TRANSPORTATION/LAND USE WORKGROUP BACKGROUND REPORT
HAMILTON-WENTWORTH AIR QUALITY INITIATIVE

JUNE 29, 2004

Table of Contents

1.0 Introduction

We derive many benefits from transportation: personal mobility and independence, as well as manufacturing, and other economic spin-offs. These benefits come with a price tag; the impacts of the transportation sector on the environment are broad and far-reaching. This report focuses on the *air quality* implications of transportation, as investigated by the Transportation/Land Use Workgroup.

The Workgroup was established as part of the Hamilton-Wentworth Air Quality Initiative in 1996. It was mandated with four tasks:

- Develop estimates of a baseline air pollutant emission inventory for transportation sources.
- Estimate the impacts of changes to transportation patterns, transportation technologies and land use patterns on the release of pollutants into the air (and the resulting impacts on Hamilton-Wentworth).
- Identify and comment on major issues relating to transportation and land use that have an impact on Hamilton-Wentworth. Assess policies and programs that have an impact on air quality.
- Identify areas of research that are required to better understand the impacts of transportation and land use patterns on air quality in Hamilton-Wentworth.

This report documents the results of the Workgroup's investigations in the following areas: 1) the importance of transportation emissions, 2) travel, land use, and population characteristics in Hamilton-Wentworth, 3) a simulation which forecasts the effect of transportation choices, land use decisions, and technological changes and 4) subjects for further research.

2.0Transportation Emissions and Their Impact

The first task of the Transportation/Land Use Working Group was to estimate the emissions of transportation-related air pollutants from a variety of reports (see References).

All motorized vehicles produce emissions during use. Emissions from vehicles consist mostly of gases, but also include microscopic particulates from combustion. In addition, particulate matter of various sizes is released into the air from tires and roadway dust. Gases produced through combustion also react outside the vehicle to form secondary particles.

Vehicles are the largest single source of the smog-related pollutants, nitrogen oxides (NO_x) and volatile organic compounds (VOCs) which include hydrocarbons such as gasoline. Vehicles are also a major source of climate change gases such as carbon dioxide (CO_2), and carbon monoxide (CO), and to a lesser extent, a source of acidifying emissions such as sulphur dioxide (SO_2), and toxics such as benzene (a component of gasoline) and polycyclic aromatic hydrocarbons (PAHs). This report focuses on vehicle emissions except toxics, in the absence of data on transportation emissions of the latter substances for Hamilton-Wentworth.

For convenience we can classify transportation emissions by vehicle type: “light duty” (eg. cars, vans, sport utility vehicles, light trucks of gross weight less than 4,500 kilograms), “heavy duty” (eg. delivery vans, large transport trucks of gross weight greater than 4,500 kilograms), “off-road” (construction, farm), and “other” (rail, aircraft, marine). In general, light duty vehicles use gasoline, while heavy duty vehicles use diesel fuel. All other sources have been classified as "non-transportation" emissions, and include industrial, commercial, and residential emissions.

Tables 1 and 2 indicate the Workgroup's estimate of the relative emissions of transportation, and non-transportation sources (NO_x, VOCs, particulate matter (PM) SO_2, CO and CO_2) in Ontario as a whole and specifically in Hamilton-Wentworth.

Table 1:Ontario Emissions For 1990 By Source (MOEE, 1996a and 1996b).

<table>
<tr><th rowspan="2">SOURCES</th><th colspan="6">% of Total Emissions</th></tr>
<tr><th>NO_x</th><th>VOCs</th><th>PM*</th><th>SO_2</th><th>CO</th><th>CO_2</th></tr>
<tr><td>TRANSPORTATION</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>· Light Duty Vehicles</td><td>22</td><td>24</td><td>2</td><td rowspan="2">2</td><td rowspan="2">59</td><td rowspan="4">30</td></tr>
<tr><td>· Heavy Duty Vehicles</td><td>18</td><td>2</td><td>5</td></tr>
<tr><td>· Off-Road (gas, diesel: construction, farm equipment)</td><td>17</td><td>4</td><td>2</td><td>1</td><td>12</td></tr>
<tr><td>· Other (rail, aircraft, marine)</td><td>3</td><td>3</td><td>1</td><td>2</td><td>2</td></tr>
<tr><td>NON-TRANSPORTATION</td><td>39</td><td>67</td><td>89</td><td>96</td><td>28</td><td>70</td></tr>
<tr><td>TOTAL EMISSIONS *
(kilotonnes)</td><td>100%
(659)</td><td>100%
(933)</td><td>100%
(335)</td><td>100%
(1,190)</td><td>100%
(3,440)</td><td>100%
(147,700)</td></tr>
<tr><td colspan="7">* Totals may not add up to 100% because numbers have been rounded.</td></tr>
</table>

