City of Brampton

Transportation and Transit Master Plan Sustainable Update 2009 Appendix G - Air Quality Strategic Direction

November 2009

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EXECUTIVE SUMMARY

Transportation (including transit) sources emit significant quantities of substances that directly impact the health of humans and change the climate we live in. Worldwide emission estimates of substances that cause climate change indicate transportation sources account for approximately 24% of equivalent carbon dioxide (CO_2) emissions. While in Ontario the transportation sector is responsible for approximately 26.4% of the nitrogen oxide (NO_x) emissions and 41.8% of the carbon monoxide (CO) emissions, but only 0.3% of the PM_{10} emissions province wide.

Studies indicate that both the number of vehicles and the distances being driven in Ontario are increasing, whereas emissions from each vehicle are decreasing as a result of improved engine technologies. It is also evident that much of the air pollution problem arising from urbanisation is related to motor vehicle use.

The City of Brampton can reduce emissions from the transportation sector in many ways including:

- Public Education and Consultation
- Command and Control Options
- Various Methods for Charging Users
- Subsidy Options
- Governance Options
- Municipal Act
- Local Offset Approaches
- Local Roads Infrastructure
- Fleet Mix
- Revising Zoning
- Reducing the Number of Vehicle Kilometres Travelled
- Technology Improvements
- Street Washing
- Installing “Pervious” Concrete Edges Along Roadways

Detailed descriptions of the above options including jurisdictions where some of these solutions are currently being employed are provided within this report.

TABLE OF CONTENTS

Appendices

Tables

Exhibits

1. INTRODUCTION

SENES Consultants Limited (SENES) is part of the HDR|iTRANS (iTRANS) team retained by the City of Brampton to conduct a Transportation and Transit Master Plan (TTMP) Update. This report:

- Provides an overview of transportation and transit based emissions affecting air quality
- Provides an overview of existing air quality conditions within the City of Brampton today
- Summarizes some potential solutions the City of Brampton could undertake to reduce transportation and transit based air quality emissions

Transportation (including transit) sources emit two primary groups of pollutants: Greenhouse Gases (GhG) and Criteria Air Contaminants (CACs). Studies also indicate that both the number of vehicles and the distances being driven in Ontario are increasing – both of which increase emissions. These facts coupled with the rapid growth of Brampton suggest air quality within the City could easily deteriorate in future years.

The transportation sector is a significant source of emissions affecting air quality; however the City of Brampton can reduce transportation sector emissions in many ways, which will be discussed in detail within this report.

1.1 Greenhouse Gas (GhG) Emissions

Transportation sources emit significant quantities of greenhouse gases (GHG) that directly change the climate we live in. Climate change emissions in terms of equivalent CO_2 emissions worldwide in the year 2000 were approximately 8 billion tonnes. That total is projected to rise to 16 billion tonnes by the year 2050. The 2000 emissions are made up from the following sectors:

- Electricity generation – 42%
- ***Transportation sector – 24% (almost 2 billion tonnes)***
- Industrial processes – 20%
- Residential and commercial uses – 14%

Table 1 below outlines GHG emissions from each Ontario transportation sector and compares them to overall Ontario GHG emissions. The primary transportation source within the City of Brampton is Road Transportation, which is the focus of this report. **Table 1** shows, in terms of CO_2-equivalents, that the Road Transportation sector in Ontario accounts for approximately 24% of overall Ontario GHG emissions. Through its Transportation and Transit Master Plan (TTMP) the City of Brampton can reduce GHG emissions from the Road Transportation sector.

Table 1: Greenhouse Gas Emissions from the Transportation Sector in Ontario

ONTARIO EMISSIONS	CO_2	CH_4	CH_4	N_2O	N_2O	TOTAL
Units	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq
Domestic Aviation	1690	0.1	1.9	0.2	62.0	1754
Railways	1400	0.1	1.7	0.1	18.6	1420
Domestic Marine	561	0.0	0.8	0.1	27.9	590
Others	12000	7.0	147.0	2.0	620.0	12767
Off-Road Gasoline	3000	4.0	84.0	0.1	21.7	3106
Off-Road Diesel	5600	0.3	6.3	2.0	620.0	6226
Pipelines	2970	3.0	63.0	0.1	24.8	3058
Light-Duty Gasoline Vehicles	16200	1.2	25.2	1.8	558.0	16783
Light-Duty Gasoline Trucks	16600	1.0	21.0	2.2	682.0	17303
Heavy-Duty Gasoline Vehicles	1270	0.1	1.3	0.1	27.9	1299
Motorcycles	67	0.1	1.1	0.0	0.0	68
Light-Duty Diesel Vehicles	144	0.0	0.0	0.0	3.1	147
Light-Duty Diesel Trucks	482	0.0	0.2	0.0	12.4	495
Heavy-Duty Diesel Vehicles	12000	0.5	10.5	0.4	124.0	12135
Propane & Natural Gas Vehicles	336	0.5	10.5	0.0	3.1	350
Road Transportation TOTAL	**47099**	**3.3**	**69.7**	**4.6**	**1411**	**48579**
TOTAL Transportation	62600	10.0	210.0	8.0	2480.0	65290
ONTARIO TOTAL GHG EMISSIONS	**174020**	**660**	**1000**	**38**	**12000**	**201000**
% Road Transportation of Total	**27%**	**1%**	**7%**	**12%**	**12%**	**24%**

Source: http://www.ec.gc.ca/pdb/cac/Emissions1990-2015/2006/2006_ON_e.cfm

1.2 Criteria Air Contaminant (CAC) Emissions

Transportation sources also emit significant quantities of Criteria Air Contaminants (CACs), which directly impact air quality and the health of humans. Significant portions of CAC emissions in Ontario are also from the Roads Transportation sector. **Table 2** below identifies total Ontario transportation emissions and the percentage of the total emissions caused by transportation sources. The table shows that the road transportation sector is responsible for 26.4% of the nitrogen oxide (NO_x) emissions and 41.8% of the carbon monoxide (CO) emissions, but only 0.3% of the PM_{10}.

Table 2: Selected Mobile CAC Emissions in Ontario

ONTARIO EMISSIONS	TPM	PM_{10}	$PM_{2.5}$	NO_x	VOC	CO
Mobile Sources	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
Air Transportation	300	300	293	23,838	3,608	17,410
Marine Transportation	1,328	1,276	1,174	14,146	475	1,204
Off-road use of diesel	9,293	9,293	9,014	100,854	10,297	50,541
Off-road use of gasoline/LPG/CNG	3,089	3,089	2,846	15,185	91,977	903,167
Rail Transportation	1,330	1,330	1,224	36,964	976	5,329
Heavy-duty diesel vehicles	1,450	1,450	1,339	66,919	2,473	13,516
Heavy-duty gasoline trucks	62	61	52	3,853	902	14,036
Light-duty diesel trucks	81	81	74	857	371	676
Light-duty diesel vehicles	43	43	40	325	112	515
Light-duty gasoline trucks	187	181	158	30,453	23,971	504,280
Light-duty gasoline vehicles	192	186	172	30,072	29,714	561,629
Motorcycles	6	6	4	401	1,267	5,027
Tire wear & Brake Lining	1,790	1,769	620			
Total Road Transportation	**3,811**	**3,777**	**2,460**	**132,880**	**58,811**	**1,099,678**
ONTARIO TOTAL AP EMISSIONS	**3,650,957**	**1,130,803**	**252,982**	**503,708**	**4,778,751**	**2,633,239**
% Road Transportation of Total	0.1%	0.3%	1.0%	26.4%	1.2%	41.8%

Source:http://www.ec.gc.ca/pdb/cac/Emissions1990-2015/2006/2006_ON_e.cfm
Note: TPM, PM10 and PM2.5 emissions do not include emissions from road dust

1.3 Vehicle Trends in Ontario

Studies indicate that both the number of vehicles and the distances being driven in Ontario are increasing, whereas emissions from each vehicle are decreasing as a result of improved engine technologies. It is also evident that much of the air pollution problem arising from urbanisation is related to motor vehicle use. **Exhibit 1** below shows that both the number of vehicles and the distances being driven were increasing up to 2003.

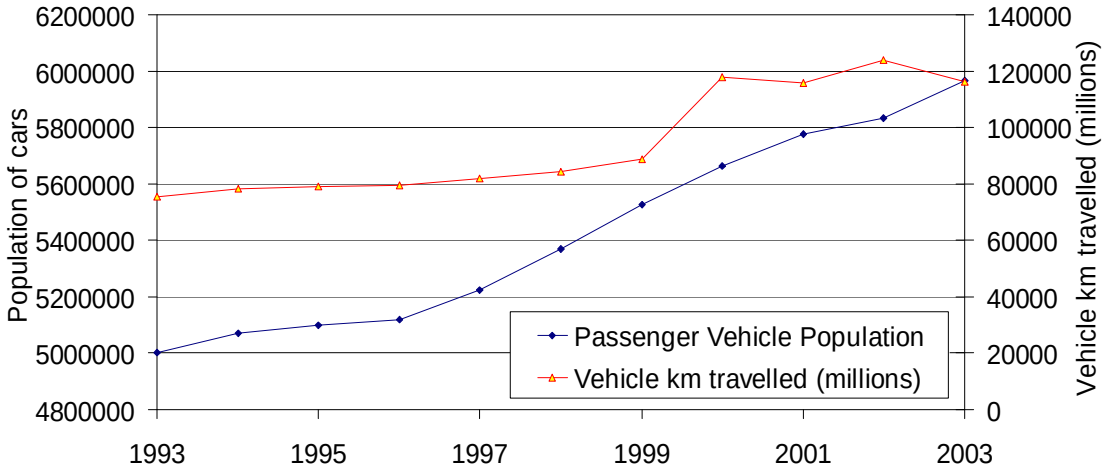


Exhibit 1: Vehicle Trends in Ontario

Emissions from vehicles, however, have been decreasing as a result of improved engine technologies. This is shown graphically in **Exhibit 2**.

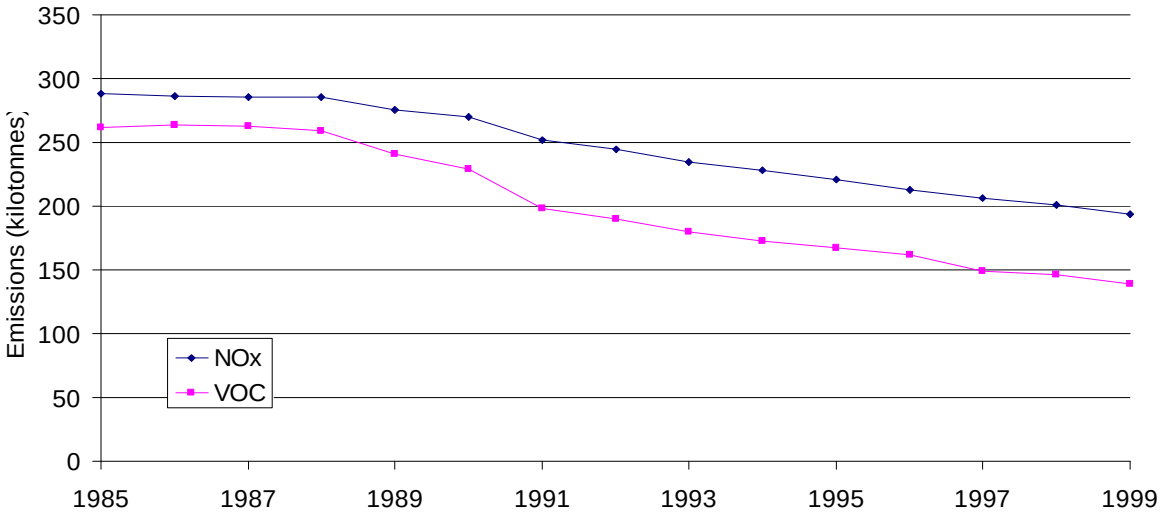


Exhibit 2: Vehicle Emissions in Ontario

It is also evident from the emissions numbers that much of the air pollution problem arising from urbanisation is related to motor vehicle use. Improvement (reduced emissions from the transportation sector) will likely require big sticks (higher fuel prices, congestion charges, etc.) and carrots (improved urban design and transit systems, etc.).

