TRAFFIC CALMING
WITHIN METROPOLITAN TORONTO

by

Mobushar A. Pannu, P.Eng.

A Thesis Submitted in Conformity with the Requirements
for the Degree of Master of Engineering
The Department of Civil Engineering
University of Toronto

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Traffic Calming
Within Metropolitan Toronto

Mobushar A. Pannu
Master of Engineering, 1999
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ABSTRACT

This report evaluates and summarizes the use of various Traffic Calming Measures, within the Metropolitan Toronto (Metro) area. The evaluation is based upon the social acceptance of these measures, their adverse impacts on energy consumption and the environment, their ability to achieve intended objectives, their economic feasibility, and their adverse impacts on the safety of non-motorized street users. Issues were addressed by means of a literature review, a public attitude survey/questionnaire, a survey of the local municipal transportation professionals, as well as an analysis of traffic calming measures in relation to fuel consumption, user safety, and economics.

Based on the findings of this study, a systematic planning and evaluation procedure was developed to help in the assessment and selection of different calming measures. The procedure accounts for characteristics such as road hierarchy, area characteristics, environmental concerns, cost and ease of maintenance, and user safety. All of these are important for the implementation and success of any traffic calming plan. Other factors such as public expectations can be considered further at the final decision making stage. In addition, this report makes recommendations to improve conditions for non-motorized users in our environment. This study has been carried out to satisfy the project requirements for the Masters in Engineering (Civil) program.
Acknowledgements

I would like to thank Professor Richard M. Soberman for his guidance, support and patience during this project.

To my parents for their endless support, and my wife, Fariha, my daughter, Fatima, and my family for their understanding and encouragement.

To my colleagues for providing useful information and particularly to Ms. Jennifer Smysnuik for her valuable efforts in proof reading this project.
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1.0 INTRODUCTION

As one of the many concerns we are facing today, traffic calming has recently become a major challenge for many transportation engineers and planners. It is a concept which attempts to reduce the negative effects of motor vehicle use, alter driver behaviour, and improve conditions for non-motorized street users.

Studies have been carried out on diverse aspects of traffic calming, ranging from the development of a common definition, to the influence of traffic calming on emergency response time. In some jurisdictions, traffic calming measures have been quite successful. However, for others, there have been many disappointments to report. In some of the areas, performance was so unacceptable that it required the removal of these measures. Whatever the reasons for such varied behaviour, it remains unchanged that neighbourhood safety, adverse effects of motor vehicle use on the environment, and the improvement of conditions for non motor vehicle users are the major priorities. This, in turn, makes it necessary to further investigate available traffic calming measures in order to justify the use and adoption of these alternatives with more understanding and confidence.

The notion of traffic calming has progressed over the years. It means different things to different people. Initially, it was used to describe the speed control measures applied to local residential streets. Later on, it broadened to included residential collector as well as local arterial roads. In other instances traffic calming was augmented to include the partial or complete prohibition of traffic from certain roads and town centres. A broader interpretation of traffic calming includes the concepts of multi modal planning, city wide traffic reduction, alternative mode selection, driver behaviour change, and variable land use. A recent definition and its interpretation of traffic calming, put forward by the Institute of Transportation Engineers (ITE), provides a clear understanding of the intent (1).
1.1 What is Traffic Calming?

Until recently, a common definition for traffic calming did not exist, although traffic calming measures and ideas have been in use for over thirty years in different parts of the world. The Institute of Transportation Engineers (ITE) established a committee to determine a common definition and interpretation. According to the ITE March, 1997 International Conference held in Tampa, Florida, traffic calming is defined as:

"The combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behaviour and improve conditions for non-motorized street users" (2)

The intended interpretation for the traffic calming definition presented by the committee, is that “mainly physical measures” means both physical measures and a supportive environment, such as policy and legislative support for traffic calming, and flexibility of standards, guidelines and practice. The term “reduce the negative effects of motor vehicle use” means changing the design and role of the street in order to reduce the negative social and environmental effects of motor vehicles on individuals (e.g., speeding, volume, accidents, etc.), and on society in general (e.g., energy consumption, pollution, urban sprawl, etc.). To “alter driver behaviour” involves the self enforcement aspect of traffic calming; the reduction of aggressive driving, the lowering of speed, and the increase in respect for non-motorized users of the street. To “improve conditions for non-motorized street users” means to promote walking and cycling, increase safety, and improve aesthetics (2).
1.1.1 Goals and Objectives of Traffic Calming

The goals of traffic calming are to:

- improve the quality of life,
- create safe and attractive streets,
- reduce the negative effects of motor vehicles on the environment, and
- promote pedestrian, bicycle and transit use.

The objectives of traffic calming are to:

- achieve slow speeds for motor vehicle traffic,
- increase safety, and the perception of safety, for the non-motorized users of the street(s),
- reduce collision frequency and severity,
- reduce the need for police enforcement,
- enhance the street environment,
- encourage water infiltration into the ground,
- increase access for all modes of transportation,
- reduce cut-through traffic, and
- alter traffic patterns (3).
1.2 Review of Study Objectives and Approach

1.2.1 Study Objectives

The main objective of this research project is to evaluate the merits of some of the commonly used traffic calming measures (TCMs) within the Metro area. The study will further determine the possibility of implementing these TCMs in our existing road network, within the context of current transportation techniques and practices. The study will focus on the current traffic calming measures as a technique towards sustainable traffic management, and will assist in making informative decisions in the future.

The objectives of the study are as follows:

i) Evaluate the merits of commonly used Traffic Calming Measures, as a technique towards sustainable traffic management, in terms of neighbourhood safety, energy conservation and air pollution.

ii) Determine the negative environmental impacts associated with the implementation of these TCMs, particularly the higher noise levels, air pollution, increased energy consumption, and safety issues.

iii) Develop guidelines which would assist in selecting an appropriate integrated traffic calming approach in accordance with specific criteria such as area characteristics, road hierarchy, environmental concerns, safety issues, cost, and ease of maintenance.

iv) Based on the developed guidelines, make recommendations to improve the selection process of where, when, and what type of TCMs may be used.
1.2.2 Study Approach and Methodology

Traffic calming is a relatively new area of study in the transportation engineering field. There is not as much information available as one would expect, to reach certain conclusions with confidence. In order to achieve the objectives of this study, the approaches adopted during the research was kept flexible. An attempt was made to remain impartial throughout the study in order to obtain unbiased results.

In order to address the objectives of the study the following specific tasks were undertaken:

**Literature Review**

The purpose of the literature review was to obtain information regarding traffic calming measures through the experience of other urban areas, and to improve the understanding of the advantages and disadvantages of various TCM's. The general findings of the literature review are presented in Section 2. The necessary technical data, reports, and existing policies were reviewed to justify the implementation of TCM's within the context of this study. Section 3 outlines a number of existing and new traffic calming measures used within study area. This section further addresses the measures that conform to the traffic calming definition as presented in section 1.1.

**Surveys/Interviews/Questionnaires**

In order to identify and quantify attitudes, experiences, potential benefits, and costs associated with various techniques of traffic calming, two surveys were conducted. Other issues identified through such inquiries are related to area level service, user safety, and environmental impacts. A detailed analysis of the survey is presented in Section 4.
Analysis and Recommendations

The impact of increased energy consumption and air pollution, resulting from the implementation of traffic calming measures, is a concern which is usually ignored in traffic calming studies. As part of this study, an attempt is made to determine the negative environmental impacts associated with the implementation of various TCM’s. Section 5 of the report discusses these impacts in detail. Section 6 discusses the safety issues associated with TCM’s with respect to pedestrians, cyclists, and vehicles. Section 7 provides information on the costs associated with the implementation of traffic calming measures, by analysing the economic considerations associated with these initiatives. The principles associated with the successful planning, implementation, and evaluation of the effectiveness of each measure are presented in detail in Section 8 of this study. This section further provides a selection process for where, when, and what type of TCM’s should be used.

1.3 Why we Need this Study?

Automobile-dependency, suburban sprawl, congested roadways, and the race of automobiles to discover the shortest and fastest routes to get from point A to B, has become a threat to our liveability. In order to avoid these problems we began searching for solutions in areas such as transportation planning, traffic management, and traffic calming, which may provide relief from these adversities. In the past, traffic calming measures that were used by urban communities included speed humps, traffic circles, chokers, raised junctions, street closures, diverters and restrictive one way streets.

From a traffic engineers’ point of view, traffic calming measures if well designed and implemented, may well achieve their objectives. However, as some studies suggest from the emergency services point of view, such measures cause delays in response time. It is still unclear as to when and where traffic calming measures are appropriate and effective. As the use of these measures extend from local residential streets to collectors and arterial streets, an understanding of the issues associated with these measures become even more important (4).
1.4 Impacts on our Environment

In the past few years, a number of traffic calming measures have been used in Ontario to slow vehicle speeds, and to enhance pedestrian, bicycle and transit safety. Some of these measures may have achieved their intended objectives without having a significant impact on convenience, mobility and travel time for drivers. Unfortunately, in most cases traffic calming measures which reduce overall vehicular speed, can also cause emergency response delays and adverse environmental impacts such as air pollution, increased energy consumptions, noise, increased maintenance efforts, and higher overall costs. Emissions from vehicles include carbon dioxide (CO₂), air pollutants such as carbon monoxide (CO), nitrogen oxides (NOₓ), oxides of sulphur (SOₓ), hydrocarbons (HC), and other particulate matter. Three major concerns arise regarding vehicle emissions on a traffic calmed street: impact on human health, global warming, and the undue consumption of energy resources (5).
2.0 LITERATURE REVIEW

Over 100 references consisting of scientific articles, books, and newspaper clippings were collected during the literature search. Sources of information included the NT LINK (a service available through the Internet), the on-line reference system from the Transportation Research Board, the University of Toronto Libraries, Metropolitan Toronto Area transportation professionals, and experience related information obtained from local municipalities.

