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# DISCUSSION PAPER FOR CLEAN AIR PLAN

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Region of Waterloo  
PUBLIC HEALTH

## **DISCUSSION PAPER FOR CLEAN AIR PLAN**

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## DISCUSSION PAPER FOR CLEAN AIR PLAN

<b>TABLES AND FIGURES</b>	<b>6</b>
<b>EXECUTIVE SUMMARY</b>	<b>7</b>
<b>OVERVIEW</b>	<b>12</b>
<b>INTRODUCTION</b>	<b>12</b>
<b>OBJECTIVES</b>	<b>13</b>
<b>THE REGION OF WATERLOO'S ENERGY USE EMISSIONS INVENTORY</b>	<b>14</b>
<b>BUILDINGS</b>	<b>15</b>
<b>VEHICLE FLEET</b>	<b>17</b>
<b>STREETLIGHTING</b>	<b>18</b>
<b>WATER AND SEWAGE PUMPING</b>	<b>18</b>
<b>EVALUATIVE FRAMEWORK</b>	<b>20</b>
<b>EMISSION REDUCTION STRATEGIES</b>	<b>21</b>
<b>BUILDINGS</b>	<b>21</b>
<b>OPTION 1: LIGHTING EQUIPMENT EFFICIENCY IMPROVEMENTS IN PRIMARY REGIONAL BUILDINGS</b>	<b>22</b>
<b>OPTION 2: HVAC SYSTEM UPGRADES, BUILDING ENERGY MANAGEMENT AND EXHAUST HEAT RECOVERY</b>	<b>22</b>
<b>OPTION 3: ENERGY STAR OFFICE EQUIPMENT AND IMPLEMENT AUTOMATIC POWER DOWN SOFTWARE</b>	<b>24</b>
<b>OPTION 4: ENERGY EFFICIENT LIGHTING IN REGIONAL AFFORDABLE HOUSING</b>	<b>24</b>
<b>OPTION 5: GREEN POWER</b>	<b>25</b>
<b>FUELS</b>	<b>26</b>
<b>OPTION 6: REPLACE GASOLINE WITH 10% ETHANOL (E10) IN REGIONAL FLEET</b>	<b>27</b>
<b>OPTION 7: REPLACE DIESEL WITH B20 IN ON-ROAD AND OFF-ROAD FLEETS</b>	<b>28</b>
<b>OPTION 8: REPLACE DIESEL WITH ULSD IN ON-ROAD, OFF-ROAD AND GRT FLEETS</b>	<b>29</b>
<b>OPTION 9: REPLACE DIESEL WITH #1 PREMIUM (ADDITIVE) IN ON-ROAD, OFF-ROAD AND GRT FLEETS</b>	<b>30</b>
<b>OPTION 10: GRT CATALYTIC EXHAUST MUFFLER</b>	<b>31</b>
A. Catalytic Mufflers with Diesel	32
B. Catalytic Mufflers with ULSD	32
<b>OPTION 11: REPLACE COLOURED DIESEL WITH NO.2 DIESEL IN OFF-ROAD FLEET</b>	<b>33</b>
<b>OPTION 12: DRIVER EDUCATION FOR FUEL EFFICIENCY</b>	<b>33</b>
<b>OPTION 13: EMPLOYEE TRANSPORTATION DEMAND MANAGEMENT PROGRAM – PHASE 1</b>	<b>34</b>
<b>STREETLIGHTS</b>	<b>35</b>

<b>OPTION 14: RETROFIT TRAFFIC SIGNAL LIGHTS TO LED LAMPS</b>	35
<b>OPTION 15: USE ENERGY EFFICIENT LUMINAIRES, BALLASTS AND PHOTOELECTRIC CELLS</b>	35
<b>DEMONSTRATION PROJECTS</b>	<b>36</b>
<b>OPTION 16: INNOVATIVE TECHNOLOGY FOR NEW BUILDING DESIGN</b>	36
<b>OPTION 17: ALTERNATIVE BUS TECHNOLOGY – ELECTRIC HYBRIDS</b>	37
<b>OPTION 18: USE MORE EFFICIENT VEHICLES</b>	38
<b>ENDORSEMENT OF INITIATIVES UNDERWAY</b>	<b>40</b>
<b>ANTI-IDLING POLICY</b>	40
<b>ENERGY CONSERVATION – OCCUPANT EDUCATION</b>	40

**CONCLUSIONS** **40**

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<b>APPENDIX A. HEALTH EFFECTS OF POLLUTANTS</b>	<b>44</b>
PARTICULATE MATTER (PM) LEGISLATION	46
<b>APPENDIX B. REGION OF WATERLOO/CACAQ - CLEAN AIR PLAN (CAP) SUCCESSION</b>	<b>47</b>
<b>APPENDIX C. EMISSION REDUCTION STRATEGIES EXCLUDED FROM THE INVENTORY</b>	<b>48</b>
<b>APPENDIX D. DATASOURCES AND ASSUMPTIONS</b>	<b>49</b>
<b>EMISSIONS INVENTORY</b>	<b>49</b>
BUILDINGS	49
VEHICLE FLEET	50
STREETLIGHTING	52
WATER/SEWAGE TREATMENT	53
<b>MEASURES ANALYSIS</b>	<b>53</b>
BUILDINGS	53
<b>Option 1: Lighting Equipment Efficiency Improvements</b>	53
<b>Option 2: HVAC System Upgrades, Building Energy Management, Exhaust Heat Recovery</b>	53
<b>Option 3: Energy Star Office Equipment and Implement Automatic Power Down Software</b>	54
<b>Option 4: Energy Efficient Lighting in Regional Affordable Housing</b>	54
<b>Option 16: Innovative Technology for New Building Design</b>	54
VEHICLE FLEET	55
<b>Option 6: Replace Gasoline with E10</b>	55
<b>Option 7: Replace Diesel with B20 in On-road and Off-road Fleets</b>	55
<b>Option 8: Replace Diesel with ULSD in On-road, Off-road and GRT Fleets</b>	56
<b>Option 10: GRT Catalytic Exhaust Muffler</b>	56
<b>Option 11: Replace Coloured Diesel with No. 2 Diesel in Off-road Fleet</b>	57
<b>Option 12: Employee Driver Education Program</b>	57
<b>Option 17: Alternative Bus Technology – Electric Hybrids</b>	57
STREETLIGHTING	58
<b>Option 14: Retrofit Traffic Signal Lights to LED Lamps</b>	58
<b>Option 15: Use Energy Efficient Luminaires, Ballasts and Photoelectric Cells</b>	58
<b>EMISSION FACTORS</b>	<b>58</b>
<b>APPENDIX E. THE TORRIE SMITH ASSOCIATES GLENEAGLE AIR EMISSIONS STRATEGY SOFTWARE</b>	<b>60</b>

**REFERENCES** **61**

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## TABLES AND FIGURES

Figure 1. The cascading health effects of air pollution _____	12
Table 1. Volume of Air Emissions Per Year by Regional Sector _____	7
Table 2. Region of Waterloo Common Air Contaminant Emissions by Sector _____	14
Table 3. Air Pollution Emissions from the Region of Waterloo's Buildings and Building Groups _____	15
Table 4. Air Pollution Emissions from the Region of Waterloo's Vehicle Fleet _____	18
Table 5. Air Pollution Emissions from the Region of Waterloo's Streetlights _____	19
Table 6. Air Pollution Emissions from the Region of Waterloo's Largest Water and Sewage Pumping Stations _____	20
Table 7. Number of Individuals who Avoided Health Effects with Reduced Sulphur Content _____	26
Table 8. Three Cost Options to Address Clean Air Plan _____	41
Table 9. The Region of Waterloo Clean Air Plan Financial Summary _____	42
Table 10. Region of Waterloo Clean Air Plan Emission Reduction Potential _____	43
Table 11. Sources and Health Effects of Air Pollutants _____	44
Table 12. Vehicle Fuel Consumption Totals by Regional Service Category and Fuel Type _____	51

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## EXECUTIVE SUMMARY

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**BACKGROUND:** Improving air quality is a public health priority. According to the Ontario Medical Association air pollution triggers more than 1900 premature deaths in Ontario a year – 70 of these occur in the Region of Waterloo. In an effort to prevent some of these deaths and associated morbidity, several Ontario municipalities are implementing initiatives to reduce the amount of air pollution they produce. The range of initiatives includes but is not limited to using cleaner fuels, retrofitting facilities to reduce energy use and advocating for the development of renewable energy. The Region of Waterloo is also making advancements. In 2002 the Region adopted the Clean Air Plan. The primary goal of the Plan is to improve the health of residents by reducing the amount of air pollution in the Region of Waterloo.

**REGION OF WATERLOO INVENTORY OF AIR EMISSIONS:** Between March and September 2002 Region of Waterloo Public Health facilitated an inclusive Region-wide in-house exercise to evaluate measures to reduce the amount of air pollution created by Regional operations. An emissions inventory to identify current sources and volume of air pollution emitted by Regional activities was conducted. Staff from several departments (Clean Air Plan Committee) contributed the data required to carry out the analysis and suggested measures within their respective departments that could reduce air emissions. The consulting firm Torrie Smith Associates Inc., calculated emissions of the five criteria air contaminants (NO<sub>x</sub>, SO<sub>x</sub>, CO, VOCs and PM<sub>10</sub>) associated with all Regional operations and potential emission reductions of all suggested measures. The reduction measures were ranked according to their impact on reducing air emissions, feasibility and cost-effectiveness.

**RESULTS:** The Region produces a total of 724,704 kg of air emissions each year. About 60% of these are emitted locally through Regional vehicle fuel consumption, while the remaining 40% result from electricity usage and are produced outside the region at power generating plants such as Nanticoke. Table 1 presents the volume of emissions produced in each Regional sector.

**Table 1.** Volume of Air Emissions Per Year by Regional Sector

Regional Source	Total emissions (kg/year)	Percent of Regional Emissions (%)
Buildings	81,207	11.2
On-road vehicles	361,658	50.0
Off-road vehicles	70,480	9.7
Employee commute	53,459	7.3
Streetlights	14,777	2.0
Water/sewage	143,123	19.8
<b>Total</b>	<b>724,704</b>	<b>100</b>

**RECOMMENDED MEASURES – THE ‘TOP 11’:** Initially a list of over 25 measures to reduce air pollution, touching on all sectors of the Region, was compiled. Some of these measures were excluded because there was insufficient data to quantify their impacts in terms of emissions reduction, the strategy represented an option that was not relevant to the next business cycle or the option was not feasible or cost effective.

The ‘top 11’ emission reduction measures were identified using the criteria of impact on emissions reduction, cost effectiveness and feasibility. Five measures address fuel and vehicle use; two aim to improve the efficiency of street and traffic lights; and four measures suggest reduction in energy consumption in Regional buildings. Descriptions of each measure are provided below. Full implementation of the ‘top 11’ measures over a two to five year period would reduce Regional emissions by 17%.

#### **FUEL AND VEHICLE USE:**

##### **1. Replace Gasoline with 10% Ethanol (E10) in Regional Fleet**

Ethanol gasoline is a grain-based alcohol made primarily from corn. It is a cleaner burning fuel than regular gasoline, producing fewer emissions and subsequently less ground level ozone. It is available at the same rate as regular gasoline. Switching to ethanol would require a one-time cost to survey Regional fuel sites, prepare storage tanks, and fit in-line fuel filters to existing pumps. Both the City of Waterloo and Toronto Hydro successfully use E10 for their gasoline fleets.

##### **2. Replace Diesel with ULSD in GRT Fleet and #1 Premium (Additive) Fuel in On-road and Off-road Diesel Fleets**

Ultra low sulphur diesel fuel has a sulphur content of less than 15ppm compared to approximately 500 ppm in current diesel. Government legislation limiting all on-road diesel fuel to 15 ppm sulphur content will be effective in 2006. Currently ULSD is not available on the Canadian market; however, PetroCan has been sourced and is potentially interested in providing the Region with this product. Concerns with reduced horsepower, lubricity and potential issues with seals surround the use of ULSD in the Region’s on-road and off-road fleets. These issues should not be experienced by the GRT fleet as they currently use a lighter density diesel fuel. The #1 Premium (Additive) fuel is suitable for use in on-road and off-road diesel vehicles. Emissions of particulate matter, black smoke and hydrocarbons are reduced with its use without affecting vehicle performance.

##### **3. GRT Catalytic Exhaust Muffler**

Retrofitting older buses with catalytic exhaust mufflers reduces emissions of particulates and carbon-based pollutants as well as some oxides of nitrogen. Using ULSD fuel can enhance emission reductions significantly.

##### **4. Employee Transportation Demand Management Program – Phase 1**

The Region can establish an employer-based Transportation Demand Management program to assist employees in traveling to work in modes other than by single occupant vehicle. The emissions reduced assume a 5 per cent switch from single

occupant vehicle to other modes. This program would review and determine possible options for staff. Options could include a ride- matching service to find carpool partners, transit passes and other incentives to encourage a modal shift.

#### **5. Green Power Purchase Plan**

Green power costs more to purchase than power produced by coal or gas fired turbine plants. At this time, Green power primarily includes wind, solar, bio-mass and hydroelectric power generators. The initial target would be that 10% of the power purchased by the Region be Green power starting in 2004. An energy procurement strategy will be presented to Council in 2003 with more details.

#### **6. Alternative Bus Technology – Electric Hybrids**

A hybrid electric bus operates partially on diesel or compressed natural gas and electric power. It consumes 30% less fuel than regular buses and over the lifetime of a bus. Hybrid electric buses are available for three year lease terms for demonstration purposes. The lessee is responsible for all maintenance costs. Leasing a demonstration bus has high community visibility and profile and provides direct operating experience on which to base future purchasing decisions. Toronto and BC Transit are currently testing hybrid models.

*\*\*\*The remaining options result in reduced energy (e.g., electricity and natural gas) needs thereby decreasing emissions from coal-burning remotely. All measures offer energy savings and subsequently pay for themselves over a period of time.\*\*\**

### **TRAFFIC AND STREET LIGHTS:**

#### **7. Retrofit Traffic Signal Lights to LED (light emitting diode) Lamps**

LEDs consist of a number of small pinpoint lights that together produce brighter light than the single incandescent bulb they replace. They are 85% more efficient than incandescent bulb. About 10% of Region's traffic lights already replaced with LED's.

#### **8. Use Energy Efficient Luminaires, Ballasts and Photoelectric Cells**

New lighting technology uses lower wattage flat lens fixtures. These lights also reduce greenhouse gas production, roadway glare and light pollution. The City of Calgary is currently retrofitting 11,000 light fixtures.

### **REGIONAL BUILDINGS:**

#### **9. Energy Efficient Lighting in Regional Affordable Housing**

This project involves retrofitting the lighting in "public spaces", such as hallways, with more efficient lamps in the Region's Affordable Housing projects. Note this project does not include lights that are tenant's responsibility.

#### **10. Lighting Equipment Efficiency Improvements in Primary Regional Buildings**

The range of retrofits includes switching to more efficient lamps and ballasts and improving illumination with reflectors.

### **11. HVAC System Upgrades, Building Energy Management and Exhaust Heat Recovery**

This includes improving the efficiency of automated HVAC systems by changing software and parameters. It also includes air sealing and capturing heat exhaust and using it to heat incoming air.

