This staff report provides valuable context to the Reducing Exposure to Traffic Emissions (RETE) Project. The full RETE Report follows this staff report.

To: Regional Engineers Advisory Committee

From: Laurie Bates-Frymel, Air Quality Planner
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Date: September 24, 2013 Meeting Date: October 4, 2013

Subject: **Reducing Exposure to Traffic Emissions**

RECOMMENDATION

That the Regional Engineers Advisory Committee receive for information the report dated September 24, 2013 titled "Reducing Exposure to Traffic Emissions".

PURPOSE

To share the results of a recent consultant study regarding options for reducing resident exposure to traffic-related air pollution and to invite Regional Engineers Advisory Committee members to participate on the health impact assessment, best management practices and/or stakeholder engagement sub-committees. The Regional Engineers Advisory Committee received a previous report on the Reducing Exposure to Traffic Emissions project at its July meeting, expressed concern with certain key strategies, and requested that Metro Vancouver staff rework the table of recommended strategies based on smart growth principles and return with an amended report. This report responds to the Committee's request.

BACKGROUND

Recent local studies link proximity to higher volume traffic corridors (e.g. major roadways, truck routes, major bus routes, and bus and freight terminals) with exposure to harmful air pollutants and adverse health impacts. There are several factors that determine the level of exposure to air pollution and associated health impacts, including the amount and type of vehicle traffic, the surrounding environment and characteristics of the population being exposed. There are many ways to reduce exposure to traffic emissions, and although no one agency or level of government has been delegated the responsibility to address the issue, it has nevertheless been identified as a regional priority. For example, within the Metro Vancouver region, the *Integrated Air Quality and Greenhouse Gas Management Plan* and *Regional Growth Strategy* have established regional air quality and growth management priorities which include consideration of the health impacts associated with new communities, infrastructure and transportation services, in addition to supporting other regional objectives like smart growth.

Metro Vancouver, the BC Ministry of Environment and TransLink retained Stantec Consulting to evaluate strategies to reduce resident exposure to traffic-related air pollution within British Columbia. Titled the "Reducing Exposure to Traffic Emissions" (RETE) project, the work was guided by a multi-agency Steering Committee which included staff from Metro Vancouver; TransLink; the BC

Ministries of Environment, Transportation and Infrastructure, and Health; the Fraser Valley Regional District; Vancouver Coastal Health Authority; Fraser Health Authority; Health Canada; BC Lung Association; the Cities of Vancouver, Surrey, New Westminster, and Chilliwack; and UBC School of Population and Public Health.

DISCUSSION

The consultant assessed over 100 strategies in terms of three criteria:

1) Effectiveness at reducing exposure,
2) Feasibility (e.g., political will, practicality, cost), and
3) Potential to achieve co-benefits (e.g., promotes active transportation; supports economic development; creates sense of community and enhances/maintains livable vibrant communities; reduces greenhouse gas emissions; enhances affordability for users).

The Steering Committee provided input throughout the project and several municipal stakeholders were interviewed to help identify unintended consequences. Stantec ultimately recommended strategies for consideration by the Steering Committee that support many regional priorities like transit-oriented development and smart growth (which aim to reduce overall traffic volumes) and reduce exposure to traffic-related air pollutants. The strategies range in approach from land use, design, and transportation management, to education/outreach.

Following finalization of the consultant report, the RETE Steering Committee prioritized the consultant's recommended strategies, and decided to focus its efforts on strategies that address gaps in current work plans. Attachment 1 summarizes the consultant's recommended strategies and identifies the RETE Steering Committee's short-term priorities. As noted in this table, several strategies that the consultant recommended are already underway in Metro Vancouver. For example, options to reduce emissions from heavy-duty diesel vehicles are currently being explored by the AirCare Steering Committee Diesel Vehicle Sub-committee – a multi-agency group which includes AirCare, BC Ministry of Environment, BC Ministry of Transportation and Infrastructure, Environment Canada, Fraser Valley Regional District, ICBC, Metro Vancouver, Port Metro Vancouver and Fraser Basin Council. In addition, municipalities and TransLink are already implementing many other actions, such as increasing cycling infrastructure and transit service.

The RETE Steering Committee plans to form three sub-committees to further investigate the feasibility and possible processes for implementation of the following highest priority strategies:

1. Health Impact Assessment Sub-committee
   This sub-committee proposes to investigate health impact assessment (HIA) processes in other jurisdictions and develop a framework to aid in the development of new communities, infrastructure and transportation services by incorporating consideration of health impacts (positive and negative) into municipal and regional planning processes. The sub-committee may also explore the application of a HIA framework on one large project as a pilot. It is anticipated that an HIA framework could provide useful information for community plan development and public consultation.

   The work of this sub-committee will help to achieve Action 4.2.4(d) in the *Regional Growth Strategy* – "The role of municipalities is to… Include policies within municipal plans or strategies, that may be referenced in the Regional Context Statements, which… d) assess overall health

implications of proposed new communities, infrastructure and transportation services, including air quality and noise, with input from public health authorities" – in addition to supporting other regional objectives.

Thus far, representatives from the following agencies have volunteered to participate on the Health Impact Assessment Sub-committee:

- TransLink
- Metro Vancouver
- Vancouver Coastal Health Authority
- Fraser Health Authority
- Provincial Health Services Authority
- BC Ministry of Health
- UBC School of Population and Public Health
- BC Ministry of Environment
- BC Ministry of Transportation and Infrastructure
- Fraser Valley Regional District

2. Best Management Practices Sub-committee

Building on the BC government's *Develop with Care* guidelines and the consultant's recommended modifications, this sub-committee proposes to develop a set of best management practices that will reduce exposure to traffic-related air pollution related to new development. For example, this could include building design and operation considerations, such as orientation of ventilation system intakes away from busy roads or locations where vehicles tend to idle. In some cases, prioritization of higher traffic-related air pollution exposure areas may be necessary. These air quality-related best management practices might be one input into an HIA. This sub-committee will help to achieve:

a) Action 1.1.4 in the *Integrated Air Quality and Greenhouse Gas Management Plan* – "Metro Vancouver will… Work with municipalities, health authorities, the Provincial government, and TransLink to develop air quality-focused land use planning and urban design guidelines that will minimize resident exposure to diesel emissions and other traffic-related air pollution."
b) Action 4.2.2 in the *Regional Growth Strategy* – "The role of Metro Vancouver is to… Provide technical advice and assistance on air quality aspects of land use and infrastructure decisions."

in addition to supporting other regional objectives like smart growth.

Thus far, representatives from the following agencies have volunteered to participate in the Best Management Practices Sub-committee:

- Metro Vancouver
- TransLink
- Vancouver Coastal Health Authority
- Fraser Health Authority
- Fraser Valley Regional District
- City of Vancouver (reviewer)
- City of New Westminster (reviewer)
- City of Surrey (reviewer)

3. Stakeholder Engagement Sub-committee
   The Stakeholder Engagement sub-committee will develop an engagement strategy that a) informs planners, engineers, developers and other relevant audiences about the need for traffic-related exposure reduction measures, and b) gathers feedback on behalf of the Health Impact Assessment and Best Management Practices Sub-committees. Thus far, representatives from the following agencies have volunteered to participate in the Stakeholder Engagement Sub-committee:
   - BC Lung Association
   - Health Canada
   - Metro Vancouver
   - BC Ministry of Environment
   - BC Ministry of Health
   - Vancouver Coastal Health Authority
   - Fraser Health Authority

This Advisory Committee report has also been shared with the Lower Mainland Medical Health Officers Administrative Council, the Major Roads and Transportation Advisory Committee, the Regional Engineers Advisory Committee-Climate Protection Sub-committee, and the Regional Planning Advisory Committee.

The RETE Steering Committee welcomes additional municipal participation on the Steering Committee and three sub-committees. We also plan to share the report and next steps with Metro Vancouver's Environment and Parks Committee in November.

ALTERNATIVES
This is an information report. No alternatives are presented.

SUMMARY / CONCLUSION
The RETE Steering Committee has reviewed and prioritized a set of consultant-recommended strategies to reduce exposure to traffic-related air pollution, with the intent of augmenting existing strategies and plans for vibrant, compact communities. The Steering Committee invites members of the Regional Engineers Advisory Committee to participate in further developing strategies for health impact assessment, best management practices and/or stakeholder engagement.

Attachments and References:
Attachment 1: Stantec's Recommended Strategies and Short-term RETE Steering Committee Priorities

Attachment 1: Stantec's Recommended Strategies and Short-term RETE Steering Committee Priorities

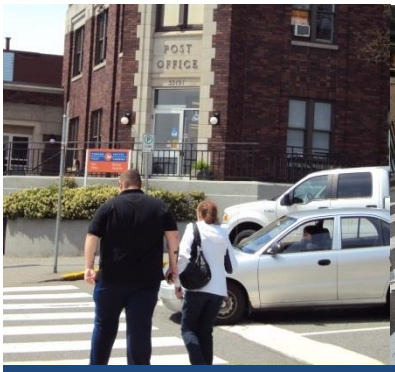
		Strategies Recommended by Consultant	RETE Steering Committee Priority in 2013-2014?	RETE Sub-committee responsible	Other agencies or groups working on this
Health Impact Assessments	1	Work with health authorities and other relevant agencies to develop a process for assessing health impacts of proposed new communities, infrastructure and transportation services, using an integrated approach that assesses the full range of health impacts, including quantification of air quality-health impacts	Yes	Health Impact Assessment Sub-committee	
Best Management Practices	2	Work with health authorities and other relevant agencies to develop best management practices that will mitigate exposure to TRAP in *identified* higher TRAP exposure areas as part of zoning and development permit processes For development / permit applications, promote best practices for indoor air quality management that reduce levels of outdoor pollutants and if municipalities have the authority, implement these practices	Yes	Best Management Practices Sub-committee	
	3	Review urban growth and infill strategies and plans to incorporate TRAP considerations			
	4	Adopt siting considerations (and designs) for medical, health, and long-term care facilities			
	5	a) Update BC Building Code to require indoor air quality management practices that reduce levels of outdoor pollutants and/or b) investigate whether municipalities/regional districts already have the authority to require indoor air quality management practices using powers granted in the Community Charter and the Local Government Act and if necessary provide municipalities with authority to require such practices *(N.B. City of Vancouver already has authority)*			

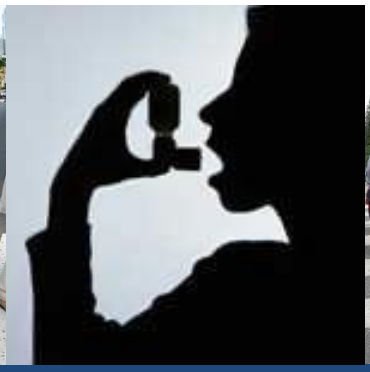
		Strategies Recommended by Consultant	RETE Steering Committee Priority in 2013-2014?	RETE Sub-committee responsible	Other agencies or groups working on this
Sustainable Transportation Strategies	6	Improve transit service quality			TransLink
	7	Locate designated pedestrian and cycling routes further away from busy roads (e.g. parallel roads, separated bike paths) wherever possible			
	8	Enhance pedestrian and cycling infrastructure			Municipalities, TransLink and Provincial government
	9	Expand ride-share programs, including vanpooling, for trips to work, school, and events			TransLink TravelSmart Business program in place
	10	Introduce or enhance commute trip reduction programs			TransLink TravelSmart Business program in place
Private Vehicle Strategies	11	Limit private vehicles near schools and daycares			
	12	Implement parking management strategies that help reduce TRAP (goal is to reduce vehicle kilometres traveled and the amount of time spent idling and driving around looking for parking)			
	13	Establish public idling restrictions and campaigns			Underway in many municipalities. BC Idling Evaluation results will be available soon
Heavy-Duty Vehicle Strategies	14	Implement or expand targeted mandated inspection and maintenance programs for cars, buses, trucks, and older vehicles			AirCare Steering Committee Diesel Vehicle Sub-committee is evaluating options

		Strategies Recommended by Consultant	RETE Steering Committee Priority in 2013-2014?	RETE Sub-committee responsible	Other agencies or groups working on this
	15	Establish Enviro-Fleets for vehicles that operate in residential neighbourhoods			TransLink Emissions Policy
	16	Encourage a truck licensing program to be implemented at ports			Port Metro Vancouver has implemented a truck licensing program
Education and Outreach Strategies	17	Develop a stakeholder engagement strategy. Possible components could include: • Educate and consult with stakeholders (municipal planners, engineers, developers, etc.) • Develop a fact sheet and / or workshop module on reducing exposure to TRAP • Educate the general public about health impacts of transportation decisions • Where feasible, educate vulnerable individuals regarding the risk of living, working and exercising in higher TRAP exposure areas • Educate the trucking community about exposure to TRAP • Encourage cyclists to choose low-traffic routes wherever possible • Encourage children and parents to walk and bike to school	Yes	Stakeholder Engagement Sub-committee	
Pricing	18	Increase fuel prices*			
	19	Implement pay-as-you-drive insurance*			
	20	Introduce vehicle registration fees based on size of vehicle or emission rate*			
	21	Implement congestion pricing on provincial and / or arterial roads*			
	22	Establish low emission zones where vehicles that do not meet certain emission standards must pay a substantial fee for each day they operate in the zone*			

		Strategies Recommended by Consultant	RETE Steering Committee Priority in 2013-2014?	RETE Sub-committee responsible	Other agencies or groups working on this
Other	23	Implement a logistics program to reduce the number of loaded and empty truck trips in higher TRAP exposure areas, or by increasing vehicle load factors*			
	24	Implement alternatives to transporting goods from ports by truck*			
	25	Develop or expand electric or zero-emission transit systems*			
	26	Use neighbourhood design guidelines to avoid or mitigate street canyon effects*			

* Stantec noted that these strategies may be difficult to implement due to cost of implementation and / or low political or technical feasibility. As a result, they were not seen as the highest near-term priorities for the RETE Steering Committee.




Reducing Exposure to Traffic Emissions Project

Final Report, March 15, 2013

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Disclaimer:

This report has been reviewed by representatives of the BC Ministry of Environment, TransLink and Metro Vancouver (the funding parties), but the interpretation of the results of this study, as expressed in the report, is entirely the responsibility of the consultant authors and does not imply endorsement of specific points of view by the funding parties. The findings and conclusions expressed in the report are the opinion of the authors of the study and may not necessarily be supported by the funding parties.

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TABLE OF CONTENTS

Table of Contents ii

Executive Summary iv

Glossary xii

1. Introduction 1

1.1. Study Purpose and Objectives 1
1.2. Study Approach 2
1.3. Target Audience and How to Use this Document 3
1.4. Organization of Report 3

2. Context 5

2.1. Traffic Related Air Pollutants (TRAP) 5
2.2. Factors that Affect TRAP Exposure and Risk 9
2.3. Integrating TRAP Exposure Reduction with Other Community Objectives 17
2.4. Exposure Levels within Lower Fraser Valley and British Columbia 19
2.5. Current Policy and Regulatory Context 25

3. Overview of Strategies Considered and Evaluation Criteria 26

3.1 Summary of Strategies Considered 26
3.2 Key Evaluation Criteria 26
3.3 Summary of Evaluation Results 27

4. Provincial and Regional Agency Strategies 31

4.1 Roles and Opportunities for Provincial and Regional Initiatives / Policies / Regulations 31
4.2 Case Studies / Lessons Learned from BC and Other Areas 43

5. Municipal Framework for Reducing TRAP Exposure 46

5.1 Is Exposure to TRAP a Municipal Issue? 46
5.2 Communities where TRAP is a Concern 46
5.3 Locate the Concern: Identifying Potential Higher TRAP Exposure Areas 48
5.4 Consider TRAP: Areas of Municipal Influence on Exposure Levels 49
5.5 Embed TRAP Considerations into Community Planning 50

6. Municipal and Local Organization Strategies 51

6.1 Opportunities for Municipalities / Local Organizations 51
6.2 Case Studies / Lessons Learned from BC and Other Areas 65

7. Recommended Engagement Strategy 74

7.1 Create a Common Language 74
7.2 Identify Key Organizations and Align with Existing Initiatives 75
7.3 Create Partnership for Air Quality Protection to Maintain Dialogue 76

8. Areas for Further Research **77**

8.1 Assessment of Higher TRAP Exposure Areas and On-going Monitoring 77

8.2 Exposure to TRAP for Susceptible Activities 77

8.3 Full Impacts of Emission and Exposure Reduction Strategies 78

9. Conclusion **79**

10. References **80**

APPENDICES **77**

Appendix A: Exposure Levels within Lower Fraser Valley and British Columbia 90

Appendix B: Current Policy and Regulatory Context 101

Appendix C: Evaluation Matrix and Results, and Evaluation Criteria Definitions 108

EXECUTIVE SUMMARY

Introduction

The Lower Fraser Valley, as well as the rest of the province of British Columbia, is known for its environmental attributes and beauty. Our air quality is relatively good compared to other places, making it an attractive and healthy place to live. However, even with this relatively good air quality, recent local studies indicate strong links between proximity to corridors that have higher volumes of traffic (e.g. major roadways, truck routes, major bus routes, and bus and freight terminals), and exposure to harmful air pollutants and adverse health impacts (Amram et al, 2011; Gan et al., 2011; Wang, 2010; Brauer et al., 2008; Thai et al., 2008; Thai, 2007; Liu et al., 2003).