Particulate matter refers to a wide range of particulates from microscopic (less than 10 micrometers in size) to coarse (up to around 100 micrometers) that can be air borne. As discussed in other HAQI reports, microscopic particulates (less than 10 micrometers) are the most harmful to human health. We do not have good estimates of emissions of these microscopic particulates, but preliminary information indicates that if we consider transportation sources alone, heavy duty vehicles (both on and off-road) are responsible for the majority of emissions.

Table 2:Hamilton-Wentworth emissions for 1990 by source (MOEE, internal data)

SOURCES	% of Total Emissions					
	NO_x	VOCs	PM	SO2	CO	CO_2
TRANSPORTATION						not recorded
· Light Duty Vehicles	28	22	2	1	1	
· Heavy Duty Vehicles	10	1	2	2	23	
· Tire Wear	0	0	5	0	0	
· Off-Road (gas, diesel: construction, farm equipment)	11	3	2	1	4	
· Other (rail, aircraft, marine)	4	1	1	3	0	
NON-TRANSPORTATION	47	73	89*	93	73	not recorded
TOTAL EMISSIONS (kilotonnes)	100% (39.4)	100% (59.9)	100% (19.5)	100% (36.5)	100% (521.8)	(2,420)

* The particulate matter estimate for non transportation sources is tentative.

It is important to note that emission levels are only part of the picture. Up to 50% of the smog pollutants come from outside Hamilton-Wentworth, primarily the US[1]. Emissions can have local (within a few hundred meters), regional, and long range effects. The mixture and movement of the pollutants in the air (dispersion), and the reactions among the pollutants (eg., NO_x and VOCs reacting in the presence of sunlight to form ground level ozone) are very complex and require computer models to estimate what concentrations may be expected downwind.

Unlike most non-transportation emissions that come from single locations or stacks (commercial and residential "point sources"), transportation is a mobile source, releasing emissions along vehicle corridors. Not only are transportation emissions spread across and between populated areas, the emissions vary greatly throughout the day, with the highest

[1] Similarly, communities downwind from the Regional Municipality of Hamilton-Wentworth are effected by emissions here.

levels during peak travel periods or “rush hours”. On some corridors it is increasingly difficult to find a lull during the day. This may be partly explained by considering U.S. survey data which indicates only about one third of travel is commuting to work (LBNL 1995). The remainder is for family business and recreation. A consequence of peak traffic all day is serious congestion, a topic that is discussed later on.

3.0Hamilton-Wentworth Travel, Land Use and Population Characteristics

Since transportation contributes to the overall air quality of Hamilton-Wentworth, it is helpful to understand transportation patterns and trends. Transportation reports are published by the Region of Hamilton-Wentworth, the Hamilton Street Railway, the Ministry of Transportation and Communication, Statistics Canada, and the former Ontario Roundtable on Environment and Energy (see References). These reports allowed study of these travel characteristics in Hamilton-Wentworth:

- Modal split (percentage of car use compared with other forms of transit),
- Public transit use,
- trip length,
- volume of trips,
- truck traffic, and
- marine, air and rail traffic.

The impact on air quality is also discussed.

3.1Modal Split

Surveys of transportation use have been conducted in Hamilton-Wentworth on three occasions: 1974, 1986 and 1991. Modal split (the percentage of car use compared with other forms of transit) was one aspect of these studies. The results show an increase in auto use and decrease in transit over time. As the following table illustrates, over time, there are more drivers, more cars and more trips. The average auto trip is also longer.