The Internet databases contain information from journals, books, government publications, special reports, and many other published sources from around the world. Other sources of scientific data include recent relevant publications, Transportation Association of Canada (TAC) conference proceedings, ITE Journals, and libraries/reports of the area municipalities available on related issues.

Topics or key words used to locate the relevant literature during the searches of electronic databases were not limited to Traffic Calming topics but also included such key words as; Residential Street Design. Urban Planning, Environmental Urban Planning, Residential Street Traffic Control, Traffic Management, Traffic Accidents, Pedestrian Safety, Vehicular Safety, Automobile Pollution, Traffic Congestion, Driver Attitude, Road Design, and Road Standards.

A reference list of additional literature, which was found to be of some relevance to the subject matter, is included in the report as Appendix B. The majority of the information used was available from the University of Toronto Library or from the ITE. The literature data is referenced throughout the report where appropriate.
One observation which was made, with respect to the collected information, was with the year of publication. As shown in Figure 2.1, most of the relevant literature is quite recent and has been published within the last five years. It was also observed that in most of the references, in which residential street design or traffic management issues were discussed, the emphasis was on the increased traffic volume, perceived higher operating speeds, and the cut through traffic and its perceived adverse impacts on neighbourhoods. Many of the articles provided information and guidelines on the use of innovative traffic calming devices available to reduce traffic volume, speed, and cut through traffic in highly urban residential neighbourhoods, and the benefits achieved through the use of these devices.

Figure 2.1 Distribution of dated literature

The most recent literature confirms that problems associated with the use of traffic calming measures have emerged in many jurisdictions, and have raised concerns on the use of these measures in these areas. However, there are only a few studies available which indicate the impact that traffic calming measures may have on emergency services response time. None of the references reviewed for this study provided any information regarding the population density.
of the neighbourhood, and the percentage of the non-motorized users of the roadway where the use of traffic calming measures is advocated. In addition, there were no studies encountered in this review that indicated the impact of traffic calming measures on increased energy consumption, increased exhaust pollution, and the associated environmental impacts.

As such, the literature review, and other venues of search, indicated that the scientific community as well as the public are deeply divided over the use of traffic calming measures and their advantages and disadvantages. The majority of the areas within the Greater Toronto Area (GTA) and Ontario which are using these devices refer to the success of these traffic calming devices elsewhere, particularly in European cities or communities. The quest for effective and economical solutions to address some or all of our traffic calming concerns is often documented through experiences with new control measures. Unfortunately, most of these measures lack the long term monitoring data required to demonstrate and quantify their effectiveness and maintenance requirements.
3.0 TRAFFIC CALMING MEASURES

Numerous metropolitan areas, throughout North America and Europe, have implemented the use of traffic calming measures. In addition, several new systems are under consideration in many areas. This chapter describes the different types of traffic calming devices commonly used throughout North America.

3.1 Description of Traffic Calming Measures

The Guide to Neighbourhood Traffic Calming (draft, 1997), lists twenty five traffic calming measures, all of which have been used by at least one Canadian municipality to calm traffic. Some measures such as STOP signs or textured pavements, are used for reasons other than traffic calming. However, they may provide a secondary benefit in slowing vehicles, discouraging short-cutting and enhancing neighbourhood environments. An alphabetical list of these twenty-five measures is described in Table 3.1.1. An individual description of each of these measures is included in Table 3.1.2, except for signage which is self explanatory (6).

Table 3.1.1
A List of Traffic Calming Measures

<table>
<thead>
<tr>
<th>Horizontal Deflection</th>
<th>Vertical Deflection</th>
<th>Obstruction</th>
<th>Signage</th>
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<td>Chicane</td>
<td>Raised crosswalk</td>
<td>Directional closures</td>
<td>No through traffic</td>
</tr>
<tr>
<td>Curb Extension</td>
<td>Raised intersection</td>
<td>Diverters</td>
<td>One-way street sign</td>
</tr>
<tr>
<td>Curb radius</td>
<td>Rumble strip</td>
<td>Full closure</td>
<td>Specialty signs for school,</td>
</tr>
<tr>
<td>Median Island</td>
<td>Sidewalk extension</td>
<td>Intersection channelization</td>
<td>playgrounds etc.</td>
</tr>
<tr>
<td>On-street parking</td>
<td>Speed hump</td>
<td>Median barrier</td>
<td>Speed limit sign</td>
</tr>
<tr>
<td>Traffic circles</td>
<td>Textured crosswalk</td>
<td>Right-in / right-out island</td>
<td>STOP sign</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Turn prohibition sign</td>
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<td></td>
<td></td>
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<td>Yield sign</td>
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</table>
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**Description of Traffic Calming Measures**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
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<tbody>
<tr>
<td>Chicane</td>
<td>A series of three staggered curb extensions on alternating sides of the roadway. This modification creates a horizontal deflection in the travel path of a vehicle.</td>
</tr>
<tr>
<td>Curb extension</td>
<td>The intrusion of the curb into the roadway to reduce its width.</td>
</tr>
<tr>
<td>Curb radius</td>
<td>The use of smaller curb radius at intersection corners.</td>
</tr>
<tr>
<td>Median Island</td>
<td>An Island constructed on the centerline of a two-way roadway to reduce the overall travel width of the adjacent travel lanes.</td>
</tr>
<tr>
<td>On-Street Parking</td>
<td>Parking is permitted to reduce the width of the roadway available for vehicle movement.</td>
</tr>
<tr>
<td>Traffic Circles</td>
<td>Circular raised island located in the centre of an intersection to create a circular flow patterns operating under yield rather than STOP controlled conditions.</td>
</tr>
<tr>
<td>Raised Crosswalks</td>
<td>The elevation of a pedestrian crosswalk is raised to the same height as the adjacent curbs and sidewalks.</td>
</tr>
<tr>
<td>Raised Intersection</td>
<td>The centre area of an intersection, including crosswalks, is raised to the same height as the adjacent curb and sidewalks.</td>
</tr>
<tr>
<td>Rumble Strip</td>
<td>Raised buttons or bars closely spaced at regular intervals to warn drivers of upcoming situation.</td>
</tr>
<tr>
<td>Sidewalk Extension</td>
<td>Sidewalk continues across a local street intersection at its normal elevation and local street is raised at the intersection to level of sidewalk.</td>
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Table 3.1.2 Description of Traffic Calming Measures Contd.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
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<tbody>
<tr>
<td>Speed Humps</td>
<td>An elliptical section of the road extended across the roadway and placed at intervals of 80 m to 130 m. It deflects both wheel and frame of a vehicle to control speed.</td>
</tr>
<tr>
<td>Textured Crosswalk</td>
<td>Use of textured material which contrasts with the roadway colour to visually demarcate the pedestrian crosswalk area.</td>
</tr>
<tr>
<td>Directional Closures</td>
<td>The intrusion of the curb into the roadway to prohibit one direction of traffic.</td>
</tr>
<tr>
<td>Diverter</td>
<td>A raised barrier placed diagonally across an intersection to force the traffic to turn.</td>
</tr>
<tr>
<td>Full Closure</td>
<td>A raised barrier extending across the entire width of a roadway, which prohibits all vehicular movements (except emergency).</td>
</tr>
<tr>
<td>Intersection Channelization</td>
<td>Raised islands at an intersection that restrict specific movements and thereby provide better definition of large uncontrolled pavement areas.</td>
</tr>
<tr>
<td>Median Barrier</td>
<td>A raised island on the centerline of a roadway through an intersection which prevents left turn or straight through movement being made to and from a side street.</td>
</tr>
<tr>
<td>Right-in/Right-out Island</td>
<td>A raised triangular island at an intersection approach that prevents left turn and through movements to and from the side street.</td>
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Source: Canadian Guide to Neighbourhood Traffic Calming (draft 1997)
3.2 Examples of Traffic Calming Measures

Based upon the municipal survey and a number of field trips to various treated locations it was noticed that the following traffic calming measures are commonly used within Metropolitan Toronto (Metro).

3.2.1 Raised Intersection

The purpose of a raised intersection is to reduce motorized vehicle speeds and to better define crosswalk areas, in order to reduce pedestrian vehicle conflicts. Example installations include; Huron Street, and Logan Avenue, Toronto.

Figure 3.2.1 Raised Intersection (Huron Street At Sussex Avenue, Toronto).
3.2.2 Raised Crosswalk

The purpose of a raised crosswalk is to reduce motorized vehicle speeds and to improve pedestrian visibility, in order to reduce pedestrian vehicle conflicts.

Figure 3.2.2 Raised Crosswalk (Balliol Street, Toronto).
3.2.3 Speed Hump

The intent of a speed hump is to reduce vehicle speeds by creating vertical constraints on a roadway. The desired motor vehicle speed is determined by the dimensions of the speed hump and the spacing between humps. Example installations include; Bridle Path, North York and Huron Street, Toronto.

Figure 3.2.3 Speed Hump (Huron Street, Toronto).
3.2.4 Textured Crosswalk

The intent of a textured crosswalk is to better define the crosswalk, and to emphasize pedestrian priority, thereby reducing pedestrian-vehicle conflict. It is one of the most commonly used device by many area municipalities.