To address these concerns, this report provides recommended strategies to shape the community and environment so that residents' exposure to traffic-related air pollutants (TRAP) is reduced through design and mitigation, as well as strategies to reduce overall vehicle emissions from traffic. The study recommends strategies that contribute to communities' existing strategies and plans for vibrant, compact communities, and resolve the apparent dilemma that can exist between TRAP exposure reduction and smart growth infill development objectives.

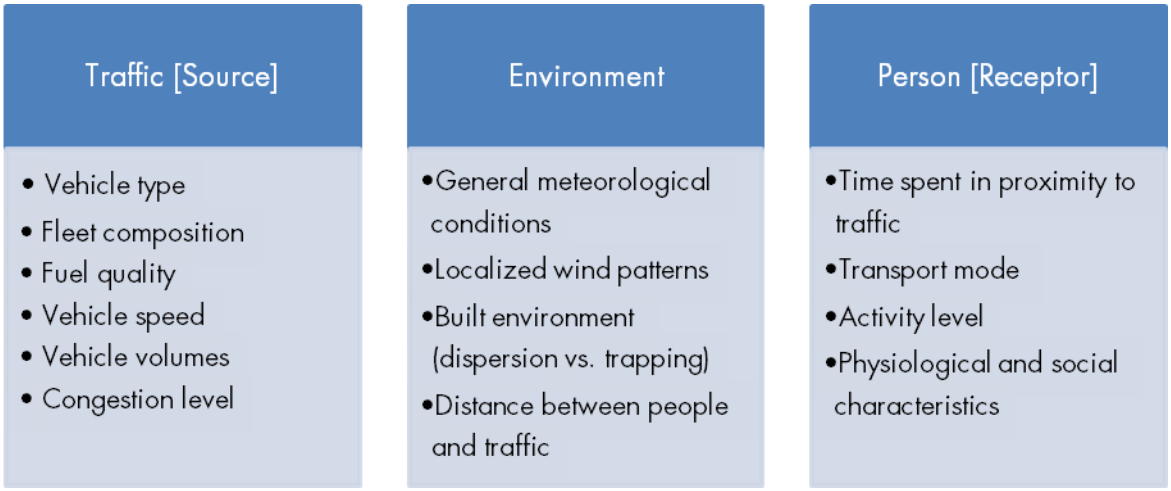
No particular agency or level of government has the sole mandate and responsibility to take on the reduction of exposure to traffic emissions. This study identifies key strategies and roles for various agencies to take action as well as areas to collaborate. The actions recommended in this study include land use, design, transportation management, and education / outreach strategies to reduce, mitigate and prevent exposure.

Context

Motor vehicles in operation release TRAP into the air from the combustion of fuel (gasoline, diesel and natural gas) and brake and tire wear. These pollutants can cause or elicit significant and adverse human health effects, including respiratory, cardiovascular, and immunological illnesses.

The extent to which a person is exposed to TRAP and the resulting health impacts an individual experiences are determined by a number of factors. These include the level and type of vehicle traffic (emission source), the overall environment, and the characteristics of the individual being exposed (receptor). These various factors are summarized in the following figure. Understanding these factors helps identify potential strategies for reducing exposure to these pollutants.

Factors that Affect Traffic-Related Air Pollution (TRAP) Exposure Risks



Overview of Strategies Considered and Evaluation Criteria

There are many possible ways to reduce TRAP. Some strategies have other significant impacts that should be considered when assessing measures to reduce TRAP exposure. For example, some emission reduction strategies also help achieve other community objectives, including reduced traffic congestion, increased mobility for non-drivers, increased public health and fitness, and many others. Conversely, some strategies face specific practical or political challenges. Thus, this study has examined a range of possible strategies and identified those that are most effective, practical, and beneficial to communities overall.

Provincial and Regional Government Strategies

One of the key recommended provincial strategies is for the provincial government to conduct a **province-wide high-level assessment** to identify potential locations with higher exposure. Regional governments can also assist municipal governments in identifying **higher TRAP exposure areas at a regional level**. The following table lists various emission reduction strategies evaluated by this study. For each strategy, the leading and supporting agencies are identified.

Recommended Provincial / Regional Strategies

		Responsibility
	Key Recommended Strategies	
	Land Use Strategies	
1	Adopt a policy to require new large-scale transportation infrastructure projects and plans involving provincial roads or the Major Road Network in Metro Vancouver to quantify air quality-health benefits and costs through Health Impact Assessments prior to approval	P and TA (for Major Road Network projects in Metro Vancouver) (Leads)
2	Adopt siting considerations (and designs) for medical, health, and long-term care facilities	HA (Lead)
	Design Strategies	
3	a) Update BC Building Code to require indoor air quality management practices that reduce levels of outdoor pollutants and/or b) investigate whether municipalities/regional districts already have the authority to require indoor air quality management practices using powers granted in the Community Charter and the Local Government Act and if necessary provide municipalities with authority to require such practices (N.B. City of Vancouver already has authority)	P (Lead)
	Transportation Management Strategies	
4	Improve transit service quality ◆	TA (Lead); P and M (Support)
5	Increase fuel prices ◆	P or F (Lead)
6	Implement or expand targeted mandated inspection and maintenance programs for cars, buses, trucks, and older vehicles	R or P (Lead)
7	Expand ride-share programs, including vanpooling, for trips to work, school, and events	TA (in Metro Vancouver) or M (Lead); involve rideshare providers too
8	Introduce or enhance commute trip reduction programs ◆	TA (in Metro Vancouver) or M (Lead)
9	Implement pay-as-you-drive insurance* ◆	P (Lead), including Insurance Corporation of British Columbia
10	Introduce vehicle registration fees based on size of vehicle or emission rate* ◆	P (Lead), including Insurance Corporation of British Columbia
11	Implement a logistics program to reduce the number of loaded and empty truck trips in higher TRAP exposure areas, or by increasing vehicle load factors* ◆	P (Lead); M and PA (Support); involve BC Trucking Association too
12	Implement alternatives to transporting goods from ports by truck* ◆	F (Lead); P and PA (Support)
13	Develop or expand electric or zero-emission transit systems* ◆	TA (Lead); F and P (Support)
14	Implement congestion pricing on provincial and / or arterial roads* ◆	P and / or TA (in Metro Vancouver) (Lead), depending on road type; M (Support)
	Education / Outreach Strategies	
15	Educate the general public about health impacts of transportation decisions	P, R, HA (Leads); M (Support)
16	Encourage cyclists to choose low-traffic routes wherever possible ◆	HA, TA (in Metro Vancouver) and M (Leads); involve bicycle user groups too
17	Develop a fact sheet and / or workshop module on reducing exposure to TRAP	P and/or R (Leads), and HA (Support); involve BC Lung Association too
18	Where feasible, educate vulnerable individuals regarding the risk of living, working and exercising in higher TRAP exposure	HA (Lead), M (Support)

	areas	
19	Educate the trucking community about exposure to TRAP	HA (Lead), R (Support); involve BC Trucking Association too

*Strategy may be difficult to implement due to cost of implementation and / or low political or technical feasibility

◆Strategy has significant co-benefits such as positive impacts to human health, economy, culture, society, and / or the environment

TA = Transportation authority
M = Municipal government
P = Provincial government
SD = School district
PA = Port authority
R = Regional government
F = Federal government
HA = Health Authority

Municipal Framework for Reducing TRAP Exposure

Although municipalities in BC do not have direct authority over the management of air quality or the levels of emissions from vehicles, municipalities do have authority over land use planning and urban design. These activities impact vehicle travel distances (complete, compact communities have shorter vehicle trips), and the location of those emissions (vehicles on highways and major roadways) are in relation to people's activities (residences and sensitive land uses). Therefore, exposure to TRAP is an issue that municipalities increasingly need to be aware of, and to consider the impacts of it in planning, policies and programs being undertaken in the community.

The key areas where municipalities can influence exposure levels to traffic emissions are:

- Land use planning (long-range and development) – e.g. aligning smart growth principles and practices with other TRAP exposure reduction strategies, as both have significant health and sustainability benefits
- Municipal road, cycling and pedestrian design and infrastructure
- Traffic management
- Parking management

Municipalities, with support from regional or provincial air quality authorities, should consider an assessment of their communities' traffic patterns relative to sensitive populations and land uses to understand the levels of TRAP exposure in their communities (see description of strategy #1 in main body of report for more resources on health impact assessments). Other strategies that should be considered by municipalities and local organizations are described below.

Municipal and Local Organization Strategies

The key recommended strategies that are within the authority of municipalities and local organizations are listed in the following table.

Recommended Municipal / Local Strategies

		Responsibility
	Key Recommended Strategies	
	Land Use Strategies	
1	Work with health authorities and other relevant agencies to develop a process for assessing health impacts of proposed new communities, infrastructure and transportation services, using an integrated approach that assesses the full range of health impacts, including quantification of air quality-health impacts	M and TA (for Major Road Network projects in Metro Vancouver) (Leads), HA, P and R (Support)
2	Work with health authorities and other relevant agencies to develop best management practices that will mitigate exposure to TRAP in *identified* higher TRAP exposure areas as part of zoning and development permit processes	M (Lead), HA and SD (Support)
3	Review urban growth and infill strategies and plans to incorporate TRAP considerations ◆	M (Lead)
4	Use neighbourhood design guidelines to avoid or mitigate street canyon effects*	M (Lead)
	Design Strategies	
5	Locate designated pedestrian and cycling routes further away from busy roads (e.g. parallel roads, separated bike paths) wherever possible ◆	M (Lead)
6	For development / permit applications, promote best practices for indoor air quality management that reduce levels of outdoor pollutants and if municipalities have the authority, implement these practices	M (Lead)
	Transportation Management Strategies	
7	Enhance pedestrian and cycling infrastructure ◆	M (Lead); TA (in Metro Vancouver) (Support)
8	Expand ride-share programs, including vanpooling, for trips to work, school, and events	M or TA (in Metro Vancouver) (Lead); involve rideshare providers too
9	Introduce or enhance commute trip reduction programs ◆	M or TA (in Metro Vancouver) (Lead)
10	Limit private vehicles near schools and daycares ◆	M (Lead); SD (Support)
11	Implement parking management strategies that help reduce TRAP (goal is to reduce vehicle kilometres traveled and the amount of time spent idling and driving around looking for parking) ◆	M (Lead); R (Support)
12	Establish public idling restrictions and campaigns	M (Lead); R (Support)
13	Establish Enviro-Fleets for vehicles that operate in residential neighbourhoods	M (Lead)
14	Encourage a truck licensing program to be implemented at ports (Port Metro Vancouver has already implemented a truck licensing program)	M (to encourage PA to implement the program) (Lead); PA to implement program
15	Establish low emission zones where vehicles that do not meet certain emission standards must pay a substantial fee for each day they operate in the zone*	M (Lead); R and P (Support)
	Education / Outreach Strategies	
16	Encourage children and parents to walk and bike to school ◆	SD (Lead); M, TA (in Metro Vancouver), and HA (Support); involve other non-government organizations such as HASTeBC too
17	Encourage cyclists to choose low-traffic routes wherever possible ◆	M, HA, and TA (in Metro Vancouver) (Leads); involve bicycle user groups too

*Strategy may be difficult to implement due to cost of implementation and / or low political or technical feasibility

◆Strategy has significant co-benefits such as positive impacts to human health, economy, culture, society, and / or the environment

TA = Transportation authority
PA = Port authority
M = Municipal government
R = Regional government
P = Provincial government
F = Federal government
SD = School district
HA = Health Authority

Recommended Engagement Strategy

Many opportunities identified in this report do not fall within one organization's authority or realm of influence, but rather across organizational and jurisdictional boundaries. Therefore, undertaking a comprehensive strategy for minimizing current and potential future exposure levels will involve identifying and engaging a cross-section of organizations, and people within the organizations, to:

- Create a common language for communicating about TRAP;
- Engage other organizations, including non-government organizations and private sector;
- Raise awareness about the impact of each organization's initiatives on exposure to TRAP;
- Align with related initiatives and objectives; and
- Create a multi-agency partnership for air quality protection to maintain ongoing dialogue, enable local governments to share their knowledge, experiences, challenges, and solutions to reducing exposure to TRAP, and share information about new research.

Conclusion

Exposure to motor vehicle pollution poses human health risks. This study identified and evaluated numerous potential transportation air pollution exposure reduction strategies. Some of these strategies reduce total transportation emissions. Others reduce the total number of people exposed to emissions or exposure by vulnerable populations, and some address activities that increase individuals' respiration rates or duration of exposure in higher TRAP exposure areas. These strategies were evaluated according to various criteria, including their effectiveness, feasibility and co-benefits.

This analysis identified more than two dozen transportation emission exposure reduction strategies that are considered both effective and feasible for implementation, and so are recommended for implementation. Although there are still issues of uncertainty, and so deserve further research, there is sufficient confidence about these results to justify action on many of these strategies in the near term. Many of the recommended strategies provide significant co-benefits, including more efficient transportation or additional health benefits.

While there is an apparent dilemma between some of these strategies and other strategic planning objectives such as smart growth development (e.g. measures that limit proximity of development near major roads or highways may seem inconsistent with smart growth infill development measures), TRAP implications are not a reason to change the overall direction toward more compact communities. This report recommends fine-tuning land use and infrastructure plans, building designs, and transportation management strategies to reduce exposure to TRAP. Policies that reduce exposure to TRAP in the context of smart growth include: locating pedestrian and cycling routes further away from highways; shifting from diesel to electric transit, truck, and private vehicles on busy roads; increasing greenspace; and designing building ventilation systems with air intakes positioned away from highways and locations where vehicles idle.

The analysis identified the levels of government, agencies or organizations most able to implement these strategies. This can help governments and organizations identify the specific actions they can take to reduce exposure to TRAP and overall vehicle-related emissions. Many of these strategies are best implemented through cooperative efforts involving various jurisdictions, agencies and organizations.

As a next step, it is recommended that a "Toolbox" of factsheets be created and that they be tailored to different audiences. As well, efforts could be made to establish a regional or provincial partnership for air quality protection to enable participating governments and agencies to share their knowledge, experiences, challenges, and solutions to reducing exposure to TRAP.