Table 3: Trends in Vehicle Use, 1974-1991, Hamilton-Wentworth

Driver and Vehicle Characteristics	1974	1986	1991
Drivers per Household	1.5	1.7	1.7
Vehicles per Household	1.2	1.4	1.4
Daily Trips per Person	2	2.1	2.2
Per Cent of Total Trips by Mode of Transportation (over 24 hours)			
Auto Driver	60%	63%	66%
Auto Rider (passenger)	20%	18%	16%
Transit	12%	10%	7%
Walking/Cycling	-	7%	7%
Average Trip Length (kilometres)			
Auto Driver	-	7.6	8.1
Transit	-	6.2	5.5
GO	-	56.6	56.2

3.2Public Transit

Hamilton Street Railway ridership has declined. Ridership in 1995 (20.4 million trips) was 68% of the 1984 level (29.8 million trips). This decrease is attributed to

- fewer people aged 15-24 (largest proportion of ridership comes from this group),
- migration to suburban areas that are neither well served nor well suited to public transit, and
- increased automobile ownership and use.

In response to this trend, the HSR has reduced its fleet size. The existing fleet now has a higher percentage of natural gas powered buses than it did in 1988. Natural gas buses generally emit fewer pollutants than diesel buses, especially particulates.

It is the policy of the Council of the Regional Municipality of Hamilton-Wentworth to purchase buses fuelled by natural gas. Public transit subsidies offered by the provincial government in 1997 required delivery in the same year. Because natural gas fuelled buses were not available Council was obliged to purchase diesel fuelled buses to take advantage of the subsidy. The new diesel buses have lower emissions than the diesel buses already on the road.

3.3Auto Traffic Within Hamilton-Wentworth

Traffic in the Region of Hamilton-Wentworth is measured by counting the volume of vehicles at specific points on Regional Roads and provincial highways.

On Regional Roads, two way north south traffic volume was estimated crossing the escarpment. East-west traffic was measured crossing the Red Hill Creek.

Traffic volume counts through the mountain accesses between 1974 and 1992 are illustrated below:

Table 4: Aggregated Traffic Volumes for North South Accesses (1974 to 1992)

Access	1974	1979	1984	1990	1992	% Change, 1974-92
Central	126,100	125,700	125,015	133,867	151,125	20
West	31,300	34,400	36,023	58,181	60,486	93
East	25,170	27,460	33,458	42,714	46,985	87

Accesses:
east: Centennial Parkway & Mount Albion Road
central: Kenilworth & Sherman Accesses, Jolley Cut, Claremont Access, James Mtn. Road., Beckett Drive
west: Highway 403 & Main Street

The Central Accesses carried the largest volume of traffic throughout the period. All accesses have increased volume counts over the 1974-1992 period. However, the East and West Accesses have both experienced substantial increases in traffic volumes, particularly the Western accesses.

East-west traffic is, in contrast, more stable. Measuring the number of crossings at the Red Hill Creek, it was determined that east-west traffic volumes in Hamilton-Wentworth have remained relatively constant over the last 20 years.

3.4Inter-Regional Commuting

Hamilton-Wentworth has a relatively low rate of commuting to areas outside of the Region compared to Toronto area communities. Nonetheless, there is a growing trend among Hamilton-Wentworth Residents to commute long distances to work. Table 5 shows that the percentage of work trips by Hamilton-Wentworth residents to destinations outside Hamilton-Wentworth has increased significantly since 1971 (Statistics Canada, 1991 Census).

Table 5: Percentage of Work Trips by Hamilton-Wentworth Residents to destinations outside Hamilton-Wentworth

Year	Work Trips Outside Hamilton-Wentworth as a % of Total
1971	9.4%
1981	12.5%
1991	19.2%

The number of people who commute to the Region to work also increased during the same period:

Table 6: Number of Commuters to Hamilton-Wentworth, 1971-1991

Year	Trips to Hamilton-Wentworth to Work	% Change in # of Trips
1971	22,505	
1981	30,847	37
1991	34,360	11

The increases in commuters and (presumably) commuting distances does not translate directly into increases in pollution because emissions standards have become more stringent during the same period.

3.5Truck Traffic

Early in the Hamilton-Wentworth Air Quality initiative, the lack of information on truck traffic was identified. Local truck traffic has not been studied in detail. Data about the origin and destination of truck trips in and around Hamilton-Wentworth are extremely limited. Results of the periodic surveys by Transport Canada are very approximate and include an unknown number of non-semi trailer vehicles (e.g., cube vans, smaller delivery trucks).

