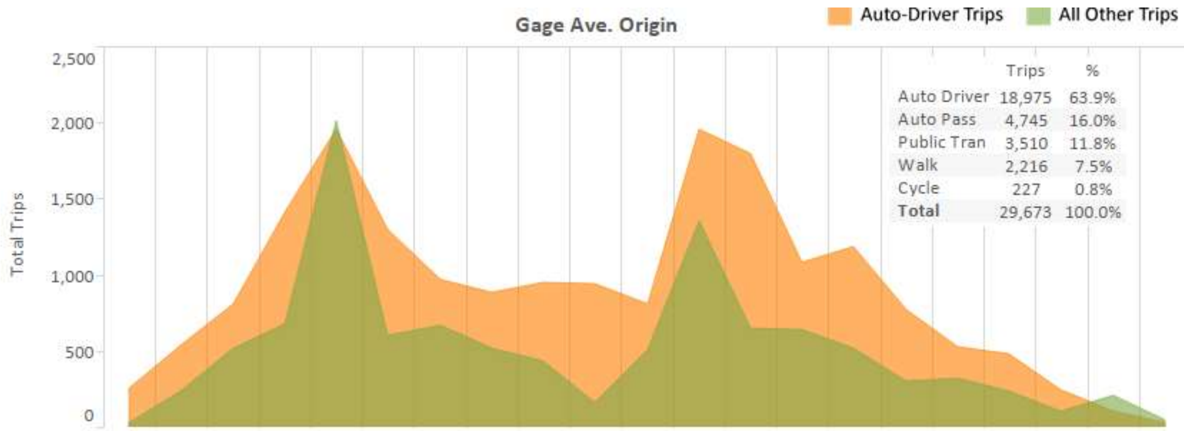


Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	83	124	588	1,152	1,777	960	729	687	922	841	1,042	1,599	1,681	1,260	1,525	1,053	668	611	326	218	206
Auto Pass		19	59	168	438	114	148	82	312	267	377	498	294	406	449	450	195	365	228	112	21
Public Tran	13	18	100	450	475	94	122	191	125	154	253	161	368	229	343	18	105	135	56	48	
Walk	18		16	154	849	81	48	153	181	77	226	321	231	277	184	94	21	77	28	13	
Cycle					20	16		28		34			41	37	50					44	
Total	114	161	763	1,924	3,559	1,265	1,047	1,141	1,540	1,373	1,898	2,579	2,615	2,209	2,551	1,615	989	1,188	638	435	227

Hourly % of Daily Trips for Given Mode 0.38% – 27.85%

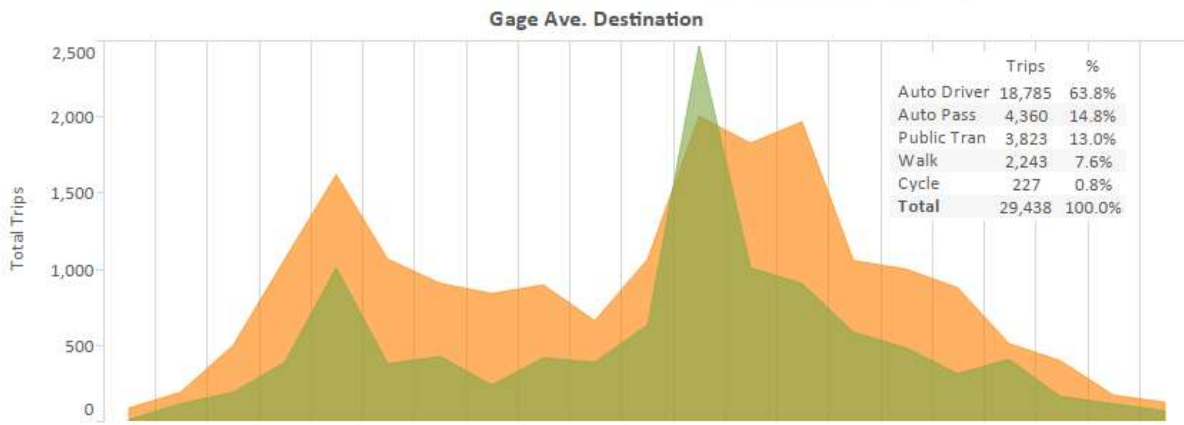
7.3.5 Minor Suburban Arterials

Gage Ave.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	255	532	808	1,406	1,957	1,301	967	888	950	943	809	1,958	1,791	1,080	1,184	770	526	477	241	108	24
Auto Pass	24	91	184	242	777	269	224	192	127	70	174	437	366	322	470	214	239	142	102	79	
Public Tran		120	250	411	497	274	348	187	240	47	273	349	159	140	19	48	78	22		34	14
Walk		24	58	23	706	61	95	105	37	19	46	563	123	126	29	43		67		91	
Cycle			24		29			33	24	24	14			48							31
Total	279	767	1,324	2,082	3,966	1,905	1,634	1,405	1,378	1,103	1,316	3,307	2,439	1,716	1,702	1,075	843	708	343	312	69

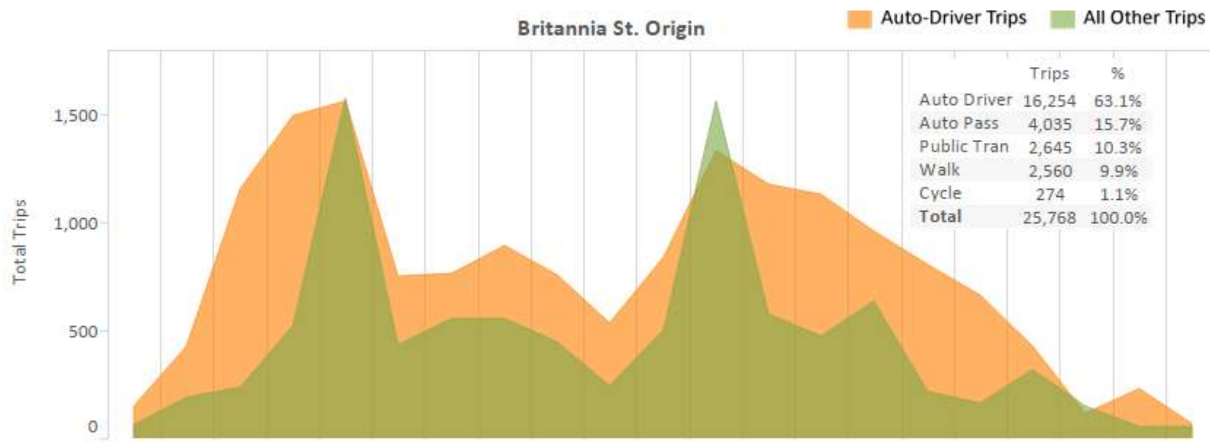
Hourly % of Daily Trips for Given Mode 0.13% – 31.86%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	88	192	494	1,064	1,614	1,061	902	835	897	657	1,064	2,006	1,825	1,967	1,053	992	871	508	399	173	123
Auto Pass		66	47	104	333	228	180	101	145	114	243	653	353	503	393	297	274	204	103		19
Public Tran	14	24	50	285	126	92	152	37	210	189	259	976	513	294	129	139	37	177	24	48	48
Walk		24	87		545	60	95	99	33	19	99	813	105	101	29	43		19	29	43	
Cycle									24	62	31	24	38		29					19	
Total	102	306	678	1,453	2,618	1,441	1,329	1,072	1,309	1,041	1,696	4,472	2,834	2,865	1,633	1,471	1,182	908	555	283	190