Figure 3.2.4  Textured Crosswalk (Yonge Boulevard, North York).
3.2.5 Chicane

The purpose of a chicane is to discourage cut-through traffic and reduce vehicle speeds. The streets are narrowed by curb extensions on alternating sides of the roadway. Example installations include; Balliol Street, Logan Avenue, Toronto.

Figure 3.2.5 Chicane (Balliol Street, Toronto).
3.2.6 Curb Extension

The purpose of a curb extension is to reduce the width of the roadway, thereby reducing vehicle speed, pedestrian crossing distance, and increasing pedestrian visibility. Example installations include; Balliol Street, Huron Street, Logan Avenue, Toronto.

Figure 3.2.6 Curb Extension (Balliol Street, Toronto).
3.2.7 Curb Radius Reduction

The purpose of a curb radius reduction is to slow right turning vehicles and reduce the pedestrian crossing distance. Curb radius reduction is commonly used by many municipalities.

Figure 3.2.7 Curb Radius Reduction (Huron Street, Toronto).
3.2.8 Raised Median

The intent of a raised median is to reduce the driving surface width, thereby reducing vehicle speed. Example installation includes: Young Boulevard, North York.

Figure 3.2.8 Raised Median (Yonge Boulevard, North York).
3.2.9 Raised Median Islands

The purpose of a raised median island is to reduce the width of travel lane in both directions and thereby reduce vehicle speed. It may be used as pedestrian refuge area and hence reduces pedestrian-vehicle conflict. Raised median islands are typically used by many municipalities.

Figure 3.2.9 Raised Median Island (Carlaw Avenue, Toronto).
3.2.10 On Street Parking

The intent of permitting on street parking is to reduce vehicle speed and discouraging cut-through traffic. This measure is commonly used by almost all communities.

Figure 3.2.10 Typical On Street Parking (Duplex Avenue, Toronto).
3.2.11 Traffic Circles

The purpose of traffic circles is to create circular flow patterns to reduce vehicle-vehicle conflict at intersections, and to reduce vehicle speeds. Example installations include: Oak Street, Toronto.

Figure 3.2.11 Traffic Circle (Oak Street, Toronto).
3.2.12 Intersection Channelization

The intent of an Intersection Channelization is to obstruct short-cutting or through traffic by preventing certain movements. An intersection channelization may also reduce pedestrian walking distance by providing refuge area.

Figure 3.2.12 Intersection Channelization (Yonge Boulevard, North York).
3.3 Measures That Meet the Definition

As this study is focused on “traffic calming measures” it will be useful to point out which of the measures described under section 3.1 conform to the definition of a traffic calming device. The common term “traffic calming measures” typically refers to physical features placed within the limits of the roadway environment. It includes vertical changes in the road (speed humps, raised pedestrian cross-walks), lateral changes in the road (chicanes, curb extensions), construction (median islands, street narrowing), traffic circles, smaller corner radii, gateway treatments, street parking and street scaping.

Frequently the term “traffic calming” is interchangeably used, or confused, with route modification (traffic management) and traffic control devices. Although route modification may share the goals of improving quality of life by reducing cut-through traffic with traffic calming, it is often employed to change the traffic flow on a particular neighbourhood. Examples include diverters, closures, one-way streets, and turn prohibitions. Similarly the traffic control devices are signs, signals, and pavement markings that are designed to regulate, warn, guide, and inform the road users. Examples included STOP signs, Yield signs, speed limit signs, and traffic signals (7).

Based upon the definition of these terms some of the measures included in section 3.1 of this report do not conform to the definition of a traffic calming measure. These measures may be helpful in overall traffic management, however, they will not be considered or assessed as a traffic calming device in this study. According to the definition the measures that actually conform to the definition of a traffic calming device are presented in Table 3.1.3 and will be the only measures considered as a traffic calming device for the purpose of this study.
### Table 3.1.3
Traffic Calming Measures which Conform to the Definition

<table>
<thead>
<tr>
<th>Horizontal Deflection</th>
<th>Vertical Deflection</th>
<th>Obstruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicane</td>
<td>Raised crosswalk</td>
<td>Intersection channelization</td>
</tr>
<tr>
<td>Curb Extension</td>
<td>Raised intersection</td>
<td>Median barrier</td>
</tr>
<tr>
<td>Curb radius</td>
<td>Rumble strip</td>
<td>Right-in / right-out island</td>
</tr>
<tr>
<td>Median Island</td>
<td>Sidewalk extension</td>
<td></td>
</tr>
<tr>
<td>On-street parking</td>
<td>Speed hump</td>
<td></td>
</tr>
<tr>
<td>Traffic circles</td>
<td>Textured crosswalk</td>
<td></td>
</tr>
</tbody>
</table>
4.0 QUESTIONNAIRE AND SURVEYS

Two questionnaires were formulated for the purpose of the survey in order to identify public attitudes, perceptions, and experiences associated with the implementation of traffic calming treatments. The first survey contained technical questions and was developed mainly for the transportation engineers and planners, while the second survey was more qualitative and derived for a non-technical audience. Copies of the surveys are presented in Appendix “A” with a detailed breakdown of responses.

The technical questionnaire was sent to a total of 15 transportation engineers and planners from all six previously existing Metropolitan Toronto municipalities, and some of the neighbouring municipalities in the GTA. Out of the 15 questionnaires which were sent out, a total of 8 were returned. Although a 53% response rate is usually considered very good in such surveys, it should be noted that the sample population used was small and the survey was sent to only one representative from each municipality. Therefore, the results provided in this study may not represent the opinion of all professionals in those municipalities.

Due to the scope of this study, budget limitations, and the fact that the general public may not be particularly aware of the concept, an intensive public survey was not undertaken. In order to simplify the questionnaire, it referred to traffic calming in general, instead of using individual traffic calming measures. Six areas within metropolitan Toronto, where various traffic calming measures have been implemented, were randomly selected to obtain public input for the survey.

A total of 52 residents across Toronto were asked to answer survey questions based on their knowledge of, and experience with traffic calming measures. Area group 1 (Yonge Boulevard) includes street narrowing with a raised, drivable central median, and a reinforcement of a pedestrian cross walk with a textured pedestrian crosswalk. Area group 2 (Logan Ave.) contains a combination of chicanes, reduced curb radius, curb extensions, and raised intersections, etc.. Area group 3 (South Eglinton) incorporates a combination of measures including precast modular curbstone islands and planters, curb build-outs, chicanes, curb extensions, reduced curb radius,
and raised intersections. Area group 4 (Huron Street) incorporates a combination of measures including raised intersections, curb extensions, reduced curb radius, and raised cross walks. Area group 5 (Carlaw Ave) includes street narrowing with precast modular curbstone islands, pavement marking and street parking. Area group 6 (Bridle Path) includes a street where traffic is calmed by speed humps. All of these efforts are further reinforced with traffic calmed neighbourhood signs.

It is further emphasized that the results presented in this section were also obtained from a limited number of residents from these areas, and as such may not be a true representation of the public opinion in these areas. Furthermore, public preferences can differ depending on location, specific neighbourhood characteristics, and the traffic calming measures used for treatment.

4.1 Assessment of Public Attitudes and Perceptions

The knowledge and understanding of public attitudes, perceptions, and preferences with respect to implementation of traffic calming devices, can become a valuable asset in determining what type of measures would be acceptable, and which could become a resistance factor. An assessment of public attitudes and perceptions was established based on the responses obtained for a series of relevant questions in the survey. Although a general survey was used across the city, the results obtained from different areas reflect public attitudes and perceptions towards various devices used in those neighbourhoods. The responses from all areas were combined to assist in the overall interpretation of the results.

4.1.1 Street Aesthetics

In order to address this issue, the survey asked how traffic calming influenced the residents perception of the overall aesthetics of that street or area. The results of the survey indicate that 58% of the respondents felt that traffic calming has a negative influence on the overall aesthetics of the area. It is interesting to note that this feeling varied from 30% in group area 1 to 100% in group area 5. Figure 4.1.1(a) summarizes the individual responses from various areas and the combined response is shown in figure 4.1.2.
4.1.2 Level of Service

When the participants were asked about their perception towards the level of service, such as street sweeping, snow removing etc, provided on a traffic calmed street, a large number (67%) of the respondents perceived a lower level of service, and the feeling was shared in all six area groups. Figure 4.1.1(b) summarizes the individual responses from various areas and the combined response is shown in figure 4.1.2.

4.1.3 Environmental Impacts

The survey tried to identify if there was a perceived link between the traffic calming measures used, and potential environmental impacts, such as noise, air quality, and energy consumption. As such, 56% of respondents indicated that traffic calming has a negative influence on the environment, and 27% indicated that it has positive influence. The results presented in Figure 4.1.1 (c) and 4.1.2 were obtained based on the results of the survey.

4.1.4 Access to Emergency Vehicles

When the participants were asked their opinion towards the impacts that traffic calming measures may have on emergency services, a large number of respondents (nearly 77%) indicated that traffic calming has a negative influence on emergency access. However, it was interesting to note that a fair number of respondent 23% either chose no influence or were unsure. The results presented in Figure 4.1.1 (d) and 4.1.2 were obtained based on the results of the survey.
Figure 4.11: Public perception/attitudes towards: (a) street aesthetics, (b) street level of service, (c) environmental impacts, and (d) access to emergency vehicles on traffic-calmed streets from individual area groups.
Figure 4.1.2: Summary of combined responses from all group areas towards Aesthetics, Level of Service, Environmental Impacts and Access for Emergency vehicles.
4.1.5 Effectiveness of Traffic Calming

From our survey of the Toronto area municipalities, it is evident that in most cases, traffic calming measures are implemented in response to public requests, or complaints regarding traffic volumes, higher speeds, etc. It was felt to be important to obtain public opinions on traffic volume, traffic speed, vehicle-pedestrian conflict, and vehicle-bicycle conflict in traffic calmed areas in order to evaluate the effectiveness of these measures. Question No. 3 within the survey was formulated to indicate the perception of residents related to these basic concerns. Nearly 52% of respondents felt that traffic calming has no positive influence on volume reduction, while about 46% felt that speeds were reduced on traffic calmed streets. 50% felt that traffic calming has no impact on vehicle-pedestrian conflict reduction, and 62% of the respondents indicated that it increases vehicle-bicycle conflict. Figure 4.1.3 summarizes a combined response of the participants from all areas.