#### **RECOMMENDED POLICIES:**

An additional four measures were evaluated and are recommended for future Regional policy as they all have implications that extend beyond the current budget cycle. They are:

##### **1. Energy Star Purchase Policy**

Energy efficient equipment reduces power usage by 50%. When fully implemented, this option can reduce air emissions by 4,000 kg – which is 0.5% of total regional emissions. There is no premium to purchasing energy-efficient office equipment. The current practice in most departments is to purchase energy-efficient equipment when available however there is not yet a formal policy.

##### **2. Driver Education for Fuel Efficiency**

Poor driving habits, such as idling and 'jack rabbit' starts, can unnecessarily waste fuel. If 20% of Regional drivers reduce their fuel consumption by 10% through efficient operation, emissions would reduce by 1000 kg, amounting to 0.1% of total Regional emissions. This can be achieved at no cost. Environment Canada provides a pollution prevention fact sheet that outlines proper driving practices.

##### **3. Innovative Technology for New Buildings**

Examples include increasing the proportion of natural light in a building and installing photovoltaic cells and solar panels in new buildings. These technologies reduce electrical consumption and demonstrate environmental leadership. The cost of installing these modifications in existing buildings is prohibitive; a more cost effective option is to introduce them with new building projects.

##### **4. Hybrid Electric Cars**

Hybrid vehicles use mechanical power from small gasoline combustion engines and electrical power from a generator/motor that can be used to charge on-board batteries or drive the vehicle directly. Hybrid vehicles have the best ratings profiles for green house gas and smog-forming emissions for all vehicle types. A hybrid vehicle (Honda Insight, Honda Civic Hybrid or Toyota Plus) costs \$30,000, approximately \$10,000 more than a gasoline powered sedan. As the leases on Regional sedans expire, consideration should be given to leasing hybrid vehicles.

**RECOMMENDATION:** THAT the Regional Municipality of Waterloo forward the following strategies for the reduction of emissions to the Budget Committee of the Whole for consideration during the 2003 budget process:

- 1) Replace Gasoline with 10% Ethanol (E10) in Regional Fleet;
- 2) Replace Diesel with ULSD in GRT Fleet and with #1 Premium (Additive) Diesel in On-road and Off-road Fleets;
- 3) Install Catalytic Exhaust Mufflers on GRT Fleet;
- 4) An Employee Transportation Demand Management Program – Phase 1;
- 5) 10% Green Energy Purchase; and
- 6) Electric Hybrid Bus

AND THAT the Regional Municipality of Waterloo support in principle funding for:

- 7) Retrofit Traffic Signal Lights to LED Lamps;
- 8) Use Energy Efficient Luminaires, Ballasts and Photoelectric Cells;
- 7) Energy Efficient Lighting in Regional Affordable Housing;
- 8) Lighting Equipment Efficiency Improvements in Primary Regional Buildings; and
- 9) HVAC System Upgrades, Building Energy Management and Exhaust Heat Recovery

and forward the remaining strategies and policy issues back to staff for follow up.

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## OVERVIEW

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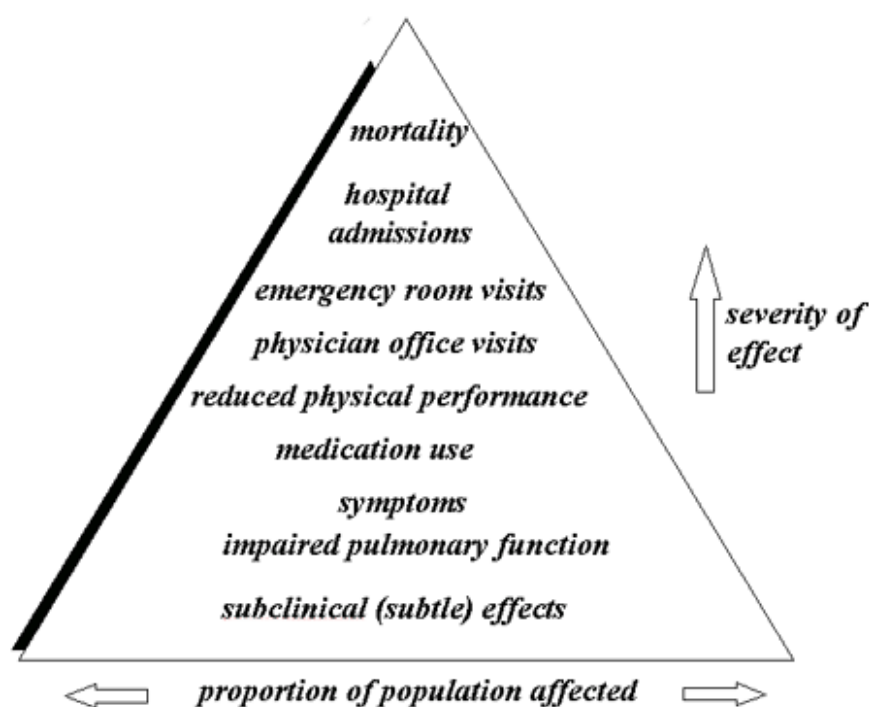
This Discussion Paper has been prepared to provide a baseline inventory of Regional air emissions (2001 used as baseline), investigate options for an emission reduction strategy and develop an implementation plan, as inspired by the Clean Air Plan (CAP). The paper examines opportunities to maximize reductions of air pollutant emissions from Regional operations in a cost-effective manner. It identifies and quantifies sources of emissions from Regional operations and measures to reduce emissions. Measures are prioritized through the use of an evaluative framework that considers potential emission reductions, potential health benefits, costs and feasibility of implementation.

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## INTRODUCTION

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During the summer of 2002 there were 19 days in which smog alerts were issued. These alerts are targeted at vulnerable populations, such as residents with underlying cardiopulmonary and asthmatic illnesses, whose health is jeopardized by bad air. A detailed description of common air contaminants is provided in Appendix A. According to 1998 estimates, air pollution triggers more than 70 premature deaths in the Region of Waterloo each year. These deaths represent the apex of the pyramid of cascading health effects of air pollution. (Figure 1) The only solution is to clean up the air.



**Figure 1.** The cascading health effects of air pollution

(adapted from the Canadian Respiratory Journal 2,3 (1995): 155-160)

As awareness about the health and economic impact of air pollution grows, so do efforts to monitor and reduce its burden. Environmental issues and the Kyoto accord were both high profile at the premiers' annual meeting in August. The Ontario Ministry of Environment and Energy recently revised the Air Quality Index to include particulate matter as one of its parameters.

At the local level, several Ontario municipalities are undertaking initiatives to reduce air emissions. In addition to inter-departmental activities, Waterloo Regional Council has endorsed several Committee reports advocating for federal and provincial action around strategies to reduce air pollution in all sectors locally and those produced by neighboring U.S. states. Initiatives in neighboring jurisdictions include building energy efficiency programs in Middlesex-London, the City of Mississauga and the City of Toronto; the introduction of gasoline-electric hybrid vehicles by the Hamilton Street Railway; and the use of alternative fuels such as biodiesel by the City of Brampton and Toronto Hydro and ethanol also used by Toronto Hydro. Furthermore, plans to increase the purchase of 'green energy' thereby decreasing the purchase of coal-fired electricity are being considered by the City of Toronto.

In 2002 the Region and Municipalities adopted the Clean Air Plan developed by the Citizen's Advisory Committee on Air Quality. The Waterloo Regional Clean Air Committee was subsequently formed to assist the Region in meeting the objectives of the Clean Air Plan. This committee is composed primarily of Regional managers who manage or operate the main consumers of energy in the Region: i.e. buildings, fleets, light and heavy vehicles, streets, lighting, transportation services and planning. Between January and July 2002 the Public Health Department coordinated a number of meetings with the Waterloo Region Clean Air Committee to discuss possible measures the Region could implement to reduce the amount of air pollution the Region is producing. The development of the Clean Air Plan and subsequent milestones are outlined in Appendix B.

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## OBJECTIVES

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In order to realize the objectives of the Clean Air Plan and improve local air quality the current project had two primary objectives:

1. Develop a baseline inventory of the five criteria air pollutant ( $\text{NO}_x$ ,  $\text{SO}_x$ , CO, VOC,  $\text{PM}_{10}$ ) emissions created by Regional operations; and,
2. Identify measures that offer the greatest reduction in the quantity of air emissions in the most cost-effective manner (as these strategies also offer the greatest health benefit).

A detailed description of the Region of Waterloo's emissions inventory and potential emission reduction strategies are described in subsequent sections.

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**THE REGION OF WATERLOO'S ENERGY USE  
EMISSIONS INVENTORY**

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The Region of Waterloo's emissions inventory was developed from detailed records of energy consumption by sector, end-use and fuel type. This information was collected by Regional staff. In most cases, the annual energy consumption expenditures for each utility was used to estimate annual energy consumption. Where data were missing, energy consumption was estimated, usually by using comparable data from the Region itself. Energy consumption data were entered by individual building, building group, vehicle group, streetlighting group or individual well, pumping station or wastewater treatment plant. In total, the inventory contains over 180 individual records. These records are stored in the Torrie Smith Gleneagle Air Emissions Strategy software by sector. These sectors and associated energy use are:

<u>Sector</u>	<u>Energy</u>
Buildings	Electricity, Natural Gas
Vehicle Fleet	Gasoline, Diesel, Compressed Natural Gas
Streetlighting	Electricity
Water and Sewage	Electricity

Specific details related to the inventory for each of these sectors are presented below. Additional data sources and assumptions, including emission factors, for the inventory are presented in Appendix D.

Overall, the Region of Waterloo emits an estimated 724,704 kg of air pollutants each year. The breakdown by sector is presented in Table 2. The baseline inventory for each sector is described below.

**Table 2.** Region of Waterloo Common Air Contaminant Emissions by Sector

Sector	Emissions					
	NOx	SOx	CO	VOC	PM10	Total
	(kg)	(kg)	(kg)	(kg)	(kg)	Emissions
<b>Buildings</b>	38,317	35,597	5,193	978	1,122	<b>81,207</b>
<b>Streetlights</b>	5,617	8,691	282	28	159	<b>14,777</b>
<b>Water/Sewage</b>	54,403	84,173	2,733	271	1,543	<b>143,123</b>
<b>Onroad Vehicle Fleet</b>	131,258	5,707	244,127	27,937	6,089	<b>415,117</b>
<b>Offroad Vehicle Fleet</b>	40,168	11,173	12,116	3,440	3,583	<b>70,480</b>
<b>Total</b>	<b>269,763</b>	<b>145,341</b>	<b>264,451</b>	<b>32,654</b>	<b>12,496</b>	<b>724,704</b>

## BUILDINGS

In the buildings sector, the inventory is described by individual building or in the case of social housing, by building group. The information contained in the inventory for each one of the buildings or building groups includes electricity consumption (in kWh), natural gas consumption (in cubic metres), floor area (in square meters), energy expenditures (where available) and emissions of each of the five common air contaminants, in kilograms. With the exception of the Region's 11 largest buildings, natural gas consumption is estimated using floor area.

The buildings and building groups, and their annual baseline emissions, are presented in Table 3 below.

**Table 3.** Air Pollution Emissions from the Region of Waterloo's Buildings and Building Groups

Building or Building Group	Source	Emissions						Total Emissions	Percent SubTotal
		NOx (kg)	SOx (kg)	CO (kg)	VOC (kg)	PM10 (kg)			
Social Housing - Townhomes	Electricity	5,674	8,779	285	28	161			
	Natural Gas	6,305	251	1,628	347	193			
<b>Subtotal Social Housing - Townhomes</b>		<b>11,979</b>	<b>9,030</b>	<b>1,913</b>	<b>375</b>	<b>354</b>	<b>23,651</b>	29%	
Social Housing - Apartments	Electricity	2,772	4,289	139	14	79			
	Natural Gas	3,080	123	795	170	94			
<b>Subtotal Social Housing - Apartments</b>		<b>5,852</b>	<b>4,411</b>	<b>935</b>	<b>183</b>	<b>173</b>	<b>11,554</b>	14%	
Kitchener Depot - Strasburg Rd	Electricity	2,488	3,849	125	12	71			
	Natural Gas	2,642	105	682	146	81			
<b>Subtotal Kitchener Depot - Strasburg Rd</b>		<b>5,130</b>	<b>3,955</b>	<b>807</b>	<b>158</b>	<b>151</b>	<b>10,201</b>	13%	
Administration Building	Electricity	2,398	3,711	121	12	68			
	Natural Gas	642	26	166	35	20			
<b>Subtotal Administration Building</b>		<b>3,040</b>	<b>3,736</b>	<b>286</b>	<b>47</b>	<b>88</b>	<b>7,197</b>	9%	
CH&SS	Electricity	2,228	3,448	112	11	63			
	Natural Gas	444	18	115	24	14			
<b>Subtotal CH&amp;SS</b>		<b>2,672</b>	<b>3,465</b>	<b>227</b>	<b>36</b>	<b>77</b>	<b>6,477</b>	8%	
Police Headquarters	Electricity	1,855	2,870	93	9	53			
	Natural Gas	465	19	120	26	14			
<b>Subtotal Police Headquarters</b>		<b>2,320</b>	<b>2,888</b>	<b>213</b>	<b>35</b>	<b>67</b>	<b>5,523</b>	7%	
Operations Centre	Electricity	1,174	1,817	59	6	33			
	Natural Gas	755	30	195	42	23			
<b>Subtotal Operations Centre</b>		<b>1,929</b>	<b>1,847</b>	<b>254</b>	<b>47</b>	<b>56</b>	<b>4,133</b>	5%	
Kitchener Terminal - 15 Charles St	Electricity	794	1,228	40	4	23			
	Natural Gas	126	5	32	7	4			
<b>Subtotal Kitchener Terminal - 15 Charles St</b>		<b>920</b>	<b>1,233</b>	<b>72</b>	<b>11</b>	<b>26</b>	<b>2,262</b>	3%	
Police Division #1	Electricity	569	881	29	3	16			
	Natural Gas	308	12	79	17	9			