1.4 City of Brampton Green Initiatives

The City of Brampton maintains a leadership role in environmental protection and has launched a number of initiatives over the last few years. These include the following corporate initiatives related to transportation:

- Purchase of Smart Cars and hybrid vehicles for the City fleet.
- Use of biodiesel in Brampton Transit Vehicles.
- Use of low-emission street sweepers which use no water.
- Use of less winter salt through the use of high-tech Epoke salt spreaders and pre-spraying with a brine solution.
- In May 2005, the City switched form a hub to a grid system for transit (AcceleRide) to reduce travel times and made transit much more accessible to the public.
- partnering with Natural Resources Canada and the Clean Air Partnership (CAP) to educate the public about reducing engine idling in hot spots throughout the City.
- Working with other GTA municipalities, the City of Hamilton and Transport Canada to help reduce traffic congestion through the Smart Commute program.

The City of Brampton has also undertaken some transportation related *community initiatives* as follows:

- Street tree replacement program
- The Community Forest Project at Hurontario and Elgin Drive (absorbs transportation pollutants)

In 2005, the Ontario Medical Association released a report detailing health effects and costs associated with air pollution. It identified a significant number of premature deaths and increases in hospital visits each year and its associated high economic costs. The City of Brampton can further reduce emissions from the transportation sector in many other ways including increasing fuel prices, imposing charges for driving during peak traffic periods, and incentives to use the urban transit system to name a few. A comprehensive list of potential methods for reducing transportation emission sources along with example jurisdictions where some of these solutions are currently being employed is provided in **Section 3** below.

2. TRANSPORTATION RELATED AIR POLLUTANTS

2.1 Types of Pollutants

Emissions from the transportation sector include the following pollutants:

- Particulate Matter (PM) Including: TSP, PM_{10},and $PM_{2.5}$
- Nitrogen Oxides (NO_x)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO_2)

2.1.1 Total Suspended Particulate (TSP)

Total Suspended Particulate (TSP), is often used to characterize air quality near a dust source. The ambient TSP standards and criteria were set to prevent a reduction in visibility. Particles suspended in the atmosphere reduce visibility or the visual range by reducing the contrast between an object being viewed and its background. This reduction is a result of particles scattering or absorbing light coming from both the object and its background, and from particles scattering light into the line of sight. Particles with a radius of 0.1 to 1.0 μm are most effective at reducing visibility. In a rural area where TSP levels are on the order of 30 μg / m^3, the visibility would be about 40 km. At 150 μg / m^3, a common urban concentration, the range would be reduced to about 8 km.

The importance of TSP as an indicator of air quality is generally decreasing. Impacts from elevated TSP concentrations are extremely localized and generally are nuisance based, rather than health based. Consequently more emphasis is being placed on the finer particulate fractions, namely PM_{10} and $PM_{2.5}$.

2.1.2 Fine Particulate Matter PM_{10} and $PM_{2.5}$

Many studies over the past few years have indicated that fine particulate matter (PM_{10} and $PM_{2.5}$) in the air is associated with various adverse health effects in people who already have compromised respiratory systems and suffer from asthma, chronic pneumonia and cardiovascular problems. However, the available studies have not been able to link the adverse health effects in such people to any one component of the pollution mix. Fine particulate matter is a mixture of chemically and physically diverse dusts and droplets, and some of these components may be important in determining the effects of PM_{10} and $PM_{2.5}$ on health.

2.1.3 Nitrogen Oxides (NO_x)

The term nitrogen oxides (NO_x) is the generic name for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying ratios. Nitrogen dioxide (NO_2) is the primary component of concern in NO_x. NO_2 is a reddish brown gas with a pungent odour, which upon reaction with other atmospheric compounds, becomes a major contributor to smog, acid rain, inhalable particulates and reduced visibility. NO_2 also plays a major role in atmospheric reactions that produce ground level ozone. Man-made sources of NO_x include

all fossil fuel combustion such as heating buildings, commercial and industrial operations, etc. While, motor vehicle exhaust is a significant source of NO_x only a small percentage is emitted as NO_2 directly from the tailpipe. The main component of NO_x from tailpipes is NO which reacts in the atmosphere over time and distance to form NO_2. The rate of reaction is influenced by many factors including initial concentration, sunlight, ozone concentrations and others.

2.1.4 Carbon Monoxide (CO)

Carbon monoxide (CO) is a colorless, odourless gas that is produced as a result of incomplete oxidation of carbon during combustion. As indicated in **Table 2** above, in Ontario, approximately 42% of CO produced is from the roads transportation sector. The remainder is the result of other sources of fossil fuel combustion such as other transportation sources, heating buildings, commercial and industrial operations, etc.

2.1.5 Carbon Dioxide (CO_2)

Carbon dioxide (CO_2) is also a colorless, odourless gas, present in the atmosphere at a concentration of approximately 385 ppm by volume. It is estimated the concentration of atmospheric carbon dioxide has increased by approximately 32% since the beginning of industrialization, in large part due to the combustion of fossil fuels. Combined with other factors the increase in atmospheric CO_2 concentrations has led to increased global temperatures. A carbon dioxide equivalency term has been developed to describe, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential (GWP), when measured over a specified timescale (generally, 100 years). **Section 1.1** and **Table 1** above outline Ontario and Road Transportation carbon dioxide equivalent emissions.

2.2 Sources

Emissions of air pollutants from the transportation sector can occur from many sources. A brief summary of potential sources is as follows:

Tailpipe: Emissions created during the combustion of fossil fuels in vehicle engines are emitted directly through the tailpipe. These emissions can be reduced by the use of catalytic converters.

Fuel: Each fuel used will have different characteristics and will emit different amounts of each type of pollutant.

Silt Loading: All roads have a loading of fine particulate matter that has settled there from transportation sources or has blown over from other sources. The higher the silt loading, the more silt (dust) will be emitted when a vehicle passes over the road.

Wind Blown: Wind can blow dust or other pollutants from non-road sources onto roads and into the air intakes of vehicles. See also silt loading above.

Electricity: If electric vehicles become more common within urban areas, it will be important to include a portion of power plant emissions within the transportation sector emissions total. Power plants generate the electricity used to charge electric vehicle batteries.

2.3 Current Transportation Emissions in Brampton

Emissions to the atmosphere from the roads transportation sector in Brampton were estimated in two ways. The first was by pro-rating Ontario Ministry of Environment emission estimates to Brampton by population, and the second was by using peak hourly traffic counts on major Brampton roads to estimate transportation emissions and assigning them to wards.

2.3.1 Pro-Rating Ontario Ministry of Environment Emission Estimates

Table 3 below summarizes the population of Ontario and Brampton in the year 2006. It shows that Brampton accounted for 3.56% of Ontario's population in that year. This factor was used to prorate emissions of GHGs and CACs outlined in **Table 1** and **Table 2** above.

Table 3: Brampton and Ontario Population Data in 2006

Location	Population (2006)	% of Brampton Total
Brampton Ward 1	42,400	9%
Brampton Ward 2	46,610	10%
Brampton Ward 3	41,610	9%
Brampton Ward 4	49,850	11%
Brampton Ward 5	37,770	8%
Brampton Ward 6	54,920	12%
Brampton Ward 7	38,190	8%
Brampton Ward 8	42,360	9%
Brampton Ward 9	47,070	10%
Brampton Ward 10	50,930	11%
Brampton Total	451,710	100%
Ontario Total	12,705,300	-
% Brampton of Ontario	3.56%	-

Table 4 below uses this population ratio to develop an estimate of greenhouse gas emissions from the roads transportation sector for Brampton. **Table 4** illustrates that approximately 70% of GHG emissions come from the personal vehicle and trucks and an additional 25% from heavy trucks. The number of CO_2-equivalent emissions from the transportation sector in Brampton in 2006 was estimated to be 1727 tonnes.

Table 4: GHG Emissions from the Roads Transportation Sector in Brampton

BRAMPTON EMISSIONS	CO_2	CH_4	CH_4	N_2O	N_2O	TOTAL	% of Total
Units	kt	kt	kt CO_2 eq	kt	kt CO_2 eq	kt CO_2 eq	kt CO_2 eq
Light-Duty Gasoline Vehicles	576.0	0.04	0.9	0.06	19.8	596.7	35%
Light-Duty Gasoline Trucks	590.2	0.04	0.7	0.08	24.2	615.2	36%
Heavy-Duty Gasoline Vehicles	45.2	0.00	0.0	0.00	1.0	46.2	3%
Motorcycles	2.4	0.00	0.0	0.00	0.0	2.4	0%
Light-Duty Diesel Vehicles	5.1	0.00	0.0	0.00	0.1	5.2	0%
Light-Duty Diesel Trucks	17.1	0.00	0.0	0.00	0.4	17.6	1%
Heavy-Duty Diesel Vehicles	426.6	0.02	0.4	0.01	4.4	431.4	25%
Propane & Natural Gas Vehicles	11.9	0.02	0.4	0.00	0.1	12.4	1%
Brampton Road Transportation	**1674**	**0.1**	**2.5**	**0.16**	**50**	**1727**	**100%**

Table 5 and **Table 6** below use the same population ratio to develop an estimate of selected criteria air contaminant emissions from the transportation sector for Brampton and total emissions by municipal ward.

Table 5: Selected CAC Emissions from the Roads Transportation Sector in Brampton

BRAMPTON ROAD TRANSPORTATION EMISSIONS	TPM	PM_{10}	$PM_{2.5}$	NO_x	VOC	CO
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
Heavy-duty diesel vehicles	51.6	51.6	47.6	2379.2	87.9	480.5
Heavy-duty gasoline trucks	2.2	2.2	1.9	137.0	32.1	499.0
Light-duty diesel trucks	2.9	2.9	2.6	30.5	13.2	24.0
Light-duty diesel vehicles	1.5	1.5	1.4	11.6	4.0	18.3
Light-duty gasoline trucks	6.6	6.4	5.6	1082.7	852.2	17928.6
Light-duty gasoline vehicles	6.8	6.6	6.1	1069.2	1056.4	19967.5
Motorcycles	0.2	0.2	0.1	14.3	45.1	178.7
Tire wear & Brake Lining	63.6	62.9	22.1			
Total Road Transportation Sources	**135.5**	**134.3**	**87.5**	**4,724**	**2,091**	**39,097**

Note: TPM, PM_{10} and $PM_{2.5}$ emissions do not include emissions from road dust

Table 6: Selected CAC Emissions by Municipal Ward from the Roads Transportation Sector in Brampton

BRAMPTON TOTAL ROAD TRANSPORTATION EMISSIONS BY WARD	TPM	PM_{10}	$PM_{2.5}$	NO_x	VOC	CO
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
Ward 1	12.7	12.6	8.2	443	196	3,670
Ward 2	14.0	13.9	9.0	487	216	4,034
Ward 3	12.5	12.4	8.1	435	193	3,601
Ward 4	15.0	14.8	9.7	521	231	4,315
Ward 5	11.3	11.2	7.3	395	175	3,269
Ward 6	16.5	16.3	10.6	574	254	4,753
Ward 7	11.5	11.4	7.4	399	177	3,305
Ward 8	12.7	12.6	8.2	443	196	3,666
Ward 9	14.1	14.0	9.1	492	218	4,074
Ward 10	15.3	15.1	9.9	533	236	4,408
TOTAL BRAMPTON	135.5	134.3	87.5	4,724	2,091	39,097

Note: TPM, PM_{10} and $PM_{2.5}$ emissions do not include emissions from road dust

2.3.2 Estimating Emissions from Traffic Counts on Major Brampton Roads

The second approach used peak PM traffic data for major routes in Brampton supplied by iTRANS. This data was pro-rated to estimated daily totals, converted to emissions by road type and then assigned to one of the ten City of Brampton Municipal wards. **Table 7** below

presents the total transportation emissions by ward as well as the overall total. It should be noted that the PM_{10} emissions estimates include road dust emissions.

A comparison of NO_x and CO estimates in **Table 6** and **Table 7** suggest that estimating emissions from traffic counts is likely a more conservative method; NO_x estimates are approximately 25% higher and CO estimates are approximately 33% higher.