![Figure 4.1.3](image)

Figure 4.1.3 Public perception towards traffic volume, traffic speed, vehicle-pedestrian conflict, and vehicle-bicycle conflict on a traffic calmed street.
4.1.6 Public Perception Towards Safety on a Traffic Calmed Street

Pedestrian / Bicycle Safety

A primary objective of traffic calming is to free up more space for pedestrians and bicycle riders. Therefore, it was important to determine the perception or attitude of people towards these modes of transportation. Question No’s 4 and 5 asked the participants how comfortable they felt walking or riding a bicycle on a traffic calmed street. With respect to walking, nearly 54% of participants indicated that traffic calming has no effect. The results indicate that a large number, 79%, of respondents felt very uncomfortable or not comfortable riding a bicycle on a road where traffic calming measures have been implemented. Figure 4.1.4 summarizes a combined response of the participants from all areas.

![Safety Chart]

**Figure 4.1.4** Response to the question: How comfortable do you feel walking or riding a bicycle on a street equipped with traffic calming measures?
Driver Perception Towards Safety

The use of traffic calming in many jurisdictions is advancing towards network wide traffic calming practices. Some neighbourhoods, in addition to the residential streets, desire to include more collectors and arterial roads into their traffic calming programs. It will be helpful for our future traffic calming endeavours that we understand public perception towards the implementation of traffic calming on our collector, as well as arterial streets. Question No. 8 asked the participants about their level of comfort while driving on a local residential, residential collector, and arterial streets with traffic calming measures. The results of the survey indicated that 70% of participants felt comfortable driving along a local residential street with traffic calming. Nearly 46% felt either very uncomfortable or not comfortable while driving along collector streets with traffic calming, and another 30% indicated that it had no effect. Over 92% felt very uncomfortable or not comfortable driving along an arterial street with traffic calming measures. Figure 4.1.5 summarizes the responses of the participants.

![Figure 4.1.5 How comfortable do you feel driving along a street with traffic calming](image)

Figure 4.1.5 How comfortable do you feel driving along a street with traffic calming
4.1.7 Public Approach Towards Mode and Route Selection

Many previously completed traffic calming studies indicate that traffic volume is reduced on a treated street. These studies tend to attribute this reduction to a change in the mode of transportation i.e. less people using vehicles, or a change in route selection (avoiding the traffic calmed street). Question No. 6 was included to determine how traffic calming would influence a person’s chosen mode of travel (i.e. vehicle, walking, bicycle) for a short trip. Question No. 7 asked people if they would avoid using a treated street? Almost, 85% of participants indicated that it has no influence on their mode choice, and another 79% indicated that traffic calming on streets will not influence their route selection. The response of the participants is summarized in Figure 4.1.6.

![Figure 4.1.6](image.png)

Figure 4.1.6 Participants approach towards mode and route selection in a traffic calmed area.
4.2 Assessment of Municipal Perspectives

The survey which was prepared for the municipal representatives asked if the participants were aware of different traffic calming measures, and if any of those measures were implemented in their jurisdictions. If so, the survey asked if the participating municipality had its own guidelines for traffic calming, what criteria they use in the selection of traffic calming measures, why a particular measure was chosen for a particular location, and was a before-after study carried out? The questionnaire inquired about the effectiveness of a calming system, additional capital and maintenance costs, and overall satisfaction with a system that the municipality may have implemented. The participants were further requested to express their concerns regarding the use of traffic calming measures, and to indicate their level of comfort in implementing traffic calming systems on local, collector, and arterial streets within a road network. The responses are summarized below:

Nearly 53% (8 out of 15) of the municipalities which were contacted participated in the survey. According to the survey results, 100% of the participants indicated that they were aware of traffic calming measures. A significant number of participants indicated that traffic control signs are not a traffic calming measures. One of the participants indicated that a bicycle lane is a traffic calming measure.

Table 4.2.1, indicates the actual number of responses received and the participants’ preference towards the following questions in the survey:

- **B) Have you implemented this measure for neighbourhood traffic calming?**
- **C) Are you considering the use of this measure for neighbourhood traffic calming?**
- **D) Do you support the use of this measure for its intended function?**

It was noticed from the results of the survey, that Raised Crosswalks are the most well supported (5 out of 8 respondents) measure by the area transportation professionals. This is followed by the Median Island (4 out of 8) and Intersection Channelization (4 out of 8). The Traffic Circle was found to be the most commonly (5 out of 8) implemented measure in past, however, it is interesting to note that only 2 out of 8 respondents indicated that they were considering the use
of this measure, and only 3 out of 8 supported the use of this measure for its intended function. Speed humps with Road closures were indicated as the least desired (2 out of 8) traffic calming measures.

<table>
<thead>
<tr>
<th>Measure</th>
<th>No. Of Respondent (B)</th>
<th>No. Of Respondent (C)</th>
<th>No. Of Respondent (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Raised crosswalk</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Raised intersection</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3. Speed hump</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>4. Chicane</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5. Curb extension</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>6. Median island</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. Traffic circle</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>8. Diverter</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>9. Road closures</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>10. Intersection channelization</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>
Approximately 75% of the participants indicated that their corresponding municipalities do not have their own traffic calming guidelines. In response to Question No. 6, regarding the most commonly used criteria in the selection of traffic calming measures, the most commonly used criteria were; i) Residents request, and ii) the success of a measure in other municipalities. The following results were obtained in response to question No. 6 and are presented here in order of preference:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>No. of Respondent Selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residents requests</td>
<td>7</td>
</tr>
<tr>
<td>Success of a measure in other municipalities</td>
<td>7</td>
</tr>
<tr>
<td>Council directive</td>
<td>5</td>
</tr>
<tr>
<td>Engineering judgment</td>
<td>4</td>
</tr>
<tr>
<td>Implementation and future maintenance cost</td>
<td>4</td>
</tr>
<tr>
<td>Warranted</td>
<td>2</td>
</tr>
</tbody>
</table>

In response to Question No. 7, regarding who initiates the consideration of implementation of a traffic calming measure. 7 out of 8 times the respondents indicated that it is the Residents who initiate. The results of the survey are presented below in the order of most preference choice:

<table>
<thead>
<tr>
<th>Initiated by</th>
<th>No. of Respondent Picked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residents</td>
<td>7</td>
</tr>
<tr>
<td>Business Development Associations</td>
<td>1</td>
</tr>
<tr>
<td>Council</td>
<td>1</td>
</tr>
<tr>
<td>Transportation Staff</td>
<td>1</td>
</tr>
</tbody>
</table>

In response to a question regarding the additional implementation costs for traffic calming measures, as compared to conventional systems, the majority of the respondents did not answer this question. However, 2 out of 8 respondents indicated that additional implementation costs
for traffic calming may range between 0% and 75%. When asked about future maintenance costs, 3 out of 8 indicated that the maintenance costs for a traffic calmed street would be more, 2 out of 8 indicated it would be the same and 3 participants did not respond.

Local residential streets were the most popular choice among transportation professionals as the road class they would most like to implement traffic calming measures on. Residential collector streets were also identified as potential candidates, but for selected measures only. Only one of the respondents indicated that traffic calming devices such as median islands, intersection channelization, and curb extensions may also be implemented along arterial roads.

For those who would not consider the use of a traffic calming measures, their main reasons were; i) false sense of pedestrian, cyclist and vehicular safety, and ii) additional capital and maintenance costs. The aspect which was perceived to be the least affected by the use of traffic calming, is the lower standards for roads. Results of the survey are presented below in order of the most preferred reasons:

<table>
<thead>
<tr>
<th>Reason</th>
<th>No. of Respondent Selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>False perception of safety - vehicular, cyclist, pedestrian</td>
<td>5</td>
</tr>
<tr>
<td>Additional capital and maintenance cost</td>
<td>4</td>
</tr>
<tr>
<td>In your view traffic calming does not achieve its intended function</td>
<td>3</td>
</tr>
<tr>
<td>Lack of information regarding the systems performance</td>
<td>3</td>
</tr>
<tr>
<td>Perceived lower standards for roads</td>
<td>0</td>
</tr>
</tbody>
</table>

As the installation of traffic calming measures extend to collector and arterial roads, it was felt that the opinion of the municipal transportation professionals, towards the extension of traffic calming measures, will provide valuable direction for future traffic calming installations on these type of streets. Question No. 11 asked the participants about their level of comfort while driving on a local residential, residential collector, and arterial streets with traffic calming measures. The results of the survey indicated that 85% of participants felt comfortable driving along a local residential streets with traffic calming. Nearly 71% did not feel comfortable driving along collector streets.
with traffic calming. Almost 85% felt either very uncomfortable or not comfortable driving along arterial streets with traffic calming measures. Figure 4.2.1 summarizes the responses.