GLOSSARY

AADT	Annual average daily traffic
Busy / Major Road	A road with greater than 15,000 vehicles per day based on annual average traffic counts, has two or more lanes spanning several kilometres, and speed limits above 50 km/hr (Brauer et al., 2012, p. 32).
CO	Carbon monoxide
Distribution centre	A distribution centre that accommodates more than 100 trucks per day, more than 40 trucks with operating truck refrigeration units per day, or where truck refrigeration unit operations exceed 300 hours per week.
DMTI	Canadian road network classification system developed by DMTI Spatial, Inc.
FVRD	Fraser Valley Regional District
HIA	Health impact assessment, which is a set of "procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population" (WHO, 1999).
Highway	Includes principal and secondary highways. In British Columbia, there are no vehicle volume thresholds for highways.
MV	Metro Vancouver
NOx	Nitrogen oxides
NO	Nitric oxide
NO_2	Nitrogen dioxide
N_2O	Nitrous oxide
O_3	Ozone
PM	Particulate matter
$PM_{0.1}$	Particular matter with an aerodynamic diameter of less than 0.1

	microns. They are also known as ultrafine particulates.
PM_1	Particulate matter with an aerodynamic diameter of less than 1 micron. These are also known as very fine particulates.
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of less than 2.5 microns. These are also known as respirable particulates that can penetrate into the lower respiratory tract (lungs).
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 microns. These are also known as inhalable particulates that can be inhaled through the nose or mouth.
Sensitive land uses	Land uses such as: schools; daycare facilities; health care facilities (hospitals, hospices, long-term care facilities, adult group homes, senior residences); and low-income neighbourhoods or housing developments
Susceptible activities	Certain activities have been identified that may lead to increased exposure due to spending significant amounts of time in traffic (e.g., occupations such as taxi and bus drivers, or transit users on major traffic corridors), or due to increased respiration rates while in close proximity to traffic (e.g. walking and cycling)
SOx	Sulphur oxides
TRAP	Traffic-related air pollution
VKT	Vehicle kilometres traveled
VOC	Volatile organic compound
Vulnerable individuals	Include pregnant mothers and their fetuses, children, elderly, low-income individuals, and people with respiratory and cardiovascular conditions.

1. INTRODUCTION

1.1. STUDY PURPOSE AND OBJECTIVES

The Lower Fraser Valley (LFV) airshed, which is comprised of Metro Vancouver, the Fraser Valley Regional District (FVRD), and Whatcom County in the United States, (see Figure 1) typically experiences relatively good ambient air quality compared to other urban areas. On-going programs and policies are needed to maintain and continue to improve the air quality over time as population and development continue to grow in the region. However, even with this overall good air quality, recent local studies indicate strong links between proximity to higher traffic corridors (e.g. major roadways including truck routes, bus and freight terminals, and major bus routes), exposure to harmful air pollutants and adverse health impacts.

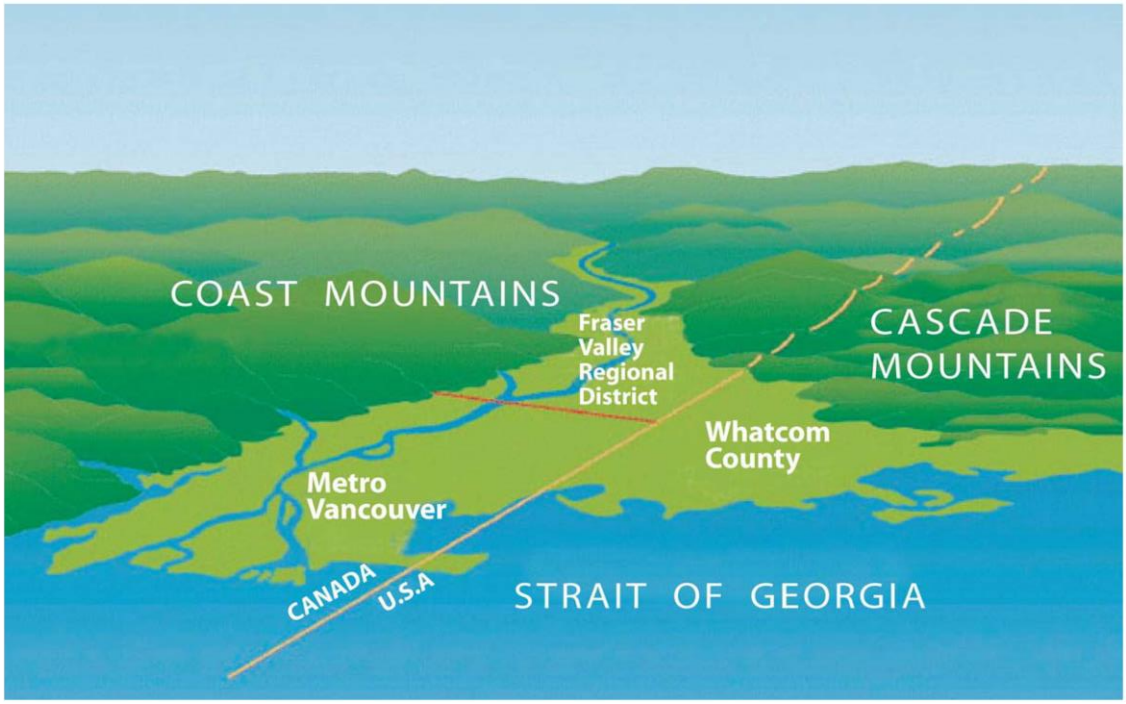


Figure 1: Lower Fraser Valley Airshed

Source: Metro Vancouver (2007).

Metro Vancouver and the Fraser Valley Regional District (FVRD) have taken proactive approaches to managing air quality through ongoing air quality monitoring, modeling and the development of several air quality management plans over the last two decades. These efforts indicate that pollutants from **on-road transportation sources are significant contributors to local air quality contaminants**. Metro Vancouver estimated that in 2010, 22% of smog-forming pollutants resulted from cars and trucks and that on-road vehicles were the largest group of contributors (other contributors included solvents, non-road equipment, and marine vessel) (Metro Vancouver,

2011). As such, in Metro Vancouver's *Integrated Air Quality and Greenhouse Gas Management Plan* (*IAQGGMP*), one of the identified actions is to:

> "Work with municipalities, health authorities, the Provincial government, and TransLink to develop air quality-focused land use planning and urban design guidelines that will minimize resident exposure to diesel emissions and other traffic-related air pollution" (Action 1.1.4).

This study, which has been initiated in part by Action 1.1.4 of the *IAQGGMP,* identifies strategies for mitigating exposure to traffic-related air pollutants (TRAP) in British Columbia, with significant focus on the Lower Fraser Valley. The study considers strategies that have the potential for reducing:

- Exposure of **vulnerable populations** (including pregnant mothers and their fetuses, children, elderly, low-income individuals, and people with respiratory and cardiovascular conditions) to traffic emissions;
- Exposure of people in residences, hospitals, schools, or other sensitive land uses in **higher TRAP exposure areas**;
- Exposure during **susceptible activities**, - people undertaking certain activities that may lead to increased exposure (e.g. spending a lot of time in traffic, walking, cycling, using transit, or driving along major traffic corridors); and
- **Overall traffic-related emissions.**

1.2. STUDY APPROACH

Stantec Consulting teamed with Pinna Sustainability, Heather Evans Consulting, and the Victoria Transport Policy Institute to conduct this review. The consulting team worked closely with Metro Vancouver, TransLink, the British Columbia (BC) Ministry of Environment, as well as a larger Steering Committee to identify exposure reduction strategies. The Steering Committee includes: Metro Vancouver, TransLink, the British Columbia (BC) Ministry of Environment, the BC Ministries Transportation and Infrastructure, and Health; the Fraser Valley Regional District; Vancouver Coastal Health Authority; Fraser Health Authority; Health Canada; BC Lung Association; the Cities of Vancouver, Surrey, and New Westminster; and the University of British Columbia (UBC) School of Population and Public Health. Although the Steering Committee provided input, the findings and conclusions expressed in the report are the opinion of the consulting team.

The following steps were taken in this study:

- Conduct a review of existing literature and data on best practices to reduce resident exposure to traffic-related air pollutants (for the purposes of this study, most of the literature reviewed was secondary research);

- Compile an initial list of exposure reduction strategies and revise strategies based on feedback from the Steering Committee;
- Evaluate the strategies using a multi-criteria assessment approach to determine the effectiveness and practicality of each strategy, as well as the co-benefits and trade-offs;
- Based on the evaluation results, identify key recommended strategies, as well as additional strategies to consider;
- Identify strategies that are appropriate for three different land use typologies – urban centres, suburban / general urban areas, and rural areas;
- Further investigate three case study areas – the Broadway corridor in the City of Vancouver, areas within the City of Surrey's municipal boundaries but are outside urban centres, and the City of Kelowna. The objective of these case studies was to determine their current practices to reduce exposure to traffic-related air pollutants in municipalities and to gather feedback on the short-listed strategies (the feedback and information they provided has been integrated throughout the report); and
- Develop a guiding framework and identify strategies for provincial, regional, and local agencies within the Lower Fraser Valley and British Columbia to reduce residents' exposure to traffic-related air pollutants.

1.3. TARGET AUDIENCE AND HOW TO USE THIS DOCUMENT

The target audience for this report is organizations within British Columbia that implement programs or policies that directly or indirectly influence people's exposure levels to traffic-related air pollutants. These organizations include federal, provincial, regional (including regional governments and transportation authorities), and municipal government agencies and other local organizations (e.g. school districts).

The chapters of this report are designed such that the different types of readers listed above can easily extract sections of information that are of most relevance to them.

1.4. ORGANIZATION OF REPORT

The subsequent chapters of this report are organized as follows:

- **Chapter 2** provides the context to this study, explaining what traffic-related air pollutants (TRAP) are and what health impacts they have, factors that affect exposure to TRAP, and how TRAP exposure reduction is linked to other community objectives. The chapter also provides a summary of current exposure levels with the Lower Fraser Valley and BC, and the current policy and regulatory framework.
- **Chapter 3** describes the strategies that have been considered, the evaluation criteria used in the multi-criteria assessment, and a summary of the evaluation results.

- **Chapter 4** identifies opportunities where provincial and regional agencies can help implement measures to reduce exposure to TRAP, including providing support to local governments in their TRAP exposure-reduction initiatives.
- **Chapter 5** describes why air quality is also a local government issue, and the role that local governments have in reducing exposure to TRAP.
- **Chapter 6** presents strategies that municipal governments and local organizations can implement to reduce exposure to TRAP. Strategies that are most appropriate for different land use typologies are identified, and case studies, lessons learned, and relevant resources are included.
- **Chapter 7** describes a recommended strategy to engage local governments and other partners that also have a role in reducing exposure to TRAP to work together collaboratively.
- **Chapter 8** identifies areas for further research, and finally **Chapter 9** concludes the report.
- A series of **Appendices** provide more detailed information on: the evaluation results of the strategies; exposure levels within the Lower Fraser Valley and BC; and the current policy and regulatory framework. The complete list of strategies that are within the purview of municipalities and local organizations is also provided in the appendices.

2. CONTEXT

2.1. TRAFFIC RELATED AIR POLLUTANTS (TRAP)

The purpose of this section is to provide a general description of TRAP, and summary information about the health impacts of exposure. The information is based on comprehensive studies and evidence reviews. The focus is on urban settings.

2.1.1 What Are Traffic-Related Air Pollutants (TRAP)?

When vehicles are in operation, traffic-related air pollutants are released into the air due to the combustion of fuel (gasoline, diesel and natural gas) and brake and tire wear. These pollutants can cause or elicit significant and adverse human health effects (Brauer et al., 2012). The impact of TRAP on human health warrants consideration of strategies to reduce population exposure to TRAP in urban and transportation planning. People who live, work, or play close to busy and major roads (roads with an average daily traffic volume of 15,000 or more) are exposed to higher concentrations of traffic-related air pollution.[1]

Traffic emissions include compounds in both particle and gas phases (Health Effects Institute, 2010). Primary pollutants are formed directly from combustion and have a local impact close to the source; examples are nitric oxide (NO) and black carbon (Brauer et al., 2012). Secondary transport-related pollutants such as nitrogen dioxide (NO_2) and ozone (O_3) are formed in the atmosphere through chemical and physical conversions of gaseous precursors (Brauer et al., 2012). Exposure to these secondary pollutants may occur at greater distances from roadways with complicated geographical and temporal climate patterns, owing to the constant interaction between various emissions in the atmosphere (World Health Organization, 2005).

Table 1 (below) lists some of the main traffic-related air pollutants linked to harmful human health effects, along with a description of each pollutant, how they are formed, and the spatial extent of each pollutant.

[1] In this report, the definition of a major or busy road is the same as that used in the BC Ministry of Environment's *Develop with Care 2012* guidelines.

Table 1: Traffic-Related Air Pollutants with Direct Human Health Impacts

N.B. Words in *italics* are explained in the text below the table.

Emission	Description	Vehicle-related Sources	Geographic Scale
Carbon monoxide (CO)	A toxic gas caused by incomplete combustion.	Tailpipes.	*Very local*
Coarse particulate matter ($PM_{2.5}$ to PM_{10})	*Inhalable* particles.	Brake lining, tire wear, road dust, etc.	*Local*
Fine particulate matter ($PM_{2.5}$)	*Respirable* particles.	Tailpipes, brake lining, road dust, etc.	*Local and Regional*
Ultrafine particulate matter ($PM_{0.1}$)	Particles smaller than 0.1µm in diameter.	Tailpipes.	*Very Local*
Diesel particulate matter	Fine and ultrafine particulate emitted during diesel combustion.	Tailpipes.	*Local and Regional*
Nitrogen oxides (NOx)	Various compounds, some are toxic, all contribute to the formation of ground-level ozone.	Tailpipes.	*Local and Regional*
Ground-level ozone (O_3)	Major urban air pollutant caused by NOx and VOCs combined in sunlight.	NOx and VOCs.	*Regional*
Sulfur oxides (SOx)	Lung irritant and component of acid rain.	Diesel vehicle tailpipes and fuel refining.	*Local and Regional*
VOC (volatile organic hydrocarbons)	Various hydrocarbon (HC) gasses.	Fuel production, storage, tailpipes. (*)	*Local and Regional*
Toxics (e.g. benzene, 1,3-butadiene, formaldehyde, polycyclic aromatic hydrocarbons)	Toxic or carcinogenic VOCs.	Fuel production and tailpipes. (*)	*Very local*

Adapted from USEPA (2000) and ORNL (June 25, 2011) in VTPI (2012d)

Notes and Explanation of terms in Table 1

Inhalable - means that the pollutant can be inhaled through the nose and mouth.

Respirable - means that the pollutant can penetrate into the lower respiratory tract (lungs).

Very Local and Local (geographic scale) – means on roads and directly adjacent to roads that are busy with vehicle traffic. In general terms, a Very Local scale could refer to 0 to 100 m, and a Local scale could be up to 500 m. Human exposure to primary pollutants occurs close to the source of emission, at a very local and local geographic scale.

Regional (geographic scale) – means some distance away from the source of emission. The scale tends to relate to an airshed, e.g. the Lower Fraser Valley Airshed. Human exposure to secondary pollutants occurs at a distance from the source of emission. Concentration of the pollutants and exposure at a regional scale can be complicated by the geographic and temporal patterns, meteorology, topography, atmospheric conditions, etc.

(*) Gasoline evaporative emissions are also released through the non-tailpipe parts (e.g. tubing) of vehicles as hot soak emissions[2] and in sitting vehicles, particularly in warm months.

Specific types of TRAP contaminants are associated with particular health impacts. For example, inhalable particulate matter aggravates respiratory and cardiovascular diseases, reduces lung function, increases respiratory symptoms, and can lead to premature death. There is also growing evidence that short term exposure, not just chronic long term, affects heart attack rate (Mustafic et al., 2012). Black carbon health impacts are closely linked with diesel and linked with cancer risk (Health Effects Institute, 2010).[3] Further and more specific associations between pollutants and health impacts are not listed here, but can be found in many of the referenced reports.

A number of key pollutants (e.g. CO, NO, NO_2, particulate matter, and black carbon) can be used to represent exposure to TRAP to gain an understanding of TRAP conditions in a particular location. These 'pollutant species' are measured on an ongoing basis at monitoring sites in many urban areas. For example, the Lower Fraser Valley Air Quality Monitoring Network measures these pollutants on a continual basis and compares them to Metro Vancouver's ambient air quality objectives – see Table 2 (Metro Vancouver, 2012). However, the thresholds included in these objectives may not provide adequate health protection, as health impacts can still be experienced below these levels (e.g. $PM_{2.5}$ is a non-threshold pollutant), particularly for vulnerable populations.