Table 7: Brampton Transportation Emissions by Ward

	NO_x	**CO**	**PM_{10}**	**CO_2**
Ward #	tonnes	tonnes	tonnes	tonnes
1	328	3,104	82	82,603
2	344	3,278	85	87,501
3	1,059	8,383	258	256,123
4	411	3,843	104	101,527
5	207	1,971	52	52,624
6	954	8,924	243	235,800
7	269	2,508	59	66,128
8	956	8,897	239	234,414
9	515	4,795	121	126,309
10	1,377	12,717	323	333,583
Total	**6,421**	**58,419**	**1,568**	**1,576,612**

Note: PM_{10} emission estimates include road dust

3. MITIGATION OPTIONS FOR TRANSPORTATION AIR POLLUTANTS

3.1 Introduction

SENES has reviewed the actions of a number of municipalities elsewhere, particularly in the United States and Europe. The actions of particular interest have been organized under various options. In this section of the report, each option is briefly summarized, with reference provided to the municipality or jurisdiction where such an option is currently being implemented. This series of options is provided as a starting point for a future strategic direction discussion.

3.1.1 Public Education and Consultation Options

Virtually all options identified will require public education by the City of Brampton. The options that have received specific attention are those options for which the principal City action is education (because the program is implemented by others). Details are provided in **Appendix A**.

The options are:

- Mileage-based insurance pricing (Houston, Texas)
- Automobile sharing companies / cooperatives (Seattle, Portland, San Francisco Vancouver, Paris, others)
- Market-based shuttle van transit systems (United States). This might be a useful addition to AcceleRide

3.1.2 Command and Control Options

These options relate to the City exercising its traditional model of regulation. All options involve the City passing a by-law or by-laws, which set out new standards to restrict conduct causing air pollution from transportation sources. The City then also enforces such standards to ensure City-wide compliance. Details are provided in Appendix B. The options are:

- Transportation “Structure Plans” (Leicester, England)
- Integrated Transportation Modelling (Bristol, England)
- Integrated Transportation Management (Copenhagen, Denmark)
- Bicycle Friendly City (Erlangen, Germany)
- Air Toxics Control Plans (California)
- Land Use / Air Quality Integrated Plan (West Linn, Oregon)
- Prioritizing Commercial Traffic in the City (Netherlands)
- Street System Connections and Pedestrian Pass-throughs (Portland, Oregon)
- Vehicle Screening and Remote Sensing Detection of High Emissions

3.1.3 Charging Options

These options would involve the City establishing legally binding programs which involve economic charges to promote lower air emissions from transportation services. Details are provided in Appendix C. The options are:

- Environmental Zones with Traffic Restrictions and Charges (Gothenberg, Sweden)
- Emission-trading (San Francisco, California)
- Time-of-Day Parking Pricing
- Time-of-Day Pricing for Off-Road Equipment Emissions
- Traffic Control Tolls and Pricing (Portland, Oregon)
- Emission Budgets or Quotas (California)

3.1.4 Subsidy Options

These options involve the City establishing economic subsidies to promote lower air emissions from the transportation sector. Details are provided in Appendix D. The options are:

- Incentives for Telecommuting or Commuter Alternatives (Maryland, California, Washington, others)
- Gasoline Can Replacement Incentives (California, Louisiana, Connecticut)
- Incentives to Use Ozone-eating Catalyst for Air Conditioning Equipment (California)
- Incentives to Retrofit Diesel Engines
- Incentives to Retrofit Heavy-Duty Equipment

3.1.5 Governance Options

These options are presently beyond the legal authority of the City, and are, therefore, targets for future City actions to increase its legal authority. Details are provided in Appendix E. The examples are:

- Mileage-based insurance pricing (Houston)
- Emission check buyout (California)

3.2 Policies

3.2.1 Municipal Act

The current Municipal Act gives authority for parking and parks to Brampton. The two examples below are ways of thinking outside of the box and using this authority to improve air quality in a way that has not been done elsewhere.

Control of Parking
There are numerous options available to change parking by-laws so that using transit becomes more attractive. For example, (1) raising parking fees in general and for single occupancy vehicles in particular, (2) relate parking fees to road use or wear and tear from the vehicle, (3) raise the parking fee for a second car, and (4) by-law to reduce the number of spaces provided in new developments and redevelopments. See Appendix F for a detailed approach and costing that could be applied in Brampton.

Air Quality Park
The idea here is to establish an Air Quality Park within a given area of the city, say the downtown core. This is one option that could be used to reduce air quality impacts in certain locations within the city by (1) restricting the use of vehicles within the park, (2) allowing only non-polluting vehicles (electric, solar, bicycles) within the park, (3) more stringent air

quality standards within the park, (4) increased tree planting within the park to absorb pollutants.

Retrofits
Street lighting retrofits to lower energy consumption thereby lowering greenhouse gas emissions.

3.2.2 Offsets

Urban Reforestation
Planting trees and bushes to absorb pollutants can lead to cleaner air. The following summary outlines the potential range of reductions in terms of tonnes of pollutant reduced per year per square kilometre of trees. This would be in addition to the actions already taken by Brampton but allows a method for quantifying the reductions.

Pollutant	Low	High	
PM_{10}	3.2	5.4	tonnes/km^2 of trees/year
O_3	2.9	3.9	tonnes/km^2 of trees/year
SO_2	1.3	2.1	tonnes/km^2 of trees/year
NO_2	1.3	2.4	tonnes/km^2 of trees/year
CO	0.2	0.4	tonnes/km^2 of trees/year

Carbon Tax
Carbon taxes are taxes based on fossil fuel carbon content, and therefore a tax on carbon dioxide emissions. They differ from current North American fuel excise taxes, which are applied primarily to motor vehicle fuels as a way to finance highways and other transportation services. Because carbon taxes are intended primarily to internalize the environmental costs of fuel consumption and encourage energy conservation, there is no particular requirement for how their revenues should be used. Revenues can be used to reduce taxes, provide rebates, or finance new public services, including energy conservation programs. If most revenues are returned to residents and businesses, resulting in no significant increase to total government income, the taxes are considered *revenue neutral*, called a *tax shift*. Many economists advocate tax shifting to help achieve strategic policy objectives: raise taxes on *bads*, such as pollution emissions, and reduce taxes on *goods*, such as labour and investments. Carbon taxes are generally applied by state, provincial or federal jurisdictions at the point of production, distribution or sales.

3.2.3 Infrastructure

No Future Roadway Improvements
This is one of a number of strategies aimed at encouraging individuals to switch from private vehicles to public transit. The basic idea here is to not fund roadway improvements that would ease traffic flows such that the frustration factor drives the shift away from private vehicles.

Put Money into Public Transit Systems
The idea here is to improve public transit systems to the point that they become attractive to the individual who is still driving his / her private vehicle. The idea is that the better the transit system, the more people will use it. Brampton is well along the way in this area with AcceleRide.

Car Pooling
Car pooling is a way for individuals to save money while improving air quality. Car pooling can be encouraged through the provision of High Occupancy Vehicle (HOV) lanes that improve traffic flow for those commuters that choose to car pool. Car pooling can also be done by individual corporations through incentives, perhaps as a partnership program with the City.

Anti-Idling By-Law
Emissions of vehicles are higher at idle than during the rest of the driving cycle. This is shown in **Exhibit 3** below which was constructed for the Ontario Fleet Mix. While Brampton has an educational program on this topic, there may be improvements to be found through enforcement by Parking Enforcement Officers.

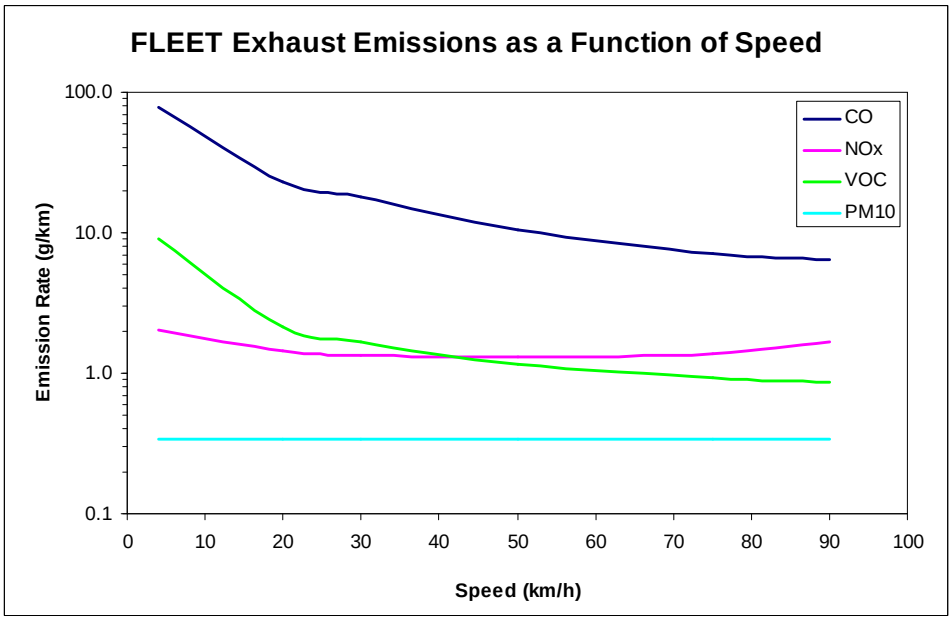


Exhibit 3: Ontario Vehicle Emissions by Vehicle Speed

Residential Intensification
The need for transportation is reduced if more residences are available in a smaller area. This is because a support infrastructure of shops becomes available because of the market demand.

Telecommuting
Allowing people to work from home where this will not affect job performance reduces the demand for transportation services of all kinds.

3.2.4 Fleet Mix

Target for Low and Zero Emission Vehicles (LEVs and ZEVs)
If the City were to set a target for electric and / or solar powered vehicles for a given year in the future, this has been shown in California to encourage entrepreneurs to create new industries to meet this type of goal. A typical target might be to aim for 10% ZEVs within 10 years. LEVs can be part of this targeting as well.

Compressed Natural Gas
Using compressed natural gas to power vehicles leads to a significant lowering of vehicle emissions. One issue is the need for infrastructure to support natural gas refilling. The California South Coast Air Quality Management District (SCAQMD) introduced, in September 2008, a subsidy program for Home Refuelling Units to encourage the switch to personal vehicles away from conventional gasoline vehicles. This was to augment the school bus retrofit and infrastructure program outlined in **Section 3.3.5** below.

Biofuels
The use of alternative fuels can improve certain aspects of air quality depending upon the composition of the fuel. The drive behind biofuels is to use waste biological materials to produce a methanol type of fuel. Brampton is already using biofuels in part of its fleet.

Hydrogen Technology
The idea behind using hydrogen is that there are virtually no emissions other than water vapour. So each hydrogen fuelled vehicle has a direct impact on improving air quality. The problems are that there is no infrastructure to support refuelling. The City could set a target of 5% hydrogen fuelled cars within 10 years.

Hybrids
More and more hybrid vehicles are becoming available as part of the automobile industry's fleet of personal vehicles. Since Brampton is part of a large metropolitan area, there will be no servicing infrastructure issues like those in smaller communities. Brampton could set a higher target for a percentage of hybrid vehicles within the municipal government within a few years.

Re-Formulated Gasoline
This is another option for lowering emissions from vehicle use.

Vehicle Inspection & Maintenance
It has been shown in other communities that regular inspection and maintenance programs reduce vehicle emissions. There are a number of examples that can be examined such as the Greater Vancouver Regional District (GVRD) program.

3.2.5 Zoning

Air Quality Park
The City has the jurisdiction to create a centre-town air quality park with restricted fuels types and / or no personal traffic entry. This could dramatically reduce transportation emissions and impacts in this area.

No Drive Zones
The City could establish shopping areas that are no drive zones that are only accessible by foot such as the Sparks Street area in Ottawa.

No Park Zones
The concept here is to encourage the use of public transit by restricting areas that are accessible to private vehicles.

One-Way Streets
Exhibit 3 above indicates that emissions increase at slower speeds. Providing one-way streets is one way to improve the flow of traffic allowing fewer emissions due to vehicles running at higher speeds.