Building or Building Group	Source	Emissions						Total Emissions	Percent SubTotal
		NOx (kg)	SOx (kg)	CO (kg)	VOC (kg)	PM10 (kg)			
<b>Subtotal Police Division #1</b>		<b>877</b>	<b>893</b>	<b>108</b>	<b>20</b>	<b>26</b>	<b>1,924</b>	<b>2%</b>	
Police Division #3	Electricity	413	638	21	2	12			
	Natural Gas	132	5	34	7	4			
<b>Subtotal Police Division #3</b>		<b>545</b>	<b>644</b>	<b>55</b>	<b>9</b>	<b>16</b>	<b>1,269</b>	<b>2%</b>	
Courthouse	Electricity	341	527	17	2	10			
	Natural Gas	214	9	55	12	7			
<b>Subtotal Courthouse</b>		<b>555</b>	<b>536</b>	<b>72</b>	<b>13</b>	<b>16</b>	<b>1,192</b>	<b>1%</b>	
Police Division #2	Electricity	342	529	17	2	10			
	Natural Gas	169	7	44	9	5			
<b>Subtotal Police Division #2</b>		<b>511</b>	<b>536</b>	<b>61</b>	<b>11</b>	<b>15</b>	<b>1,134</b>	<b>1%</b>	
Wat. Landfil	Electricity	353	546	18	2	10			
	Natural Gas	38	2	10	2	1			
<b>Subtotal Wat. Landfil</b>		<b>391</b>	<b>548</b>	<b>28</b>	<b>4</b>	<b>11</b>	<b>982</b>	<b>1%</b>	
GRT South Depot	Electricity	277	429	14	1	8			
	Natural Gas	174	7	45	10	5			
<b>Subtotal GRT South Depot</b>		<b>451</b>	<b>436</b>	<b>59</b>	<b>11</b>	<b>13</b>	<b>970</b>	<b>1%</b>	
Kit. Landfill Gas Control Bldg.	Electricity	213	330	11	1	6			
<b>Subtotal Kit. Landfill Gas Control Bldg.</b>		<b>213</b>	<b>330</b>	<b>11</b>	<b>1</b>	<b>6</b>	<b>561</b>	<b>1%</b>	
Cambridge Terminal	Electricity	139	215	7	1	4			
	Natural Gas	43	2	11	2	1			
<b>Subtotal Cambridge Terminal</b>		<b>182</b>	<b>217</b>	<b>18</b>	<b>3</b>	<b>5</b>	<b>425</b>	<b>1%</b>	
Joseph Schneider House	Electricity	138	213	7	1	4			
	Natural Gas	27	1	7	1	1			
<b>Subtotal Joseph Schneider House</b>		<b>165</b>	<b>214</b>	<b>14</b>	<b>2</b>	<b>5</b>	<b>400</b>	<b>0%</b>	
Library Headquarters	Electricity	76	117	4	0	2			
	Natural Gas	24	1	6	1	1			
<b>Subtotal Library Headquarters</b>		<b>100</b>	<b>118</b>	<b>10</b>	<b>2</b>	<b>3</b>	<b>233</b>	<b>0.3%</b>	
Christopher House Day Care	Electricity	51	79	3	0	1			
	Natural Gas	28	1	7	2	1			
<b>Subtotal Christopher House Day Care</b>		<b>79</b>	<b>80</b>	<b>10</b>	<b>2</b>	<b>2</b>	<b>173</b>	<b>0.2%</b>	
Cambridge Day Care	Electricity	51	79	3	0	1			
	Natural Gas	22	1	6	1	1			
<b>Subtotal Cambridge Day Care</b>		<b>73</b>	<b>80</b>	<b>8</b>	<b>1</b>	<b>2</b>	<b>164</b>	<b>0.2%</b>	
Elmira Day Care	Electricity	50	77	2	0	1			
	Natural Gas	23	1	6	1	1			
<b>Subtotal Elmira Day Care</b>		<b>73</b>	<b>78</b>	<b>8</b>	<b>2</b>	<b>2</b>	<b>163</b>	<b>0.2%</b>	
Elmira Library	Electricity	62	96	3	0	2			
<b>Subtotal Elmira Library</b>		<b>62</b>	<b>96</b>	<b>3</b>	<b>0</b>	<b>2</b>	<b>163</b>	<b>0.2%</b>	
Kitchener Day Care	Electricity	35	54	2	0	1			
	Natural Gas	20	1	5	1	1			
<b>Subtotal Kitchener Day Care</b>		<b>55</b>	<b>55</b>	<b>7</b>	<b>1</b>	<b>2</b>	<b>120</b>	<b>0.1%</b>	
Police Division #3A	Electricity	40	62	2	0	1			
	Natural Gas	9	0	2	0	0			

Building or Building Group	Source	Emissions						Total Emissions	Percent SubTotal
		NOx (kg)	SOx (kg)	CO (kg)	VOC (kg)	PM10 (kg)			
<b>Subtotal Police Division #3A</b>		<b>49</b>	<b>62</b>	<b>4</b>	<b>1</b>	<b>1</b>	<b>117</b>	<b>0.1%</b>	
Kinsmen Day Care	Electricity	32	49	2	0	1			
	Natural Gas	18	1	5	1	1			
<b>Subtotal Kinsmen Day Care</b>		<b>49</b>	<b>50</b>	<b>6</b>	<b>1</b>	<b>1</b>	<b>107</b>	<b>0.1%</b>	
Police Division #1A	Electricity	14	21	1	0	0			
	Natural Gas	9	0	2	0	0			
<b>Subtotal Police Division #1A</b>		<b>22</b>	<b>21</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>48</b>	<b>0.1%</b>	
Wellesley - Crosshill Transfer Stn.	Electricity	13	20	1	0	0			
<b>Subtotal Wellesley - Crosshill Transfer Stn.</b>		<b>13</b>	<b>20</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>34</b>	<b>0.04%</b>	
Wilmot Transfer Station	Electricity	6	9	0	0	0			
<b>Subtotal Wilmot Transfer Station</b>		<b>6</b>	<b>9</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>15</b>	<b>0.02%</b>	
Ayr Transfer Station	Electricity	5	8	0	0	0			
<b>Subtotal Ayr Transfer Station</b>		<b>5</b>	<b>8</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>13</b>	<b>0.02%</b>	
<b>Total Emissions, Buidings Sector</b>		<b>38,317</b>	<b>35,597</b>	<b>5,193</b>	<b>978</b>	<b>1,122</b>	<b>81,207</b>	<b>100%</b>	

## VEHICLE FLEET

The Region's vehicle fleet is broken out into seven groups. For each of these groups of vehicles, fuel consumption is described by fuel type: gasoline, compressed natural gas, diesel and in the case of the offroad fleet, coloured diesel. Within each of these categories of fuel type, the fleet is further broken out by vehicle class:

1. Heavy Duty Vehicle (Buses and Heavy Trucks);
2. Light Duty Vehicle (Minivans, SUVs and Pickup Trucks);
3. Automobile:
  - a. Subcompact/Compact (Cavalier, etc.)
  - b. Mid-Size (Grand Prix, etc.);
  - c. Full-Size (Crown Victoria, etc.)
4. Offroad Vehicles

The emissions inventory is presented at this level of detail because vehicles in each of these classes produce different amounts of pollution per vehicle kilometer of travel. Therefore, in order to develop an accurate inventory, a highly disaggregated profile of the vehicle fleet is needed.

For each of these combinations of fuel type and vehicle class, fuel consumption in litres is provided, except for personal vehicle use vehicles, for which only vehicle kilometers of travel was available (rather than litres of fuel consumed which was subsequently estimated). Data for each of these groups was derived from the Region's records, with the exception of garbage and recycling collection vehicles. This data were estimated by the Region's two garbage and recycling collection contractors. Table 4 provides the inventory of emissions from the vehicle fleet.

**Table 4.** Air Pollution Emissions from the Region of Waterloo's Vehicle Fleet

Vehicle Group	Source	Emissions						Total Emissions	Percent SubTotal
		NOx (kg)	SOx (kg)	CO (kg)	VOC (kg)	PM10 (kg)			
Grand River Transit Authority	Diesel	86,883	2,936	57,618	7,393	4,144			
	CNG	264	4	620	107	1			
<b>Subtotal Grand River Transit Authority</b>		<b>87,147</b>	<b>2,940</b>	<b>58,238</b>	<b>7,500</b>	<b>4,145</b>	<b>159,970</b>	<b>33.0%</b>	
Police Services	Gasoline	8,389	844	83,657	8,824	179			
	Diesel	84	10	76	29	14			
<b>Subtotal Police Services</b>		<b>8,474</b>	<b>854</b>	<b>83,733</b>	<b>8,853</b>	<b>193</b>	<b>102,107</b>	<b>21.0%</b>	
Corporate On-Road Fleet	Gasoline	2,748	313	28,474	3,002	59			
	Diesel	4,960	172	3,302	435	243			
<b>Subtotal Corporate On-Road Fleet</b>		<b>7,708</b>	<b>485</b>	<b>31,776</b>	<b>3,438</b>	<b>302</b>	<b>43,709</b>	<b>9.0%</b>	
Garbage and Recycling Collection	Diesel	20,172	682	13,377	1,716	962			
<b>Subtotal Garbage and Recycling Collection</b>		<b>20,172</b>	<b>682</b>	<b>13,377</b>	<b>1,716</b>	<b>962</b>	<b>36,909</b>	<b>7.6%</b>	
Personal Vehicle Use	Gasoline	1,097	98	10,781	1,115	24			
<b>Subtotal Personal Vehicle Use</b>		<b>1,097</b>	<b>98</b>	<b>10,781</b>	<b>1,115</b>	<b>24</b>	<b>13,115</b>	<b>2.7%</b>	
Employee Commute		4,472	399	43,946	4,545	98			
<b>Subtotal Employee Commute</b>		<b>4,472</b>	<b>399</b>	<b>43,946</b>	<b>4,545</b>	<b>98</b>	<b>53,459</b>	<b>11.0%</b>	
Emergency Medical Services	Gasoline	31	4	322	34	1			
	Diesel	1,161	132	1,052	396	196			
<b>Subtotal Emergency Medical Services</b>		<b>1,192</b>	<b>136</b>	<b>1,374</b>	<b>430</b>	<b>197</b>	<b>3,329</b>	<b>0.7%</b>	
Mobility Plus	Diesel	996	113	902	340	168			
<b>Subtotal Mobility Plus</b>		<b>996</b>	<b>113</b>	<b>902</b>	<b>340</b>	<b>168</b>	<b>2,519</b>	<b>0.5%</b>	
Corporate Off-Road Fleet	Col. Diesel	32,420	10,660	6,984	2,647	3,039	55,750		
	Diesel	7,657	504	1,649	625	538	10,973		
	Gasoline	91	9	3,483	168	6	3,757		
<b>Subtotal, Corporate Offroad Fleet</b>		<b>40,168</b>	<b>11,173</b>	<b>12,116</b>	<b>3,440</b>	<b>3,583</b>	<b>70,480</b>	<b>14.5%</b>	
<b>Total Emissions, Vehicle Fleet Sector</b>		<b>171,426</b>	<b>16,880</b>	<b>256,243</b>	<b>31,377</b>	<b>9,672</b>	<b>485,597</b>	<b>100%</b>	

### STREETLIGHTING

Streetlighting emissions are broken out by electricity account, of which there are eleven. In terms of specific end-uses, streetlighting encompasses signal lights, streetlights and municipal yard lighting. For each of these accounts, the inventory contains total electricity consumption (in kWh) and emissions by air pollutant in kilograms. Table 5 below provides the emissions inventory for streetlighting.

### WATER AND SEWAGE PUMPING

The Region of Waterloo has 134 separate electricity accounts covering different wells, pumping stations and wastewater treatment plants. For each of these accounts, the

inventory contains total electricity consumption (in kWh) and emissions by air pollutant in kilograms. Table 6 below shows the 21 largest energy consuming wells, pumping stations and wastewater treatment plants in the Region, which collectively are responsible for 75% of the emissions from this sector. Table 6 also shows total emissions of the sector.

**Table 5.** Air Pollution Emissions from the Region of Waterloo's Streetlights

Streetlighting Group	Source	Emissions						Total Emissions	Percent SubTotal
		NOx (kg)	SOx (kg)	CO (kg)	VOC (kg)	PM10 (kg)			
Street Lights (CND)	Electricity	2,356	3,645	118	12	67	6,198	41.9%	
Signal Lights (KW, C8825285300)	Electricity	1,828	2,828	92	9	52	4,809	32.5%	
Signal Lights (WN)	Electricity	1,120	1,733	56	6	32	2,947	19.9%	
Phillipsburg Yard	Electricity	86	133	4	0	2	225	1.5%	
Heidelberg Yard	Electricity	65	101	3	0	2	171	1.2%	
Street Lights (WN, 346890)	Electricity	55	86	3	0	2	146	1.0%	
North Dumfries Yard	Electricity	33	51	2	0	1	87	0.6%	
Street Lights (WN, 359480)	Electricity	26	40	1	0	1	68	0.5%	
Street Lights (WN, 359470)	Electricity	25	38	1	0	1	65	0.4%	
Signal Lights (KW, C8825284709)	Electricity	15	24	1	0	0	40	0.3%	
Street Lights (WN, 379590)	Electricity	8	13	0	0	0	21	0.1%	
<b>Total Emissions, Streetlighting Sector</b>		<b>5,617</b>	<b>8,691</b>	<b>282</b>	<b>28</b>	<b>159</b>	<b>14,777</b>	<b>100.0%</b>	

**Table 6.** Air Pollution Emissions from the Region of Waterloo's Largest Water and Sewage Pumping Stations

Water/Sewage Pumping Group	Source	Emissions						Total Emissions	Percent SubTotal
		NOx (kg)	SOx (kg)	CO (kg)	VOC (kg)	PM10 (kg)			
Hidden Valley P.S.	Electricity	5,724	8,855	288	28	162	15,057	10.5%	
Mannheim Treatment Plant	Electricity	4,145	6,413	208	21	118	10,905	7.6%	
Kitchener Wastewater Treatment Plant	Electricity	3,957	6,122	199	20	112	10,410	7.3%	
Galt Wastewater Treatment Plant	Electricity	3,664	5,669	184	18	104	9,639	6.7%	
Waterloo Wastewater Treatment Plant	Electricity	2,990	4,627	150	15	85	7,867	5.5%	
Middleton P.S.	Electricity	2,716	4,203	136	14	77	7,146	5.0%	
Mannheim P.S.	Electricity	1,760	2,723	88	9	50	4,630	3.2%	
Greenbrook P.S., Wells K3,5 & 6	Electricity	1,727	2,672	87	9	49	4,544	3.2%	
Shades Mill Treatment Plant	Electricity	1,710	2,645	86	9	48	4,498	3.1%	
Preston Wastewater Treatment Plant	Electricity	1,530	2,367	77	8	43	4,025	2.8%	
Hespeler Wastewater Treatment Plant	Electricity	1,483	2,294	74	7	42	3,900	2.7%	
Turnbull P.S.	Electricity	1,476	2,284	74	7	42	3,883	2.7%	
Well K26	Electricity	1,063	1,644	53	5	30	2,795	2.0%	
Elmira Wastewater Treatment Plant	Electricity	993	1,536	50	5	28	2,612	1.8%	
Parkway P.S., Wells K31,32 & 33	Electricity	980	1,517	49	5	28	2,579	1.8%	
William St Pumping Stn.	Electricity	967	1,496	49	5	27	2,544	1.8%	
New Hamburg Wastewater Treatment Plant	Electricity	895	1,385	45	4	25	2,354	1.6%	
Wat. Landfil	Electricity	847	1,311	43	4	24	2,229	1.6%	
Wells K50 & K51	Electricity	811	1,255	41	4	23	2,134	1.5%	
Well W7	Electricity	716	1,108	36	4	20	1,884	1.3%	
Pinebush TP	Electricity	532	823	27	3	15	1,400	1.0%	
<b>Total Emissions, Water/Sewage Pumping Sector</b>		<b>54,403</b>	<b>84,173</b>	<b>2,733</b>	<b>271</b>	<b>1,543</b>	<b>143,123</b>	<b>100%</b>	

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## EVALUATIVE FRAMEWORK

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An evaluative framework was developed to uniformly assess and prioritize emission reduction measures. Highest priority was placed on strategies that offered the greatest reduction in the quantity of air emissions in the most cost-effective manner since these strategies also carry the greatest health benefit. Wherever possible, the cost implications of these strategies were calculated. Additional criteria, such as the feasibility of the strategy, its anticipated degree of social profile and whether other municipalities have successfully adopted the strategy, were also considered.

In addition, a number of possible air emission reduction strategies were considered and excluded. The process involved 3 steps:

### 1. Brainstorming

Initially members of the Waterloo Regional Clean Air Committee met and brainstormed to generate a preliminary list of possible ways the Region might reduce its air pollution. Several of these strategies originated from the Clean Air Plan. Furthermore, Torrie, Smith Associates identified strategies that have been proven to be successful in other jurisdictions.