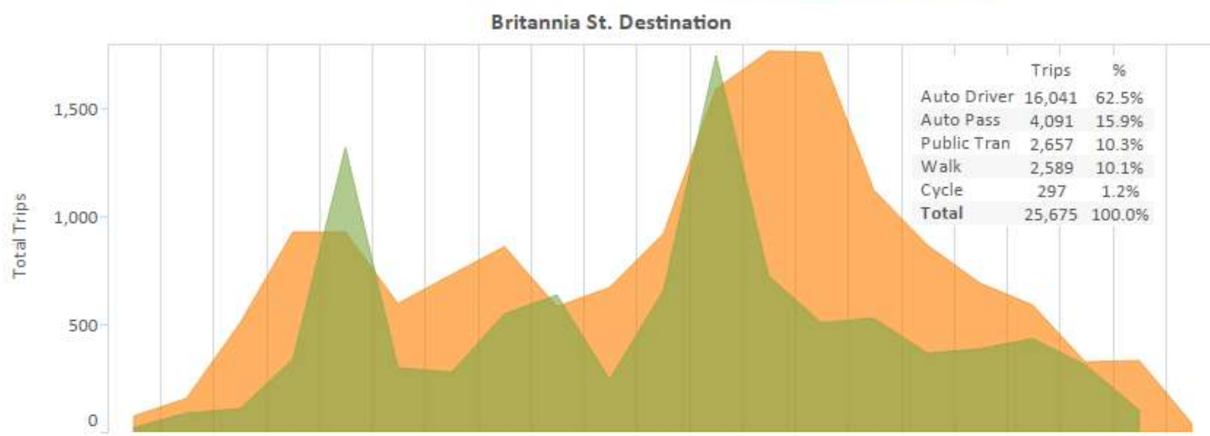
Hourly % of Daily Trips for Given Mode 0.35% – 36.25%

Britannia St.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	150	428	1,160	1,493	1,565	751	765	895	761	537	836	1,334	1,178	1,133	960	807	661	429	116	227	68
Auto Pass	59	87	85	125	348	122	288	244	209	139	154	273	345	377	438	123	137	257	117	55	53
Public Tran		82	114	335	418	198	148	125	122	106	152	405	59	97	142	95		18	29		
Walk			36	58	813	100	72	150	115		192	795	145		20		23	41			
Cycle		23				14	48	37				92	24		36						
Total	209	620	1,395	2,011	3,144	1,185	1,321	1,451	1,207	782	1,334	2,899	1,751	1,607	1,596	1,025	821	745	262	282	121

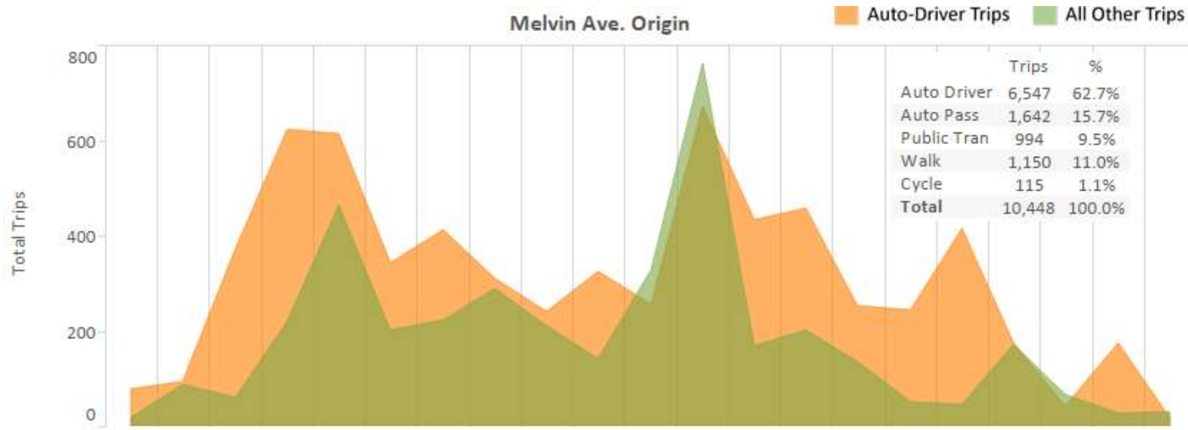
Hourly % of Daily Trips for Given Mode 0.42% – 33.58%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	75	155	506	930	924	598	732	862	585	671	922	1,589	1,768	1,762	1,121	865	689	592	325	329	41
Auto Pass	23	48	74	136	299	112	164	265	296	71	286	298	285	313	344	343	241	289	204		
Public Tran		17		131	200	87	15	65	204	174	190	546	283	171	149		122	100	104	99	
Walk			36	74	797	77	72	179	133		180	786	145	23		23	23	41			
Cycle		23			23	24	24	37				116	14		36						
Total	98	243	616	1,271	2,243	898	1,007	1,408	1,218	916	1,578	3,335	2,495	2,269	1,650	1,231	1,075	1,022	633	428	41

Hourly % of Daily Trips for Given Mode 0.16% – 39.06%

Melvin Ave.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	78	93	374	622	613	342	412	309	241	325	255	672	434	457	253	244	414	174	41	175	19
Auto Pass	18	46	18	75	157	89	156	99	93	126	85	55	69	170	72	32	46	113	66	26	31
Public Tran		18	41	116	47	52	32	79	95	14	73	296	36	33	26	18		18			
Walk				29	259	48	36	75	23		169	386	64		20			41			
Cycle		23				14		37				23			18						
Total	96	180	433	842	1,076	545	636	599	452	465	582	1,432	603	660	389	294	460	346	107	201	50