Data for all of Ontario are limited as well. The Ontario Roundtable on the Environment and Economy (1995) reported that trucks move the largest tonnage of freight in Ontario (40%). This accounts for 70% of the freight-related carbon dioxide emissions. It was found that trucking as a mode of freight transport is on the rise compared to air, marine and rail. Transport Canada's (1996) economic model of inter-urban traffic on the Canadian Highway network suggests that the largest number of one-way truck trips per day is in the Hamilton-Toronto corridor. The model also indicates that the average trip length for trucks is 230 kilometres, but those over 70% of one-way trips are less than 200 kilometres, and about 45% are less than 100 kilometres. Apparently many trucks travel relatively short distances, while a lesser number travel over 1,000 kilometres. Estimating emissions from such a variety of vehicles and trip types poses a special challenge for future studies.

The significance of truck travel to freight emissions in Ontario indicates the need for more study of provincial and local truck traffic. Modeling of truck emissions and their impacts is critical to our understanding of emissions sources.

3.6Air/Marine/Rail

Air, marine and rail transit are not major sources of the priority pollutants, but the available data was reviewed for trends in use. Air traffic is growing, primarily due to increases in cargo transport. In 1996, there were averages of 193 flights per day.

Rail and marine traffic are relatively stable in Hamilton-Wentworth. While the total number of ships has declined, their capacity has increased. In the last 15 years, the average tonnage has ranged consistently between 10 and 13 million tonnes.

Rail traffic is steady with an average of 12 Toronto-Niagara Falls trips (crossing north Hamilton), 6 Hamilton-Toronto Trips (TH&B GO Station), 44 London-Toronto trips (northern border of Region of Hamilton Wentworth) and yard work (shunting).

3.7Air Quality Impacts of Transportation Sources

There are a number of factors at play when considering the impact of transportation sources on air quality. First, is the increase in car use. *In the absence of continued improvement in vehicle technology*, the increase in private auto use would increase emissions of all of the priority pollutants, due both to more vehicles and to increased congestion . At the same time, while mission standards for new vehicles are improving, owners are keeping their vehicles longer (vehicles originally built to meet less stringent standards). The introduction of Ontario's Drive Clean program (announced by the Minister of Environment and Energy in August 1997), which will start in the GTA and Hamilton-Wentworth in 1998, will require owners to keep their vehicles well tuned.

Second, the shift to increased car use and away from public transit works against improvements in air quality. Declining ridership means lower levels of service to the remaining users. Thus the impact of the shift to natural gas powered buses, which means a significant reduction in emissions, is muted by the decline in service.

Third, assuming regional trends are consistent with the province, freight shipments by truck are becoming more important as a source of priority pollutants. Diesel fuel emits more fine particulates than gasoline or natural gas. This area needs to be studied further because of the health impacts of the fine particulates.

Finally, emissions from transportation sources are affected by population growth and the pattern of land development in the community. A discussion of the trends, and their impact on Air Quality in Hamilton-Wentworth, follows.

3.8Population/Land Use Trends: Transportation Implications

There are several studies which document the connection between transportation patterns and urban design (Region of Hamilton-Wentworth, 1995 and 1996, and Delcan, 1996). Low density, single use residential development encourages private auto use. Mixed uses and higher densities are better able to support public transit, bicycles and pedestrians. New development in Hamilton-Wentworth has tended to support private auto use. Although density levels in the suburbs are increasing somewhat due to smaller lot sizes, residents of new subdivisions are not using public transit or walking to destinations. The fact that subdivisions are not designed to provide a high level of pedestrian mobility and transit access is a factor in the predominance of car use and lack of transit service.

The population in Hamilton-Wentworth has shown consistent growth which is expected to continue into the next century.