### 2. Short-listing the options prior to conducting the emissions inventory

Some of the reduction measures that resulted from the brainstorm session were not carried forward to the inventory emissions exercise. Reasons for excluding strategies from the exercise and subsequently from the budget options outlined in this paper included:

- insufficient data to quantify their impacts in terms of emissions reduction;
- the strategy represented a remote option that was most likely not relevant to the current business cycle;
- initiatives were already underway to present the option as a budget item;
- the option was not cost effective; or
- the option was not feasible.

Options that were excluded and reasons for exclusion are presented in Appendix C.

### 3. Final prioritization based on emission reduction impact

All reduction measures for which complete emission reduction and costing information was available were considered and prioritized according to the evaluative framework. The final ranking of measures (Table 8) was largely based on emission reduction potential. However, some initiatives were given priority because of their anticipated social profile.

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## EMISSION REDUCTION STRATEGIES

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### **BUILDINGS**

Electricity to run the Region's buildings comes from 3 principal sources: hydroelectricity, nuclear power and the burning of coal. During peak periods of energy use the electricity mix draws on a greater proportion of fossil fuel, predominantly generated by the combustion of coal at the Nanticoke plant near Port Dover on Lake Erie. Coal burning produces NO<sub>x</sub>, SO<sub>x</sub>, VOCs, CO, particulates and CO<sub>2</sub>. The Nanticoke plume encompasses the Region's airshed due to prevailing wind patterns. Although these emissions are not produced locally, there is a direct association between the amount of electricity used by the Region and the amount of coal burned at Nanticoke.

Energy use within the Region’s building stock accounts for approximately 12 per cent of the Region’s total emissions. The following options were suggested to improve building energy efficiency, thereby reducing energy requirements and associated air emissions.

**Option 1: Lighting Equipment Efficiency Improvements in Primary Regional Buildings**

Retrofits to building lighting systems can improve building energy efficiency. For example, replacing T12 linear fluorescent lamps and electromagnetic ballasts with T8 fluorescent lamps, electronic ballasts and improved reflectors. T8 lights and electronic ballasts provide increased light output and better quality lighting. When placed in fixtures with improved reflectors, energy consumption is reduced by approximately 30 per cent.

Costs and potential emission reductions for each of these measures are listed below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b>	<b>SO<sub>x</sub></b>	<b>CO</b>	<b>VOC</b>	<b>PM<sub>10</sub></b>	<b>Total Reduction</b>
<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>
1,610	2,491	81	8	46	4,236
<b>Cost:</b> \$350,000					
<b>Savings:</b> \$82,555 (in first year)					
<b>Payback Period:</b> 3 years					

**Option 2: HVAC System Upgrades, Building Energy Management and Exhaust Heat Recovery**

Heating, ventilation and air conditioning (HVAC) systems use a great deal of energy to maintain a building’s internal environment. Upgrades to existing systems can improve their energy efficiency by ensuring optimum working efficiencies. There are a number of individual measures that can be implemented to improve the overall energy efficiency of a building’s heating, ventilation and air conditioning equipment, including improvements to the building’s shell (walls, roof, windows and doors), the HVAC equipment itself and to the management of these systems. Without a proper energy audit, it is impossible to determine the overall improvement in energy efficiency that may be possible from individual measures, but overall, energy efficiency of a building’s systems can usually be improved by 20%.

This option may include measures such as the installation of high efficiency motors, fans, pumps and blowers, high efficiency air conditioners (desiccant cooling and dehumidification systems and natural ventilation) and heating systems, along with improved building energy management controls, air sealing and heat recovery

ventilation. The assumed energy savings from improved heating, water heating, cooling and fan, pump and blower systems is 20% from current energy consumption levels. While it is very difficult to gauge the cost of such improvements, 5-7 year paybacks are typical. Therefore, the cost has been estimated at approximately \$2 million.

The estimated emission reductions and measure cost is shown below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
2,292	1,646	377	75	68	4,458
<b>Cost:</b> \$2,000,000					
<b>Savings:</b> \$61,513 (in first year)					
<b>Payback Period:</b> 7 years					

A brief discussion of some of the principal elements of this option is provided below:

**Building Energy Management:** The Region’s main eleven buildings are controlled by building automation systems, software programs that control the internal environment of each building. More specifically, a building automation system is the automatic control of one or more major building system functions such as heating, ventilating and air conditioning systems. In many cases, a building automation system also includes lighting, security and fire safety systems. The software is set to detect changes in parameters such as temperature, relative humidity and pressure. When a change in one of the parameters is detected, the system reacts by heating or cooling the building. Adjustments to the set parameters or type of software used can affect the energy efficiency of a building.

**Air Sealing:** Properly sealing doors and windows that open to outside environments can prevent air leakage, reduce energy use and thus reduce air emissions.

**Heat Recovery Ventilation:** All buildings have a ventilation system that draws fresh air in from the external environment, heats or cools it, and exhausts it back into the external environment. This cycle is continuous and always cools or heats the ‘new’ air, a process that is relatively energy intensive. A heat recovery ventilation system uses a device that transfers warm or cold air from the outgoing air to the incoming air, thereby decreasing heating and cooling energy consumption.

**Option 3: Energy Star Office Equipment and Implement Automatic Power Down Software**

Energy Star compliant office equipment (computers, monitors, fax machines, printers, photocopiers, scanners, and multifunction devices) consume far less energy than non-compliant devices. For example, an LCD Flat Screen monitor consumes only about 30% of the energy of a typical CRT (cathode ray tube) monitor. The US EPA estimates that a typical office purchasing Energy Star compliant devices and utilizing the power management features for computers could cut its power consumption from these devices in half. Energy Star office equipment and power down software have a negligible additional cost, with the exception of LCD flat screen monitors, which have an initial incremental cost of about \$250.

Region employees use more than 1300 personal computers. Opting for energy-efficient equipment with enabled power-down features, such the Energy Star labeled office equipment designated by the EPA, can reduce power usage by as much as 50%. Presently the Region does not automatically power down personal computers, although Region employees are encouraged to turn off their machines at night. A formal Energy Star purchasing policy is presently not in place for the Region, although environmental and energy considerations do influence many of the purchases that occur.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b>	<b>SO<sub>x</sub></b>	<b>CO</b>	<b>VOC</b>	<b>PM<sub>10</sub></b>	<b>Total Reduction</b>
<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>
1,504	2,327	76	8	43	3,958
<b>Cost:</b> \$0					
<b>Savings:</b> Not applicable					
<b>Payback Period:</b> Not applicable					

**Option 4: Energy Efficient Lighting in Regional Affordable Housing**

Retrofits to lighting in common areas, such as hallways, in Regionally owned housing projects are proposed. Lighting efficiency in these buildings would be improved by replacing existing T12 linear fluorescent lamps and electromagnetic ballasts with T8 fluorescent lamps, electronic ballasts and improved reflectors. T8 lights and electronic ballasts provide increased light output and better quality lighting. When placed in fixtures with improved reflectors, energy consumption is reduced by approximately 30 per cent. The expected emission reductions and costs for the first year of this project are shown below, and are significant given the total of 2,557 housing units owned by the Region of Waterloo.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
1,640	2,538	82	8	47	4,315

**Cost:** \$1,011,000  
**Savings:** \$70,080 (in first year)  
**Payback Period:** 5 years

**Option 5: Green Power**

Green power primarily includes wind, solar, bio-mass and hydro-electric power generators. Two types of green power are available from Ontario Power Generation: 1) Evergreen Clean Green Power which is a blend of power generated by renewable energy facilities of which 50 per cent were built prior to 1991 and 50 per cent after 1991; and 2) Evergreen Pure Green Power which is power generated by facilities built after 1991. The former includes most hydro-electric sources while the latter includes bio-mass, wind, etc.

Green power costs more to produce than power produced by coal or gas fired turbine plants. By purchasing a percentage of its power as green power the Region will encourage the future development of new greensources and demonstrate that the Region is committed to clean air.

As an initial target for 2003 it is proposed that 10 per cent of the power purchased by the Region be Green Power. Future targets would be set as part of the energy procurement strategy to be presented to Council in 2003. The expected emission reduction and annual costs are shown below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
5,986	9,262	301	29	170	15,748

**Cost:** \$351,000  
**Savings:** Not applicable  
**Payback Period:** Not applicable

## FUELS

Gasoline and diesel fuel are currently dispensed from eleven (11) fuel sites (including GRT) located across the Region. Fuel, and its many components and additives, is regulated by federal government legislation and standards.

Sulphur, a major source of pollution associated with both gasoline and diesel fuel, is found in all crude oil and contributes to increased emissions of sulphate particulate matter, sulphur dioxide and other sulphates. Sulphur adversely impacts the health of Canadians and impairs the optimum functionality of emission control devices and technology. By reducing the effectiveness of emission control devices, other pollutants such as nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO) and hydrocarbons are increased.

Estimates of the avoided health effects associated with reductions in sulphur content in fuels are provided in Table 7. The data is based on sulphur in fuel emission scenarios for seven Canadian cities - Vancouver, Edmonton, Winnipeg, Toronto, Montreal, Saint John and Halifax - and reports on reductions which are achievable by 2020.

**Table 7.** Number of Individuals who Avoided Health Effects with Reduced Sulphur Content

Avoided Health Effect	Gasoline (By Sulphur Content)			Diesel (By Sulphur Content)	
	360 ppm	150 ppm	30 ppm	300 ppm	50 ppm
Premature Mortality	533	1020	1352	143	318
Chronic Respiratory Disease Cases	1880	3600	4770	503	1120
Respiratory Hospital Admissions	335	640	848	90	200
Cardiac Hospital Admissions	272	520	689	73	162
Emergency Room Visits	1480	2840	3760	399	887
Asthma Symptom Days	205000	390000	517000	55000	122000
Restricted Activity Days	296000	565000	749000	80000	177000
Acute Respiratory Symptoms	7070000	13500000	17900000	1900000	4220000
Lower Respiratory Illness (Child)	25000	47000	62000	8000	15000

In 2000, the average sulphur content for gasoline in Ontario was 457 ppm - the highest average level in Canada. New government legislation is being introduced to further reduce the level of sulphur found in gasoline and diesel fuel refined and sold in Canada. This legislation closely aligns Canada with current United States Environmental Protection Act (EPA) and European Union initiatives. The current maximum allowable content of sulphur in gasoline is 150 ppm and in diesel 500 ppm. New legislation will

reduce gasoline sulphur content to 30 ppm by 2005 and diesel content to 15 ppm in 2006.

It is intended that these regulations be developed by the end of 2002 in order to align Canadian emissions standards with legislation being introduced under the U.S. EPA. In the interim, alternative fuels such as ethanol, biodiesel and ultra-low sulphur diesel are currently available at a premium price. Potential applications of these alternative fuels within the Regions fleets are discussed below.

**Option 6: Replace Gasoline with 10% Ethanol (E10) in Regional Fleet**

Ethanol (ethyl alcohol) gasoline is a grain-based alcohol made primarily from corn, but can also be manufactured from other, renewable, biological feedstocks. Ethanol gasoline is available in two forms, E10 and E85. E10, the most commonly available form of ethanol, is composed of 10% ethanol and 90% gasoline. Ethanol is a cleaner-burning fuel than regular gasoline, reducing emissions of a wide variety of pollutants. Emissions from ethanol are less reactive with sunlight than regular gasoline, resulting in an overall reduction of ozone-forming compounds (smog). Furthermore, ethanol gasoline has fewer additives which helps to reduce secondary pollution. E10 (Sunoco) is priced at the same rate as regular gasoline – making this fuel an economically viable alternative.

Although E10 is stored, transferred and dispensed in the same manor as conventional gasoline, storage tanks must undergo a “one-time” preparation to ensure that they contain no water. A survey of all Regional fuel sites would need to be conducted so that new in-line fuel filters could be incorporated into existing pumps in preparation for ethanol use.

In some cases, vehicle fuel filters must be changed during the initial use of E10 as ethanol has a tendency of cleansing fuel lines and depositing small particles within the fuel filter. Changing the vehicle fuel filters after switching to ethanol would also be a one-time cost. Both the City of Waterloo and Toronto Hydro use E10 for their gasoline powered fleet - reportedly, without incident. The emissions impact and cost of replacing gasoline with E10 in the regional fleet is shown below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
1,691	65	32,908	2,351	149	37,164
<b>Cost:</b> \$15,125 (one-time cost only)					
<b>Savings:</b> Not Applicable					
<b>Payback Period:</b> Not Applicable					

**Option 7: Replace Diesel with B20 in On-road and Off-road Fleets**

Biodiesel is a proven alternative to regular fuel. Although biodiesel can be manufactured from a variety of renewable sources commercially available biodiesel is generally based on refined soybean oil - Soy Methyl Ester (SME). B20 is currently the most common form of biodiesel, requiring no vehicle, equipment or infrastructure modifications to use the fuel. It is dispensed, handled, stored and transported in the same manner as regular diesel. Most OEM engine manufacturer warranties are not affected by the use of biodiesel. However, GRTs manufacturer warranty does not support the use of biodiesel, thus this option is considered only for the on-road and off-road diesel fleets.

B20 is a cleaner burning fuel which can substantially reduce emissions of a variety of pollutants (carbon monoxide, particulate matter, polycyclic aromatic hydrocarbons and sulphates). Visible emissions are reduced (little-to-no smoke), engines reportedly run quieter and appear to perform more efficiently.

Biodiesel is blended in Toronto by BigK Fuels – the only Canadian distributor – from 100% refined soy oil imported from the United States. Biodiesel is available at a premium – \$0.675 per litre compared to \$0.5877 per litre for No.2 diesel and \$0.4165 per litre for coloured (off-road use only) diesel. B20 is currently the most common form of biodiesel, requiring no vehicle, equipment or infrastructure modifications to use the fuel. It is dispensed, handled, stored and transported in the same manner as regular diesel. Most OEM engine manufacturer warranties are not affected by the use of biodiesel.

Toronto Hydro, the City of Brampton and the Town of Caledon are currently utilizing this product and are enthusiastic supporters of biodiesel's wide-spread use. None of the aforementioned agencies have experienced any problems with the use of B20.

The emissions impact of replacing diesel with B20 in the regional off-road and on-road fleets is shown below.

<b>Potential Emission Reductions:</b>						
	<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
On-road Fleet	+62	63	398	120	37	556
Off-road Fleet	+401	9,055	1,209	294	985	11,142
						11,698

**Cost:** \$163,887  
**Savings:** Not Applicable  
**Payback Period:** Not Applicable

**Option 8: Replace Diesel with ULSD in On-road, Off-road and GRT Fleets**

Government legislation regulating the level of sulphur in on-road diesel passed into law this summer (2002). This legislation, which limits the content of sulfur in diesel fuel from its current level of 500 ppm to 15 ppm, comes into effect on June 1, 2006. According to the schedule proposed under the new regulations this product, known as Ultra Low Sulphur Diesel (ULSD), will be available on the market by September 1, 2006. The lower sulphur content substantially reduces the emissions of other pollutants such as particulate matter, nitrogen oxides and sulphates.