HOV Lanes
This was discussed earlier in car-pooling as a way to encourage people to commute together (a 50% reduction) as well as maintaining a higher vehicle speed and thereby less pollution.

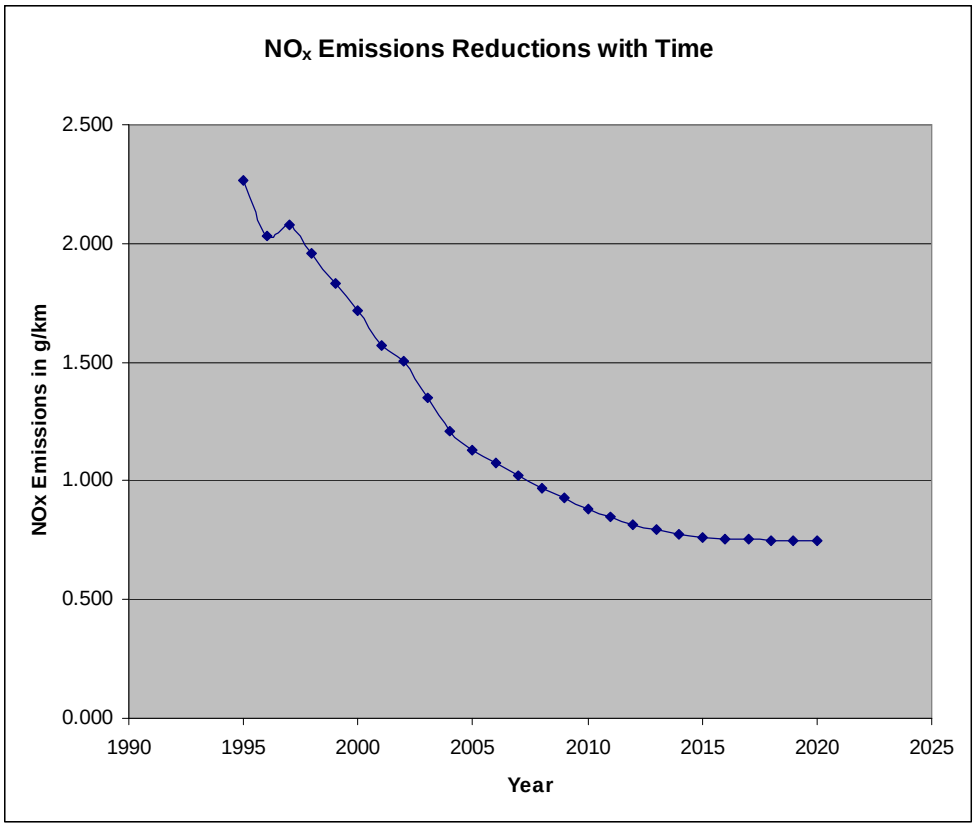
3.3 Practices

3.3.1 Reducing Number of Vehicle Kilometres Travelled

Emissions of air pollutants are directly proportional to the number of vehicles. Reducing the number of vehicle kilometres travelled will improve air quality.

3.3.2 Technology Improvements

Over the next few years, improvements in vehicle engine technology are going to reduce emissions overall, in essence holding emissions at the current level even as the number of vehicles increases as a result of population increases. **Exhibit 4** below presents an example of the anticipated reductions expected in NO_x emissions over time. The exhibit shows for a vehicle running at about 67 km / hour a 67% reduction from 1995 levels by 2020.



Source: Mobile 6C Emission Factors for NO_x

Exhibit 4: NO_x Emission Reduction Due to Technology Improvements

3.3.3 Street Washing

The City of Hamilton as early as 1980 showed that increased street washing could reduce emissions of particulate matter (PM) into the air by as much as 80%. It is possible to simulate, for any set of conditions of traffic and silt loadings, how much PM reduction could be achieved for a certain frequency and intensity of washing. A simple example is given below.

Number of Litres of Water Used
7680

Area of Paved Road (m^2)
1000

Total Number of Vehicles/Day
500

Number of Passes per Day
4

Vaccuum Sweeping = 46%

Water Flushing = 69 - 0.231 * V where V = # vehicles passing since application
Water application at 0.48 gal/yd^2. 0.1 gal/sq. yd. = 0.4 L/sq. metre

V = 125 % Control = **40**

Water Flushing followed by Sweeping = 96 - 0.263 * V

V = 125 % Control = **63**

Since Brampton already uses low-emission sweepers, thought could be given to an increase in the number of sweepers and the area swept.

3.3.4 Installing "Pervious" Concrete Edges

A new type of porous concrete is just becoming available in Ontario that may provide some additional particulate matter control for roadways. It is called "pervious" concrete and while it does not have the strength to be used for the driving area of the road, it may be able to be used in run-off gutters or edges to allow particulate matter laden rainwater to run through into the ground, thereby removing the PM from becoming re-suspended by the action of the vehicle's wheels on the road. As this is a very new product, SENES is not aware of any jurisdictions where this technology has been applied.

3.3.5 Education and Subsidies

In September 2008, the South Coast Air Quality Management District (SCAQMD) in California announced significant funding to replace dirty diesel school buses with clean burning compressed natural gas buses. The funding was to purchase some new buses, to retrofit others with particulate traps and also to help pay for the fuelling infrastructure for compressed natural gas (CNG). CNG buses on average emit 6 times less smog and particulate forming nitrogen oxides than diesel buses.

4. SCREENING AIR QUALITY ASSESSMENT

4.1 Introduction

A screening level air quality assessment was undertaken to look at the relative change in air quality that could be expected through the use of some of the mitigation approaches outlined in **Section 3**.

Emissions data was available though the NPRI database for all of Ontario. This data provided the total emissions to atmosphere from all of Ontario broken down by source type and pollutant. The transportation portion of the Ontario emissions was then pro-rated by population as a first estimate of the transportation emissions occurring in each ward across the City of Brampton.

Where data allowed a second more detailed approach was examined to try to look at the uncertainty levels associated with the screening level approach taken.

4.2 Approach

The air pollution dispersion model used was the Industrial Source Complex – Version 3 (ISC3) Model which has been used internationally for many years. It was used to provide annual estimates of concentration changes attributable to the various mitigation measures examined.

The ten City of Brampton municipal wards were used as area emission sources, with output locations near the centre of each ward.

The ISC3 Model was used to generate meteorological transfer coefficients between the emissions from each ward and specific receptor points across Brampton. These were put into a spreadsheet model called a Transfer Matrix Model (TMM) that allows emission changes by ward to be simply modelled into the resulting concentration levels at each receptor location.

4.3 Modelling

4.3.1 ISC3 Model

The Industrial Source Complex Version 3 (ISC3) model is specifically designed to permit analysis of emission sources from complex industrial settings (multiple stacks, fugitive emissions, building wake effects, etc.). This model is used for compliance modelling and is used by many countries around the world. It has been accepted for use in most provinces across Canada. The ISC3 Model calculates concentrations and depositions in rural or urban environments.

Although the Industrial Source Complex Short Term Version 3 (ISCST3) model is the workhorse of the various dispersion models available today, it is also well recognized that the algorithms in this model are over 20 years old, and do not represent the most current

understanding of dispersion dynamics. While the model is still considered to be suitable for most applications, it is more reliable for modelling long-term average concentrations than for estimating maximum short-term concentrations.

For ISC3 modelling, hourly meteorological data are required including: mixing height, temperature, cloud cover, cloud opacity, wind speed and wind direction. For calculating hourly mixing heights, upper air measurements are needed. Using upper air observations (twice daily) morning and afternoon mixing heights are calculated and, based on these measurements, hourly mixing heights are estimated using the U.S. EPA's regulatory meteorological pre-processor PCRAMMET.

4.3.2 Meteorological Driver Used

Hour by hour data from Pearson Airport for the year 2007 was used as the driving force to run the ISC3 Model.

4.3.3 Transfer Matrix Model

The Transfer Matrix Model (TMM) is essentially a spreadsheet that contains the output of the air dispersion model. The air dispersion model is used to calculate the concentration impact of a unit emission from each emitting source at each receptor. The relationship between each source and each receptor is called a meteorological transfer coefficient and is multiplied by the actual emissions for each source and each pollutant to determine the individual source impact on each receptor. The total impact from all sources on each receptor is simply the sum of all of the partial contributions. Also included in the TMM is the background level of each pollutant, the part that we can do nothing about.

The TMM that was developed for the City of Brampton can be used to test a given piece of control technology, or a corporate strategy, for reducing emissions. Emissions can be input and the TMM will output the impact at a selected receptor location.

4.3.4 Receptors Selected

At least one receptor within each ward was selected as a typical output point for the screening modelling.

Exhibit 5 presents the locations of the receptors selected for this analysis on a ward map of Brampton. Included on this map as one of the receptor locations is the MOE monitoring station (R1b) located at 525 Main Street (MOE #46089).

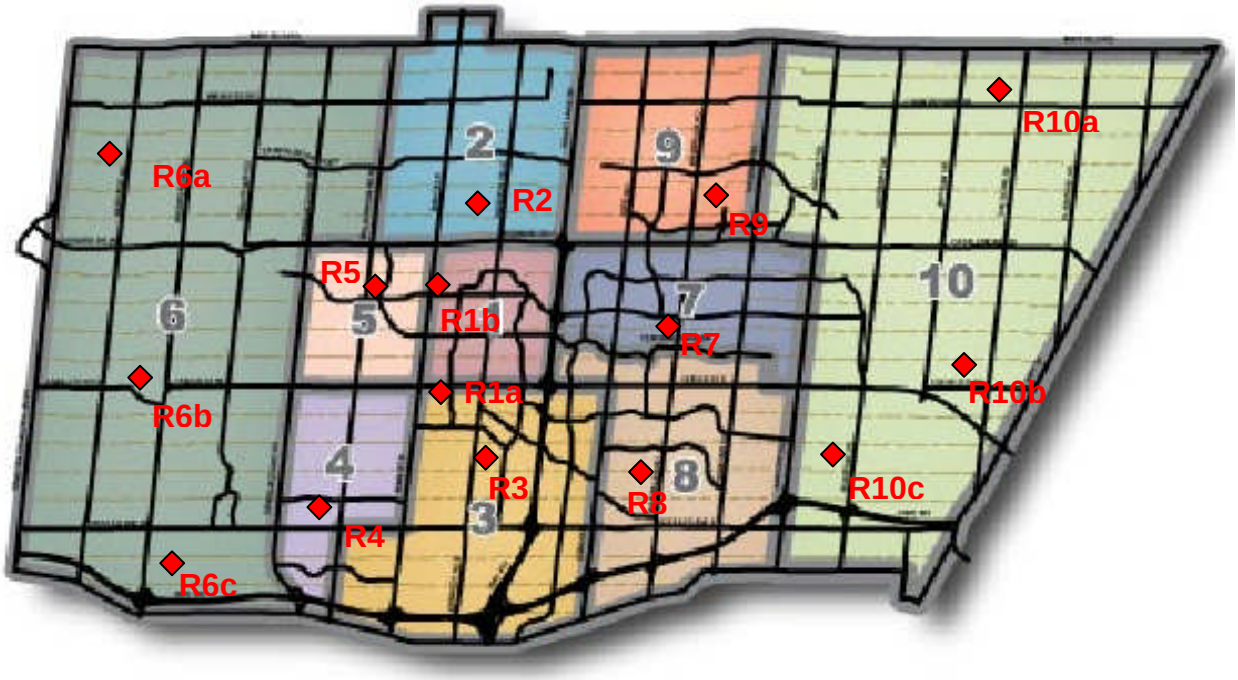


Exhibit 5: Air Quality Receptor Points within Brampton Wards

4.4 Results

4.4.1 The Current Situation

Table 8 presents the estimated current air quality levels resulting from all sources in Brampton, for the pollutants studied, at the receptor locations selected across Brampton.