Table 2: Metro Vancouver Ambient Air Quality Objectives

Air Contaminant	Averaging Time	Ambient Air Quality Objectives	
		µg/m3	parts per billion
Carbon monoxide (CO)	1-hour	30,000	26,500
	8-hour	10,000	8,800
Nitrogen dioxide (NO_2)	1-hour	200	107
	Annual	40	22
Sulphur dioxide (SO_2)	1-hour	450	174
	24-hour	125	48
	Annual	30	12
Ozone (O_3)	1-hour	160	82
	8-hour	126	65
Inhalable particulate matter (PM_{10})	24-hour	50	-
	Annual	20	-
Respirable particulate	24-hour	25	-

[2] Hot soak emissions occur when a warmed up vehicle is turned off. The engine remains hot for a period of time, and gasoline evaporation continues when the vehicle is parked while cooling down.

[3] Additional information about health impacts of particular air pollutants and contaminants is available in the Health Impact Institute's report, Traffic-related air pollution: A critical review of the literature on emissions, exposure, and health effects. Final Version of Special Report No. 17. http://pubs.healtheffects.org/view.php?id=334.

matter ($PM_{2.5}$)	Annual	8 (6)*	-

* The annual $PM_{2.5}$ objective of 8µg/m^3 and the planning goal is 6 µg/m^3

Furthermore, to do an exposure assessment, more detailed measurements and models are needed. For example, land use regression models are a way to estimate TRAP in epidemiological studies and to inform local transportation plans and air quality plans (Brauer et al., 2012). A significant amount of this work has been done within Metro Vancouver, but more research is required to understand local exposure levels within the rest of British Columbia.

2.1.2 Adverse Health Effects of Exposure to TRAP

In Canada 10 million people (32% of the population) live within 100 m of a major road or 500 m of a highway, and in BC the proportion is slightly higher (37% of the population). Residential location is considered a reasonable proxy for exposure assessment and this data tends to be the most available and analyzed (Brauer et al., 2012). In addition, school and work locations are important determinants of exposure to TRAP (Brauer et al., 2012). Some sub-populations are at increased risk such as people with long commutes in traffic and people exercising or engaging in active transport (e.g. cycling) in proximity to TRAP (Brauer et al., 2012).

Relatively few studies address the duration of exposure that is relevant to health impacts. Some evidence suggests that the period of exposure to TRAP need not be very long to impact health. For example, asthma responses can occur with TRAP exposure of one hour or less. The Canadian Medical Association estimated that in 2008, as many as 21,000 Canadians died as a result of air pollution (including but not limited to TRAP), which is relatively high (e.g. in comparison, the number of road user fatalities in Canada in 2009 was about 2,200, Transport Canada). Of these, roughly 18,000 were the result of chronic exposure over a number of years, and almost 3,000 were the result of acute, short-term exposure (Canadian Medical Association, 2008). The majority of these premature deaths are suffered by the elderly. As Canada's aging population increases, the number of premature deaths from air pollution is expected to increase significantly as well.

The Health Effects Institute (HEI)[4] (2010) commissioned an international panel to critically review the body of existing evidence and literature on health effects of exposure to TRAP. The HEI summarized and synthesized information on TRAP and health effects, and used a series of criteria from the US Surgeon General to assess the health evidence and health outcomes. HEI assessed that exposure to TRAP is likely to be a **public health concern deserving of public attention** (emphasis added). A subsequent Canadian study (Brauer et al., 2012) updated HEI's findings and highlighted Canadian studies, and specifically concluded that there is a relatively strong association between TRAP and the human health conditions listed below:

[4] The Health Effects Institute (HEI) is a non-profit Boston-based corporation which was chartered in 1980 as an independent research organization to provide high-quality, impartial, and relevant science on the health effects of air pollution. HEI typically receives half of its core funds from the US Environmental Protection Agency and half from the worldwide motor vehicle industry. See www.healtheffects.org/about.htm

- Exacerbation of asthma: causal association
- Onset of childhood asthma: suggestive evidence of causal association
- Non-asthmatic respiratory symptoms: suggestive evidence of causal association
- Impaired lung function: suggestive evidence of causal association
- Total and cardiovascular mortality (death): suggestive evidence of causal association (after long-term exposure)
- Cardiovascular morbidity (diseased condition or state): suggestive evidence of causal association

Exposure to TRAP is linked with adverse health effects including:

- onset and exacerbation of asthma
- respiratory problems
- impaired lung functioning
- cardiovascular problems
- some cancers
- adverse pregnancy outcomes
- increased heart attack rates
- exacerbation of immunological illnesses

The phrase "suggestive evidence of causal association" means that consistent evidence in published studies links traffic exposure (measured) as a reason for disease risk. Please see the Health Effects institute for a more technical definition.[5]

In addition to the conditions listed above, Brauer et al. (2012) link TRAP with adverse pregnancy outcomes (such as pre-term birth, low birth weights, and other negative impacts) and lung cancer. Based on a smaller number of studies, association is also drawn between TRAP and other health outcomes, including diabetes and cognition (Brauer et al., 2012). In addition, as immune systems are affected by air pollution (air pollution leads to more inflammatory reactions), those with immunological conditions can experience higher levels of health issues, including acute health problems (Ritz, 2010).

2.2. FACTORS THAT AFFECT TRAP EXPOSURE AND RISK

To develop strategies that are effective in reducing exposure to TRAP, it is important to understand the relevant factors that affect TRAP exposure and risk. These variables include: types of pollutants present; distance to the emission source; the quantity and volume of emissions (which is impacted by traffic volume, vehicle type, vehicle operation, etc.); and local conditions such as climate. Equally important is to target strategies that address the human and social dimension of reducing exposure and risk of TRAP: who are the sensitive sub-populations and where are the most pressing vulnerabilities to TRAP that need to be prioritized and addressed? These factors and dimensions are outlined below.

[5] The Health Effects Institute (2010, page xi) describes "sufficient evidence to infer the presence of a causal association" as follows: "The evidence was deemed sufficient to conclude that an association observed between a metric of traffic exposure and a disease (or a biomarker of disease) risk was causal in studies where chance, bias, and confounding could be ruled out with reasonable confidence, and the effect estimates were consistent in magnitude and direction." A Canadian study updates on the Health Effects Institute conclusions about strength of causality as well (Brauer et al., 2012, page 29).

2.2.1 Types of Pollutants

As explained earlier, the key marker pollutants of TRAP are CO, NOx, particulate matter, and black carbon. Primary pollutants such as CO, NO, particulate matter, and black carbon are formed directly from the combustion of fossil fuels, brake and tire wear and road dust, while secondary pollutants such as NO_2 are formed in the atmosphere through chemical and physical conversions of primary pollutants.

Emissions from diesel vehicles are of particular concern.

Diesel vehicles (heavy-duty trucks and conventional buses) are considered the most critical source of TRAP; diesel-exhaust particles are the most harmful vehicle related pollutant and a harmful human carcinogen (BC Ministry of Environment, 2012, p. 1). Although diesel engines are more fuel-efficient than fuel-spark engines, they emit far more particulate matter per vehicle or per litre of fuel burned. Particulate matter (PM) emissions from heavy-duty diesel vehicles are 10 times more than from light-duty gasoline vehicles (Dallmann and Harley in Brauer et al., 2012). In the longer term, reduced emissions are expected with particle traps, lower sulphur fuel, vehicle replacement and use of alternative propulsion systems such as electric and hybrid electric vehicles (BC Ministry of Environment, 2012). In the short term, however, TRAP reduction strategies must pay attention to the proportion of heavy-duty vehicles in traffic on a given roadway, and emission reduction strategies should consider both diesel and gasoline vehicles (Brauer et al., 2012). A heavy-duty diesel vehicle remote sensing study is underway in Metro Vancouver as of July 2012 to better understand the emissions from these vehicles and design programs and policies to target and reduce them (BC Lung Association, 2012).

2.2.2 Proximity to Motor Vehicle Traffic

"Canadian cities have relatively good ambient air quality, but health effects of TRAP are similar to other international urban settings" (BC Ministry of Environment, 2012).

What is a Higher TRAP Exposure Area? A panel coordinated by the Health Effects Institute (2010) reviewed a vast array of gradient studies (i.e., studies that examine pollutant concentrations as a function of distance from roadways). The results of these individual studies indicate that TRAP exposure is typically higher within a range of 50 to 1,500 m from roads, depending on traffic volume, vehicle types, congestion levels, etc. When the results of multiple studies are combined and compared, the findings suggest that TRAP exposure is typically higher within "a range of up to 300 to 500 m from *highways and major roads* depending on background pollutant concentrations and meteorological factors" (Health Effects Institute, 2010).

Figure 2 shows estimated traffic pollutant gradients (i.e., change in pollutant concentration compared to edge of road

37% of BC population lives within 100m of major road or 500m of highway.

concentrations) based on a 2010 study of several monitoring studies that each had different conditions (road type, topography etc.) (Karner et al., 2010 in Brauer et al., 2012). Gradients range from 100 m to 500 m from the edge of the road. Overall, carbon monoxide (CO) had the smallest spatial gradient as its levels dropped off dramatically within the first 200 m of the edge of the road. Secondary volatile organic compounds (VOCs), $PM_{2.5}$ and PM_{10} had the largest spatial gradient, as their levels dropped off the least or more gradually with distance from the edge of the road.

Based on this research, the BC Ministry of Environment's *Develop with Care 2012* guidelines recommend that special consideration should be given to buildings, especially sensitive land uses, within 150 m of busy roads, as well as buildings along truck routes (elevated levels of TRAP can be detected as far as 750 m of truck routes, Henderson and Brauer, 2005). The California Air Resources Board's *Air Quality and Land Use Handbook* (2005) also states that that siting of new sensitive land uses should be avoided within 300 m from distribution centres (that accommodate more than 100 trucks per day, more than 40 trucks with operating truck refrigeration units per day, or where truck refrigeration unit operations exceed 300 hours per week).

Defining "higher TRAP exposure areas" in the local context will involve gathering local population and traffic data, and may involve air dispersion modelling and risk assessment expertise.

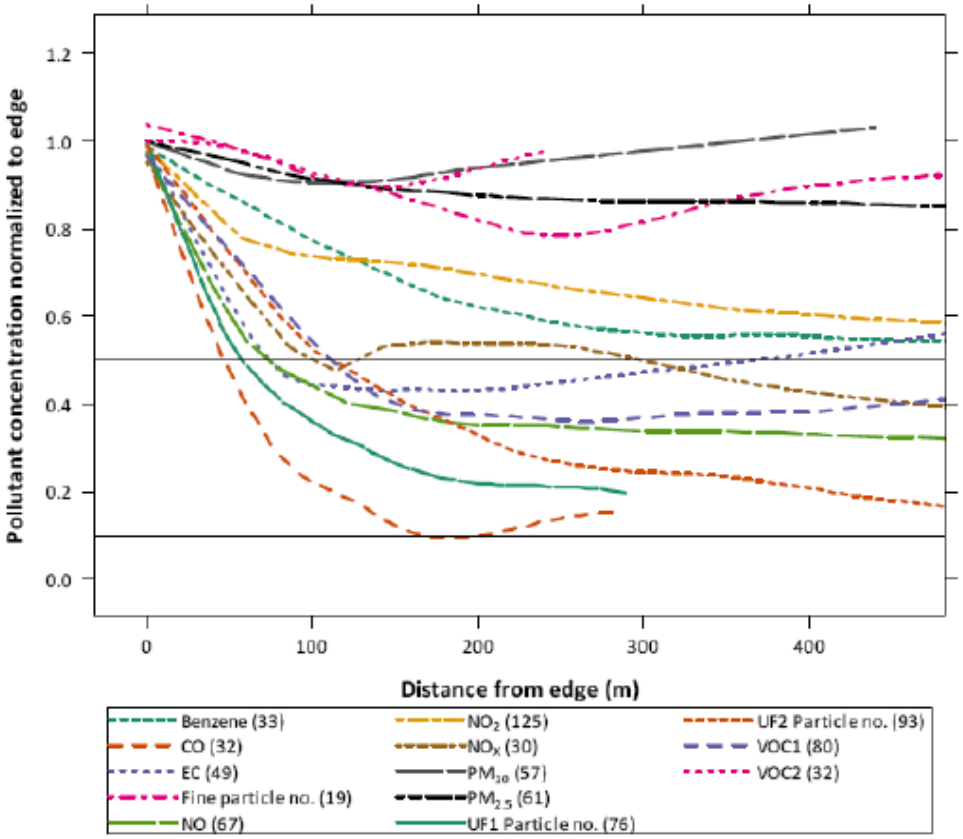


Figure 2: Pollution Exposure Gradient

Source: Karner et al., 2010 in Brauer et al., 2012.

The black lines show a reduction from edge of road concentration of 50% (at 0.5) and 90% (at 0.1). The number of published measurements (n) used to estimate the curve is in parentheses after each pollutant.

CO = carbon monoxide, EC = elemental carbon, NO = nitrogen oxide, NO_2 = nitrogen dioxide, NOx = NO+NO_2, PM_{10} = inhalable particulate matter (<10 µm), $PM_{2.5}$ = respirable particulate matter (<2.5 µm), UF = ultrafine particulate matter (<0.1 µm), VOC = volatile organic compounds

2.2.3 Volume of Pollutant Emissions

Two of the key variables that impact volume of emissions are traffic volume (i.e., number of vehicles on a roadway) and type (i.e., the proportion of light-duty to heavy-duty vehicles in the traffic mix) (Brauer et al., 2012). Hence roads with average daily volumes of 15,000 or more, as well as truck routes, major bus routes, and freight and bus terminals, are considered to have important TRAP influence.

Another key factor is vehicle operation. Idling vehicles emit high levels of pollution concentrations.[6] In a school setting, a study detected elevated concentrations of black carbon and (lesser extent) $PM_{2.5}$, when diesel school buses idle (Richmond-Bryant et al., 2009; Richmond-Bryant et al., 2011). These pollutants are particularly hazardous to children's lungs and health.

Emissions also generally increase with vehicle speeds above 60 to 80 km/h (BC Ministry of Environment, 2012) and with stop-and-go traffic (Brauer et al., 2012). Figure 3 below shows a sample speed-emission curve, illustrating how typical vehicle emissions are affected by speed. VOC and carbon monoxide levels are generally lowest at about 60 mph (97 km/hr), while NOx levels are lowest at about 30 mph (48 km/hr). Vehicle speeds above or below these thresholds lead to higher emission levels. Interventions tend to be more successful when strategies address both speed and traffic dynamics (Brauer et al., 2012). More information on this can be found in Chapters 4 and 6.

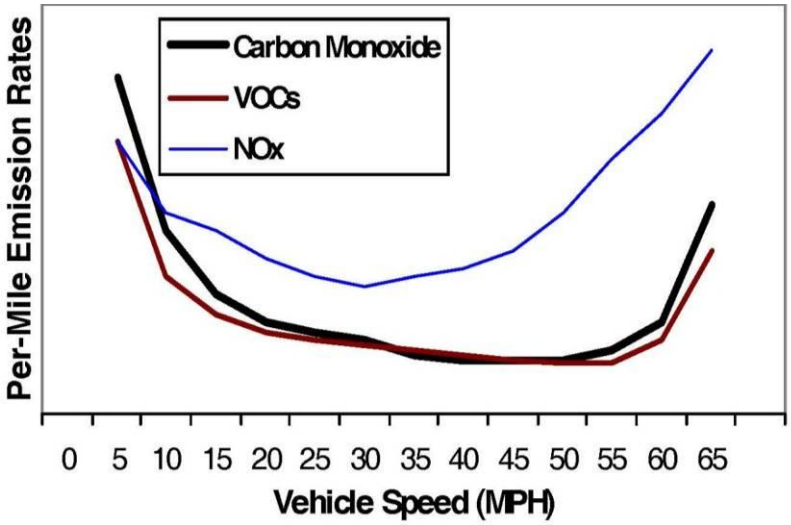


Figure 3: Sample of Speed-Emission Curve

Source: Transportation Research Board, 2005 in Victoria Transportation Policy Institute (2012).

2.2.4 Micro-Climate

Meteorological conditions, i.e. wind speed and direction, affect the transport and dispersion of pollutants (BC Ministry of Health, 2012; Brauer et al., 2012). These conditions can affect people's exposure when they are near vehicle emissions on roadways, e.g. walking, waiting for the bus, cycling, etc. Risks are greatest in areas located downwind of emission sources. Regionally relevant information about meteorological conditions is shared in the next section.