ULSD is required for new legislation for model year 2007, and beyond, engine technology. Very little information currently exists on the effect ULSD may have on pre-2007 engine technology. Although specific data was not available at the time of writing, there is some indication that lower kpl could be experienced by the corporate fleet as well as reduced horsepower, lubricity and potential issues with seals. These issues should not be experienced by the GRT fleet as they currently use a lighter density diesel fuel and are designed to use premium #1 diesel, a more refined product. New York MTA Transit fleet has 4,400 diesel buses currently using ULSD without incident.

Although ULSD diesel fuel is not currently available on the general market, a possible producer of ULSD – PetroCan - has been sourced and is potentially interested in providing the Region with this product. A meeting with representatives from the Region, several transit properties and PetroCan has been set for early October 2002 and ULSD could be available to the Region as early as December 2002.

As with any product which requires greater refining or manufacturing, ULSD diesel will be available at a premium price. For the purpose of this report, ULSD diesel will be priced at 67.5 cents per litre.

The emissions impact and associated costs of replacing diesel with ULSD in the on-road, off-road and GRT fleets are shown below.

<b>Potential Emission Reductions:</b>						
	<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
On-road Fleet	0	300	0	0	114	414
Off-road Fleet	0	11,050	0	0	1,464	12,514
GRT Fleet	0	2,810	0	0	1,035	3,845
						16,773

<b>Cost:</b>	
On-road Fleet	\$48,015
Off-road Fleet	\$113,998
GRT Fleet	\$321,510
	\$483,523

**Savings:** Not Applicable  
**Payback Period:** Not Applicable

**Option 9: Replace Diesel with #1 Premium (Additive) in On-road, Off-road and GRT Fleets**

A new diesel ‘additive package’ or ‘premium diesel product’ has recently become available through PetroCan. Extensive testing of this product worldwide has demonstrated immediate reductions in both black smoke and particulate matter. These reductions are sustained over long-term testing.

Common fuel additive cetane is known to improve combustion and reduce hydrocarbons, CO, NOx and particulate emissions. This new additive package “combines conventional detergent, defoamant, cold flow improvers and corrosion inhibitors...with a unique combustion catalyst” technology which provides immediate and sustained reductions among particulate matter, black smoke and hydrocarbons. Specifically, an *SAE Technical Paper* (Society of Automotive Engineers, Inc. 1997) reported a 22 per cent reduction in black smoke, a 16 per cent reduction in particulate matter, and a 10 per cent reduction in hydrocarbons.

The results represent average reductions calculated over a variety of long-term tests using several different engine types. The additive package maintains fuel economy and power and is a lower cost option than some alternative fuel products. Although this

product does not contain reduced sulphur (such as ULSD) it is compatible with Oxidation Catalyst systems. Lubricity, engine durability and performance are unaffected by the use of this product. It should be noted that most of the results reported in the SAE paper are based on tests conducted on European engines and equipment which may differ from North American manufacturer specifications. Independent studies were not available. Potential emission reductions and costs are outlined below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
0	8,528*	0	874	1,695	11,097

**Cost:**

On-road Fleet	\$15,015
Off-road Fleet	\$87,538
GRT Fleet	\$70,837
	<b>\$173,390</b>

**Savings:** Not Applicable  
**Payback Period:** Not Applicable

\*SO<sub>x</sub> reductions would be realized in off-road fleet only because current fuel (coloured diesel) has a much higher sulphur content than #1 Premium (Additive)

**Option 10: GRT Catalytic Exhaust Muffler**

Catalytic exhaust mufflers are essentially a type of catalytic converter for heavy-duty 4 stroke diesel engines that replaces the original noise muffler installed in the exhaust system. The catalytic mufflers reduce particulates and carbon-based pollutants as well as some oxides of nitrogen. According to the US EPA the potential emission reductions for this retrofit program are:

<i>Particulate matter</i>	<i>39 - 50%</i>
<i>Carbon monoxide</i>	<i>40 - 43%</i>
<i>Hydrocarbons</i>	<i>43 - 50%</i>
<i>Nitrous oxides</i>	<i>2.8 - 4.4%</i>

*\*these numbers assume use of fuel with sulphur content of 50 ppm or less\**

According to a manufacturer of catalytic mufflers, the performance of these mufflers is unaffected by fuel sulphur content. However, emissions of particulate matter and sulphur oxides are known to vary with sulphur content of the fuel. It is assumed that catalytic mufflers have no direct impact on SO<sub>x</sub> emissions, and that approximately half of the particulate matter emission reductions shown in the above table are due to the mufflers, while the other half are due to lower sulphur content in the fuel. Emissions of SO<sub>x</sub> and PM have been calculated for the bus fleet based on the presence of a catalytic muffler and whether it is assumed they are burning No.1 diesel or ultra low sulphur diesel. However, emission reductions of other pollutants possible from the installation of catalytic mufflers are assumed to be identical regardless of whether No. 1 diesel or ultra low sulphur diesel is being used. While many studies conclude that this is not the case, a reasonable formula was not available to reflect this potential difference. The following scenarios demonstrate the emission reductions using diesel fuel and ULSD.

*A. Catalytic Mufflers with Diesel*

The annual emissions impact of installing catalytic mufflers on 86 of the region's 143 transit buses while continuing to use No.1 diesel is shown in the table below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
1,881	0	14,206	2,044	499	18,630

**Cost:** \$180,000  
**Savings:** Not Applicable  
**Payback Period:** Not Applicable

*B. Catalytic Mufflers with ULSD*

The annual emissions impact of using ULSD in the entire fleet and installing catalytic mufflers on 86 of the region's 143 transit buses is shown in the table below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
1,881	2,810	14,206	2,044	1,536	22,477

**Cost:** \$180,000  
**Savings:** Not Applicable  
**Payback Period:** Not Applicable

**Option 11: Replace Coloured Diesel with No.2 Diesel in Off-road Fleet**

Landfill or off-road vehicles use coloured diesel, an unrefined and “dirty” fuel. Current legislation allows coloured diesel to have a sulphur content of up to 5,000 ppm however, the Region uses coloured diesel with a sulphur content of 2,400 to 3,000 ppm. No.2 diesel is much more refined than coloured diesel with a sulphur content of approximately 350 to 450 ppm. The emissions impact and cost of replacing coloured diesel with No.2 diesel in the regional off-road fleet is shown below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
0	8,528	0	0	760	9,288

**Cost:** \$76,278  
**Savings:** Not Applicable  
**Payback Period:** Not Applicable

**Option 12: Driver Education for Fuel Efficiency**

Currently new drivers receive the Region’s driver education handbook and defensive driving training, which varies depending on whether the employee drives a light or heavy vehicle or bus. The existing driver training material touches on issues of fuel economy only tangentially, through directions to drive within the speed limit and to refrain from engine idling. This message could be enhanced through the development of a fuel-economy driver education package.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b>	<b>SO<sub>x</sub></b>	<b>CO</b>	<b>VOC</b>	<b>PM<sub>10</sub></b>	<b>Total Reduction</b>
<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>
87	4	895	93	2	1,081

**Cost:** Not Applicable  
**Savings:** Not Applicable  
**Payback Period:** Not Applicable

**Option 13: Employee Transportation Demand Management Program – Phase 1**

The Region can establish an employer-based Transportation Demand Management program to assist employees in traveling to work in modes other than by single occupant vehicle. The success of these programs over the long term hinges on the ability of the employer to package a mix of attractive options and to sustain commitment over time. The provision of transit passes, carpool ride matching service, change room and shower facilities, secure bike parking, guaranteed rides home, access to occasional parking spots, and other incentives to switch modes have been proven to be successful in other organizations. The emissions saved are calculated by reducing the number of kilometres traveled by single occupant vehicles when an employee changes mode. For phase one of this program it is assumed that five per cent of employees who work at primary Regional buildings (65 employees) will switch from single occupant vehicle to other travel modes. The cost reflects a program which could include a ridematching service to find carpool partners, reduced transit passes for cyclists during the winter months, transit passes and other incentives to encourage modal shift. The potential annual impact of a TDM program for Regional employee’s commute trip is estimated below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b>	<b>SO<sub>x</sub></b>	<b>CO</b>	<b>VOC</b>	<b>PM<sub>10</sub></b>	<b>Total Reduction</b>
<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>
638	57	6,266	648	14	7,623

**Cost:** \$40,000  
**Savings:** Not Applicable  
**Payback Period:** Not Applicable

**STREETLIGHTS**

**Option 14: Retrofit Traffic Signal Lights to LED Lamps**

The Region has 400 signalized intersections. Most (90%) use standard incandescent light bulbs ranging in wattage from 60-160 watts. New light emitting diodes (LEDs) offer a more energy efficient alternative. Instead of a single bulb, LED lights feature a number of small lights assembled together in 1 unit. Together, the numerous pinpoints of LED light produce a brighter light than the traditional incandescent bulb, with as much as an 85% reduction in energy consumption. LED lights typically use between 10-25 watts. A retrofit program for the Region’s traffic signal lights is estimated to cost approximately \$3 million. The emissions impact of installing LED traffic signal lights is shown below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
2,519	3,897	127	13	71	6,627
<b>Cost:</b> \$3,000,000					
<b>Savings:</b> \$101,655 (in first year)					
<b>Payback Period:</b> 6 years					

**Option 15: Use Energy Efficient Luminaires, Ballasts and Photoelectric Cells**

High pressure sodium lamps are an energy efficient source of light with acceptable colour rendition for street lighting use, with about 29% of the energy used by the lamp producing light. Nearly all (98%) Regional street lamps are high pressure sodium lamps. A standard “cobra head” street lighting fixture uses a refractor lense underneath the bulb to diffuse the light. The refractor sends light in virtually every direction including up, causing street lights to be sources of “light pollution” and sideways glare, reducing visibility for drivers. The intended purpose of street lighting is to illuminate the street, and this can be done much more efficiently when instead of using a refractor lense underneath the light bulb, a reflector is placed above the bulb. The reflector directs the light downwards to street level. Street lighting fixtures that use reflectors instead of refractors are commercially available and allow the 200-250 watt high-pressure sodium light bulb found in standard cobra head fixtures to be replaced with a 100-150 watt high-pressure sodium light bulb. Experience in the City of Calgary suggests that the cost of retrofitting street lights is \$150 per fixture. The energy savings are approximately 40%. The emissions impact of upgrading streetlight technology is shown below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
988	1,528	50	5	28	2,599

**Cost:** \$500,000  
**Savings:** \$33,764 (in first year)  
**Payback Period:** 5 years

**DEMONSTRATION PROJECTS**

**Option 16: Innovative Technology for New Building Design**

Natural lighting or day lighting, and solar energy are both considered to be innovative technologies. Natural lighting can be brought into a building through installing large glass panes in the roof of a building, thereby allowing sunlight to light midsections of the building during working hours. In addition light pipes, which are reflective flexible tubes that transport light to a specific location, and light shelves, which are an architectural device that allows light to penetrate deep into a building interior from the perimeter, can be used. Using natural light is best for lighting areas where reading or concentration is not required, such as in lounges, hallways, common areas or cafeterias, because of possible rapid shifts in light intensity. Emission savings were calculated for the use of natural lighting in the Operations Centre and are shown below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b> <b>(kg)</b>	<b>SO<sub>x</sub></b> <b>(kg)</b>	<b>CO</b> <b>(kg)</b>	<b>VOC</b> <b>(kg)</b>	<b>PM<sub>10</sub></b> <b>(kg)</b>	<b>Total Reduction</b> <b>(kg)</b>
31	48	2	0	1	82

**Cost:** Feasibility study required  
**Savings:** Unknown  
**Payback Period:** Unknown

Photovoltaic cells and solar panels are used to convert sunlight into electricity and heat. Photovoltaic cells are non-mechanical devices, usually made from silicon alloys. The cells absorb photons, or particles of energy, from sunlight which excites electrons in a semiconductor. The cell takes a percentage of these electrons and directs them to flow

in a path, which becomes an electrical current. Solar panels convert solar energy into heat energy through heat transfer technology. Solar thermal collectors mounted on the roof of a building capture solar energy. The resulting heat is transferred to water via a heat transfer/storage unit. Solar panels can be used to heat hot water and/or provide space heating.

Locally, Arise Technologies Corporation and ATS Automation Tooling Systems engineer and manufacture solar energy solutions. Solar photovoltaic systems are priced according to kilowatt hour (kWh) per hour of insolation (i.e., how much sunlight reaches the surface per day). Prices vary depending on how the system is installed, how far it is from the grid and whether it will use a backup battery. A typical system costs \$16,000 per kilowatt hour (including installation). Emission savings were calculated for the use of a single 5 kilowatt system at the Operations Centre and are shown below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b>	<b>SO<sub>x</sub></b>	<b>CO</b>	<b>VOC</b>	<b>PM<sub>10</sub></b>	<b>Total Reduction</b>
<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>
25	10	5	1	1	42
<b>Cost:</b> \$80,000					
<b>Savings:</b> Unknown					
<b>Payback Period:</b> Unknown					

The cost of retrofitting an existing building to include natural lighting and/or solar energy technology is cost prohibitive as the potential emission reductions are small. A more cost effective practice would be to incorporate these technologies into new building design.

**Option 17: Alternative Bus Technology – Electric Hybrids**

Although there are several alternatives to current transit buses, the most feasible type is the hybrid diesel-electric. Other more cost-prohibitive technologies such as fuel cell buses have not yet reached product maturity and require further development for mass use. Diesel-electric hybrid buses are a potential transitional technology for the next several years as they operate on diesel fuel. Hybrid diesel-electric vehicles use both an internal combustion engine and electric motors to provide propulsion energy, dramatically increasing the overall fuel efficiency of the bus. The diesel engine generates electricity which is subsequently stored in batteries for use by the electric motor. When high power output is required, such as when the bus is accelerating, both the diesel engine and the electric motor are used to provide propulsion. At low speeds,

the electric motors alone will drive the bus. The advantage of this system is that a much smaller diesel engine is required to power the bus, and the engine operates in a very narrow RPM range. The result is much greater fuel efficiency and greatly reduced emissions.

New York City and Minneapolis transit authorities are both testing diesel hybrid electric buses while Denver is assessing a CNG hybrid system for their fleet. A few Canadian municipalities are also considering the integration of hybrid vehicles for their transit fleets. Toronto and BC Transit are currently testing out some hybrid models as well. Transit personnel in many cities will have had experience using similar technology in rail cars and trolley buses.

Considering GRT's fleet will number over 200 vehicles in the near future, a slow introduction of hybrid vehicles could yield substantial reductions of key air contaminants resulting from regional transit operations.

While the purchase price of a hybrid diesel-electric vehicle is approximately \$750,000, a 15-50 % premium over regular diesel/CNG buses, the operating costs for hybrid diesel-electric buses should ultimately be lower due to reduced fuel consumption. Manufacturers expect hybrid-electric buses to consume 30 to 50 per cent less fuel than regular fuelled transit vehicles.

A demonstration project (i.e. use of 1 or 2 hybrid-electric vehicles for three years) could cost approximately \$50,000 - \$60,000 per year under a trial lease arrangement. GRT would then have the option to purchase more hybrids with some direct experience in operating this technology. Potential emission reductions and costs are shown below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b>	<b>SO<sub>x</sub></b>	<b>CO</b>	<b>VOC</b>	<b>PM<sub>10</sub></b>	<b>Total Reduction</b>
<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>
138	9	303	74	3	527
<b>Cost:</b> \$60,000					
<b>Savings:</b> \$8,585 (in first year)					
<b>Payback Period:</b> Not applicable					

**Option 18: Use More Efficient Vehicles**

Hybrid gasoline -electric vehicles generally utilize two (or more) sources of energy to propel themselves – mechanical power, from a small internal combustion engine and electrical power, from a generator/motor which can be used to charge on-board

batteries or drive the vehicle directly. There are three methods or configurations which are used in hybrid gasoline -electric vehicles: series, parallel and split. In a series system, the engine is used solely to power a generator, which provides power for an electric motor which in turn drives the vehicle. In a parallel system, the engine and electric motor are both connected to the transmission – thus allowing for a greater degree of flexibility and adaptability to different driving conditions. Finally, in the split system, the engine drives the wheels of one axle and the electric motor drives the wheels of the other – there is no connection between the two systems.