Table 7: Population Projections by Municipality, 1991-2021 (RMHW, 1992)

Municipality	1991	2001	2011	2021	% Change 1991-2021
Upper Hamilton	131,000	148,070	152,310	155,415	19
Lower Hamilton	187,500	186,790	186,685	186,685	0
Hamilton	318,500	334,855	338,970	342,100	7
Ancaster	21,990	28,500	35,680	42,955	95
Dundas	21,870	23,405	24,210	25,515	17
Flamborough	29,615	37,005	45,290	52,925	79
Glanbrook	9,726	11,875	14,090	15,975	64
Stoney Creek	49,970	62,425	74,615	86,995	74
Total	451,675	498,045	532,830	566,480	25

It is expected that the Region's population will increase by 25% during the 1991-2021 period. However, this growth will be far from evenly distributed. Ancaster is expected to double in population, while the population of the City of Hamilton below the mountain is expected to remain virtually unchanged.

There will also be a significant shift in age of the population during the 1991-2021 periods.

Table 8: Populations Projections by Age Group, 1991-2021 (RMHW, 1992)

Age Group	Population		% of Total		% Change
	1991	2021	1991	2021	1991-2021
0-14	88,675	91,965	20	16	4
15-24	63,010	66,600	14	12	6
25-44	147,645	149,535	33	26	1
45-64	91,885	154,335	20	27	68
65-79	48,015	78,175	11	14	63
80+	12,445	25,870	3	5	108
Total	451,675	566,480	100	100	25

In the 1991-2021 period, the impact of the aging of "baby boomers" can definitely be seen. The number in the younger age groups (to age 45) will remain virtually unchanged. At the other end of the scale, those over 80 will more than double.

This anticipated growth poses significant challenges to improving air quality. From a public transit perspective, the denser lower city of Hamilton, most conducive to public transit, is not expected to grow at all. The areas where growth is anticipated are not typically developed at a high enough density to make public transit feasible.

There are also a number of indications that vehicle use will continue to increase. First, in all areas of the Region, residents are increasingly using cars to commute and to commute outside the Region. Second, the distribution of population growth, primarily in suburban municipalities, suggests private vehicles will be a feature of new households. Third, as people age, they tend to choose automobiles over other modes of transit. Therefore the number of vehicles on the roads can be expected to increase due to the aging of the population. Thus private vehicles will continue to be a fixture in the lives of Hamilton-Wentworth residents and an important factor to be considered in the Hamilton-Wentworth air quality equation. In these circumstances, predicting the emissions from traffic is very important.

4.0 IMULATE Modelling: Transportation Policy Implications

Historic increases in vehicle use suggest vehicle emissions may increasingly influence air quality. The Hamilton-Wentworth Air Quality Initiative commissioned the use of the IMULATE[2] simulation model to evaluate the effect of a variety of policy options. IMULATE estimates automobile emissions of hydrocarbons (VOCs), nitrogen oxides (NO_x), and carbon monoxide (CO). The model incorporated spatial projections of population growth, employment, household structure and transportation infrastructure provided by the Regional Municipality of Hamilton-Wentworth. A key feature of the model is its ability to reflect that emissions are higher (per kilometre) in stop and go traffic than on free flowing routes. Because of the impact of congestion on emissions, a 10% reduction in the number of cars on the road will result in a reduction of greater than 10% in emissions. The model was used to generate emissions at 10 year intervals from 1991 to 2021.

The goal of the study was not to provide accurate predictions of the future, but to predict the relative importance of various factors in determining future emission levels. Many factors not included in the model would likely increase the actual emissions levels under the various scenarios: driving habits (rapid acceleration and braking), less than ideal vehicle maintenance despite Ontario's emission testing program (eg. low tire pressure), more travel during non-rush hour periods, an increase in average vehicle age (greater proportion of vehicles with older emission technologies), demographics (older people preferring cars), and sporadic road hazards (construction, accidents, inclement weather).

Six scenarios were developed:

- **Base**: road networks to remain unchanged in extent and capacity.

2 Integrated Model of Urban Land-use, Transportation, and Environmental Analysis. The full report is available from McMaster University. Please see *References* at the end of this report for details.

- **New Roads**: incorporate all the Region's planned improvements and expansions, including the Red Hill Expressway and the bypass of Highway 5 around Waterdown.
- **Technological Improvements**: improvements in vehicle emissions based on full phase-in of emissions standards defined by the US Environmental Protection Agency.
- **25% Transit**: assumes 25% of morning rush hour trips are made by transit as compared with 11% now.
- **Dispersed Land Use:** assumes new developments would be at a density no lower than Westdale, an ‘old suburb’ neighbourhood of Hamilton.
- **Concentrated Land Use:** assumes infill instead of peripheral development.