[6] In studies about pollution from vehicle emissions during idling there are technical considerations and qualifiers to be considered such as type and age of vehicle, whether idling is occurring close to the start-up of engine, pollutants being measured, etc. However, what is the important note for this study is that the anti-idling practices that are being developed and regulated in many progressive municipalities are supported due to reduction of emissions and exposure.

Street canyons can be created when tall buildings are constructed on both sides of the street and perpendicular to predominant wind direction, particularly in low or no wind conditions (Brauer et al., 2012). Air pollution becomes trapped and dispersion is limited, leading to higher exposure (measurements and more specific information can be found in BC Ministry of Environment, 2012). Downtown urban areas are likely settings for the street canyon condition, where there also tends to be a high population density (both daytime office workers and residents) and high traffic volume that amplifies the effect and the exposure of this condition. According to the BC *Develop with Care 2012* guidelines (2012, p. 2) "To avoid creating street canyons, buildings that are perpendicular to the predominant wind direction should be staggered or high-rise buildings should be developed on only one side of the street (when perpendicular to the predominant wind direction)". In Brauer et al. (2012, page 36): "A potential street canyon can by identified by calculating the ratio of the height (H) of buildings adjacent to roads to the road width (D). An H/D ratio above 0.7 suggests a canyon road with the potential for TRAP accumulation."

2.2.5 Exposed Persons' Vulnerability – Sensitive People and Land Uses

The vulnerabilities of sensitive and at-risk people to TRAP can be defined by physiological or social characteristics. Children, seniors, pregnant mothers, and people with pre-existing health conditions (respiratory and cardiovascular illnesses) may be affected by poor air quality. Also the genetics of an individual can influence their susceptibility to environmental contaminants. Land uses where physiologically sensitive individuals are most likely to spend time include schools and schoolyards, parks and playgrounds, daycare centers, nursing homes, hospitals, and residential communities (CARB, 2005). Sensitive individuals bear a significant proportion of the health burden of TRAP. It is estimated that "completely removing sensitive individuals from the impact of TRAP could reduce air pollution mortality by up to 50%" (BC Ministry of Environment, 2012).[7]

Social or physiological characteristics (e.g. children, seniors, pregnant mothers and their fetuses, people living in lower socio-economic status neighbourhoods) are linked to higher risk of adverse impacts

Health inequities are differences in health outcomes that are unavoidable, and are shared by factors like income distribution, access to education, housing, early childhood development, languages, social connections, etc. (Canadian Institute of Planners, 2012). This concept of "health equity" underlines an ethical principle closely related to human rights and social justice in health. Inequities in health systematically put groups of people who may already be socially disadvantaged and face a number of physical and environmental stressors, such as the homeless and ethnic minorities, at a further disadvantage with respect to their health (CIHI, 2012).

Canadian research shows that those who are already more vulnerable to poor health, namely those with low income, lower socio-economic status and low levels of education, may be at

[7] Relocation of all sensitive individuals is not a practical proposition, but the point is shared here to illustrate the proportion and extent of burden on sensitive individuals.

increased risk of exposure to the effects of air pollution (CIHI, 2011) by virtue of their mode of travel and location of residence. According to a CIHI 2011 report, "lower socio-economic status neighbourhoods are often situated closer to areas of high traffic density, thereby exposing residents of these neighbourhoods to higher levels of traffic-related pollution". Lower income people may also be less likely to own a vehicle. There are some studies showing that although public transport modes generally expose people to a lower concentration of TRAP than driving a car (discussed below, see Table 3), it may take travelers longer to reach their destination than if they drove from A to B. The increase in travel time may increase overall TRAP exposure if conventional diesel buses are used (World Health Organization, 2005).

The capacity of vulnerable populations to act on information and advice and modify behaviour (e.g. avoiding exercising in higher TRAP exposure areas, selecting routes with lower TRAP exposure) is also a factor to consider (CIHI, 2011).

2.2.6 Additional Factors that Increase Susceptibility

In addition to those who are vulnerable by way of their physiological and socioeconomic characteristics (described above), other factors that can make people more vulnerable to TRAP include how much time they spend in and close to traffic, and the type of travel modes they use to get around.

People who spend a considerable amount of time in traffic (e.g. taxi, bus, and truck drivers, police, couriers, commuters, some school children with long commutes, etc.) have significantly increased exposure to TRAP (Health Effects Institute, 2010).

Adult commuters are exposed to up to 50% (Health Effects Institute, 2010) or 60% (Kingham et al., 2011) of daily traffic-related air pollution when they are in or near vehicles during their commute to and from work. The commuting time is during rush hour when high traffic volume results in high pollution (World Health Organization, 2005). During the rest of the day many commuters are working indoors at their jobs (e.g. offices) and they are exposed to less pollution.

People who spend significant amounts of time in traffic may be more susceptible to TRAP exposure.

Mode of travel also affects the type and amount of personal exposure to emissions. Studies about exposure related to mode of travel and TRAP exposure vary somewhat in terms of what is measured (e.g. pollutant types, which modes) and the measurement methods, etc. The findings of these studies also vary in terms of which modes of transport have greater or less personal exposure to emissions. While cars and motorcycles expose drivers and passengers to higher TRAP, "when total accumulative intake is measured, car

travel might not be the most detrimental mode [in terms of exposure to TRAP] when travel times and breathing rates are taken into account, especially compared to active modes" (Kingham et al., 2011). People who cycle, walk, and take transit contribute to society's environmental objectives to reducing overall emissions and increasing physical activity, but they may (evidence is not unanimous or consistent) be penalized in terms of personal TRAP exposure as compared to vehicle drivers. This is an indication that local research to compare TRAP exposure by different modes of travel would be beneficial. As such, Health Canada is planning to conduct a study in 2013 to characterize personal air pollution exposures during commutes by light rail, bus, and private car transportation methods in Vancouver.

Information in Table 3 comes (except as noted) from a 2009 study in two New Zealand cities. Concentrations of the key traffic-related pollutants (PM_{10}, $PM_{2.5}$, PM_1, UFPs, and CO) were simultaneously monitored on pre-defined routes in Auckland and Christchurch during the morning and evening commutes for people travelling various modes over a period of several months.

Table 3: Mode of Transport and Personal TRAP Exposure Considerations while Traveling by Different Modes

N.B. Variables affecting personal exposure of various transportation modes (e.g. open windows in a car, use of the air conditioning or ventilation, traffic volume and congestion, routes, etc.) are not accounted for in the table below.

Transport Mode – personal exposure to driver, passenger(s)	**TRAP Exposure Considerations**
Motorcycle	High TRAP exposure. The driver is not shielded from the stream of pollutions, and is close to exhaust tailpipes of traffic ahead.
Car	Very high exposure to TRAP
Bus (diesel, electric)	Diesel: Very high rate of exposure to passengers (Zuurbier et al., 2010) from self-pollution to passengers on diesel buses, (i.e., pollution from the bus in which they are passengers) and high PM pollution exposure from opening and closing doors. Electric: Bus passengers and drivers are exposed to very low concentration of pollution, benefitting both urban air quality and bus passengers' health. (Zuurbier et al., 2010)
Pedestrians	Relatively low exposure compared to most modes. Exposure depends on relative separation from traffic emission stream, route choice. However, when travel times and breathing rates are taken into account, active

	modes such as cycling and walking may increase overall exposure compared with driving a vehicle (Kingham et al., 2011). See discussion in Section 2.3.1 about additional health benefits and trade-offs of active transportation.
Bicycles	Concentration of TRAP encountered by cyclists is similar to drivers (Brauer et al. 2012). When travel times and breathing rates are taken into account, active modes such as cycling and walking may increase overall exposure compared to driving a vehicle (Kingham et al., 2011). Road design often allocates space for cyclists to be beside vehicular traffic rather than directly behind vehicles. This design (though not intentional) is shown to reduce cyclists' direct exposure to vehicle emissions (Thai, 2007). See discussion in Section 2.3.1 about additional health benefits and trade-offs of active transportation.
Subways	Significant variance in studies and conditions, therefore not conclusive
Electric rail	Low exposure compared with all modes. Usually the system is in a separated right-of-way or segregated from vehicular modes (e.g. elevated or underground system).

Source: Kingham et al. (2011) except as noted separately in table.

2.3. INTEGRATING TRAP EXPOSURE REDUCTION WITH OTHER COMMUNITY OBJECTIVES

2.3.1 Health Benefits

In addition to considering the health impacts of TRAP exposure that are associated with various modes of travel (as discussed above), it is imperative that additional human health factors be considered and balanced to truly understand the 'net health benefit' of potential policies and strategies that facilitate active transportation (including transit) and supportive land use. Some of these important health factors are described below.

Physical Activity: Health Benefits – 15% of Canadian adults and 7% of Canadian children and youth get the recommended amount of physical activity (Heart and Stroke Foundation, 2011). A trend of sedentary lifestyles and escalating rates of overweight, obesity, and chronic disease has significantly negative health implications. It is imperative that Canadians become more active in their daily lives. Community design and infrastructure is a strong determinant for walking and cycling for both utilitarian (work trips and school trips) and recreation trips. Smart growth strategies such as mixed land uses, destinations close together, improved walking and cycling conditions and transit services, improved public realm, and a density of street intersections in a neighbourhood result in significantly more active transportation trips. The risk of obesity has been shown to decline by 4.8% for each additional kilometre walked per day and can increase by 6% for each hour spent in a car per day (Heart and Stroke Foundation of Canada, 2011). A recent study compared rates of active transportation with obesity in Europe, North America and

If possible it is healthier to exercise (biking, walking, sports) away from traffic areas. But even in areas with TRAP, the health benefits of physical activity outweigh risks of TRAP exposure.

Australia and found that generally, the countries with higher rates of active transportation had lower levels of obesity (Heart and Stroke Foundation of Canada, 2011). In addition, an American study has shown that smart growth communities have about a fifth of the traffic fatalities experienced in sprawled neighbourhoods (Ewing et al., 2003).

A concern is that when people are walking or cycling they are breathing more heavily due to exertion and may have longer trips and exposure, resulting to greater TRAP exposure. While there is some evidence that bike users may experience higher exposures than car users if they travel on busy routes, health experts have concluded that cyclists can reduce their pollution exposure substantially by selecting low-traffic routes (Teschke et al., 2012). As well, a European Commission study (2012) found that the benefits of cycling or walking in terms of the effects of physical activity on the body outweighed by far any possible increase in exposure to pollution.

The British Medical Association and many other studies concur that "there is a large net health benefit of increased cycling, since the risk of fatal injury is greatly outweighed by the reductions in mortality afforded by increased physical activity. Air pollution risks and benefits had smaller impacts in either direction. Benefit to risk ratios ranged between 9 to 1 and 96 to 1" (Teschke et al., 2012).

Mental health: Mental health benefits of active transportation are challenging to quantify but are nonetheless valuable to individuals and society. Active transportation modes improve mobility and access to community opportunities and services such as education, employment, shopping areas, and recreational facilities. They also improve community cohesion (i.e., positive interactions among neighbours) (VTPI, 2010b). Many commuters also find high quality public transit travel less stressful than driving (VTPI, 2010b). Exercise during active transportation (walking to destination or to transit stop, cycling, etc.) not only has physical benefits, but mental health benefits as well (Teschke et al., 2012).

Also, from a society-wide perspective, active transportation is beneficial (VTPI, 2010b): an increase in active transportation and transit use means fewer cars, which reduces overall TRAP.

2.3.2 Land Use Objectives

It is widely acknowledged by planning practitioners and elected officials that co-benefits and trade-offs among planning and community objectives (sustainability, social development, health, economic development – to name a few) always need to be considered and weighed when creating and implementing land use policies.

Over the last decade (or more) municipalities across BC have increasingly incorporated "smart growth"[8] principles and approaches into local land use planning processes. Smart growth refers to various land use development policies that create more compact, accessible, and multi-modal communities. These include policies that: increase development density and mix, road network,

[8] Smart Growth principles can be found on the Smart Growth America website: http://www.smartgrowthamerica.org/

and path connectivity; improve walking and cycling conditions; enhance public transit services; reduce parking supply; foster the adoption of transportation demand management programs; and improve the public realm (more attractive streets and local parks).

People who live in 'smart growth', multi-modal communities drive less and rely more on walking, cycling and public transit (Ewing et al., 2003 and Frank et al., 2010b). As a result, total per capita regional emissions tend to decline. This is a very positive outcome from a TRAP exposure perspective, because emissions are reduced.

With the 'smart growth' planning direction, increased development density and mix tends to increase emissions per land unit (hectare or square kilometer) and increase proximity between people and emission sources. As a result, human exposure to local emissions (particulates, air toxins, etc.) tends to increase. However, TRAP implications are not a reason to change the overall direction toward more compact communities, which have numerous community benefits. Rather, implementing new knowledge of TRAP and fine-tuning land use, building designs, and transportation management strategies to reduce exposure to TRAP in conjunction with smart growth strategies is recommended.

Policies that reduce exposure to TRAP in the context of smart growth include: locating pedestrian and cycling routes away from busy highways, shifting from diesel to electric transit, truck, and private vehicles on busy roadways, increasing greenspace, and designing building ventilation systems with air intakes positioned away from busy highways and areas where vehicles idle. See Chapters 4 and 6 for a more complete of list of strategies.

2.4. EXPOSURE LEVELS WITHIN LOWER FRASER VALLEY AND BRITISH COLUMBIA

2.4.1. Spatial Variability within Lower Fraser Valley and BC

In the Lower Fraser Valley, weather patterns largely determine air quality. Weather patterns circulate air throughout the airshed, and these in turn are influenced by the topography of the region (Environment Canada, 2004). During the summer and winter, there are periods of stagnation as wind speeds are reduced, enabling air pollutants to build up.

Due to climatic and geographic conditions, portions of the Lower Fraser Valley can experience elevated levels of ozone in the summer months, as well as particulate matter due to forest fire activity. In winter, prevailing winds from the northeast generally reduce the pollutant levels.

Across the region, there are also differences in traffic volumes and congestion levels. As a result there are local differences in TRAP levels. Figure 4 shows areas within Metro Vancouver where annual ambient levels of NO and NO_2 can be higher – namely in Downtown Vancouver and along major roads and highways. These levels were determined using measured and modelled

data[9]. As the Metro Vancouver annual objective for NO_2 is 22 ppb, these maps indicate that annual ambient NO_2 levels are below the annual objective. They also show that levels of both pollutants have been reduced between 2003 and 2010.

However, emissions of several traffic-related air pollutants are predicted to increase over the next decade due to continued growth in population, international trade and transportation. Health effects also occur when air pollutant concentrations are below Metro Vancouver's ambient air quality objectives.

In other parts of BC, in cities and regions such as Prince George, the Bulkley Valley, and the Okanagan Valley, geographical conditions also create restricted air basins, trapping air pollutants and creating poor air quality conditions.

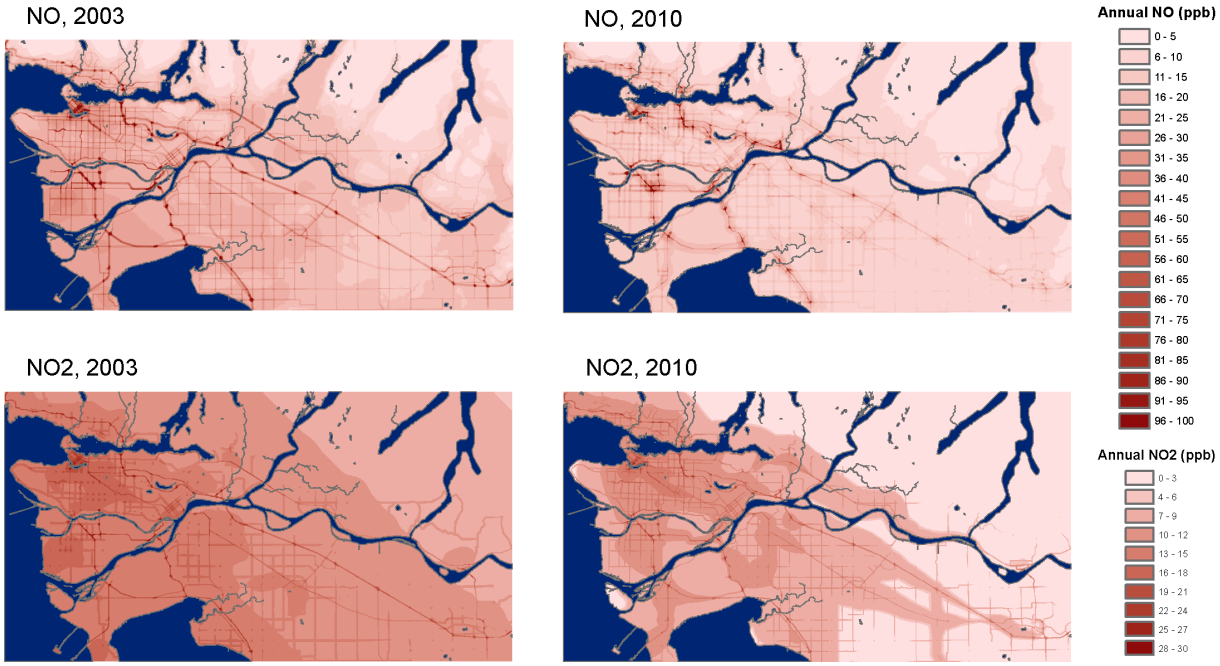


Figure 4: NO and NO_2 Levels within Metro Vancouver, 2003 and 2010

Source: Wang (2011).