As of the 2003 model year, three hybrid electric vehicles (HEV) will be available on the market: the Toyota Prius, Honda Insight and Honda Civic Hybrid. Other vehicle manufacturers, including Ford, General Motors and Daimler-Chrysler, will introduce HEV sedans, pick-up trucks and SUVs from the 2004 to 2006 model years. Currently, there are between 10 – 12 possible (future) applications for these vehicles within the Region of Waterloo. Typically, vehicles used by by-law enforcement and summons could potentially be replaced by HEVs once the existing vehicles have ended their useful life. Presently, these departments are using Chevrolet Cavaliers which could easily be substituted by HEV vehicles. Other departments which currently employ large sedans or vans/trucks which are underutilized could also qualify as candidates for HEV vehicle replacement. The use and operation of HEV vehicles requires no change to the Region’s existing infrastructure.

Because hybrid electric vehicles employ both conventional combustion and electric engines for propulsion, they are both very fuel efficient and environmentally friendly – having among the best ratings profiles for greenhouse gas and smog-forming emissions for all vehicle types. Reducing emissions of known pollutants has positive health benefits. The emissions impact of switching to gas-electric hybrid vehicles is shown below.

<b>Potential Emission Reductions:</b>					
<b>NO<sub>x</sub></b>	<b>SO<sub>x</sub></b>	<b>CO</b>	<b>VOC</b>	<b>PM<sub>10</sub></b>	<b>Total Reduction</b>
<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>	<b>(kg)</b>
13	1	139	19	1	173
<b>Cost:</b> \$10,000					
<b>Savings:</b> \$740					
<b>Payback Period:</b> Not applicable					

Data sources and assumptions for most measures are presented in Appendix D.

## **ENDORSEMENT OF INITIATIVES UNDERWAY**

### **Anti-idling Policy**

Regional and municipal employees are setting the example for the community by abiding by the Waterloo Region Idling Control Policy implemented in spring 2002. According to this policy employees shall not allow vehicles to idle for more than 10 seconds since idling for more than 10 seconds uses more fuel than turning off the vehicle and restarting it again. In addition, all contractors on capital construction projects must also abide by the Region's anti-idling policy which limits idling of contractor's equipment on Regional projects to a maximum of 10 minutes.

### **Energy Conservation – Occupant education**

The Region's Facilities Maintenance group sends all Regional employees e-mail reminders about closing window blinds when possible in the hot summer months. Employees are educated about energy savings potential in these messages. This is done on an ad hoc basis.

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## **C O N C L U S I O N S**

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Considering criteria from the evaluative framework, the best 11 emission reduction strategies were selected. Strategies were primarily ranked according to greatest emission reduction potential as these also offer their greatest health benefit. The demonstration of alternative bus technology was also included in the top 10 as it is a strategy that is visible to the public. Table 8 outlines the best 11 emission reduction strategies with emission reduction potential, divided into low, medium and high cost bundles.

Options 3 and 7 through 10 are suggested to be implemented over a period of time. Table 9 demonstrates the annual expenditures, financial savings and emission reduction potential (per year) of each of these initiatives.

Furthermore, four measures are recommended for review for Regional policy:

1. Energy Star office equipment and implement automatic power down software;
2. Driver education for fuel efficiency;
3. Innovative technology for new building design; and
4. Use more efficient vehicles.

**Table 8.** Three Cost Options to Address Clean Air Plan

<b>Emission Reduction Strategies</b>		<b>Emission Reduction Potential (kg)</b>	<b>Cost (\$)</b>
1	Replace Gasoline with E10	37,164	15,125*
2	Replace Diesel with ULSD in GRT Fleet and Replace Diesel with #1 Premium (Additive) in On-road and Off-road Diesel Fleets	14,069	424,010
3	GRT Fleet Catalytic Exhaust Muffler	18,630	360,000*
<b>Cost Option 1</b>		<b>69,863</b>	<b>799,135</b>
<hr/>			
4	Employee Transportation Demand Management Program – Phase I	7,623	40,000
5	10% Green Power Purchase Plan	15,748	351,000
6	Hybrid Electric Bus	658	60,000
<b>Cost Option 2</b>		<b>24,029</b>	<b>451,000</b>
<b>Cost Option 1 + Cost Option 2</b>		<b>93,892</b>	<b>1,250,135</b>
<hr/>			
7	Retrofit Traffic Signal Lights to LED Lamps	6,627	3,000,000*
8	Use Energy Efficient Luminaires, Ballasts and Photoelectric Cells	2,599	500,000*
9	Energy Efficient Lighting in Regional Affordable Housing	4,315	1,011,000*
10	Lighting Equipment Efficiency Improvements in Primary Regional Buildings	4,236	350,000*
11	HVAC System Upgrades, Building Energy Management, Exhaust Heat Recovery	4,458	2,000,000*
<b>Cost Option 3</b>		<b>22,235</b>	<b>6,861,000</b>
<b>Cost Option 1 + Cost Option 2 + Cost Option 3</b>		<b>116,127</b>	<b>8,111,135</b>

\*option represents a one-time cost; remaining costs are annual

**Table 9.** The Region of Waterloo Clean Air Plan Financial Summary

<b>Expenditures</b>	2003	2004	2005	2006	2007	2008
1 Replace Gasoline with E10	15,125					
2 ULSD for GRT; #1 Premium (Additive) for On-road and Off-road Fleets	424,010	424,010	424,010	424,010	424,010	424,010
3 GRT Catalytic Muffler	180,000	180,000				
4 Employee Demand Mgt Program	40,000	40,000	40,000	40,000	40,000	40,000
5 10% Green Power Purchase	351,000	351,000	351,000	351,000	351,000	351,000
6 Hybrid Electric Bus	60,000	60,000	60,000			
7 Traffic Signal Retrofit	600,000	600,000	600,000	600,000	600,000	
8 Energy Efficient Luminaires	166,667	166,667	166,667			
9 Lighting Equipment – Regional Affordable Housing	91,000	920,000				
10 Lighting Equipment – Regional Bldgs	175,000	175,000				
11 HVAC System Upgrades	400,000	400,000	400,000	400,000	400,000	
<b>Total Expenditures</b>	<b>\$2,502,802</b>	<b>\$3,316,677</b>	<b>\$2,041,677</b>	<b>\$1,815,010</b>	<b>\$1,815,010</b>	<b>\$815,010</b>
<b>Financial Savings</b>						
6 Hybrid Electric Bus	8,585	8,585	8,585			
7 Traffic Signal Retrofit	101,655	203,310	304,965	406,620	508,275	508,275
8 Energy Efficient Luminaires	33,764	67,528	67,528	67,528	67,528	67,528
9 Lighting Equipment – Regional Affordable Housing	0	210,240	210,240	210,240	210,240	210,240
10 Lighting Equipment – Regional Bldgs	82,555	165,110	165,110	165,110	165,110	165,110
11 HVAC System Upgrades	61,513	123,026	184,539	246,052	307,565	307,565
<b>Total Financial Savings</b>	<b>\$288,072</b>	<b>\$777,799</b>	<b>\$940,967</b>	<b>\$1,095,550</b>	<b>\$1,258,718</b>	<b>\$1,258,718</b>
<b>Net Cost</b>	<b>\$2,214,730</b>	<b>\$2,538,878</b>	<b>\$1,100,710</b>	<b>\$719,460</b>	<b>\$556,292</b>	<b>\$(433,708)</b>

**Table 10.** Region of Waterloo Clean Air Plan Emission Reduction Potential

Emission Reduction (kg)	2003	2004	2005	2006	2007	2008
1 Replace Gasoline with E10	37,164	37,164	37,164	37,164	37,164	37,164
2 ULSD for GRT; #1 Premium (Additive) for On-road and Off-road Fleets	14,069	14,069	14,069	14,069	14,069	14,069
3 GRT Catalytic Mufflers	9,315	18,630	18,630	18,630	18,630	18,630
4 Employee Demand Mgt Pgm	7,623	7,623	7,623	7,623	7,623	7,623
5 10% Green Power Purchase	15,748	15,748	15,748	15,748	15,748	15,748
6 Hybrid Electric Bus	658	658	658			
7 Traffic Signal Retrofit	1,325	2,650	3,975	5,300	6,625	6,625
8 Energy Efficient Luminaires	866	1,732	2,599	2,599	2,599	2,599
9 Lighting Equipment – Regional Affordable Housing	1,438	2,876	4,314	4,314	4,314	4,314
10 Lighting Equipment – Regional Bldgs	2,118	4,236	4,236	4,236	4,236	4,236
11 HVAC System Upgrades	891	1,782	2,673	3,564	4,455	4,455
Total Emission Reduction	91,215	107,168	111,689	113,247	115,463	115,463

## Appendix A. HEALTH EFFECTS OF POLLUTANTS

This initiative focuses primarily on strategies for reduction of the five criteria air contaminants (CACs): volatile organic compounds (VOCs); sulphur oxides (SO<sub>x</sub>); oxides of nitrogen (NO<sub>x</sub>); carbon monoxide (CO); and respirable particulate matter (PM) less than or equal to 10 micrometers in diameter. CACs were chosen because of their known adverse health effects. Recent evidence indicates there is no safe level below which no health effects are observed. Thus the Ontario Medical Association (OMA) has recommended shifting from a threshold level of thinking. In addition, VOCs, NO<sub>x</sub> and PM are precursors for ground-level ozone (O<sub>3</sub>) formation. (sources and health effects of each pollutant are listed below) Strategies to reduce exposure to air toxics, benzene, mercury (Hg), and polycyclic aromatic hydrocarbons (PAHs) were initially considered because of their known adverse health effects. However, these pollutants are not routinely measured thus levels of exposure are not known. Furthermore, in the case of mercury, local exposure levels are very low therefore air toxics were not included in this analysis. The following table outlines sources and known adverse health effects of the CACs and O<sub>3</sub>.

**Table 11.** Sources and Health Effects of Air Pollutants

POLLUTANT	DEFINITION	COMMON SOURCES	KNOWN ADVERSE HEALTH EFFECTS
Volatile Organic Compounds (VOCs)	<ul style="list-style-type: none"> <li>- group of compounds that contain carbon and evaporate rapidly</li> </ul>	<ul style="list-style-type: none"> <li>- approximately half are from natural sources</li> <li>- man-made sources include motor vehicle exhaust, industrial processes and evaporation of solvents, oil-based paints, gasoline from gas pumps</li> </ul>	<ul style="list-style-type: none"> <li>- many individual VOCs are known or suspected of having health effects ranging from carcinogenicity to neurotoxicity</li> <li>- VOCs are a building block for ozone formation (see below)</li> </ul>
Nitrogen Oxides (NO <sub>x</sub> )	<ul style="list-style-type: none"> <li>- group of 7 compounds composed of nitrogen and oxygen</li> <li>- nitrogen oxide (NO) is a major component that oxidizes to form NO<sub>2</sub></li> </ul>	<ul style="list-style-type: none"> <li>- produced by combustion of fuel, coal-burning power plants and natural gas processing</li> </ul>	<ul style="list-style-type: none"> <li>- NO<sub>2</sub> contributes to formation of acid aerosols (small particles with NO<sub>2</sub> attached) that irritate the lung when inhaled</li> <li>- NO<sub>x</sub> can impair lung function, irritate the respiratory system at elevated levels</li> <li>- at high levels, breathing can become difficult, especially for people with asthma or bronchitis</li> </ul>

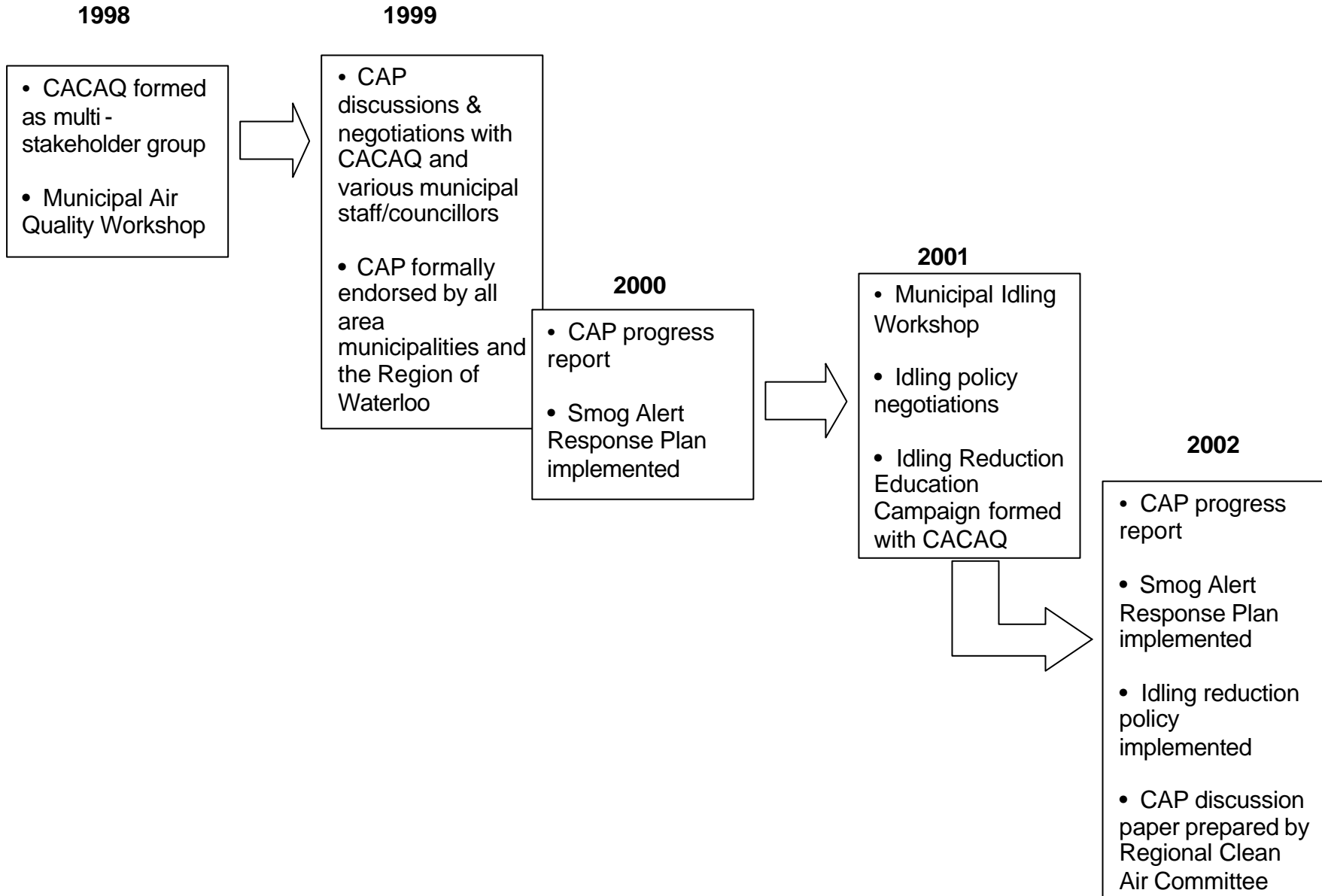
POLLUTANT	DEFINITION	COMMON SOURCES	KNOWN ADVERSE HEALTH EFFECTS
Sulphur Oxides (SO <sub>x</sub> )	<ul style="list-style-type: none"> <li>- sulphur dioxide (SO<sub>2</sub>) is a highly soluble gas</li> <li>- gradually converts to SO<sub>3</sub> when airborne where it rapidly combines with H<sub>2</sub>O to form sulphuric acid</li> </ul>	<ul style="list-style-type: none"> <li>- electric utilities, particularly coal-fired plants</li> <li>- SO<sub>2</sub> is produced primarily by industrial processes and fuel combustion</li> </ul>	<ul style="list-style-type: none"> <li>- SO<sub>2</sub> contributes to formation of acid aerosols that irritate the lung when inhaled</li> <li>- high-level exposure to SO<sub>2</sub> produces breathing discomfort, respiratory illness and aggravation of existing lung and heart disease</li> <li>- elevated SO<sub>2</sub> levels may increase hospital admissions and result in premature death</li> </ul>
Particulate Matter (PM)	<ul style="list-style-type: none"> <li>- small particles of solid and liquid matter produced by combustion of fossil fuel</li> <li>- typically reported 2 categories: all particles less than 10 micrometers (PM10) in diameter; and those less than 2.5 micrometers (PM2.5) in diameter</li> <li>- PM2.5 and PM10 were identified as toxic and added to the Canadian Environmental Protection Act's Priority Substance List on May 2001</li> </ul>	<ul style="list-style-type: none"> <li>- found in most fuel emissions; significantly higher quantities in diesel emissions</li> <li>- produced by coal-burning power plants, cement plants, mining operations, residential wood combustion, road dust</li> </ul>	<ul style="list-style-type: none"> <li>- able to penetrate deep into airways when inhaled</li> <li>- long-term ambient exposure causes lung irritation and decreases lung function among otherwise health individuals</li> <li>- acute exposure is associated with increased risk of premature deaths among persons with underlying cardiopulmonary disease</li> <li>- long-term exposure is an important risk factor for development of lung cancer and cardiopulmonary mortality</li> </ul>