Table 8: Air Quality Impacts from All Brampton Sources

Receptor	Annual Average Contaminant Concentrations (µg/m^3)			
	NO_x	PM_{10}	CO	CO_2
R1a	62.4	140.2	326	21,571
R1b	86.9	195.1	454	30,032
R2	60.8	136.5	318	21,012
R3	51.5	115.7	269	17,802
R4	82.3	184.7	430	28,427
R5	83.0	186.3	434	28,675
R6a	20.7	46.5	108	7,153
R6b	21.6	48.5	113	7,462
R6c	22.1	49.7	116	7,646
R7	66.0	148.3	345	22,816
R8	50.8	114.0	266	17,550
R9	55.1	123.6	288	19,021
R10a	17.5	39.4	92	6,061
R10b	20.7	46.4	108	7,137
R10c	25.3	56.8	132	8,742
Ontario Criteria	200 µg/m^3 24 hr AAQC	50 µg/m^3 24 hr Interim Std	15,700 µg/m^3 8 hr AAQC	no criterion

4.4.2 Portion Due to Transportation Sources

Table 9 presents the air quality impact from all transportation sources in Brampton at the receptor locations selected.

Table 9: Air Quality Impacts from Brampton Transportation Sources

Receptor	Contaminant Concentrations (µg/m^3)			
	NO_x	PM_{10}	CO	CO_2
R1a	23.2	5.7	197	5,669
R1b	18.3	4.6	171	4,590
R2	13.3	3.3	125	3,345
R3	24.5	6.0	203	5,971
R4	19.6	4.9	180	4,828
R5	14.8	3.7	138	3,712
R6a	8.1	2.0	75	1,996
R6b	8.3	2.1	77	2,061
R6c	8.3	2.1	77	2,044
R7	16.3	3.8	151	4,014
R8	25.0	6.2	230	6,141
R9	16.2	3.8	150	3,973
R10a	10.3	2.4	95	2,493
R10b	11.5	2.7	106	2,802
R10c	13.1	3.1	121	3,189

4.4.3 Impact of Mitigation Options

In order to demonstrate how air quality would change across Brampton, two mitigation examples were tested as part of this project. They were:

- Urban re-forestation (enhanced planting of trees in Ward 3 covering 1.0 km2 of the approximate 25 km2 in the Ward);
- Only zero emission vehicles (ZEVs) in Ward 1 (establish pollution free zone across Ward 1)

Table 10 presents the results of urban reforestation across Ward 3. *Baseline Emissions* are for roads transportation sources only, *Emissions After Mitigation* are after reforestation occurs across Ward 3 (i.e., only emission rates in Ward 3 are reduced after reforestation). **Table 10** also shows that enhanced tree planting does reduce emissions marginally for particulate based contaminants, with essentially no change to gaseous contaminants. The maximum reduction is 1.28% for the Ward 3 receptor.

Table 10: Air Quality Improvements due to Enhanced Tree Planting in Ward 3

WARD	RECEPTOR	POLLUTANT											
		CO				NO_x				PM_{10}			
		Baseline Emissions in g/s	Emissions After Mitigation in g/s	ug/m^3	% change from base	Baseline Emissions in g/s	Emissions After Mitigation in g/s	ug/m^3	% change from base	Baseline Emissions in g/s	Emissions After Mitigation in g/s	ug/m^3	% change from base
1	1a Hospital	98.41	98.41	196.68	0.00%	10.39	10.39	23.13	-0.11%	2.60	2.60	5.63	-1.01%
	1b MOE Station			171.21	0.00%			18.31	-0.01%			4.56	-0.11%
2	2	103.94	103.94	124.78	0.00%	10.91	10.91	13.32	-0.01%	2.71	2.71	3.29	-0.10%
3	3	265.82	265.81	202.55	0.00%	33.58	33.52	24.51	-0.13%	8.19	8.05	5.93	-1.28%
4	4	121.85	121.85	180.19	0.00%	13.03	13.03	19.57	-0.02%	3.31	3.31	4.92	-0.17%
5	5	62.51	62.51	138.25	0.00%	6.56	6.56	14.76	-0.01%	1.64	1.64	3.68	-0.12%
6	6a - North	282.98	282.98	74.98	0.00%	30.26	30.26	8.08	-0.01%	7.72	7.72	2.04	-0.08%
	6b - Centre			77.47	0.00%			8.34	-0.01%			2.11	-0.08%
	6c - South			76.58	0.00%			8.28	-0.01%			2.09	-0.12%
7	7	79.53	79.53	150.70	0.00%	8.54	8.54	16.34	-0.01%	1.86	1.86	3.79	-0.13%
8	8	282.12	282.12	230.41	0.00%	30.32	30.32	25.04	-0.01%	7.59	7.59	6.21	-0.13%
9	9	152.04	152.04	149.90	0.00%	16.35	16.35	16.21	-0.01%	3.85	3.85	3.83	-0.07%
10	10a - North	403.26	403.26	94.60	0.00%	43.68	43.68	10.27	0.00%	10.23	10.23	2.42	-0.05%
	10b - Centre			106.32	0.00%			11.53	0.00%			2.72	-0.04%
	10c - South			120.68	0.00%			13.10	-0.01%			3.12	-0.07%

Table 11 shows the results of establishing a pollution free zone in Ward 1 allowing only zero emission vehicles (ZEVs) on roads in that ward. As with **Table 10** above, Baseline Emissions are for roads transportation sources only, Emissions After Mitigation are after allowing only ZEVs on roads in Ward 1 (i.e., only emission rates in Ward 1 are reduced to zero). The table demonstrates significant changes for receptor locations near Ward 1 with marginal reductions at locations near the limits of Brampton.

Table 11: Air Quality Improvements Resulting from ZEVs in Ward 1

WARD	RECEPTOR	POLLUTANT											
		CO				NO_x				PM_{10}			
		Baseline Emissions in g/s	Emissions After Mitigation in g/s	ug/m^3	% change from base	Baseline Emissions in g/s	Emissions After Mitigation in g/s	ug/m^3	% change from base	Baseline Emissions in g/s	Emissions After Mitigation in g/s	ug/m^3	% change from base
1	1a Hospital	98.41	0.00	160.76	-18.27%	10.39	0.00	19.36	-16.38%	2.60	0.00	4.74	-16.69%
	1b MOE Station			70.52	-58.81%			7.69	-58.03%			1.90	-58.33%
2	2	103.94	103.93	108.03	-13.42%	10.91	10.85	11.56	-13.26%	2.71	2.57	2.85	-13.42%
3	3	265.82	265.81	193.66	-4.39%	33.58	33.52	23.61	-3.83%	8.19	8.05	5.77	-3.91%
4	4	121.85	121.84	176.44	-2.08%	13.03	12.97	19.18	-2.02%	3.31	3.18	4.83	-2.01%
5	5	62.51	62.50	130.71	-5.45%	6.56	6.50	13.97	-5.39%	1.64	1.51	3.48	-5.41%
6	6a - North	282.98	282.97	73.82	-1.54%	30.26	30.20	7.96	-1.51%	7.72	7.58	2.01	-1.50%
	6b - Centre			76.08	-1.79%			8.19	-1.76%			2.07	-1.74%
	6c - South			74.49	-2.74%			8.06	-2.67%			2.03	-2.65%
7	7	79.53	79.52	146.13	-3.04%	8.54	8.48	15.86	-2.96%	1.86	1.73	3.67	-3.19%
8	8	282.12	282.11	225.35	-2.20%	30.32	30.26	24.51	-2.13%	7.59	7.46	6.09	-2.15%
9	9	152.04	152.03	147.33	-1.72%	16.35	16.29	15.94	-1.68%	3.85	3.71	3.77	-1.77%
10	10a - North	403.26	403.25	93.87	-0.78%	43.68	43.62	10.19	-0.76%	10.23	10.09	2.40	-0.80%
	10b - Centre			105.11	-1.14%			11.41	-1.11%			2.69	-1.18%
	10c - South			118.85	-1.52%			12.91	-1.48%			3.07	-1.55%

5. CITY OPPORTUNITIES TO REDUCE AIR EMISSIONS

5.1 Options within the Authority of the City

All governments have two general sources of authority: authority conferred by virtue of being an owner or employer; and, authority conferred by virtue of being a legislative body. Under both sources of authority, the City has matters over which it currently exercises exclusive jurisdiction.

Measures, which could be considered by the City, include:

- Subsidizing City employees to use public transit, biking or walking as alternatives to private vehicles
- Encouraging alternative work options including technology solutions to reduce or avoid peak hour road use
- Encouraging a green economy whereby renewable energy manufacturing companies (solar panels, wind turbines, etc.) would be attracted to Brampton
- Limiting City use of 2-cycle engines on all City property for equipment such as lawnmowers and leaf-blowers and expediting replacement of this equipment with four-stroke and battery-powered models

Options within the exclusive authority of the City which could be considered for future by-laws include:

1. Licences and permits: Improving the City inventory of emission sources by requiring annual audits of personal or business activities affecting air quality to obtain various City permits (e.g., parking)
2. Parking: There are numerous options to change parking by-laws so that using transit becomes more attractive. For example, raise parking fees in general and for single occupancy vehicles in particular, relate parking fees to road use or wear and tear from vehicle, raise parking permit fee for second car, by-law to reduce number of spaces provided in new developments and redevelopments (see Appendix F)
3. Property standards: Provision of secure bicycle storage facilities
4. Streets: Banning or restricting traffic or particular types of vehicles from some roads, during certain hours or days, such as re-routing certain classes of trucks and / or cars away from the downtown core and sensitive areas, street sweeping
5. Traffic demand management and transportation management associations
6. Transportation Alternatives: Increased provision of bike lines, pedestrian space, and high occupancy vehicle lanes

The City of Brampton has some initiatives in this area already such as Smart Commute and HOV lanes but more are possible. The City would appear to have the legal authority to determine its enforcement practices and resources for each of these matters.

5.2 Options within City Authority but Subject to Concurrent Federal or Provincial Authority

Through its legislative authority, there are a number of options available to the City in domains where other levels of government have acted or could act in the future. The most important options could involve the City enhancing standards provided by other governments, without providing conflict. Details of most of the available options are given in the Appendices of this report.

Options for by-laws include but are not limited to:

- Enhanced Emission Standards: the City may consider such measures for non-vehicular equipment causing emissions such as lawnmowers and / or leaf-blowers
- Enhanced Fuel Standards: the City may consider this option for all fuels and / or specified classes of fuels in use within City boundaries (e.g., off-road diesel fuel)
- Enhanced Vehicle Emission Standards: the City may consider this option for all vehicles and / or specified classes of vehicles in use within City boundaries (e.g., diesel buses, airport ground access vehicles)
- Refuelling Standards at Gas Stations, such as truck-stop electrification
- After-Market Emission-Reduction Technologies, or after-market retrofits for heavy duty transportation equipment
- Improved Gas Cans (off-road

The City may also wish to consider a broader approach to enforcement, such as authorizing parking authority personnel and / or building inspectors to enforce aspects of its air pollution laws.