2.4.2 Higher TRAP Exposure Areas, Vulnerable Individuals and Susceptible Activities within LFV and BC

In an earlier section, the various ways that an individual can have a higher chance of being exposed to and / or experiencing health effects from traffic-related air pollution have been

[9] Land use regression involves measuring a) pollutant concentrations at multiple sites specifically selected to capture the complete intra-urban range of concentrations, and b) geographic predictor variables such as site location, surrounding land use, population density and traffic patterns. Linear regression correlates measured pollutant concentrations with the most predictive variables and the resulting equation is used to map pollutant concentrations at locations where all the geographic predictors have been measured.

defined. Higher TRAP exposure areas include locations with large numbers of vehicles, and vulnerable individuals include pregnant mothers and their fetuses, children, elderly, low-income individuals, people with respiratory conditions. Individuals who spend a lot of time in traffic such as taxi, bus, and truck drivers, and transit and active transportation users can also be more susceptible to TRAP exposure. Table 4 provides some examples of these higher TRAP exposure areas and individuals within the Lower Fraser Valley and BC. More details can be found in Appendix A.

Figure 5 (taken from Brauer et al., 2012) also shows "TRAP influence zones" at distances of 500 m from highways and 100 m from major roadways. The national road network provided by DMTI CanMap® Street was used to create this map. The expressway, primary and secondary highway DMTI classifications represented "highways" and the major road classification represented "major roads".

Table 4: Examples of Factors that Affect TRAP Exposure within LFV and BC

Factors that Affect TRAP Exposure	Examples within Lower Fraser Valley and BC
Type of pollutants	• Primary pollutants emitted by vehicles: CO, NOx, particulate matter, and black carbon. • Diesel exhaust, which is emitted by heavy duty vehicles throughout BC and worldwide, is a special concern. As mentioned before, diesel-exhaust particles are the most harmful vehicle related pollutant and a harmful human carcinogen.
Proximity to motor vehicle traffic	• Research conducted at UBC demonstrates a linkage between the levels of traffic-related nitrogen-oxides and the proximity to major roads and highways in Metro Vancouver (Wang, 2011). • In 2006 37% of the BC population lived within 500 m of a highway or 100 m of a major road (Brauer et al., 2012). • Within Metro Vancouver, 74% of the population live within 500 m of a major road, and 49% live within 250 m, 21% live within 100 m, and 11% live within 50 m of a major road (Evans et al., 2011).[10] • Residents living along truck routes have expressed concern to Metro Vancouver and municipal staff about air quality and noise.
Volume of pollutant emissions	• Lower Fraser Valley consists of many major roadways and highways, including arterial streets and provincial highways. See Figure 4 for maps of annual ambient levels of NO and NO_2 across the region and Figure 5 for "TRAP influence zones" within the City of Vancouver.
Micro-climate and Built environment	• The street canyon effect is most common in areas with taller buildings on both sides of the street, such as downtown Vancouver. In these areas, dilution rates are reduced and pollutant

[10] These distances represent the space between the centreline of a roadway to the extent of the distance specified. Property lines that fall within these distances are included in these figures. For highways, there is a centreline for each direction of travel.

Factors that Affect TRAP Exposure	Examples within Lower Fraser Valley and BC
	concentrations are higher (Wehner et al., 2002).
Exposed persons' vulnerability – sensitive individuals and land uses	• A study in 2011 (Amram et al.) found that more than half of the schools in the City of Vancouver are located within 200 m of major roadways, with a disproportionate number of these located in low-income areas. Moreover, parents often idle their vehicles when they are picking up and dropping off their children at schools and daycare facilities (this is common throughout the province). • Studies within Metro Vancouver have shown that traffic-related pollutants are associated with the highest risks increased rates of asthma diagnosis in children and with physician visits and hospitalizations for bronchiolitis among infants (BC Ministry of Environment, 2012). • A Metro Vancouver study on pregnant mothers found that there are associations between exposure to TRAP during the whole pregnancy, as well as residence within 50 m of a highway, and low birth weights, preterm births, and, perhaps an increased risk of the child developing asthma (Brauer et al., 2008). • Studies in Vancouver have shown an association between cardiovascular mortality and exposure to TRAP (Ministry of Environment, 2012). • A study in Metro Vancouver showed that when individuals moved away from TRAP proximity zones (defined as within 150m of a highway or within 50m of a major road), their risk of coronary heart disease mortality was reduced by up to 40% (Gan et al., 2010). • Locations where vehicles often idle include elementary schools during pick-up and drop-off periods (which is a common occurrence in communities across LFV), border crossings between BC and the United States, and ferry terminals such as those operated by BC Ferries. • In Metro Vancouver, a study found that lower-income areas tend to have higher nitric oxide (NO) concentrations (a marker for direct vehicle emissions) and walkability (Marshall et al., 2009). This suggests increased concentration of activities can have benefits and costs. Thus communities should consider implementing strategies to ensure communities are walkable and at the same time residents are not adversely affected by increased exposure to air pollution. • In the same study described above, it was found that neighbourhoods with high ozone levels tend to be middle income. Ozone is a regional, secondary pollutant that is formed in the atmosphere, so high concentrations tend to occur regionally downwind of the highest density areas such as suburbs. This suggests it is also important to look at exposure levels in suburbs

Factors that Affect TRAP Exposure	Examples within Lower Fraser Valley and BC
	and middle-income neighbourhoods.
Mode of travel – susceptible activities	• Many bus routes in the Lower Fraser Valley and in the rest of BC are served by diesel buses. As such, transit users can be exposed to higher levels of air pollution while waiting at bus stops, and bus exchanges, and while they are on the bus. That said, both TransLink and BC Transit are employing vehicle technologies and fuels to reduce air emissions (in 2010, only 12 % of TransLink's bus fleet was running on diesel), and enhanced transit services may encourage people to shift from private automobiles to public transit, reducing overall emissions. • Within Metro Vancouver, approximately 21% of the Major Road Network has designated bike routes (TransLink, 2012), and within the City of Vancouver, 20-25% of bike routes are along primary and secondary arterials (City of Vancouver, 2012a). • A study found that cyclists using streets in the northwestern corner of Vancouver that had less traffic or a bicycle lane further away from vehicular traffic experienced less personal exposure to ultrafine particulates (Thai, 2007).

Figure 5: TRAP Influence Zones* in Metro Vancouver

Source: adapted from Brauer et al. (2012).

*TRAP Influence Zones = distances of 500 m from highways and 100 m from major roadways

2.5. CURRENT POLICY AND REGULATORY CONTEXT

The conditions that lead to exposure to traffic emissions are created through a combination of factors that are regulated or influenced by a multitude of agencies, including all levels of government. Figure 6 on the following page outlines key regulations, strategic plans and policies that control or influence these exposure levels, grouped by organization (e.g. federal, provincial, regional, municipal governments, health authorities, school districts). The summary figure does not provide an exhaustive list of avenues for influencing TRAP, but highlights the areas that each organization has the most significant authority or influence. For more detailed descriptions of each of the items listed in the figure, refer to Appendix C.

Federal Government
- Canada Wide Standards
- National Ambient Air Quality Objectives
- Vehicle emission regulations: light duty and heavy duty
- Sulphur in gasoline and diesel regulations
- Federal roadways
- Port Authority

Regional Governments
- Regional Growth Strategies
- FVRD Air Quality Management Plan

Metro Vancouver
- Ambient air quality objectives
- Lower Fraser Valley Air Quality Monitoring Network (with FVRD)
- Non-road diesel engines bylaw
- Integrated Air Quality and GHG Management Plan

Municipal Governments
- Official Community Plans – land use planning
- Master Transportation Plans
- Municipal roadways
- Pedestrian and cycling infrastructure
- Community Energy Plans
- Municipal parking meters and lots
- Municipal fleets
- Idle-reduction bylaws/policies

BC Provincial Government
- Ambient air quality objectives
- Cleaner Gasoline Regulation
- GHG Reduction Targets Act
- Carbon Tax Act
- Local Government Act
- BC Transit – provision of transit services outside Metro Vancouver
- BC Building Code
- Provincial roadways
- Air quality monitoring (outside LFV)

TransLink
- Transit
- Major road network
- Regional cycling
- Manage AirCare

Health Authorities
- Location of hospitals and care facilities
- Healthy Families BC Communities initiative

School Districts
- School buses
- Location of schools
- Idle-reduction policies

Figure 6: Summary of Relevant Policies, Plans and Regulations that control or influence TRAP exposure levels

3. OVERVIEW OF STRATEGIES CONSIDERED AND EVALUATION CRITERIA

3.1 SUMMARY OF STRATEGIES CONSIDERED

There are numerous ways to reduce exposure to traffic emissions, including directly reducing vehicle emissions (e.g. by reducing vehicle travel and employing cleaner vehicle technologies) and removing exposure to pollutants (e.g. by siting sensitive land uses further away from major roads and installing air filters within buildings). After completing a comprehensive review of the existing literature on traffic-related pollutants and mitigation measures, an initial list of over 100 land use, design, transportation management, and education / outreach strategies were identified as measures that could potentially be used within BC to reduce exposure to traffic emissions. Focus was placed on strategies that are innovative and have not yet been implemented extensively within BC.

Once the initial list was developed, similar or related strategies were bundled together and strategies already implemented province-wide were omitted. Leading and supporting agencies were also identified for each strategy. The final list of strategies (50 in total) was then taken through the evaluation process, which is described in the next section.

3.2 KEY EVALUATION CRITERIA

To assess the impact and effectiveness of the short-listed strategies, a multi-criteria assessment approach was taken. This approach allowed for a high-level evaluation of the following:

- The overall effectiveness in reducing exposure to TRAP;
- The overall practicality; and
- The overall effectiveness in achieving co-benefits.

The final criteria selected, which are listed below, are based on feedback from the study's Steering Committee. As indicated in Table 5, each criterion had a weighting factor to represent its relative importance. For example: it was decided that the **level of TRAP exposure reduced** was relatively more important than the other criteria used to measure effectiveness in reducing exposure. As a result, this criterion had a weighting factor of 2 while the others had a weighting factor of 1. These factors were also selected based on input from the Steering Committee. While a sensitivity analysis was not conducted, it is recognized that these weighting

factors have a significant impact on the final evaluation results. The definitions of the measurement scales can be found in Appendix C.

It should be noted that there is limited information available regarding how much exposure can be reduced by the identified strategies. As a result, only a high-level qualitative evaluation was possible. With further research, however, a more detailed evaluation could be possible. See Chapter 8 for areas for further research.

Table 5: Evaluation Criteria Selected

	Measurement Scale	Weighting Factor
Overall Effectiveness in Reducing Exposure to TRAP (criteria measure impacts to human health)		
Level of TRAP exposure reduction	high / medium / low	2
Proportion of population benefitting from reduced exposure as a result of implementing the strategy	high / medium / low	1
Specifically benefits vulnerable populations in terms of exposure	yes / neutral	1
Specifically benefits areas with high density in terms of reduced exposure	yes / neutral	1
Overall Practicality (criteria measure financial, political and technical feasibility)		
Cost of implementation (opportunities for cost recovery considered) for lead government agency	high cost / medium cost / low cost	1
Feasibility / ease of implementation (political, etc.)	high / medium / low	1
Overall Effectiveness in Achieving Co-benefits (criteria measure impacts to human health, economy, culture, society, and environment)		
Increases active transportation trips (transit, biking, walking)	yes / no / neutral	2
Supports Economic Development (employment and productivity)	yes / no / neutral	1
Creates sense of community (community cohesion), and enhances / maintains livable vibrant communities	yes / neutral / no	1
Benefits transport users (or travelers) in terms of their personal travel experience (comfort, convenience, etc.)	yes / no / neutral	1
Enhances affordability for transport users (i.e., overall cost of living)	yes / no / neutral	1
Reduces greenhouse gas emissions	high / medium / low	1

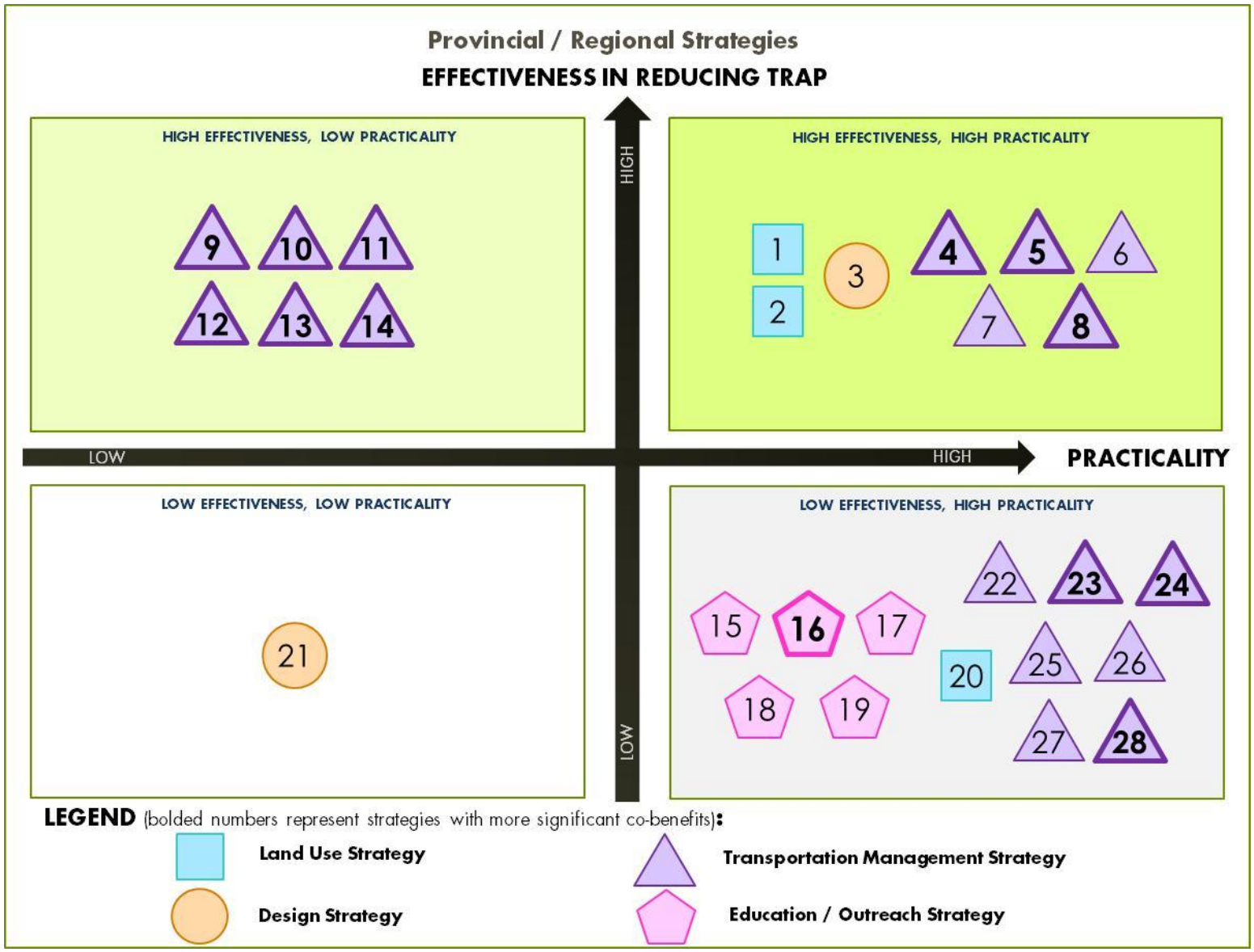
3.3 SUMMARY OF EVALUATION RESULTS

Results of the multi-criteria evaluation are summarized in Figure 7 and 8, while the detailed evaluation results can be found in Appendix C. To differentiate the various strategies' effectiveness in reducing exposure to TRAP and level of practicality, the following four categories were developed:

- High effectiveness, high practicality: Strategies that are moderately to highly effective in reducing exposure to traffic emissions and likely practical to implement
- High effectiveness, low practicality: Strategies that are moderately to highly effective in reducing exposure to traffic emissions but may be difficult to implement
- Low effectiveness, high practicality: Strategies that are moderately effective in reducing exposure to traffic emissions and likely practical to implement
- Low effectiveness, low practicality: Strategies that are not very effective in reducing exposure to traffic emissions if implemented on their own and may be difficult to implement

These graphics provide an overview of the number of transportation management, land use, design, and education / outreach strategies that fall within each of the above categories. The numbers correspond to the strategy numbers used in Chapters 4 and 6, and Appendix C. Strategies that have significant co-benefits such as positive impacts to human health, economy, culture, society, and / or the environment are shown in bold.