POLLUTANT	DEFINITION	COMMON SOURCES	KNOWN ADVERSE HEALTH EFFECTS
Ground-Level Ozone (O <sub>3</sub> )	<ul style="list-style-type: none"> <li>- a primary component of smog</li> </ul>	<ul style="list-style-type: none"> <li>- created when VOCs and NO<sub>x</sub> react in the presence of sunlight</li> <li>- PM and SO<sub>x</sub> also contribute to O<sub>3</sub> formation</li> </ul>	<ul style="list-style-type: none"> <li>- lung inflammation, decreased lung function, airway hyper-reactivity, respiratory symptoms, possible increased medication use and physician/emergency room visits among individuals with heart or lung disease, reduced exercise capacity, increased hospital admissions and possible increased mortality</li> </ul>
Carbon Monoxide (CO)	<ul style="list-style-type: none"> <li>- colourless, odourless gas created by incomplete combustion</li> </ul>	<ul style="list-style-type: none"> <li>- vehicle emissions, combustion of other fuels (e.g., wood)</li> </ul>	<ul style="list-style-type: none"> <li>- low-level, short-term, exposure to CO include decreased athletic performance and aggravated cardiac symptoms</li> <li>- if CO enters the bloodstream it reduces the ability of blood to carry oxygen and thus deliver oxygen to organs and tissues in the body, especially the brain</li> <li>- high levels of CO are most harmful to people with anemia, chronic lung disease and coronary artery disease</li> </ul>

### Particulate Matter (PM) Legislation

In June 2000, the federal, provincial (except Quebec) and territorial governments signed an agreement outlining Canada-wide standards for maximum exposure levels for PM and ozone. These standards commit the government to reducing levels of PM<sub>2.5</sub> (and smaller) and ozone by 2010. The agreement also establishes standards for reporting, monitoring protocols and procedures. Reports and standards are required to be produced every five (5) years, beginning in 2006, with annualized reports on target standards and achievements to begin in 2011.

**Appendix B. REGION OF WATERLOO/CACAQ - CLEAN AIR PLAN (CAP) SUCCESSION**



**Appendix C. EMISSION REDUCTION STRATEGIES EXCLUDED FROM THE INVENTORY**

Emission Reduction Strategy	Reason for exclusion
<b>Buildings</b>	
Hire an energy efficiency consultant	Not able to forecast and quantify emissions reduction impact
<b>Vehicles</b>	
Anti-idling technology	The anti-idling policy is considered sufficient; the technology is already in place in some vehicles
Purchase smaller transport vehicles	Not cost effective
Purchase alternative fuel vehicles	Preference is to use alternative fuels that do not require modifications to standard vehicle technology
Low particulate street sweepers	Unable to measure emission reduction impact
Switch to Ethanol-85 fuel	The availability of E85 is limited. Use of this fuel would require purchase of vehicles with modified ignition systems as well as modifications to the fuel distribution system.
More efficient off-road equipment	There will be no new equipment purchases in this business cycle.
Remedial pollution control equipment for off-road equipment	Preference is to focus on cleaner fuels.
Replace 2-stroke engines with 4-stroke	Not necessary. This option has already been legislated.
Replace low-sulfur-diesel with B20 in bus fleet	Engine compatibility issue.
<b>Streets</b>	
Restrict asphalt paving on smoggy days	No emission benefit.
<b>Energy efficiency</b>	
Water conservation technology	Community programs in place
More efficient water pumps	Recently reviewed; already efficient
More efficient sewage pumps	Contracted service

## Appendix D. DATA SOURCES AND ASSUMPTIONS

### EMISSIONS INVENTORY

The primary source of information for the Region's emissions inventory was the Region itself. However, in some cases additional detail was derived through calculations based upon estimates. This section outlines how and where information was obtained for each of the four general categories of data:

1. Buildings;
2. Vehicle Fleet;
3. Streetlighting; and
4. Water/Sewage.

The development of an emissions inventory requires information on the quantities of fuel consumed by fuel type. This information is converted, through the use of emission factors, by the Gleneagle Air Emissions Strategy Software<sup>1</sup> into quantities of common air contaminants (NO<sub>x</sub>, SO<sub>x</sub>, VOCs, CO and PM<sub>10</sub>).

#### Buildings

Electricity consumption and floor area data were provided by the Region for 29 buildings or building groups. However, gas consumption data were only provided for 11 of these buildings. In order to ensure that the inventory was as accurate as possible, natural gas consumption was estimated for 13 of the remaining 18 buildings and Regional affordable housing using floor area and typical gas consumption rates for buildings of the same use. Four buildings were assumed to have no natural gas consumption:

1. Ayr Transfer Station
2. Kitchener Landfill Gas Control Building
3. Crosshill Transfer Station
4. Wilmot Transfer Station

Floor area data for the Elmira Library could not be obtained, and therefore natural gas consumption could not be estimated.

Gas consumption was estimated by multiplying building floor area (square footage) by an "end-use intensity" or EUI factor, which is a measure of the gas consumption use per square metre of floor area for buildings with the same or similar uses. The EUIs used for the Region's daycares, the library headquarters, police division buildings and Waterloo Landfill Gas Control Building (Office component) were calculated from the Region's own buildings where gas consumption and floor area data were known. For example, the Police Division Buildings' EUIs were estimated from the EUIs of the Region's police

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<sup>1</sup> The Gleneagle Software is described in detail in Appendix E.

headquarters and other police division buildings where gas consumption and floor area was available<sup>2</sup>. In the case of Joseph Schneider House and the Daycare buildings, the EUIs were estimated based on expert knowledge of buildings with similar uses.

Energy consumption information with respect to some Regional affordable housing projects was found in a Ministry of Municipal Affairs and Housing study obtained by the Region of Waterloo. This study provided total annual energy consumption for 19 projects with 877 of the Region's 2557 units. Data from this study was broken out by building type (apartment building, townhome, etc.) and used to estimate energy consumption from the Region's total population of affordable housing units. All of these units were assumed to be using natural gas for heating and water heating purposes. Regional affordable housing's total energy consumption was disaggregated into natural gas and electricity consumption by applying ratios of gas to electricity consumption typical of these housing types (based on Natural Resources Canada data). These values were then placed into the Gleneagle Air Emissions Strategy Software in order to determine total annual emissions of common air contaminants generated from Regional affordable housing.

### **Vehicle Fleet**

Large volumes of vehicle fleet data were obtained with respect to vehicle type, vehicle use, mileage data (odometer readings) and fuel consumption. This data had to be synthesized and categorized in order to arrive at a picture of vehicle fleet fuel consumption disaggregated by vehicle type and fuel. Accurate emission estimates rely on this level of detailed vehicle data. Along with a detailed list of vehicles, odometer readings and fuel consumption data, an estimate of the Region's total annual fuel consumption by fuel type was obtained. The disaggregated fuel consumption data provided by individual vehicle was added up and compared to the aggregate Regional fuel consumption data. As might be expected, the disaggregated fuel consumption totals varied somewhat from the aggregate totals. The variation was +12.7% for gasoline, -7.4% for diesel fuel and +15.2% for coloured diesel. The aggregate totals the Region provided were assumed to be accurate, and so the disaggregated fuel consumption totals were scaled to agree with the aggregate values.

The advantage of the disaggregated data were that it was possible to break down fuel consumption totals by vehicle class. Table 12 below shows the different vehicle classes by municipal service category, along with the disaggregate and scaled fuel consumption totals.

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<sup>2</sup> For example, the Police Headquarters Building consumed 169,368 cubic metres and has a total floor area of 9100 square meters. Its EUI is therefore  $169368/9100 = 18.6$  cubic meters/square meter. This EUI is then multiplied by the square footage of other police buildings to estimate their natural gas consumption.

**Table 12.** Vehicle Fuel Consumption Totals by Regional Service Category and Fuel Type

	Litres of Fuel Consumed	
	Disaggregated Total	Scaled Total
<b>Ambulance Services</b>		
Diesel	179,783	194,060
LDT	179,783	194,060
Gasoline	5,684	5,043
LDT	5,049	4,480
Auto-Mid-Size	635	563
<b>Police Services</b>		
Diesel	13,021	14,055
LDT	13,021	14,055
Gasoline	1,304,755	1,157,603
LDT	226,843	201,259
Full-Size	1,004,176	890,923
Mid-Size	72,167	64,028
Subcompact/Compact	1,482	1,315
Motorcycle	87	77
<b>Corporate On-Road Fleet</b>		
Diesel	226,656	244,654
LDT	7,971	8,604
HDT	218,684	236,050
Gasoline	512,701	454,877
HDT	22,925	20,339
LDT	458,417	406,716
Full-Size	20,834	18,484
Mid-Size	3,857	3,422
Subcompact/Compact	6,664	5,912
<b>Corporate Off-Road Fleet</b>		
Diesel	97,489	105,231
HDT	76,096	82,138
Loader	1,680	1,813
Grader	7,712	8,324
Tractor	905	977
Recycler	11,097	11,978
Gasoline	3,795	3,367
ATV	609	540
Riding Mower	1,471	1,305
Pump	1,583	1,404
Personnel Lift	42	37
Roller	36	32
Generator	3	3
Snowblower	4	4
Coloured Diesel	513,285	445,549
Compactors	251,247	218,091
Bulldozers	112,829	97,939

	Litres of Fuel Consumed	
	Disaggregated Total	Scaled Total
Loaders	66,623	57,831
Graders	21,020	18,246
Scrapers	17,790	15,442
HDT	20,618	17,897
Tractors	9,753	8,466
Sweepers	8,775	7,617
Riding Mower	3,103	2,694
Wood Chipper	781	678
Giant Vacuum	286	248
Roller	223	194
Compressors	117	102
Generator	120	104
<b>Total Gasoline</b>	<b>1,826,934</b>	<b>1,620,890</b>
<b>Total Diesel</b>	<b>516,949</b>	<b>558,000</b>
<b>Total Coloured Diesel</b>	<b>513,285</b>	<b>445,549</b>

Detailed information on fuel consumption by the Grand River Transit Authority was calculated with available information. A diesel fuel consumption total was available, along with the total number of diesel transit buses in use. It was assumed that average consumption per transit vehicle was simply total diesel fuel consumption divided by the number of diesel transit buses.

Information with respect to Mobility Plus vehicles, including total number of vehicles vehicle type information, fuel consumption and odometer readings was made available. No data manipulation was needed in order to add this information to the inventory.

Garbage and recycling services are contracted out, but the service providers, when approached, were able to provide estimates of total fuel consumption. Additional data were requested with respect to vehicle types used, which was subsequently provided. No data manipulation was needed in order to add this information to the inventory.

An important source of transportation for Regional staff is the business use of personal vehicles. Data were obtained with respect to the total amounts in dollars claimed by Regional staff for the use of personal vehicles on corporate business. This was used to estimate total vehicle kilometers of travel. No information is available on the types of vehicles used by Regional staff, so the breakdown of this fleet of vehicles was estimated based on the province of Ontario's vehicle fleet mix. This information is available from Natural Resources Canada publications.

### Streetlighting

All electricity consumption information with respect to streetlights, signal lights and yard lighting was obtained from Regional data sources and entered directly into the inventory.

Two possible options for reducing emissions of volatile organic compounds (VOCs) during asphalt paving were considered: using low-emission asphalt and restricting paving on smoggy days. An investigation into emissions from asphalt paving led to the finding that the application of "hot mix" asphalt, which represents the bulk of paving material applied to roads, produces almost negligible amounts of VOC emissions. It is the application of "cutback" or "tack coat", a liquefied asphalt mixture applied to roads as a binding agent that produces significant emissions. Regional road paving processes do not include the use of this binding agent and therefore no restrictions on paving on smoggy days are required for Regional road improvement contracts.

### **Water/Sewage Treatment**

All electricity consumption information with respect to wells, pumps and wastewater treatment facilities was obtained from Regional data sources and entered directly into the inventory.

### **MEASURES ANALYSIS**

The following section highlights options that involved a detailed analysis by the consultant, Torrie Smith and Associates Inc. Thus options 5, 9, 13 and 18 are not discussed in this section.

### **Buildings**

#### **Option 1: Lighting Equipment Efficiency Improvements**

The installation of T8 Lighting, electronic ballasts and High Intensity Discharge (HID) Metal Halide lighting in high ceiling areas can reduce lighting energy consumption by 30%. The calculations here have not included CH&SS, which is considered as already having optimal efficiency lighting. The paybacks on this type of retrofit are typically 18 months to 3 years.

#### **Option 2: HVAC System Upgrades, Building Energy Management, Exhaust Heat Recovery**

Information provided for this sector did not describe energy upgrades that have been made to date. However, installation of high efficiency motors, fans, pumps and blowers, high efficiency air conditioners (desiccant cooling and dehumidification systems and natural ventilation) and heating systems are all possible strategies for reducing energy consumption in building HVAC equipment. According to the Consortium for Energy Efficiency in the United States, 25% of all HVAC systems are oversized, dramatically increasing energy costs. The assumed energy savings from heating, water heating, cooling and fan, pump and blower energy consumption is 20% from baseline (80% gas consumption and 21% electricity consumption). While it is very difficult to gauge the cost

of such improvements, 5-7 year paybacks are typical. Therefore, the cost has been estimated at approximately \$2 million.