5.3 Options for the City to Use the Legislative and Regulatory Processes of Other Governments to Improve Brampton's Transportation Related Air Quality

The following options could be considered by the City:

- Given the broad legislative authority provided under the *Planning Act*, and recognizing that authority under the *Municipal Act* is linked to the Official Plan, the City could use the broad, expansive powers of the Official Plan in the articulation of policies that could be used for future by-laws related to air quality
- Under the Municipal Act, the City could develop a by-law to require vehicle parking licenses and emissions audits (see Appendix F)
- Under the Municipal Act, the City could develop a by-law requiring off-road portable engine licenses and audits

A number of opportunities exist for the City to influence the legislative and regulatory processes of other governments to improve air quality in Brampton. These include:

- Participation in federal and / or provincial processes to set air quality objectives and standards
- Submission of comments on regulations proposed by the provincial or federal governments that impact on emission sources relevant to Brampton
- Participation (e.g.; comments, appeals and interventions) in municipal or provincial Planning Act processes where the City receives "party status" and has the presence to influence decisions
- Participation in provincial and municipal environmental assessments for activities causing major effects on City air quality
- Participating in federal approval and environmental assessment processes likely to cause significant adverse effects on City air quality

In the future, the City could participate fully (e.g., comments, appeals and interventions) in provincial Environmental Protection Act (EPA) / EBR processes governing provincial air approvals to:

- Achieve “net gains” in air quality
- Enhance emission standards for specific transportation sources of emissions or contaminants

The City could identify the following additional sources of revenue through by-laws:

- **Automobile fees**: One such proposal is being considered in Vancouver, but there are many possible options[1]
- **Gasoline tax**: This may be pursued unilaterally or through revenue-sharing such as arrangements in place for Montreal, Vancouver and American cities[2]
- **Toll roads**: The establishment and operation of toll roads similar to Highway 407[3]

At this time, these and other[4] related initiatives cannot be undertaken unless there are changes to the present system of municipal governance and, in particular, amendments to the various pieces of provincial legislation governing municipal powers. Without such amendments and the associated revenues, additional City measures such as subsidies for private sector use of public transit[5] or retrofits of existing vehicles[6], do not appear

1 There are numerous options available within such schemes. In a recent USEPA study, the following charging schemes were considered: (1) Emissions Fees That Vary by Vehicle Efficiency: Surcharges of one cent to five cents per highway mile led to decreases of 2 to 7 percent in VMT; 2 to 12 percent in peak period vehicle hours traveled; 8 to 37 percent in daily VOC, 4 to 17 percent in daily NOx; 8 to 20 percent in daily carbon monoxide; and 3 to 7 percent in daily PM10. (2) Emissions Fees That Vary by Vehicle Miles Traveled: Fees of $200 to $1,200 per year per vehicle led to reductions of 1 to 7 percent in trips, 14 to 37 percent in VOC, 13 to 35 percent in carbon monoxide, and 5 to 18 percent in NOx. (3) At-the-pump Charges Based on Vehicle Miles Travelled: Based on estimates for west coast metropolitan areas, the ICF/Apogee study finds VMT fees of one cent to five cents per mile would lead to decreases of 9.3 to 11 percent in VMT, 8.6 percent in trips (10 percent shift to transit), 4.5 to 8.6 percent decrease in carbon monoxide, 4.1 to 9.1 percent decrease in VOCs, 5 to 8.6 percent in NOx, 9.4 percent in carbon dioxide, and 11 percent in PM10. (4) Roadway Congestion Pricing Fees: Work by the Puget Sound Regional Council estimated that congestion fees between 5 cents and 30 cents per mile, depending on the level of congestion, time of day, and other factors could lead to the following reductions: 5 to 10 percent in peak period VMT, 0 to 2 percent in NOx, 0 to 7 percent in VOC, and 2 to 3 percent in PM10.

2 A recent USEPA study estimated that fuel tax surcharges from $0.40 to $2 per gallon have led to a 1 to 7 percent decrease in VMT, trips, VOC, CO and NOx, and a 1.4 to 25.7 percent decrease in carbon dioxide.

3 See Toronto Plan (October 2000), p.12; also, Reducing Car Dependence, ibid., p.xi.

4 The U.S. EPA study raises the option of pay-as-you-go car insurance, whereby insurance rates are changed to a per mile fee between 10 cents and 40 cents per gallon. This led the authors of a recent USEPA study to estimates of a 32 million metric ton/year reduction in carbon emissions.

5 These programs include the present US program to provide employer tax incentives or credit programs for encouraging telecommuting or commuter alternatives.

economically feasible in the present or near future. In order to change the present system of provincial-municipal governance over air quality, fundamental changes to legal constraints provided in existing legislation, particularly in the Municipal Act, would be needed. Alternatively, a provincial Act would be needed that transferred those authorities from the province to the City in a manner similar to that used for the Greater Vancouver Regional District (GVRD) in British Columbia.

5.4 Proposed Strategic Direction for Air Quality

The following steps are proposed to arrive at a forward looking strategic direction to develop a comprehensive air quality strategy and implementation plan for the City of Brampton:

STEP 1: Hold a One-Day Facilitated Think Tank

This meeting should involve decision makers from at least the transportation, health, parks & recreation and legal departments of the City of Brampton. This City-wide diversity may need to be augmented with some members of the Regional Air Quality working Group. The day would consist of setting a goal (outline for a long-term air quality strategy for the City) and presenting the full range of options for improving air quality within various categories (education, health, command & control, charging, subsidy and governance). A couple of examples of thinking outside of the box would also be presented. The output from this meeting would be a list of possible options and a second list of those options that were considered to be non-starters in Brampton. This would provide a multi-departmental series of options that could be taken away and costed and examined in more detail.

STEP 2: Prepare an Air Quality Strategic Plan for Brampton

The information from Step 1 would be examined in more detail, costed and evaluated against Brampton's long term strategic development plan goals. A ranked series of options would be developed and the top 10 (or more) built into an Air Quality Strategic Plan for Brampton. Each potential option would be evaluated against the following stated Brampton future objectives:

- To be a dynamic urban community
- To be a sustainable community
- To have a compact and transit-oriented structure
- To celebrate and preserve its unique cultural and natural heritage
- To be a multi-dimensional, full service urban economy with ample live-work opportunities
- To have building pathways as part of an integrated transportation system;
- To have transit oriented communities
- To protect, restore and enhance natural, cultural, recreational and urban open space systems
- To manage operational programs / services in an environmentally conscious way
- To be developing new environmental initiatives to meet future challenges

6 Topics which merit consideration include (1) technologies that reduce cold-start emissions, (2) ozone-eating catalysts in vehicles and air conditioners, (3) credits for scrapping old automobiles; and/or (4) credits or incentives for vehicle, engine, or fleet replacement, or for adopting alternative fuels (on- and off-road).

- To develop policies and strategies for air quality protection from municipal and residential sources
- To ensure that projects build on the greenbelt plan
- To estimate implementation costs, implementation staging and action plan

The deliverable from this step would be a Air Quality Strategic Plan for the City of Brampton.

6. CONCLUSIONS

The City of Brampton has the flexibility to make some significant changes in air quality impacts from transportation sources. Transportation (including transit) sources emit considerable quantities of substances that directly impact the health of humans and change the climate we live in. In Ontario the transportation sector is responsible for approximately 26.4% of the nitrogen oxide (NO_x) emissions and 41.8% of the carbon monoxide (CO) emissions, but only 0.3% of the PM_{10} emissions province wide.

Studies indicate that both the number of vehicles and the distances being driven in Ontario are increasing, whereas emissions from each vehicle are decreasing as a result of improved engine technologies. It is also evident that much of the air pollution problem arising from urbanisation is related to motor vehicle use.

The City of Brampton can reduce emissions from the roads transportation sector through many means, which can be categorized into the following options:

1. Options within the Authority of the City of Brampton
2. Options within City of Brampton Authority but Subject to Concurrent Federal or Provincial Authority
3. Options for the City of Brampton to Use the Legislative and Regulatory Processes of Other Governments to Improve Brampton's Transportation Related Air Quality

A proposed approach to developing a Strategic Plan for air quality improvements within the City of Brampton is presented with the recognition that air quality does not respect either political jurisdictions or municipal departments and must be addressed broadly.

Appendix G1
Public Education and Consultation Options

These actions do not involve City programs or by-laws. These actions involve options, which the City could encourage other parties to implement.

Mileage-based insurance pricing and vehicle fees.	Automobile insurance pricing might be modified to increase the component assigned based on the miles driven. This has the effect of increasing the variable cost and decreasing the fixed cost of driving. One insurance company in Houston has been reported to be considering or testing this option. It may, however, be expected to have only a limited effect, considering that recent significant increases in gasoline prices have had virtually undetectable impacts on driving. However, the concept may have merit when combined with other "fixed costs" including potentially annual vehicle taxes, etc	Houston

Incentives for establishing automobile sharing companies or cooperatives	A private company maintains a fleet of automobiles dispersed in garages in neighbourhoods throughout the cities. Members / users can make a reservation for a car at reservation centres or through the Internet. They have a special credit card, and the card then provides them access to the site, the garage, and even the ignition of the car. They can drop the car off at any site when they are done. The US firms suggest savings of half the cost of standard automobile ownership; the Swiss example states the economics demonstrate savings for drivers that drive less than 7,000 miles per year. In Switzerland, the business grew 50 percent the first year and 30 percent the year after. Initially, they assumed their market would be the environmental community, but they have found that the cost-effectiveness has spread users to the population at large.	Seattle / King County, Washington, Portland, San Francisco, Vancouver BC, Switzerland, Paris, other.

Market-based shuttle van transit systems	Mass transit programs are promoted as a method of reducing vehicle use and vehicle emissions by providing alternatives to solo driving. But traditional mass transit programs are largely ineffective at cleaning the air, and may actually make the problem worse by increasing traffic congestion. An alternative transit plan, which uses privately owned and operated shuttle vans running over a highway system with either High Occupancy Vehicle lanes, or High Occupancy / Toll lanes is also an option. Shuttle transit has been shown to be competitive with mass transit in some foreign countries. In the United States, consumers have experience with van shuttle transit in the form of hotel shuttles, airport shuttles, tourist shuttles, and employment-related vanpooling.	U.S. and international

Limiting or shifting hours for government workers	Limiting or shifting hours for some kinds of workers can cause difficulties in terms of safety and cost. However, shifting and limiting hours for most types of government workers may be more effective than other sectors, and may have far fewer secondary impacts. These workers may be shifted from 12 noon to 8 pm shifts or may be provided incentives to do so.	

Appendix G2
Options for Command and Control Programs

These options all involve the City establishing new regulatory initiatives, which it would pay for through traditional City funding mechanisms.

Transportation Planning	Leicester has become Britain's first "Environmental City" and a European Sustainable City. Environmental quality was specified as one the city's corporate priorities. The "Environmental City" program was developed around eight themes, one being transport. The transport projects are focused on improving non-motorized modes of transport. Recently, the County of Leicestershire, which surrounds the city, adopted a "Structure Plan," detailing policies to be adopted in planning development and land use to the year 2006. The plan highlights transportation requirements, specifically Sustainable Transport Systems for Leicester (STYLE). The STYLE program promotes: public transport (bus priority schemes, quality services, network information, better buses, congenial drivers); demand management (land use allocations, transport choice measures, parking controls, parking standards); environmental improvements (pollution monitoring, pedestrian preference, traffic calming), information for travelers (radio broadcasts on traffic and travel, VMS car-park system, public access terminals for bus information); network management (SCOOT traffic control, CCTV systems, camera enforcement technology, congestion flow monitoring); and modelling research.	The City of Leicester / County of Leicestershire , U.K.

Transportation Modelling	One of the most innovative developments in Bristol is the use of the BRITES (Bristol Integrated Transport and Environmental Study) model. In 1991, the Avon County Council, on behalf of the Bristol City Council, the Bristol Development Corp., the Department of Transport and Badgerline Holding, Ltd., commissioned the MVA to conduct BRITES to forecast long-term transportation investments in the Bristol area. Objectives identified for the success of future transport investment were: ▪ Reducing to 50 percent the proportion of car trips into the Bristol central business district each morning peak period by the year 2015 ▪ Progressively reducing through traffic within the city centre to zero ▪ Reducing vehicle emissions ▪ Increasing bicycle and foot journeys The real innovation of the BRITES model emerges when considering the elements (land-use scenarios and transport	City of Bristol / Avon County, United Kingdom

	strategies) that were being evaluated for the year 2015. The study concluded that a transport strategy for Bristol / Avon County should include: (1) discouraging car use by introducing restraint measures through changing the management and cost of facilities; and (2) proposals to encourage car alternatives by investing in new facilities, particularly public transport.	