Figure 4.2.1  How comfortable do you feel driving along a street with traffic calming measures?
5.0 ENERGY CONSUMPTION AND AIR POLLUTION

The transportation industry overall, and the automobile in particular, is the single largest oil consumer in Ontario, and the fastest growing air pollution threat that we face today. Figure 6.1 shows that transportation consumes more than half of the oil produced in Ontario. As a result of this consumption, we are contributing greatly to the air pollution problem. The main vehicle emissions are carbon dioxide (\( \text{CO}_2 \)) and air pollutants such as; carbon monoxide (\( \text{CO} \)), nitrogen oxides (\( \text{NO}_x \)), oxides of sulphur (\( \text{SO}_x \)), hydrocarbons (\( \text{HC} \)), and other suspended particulate (\( \text{SP} \)) matter. In the city of Toronto, road vehicles account for 93% of carbon monoxide, 70% of nitrogen oxides, 75% of total hydrocarbons, and 38% of suspended particles in our atmosphere. This translates into approximately 132 kilotons of \( \text{CO} \), 16 kilotons of \( \text{NO}_x \), and 0.6 kilotons of suspended particles emitted into Toronto's air annually (8).

![Total Oil Consumption in Ontario, 1981](image)

**Figure 5.1.0** Total Oil Consumption in Ontario, 1981

5.1 Impact on Human Health

In addition to the five major pollutants (CO₂, CO, NOₓ, HC, and SP) present in the exhaust emissions of gasoline-burning cars, nitrogen oxide and hydrocarbons interact in the sunlight to form a sixth pollutant, ozone. Air pollution aggravates coughs and sore throats, hampers breathing in asthmatics, prevents lungs from functioning properly, and adversely affects people with cardiovascular and chronic respiratory diseases. Research indicates that chronic obstructive lung diseases such as asthma, bronchitis and emphysema are the most significant long-term effects of air pollution. Studies in the U.S. show that most of the air toxic cancer risk in urban areas is due to emissions from road vehicles. Furthermore, urban areas have higher death rates from lung cancer and lung disease than rural areas, which may (in part) be due to air pollution (9).

Other pollutants from vehicles also have health consequences. Diesel-fuelled vehicles emit particulate at a rate of 50 to 80 times that of their gasoline-fuelled counterparts. As such, there is a major cause for concern related to their contribution to lung disease and cancer. On the other hand, they emit a relatively small percentage of other pollutants. Lead in the air and soil is due in part to exhaust from vehicles using leaded gasoline. Even though leaded gasoline has not been used in Canada since 1990, the residues remain in the soil. Lead toxicity affects the central nervous system, kidneys and blood synthesis, especially in young children. Sulphuric acid in the form of acid rain, produces acid aerosols which have been associated with lung dysfunction, also most common in children.

5.2 Impact on the Environment

Air pollution is largely produced by human activities such as industrial production, and the operation of automobiles. In addition, a significant amount of pollution is transported into southern Ontario from the heavily industrialised Midwestern U.S. Air pollution is also caused to a lesser extent by emissions from natural resources including plants, forest fires, volcano eruptions, etc. The most widely studied environmental impacts associated with air pollution are global warming and acid rain precipitation.
5.2.1 Global Warming

An increase in the greenhouse effect from airborne pollutants is potentially the most serious environmental consequence of automobile use. An increase in the naturally occurring greenhouse effect could have serious consequences on forest, coastal and other ecosystems, as well as on agriculture and human life. The greenhouse effect has been strengthened by emissions of human activities. Carbon dioxide is responsible for about 60% of the strengthening. Emissions related to transportation account for 30% to 40% of the total CO₂ emissions in Ontario. Of this, 60% is from gasoline-powered vehicles (10).

5.2.2 Acid Rain

Vehicle emissions contain a mixture of many chemical contaminants, including oxides of nitrogen (NOₓ) which are significant contributors to acid precipitation. Acid precipitation has been directly linked to reduced agricultural productivity, the destruction of some species of trees and plants, the disruption of delicate aquatic systems, and the accelerated deterioration of building and structures (11).

5.3 Additional Fuel Consumption and Emissions from Traffic Calming

Three major concerns arise regarding vehicle operations on a traffic calmed street; their impact on human health, global warming, and undue consumption of energy resources. The portion of energy consumption and air emissions associated with vehicle operations on residential streets within Metro may not be as significant when considering the overall energy consumption and air emissions associated with the transportation problems in Metro. However, when it comes to achieving targets, and reducing overall problems, every effort must be counted. An extensive study by the City of Toronto, Healthy City Office, suggests that a significant reduction in air emissions can be achieved by altering road use. One of the approaches proposed was traffic calming. It would be helpful to determine the impacts of traffic calming efforts on energy consumption and air pollution, particularly when the demand for the installation of traffic calming measures, on all types of streets, is on the rise.
When it comes to the environmental impacts of traffic calming, many of the studies carried out provide only general statements. Either air quality may be improved due to a reduction in traffic volume, or traffic calming has no impact on the environment. These statements may not be very useful when it comes to a city the size of Toronto, with millions of vehicle trips made every day. The studies indicate that there are nearly $4.61 \times 10^6$ vehicle kilometre travelled (VKT) within metro Toronto on non-expressway roads (12).

The number of factors that influence a vehicle’s fuel consumption and contribution to emissions is large. The following section analyses the impacts on oil consumption and emissions, as a result the implementation of various traffic calming measures.

5.3.1 Speed Humps

For a speed hump to be an effective traffic calming device it is recommended that a spacing of 80m and 125m be used between two successive installations for speeds of 40 km/h and 50 km/h respectively. In Britain a spacing of 40m is suggested to attain an average speed of 32 km/h at the midway point (13). However, using an average spacing of 80 - 100 m, a one kilometre road section would require, on average, 10 - 12 series of speed humps. Studies indicate that most cars travel at a speed of 25 km/h over a hump, and the Transportation Energy Analysis Manual indicates that speed changes consume extra fuel compared to uniform speeds. The majority of Toronto streets have posted speed limits of 40/50 km/h and the 85th percentile speed is generally 45 km/h. The implementation of speed humps requires a change in speed from 40km/h to 25km/h and a return to 40 km/h (40-25-40), at every speed hump installed. It is determined from figure 5.3.1 that for a speed change, 40-25-40, the rate of additional fuel consumption is 12 ml/speed change. With 10 speed hump installations per kilometer, to achieve desired 85th percentile speeds, the additional fuel consumption is as follows:

\[
\text{Additional fuel consumption per VKT} = (\text{No. of speed Changes/VKT}) \times (\text{ml/speed change}) = (10 \text{ speed changes/VKT}) \times (12 \text{ ml/speed}) = 120 \text{ ml/VKT}
\]
Many studies indicate that vehicle operating speeds are reduced to 25 km/h through a chicaned portion of a road, and speeds range from 40 - 50 km/h between two installations. A before-after study carried out in Toronto indicates that the 80th percentile traffic speed was reduced from 45 km/h to 30 km/h in an area traffic calmed using chicanes in combination with raised intersections. Using figure 5.3.2 it is determined that a uniform speed reduction from 45 km/h to 30 km/h increases the fuel consumption by 30 ml/VKT. Also in areas with chicanes, where the speed limits remain at 40 or 50 km/h, a change in speed from 45 km/h to 25 km/h and back to 45 km/h (45-25-45) occurs. This causes additional fuel consumption on the street and is very similar to the speed humps, approximately 90-100 ml/VKT.

a) Additional fuel consumption due to uniform speed reduction = 30 ml/VKT

b) For a 45-25-45, speed change process:

Using a chicane length of 25 m and a spacing of 100 m between chicanes, a one kilometer long street will require installations of chicanes at 8 different locations along the street to obtain desired traffic calming objectives.

Additional fuel consumption due to speed change per VKT = (No. of speed Changes/VKT) * (ml/speed change) = (8 speed changes/VKT) * (12ml/speed change) = 96 ml/VKT

Additional fuel consumption due to the use of Chicane = (a+b) / 2 = (30 + 96) / 2 = 63 ml/VKT
5.3.3 Narrow Intersections

In many instances, intersections have been narrowed using measures such as concrete traffic islands with planters, or curb build outs which make the maneuvering of vehicles and bicycles difficult. This is also observed to cause an additional delay of approximately 8-10 seconds at each intersection. It is further analysed from the available data that the majority of the intersections in Toronto are about 150 m apart. The Transportation Energy Analysis Manual indicates that an idling gasoline engine uses about 3.5 litres per hour. This translates into additional fuel consumption on roads with such measures (15).

No. of Intersections per road kilometer

\[= \frac{1000 \text{ m}}{150 \text{ m}}\]

\[= 6 - 7 \text{ intersections / km}\]

Additional delay at each intersection

\[= 8 - 10 \text{ seconds / intersection}\]

Using idling fuel consumption

\[\text{of} \ 3.5 \ l/h \text{ additional fuel consumed}\]

\[= (6 \text{ inter./km}) \times (8 \text{ sec/inter.}) \times (3.5 \text{ l/h})\]

Additional fuel consumed

\[= 47 \text{ ml/VKT}\]

5.3.4 Traffic Circles

Traffic circles are believed to cause an additional delay of approximately 5-8 seconds per installation. This would require additional energy consumption based on the frequency of installations (16).
It is well known that traffic calming measures are effective only if they are used in combination with proper frequency. Considering these factors, and the fact that additional fuel consumption varies from one measure to another, it is estimated that on average, traffic calming measures increase the fuel consumption of a vehicle by approximately 70-75 ml/VKT \([((120\text{ml} + 63\text{ml} + 47\text{ml}) / 3 = 76.6\text{ml})]\). This increase is associated with the direct impact that traffic calming measures have on fuel consumption. Also to be considered, is the impact that diverted vehicles may have on the environment due to longer travel times, or congestion that may be caused on other routes.