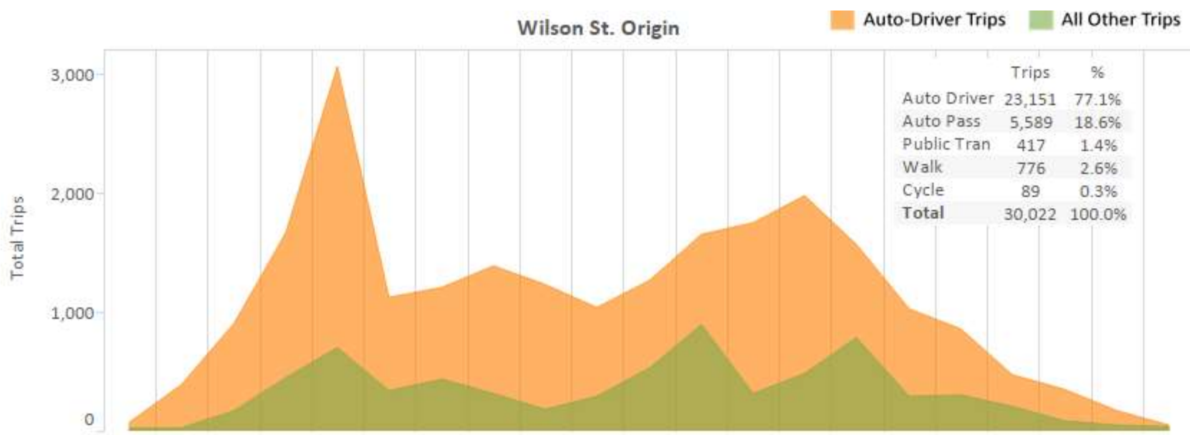
Hourly % of Daily Trips for Given Mode 0.29% – 33.57%

Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	43	68	268	344	405	160	202	353	315	287	330	615	629	592	511	268	287	351	132	114	23
Auto Pass	23	48	23	76	209	94	50	72	194	44	56	115	108	110	145	64	58	160	66		
Public Tran				131	169	69		18	69	101	23	167	116	52	94		47		58		
Walk				45	360	77	36	104	23			306	47				23	18			
Cycle								37				69	14		18						
Total	66	116	291	596	1,143	400	288	584	601	432	409	1,272	914	754	768	332	415	529	256	114	23

Hourly % of Daily Trips for Given Mode 0.22% – 50.00%

7.3.6 Comparison Cases

Wilson St.



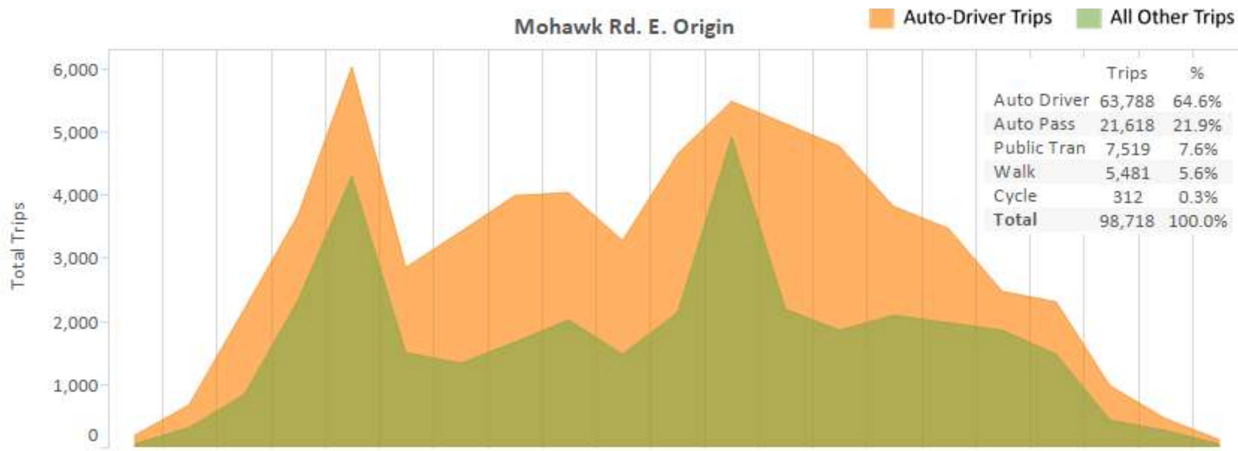
Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	76	381	902	1,656	3,050	1,124	1,209	1,381	1,224	1,034	1,260	1,649	1,746	1,974	1,564	1,020	857	471	352	167	54
Auto Pass		24	51	305	467	233	406	316	159	250	277	667	271	478	735	285	298	210	81	45	31
Public Tran	23		123	66	28	52	22			15	23	22	43								
Walk				78	205	52			26	26	182	156			51						
Cycle											49	40									
Total	99	405	1,076	2,105	3,750	1,461	1,637	1,697	1,409	1,325	1,791	2,534	2,060	2,452	2,350	1,305	1,155	681	433	212	85

Hourly % of Daily Trips for Given Mode 0.23% – 55.06%

Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	24	67	427	973	1,923	1,048	925	1,221	1,235	1,002	1,141	1,869	2,722	2,766	1,757	1,291	1,004	723	376	454	118
Auto Pass			26	353	417	210	191	228	204	134	286	804	516	488	254	532	309	303	164	43	23
Public Tran			44	23	17	15	21			15		84	66	71	49		28		22		
Walk				78	231	52			26		182	130	26		51						
Cycle											49	12				28					
Total	24	67	497	1,427	2,588	1,325	1,137	1,449	1,465	1,151	1,658	2,899	3,330	3,325	2,111	1,851	1,341	1,026	562	497	141

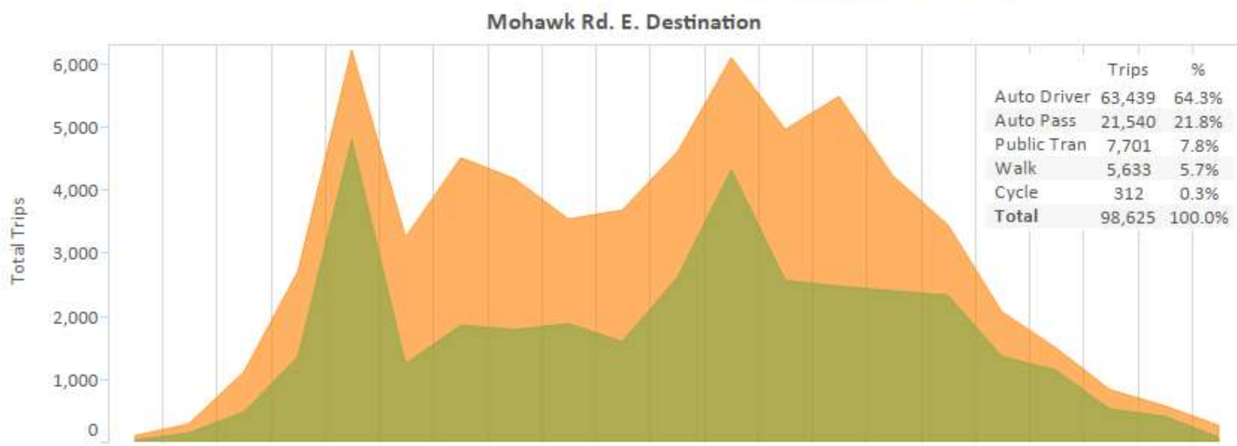
Hourly % of Daily Trips for Given Mode 0.08% – 55.06%