These evaluation results are based on feedback from the Steering Committee, as well as municipal staff of the three case study communities selected for this project – Broadway corridor in the City of Vancouver, City of Surrey's communities outside of urban centres, and the City of Kelowna.


Provincial / Regional Strategies
EFFECTIVENESS IN REDUCING TRAP
HIGH EFFECTIVENESS, LOW PRACTICALITY
9
10
11
12
13
14
HIGH EFFECTIVENESS, HIGH PRACTICALITY
1
2
3
4
5
6
7
8
HIGH
LOW
LOW
HIGH
PRACTICALITY
LOW EFFECTIVENESS, LOW PRACTICALITY
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LOW EFFECTIVENESS, HIGH PRACTICALITY
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LEGEND (bolded numbers represent strategies with more significant co-benefits):
Land Use Strategy
Design Strategy
Transportation Management Strategy
Education / Outreach Strategy

Figure 7: Summary of Evaluation Results for Provincial / Regional Strategies

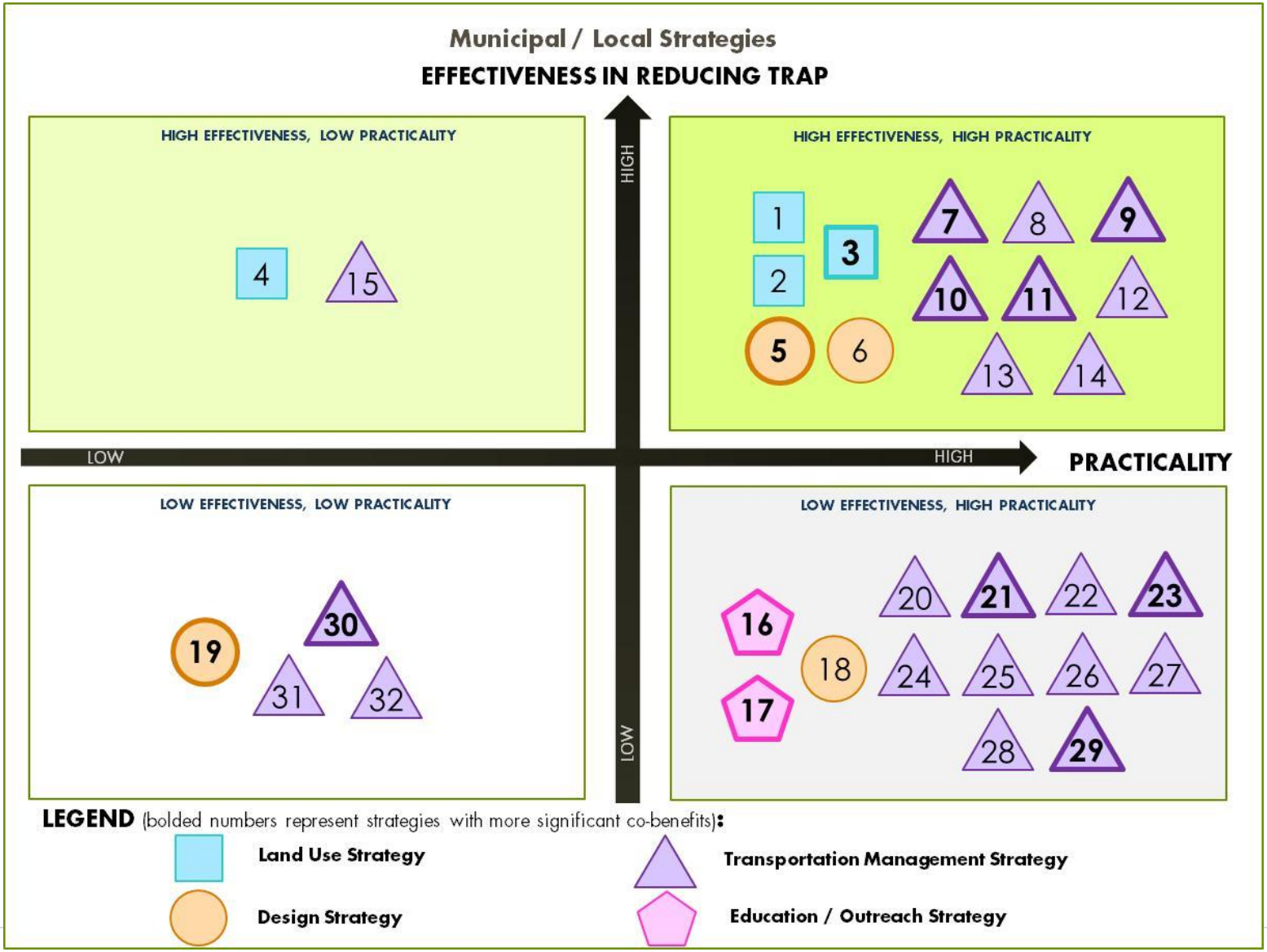

Figure 8: Summary of Evaluation Results for Municipal / Local Strategies

4. PROVINCIAL AND REGIONAL AGENCY STRATEGIES

4.1 ROLES AND OPPORTUNITIES FOR PROVINCIAL AND REGIONAL INITIATIVES / POLICIES / REGULATIONS

As noted in section 2.5 and described further in Appendix C, both provincial and regional agencies in BC have an important role in air quality, and a number of initiatives, monitoring programs, and ambient air quality objectives have been established at both levels to maintain and improve air quality. This chapter describes some additional opportunities for provincial and regional agencies to reduce levels of TRAP. These opportunities, some of which have already been introduced and could be expanded (initiatives implemented province-wide are not included), will help enhance consistency across the province and regions in terms of air quality policies / practices / initiatives. These provincial and regional initiatives will also provide support to municipalities when they are implementing their local initiatives. See Chapter 6 for strategies that would be led by municipalities or local organizations (N.B. there are some strategies where provincial / regional or municipal / local organizations could take a lead).

4.1.1 Key Recommended Strategies

One of the key recommended provincial strategies is to conduct a **province-wide high-level assessment** to identify potential locations with higher exposure. Regional governments can also assist municipal governments in identifying **higher TRAP exposure areas at a regional level**. Traffic count data, household location data collected by Statistics Canada and BC Stats, as well as data on other point sources could be used for the assessment. Land use regression or dispersion modeling would yield valuable information to help identify higher TRAP exposure areas. The results of the assessment would provide invaluable information to local governments and help them understand whether exposure to traffic-related air pollutants is of potential concern in their communities.

As a substantial amount of information is already available for Metro Vancouver (e.g. work conducted by researchers at the UBC School of Population and Public Health), this assessment may not be necessary for the Metro Vancouver region. It is therefore recommended that municipalities in this region review the assessment work that has already been completed and contact Metro Vancouver when updating land use plans and zoning, or when development permits have been submitted along the busy roads so that TRAP exposure levels for those areas can be examined.

When identifying the locations, provincial and regional agencies should consider the following:

- Location of busy roads and truck routes based on traffic data;
- Location of bus garages and distribution centres (that accommodate more than 100 trucks per day, more than 40 trucks with operating truck refrigeration units per day, or where truck refrigeration unit operations exceed 300 hours per week);
- Location of vulnerable individuals within higher TRAP exposure areas; and
- Location of higher TRAP exposure areas, determined either by direct measurement of TRAP indicator pollutants or by modeling.

The remainder of this section describes other key recommended strategies that are considered to be highly effective in reducing exposure to TRAP, although some may be more difficult to implement. The recommended strategies for the BC provincial government include a variety of approaches that range from providing education, to introducing or expanding programs and services, to changing legislative requirements. Potential changes to provincial legislation to incorporate TRAP considerations are identified among the recommended strategies, including considerations for the *Environmental Assessment Act*, *BC Building Code*, the *Carbon Tax Act*, and the *Insurance (Vehicle) Act.* As well, to enact a vehicle registration fee, enabling legislation to establish a collection mechanism through the Insurance Corporation of British Columbia would be required. The municipal strategies identified in Chapter 6 would also require a change to the *Strata Property Act* and new legislation to require or enable parking to be unbundled from residential units in new developments.

For each key strategy described, the government agencies that would have a role in these initiatives are listed. In many cases, for successful and effective implementation, partnerships are required between multiple agencies, including partnerships with local and /or federal government organizations. Therefore, these agencies are also listed where appropriate, and the leading and supporting agencies have been identified. In addition, it is recognized that these strategies also have co-benefits, and many of these are also described.

Land Use Strategies

#1 Adopt a policy to require large-scale transportation infrastructure projects and plans involving provincial roads or the Major Road Network in Metro Vancouver to quantify air quality-health benefits and costs through Health Impact Assessments prior to approval

Evaluation Result: High effectiveness, high practicality

Responsibility: Provincial government or TA (for Major Road Network projects in Metro Vancouver) (Lead)

Description: For agencies undertaking large-scale transportation infrastructure projects and plans that involve provincial roads or the Major Road Network in Metro Vancouver, adopt a policy to quantify air quality health benefits and costs through Health Impact Assessments and require appropriate mitigation measures where areas of concern are identified. These assessments should be conducted before a project or plan is approved.

- The provincial *Environmental Assessment Act* identifies which projects require a full Environmental Impact Assessment, and define elements that should be considered in the assessment. A review of the *Act* may provide an opportunity to ensure health impacts of expected changes in traffic volume resulting from the project are evaluated in relation to existing local land uses, planned land uses, and in relation to vulnerable populations. EIAs should also identify mitigation measures and incorporate these into the project plan if the project is to proceed.

  For Consideration: The University of California, Los Angeles has developed a clearinghouse of Health Impact Assessments, which could be a useful resource.

#2 Adopt siting considerations (and designs) for medical, health, and long-term care facilities

Evaluation Result: High effectiveness, high practicality

Responsibility: Health authority (Lead)

- **Description:** Adopt particular siting considerations and designs for facilities such as hospitals, major medical centres, and long-term care facilities. If possible, health authorities should consider siting new facilities outside higher TRAP exposure areas.
- **For Consideration:** Indoor air quality management practices that reduce levels of outdoor pollutants (see strategy #3) should also be considered.

Design Strategy

#3 a) Update *BC Building Code* to require indoor air quality management practices that reduce levels of outdoor pollutants and/or b) investigate whether municipalities/regional districts already have the authority to require indoor air quality management practices using powers granted in the Community Charter and the Local Government Act and if necessary provide municipalities with authority to require such practices (N.B. City of Vancouver already has its own building code).

Evaluation Result: High effectiveness, high practicality

Responsibility: Provincial government (Lead)

- **Description:** a) The BC Building Code (Provincial authority) defines standards that must be met by all new buildings in BC. Currently the Code does not make reference to the levels of outdoor air pollutants at all. Generally, municipalities cannot require standards that go beyond the BC Building Code, meaning that it would be the Province's responsibility to update the BC Building Code to require indoor air quality management practices that reduce levels of outdoor pollutants or provide municipalities with authority to require such practices. These practices would be suitable for larger commercial, institutional, and residential buildings.
- b) Municipalities are granted some Fundamental Powers in the Community Charter that provide "General authority in relation to buildings and other structures" and may allow a council to enact a bylaw for the "health, safety or protection of persons or property" (under Community Charter, section 8 (3) (l) and section 53 (2) (d)). However, Section 9 restricts these powers by requiring Provincial assent for their use (Gage and Saha, 2006). Further investigation and a legal opinion is needed to determine whether this provision may be used in relation to indoor air quality management practices as an alternative to updating the BC Building Code.

  These practices could include:

- Requiring that buildings have ventilation systems with air intakes away from busy roads, areas where vehicles idle, and loading docks (municipalities would also need to implement and enforce anti-idling bylaws).
- In higher TRAP exposure areas, requiring heating, ventilation, and air conditioning (HVAC) systems to start earlier in the morning when outdoor pollutant concentrations are lower, and turn systems off from the beginning of the morning rush hour until the systems must be on for occupation of the building.
- In higher TRAP exposure areas and in sensitive land uses, requiring that new facilities have high efficiency particulate air (HEPA) filters, and if possible retrofitting existing facilities with HEPA filters. Centralized filtration is preferred, but single room air cleaners may also work. An incentive / rebate program could also be established to provide HEPA filters for these facilities or these filters could be mandated.
- Requiring all new buildings be airtight (i.e., they must meet be at or below a certain infiltration rate) so that filtration systems work more efficiently and / or require buildings be installed with ventilation systems that keep a slight positive pressure indoors in higher TRAP exposure areas.
- In higher TRAP exposure areas, encouraging buildings to be designed with common main entrance and exit doors (if possible, orient entrances away from major roadways) to reduce infiltration of TRAP.

For Consideration: If municipalities are given the authority to require that buildings have safe indoor air quality levels, the initiative could potentially be implemented in a series of phases, where sensitive land uses and new buildings are targeted first.

For new buildings, municipalities could request for a concept plan to be submitted to address mechanical systems for building operation based on location and outside uses. Municipalities could also require a high-level assessment of mechanical systems as they are being designed to ensure indoor air quality is being considered.

It should also be noted that HEPA filters will not reduce exposure to gaseous air pollutants (e.g. CO, NOx, SO_2) (BC Ministry of Environment, 2012). Also, as HEPA filters increase air flow resistance (static pressure) and can make HVAC motors less efficient, thereby increasing energy consumption. Further research could be done to compare the benefits of reducing exposure with increasing energy consumption and costs.

Transportation Management Strategies

#4 Improve transit service quality

Evaluation Result: High effectiveness, high practicality
Responsibility: Transportation authority (Lead); provincial and municipal governments (Support)
Description: Improve transit service quality such as service frequency and operating hours, reliability and travel time (by implementing transit priority measures) and the number and condition of bus shelters. It should be noted that both TransLink and BC Transit have plans to

improve transit service quality. Funding support from municipalities and the provincial government, however, is required to make these plans a reality.

For Consideration: People who live in transit-oriented communities typically drive 10-30% less than residents of automobile-oriented areas, and transit service improvements can lead to 3-9% reduction in overall vehicle-kilometres traveled (VTPI, 2012e). The use of transit also increases physical activity. However, the use of transit could increase exposure to bus emissions, especially if the buses are conventional diesel buses.

#5 Increase fuel prices

Evaluation Result: High effectiveness, high practicality

Responsibility: Provincial or federal government (Lead)

Description: Although considered politically difficult to implement, increasing fuel prices is an economic transfer rather than a true cost, and may be acceptable as a package of tax reforms. The revenues can be used to fund alternative transportation infrastructure. In BC, this includes maintaining the current commitment to collect taxes on carbon-based fuel according to the *Carbon Tax Act*, and to consider further increasing this tax over time to further encourage fuel efficiency or use of cleaner alternatives.