The rate of CO\(_2\) emission for automobiles is directly proportional to the amount of fuel which is burned. Using available information, Table 5.3.1 summarises the additional fuel consumption and emissions caused by the implementation of traffic calming (17).

### Table 5.3.1

**Estimated Additional Fuel Consumption and Emission from Traffic Calming**

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount per 1000 VKT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>70.0 L of gasoline</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>170 kg</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>31.3 kg</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>2.05 kg</td>
</tr>
<tr>
<td>Nitrogen oxides</td>
<td>0.70 kg</td>
</tr>
<tr>
<td>Additional vehicle operating cost (at $0.55/L)</td>
<td>$38.5</td>
</tr>
</tbody>
</table>

In general, within urban areas the light vehicles average a milage of nearly 100 km/10-12L of fuel consumed. This indicates that the total consumption of a vehicle is approximately 85-100 ml/VKT. An increase of 70-75 ml/VKT in fuel consumption, due to the implementation of traffic calming, suggests an increase of 70-80% in the total fuel consumption of a vehicle. Which means that the implementation of traffic calming measures nearly doubles the total fuel consumption of a light vehicle.

Some traffic calming studies claim, without providing any detail, that traffic calming measures reduce energy consumption and air pollution. This is a claim that seems quite contrary to the results obtained in this study. Perhaps those studies assume that lower traffic volumes on a traffic calmed street means less vehicles in the network, or a lower number of trips. The survey carried out as part of this study clearly indicates that traffic calming has no impact on people’s mode selection, which means no reduction in trip generation. It is noticed that generally, in a traffic calmed area, the traffic volume remains the same unless the measures implemented are so drastic that drivers are left with very little choice. Even then the number of trips generated are not reduced. People simply divert to other streets, which relocates the problem. Many traffic calming studies are limited to the streets where the calming measures are implemented and hence tend to overlook the impacts they may have on the neighbouring streets.
Figure 5.3.1 Additional Fuel Consumption due to vehicular speed changes (light vehicle).

Example: For a speed change, 80-24-80 km/h, rate of additional fuel consumption is 46 mL/speed change.

Figure 5.3.2 Fuel Consumption from driving at various uniform speeds (light vehicle).
Example

In order to realize the impact that traffic calming measures may have on our environment, it would be helpful to further quantify the results of Table 5.3.1. If only 5% of the total vehicle kilometres travelled within Metro on non-expressway roads occur on traffic calmed streets, the estimated additional fuel consumption and emissions would be as follows:

Sample Calculation

Considering 5% of the total trips on non-expressway roads are on traffic calmed streets

Estimated VKT within Toronto on non-expressway roads = 4.61 x 10^6 VKT

The VKT on traffic calmed streets = (5%) * (4.61 x 10^6) = 230,500 VKT

From Table 5.3.1 additional fuel consumption per 1000 VKT = 70 litres
From Table 5.3.1 additional CO₂ emission per 1000 VKT = 170 kg

Therefore,

Estimated additional fuel consumed by the VKT on traffic calmed streets will be = (70/1000) * (23,0500) = 16,135 litres / day

Estimated additional CO₂ emission by the VKT on traffic calmed streets will be = (170/1000) * (230,500) = 39,185 kg = 39.185 tonnes / day

Estimated additional user cost for the VKT on traffic calmed streets will be = (16,135 litres / day) * (0.55$/litre) = $8,875 / day
6.0 SAFETY CONSIDERATIONS

The safety issues associated with the use of traffic calming are related to motorists, cyclists and pedestrians. The objective of a traffic calming measure is to improve safety for non motorized street users and to reduce conflicts between vehicles, pedestrians, and cyclists (vehicle-bicycle, vehicle-pedestrian and bicycle-pedestrian). The road and traffic components that may influence safety include road characteristics, weather conditions, driver behaviour, vehicle conditions, and numerous other factors. Traffic calming measures that may influence safety include; i) road width, horizontal and vertical obstructions within travelled portions, ii) vehicle speed, vehicle volume, iii) presence of non motorized street users and, iv) availability of bicycle/pedestrian space and its off-set from motorized traffic.

6.1 Non-motorized Street Users

It is important that the facilities provided for non motorized street users are perceived to be safe and secure. For pedestrians, this means freedom from conflict with motor vehicles, and lessens the risk of tripping on uneven surfaces. For cyclists, in addition to freedom of conflict, it also means wider curb lanes, improved pavement surfaces, and parking facilities.

6.1.1 Pedestrian Safety

The Ontario Road Safety Annual Report (1994) indicates that more than 50% of pedestrian accidents are intersection related. Many of the traffic calming treatments provided at intersections, such as raised intersections, impressed crosswalks etc., provide a false sense of security to the pedestrian. In many instances, the use of impressed concrete in pavements for cross-walks is perceived as a right of way by pedestrians. This creates a false sense of security and puts pedestrians at risk. In addition, other traffic calming measures, such as traffic circles, increase pedestrian walking distances, thereby increasing their conflict with vehicles. With respect to the documented causes of accidents, no information was found during the course of this study to provide viable statistics on urban accidents which may have been caused by traffic calming related features. (18).
Attitude surveys are generally considered a reliable source of information. The survey carried out in areas with traffic calming indicates that 54% of the participants indicated that traffic calming does not reduce pedestrian-vehicle conflict, while 10% believed that traffic calming has increased the pedestrian-vehicle conflict.

The majority of the traffic calming implementation studies, identified children and the elderly as the most vulnerable victims of pedestrian-vehicle accidents. However, an analysis of the pedestrian accident data presented in the Road Safety report indicates that in 1994, 54% of fatal accidents included pedestrian between the age of 17 - 54.

6.1.2 Bicycle Safety

Bicycle safety has been a concern in the metro area for long time and has recently started getting attention from transportation experts and local politicians. While encouragement programs are important, bicycle use will not reach its full potential until people feel that streets are safe for cyclists. The main concerns are traffic congestion, lack of bike paths, lack of on-street bike lanes, narrow curb lanes, lack of parking facilities, and poor road surface condition. These are the areas where improvement will be positively perceived by both current and potential bike users. (19).

It is important that any effort made by transportation professionals, to improve conditions for cyclists, must incorporate these basic needs into their plans. This study looks at the various traffic calming measures used in order to determine the impact that they may have on cyclists.

Reduced vehicle volume on a street may encourage cyclists, and may also reduce conflict due to lower volumes. However, lower speeds on a street will not reduce vehicle-bicycle conflict, it may only reduce the severity of injury caused to the cyclist. In other words, you may still get hit by a vehicle, but due to the lower vehicle speed your injury will not be as severe, or you may not be injured at all.

An attitude survey carried out in areas equipped with traffic calming measures, and results shown
in figure 4.1.4, indicate that nearly 79% of the participants indicated that they feel either not comfortable (35%) or very uncomfortable (44%) riding a bicycle on a street treated with traffic calming measures. Only 3% indicated that they feel comfortable riding a bicycle on a street with such treatments.

It is further observed that some traffic calming initiatives, including narrow curb lanes, chicanes, curb build outs, and center medians, reduce roadway width and increase vehicle-bicycle conflicts. Chicanes and other lateral build outs, when applied at mid blocks and at intersections, leave very little room for bicycles to manoeuvre with two way vehicle traffic, especially on local streets where most of the cyclists are children. Also, these installations block the portions of the street used by cyclists, forcing the cyclists to sewer out, which increases their exposure to traffic. Many such installations when used in Europe generally provided gaps between the curb and the calming device, as shown in figure 6.1.2. This gap separates bicycles from the vehicles and therefore was perceived as a safer path for cyclists. However, the measures used within Toronto are considered to be a threat to cyclists (20).

Speed humps as well as raised intersections and raised cross walks are perceived as extremely inconvenient for bicycles as they frequently heave or settle. Traffic circles increase travel distance for cyclists, and are also considered unsafe due to the confusion caused by their unfamiliarity to users.
Figure 6.1.2  Gap between the curb and traffic calming measure to be used by cyclist

Source:  Traffic Calming in Practice
6.2 Motorized Street Users

Even though the objective of traffic calming is to improve conditions for non-motorized street users, motorized traffic forms a major component of the traffic flow. The safety objectives for non-motorized users can not be achieved until the concerns for motorized traffic are considered. The presence of traffic calming measures divert driver's attention, reduce maneuverability, cause frustration and increase stress levels. Research indicates that as frustration, annoyance, and discomfort increase, drivers become more aggressive and inclined to take more risks. This not only jeopardizes vehicular safety, but also increases risks for cyclists and pedestrians, thereby decreasing the quality of life within the neighbourhood.

Our attempts to improve safety for non-motorized users, through the implementation of traffic calming measures, do not achieve the predicted results. Some of the traffic studies conducted within metro indicate that 70% or more of the traffic on neighbourhood streets is local traffic. It is clearly noted in our survey that the majority (85% of the participants) of drivers do not change their routes because of traffic calming on a street, which indicates no significant volume change. Many of the measures used are unable to reduce speed. The ones which do reduce speed such as speed humps, and chicanes cause difficulties for non motorized users as well. Also, its been noticed that speed goes down initially but it comes back once the drivers adjust to these changes.