Mohawk Rd. E.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	191	670	2,169	3,667	6,019	2,848	3,405	3,981	4,018	3,276	4,635	5,480	5,121	4,759	3,808	3,457	2,456	2,306	968	444	110
Auto Pass	28	165	453	979	1,773	911	995	1,151	1,360	845	1,169	2,223	1,549	1,292	1,619	1,699	1,448	1,353	334	221	51
Public Tran	14	133	250	1,006	916	390	275	339	469	563	383	987	345	337	370	218	344	95	51	34	
Walk		18	117	253	1,577	170	66	178	160	61	576	1,654	222	190	68	39	62	28	28	14	
Cycle				84	17	13			23			45	68	22	22				18		
Total	233	986	2,989	5,989	####	4,332	4,741	5,649	6,030	4,745	6,763	####	7,305	6,600	5,887	5,413	4,310	3,782	1,399	713	161

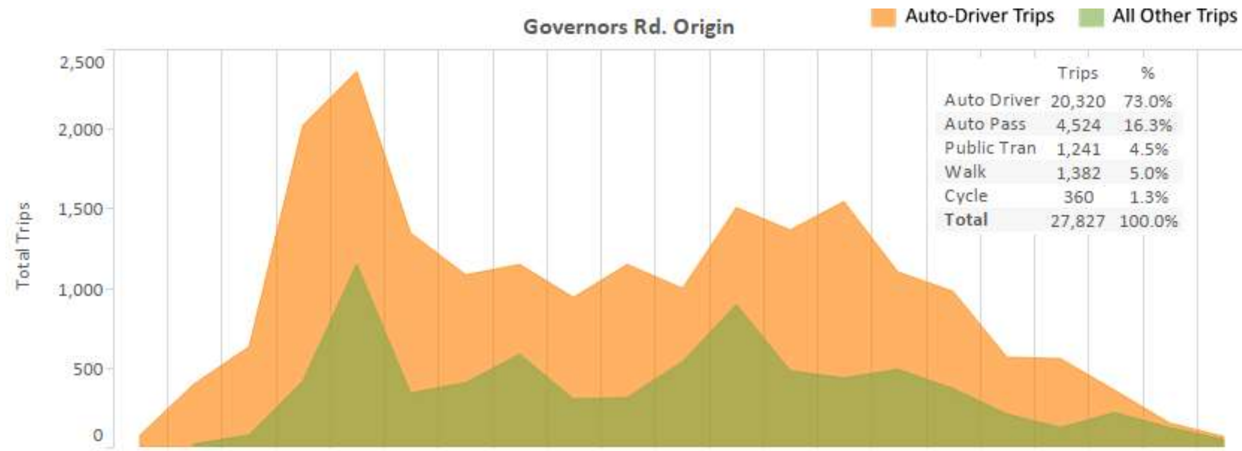
Hourly % of Daily Trips for Given Mode 0.13% – 30.18%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	84	278	1,112	2,694	6,201	3,239	4,506	4,171	3,531	3,679	4,603	6,075	4,949	5,464	4,223	3,431	2,051	1,498	819	570	261
Auto Pass	19	46	249	624	2,288	698	1,184	1,304	1,161	1,070	1,262	1,859	1,467	1,695	1,904	1,943	1,125	864	410	316	52
Public Tran		42	111	420	676	323	564	346	529	379	778	989	722	571	354	300	204	239	63	74	17
Walk		46	107	254	1,794	176	95	127	162	141	574	1,450	322	172	87	39	17	28	28	14	
Cycle				53	22	41			23			23	40	22	39	31			18		
Total	103	412	1,579	4,045	####	4,477	6,349	5,948	5,406	5,269	7,217	####	7,500	7,924	6,607	5,744	3,397	2,629	1,338	974	330

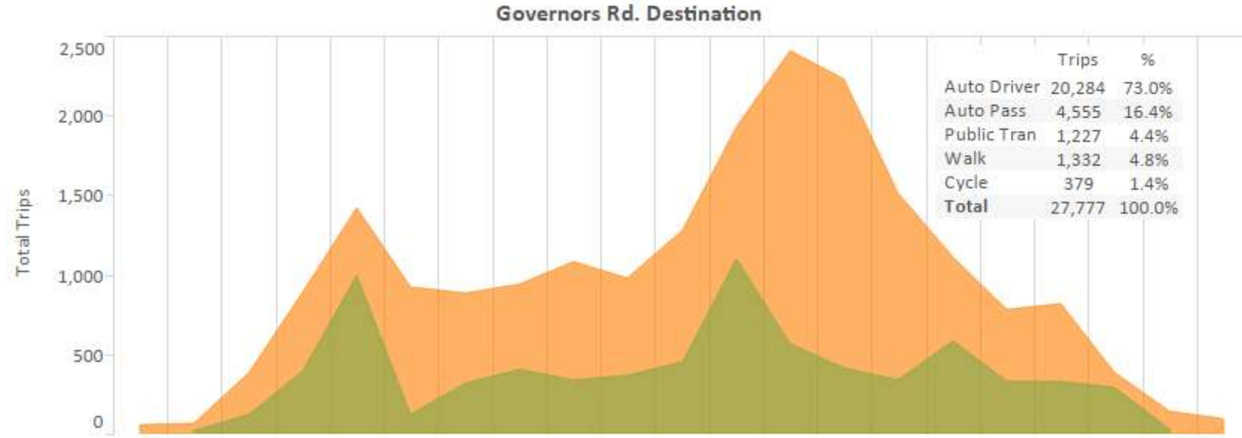
Hourly % of Daily Trips for Given Mode 0.09% – 31.85%

Governors Rd.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	77	399	629	2,019	2,361	1,348	1,077	1,149	936	1,144	997	1,504	1,363	1,543	1,099	980	566	557	356	150	66
Auto Pass				142	622	248	235	412	166	263	296	337	349	293	282	345	159	123	179	51	22
Public Tran			73	167	189	68	105	56	18	28	83	100	76	23	103	24	28			71	29
Walk				108	288		24	88	85	17	160	419	34	61	81				17		
Cycle		20			44	19	37	29	29			37	17	54	26		24		24		
Total	77	419	702	2,436	3,504	1,683	1,478	1,734	1,234	1,452	1,536	2,397	1,839	1,974	1,591	1,349	777	680	576	272	117