General Transportation Management Policy	The city of Copenhagen has adopted an overall travel management policy to improve the quality of transport, the urban environment and city life in general. The policy involves computerized traffic management, the development of public transportation, a cycle network and a parking policy. Particularly noteworthy is the fact that environmental criteria are taken into account in the development of the travel management policy. The success of Copenhagen's travel management policy may be judged against the scale of its road infrastructure network which is no larger now than it was in 1970, and traffic volume, measured in terms of kilometres driven per year which has decreased by some 10% below the 1970 level. The goals of the travel management policy in Copenhagen are: ▪ Limitation of noise and air pollution ▪ Promotion of a balanced development of the different transport modes by favouring the use of bicycles and public transport ▪ Safeguarding accessibility and the mixed social and economic functions of the historical city centre; ▪ Protection of the residential districts from negative traffic impacts ▪ Reduction of traffic congestion The policy is organised around the following strategic objectives: ▪ Introduction of computerized traffic management to minimise time spent travelling ▪ Development of public transport and a bicycle network ▪ Introduction of hierarchical parking systems The computerized traffic management involves the management of traffic primarily on the existing road network; controlling traffic flows through zoning; and providing parking areas at the entrances to the city. In	Copenhagen, Denmark

	combination these traffic management elements have enabled the abandonment of planned projects for new infrastructure. The development of public transportation has involved the improvement of the existing bus network through measures including reserved lanes and traffic light priority, rather than construction of major public transport infrastructure. The development of the cycle network involves the construction of approximately 300 km of cycle paths, including fast cycle lanes. Finally, the new parking policy is based on a concept of a hierarchy of priorities as follows: ▪ First priority to facilitating traffic flow, especially for buses ▪ Second priority to deliveries ▪ Third priority to short stay parking ▪ Least priority to long stay parking - within this last category priority is given to residents Overall, 30% of home to work trips in the summer season are by bicycle, compared to 37% by public transport and 30% by private car. As a reflection of this modal split car traffic measured in terms of kilometres driven per year has reduced by some 10% below the 1970 level. The separate management of transport planning and town planning policies constitutes the principal limitation to the implementation of Copenhagen's general travel management policy. Greater integration is required in order to attain sustainability objectives. The following lessons may be identified from the Copenhagen approach: ▪ Traffic management in an urban area is possible without extending the road infrastructure (the Copenhagen network is approximately at the same level now as in 1970). ▪ The approach shows that good results can be achieved with modest means by favouring bicycles and bus transportation. ▪ The financial revenue from the parking system can also be used to subsidise other transport modes.	

Developing a Bicycle Friendly City	The development of environmentally friendly modes of transportation, in particularly the establishment of a "bicycle friendly climate," stands at the centre of Erlangen's transport policy. In planning the network of bike paths, priority is placed on the "reduction of existing accident points, connections with existing bike paths, and meeting existing bike path demands, particularly between home and important destinations (home-school, home-work, home-shopping)." In order to do this, measures that can be implemented immediately for the improvement of bicycle infrastructure take priority, because the aim of the plan has been to create a gap-free network quickly, while creating a high level of safety and improving access to important destinations (university, schools, downtown). In Erlangen, the bike paths are wide enough for normal bicycle traffic: 1 1 / 2 metres, so far as local conditions allow. They are accompanied by foot paths 2.5 metres wide, or are built together with foot paths as 3 to 4 metre wide foot / bike paths. The bike paths are well marked; they are painted red. The reason is: "A bike path painted red not only facilitates cycling across intersections, but it is proven to be parked on less and more respected by pedestrians." Another important element of a bike path network without gaps is changing paths so that bicycles may travel both ways on one-way (auto) streets. By the placement of an additional sign, bikes are allowed to continue on streets closed to cars travelling in the same direction. A number of other measures - such as removing prohibitions on turning, the allowance to use bus lanes, and bike paths leading through the end of cul-de-sacs and closed streets - can serve as "substitute" bike paths to build a close-meshed bike path network. A detailed city map for cyclists is regularly updated. At important intersections there is a highly visible signpost system that helps people on bikes orient themselves. The city administration has set a good example by purchasing 130 bicycles to be used by employees. Aside from this bike rental services have been extended. In the planning and implementation of their cycling concept the city administration co-operates with a working group set up by the administration itself and including representatives of the	Erlangen, Germany

	General German Bike Club and the police. Lastly, the mayor appeals directly to the residents and visitors of Erlangen to "make an important contribution to keeping our cities and people healthy by using bicycles". *The original text for this project summary was given by the BUND for Environment and Nature Protection Germany, from their publication "Vorbildliche kommunale Verkehrsprojekte in Europa" (October, 1993). The text was translated and re-worked by ICLEI in April, 1996. 8 EURONET / ICLEI Consortium, 1996.*	

Air Toxics Control Plan	The goal of the plan is to reduce air toxic exposures in an equitable and cost-effective manner that will promote clean, healthful air for Basin residents and businesses. As such, the plan seeks to identify measures, which are technically feasible or are expected to be technically feasible and cost-effective in the next ten years. **Clean On-Road Vehicle Fleet Rules for Governments and Certain Private Fleets.** The proposed rules will require the public sector and certain private sector fleet operations that have 15 or more vehicles, to purchase lower emitting gasoline or alternative fuelled vehicles when adding or replacing vehicles in the fleet. In addition, any new fleets will be required to purchase cleaner burning or alternative fuelled vehicles. Specifically, the proposed rules cover all on-road vehicles including passenger cars, light-duty trucks such as pickups, medium-duty and heavy-duty vehicles for affected vehicle fleets. Additional rules under development include: ▪ Clean On-Road Residential and Commercial Refuse Collection Vehicles ▪ Commercial Airport Ground Access ▪ Clean On-Road School Buses ▪ Clean On-Road Heavy-Duty Public Fleet Vehicles ▪ Clean On-Road Street Sweeping Vehicles ▪ Lower Sulphur Content in Diesel Fuels **Goods Movement** This strategy was initially proposed in the 1991 AQMP by the Southern California Association of Governments (SCAG) to reduce truck traffic congestion related emissions. The control concepts include truck dispatching, rescheduling, and rerouting and diverting port-related truck	California

	traffic to rail. SCAG has since established a Goods Movement Advisory Committee to explore various control options, coordinate efforts among local jurisdictions and establish public-private partnerships. **Emission Reductions from Diesel Engine Idling** This strategy will seek to reduce truck idling emissions while the truck is parked at a truck stop. Currently, truck engines are left running at the stop to power the truck cab / sleeper heating / cooling, or other on-board appliances, such as refrigerators and microwave ovens. Potential technologies that can reduce the fuel consumption and associated emissions during truck idling include, but are not limited to, truck stop electrification and addition of auxiliary power units. During the development of AQMD's Rule 1613 - Credits for Truck Stop Electrification, it was determined that it was technically feasible and cost-effective for the truck stops to provide plug-in power at the parking space. In addition, the truck operator would need to install an electrification package that consists of an electric device for cab heating / cooling and outlets for such electric devices as on-board appliances. **Control of Locomotive Idling Emissions** This strategy is designed to evaluate the technical feasibility of reducing diesel locomotive idling emissions at railroad switching yards. The proposed control concept is to reduce the idling time as a function of emission characteristics. **Transit Bus Regulation** This rule contains two elements to reduce emissions from urban buses: 1) a multi-component transit bus fleet rule applicable to transit agencies; and 2) more stringent emission standards for engines used in urban buses, applicable to engine manufacturers. The fleet rule is designed to achieve near-term emission benefits while the engine standards are designed to achieve long-term emission benefits resulting from new bus engines with ultra-low, near-zero, and zero-emissions. To provide transit agencies with flexibility in determining their optimal fleet mix, the rule allows transit agencies to choose between two compliance paths, either the diesel path or the alternative fuel path. These requirements include: ▪ An in-use nox fleet average requirement that will	

	encourage the retirement of the oldest, dirtiest diesel buses (1987 and earlier model year urban buses) ▪ A PM retrofit requirement, with an emphasis on the dirtiest buses, to reduce public exposure to toxic diesel PM emissions ▪ A low-sulphur diesel fuel requirements ▪ Low-emission bus purchase requirements, based on new urban bus emission standards ▪ A zero-emission bus demonstration project ▪ Zero-emission bus purchase requirements	

Land Use / Air Quality Integration	City of West Linn, Portland Air Quality Maintenance Area **Policies** ▪ Coordinate with Department of Environmental Quality (DEQ), Metro, and other relevant agencies to reduce air pollution emission levels in West Linn and the Portland area. ▪ Continue to coordinate with DEQ on land use approval actions through use of land use compatibility statements for businesses requiring a DEQ air quality permit. ▪ Reduce pollution from vehicle emissions by pursuing an energy efficient urban form that provides for connectivity and reduces the number of vehicle miles traveled. ▪ Encourage the use of alternative modes of transportation, including mass transit, walking, and bicycling. ▪ Encourage employment, mixed uses, and home occupations within West Linn to reduce commuting and reduce the distance traveled for shopping and other essential services. ▪ Continue to minimize particulate emissions from the City street sweeping program through the use of sprayers on the equipment used for this purpose. ▪ Seek to influence other governments and private enterprises to adopt policies and practices that encourage workers to telecommute or be able to live within walking or biking distance to their work. **Recommended Action Measures** ▪ Design streets and establish traffic flow patterns that minimize or reduce vehicular emissions by implementing policies in the City's Transportation System Plan (TSP).	City of West Linn

	▪ Adopt zoning standards, such as mixed-use districts, to achieve a more efficient urban form. ▪ Actively pursue increased transit service to and within West Linn to reduce automobile emissions.	

Prioritizing Commercial Traffic	The city of Rotterdam is the largest port in Europe. The port and its industrial complex, with the urban business community, are the two major economic concentrations in the city. Accessibility is key in Rotterdam, in the city's proximity to road, water and air, and in its residents' attitude about accessibility. Goods movement and passenger transport have been central to how the city and region developed its transportation policy. The objectives of this policy that integrates traffic and transport are: ▪ Maintaining and improving accessibility of economic and social activities in the metropolitan region for people and goods; and ▪ Improving the quality of life in the metropolitan region, meaning restrictions on the hazardous effects of traffic on the environment and limiting the number of unsafe traffic situations. Restraining car use is the backbone of this regional policy. Within the city centre, guaranteeing access to hubs of economic activity to economically important traffic is the foundation of the proposed policy. Emphasis is placed on reducing "non-necessary" motor traffic by: ▪ Attending to the infrastructure and exploiting public transport; ▪ Stimulating bicycle traffic; ▪ Limiting parking capacity and regulating traffic circulation; and ▪ Stimulating initiatives to reduce car ownership and use. To combat peak-period traffic, the city's "Traffic Congestion Control Program," encourages carpooling, improved road junctions, smart information panels, stimulating alternative modes of transport, innovative public transport and others. Public transport is given priority over motor vehicle traffic. Approximately 65% of the city's traffic signals are equipped with pre-emption devices. Pedestrians, cyclists and moped riders are treated at least on equal terms with motorists.	The Netherlands

	Within the Rotterdam region, private companies can make "contracts for accessibility" with the government. The state promises to undertake actions to improve accessibility as specified by the company. The company, in turn, devises a transportation management plan, which could include such provisions as stimulating car sharing among employees or using alternative modes of transportation. The city was the first in Europe to use dynamic route information panels (DRIPs), set up along Rotterdam's ring roads to give real-time information about congestion levels. DRIPs into the city alert travelers of parking availability and if the "subway [is] running normally" to persuade travelers to switch to public transport for the remainder of their journey.	

Connected street system or pedestrian pass-throughs	Portland has street design guidelines that require streets to intersect within particular distances and restricts cul-de-sacs (which waste gas by requiring drivers to backtrack out the streets to progress). Where cul-de-sacs and similar developments exist, pedestrian walkways or pass-throughs are encouraged to assure pedestrians can use short cuts to get to mass transit or shopping areas.	Portland, OR

Clean screening and high-emitter detection with remote sensing	A minority of the cars on the road produce the majority of mobile-source pollutants given off by the entire vehicle fleet. Clean screening uses both roadside sensors and an understanding of new-car emission characteristics to exempt the bulk of the on-road vehicle fleet from the need for inconvenient, and sometimes costly annual emission testing. Using remote sensors to detect which of the cars older than 4 years is clean can also be done with high accuracy, allowing yet more focus on the remaining high-emitters. Finally, roadside sensing of high emissions allows the car to be repaired immediately. An annual test does nothing to repair cars that break a month after their last annual test. Those cars can emit at high levels for another 11 months, even 2 years, before being repaired.	