Many of the traffic calming measures, when initially used in European cities, were regulated or reinforced with traffic signs indicating right of way, figure 6.12. However, in our attempts to reduce the number of signs in our neighbourhoods, these right of way signs are not used with current traffic calming initiatives. This causes confusion on the road right of way for all users. The Ontario Road Safety Annual Report (1994) indicates that about 10% (41896 accidents) of all accidents in Ontario are due to the failure to yield right of way. Implementing traffic calming measures such as chicanes, without appropriate signs, may create situations which have the tendency to increase such accidents (21).
The Ontario Road Safety Annual Report (1994) indicates that a large number of accidents (40%) are wet weather related. It further indicates that the highest percentage of accidents occur during the winter months, January 1994 accounts for nearly 12.6% of the accidents that year. This situation may worsen due to the lateral and vertical deflections, as well as the narrowing of the travelled portion of the street caused by traffic calming measures. The report further indicates that in 1994, accidents involving curbs at normal locations accounted for 21 fatal accidents. With our depleting road maintenance resources, and longer snow accumulation periods, these deflections could be quite problematic.

A recent study carried out by the City of Portland, Oregon, indicates that traffic calming devices delay emergency vehicles by increasing their response time. The study suggests that depending upon the type of vehicle responding, a speed hump creates a delay of 1.0 to 9.4 seconds per hump, and a traffic circle might delay an emergency vehicle by 1.3 to 10.7 seconds. This reduced response time should be taken into consideration when determining the overall traffic calming benefits (22).

### 6.3 How to improve Safety

Road safety is such a critical issue that it was felt necessary to further analyse the Ontario Road Safety Annual Report (1994). The report classifies accident data and identifies apparent driver action. It was noticed that 55.1% of the accidents were caused by drivers under the age of 25. Even though it is the main reason to implement traffic calming, speeding accounts for a very small number of accidents. However, no matter what caused these accidents, it was noticed that when it comes to road safety and quality of life along our streets, traffic calming may not achieve the desired results.

As the implementation of traffic calming measures do not improve the conditions for non motorized users, the study suggests that in addition to many other initiatives, the following steps may help to achieve these desired results:
Proper driver education, followed by adequate enforcement, is a key to the safety of all road users.

Facilitate walking by addressing the real needs of pedestrians: such as maintaining sidewalks for safety, better winter/wet weather protection, and accessibility to all. It is noticed that many intersections within metro are still missing ramps at intersections, and many of the transit stops are unsheltered (even along Yonge Street the busiest street in Toronto).

Promote the use of the bicycles by providing wider curb lanes, on-street bike lanes, and parking facilities.

Encourage public transit use, and improve the public transit image with proper promotion.
7.0 ECONOMIC CONSIDERATIONS

Generally, the costs associated with any road facility, include the capital construction cost and the future maintenance cost. For traffic calming measures, the cost would be based on the measures to be installed, their frequency, road or intersection width, labour or material cost in the area, and other necessary road side improvements (such as installation of curb etc.) to ensure that the measures installed are effective. The Canadian Guide to Neighbourhood Traffic Calming provides general cost estimates of individual devices, and a summary of these costs is provided in Table 7.1.1.

7.1 Capital Expenses

It is well known that capital construction costs can vary broadly from place to place depending upon the availability of local materials, labour, weather conditions and so on. It was considered more appropriate to examine an area within Toronto to better perceive the capital costs associated with traffic calming. For this purpose, the area chosen was South Eglinton, shown in figure 7.1.1, approximately 1 km x 1 km square, and recently treated by the former City of Toronto. The traffic calming measures installed included: curb build-outs at major roads (24 locations), curb build-outs at strategic internal intersections (14 locations), and curb build-outs at two schools and playgrounds (3 locations). The estimated cost for this initiative was $270,000.00. This indicates a cost of approximately $6585 per installation. According to recent information, in the August 1998, Toronto Star, this treatment has been rejected by the area residents and will be removed by the City for an estimated cost of $100,000.00 (23).

Another example from the same area is Balliol Street from Mount Pleasant Road to Cleveland Street, Toronto, shown in figure 7.2.1. The total length of the treated section is 750 meters. The measures installed include; five raised and narrowed intersections, seven mid-block curb build-outs, decorative pavers, and increased vegetation. An estimated cost for the traffic calming measures, along this section of road, alone was $300,000.00. An additional cost of $430,000.00 was estimated for the reconstruction of the street itself. In simple terms, this shows that the
traffic calming treatment cost on Balliol Street was approximately $400 ($300,000/750m) per linear meter of street treated, and each installation cost nearly $25,000 (24).

As is obvious from the South Eglinton Area study, the implementation of low cost measures have no benefits at all, and the installation of such measures have failed. However, the treatment similar to the one used on Balliol Street has received favourable acceptance in other neighbourhoods. This type of treatment is more elaborate, and is more accepted by the area residents. It is therefore felt that only similar treatments will achieve some traffic calming objectives, and hence can be considered a guide to estimate capital construction costs.

It is also observed that the majority of traffic calming devices are recommended to be installed on roadways with a curb and gutter road environment. This means that in order for calming to be effective, a road side environment must contain a curb and gutter. Many of the local residential streets within metro still have ditches on either side. In the former municipality of Etobicoke alone more than 30% (nearly 240 km) of the road network has ditch side environment. Many of these streets may even require the installation of storm sewers if replaced with curbs and gutters. Not considering the cost of a storm sewer, it is estimated that a curb and gutter installation costs approximately $65-$70 per meter length. This would increase the cost of a road by $130-$140 per linear meter length, in order to treat it with traffic calming measures.
Based upon the local construction practices, and contracts awarded in the past, the total capital cost for traffic calming implementation on two different type of streets (a standard 8.5m wide curb and gutter street, and a standard 7.5m wide ditch street) are compared in the table below. The implementation of traffic calming along an urban street with a curb and gutter increases the total road construction cost by 50-60%, and for a ditched street, the installation of traffic calming measures can easily double the total construction cost of a street.

<table>
<thead>
<tr>
<th>Curb Street</th>
<th>Ditch Street</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost ($/m)</td>
<td>Capital Cost ($/m)</td>
</tr>
<tr>
<td>No Traffic Calming</td>
<td>With Traffic Calming</td>
</tr>
<tr>
<td>700 - 800</td>
<td>1100 - 1200</td>
</tr>
</tbody>
</table>

* The total construction cost of $1200-$1300 per linear meter for a ditched street with traffic calming includes the additional costs of; $400/m for traffic calming devices, $130-$140/m curb and gutter installation on both sides of the road, and the replacement of road shoulders with pavement structure. This cost does not include costs associated with the implementation of storm sewers. The installation of a storm sewer may require an additional $400-$500 per linear meter.
Table 7.1.2
Typical Suggested Cost Associated with Different Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cost per Installation ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Raised crosswalk</td>
<td>2,000 - 10,000</td>
</tr>
<tr>
<td>2. Raised intersection</td>
<td>20,000 - 75,000</td>
</tr>
<tr>
<td>3. Speed hump</td>
<td>1,000 - 5,000</td>
</tr>
<tr>
<td>4. Chicane</td>
<td>10,000 - 25,000</td>
</tr>
<tr>
<td>5. Curb extension</td>
<td>3,000 - 10,000 per side</td>
</tr>
<tr>
<td>6. Median island</td>
<td>5,000 - 10,000 per island</td>
</tr>
<tr>
<td>7. Traffic circle</td>
<td>5,000 - 10,000 - 30,000</td>
</tr>
<tr>
<td>8. Diverter</td>
<td>10,000 - 20,000</td>
</tr>
<tr>
<td>9. Road closures</td>
<td>2,000 - 10,000</td>
</tr>
<tr>
<td>10. Intersection channelization</td>
<td>3,000 +</td>
</tr>
</tbody>
</table>

Figure 7.1  Eglinton South Area

Source: City of Toronto
Figure 7.2.1 Balliol Street Traffic Calming Pilot Project.

Source: City of Toronto
7.2 Maintenance Expenses

The most obvious maintenance cost for a traffic calmed street are increased snow removal and sweeping costs, and general wear and tear on the devices which will probably be higher due to the unusual situation of the traffic calming devices. However, as our available resources for the maintenance of transportation infrastructure deplete constantly, it is important that the following points be carefully analysed prior to making any decision that could potentially cause higher future maintenance costs.

First, to ensure the cost effectiveness of a device, it is generally recommended that the traffic calming devices be installed during the reconstruction of a street. The pavement management techniques used by many road authorities indicate that the road life expectancy is increased with various timely maintenance strategies, other than reconstruction. In fact, on many urban streets, reconstruction is considered the least cost effective option. It is felt that the adoption of traffic calming measures will trigger the premature reconstruction of many urban streets.

Second, the presence of traffic calming may deter or limit the use of certain road maintenance strategies such as resurfacing, and hot and cold in-place recycling, which may lead to future problems with infrastructure maintenance. The life expectancy of a local street with appropriate maintenance is 50-60 years, and road resurfacing is a key component in the pavement management process. Many of the traffic calming measures installed restrain future road maintenance programs, thereby decreasing life expectancy and hence increasing the cost to maintain. Future road maintenance strategies such as resurfacing, even if used, will require some special adjustments or removal and reinstallation of traffic calming measures, thereby increasing the maintenance cost drastically.

Third, there are numerous utilities, such as watermain, sanitary, Bell, Hydro, Cable, Gas, within the road right-of-way. To provide a proficient service, all these utilities constantly require road cuts for different reasons, whether it is a maintenance problem or a new connection. With expensive traffic calming measures on roads, these utility companies will have to pay higher
Traffic Calming
Within Toronto

restoration costs.