### **Option 3: Energy Star Office Equipment and Implement Automatic Power Down Software**

Energy Star compliant office equipment (computers, monitors, fax machines, printers, photocopiers, scanners, and multifunction devices) consume far less energy than non-compliant devices. The US EPA estimates that a typical office purchasing Energy Star compliant devices and utilizing the power management features for computers could cut its power consumption from these devices in half. It has been assumed that office equipment energy consumption could be cut in half from the purchase of energy star equipment and LCD flat screen monitors.

### **Option 4: Energy Efficient Lighting in Regional Affordable Housing**

Based on data provided by the Region, the number of fixtures that are eligible for energy efficient retrofits is 10,000. For hallway lighting, the "typical" fixture is assumed to be one containing two four-foot 40-watt fluorescent tubes and a magnetic ballast. Such a fixture consumes 96 watts (80 watts for the two fluorescent tubes and 16 watts for the ballast). The retrofits the Region is considering involve replacing 40-watt fluorescent tubes with energy saving 32-watt tubes and replacing magnetic ballasts with electronic ballasts, which consume only about 8 watts. The result is a savings per fixture of 24 watts. These fixtures are assumed to be on 24 hours per day, 365 days per year. The drop in annual energy consumption per fixture is therefore 210 kilowatt-hours. Other lighting fixtures slated for energy efficiency improvements would be those found within apartment suites. These may include, for example, bathroom fixtures containing two 60-watt incandescent light bulbs. Such fixtures could be replaced with fluorescent or compact fluorescent fixtures. While the duration of operation of these light fixtures will be less than those found in hallways (e.g. they are not turned on all day long), the reduction in electrical demand is much greater (from as much as 200 watts to 72 watts or less).

While the specific energy audit report that provides all the details of the energy-efficient retrofits planned for Regional affordable housing has not been reviewed, the report states the total cost of retrofits will be \$981,000 with an approximate payback of around five years. Based on these figures, the expected annual energy consumption reduction will be approximately 2 million kilowatt-hours.

### **Option 16: Innovative Technology for New Building Design**

Emission reductions were calculated for the use of daylighting measures, i.e., skylights, light shelves or light pipes, at the Operations Centre. The assumption is that a

combination of daylighting measures could reduce lighting requirements in the Operations Centre by 5%.

Similarly, emission reductions were calculated for the use of a solar array and solar hot water heating system at the Operations Centre. A 5 kw array would be installed on the roof of the Operations Centre. Every watt of solar capacity typically produces between 2 and 6 watt-hours per day of electricity. Assuming 4 watt-hours per watt, the Operations Centre solar array would produce 20 kWh/day or 7300 kWh/year. The expected life of the array is 20 years. Total installation cost is estimated at around \$50,000.

According to ARISE Technologies of Waterloo, a typical solar hot water heating system can supply 50% of the hot water needs of a building. The Operations Centre's hot water heating needs were estimated by using typical end-use breakdowns (percentages of total energy consumption for heating, lighting, hot water heating, etc) of office building energy consumption available from Natural Resources Canada. The total cost is estimated at around \$30,000, and the total expected life of the system is 20 years.

**Vehicle Fleet**

**Option 6: Replace Gasoline with E10**

No specific assumptions were made with respect to converting the corporate fleet to E10 from ordinary gasoline.

**Option 7: Replace Diesel with B20 in On-road and Off-road Fleets**

There is a wealth of literature available on the expected emission reductions possible from switching from regular diesel fuel to B20. The annual emission reductions assumed in the assessment of this option were:

	N <sub>2</sub> O	CH <sub>4</sub>	NO <sub>x</sub>	SO <sub>x</sub>	CO	VOC	PM10
No Change		14%	-1%	20%	9%	14%	8%

**Note: A negative value denotes an increase in emissions**

Specific data with respect to changes in the emissions of SO<sub>x</sub> from using B20 were not available, but it was assumed that biodiesel contains no sulphur, and therefore the SO<sub>x</sub> emission reductions possible were 20%.

It should be noted that the calculated emission reductions possible from switching to B20 in the on-road fleet assume that it will not be possible to switch garbage and recycling vehicles to B20 in this budget cycle, as the current contracts do not specify the

use of B20 and they are not scheduled for re-negotiation at this time. Therefore, garbage and recycling trucks are excluded from this measure.

Switching to B20 in the offroad fleet provides for very large reductions in SOx and PM emissions because B20 is a blend of 20% biodiesel and 80% No.2 diesel. No.2 diesel has dramatically lower sulphur content than coloured diesel and in addition B20 has no sulphur content at all. The net effect is dramatically low SOx and PM emissions.

### **Option 8: Replace Diesel with ULSD in On-road, Off-road and GRT Fleets**

An analysis of the impact of ultra-low sulphur diesel on vehicle emissions was conducted in order to develop appropriate emission factors. Our research indicates that two pollutants are directly affected by lowering the sulphur content in diesel: SOx and particulate matter emissions. SOx emissions are a direct result of the amount of sulphur contained in fuel. As fuel sulphur is lowered, emissions of SOx are lowered by an equal amount. While there is some contradictory evidence as to the amount of sulphur contained in Ontario diesel fuel, it was assumed that current concentrations are 350 parts per million (ppm). Ultra Low Sulphur Diesel (ULSD) must have a sulphur concentration of less than 30 ppm, but most analyses appear to assume that ULSD will have a sulphur content of 15 ppm. Given the relationship between fuel sulphur and SOx emissions, the emission reductions possible from using ULSD were therefore calculated to be 15/350 or a 95.7% reduction.

According to a study conducted by the United States Environmental Protection Agency, moving to ULSD also reduces particulate matter emissions by 20-25%. A 25% reduction was assumed for this analysis. No mention of the specific impact of lowering sulphur content in fuel on emissions of NOx, VOCs, or CO could be found in the various studies consulted, although statements to the effect that lowering sulphur in fuel does lower emissions of these other pollutants were found in some non-scientific literature. Without a clear understanding of the impact of lowering sulphur on NOx, VOCs and CO, a conservative assumption was made that converting the Regional fleet of diesel-powered vehicles to ULSD would have no impact on emissions of these pollutants.

### **Option 10: GRT Catalytic Exhaust Muffler**

Data on the emission reduction potential from the use of catalytic mufflers on diesel transit buses is available from the U.S. EPA. Reductions in NOx, VOCs, CO and PM are shown. The emission reductions assume the use of ultra low sulphur diesel. A representative of Engelhard Corporation (makers of catalytic mufflers) indicated that the performance of catalytic mufflers was unaffected by sulphur content in fuel. As such, the emission reductions possible for NOx, VOCs and CO are assumed to be identical whether ULSD or No.1 diesel is used. Several documents from the U.S. EPA, Environment and Health Canada and the Canadian Vehicle Manufacturers Association

state otherwise. Yet, there was no clear formula provided within these documents to reflect the synergistic effect of both ULSD and the catalytic system. However, PM emissions are known to be lowered by 25% simply by moving from No.1 diesel to ULSD (e.g. without the use of a catalytic muffler). It has been assumed in this study that 25% of the expected reduction in PM emissions attributable to the use of a catalytic muffler with ULSD is due to the use of ULSD alone. The other 20% drop in PM emissions is assumed to be attributable to the catalytic muffler. SOx emissions are a direct result of fuel sulphur content and in fact, the U.S. EPA study showed no reduction in SOx emissions from the use of catalytic mufflers alone (the SOx reductions are ONLY due to lower sulphur content in the fuel). SOx emissions from the use of No.1 diesel and a catalytic muffler are therefore assumed to be zero.

### **Option 11: Replace Coloured Diesel with No. 2 Diesel in Off-road Fleet**

Higher SOx emissions from the use of coloured diesel are assumed to be proportional to the increased sulphur content of coloured diesel over regular (No.2) diesel fuel. Similarly, lower SOx emissions from the use of ULSD are also assumed to be proportional to the decreased sulphur content of ULSD over regular (No.2) diesel fuel. Coloured diesel emissions of particulate matter (PM10) are expected to be 25% greater than particulate matter emissions from No.2 diesel, and ULSD particulate matter emissions 25% below No.2 diesel, as shown in research done for the U.S. EPA. As noted above, the impact of sulphur content in fuel is assumed to apply only to SOx and PM emissions and therefore only emissions of these two pollutants were adjusted based on offroad use of coloured diesel and ULSD. B20's expected impact on emissions, as shown above, was applied to the offroad No.2 diesel emission factors.

Once specific emission factors for offroad use of No.2 diesel, coloured diesel, B20 and ULSD were researched and calculated, it was possible to determine the effect of fuel switching in the offroad fleet.

### **Option 12: Employee Driver Education Program**

Proper vehicle maintenance and operation can significantly reduce fuel consumption. Lowering driving speed, gradual acceleration, maintaining tire pressure, recognizing the need for vehicle tune-ups, etc. are all ways of improving vehicle performance. This measure assumes that a properly educated driver could reduce fuel consumption by 10% on average, and that about 20% of drivers would implement what they have learned. This measure is assumed to apply only to the corporate non-emergency fleet.

### **Option 17: Alternative Bus Technology – Electric Hybrids**

Diesel-Electric Hybrid Buses consume just 60% of the fuel of a regular diesel bus. This measure assumes the diesel-electric hybrid bus is in service for the same number of

hours per year as a regular diesel bus (each GRT bus consumed approximately 29,000 litres of fuel per annum).

## **Streetlighting**

### **Option 14: Retrofit Traffic Signal Lights to LED Lamps**

LED traffic lights reduce traffic light energy consumption by 85% when compared with standard incandescent traffic lights. Standard traffic lights consume about 150 watts/bulb, whereas similar LED Traffic Signal Lights consume just 25 watts/bulb.

### **Option 15: Use Energy Efficient Luminaires, Ballasts and Photoelectric Cells**

Street lighting fixtures that use reflectors instead of refractors allow the 200-250 watt high pressure sodium light bulb found in standard cobra head with refractor fixtures to be replaced with a 100-150 watt high pressure sodium light bulb. Experience in the City of Calgary suggests that the cost of retrofitting street lights is \$150 per fixture. The energy savings are approximately 40%.

## **EMISSION FACTORS**

The emission factors used to develop both the air pollution inventory and to determine the air pollution impact of measures were developed by Torrie Smith Associates for the Gleneagle Air Emissions Software. These emission factors were developed for the United States.

Fuels such as natural gas and propane and the fuel-burning equipment that uses them are effectively the same in both countries, and therefore the emission factors are expected to be the same. The vehicle fleet related emission factors are considered to be generally applicable in the Canadian context because both countries share a virtually identical fleet. Emission factors were developed by using detailed U.S. EPA and Energy Information Administration (EIA) data that shows energy use or vehicle miles of travel and emissions by fuel, fuel burning technology or vehicle type. In the case of the vehicle fleet, U.S. gasoline vehicle emission factors were adjusted to reflect the difference in fuel sulphur content between the United States and Ontario. Ontario has gasoline fuel sulphur levels that are approximately two times the levels in the United States. U.S. diesel vehicle emission factors were not adjusted, as the United States and Ontario have the same sulphur regulations for diesel fuel. Changes in fuel sulphur content affect emissions of sulphur oxides and particulate matter.

Emissions from the offroad fleet were calculated by using the U.S. EPA's AP-42 manual. This authoritative source was used extensively in the development of all emission factors used in this inventory and measures analysis. However, the software used to calculate and house this inventory does not contain emission factors for offroad

vehicles<sup>3</sup>, and so additional research was conducted for the Region's inventory and measures analysis. AP-42's emission factors for gasoline and diesel industrial engines were used. There are two general sets of emission factors for all offroad equipment, one for gasoline and another for diesel. These factors were converted into emission factors for offroad equipment use of coloured diesel, B20 and ULSD based on the expected differences in emissions of these fuels from No.2 diesel.

The electricity emission factors developed for the Gleneagle software are not appropriate for use in Ontario, as the mix of fuels used to generate electricity is unique to each jurisdiction and Gleneagle does not contain Ontario emission factors. As such, emission factors for grid average electricity were developed for the province of Ontario for this project. A study completed by Torrie Smith Associates for Environment Canada last spring created air pollution emission factors for electricity for each province and territory in Canada. These emission factors were created by dividing total power plant emissions of each pollutant generated in the province by total energy (in kWh) delivered to customers. However, the pollution data inventory maintained by Environment Canada was created in 1995. As such, these emission factors were considered invalid for this project, which has an inventory year of 2001. Emission factors by individual power plant fuel type were established using the Environment Canada data, then, using the mix of fuels used in the year 2000 to generate electricity in Ontario, a new air pollution inventory was created for that year. This inventory of pollutants emitted by power plants was then divided by total energy delivered to customers in 2000. This method creates a new set of emission coefficients for Ontario for the year 2000. Electric power emission coefficients could not be created for 2001 because the energy data is not yet available for that year. It was felt that, although not perfect, the year 2000 emission coefficients provided the best level of accuracy possible for this project.

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<sup>3</sup> Emissions vary depending on the engine type and emissions control technology employed, as well as the fuel's characteristics such as sulphur content.

## **Appendix E. THE TORRIE SMITH ASSOCIATES GLENEAGLE AIR EMISSIONS STRATEGY SOFTWARE**

Torrie Smith Associates was approached by the State and Territorial Air Pollution Program Administration and the Association of Local Air Pollution Control Officials (STAPPA/ALAPCO) and the International Council for Local Environmental Initiatives (ICLEI) to develop an easy-to-use software tool that can assist in the development of harmonized strategies for common pollutant and greenhouse gas reduction at the state, air quality management district and local government levels. The fundamental characteristics of the software are its user-friendly design, its calculation transparency, its decoupling of baseline emissions from measures, and its focus primarily on demand-side measures.

The software is based on the well established "Cities for Climate Protection" Greenhouse Gas Emissions software system (CCP) developed by Torrie-Smith Associates (TSA), which is currently in use by over 300 cities worldwide. Like greenhouse gases, fossil fuel combustion is also the primary source of air pollutant emissions, and this is the central design fact behind the software, which assists in the development of harmonized strategies for greenhouse gas and criteria air pollution reduction.

The software is primarily intended to account for the major greenhouse gas pollutants carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O), and the commonly defined set of air pollutants sulfur oxides (primarily SO<sub>2</sub>), nitrogen oxides (primarily NO<sub>2</sub>), particulate matter less than 10 microns in size (PM<sub>10</sub>), carbon monoxide (CO) and volatile organic compounds (VOCs). Emission factors are specified for typical fuels consumed within municipal boundaries and in the case of the measures analysis module, emission factors are also specified for specific fuel burning technologies.

The software is designed as a simple and flexible tool for (a) preparing inventories and baselines for a local government, and (b) examining the potential for emission reductions in that system through the introduction of various mitigation measures.

The software covers emissions and emission reduction measures for both a "community" module (residential, commercial, industrial, road and rail and marine transport, and waste sectors) and a "corporate" module (buildings, vehicles, streetlights, water and sewage treatment plant energy use, employee commute, business travel, and waste). Both modules include a miscellaneous ("other") sector where emissions and emission reductions for any pollutant can be included, but without any specific algorithmic support for particular sources. Emissions and emission reductions can therefore be entered in the software for virtually any air pollution source.

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