It should be noted that the scenarios for technological improvements, 25% transit, dispersed land use and concentrated land use all include the New Roads scenario. Since the changes in the New Roads scenario were based on existing plans, it was considered more likely than the base scenario in which the network would remain unchanged.

The next table summarizes the detailed results of the model simulations under the six scenarios. Note that the data reflect relative changes in vehicle kilometres *during a single morning rush hour period.* It assumes vehicles meet emission standards for their model years.

Table 9 Changes in key variables for morning rush hour period, 1991-2021 (Kanaroglou et. al., 1997)

Scenario	Vehicle Kilometres Travelled	Average Congested Speed (km/hour)	Emissions of HC (kg)	Emissions of NO_x (kg)	Emissions of CO (kg)
1991	797,085	33.28	7,480	6,577	80,983
2021 Base	972,619	30.78	12,136	8,611	132,527
2021 New Roads	995,324	32.68	10,134	8,308	111,022
2021 Technological Improvements + New Roads	995,324	32.68	5,119	4,759	58,052
2021 25% Transit + New Roads	891,151	33.71	7,982	7,309	87,573
2021 Dispersed Land Use + New Roads	1,016,085	32.66	10,157	8,324	111,242
2021 Concentrated Land Use + New Roads	961,180	32.75	9,952	8,199	108,983

In comparison with the **new roads** scenario

- the **technological improvements scenario** results in significant reductions in all three pollutants.
- the **25% transit use scenario** increases the average speed, and reduces congestion, emissions and Vehicle Kilometres Travelled (VKT)
- the **dispersed land use scenario** increases VKT, and has little impact on speed or emissions
- the **concentrated land use scenario** reduces VKT and emissions. In spite of increased concentration in land use, there is only a slight increase in congested speed.

Table 10 translates the emissions levels in Table 9 to percentage changes.

Table 10: Percentage Change in key variables for morning rush hour period, 1991-2021 (Kanaroglou et. al., 1996)

Scenario	Vehicle Kilometres Travelled (% Change)	Average Congested Speed (% Change)	Emissions of HC (% Change)	Emissions of NO_x (% Change)	Emissions of CO (% Change)
2021 Base	22	-8	62	31	64
2021 New Roads	25	-2	35	26	37
2021 Technological Improvements + New Roads	25	-2	-32	-28	-28
2021 25% Transit + New Roads	12	1	7	11	8
2021 Dispersed Land Use + New Roads	27	-2	36	27	37
2021 Concentrated Land Use + New Roads	21	-2	33	25	35

The key findings of the IMULATE modelling exercise are summarized as follows:

- Regulations to further reduce car emissions have been approved by the US Environmental Protection Agency and will be introduced over time. These improvements to automobiles offer the most promise for lowering or at least reducing the growth in emissions due to an increase in population and auto use. Without the projected gains from technological improvements, emissions from light vehicles will increase dramatically between 1991 and 2021 (hydrocarbons 62%, NO_x 31% and CO 64%). Note, however, that the assumptions used in this projection may be optimistic because they don't reflect degradation in performance of emissions control equipment.
- Increasing the level of public transit use could have a major impact on slowing the growth of transportation emissions. Promotion of high occupancy vehicle use, car-pooling, or the use of smaller, more innovative public transit, would offer similar gains and may be more acceptable in a car oriented community.
- Dispersed land development will increase the vehicle kilometres travelled, and increase traffic congestion and emissions of HC (36%), NO_x (27%) and CO (37%)
- Concentrated land development and the approval of new development within the existing urban boundary could lead to reductions in emissions from transportation sources. However, these effects are marginal because so much of the municipality is already built and will not be significantly altered over the next 10-20 years.
- New and improved roads will reduce congestion and thus will also reduce emissions of air pollution from transportation sources in the short term. However, in the longer term, construction of new roads will encourage an increase in car use thus increasing air pollution.