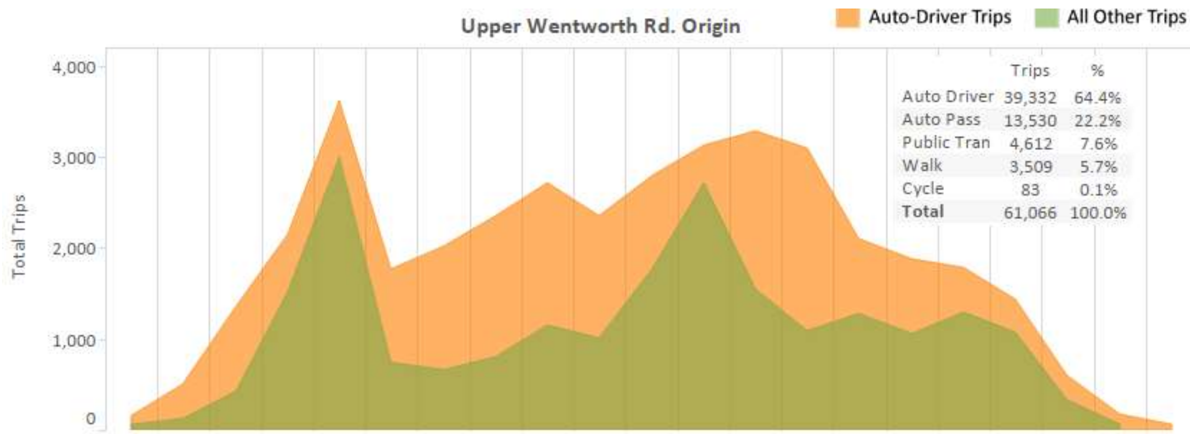
Hourly % of Daily Trips for Given Mode 0.28% 30.32%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	58	65	381	892	1,418	923	881	939	1,079	973	1,279	1,923	2,409	2,229	1,514	1,112	780	814	383	141	91
Auto Pass			60	184	504	91	217	242	236	252	231	500	310	255	212	476	308	315	138	24	
Public Tran		19	41	46	82	28	42	82	37	95	88	165	148	107	67	71		17	92		
Walk			24	125	345		24	64	44	17	110	393	34	54	61				37		
Cycle				36	62		37	12	19		20	37	70			38	24		24		
Total	58	84	506	1,283	2,411	1,042	1,201	1,339	1,415	1,337	1,728	3,018	2,971	2,645	1,854	1,697	1,112	1,146	674	165	91

Hourly % of Daily Trips for Given Mode 0.21% 29.50%

Upper Wentworth Rd.



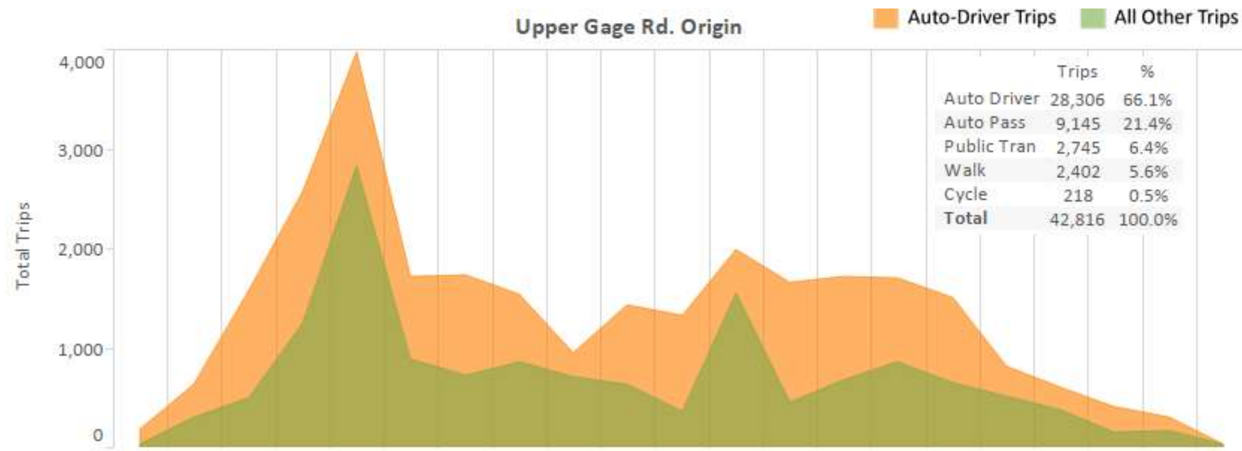
Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	158	499	1,361	2,151	3,611	1,762	2,021	2,347	2,722	2,356	2,792	3,124	3,287	3,098	2,103	1,881	1,786	1,436	601	178	58
Auto Pass	47	66	215	524	1,524	505	488	435	783	609	890	1,272	1,194	789	896	852	1,142	991	277	31	
Public Tran	18	60	190	766	781	152	139	206	219	373	223	418	185	157	308	168	138	50	29	32	
Walk			28	213	689	68	43	142	148	24	661	1,019	140	144	68	44	22	28	28		
Cycle				13		13		29					28								
Total	223	625	1,794	3,667	6,605	2,500	2,691	3,159	3,872	3,362	4,566	5,833	4,834	4,188	3,375	2,945	3,088	2,505	935	241	58

Hourly % of Daily Trips for Given Mode 0.09% – 34.94%

Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	97	188	658	1,159	4,142	2,342	2,745	2,823	2,230	2,113	2,789	3,508	3,647	3,219	2,093	1,927	1,311	1,224	495	293	147
Auto Pass		20	208	391	1,450	589	613	689	658	584	761	1,442	1,136	1,183	802	1,009	764	688	248	168	31
Public Tran			59	365	289	182	352	234	327	200	523	735	474	398	201	192	89	94	71	41	
Walk		28	56	351	1,006	180	60	147	113	53	372	740	117	198		22		28	28		
Cycle				13		41													29		
Total	97	236	981	2,279	6,887	3,334	3,770	3,893	3,328	2,950	4,445	6,425	5,374	4,998	3,096	3,150	2,164	2,034	871	502	178

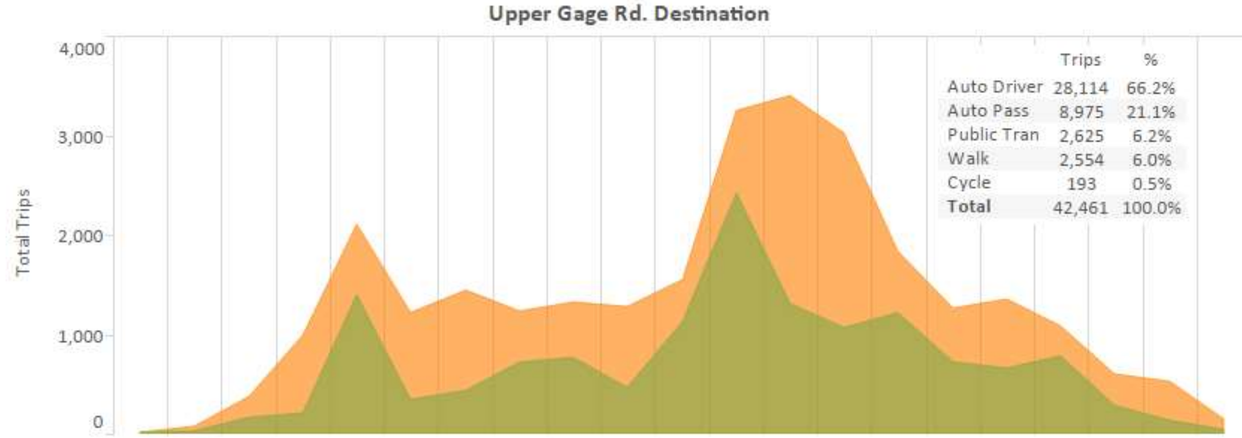
Hourly % of Daily Trips for Given Mode 0.15% – 49.40%