Appendix G3
Options to Establish Charging Programs

These options provide examples of municipal programs, which control air quality by imposing some form of pollution charges

Environmental Zones Pricing / restrictions	Gothenburg, like Stockholm and Malmo, has developed a policy to move heavy goods in central areas of the city. This policy delineates an "Environmental Zone" within a developed area, which is sensitive to traffic disturbances and where traffic restrictions will be implemented. These zones are being introduced to improve air quality. In these areas, the municipal council has forbidden truck and bus traffic fuelled by polluting diesel and weighing more than 3.5 tons. Vehicles are environmentally classified by a windscreen sticker allowing them zone access. Although trucks and buses account for 5 percent of the traffic, they contribute 50 percent of the pollution. Another regulation the city has employed deals with non-fossil fuelled vehicles. If you have an ethanol, natural gas or biogas vehicle, you can obtain a pricing incentive for parking downtown. Partially in response to this initiative, Volvo has developed new trucks that use both diesel and electric power trains. Diesel engines would be used outside the city, and the electric engine inside city zones. The city also is considering building a vehicle database that would track the environmental consequences of travel patterns. This would be used to measure progress made on environmental goals.	The City of Gothenburg, Sweden

Emission-trading programs	In emission-trading programs such as the national SO2 trading program, or the RECLAIM VOC (volatile organic compound) trading program, an emission cap is established over an area, emission rights are established, and a system is designed to allow trading in those emission rights between firms within the capped area. California's Bay Area Air Quality Management District has also implemented an emission pricing regime, allowing trading in Bay Area Emission Reduction Credits. One relatively untapped option would allow trades between mobile and stationary sources, for example, through automobile repair-assistance or scrap page trading programs.	California Air Quality Management District San Francisco

Expanded or enhanced credits for purchase / replacement of vehicles / engines	A credit system, similar to those established for scrapping high-polluting automobiles, could be established for replacing high emitting automobile or diesel engines with lower polluting engines (e.g., alternative fuels, diesel hybrid engines, etc.) could be established. The credits would be performance-based in their values (rather than technology based), could allow for alternative fuels (where appropriate). The credits could be banked, applied against other retrofit opportunities, or traded / sold. These could be established for the range of polluting engines found in the city, including automobiles and trucks, as well as off-road sources like marine and recreational vehicles. This credit should apply to purchase / upgrade of automobiles, construction equipment, diesel vehicles, marine equipment, and other engines.	California

Time-of-day / congestion parking pricing	Parking pricing can be set much higher during periods during which driving is to be discouraged in order to encourage use of mass transit, off-peak time driving, or use of multiple occupancy vehicles. In addition, parking prices can be set much higher for SOVs and much lower for HOVs.	

Traffic control measures to reduce congestion-related emissions	Such measures might include traffic signal synchronization, additional tolled road construction, incentives to promote telecommuting and flexible work-hours, and could include time-of-day congestion pricing in certain circumstances.	Portland, other

Time-of-day pricing for use of high-emitting equipment	Though this approach has not been implemented or modeled in depth, there is no theoretical obstacle to the application of time-of-day pricing approaches to major off-road mobile sources such as generators, cement mixers, tractors, bulldozers, etc. Under time-of-day pricing, equipment that emit high levels of criteria pollutants could be used freely during times when emissions were not likely to lead to air quality violations, but priced to influence reduced use during periods of air pollutant formation or concentration.	

Direct emission pricing based on emission levels and duration of use for registered high-emitting equipment	Though this approach has not been implemented or modeled in depth, there is no theoretical obstacle to the application of emission-pricing approaches to major off-road mobile sources such as generators, cement mixers, tractors, bulldozers, etc. It is likely to be politically preferable to mandate fuel type for example, requiring all such vehicles to use natural gas, ethanol, or other fuels.	

Emission budgets, quotas, or incentives for reduced emissions in association with construction contracts	Construction contracts would each have assigned an emission quota or budget that the contractor can meet using tradeoffs they determine to be most cost-effective or efficient. Firms may choose to meet the quota by limiting or shifting construction hours, shifting seasons for construction, by retrofitting heavy vehicles or purchasing lower emitting equipment, or other measures. Another enhancement on this option would be to institute a certification program for construction firms that have fleets that exceed desirable ratios of good to poor emission vehicles. There could also be incentives or credits for using "Good Construction Partners" on projects.	

Credits for scrapping old automobiles	In California, credits have been made available for removing old automobiles from operation-automobiles that have a disproportionately negative impact on air quality. These schemes have been successful in removing high-polluting vehicles from service, and the credits have been used to offset more expensive emission retrofits for industry in the state.	California

Incentives or credits for modifying diesel vehicle operation	Incentives could be provided that would help manage truck diesel emissions by managing diesel speed, and the path vehicles take through the city. For example, trucks might need to be diverted on an episodic basis to alternate roads that run "around" the city, rather than through it. Firms or fleets that agree to permanent rerouting might be another target, but abuse might be a consideration.	

Credits for truck stop electrification	The South Coast Air Quality Management District in California has rules that allow credits for truck stop electrification. Trucks would be retrofitted with on-board equipment to allow the truck to plug into an electrical outlet rather than idling the diesel engine. Credits could be offered to the trucks and potentially to the truck stop operators. These credits could go to the trucks or fleets, or potentially to third parties that need credits and are willing to pay for the retrofits. The credits could be banked, traded, sold, etc. Some monitoring would be required to assure that the drivers use this option. This technology is on the shelf, but has not been implemented widespread, nor has anyone applied for the credits in California, to date.	California

Appendix G4
Subsidy Options

Employer tax incentives or credit programs for encouraging telecommuting or commuter alternatives	Government can offer tax incentives for employers to modify benefits packages for employees to encourage transportation alternatives-including car / vanpooling, walking, biking, mass transit, etc. The federal "Commuter Choice" program (National Transportation Equity Act for the 21st Century) provides pre-tax benefits for paying up to $65 of transit, or cash outs of up to $175 / mo for parking spaces. This is currently in use, and some states have enhanced these benefits, including Maryland, California, Washington, and others. Options for rides home for emergencies must be available, and evidence indicates there is not abuse of the system. New Jersey has an employer trip reduction emission credit program, and employers submit three page plans outlining the trip reduction plan and get emissions credits that may be bought and sold.	Maryland, California, Washington, Federal, elsewhere

Incentives / discounts / distribution programs for improved gas cans	Gas cans for fuelling garden equipment, snowmobiles, chain saws, and other uses contribute to air pollution through spills, open-cap evaporation, and evaporation through the can. It has been estimated that each gas can may contribute 5 pounds of VOC per year and other emissions. Nozzles with advanced designs eliminate this source. Several areas (including California Air Resources Board, Louisiana, Connecticut) are involved in offering SIP credits or have in place programs that encourage their use, ban purchase of old-style cans, provide trade-in benefits or credits, etc. Estimates are that it is a relatively cheap source of pollution reduction, costing on the order of $1,000 per ton of reductions. California Air Resources Board calculated very large reductions from this source.	California, Louisiana, Connecticut

Incentives for ozone-eating catalyst for air conditioners and automobiles	A catalyst that converts ozone (O3) to oxygen (O2) upon contact provides advantages by reducing ozone in the environment. This technology has been applied to automobile radiators and to air conditioners. The technology is purported by the manufacturer to convert 75% of the ozone that flows across the automobile radiator and 80% of the air passing across the air conditioner condensers. The technology works at room temperature, but efficiencies increase at equipment operating temperatures. Volvo automobile company has installed the equipment in about 230,000 vehicles to	Federal, California

	date, and other auto companies are considering the technology. In December 1999, this technology became eligible for federal Tier II automobile OEM credits; California Air Resources Board (CARB) was the first to adopt credits in November 1998. The manufacturer (Englehard Corporation) is examining credits for stationary sources in Texas and federally.	

Incentives for retrofits for revised fuels or technologies to improve diesel operations	Incentives could be developed to encourage adoption of new or retrofit technologies that reduce emissions in on- and off-road vehicles. There have been demonstration projects that show potential to reduce NOx emissions for diesel and large-emitting vehicles, including construction applications. This includes SCR (selective catalytic reduction) strategies for generators for construction units (and peak power units), and in some trucks. The truck models perform best in new equipment rather than retrofit, although the generators can be successfully retrofitted. Emulsified diesel fuel also shows promise, including marine applications. Increasing the cetane level in the diesel fuel (e.g. through additives) Bshortens the time between compression and ignition and improves cold start emissions. Some municipalities are specifying 5 percent improvements in NOx and 1 cent per gallon cost increases to get PM10 reductions.	

Incentives for after-market retrofit for heavy duty equipment	Incentives could be developed to encourage adoption of new or retrofit technologies that reduce emissions in on- and off-road vehicles. There have been demonstration projects that show potential to reduce NOx emissions for diesel and large-emitting vehicles, including construction applications. This includes SCR (selective catalytic reduction) strategies for generators for construction units (and peak power units), and in some trucks.	

Air quality improvement program	Some agencies have implemented schemes that allow polluters to pay money to avoid meeting their emission requirements, and the funds are used to help reduce pollution through other strategies. This program has been implemented in South Coast Air Quality Management District in California, and the funds are redistributed through an RFP process to try to fund a variety of innovative strategies that lead to emission reductions.	California

Appendix G5
Governance Options

Mileage-based insurance pricing and vehicle fees	Automobile insurance pricing might be modified to increase the component assigned based on the miles driven. This has the effect of increasing the variable cost and decreasing the fixed cost of driving. One insurance company in Houston has been reported to be considering or testing this option. It may, however, be expected to have only a limited effect, considering that recent significant increases in gasoline prices have had virtually undetectable impacts on driving. However, the concept may have merit when combined with other "fixed costs" including potentially annual vehicle taxes, etc.	Houston

Emission check buy- out	In California, owners may pay a fee to avoid smog checks for the first five years of owning a new car. This can be an appropriate strategy because the minority of pollution is emitted from new automobiles, and the problem is disproportionately one generated from older vehicles. By paying a fee to bypass the checks (e.g. $4 / vehicle in some areas), the fee can be used to lower fees for other vehicles, or other appropriate uses may be made with the funds (contributions to a "smog fee / fund"). This strategy assures that similar emissions will be realized, but at lower cost in terms of administration, time waiting, inconvenience, and inappropriate retrofits to new automobiles.	California

Appendix G6
Example of a Transportation Emissions Mitigation Measure
[Environmental Parking Permits]

Description:
Any personal vehicle that is driven into and parked in the City of Brampton would require an annual City environmental parking & driving permit. The City would charge a fee for this permit that would be based on the size of the vehicle and transportation-related criteria such as weight and / or annual mileage. As part of applying for this annual permit, the applicant would have to fill out an electronic questionnaire that would (1) provide detailed information, for the City's emission inventory, about one of the largest air pollution sources and (2) teach the applicant about his / her impact on the City's air environment. The vehicle would be issued an electronic sticker that could be scanned by an enforcement officer. Centralized electronic records would be scanned to see if the permit was up-to-date (annual fee paid). Cars without stickers would be issued a warning referencing the license plate number; repeat offenders would be fined. Anyone living in the city core would be sent a sticker for their vehicle – a fee would only be required for parking in the City outside of the local neighbourhood.

Supporting Legislation:
- Municipal Act

Legal Implications:
- Uses two of the City's broadest Municipal Act powers: those dealing with parking and City roads. Both powers are exclusive to municipalities and thus not overlapping provincial or federal legislation.

Other:
- The program would directly assist improving the inventory of emissions.
- The program would directly contribute to driver education about emissions and emissions reductions.
- The program can be designed to be either a revenue generator or revenue neutral.

Expected Outcome:
- A source of income to fund other transportation environmental initiatives
- Provides annual information to update the City's emission inventory
- Provides annual information about individual driver's mileage patterns.

Implementation Steps:

- Set up system;
- Use existing parking inspectors, police and others to enforce
- Use computerized approach with simple notice on cars
- Computerized fines similar to the 407 ETR system.

Potential Problems:

- Might offend residents who must pay increased fee, but there could be individual variations to deal with residents parking at their home address or persons not driving on City roads (would be improved using regional structure).
- Might adversely harm tourism, but the program can be altered to deal with visitors.

Costs:

- Centralized computerized system = $100,000
- Annual permits (updateable computer chip?) = $100,000
- Enforcement = little extra cost
- Sticker scanners for enforcement staff = $40,000.