4.1 Conclusions

1. Policy Implications of Modelling

The findings of the McMaster modelling efforts provide guidance for policy direction to reduce emissions during peak traffic periods. Introduction of the planned EPA legislated auto emissions controls) will be the single most effective measure to reduce emissions. The next most effective step will be to reduce the total kilometres driven during peak hours. This could be achieved by increasing bus ridership, walking, cycling and car pooling, and changes to work arrangements such as telecommuting, and compressed work weeks.

The third step is to have higher densities in new developments (and within the existing urban boundary). Planning **now** for efficient utilization of existing infrastructure in anticipation of new development will be key to achieving this step.

2. Further Use of IMULATE

As was noted earlier, the IMULATE model has significant strengths because it can calculate the emissions which come from increased congestion and can estimate changes in vehicle flow on a geographic basis. Time and resources did not permit expansion of the simulation during this period of study. From the point of view of this initiative, the model would be more effective if it were expanded to include:

1. estimates of fine particulate and VOC emissions.
2. emission from heavy duty vehicles (ie. trucks) and
3. the "attraction" of new road ways for vehicle traffic.

5.0 Summary

The Land Use/Transportation Work Group studied the emissions from transportation sources, and the trends in transportation use in Hamilton-Wentworth in conjunction with land use. The Transportation sector is now the single largest source of smog-related pollutants (nitrogen oxides (NO_x), and volatile organic compounds (VOCs)). They also contribute significant levels of climate change gases (Carbon dioxide (CO_2), and carbon monoxide (CO)).

The IMULATE Simulation, developed by McMaster University, was used to project the effect of changes in roads, vehicle emissions technology, transit use and land development. Based on the reviewed information, changes in emission technology and reduction in vehicle use are crucial to reducing the impact of vehicle emissions on air quality.

Finally, the Land Use/Transportation Sub-Committee found very limited information about truck transportation. However, based on the information which was available, freight shipments by truck need investigation as they appear to be a significant and growing source of fine particulate emissions.

6.0References

Delcan Corporation, in association with M. M. Dillon Ltd and I. B. I. Group. Regional Transportation Review Final Report, (for the Region of Hamilton-Wentworth), April, 1996.

IBI Group. November 1995. Urban Planning, Public Transit and Initiatives for More Sustainable Transportation. Prepared for National Round Table on Environment and the Economy, Ontario Round Table on Environment and Economy in support of the Transportation and Climate Collaborative.

Kanaroglou, P.S, Robert South and W.P. Anderson. 1997. Automotive Emissions in Hamilton-Wentworth 1991-2021: Results from an Integrated Urban Simulation Model. McMaster University.

Lawrence Berkeley National Laboratory. Energy Analysis Program 1995 Annual Report. Energy and Environment Division. p.65-66.

MOEE (a): Air Quality in Ontario, 1994 Comprehensive Report (released December 1995)

MOEE (b): Fast Reference Emission Document, Version 3 (released May 1996)

MOEE (c): Towards a Smog Plan for Ontario. A discussion paper (released June 1996)

MTO: Vehicles registered in Hamilton-Wentworth and Ontario

Transportation Tomorrow Survey

Vehicle Travel Survey (Statistics Canada),

Canadian tailpipe emissions model (Mobile5c)

Regional Municipality of Hamilton-Wentworth. 1992. Population, Household and Labour Force Projections, 1991-2021.

Regional Municipality of Hamilton-Wentworth. 1995a. Towards a Sustainable Region: Official Plan for the Regional Municipality of Hamilton-Wentworth.

Regional Municipality of Hamilton-Wentworth. 1995b. Planning and Development Department, Commuter Study for Hamilton-Wentworth and Surrounding Areas.

Regional Municipality of Hamilton-Wentworth. 1996. Greenhouse gas reduction strategies. A baseline inventory of energy consumption and preliminary analysis of

carbon dioxide emissions. Prepared by Sonya Lyall, Environmental Youth Corps Program.
Transmode Consultants. 1995. Ontario Freight Study Movement. Prepared for the National Round Table on the Environment and the Economy, Ontario Round Table on Environment and Economy in support of the Transportation and Climate Change Collective.

Transport Canada. 1996. An economic model of inter-urban traffic on the Canadian Highway Network. Bob Leore, Special Infrastructure Project. Figures 15 and 16.