Upper Gage Rd.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	174	629	1,574	2,571	3,975	1,717	1,728	1,541	951	1,434	1,326	1,988	1,651	1,712	1,700	1,497	818	595	399	295	31
Auto Pass		141	384	480	1,282	506	408	636	507	401	215	775	319	604	814	627	360	370	156	135	25
Public Tran	27	118	99	482	621	271	242	120	144	143	125	93	65	29		23	110	13		20	
Walk		18	15	242	900	106	67	102	31	93	23	652	47	46	23		23			14	
Cycle		25		50	31				23			23	18		24		24				
Total	201	931	2,072	3,825	6,809	2,600	2,445	2,399	1,656	2,071	1,689	3,531	2,100	2,391	2,561	2,147	1,335	978	555	464	56

Hourly % of Daily Trips for Given Mode 0.11% – 37.47%

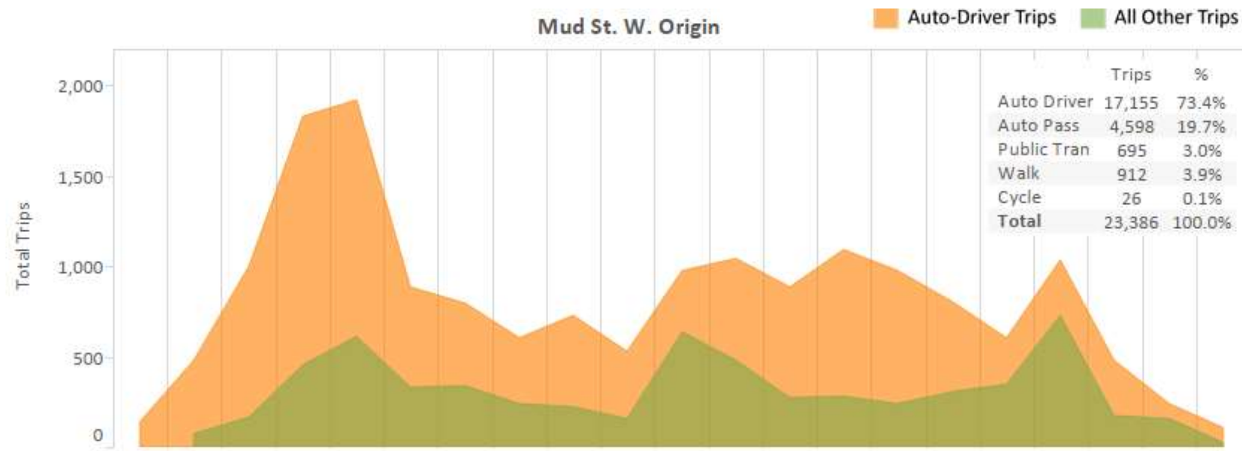


Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	14	79	375	999	2,105	1,224	1,451	1,228	1,316	1,273	1,556	3,245	3,404	3,017	1,839	1,269	1,357	1,081	603	532	147
Auto Pass			129	101	571	211	336	494	530	262	546	1,121	832	751	967	560	557	620	220	117	50
Public Tran	13	14	14	54	127	92	69	101	159	115	277	447	313	254	132	134	84	167	59		
Walk		18	18	59	699	38	36	102	55	92	307	833	146	46	91					14	
Cycle								31	23			23	18	19	24	31	24				
Total	27	111	536	1,213	3,502	1,565	1,892	1,956	2,083	1,742	2,686	5,669	4,713	4,087	3,053	1,994	2,022	1,868	882	663	197

Hourly % of Daily Trips for Given Mode 0.05% – 32.62%

Mud St. W.

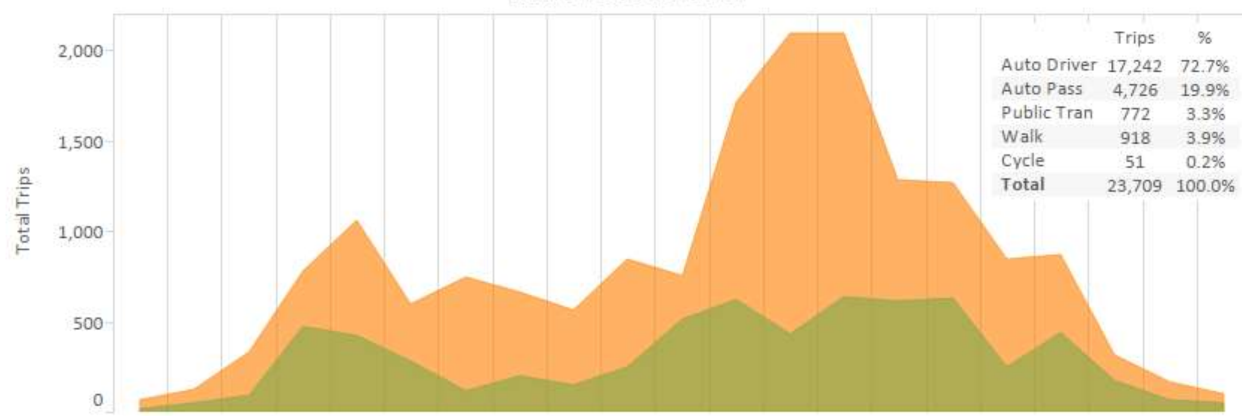
Mud St. W. Origin



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	140	482	997	1,827	1,920	889	798	601	730	530	977	1,046	882	1,095	975	805	602	1,036	479	238	106
Auto Pass		72	120	250	328	219	263	215	175	94	346	207	248	234	216	291	347	679	145	126	23
Public Tran			45	96	103	88	63	26	26	17	89	44				15		26	28	29	
Walk				111	178	26	12		26	45	200	226	22	44	22						
Cycle																		26			
Total	140	554	1,162	2,284	2,529	1,222	1,136	842	957	686	1,612	1,523	1,152	1,373	1,213	1,111	949	1,767	652	393	129