It is also noticed that some of these measures are basically installed to reduce street width. The traffic calming installations within metro indicate that most of the space freed up in the calming process is not utilized by pedestrians, cyclists, or even by the drivers, with the exception of parking. If we have realized that a 5.5 m or 6.5 m road width is sufficient for our urban traffic use, why do we keep building 8.5 m and wider road ways, and then install traffic calming measures to narrow them? It is estimated that within the metro area, road reconstruction costs nearly $90/m². This further indicates that on a 1 km long section, an additional $200,000 - $270,000 are spent on pavement structure which is not even intended to be used as a part of a roadway. The argument is that if this portion is provided for bicycle use or parking purposes, then why do we need such an elaborate pavement structure? It may be appropriate to build this section differently to serve different purpose.
8.0 PLANNING AND IMPLEMENTATION

8.1 What is necessary for successful planning?

Traffic calming experts agree that it is difficult to provide a successful recipe for the planning and design of traffic calming measures. It is well established that traffic calming treatments must be tailored for each specific site, and checking off elements from a standard list may even be more harmful than the benefits it can provide. The selection of a particular measure, or combination of measures to be part of a treatment, must be based on the combination of local needs, local knowledge, design expertise, and careful judgement.

There are different approaches available in technical guides and textbooks, which provide the fundamental principles involved in planning a successful implementation, and maximizing the effectiveness of a traffic calming treatment. Most approaches recommend that intensive public support and political consensus are the keys to success for any traffic calming treatment. There is no doubt that these two elements play a major role in the success of any transportation project. However, the search carried under this study urges that in addition to securing intensive public support and political consensus, a successfully planned traffic calming strategy must also consist of the following fundamental principles:

8.1.1 Problem Identification and Assessment

Although traffic calming can be applied to many different situations, it cannot provide solutions for all traffic problems. As the general public notices the use of traffic calming measures in various jurisdictions, they sometimes unrealistically perceive these measures as a solution to the traffic problems of their communities. As a result, the undue demand for the implementation of traffic calming measures propagates. Based on the review of many Canadian case studies, and as a result of the survey carried out in this study, it is been noticed that the majority of the traffic calming measures installed are as a result of public demand. Confronted with this situation, it is important to distinguish a perceived traffic problem from a real problem, and to determine the
extent of the problem. For example, traffic data collection is a component of the problem identification and assessment process. Many jurisdictions collect data such as traffic counts, vehicle classification counts, speed studies, licence plate traces, parking surveys, and collision information. Information regarding pedestrian and cyclist flow is rarely gathered. As the main objective of traffic calming is to reduce the negative impacts on non-motorized users of a roadway, it is necessary that the data collection process also include pedestrian counts, bicycle counts, and the general population density of the neighbourhood. Other traffic characteristics such as public transport routes and emergency routes should also be identified (26).

8.1.2 Street Classification

The purpose of traffic calming is to restore streets to their intended function. Some traffic calming experts claim that abiding by a conventional street classification system may not be necessary for the implementation of a traffic calming treatment. However, in the view of this study, for a transportation system to achieve its objectives and work efficiently, a street classification system which groups streets according to their character of service must be adopted. This leads to proper road safety planning, which benefits residential traffic control, strengthens the hierarchical structure of streets, and improves the quality of life. The Manual of Geometric Design Standards for Canadian Roads provides detailed descriptions of urban street classification. However, for traffic calming study purposes, residential streets can be simply classified into urban local (residential) streets, urban collector streets, and arterial streets (27).

8.1.3 Area Characteristics

The area characteristics of a neighbourhood are important factors when considering the implementation of a traffic calming treatment. These factors include the urban environment, proximity of houses from the pavement edge, lot sizes, road right-of-way, travelled surface width, flow of non-motorized street users in the area, provisions for cyclists and pedestrians and location of such provisions from driving surfaces, parks and open spaces in the area, as well as the overall climate of the area.
Many times, traffic calming treatments tend to utilize successful European examples to justify the implementation of these measures. It is worth noting that the road right-of-way in Europe is much narrower than that of the Canadian road right-of-way, the climate is significantly different, and the transportation needs are different. On European roads, the houses are generally closer to the driving surface, driving lanes are narrower, sidewalks are located immediately next to the curbs, and the road right-of-way is narrower as compared to our roads. As a result of these factors, residents and non-motorized street users may feel more vulnerable.

The safety concerns which exists in Europe may not necessarily exist, or be of the same magnitude, in our urban environment. Obviously, before any traffic calming action is carried out on a specific street or neighbourhood, it must be determined if a real safety concern exists, and the need for traffic calming implementation must be supported by area characteristics. Table 8.1.1 provides a comparison between general practices with regard to urban roadway width in Britain and Toronto (28).

Table 8.1.1
General practices with regard to roadway width

<table>
<thead>
<tr>
<th>Road Type</th>
<th>Road Width (m) Britain</th>
<th>Road Width (m) Toronto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Residential Streets</td>
<td>5.50 - 6.10</td>
<td>7.3 - 8.5</td>
</tr>
<tr>
<td>Residential Collectors</td>
<td>6.10 - 7.3</td>
<td>9.5 - 10.0</td>
</tr>
<tr>
<td>Arterial Streets (normal 2 lanes)</td>
<td>7.30</td>
<td>10.0 +</td>
</tr>
</tbody>
</table>

8.1.4 Area-wide Treatment

An area-wide implementation of traffic calming measures generally achieves better results as compared to an implementation on individual streets or small selected areas. The streets and areas to be included in a treatment plan must generate from the overall consideration of the network, the priorities of the community as a whole, and must not be left to the local politicians. An area-wide approach is also important because it is the only way possible to take into account the interconnections necessary to achieve an attractive pedestrian and bicycle network. This may also apply to the combining of traffic calming measures with public transit, and to avoid negative impacts on emergency. In reality, the best preparation for traffic calming is with a traffic development plan, which lays down the priorities and networks for traffic calming in the city as a whole (29).

8.1.5 Improvements to Arterial Network

Generally speaking, it is reasonable to suggest that drivers prefer to use arterial road networks over local residential streets. The lateral diffusion of through traffic from arterial or main roads, to adjacent local streets, occurs only if there is a reason to do so. Generally, the reason has been found to be congestion and delay on the areas arterial roads. It is extremely important that before we rush into the construction of massive traffic calming measures on residential streets, an arterial road network improvement plan should be seriously examined. Many times, minor operational changes such as adjusting traffic signal phasing and timing, adding turn lanes, turn prohibition, parking restriction, and effective enforcement of parking restrictions, may help to achieve adequate results and thereby eliminate the need for expensive traffic calming alternatives on residential streets.

8.1.6 Enhancing Non-Motorized Modes of Transportation

The purpose of traffic calming is to control vehicle traffic, alter driver behaviour, and improve conditions for non-motorized street users. The traffic calming measures installed must be designed so as not to have a negative impact on non-motorized users, and they must be more than
just obstacles for motorized traffic. A traffic calming strategy should not only have an impact on motor vehicle traffic, but it must also enhance the operating conditions for the non-motorized street users, and reclaim urban space for pedestrians and cyclists. For example, there is no point of narrowing down a 8.5 metre wide residential street to a width of 5.5 metre with massive concrete blocks and other intrusive measure if the recaptured 3.0 metre pavement can not be used by non-motorized users. Therefore, any recaptured portion of a roadway must be given back and utilized by the non-motorized users of the roadway.

8.1.7 Sound Design

As transportation professionals, we have long understood that the days of forcibly shaping communities are long gone, and our role is to provide the safest and most efficient transportation systems that conform to a community’s wants and needs. However, this does not mean an evening of simply counting hands at a neighbourhood community meeting. The fact is that even traffic-calmed roads are still roads. The design measures used for a traffic-calmed road must be highly acceptable, and must consider all of it’s users including pedestrians, cyclists, vehicles, public transit, and other services to the area. The design must be based on the needs of the urban environment in which it is being implemented, and the road safety concept for users must be maintained at all times (29).
**Planning and Implementation Process**

The following planning and implementation process, based upon the criteria discussed in previous sections, may be a helpful tool in future traffic calming initiatives.

![Flowchart](image)

Figure 8.1.1 Traffic Calming - Planning and Implementation Process
8.2 Traffic Calming Evaluation Criteria

In order to maximize potential benefits, and to determine when and where traffic calming would be appropriate, calming strategies must be evaluated under a well defined framework of goals, objectives, and measures of effectiveness which are consistent with our current transportation techniques. The goals and objectives of traffic calming have been briefly discussed in earlier sections, and for a measure to be sustainable, it must promote the overall objectives of traffic calming along with traditional road safety practices.

Primarily, a traffic calming treatment is implemented to improve neighbourhood protection, encourage transportation modes such as walking and cycling, discourage automobile use, and reduce pollution caused by vehicle exhaust. In order for the treatment to be effective and sustainable it must reflect improvements toward these elements. There are number of elements, based upon the specific needs of an area, that need to be considered for the applicability and effectiveness of a traffic calming treatment. The basic components that are felt to be a part of every treatment, are briefly described below.

8.2.1 Speed Reduction

One of the most apparent reasons to have a traffic calming system on a roadway is to reduce vehicle speed and increase safety for the non-motorized road users. The majority of our local residential streets, and many of the residential collector streets, have a posted speed of 40 - 50 kilometre per hour (kph). It is difficult to differentiate a safe operating speed within a narrow range, 30-50 kph. However, an operating speed of 40-50 kph is not perceived to be dangerous. The problem arises when drivers ignore posted speeds. Therefore, a system applied to control speed must have the ability to maintain vehicular speed within posted limits throughout the length of a treated street (30).