Hourly % of Daily Trips for Given Mode 0.50% – 100.00%

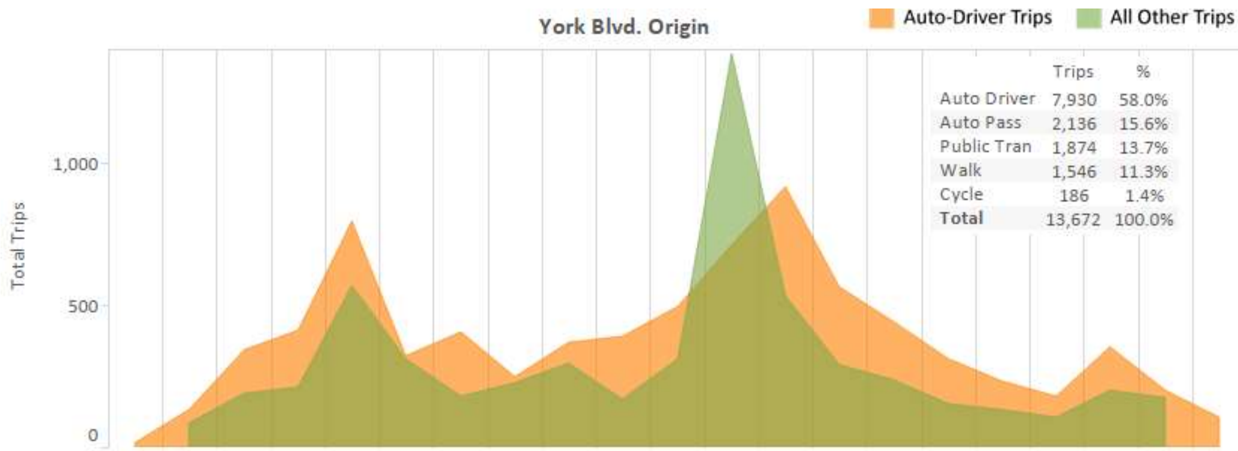
Mud St. W. Destination



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	70	127	331	774	1,058	593	741	658	561	842	751	1,709	2,091	2,094	1,282	1,268	842	872	317	164	97
Auto Pass	18	26	40	197	216	213	118	186	86	175	175	343	341	551	535	610	244	384	175	44	49
Public Tran			50	48	24	22		15	41	50	223	57	45	39	57	22		57		22	
Walk				225	178	48			26	19	111	223	22	44	22						
Cycle		25											26								
Total	88	178	421	1,244	1,476	876	859	859	714	1,086	1,260	2,332	2,525	2,728	1,896	1,900	1,086	1,313	492	230	146

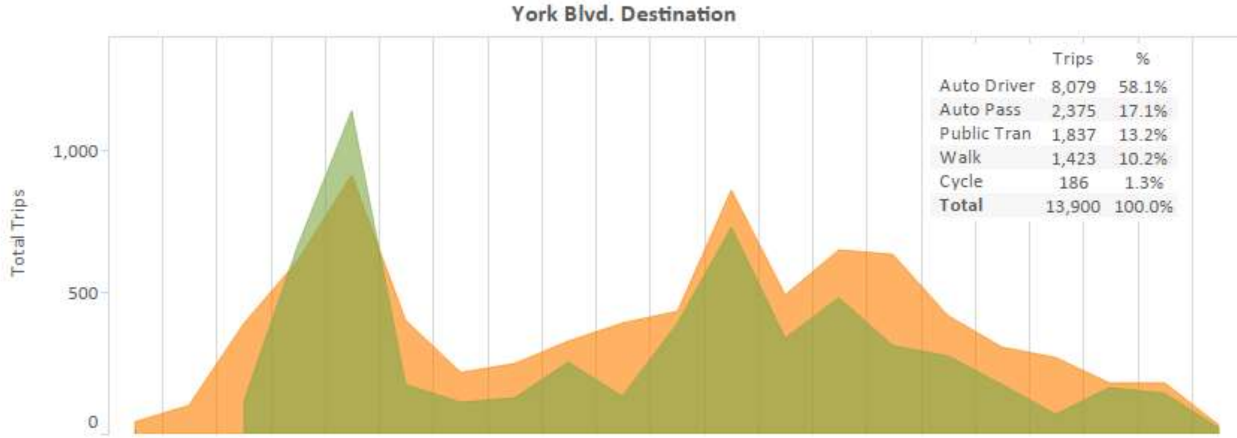
Hourly % of Daily Trips for Given Mode 0.37% – 50.98%

York Blvd.



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	16	129	340	409	794	323	406	245	366	390	495	708	916	564	441	313	234	181	355	201	104
Auto Pass			53	60	147	54	46	111	107	83	129	233	192	166	123	108	102	66	183	173	
Public Tran		86	118	56	75	92	84	91	45	73	142	626	176	82	59		28	23	18		
Walk			16	76	292	153	47	23	121	12	42	523	137	43		45		16			
Cycle				16	57	12			21				26		54						
Total	16	215	527	617	1,365	634	583	470	660	558	808	2,090	1,447	855	677	466	364	286	556	374	104

Hourly % of Daily Trips for Given Mode 0.12% – 33.83%



Mode	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 AM
Auto Driver	43	99	387	613	912	398	215	247	328	390	434	860	489	650	629	417	306	269	180	181	32
Auto Pass			36	156	290	38	70	36	151	31	204	245	74	257	189	229	129		101	118	21
Public Tran			64	438	327	74	39	90	46	64	116	161	160	105	80	21	26		26		
Walk	18		16	69	518	46			55	22	72	302	54	79	42		21	71	38		
Cycle						16				12		20	49	37		26				26	
Total	61	99	503	1,276	2,047	572	324	373	580	519	826	1,588	826	1,128	940	693	482	340	345	325	53

Hourly % of Daily Trips for Given Mode 0.38% – 36.40%

7.4 Auto/Transit Trip Share Patterns in Toronto

Figure 7.22: Auto/Transit Trip Share Patterns in Toronto (AM)

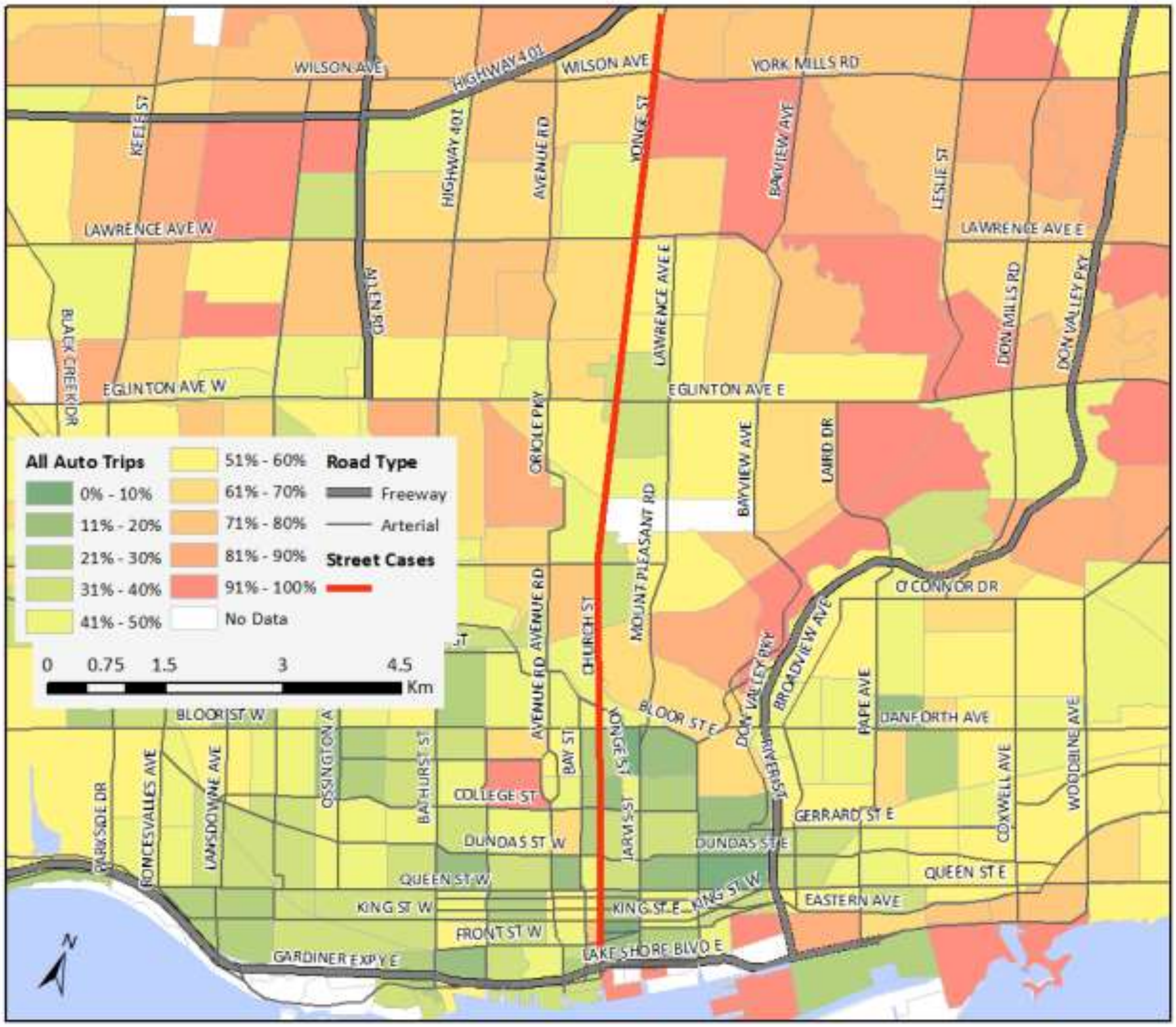
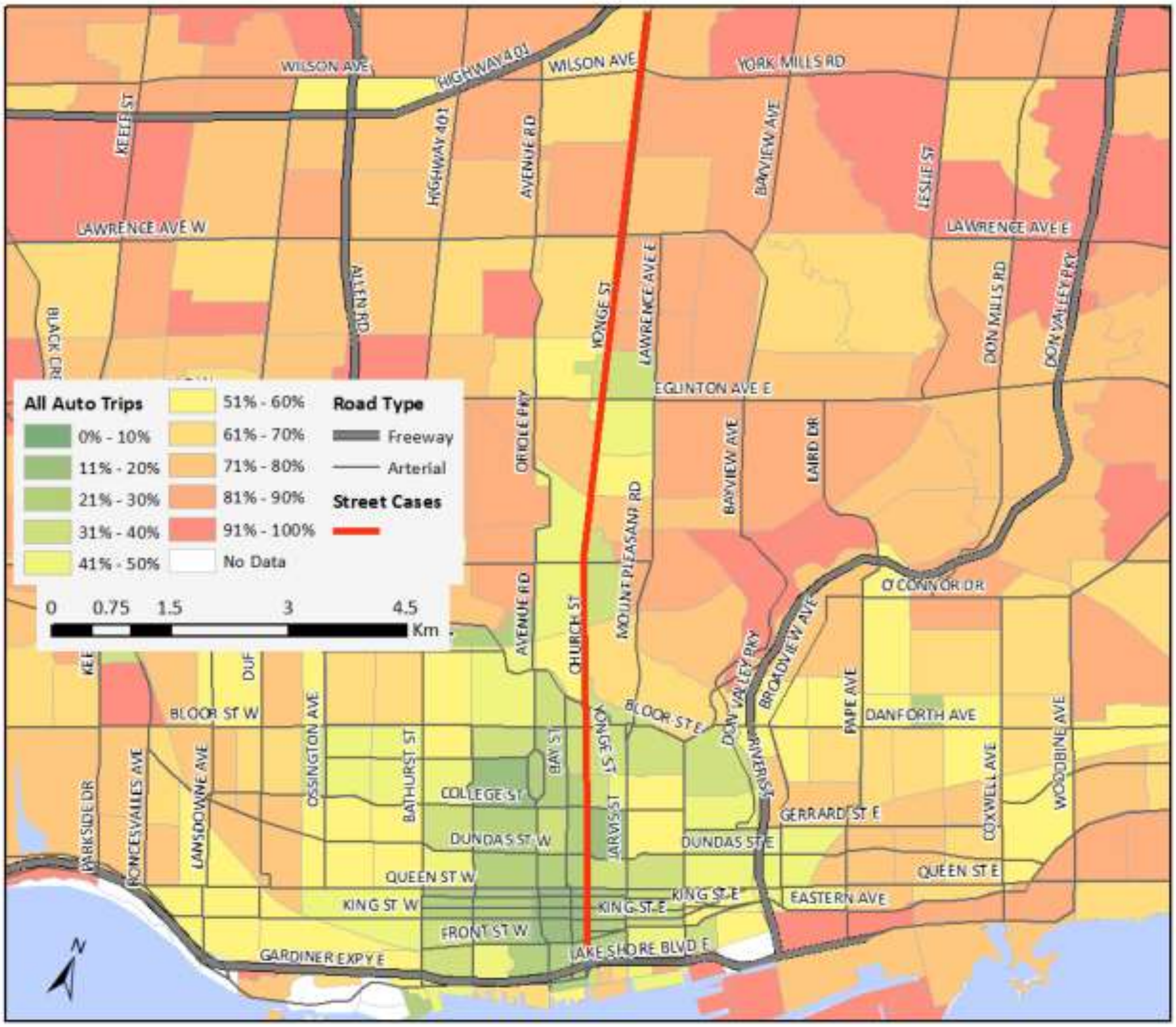


Figure 7.23: Auto/Transit Trip Share Patterns in Toronto (AM)



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