For Consideration: Increasing fuel taxes to reflect actual cost of fuel production and roadway costs can lead to 5-15% reduction in overall vehicle-kilometres traveled (VTPI, 2012e).

#6 Implement or expand targeted mandated inspection and maintenance programs for cars, buses, trucks, and older vehicles

Evaluation Result: High effectiveness, high practicality

Responsibility: Regional or provincial government (Lead)

Description: Implement or expand targeted mandated inspection and maintenance programs for cars, buses and trucks (e.g. mandatory AirCare Program for all buses and trucks, unlike the AirCare ON-ROAD program, which only targets specific vehicles), and expand Metro Vancouver and Fraser Valley's current AirCare program to the rest of BC for older vehicles. Note that currently there are plans to discontinue the existing AirCare program at the end of 2014. To ensure the emission levels of cars continue to be monitored, especially older vehicles, it is recommended that the program not be terminated.

As well, a roadside high-emitting vehicle detection program for light- and heavy-duty vehicles could be implemented. This can be accomplished through the use of roadside instruments that detect tailpipe emissions as vehicles drive by, and as such would not require vehicles to stop and be tested. If a vehicle fails to meet emission standards under the Motor Vehicle Act Regulations, the vehicle owner may be ordered to have their vehicle repaired and retested, and they may be ticketed for violation of emission standards. Teams could be employed to patrol different communities in mobile units.

- **For Consideration:** During the summer of 2012, Metro Vancouver, with the B.C. Ministry of Environment, FVRD, AirCare, Port Metro Vancouver and others, used remote sensing device (RSD) technology to collect real-life emission data representative of the local heavy-duty diesel fleet (BC Lung Association, 2012). Using infrared and ultraviolet technology, they were able to read emissions levels from vehicle exhaust as they pass by.

#7 Expand ride-share programs, including vanpooling, for trips to work, school, and events

Evaluation Result: High effectiveness, high practicality
Responsibility: Transportation authority (in Metro Vancouver) or municipal government (Lead); involve rideshare providers too
Description: Rideshare programs including vanpooling can be established for regional and municipal employees, and promoted to businesses and schools for trips to work, school, and events.
For Consideration: Ride-share programs lead to 3-9% reduction in overall vehicle-kilometres traveled (VTPI, 2012e). Local rideshare program providers such as Jack Bell Foundation would be important partners to engage.

#8 Introduce or enhance commute trip reduction programs

Evaluation Result: High effectiveness, high practicality
Responsibility: Transportation authority (in Metro Vancouver) or municipal government (Lead)
Land Use Typology Suitability: Highly suitable for urban centres and medium suitability for suburban / general urban areas and rural areas.
Description: Introduce or enhance commute trip reduction programs to give commuters resources and incentives to reduce their automobile trips (commute trip reduction programs typically include a variety of transportation demand management strategies), and establish Transportation Management Associations (TMAs) to support these programs.
For Consideration: This strategy requires involvement, initiative and cooperation of larger employers and business associations. The leading agency could start implementation with larger employers, such as hospitals, and work with large employers on the formation of TMAs.

Some of the health authorities in BC cover large amounts of geography, and within these authorities there is a desire to promote a mobile workforce and implement alternatives to reduce the amount of vehicle transportation used by staff for both commuting and work trip purposes. Hence, health authorities could work with the transportation authority or municipal government to introduce or enhance a commute trip reduction program.

#9 Implement pay-as-you-drive insurance

Evaluation Result: High effectiveness, low practicality
Responsibility: Provincial government (Lead), including the Insurance Corporation of British Columbia (ICBC)
Description: A pay-as-you-drive insurance system is one where a vehicle's insurance premiums are based on how much it is driven during the policy term (VTPI, 2012e). The more a person drives the more they pay and the less a person drives the more they save. This can be done by changing the unit of exposure (i.e., how premiums are calculated) from the vehicle-year to the vehicle-mile, vehicle-kilometer or vehicle-minute. For example, a $375 annual premium becomes 2¢ per kilometre, and a $1,250 annual premium becomes 6¢ per kilometre. Higher-risk motorists would also pay more per unit than lower-risk drivers. This would require a change to the BC *Insurance (Vehicle) Act*, which specifies how premiums can be classified.
For Consideration: Pay-as-you-drive insurance can lead to 8-10% reduction in overall vehicle-kilometres traveled (VTPI, 2012e).

#10 Introduce vehicle registration fees based on size of vehicle or emission rate

Evaluation Result: High effectiveness, low practicality

Responsibility: Provincial government (Lead), including the Insurance Corporation of British Columbia (ICBC)

- **Description:** Vehicle registration fees can be introduced, and instead of being a flat fee, it can be based on the size of the vehicle or the vehicle's emission rate. Currently, a vehicle levy is enabled in the TransLink legislation; however enabling legislation to establish a collection mechanism through ICBC would need to be introduced (Mayor's Council on Regional Transportation, 2012).
- **For Consideration:** In Metro Vancouver, there is support by local politicians to introduce a vehicle registration fee for the purpose of raising funds for transit service (Bula and Bailey, 2012). However, this has not been approved by the provincial government.

#11 Implement a logistics program

Evaluation Result: High effectiveness, low practicality

Responsibility: Provincial government (Lead); and municipal government and port authority (Support); involve BC Trucking Association too

Description: A logistics program would help reduce the number of under-loaded and empty truck trips in higher TRAP exposure areas. The leading agency can help identify and establish common terminals or consolidation centres that are available to all carriers.

For Consideration: Freight transport management programs, if implemented widely, can lead to 5-20% reduction in freight vehicle travel and 0.5-2% in overall vehicle kilometres traveled (VTPI, 2011a and 2012e). It also has the potential to reduce a shipper's costs. The BC Trucking Association would be a key partner in this type of initiative.

#12 Implement alternatives to transporting goods from ports by truck

Evaluation Result: High effectiveness, low practicality

Responsibility: Federal government (Lead); provincial government and port authority (Support)

Description: Alternatives such as electric rail or dual-mode diesel-electric rail (where the locomotives are powered by an electrical sources and a diesel engine) can be explored to reduce the number of trucks required to move goods and reduce emissions. The federal government could lead this initiative by providing funding for these alternatives, whereas the provincial government and port authority could provide funding support, as well as assist the federal government in the evaluation and selection of the appropriate alternative option.

For Consideration: There are many countries with electrified freight trains. These include the Netherlands (which has an electric freight rail linking Rotterdam to Germany), Switzerland (whose federal railway system is almost all electric), France (the French National Railway Company has over 14,500 km of electrified railways), China (where there are also many electric freight trains and more are being constructed), and Russia (over 70% of the country's freight is carried by electric trains) (Smith et al., 2008). In fact, 97% of the traffic along the East Siberian Railway in Russia (which has one of longest railway tunnels in the world) is done with electric traction (Horner and Wilson, n.d. and Triposo, n.d.). The main cargo moved along the railway includes ferrous metals, petroleum products, grain shipments, and products of the light, food, chemical, and machine-building industries.

The benefits of electric trains include reduced emissions, reduced noise and vibration, and quicker accelerations and decelerations, leading to shorter trip times. Moreover, the maintenance costs of electric locomotives are lower than those for diesel locomotives (Chandrasekaran, 2009).

#13 Develop or expand electric or zero-emission transit systems

Evaluation Result: High effectiveness, low practicality

Responsibility: Transportation authority (Lead); federal and provincial government (Funding Support)

Description: Electric and zero-emission transit systems include battery-electric buses, trolleybuses, streetcars, light rail systems, advanced light rail systems such as the SkyTrain, and commuter rail.

For Consideration: When selecting alternative vehicle propulsion systems and fuels for transit, it is also important to consider the life-cycle costs (e.g. financial and environmental cost of battery replacement) of each option, and consider if additional capital costs would lead to reduced service hours due to limited budgets.

In 2010, approximately 18% of TransLink's bus fleet was comprised of electric vehicles (trolleybuses, battery-electric, and hydrogen fuel cell vehicles), while 66% of the fleet was running on biodiesel, and 12% was running on diesel (the remainder used natural gas or other fuel sources) (Canadian Urban Transit Association, 2011).

#14 Implement congestion pricing on provincial and / or arterial roads

Evaluation Result: High effectiveness, low practicality

Responsibility: Provincial government or transportation authority (in Metro Vancouver) (Lead), depending on road type; municipal government (Support)

Description: To reduce congestion on provincial and arterial roads, and encourage the use of alternative modes of transportation and / or off-peak travel, congestion pricing can be introduced to congested areas such as certain corridors and districts. Implementing congestion pricing at a regional level will help prevent the displacement of traffic onto local roads. Road pricing is an efficient and equitable way to fund transport facilities and reduce traffic problems.

For Consideration: Road pricing strategies can lead to 3-6% reduction in overall vehicle-kilometres traveled (Brauer et al., 2012, Börjesson et al., 2011, and VTPI, 2012e).

Education / Outreach Strategies

#15 Educate the general public about health impacts of transportation decisions

Evaluation Result: Low effectiveness, high practicality

Responsibility: Provincial and regional governments, and health authorities (Leads); municipal government (Support)

Description: Educate the general public about health impacts of transportation decisions, including benefits of active transportation, adverse effects from motorized transport, and risks of exercising near busy roads and trucks routes.

For Consideration: Individuals that could help educate the public about the health impacts of exposure to TRAP include planners, public officials, and health professionals. Therefore, it is important to reach out and educate these individuals as well.

#16 Encourage cyclists to choose low-traffic routes wherever possible

Evaluation Result: Low effectiveness, high practicality
Responsibility: Health authority, transportation authority (in Metro Vancouver), and municipal government (Leads); involve bicycle user groups too
Description: Encourage cyclists to choose low-traffic routes by making them aware of the potential health benefits. Encourage use of route planners that allow active commuters to choose 'least traffic pollution' in selecting route preferences (e.g. Cycling Metro Vancouver route planner), and engage cyclists through route planners to identify barriers that cyclists face if they want to ride on routes with less traffic.

#17 Develop a fact sheet and / or workshop module on reducing exposure to TRAP

Evaluation Result: Low effectiveness, high practicality
Responsibility: Regional and / or provincial government (Leads); health authority (Support); involve BC Lung Association too
Description: Develop a fact sheet and / or workshop module that highlights the TRAP exposure considerations, recommended strategies, and available resources for land use planning, building, and transportation that are described in this report.
For Consideration: To implement this initiative successfully, consideration should be given to establishing a partnership between Health Authorities. The materials developed should also be adapted for a range of audiences, including elected officials and the general public

#18 Where feasible, educate vulnerable individuals regarding the risk of living, working and exercising in higher TRAP exposure areas

Evaluation Result: Low effectiveness, high practicality
Responsibility: Health authority (Lead); municipal government (Support)
Description: Where feasible, increase awareness amongst vulnerable individuals (e.g. seniors, pregnant mothers, individuals with pre-existing health conditions) about the risk of living, working and exercising in higher TRAP exposure areas. To do so, a community will need to have information about the traffic volumes on their streets and then identify their major / busy roadways and communicate that information to vulnerable individuals.

#19 Educate the trucking community about exposure to TRAP

Evaluation Result: Low effectiveness, high practicality
Responsibility: Health authority (Lead); regional government (Support); involve BC Trucking Association too
Description: Educate the trucking community about the fuel costs and health exposure risks of extended idling.
For Consideration: The BC Trucking Association would need to be a key partner in this strategy.

4.1.2 Additional Strategies to Consider

This section highlights additional strategies that provincial and regional governments could consider. These strategies may not be as effective in reducing exposure when implemented on their own or may not be feasible in the short term. Due to significant variations in how these strategies may be applied, their effectiveness and/or feasibility may be higher given certain conditions (e.g. building a tunnel to encapsulate traffic and reduce emissions to adjacent residents may be very feasible in the right location, but was evaluated as low feasibility for general application). These strategies may also have a significant impact when implemented together and / or may be feasible in the longer term.

Land Use Strategy

#20 Develop sample Official Community Plan (OCP) policy guidelines to reduce exposure to TRAP

Evaluation Result: Low effectiveness, high practicality
Responsibility: Regional government (Lead)
Description: Develop sample OCP policy guidelines to support effective municipal policy making in reducing exposure to TRAP. These policy guidelines could the municipal / local strategies identified in Chapter 6.

Design Strategy

#21 Build well-ventilated tunnels on provincial roads or the Major Road Network in Metro Vancouver where there is higher TRAP exposure

Evaluation Result: Low effectiveness, low practicality
Responsibility: Provincial government or transportation authority (for Major Road Network in Metro Vancouver) (Lead)
Description: For higher TRAP exposure areas along provincial roads, build well-ventilated tunnels to enclose, capture and properly disperse emissions in enclosed areas and use surface to improve pedestrian connectivity.
For Consideration: It is likely difficult to justify the construction of a tunnel if the only reason is to reduce exposure to TRAP. It is more likely that a tunnel would be built to meet other objectives such as aesthetic reasons (preserving the above-ground view, landscape, and scenery), connectivity reasons (preserving above-ground connectivity of existing pathways. However, if a tunnel is built, then residents living near the tunnel would have the added benefit of reduced exposure to pollutants from vehicles operating within the tunnel.

Transportation Management Strategies

#22 Expand car-share programs

Evaluation Result: Low effectiveness, high practicality
Responsibility: Transportation authority (in Metro Vancouver) or municipal government (Lead)

Description: Car-share programs (e.g. Modo, Car2Go, Zipcar) can be established for regional and municipal employees, and promoted to businesses and schools for trips to work and school.
For Consideration: Motorists who shift from car ownership to car-sharing typically reduce their vehicle travel 30-60%, and car-sharing programs can lead to 1-2% reduction in overall vehicle-kilometres traveled (VTPI, 2012e). Data also show that each shared vehicle can replace 15-30 privately owned vehicles (Modo, 2012 and Zipcar 2011). Local car-sharing providers such as Modo, Zipcar, and Car2Go would be important partners to engage.

#23 Encourage part-time teleworking

Evaluation Result: Low effectiveness, high practicality
Responsibility: Transportation authority (in Metro Vancouver) or municipal government (Lead); involve business industry associations too
Land Use Typology Suitability: Highly suitable for urban centres, suburban / general urban areas, and rural areas.
Description: Encourage part-time teleworking where it is possible.
For Consideration: To implement strategy, a municipality could start with large employers where teleworking is feasible.

#24 Implement or expand U-pass program

Evaluation Result: Low effectiveness, high practicality
Responsibility: Transportation authority (Lead); support from post-secondary institutions
Description: The U-pass program can be introduced for all post-secondary institutions where transit services are adequately provided, particularly private higher education institutions, and those outside the Metro Vancouver region. When implementing the program, it is important that a sustainable funding model be developed such that additional transit services can be provided for students.
For Consideration: A study that surveyed Simon Fraser University alumni on current and school transit use frequency found that the U-Pass had a significant impact on post-graduation transit use (Cooper, 2009).

#25 Encourage organizations to manage vehicle fleets to reduce vehicle kilometres traveled

Evaluation Result: Low effectiveness, high practicality
Responsibility: Transportation authority (in Metro Vancouver) and / or municipal government (Leads); regional government (Support)
Description: Organizations can be encouraged to consolidate trips and find shorter routes where possible, and a municipal or regional government can implement a Clean Fleet Challenge where businesses are challenged to reduce their commercial fleet emissions by a specified percentage (e.g. 20% by 2020).
For Consideration: The leading agency can first find out who has the largest vehicle fleets with the largest impacts, and approach them directly to discuss options that would help reduce their VKTs and the benefits of these options, including reduced operating costs for businesses.

#26 Condition or filter air in buses (school and transit)

Evaluation Result: Low effectiveness, high practicality

Responsibility: Transportation authority and school districts (Leads)
Description: Public and school buses can be fitted with air filtration units to reduce exposure to air pollutants.
For Consideration: The positive impact of filtration can easily be confounded if buses have operable windows. Filtration is only effective for particulate matter, but not for gaseous pollutants (NOx, CO, SO_2).

#27 Within higher TRAP exposure areas along provincial roads and the Major Road Network in Metro Vancouver, consider implementing or expanding vehicle speed management strategies (e.g. strategies to reduce stop-and-go traffic or reduce vehicle speeds)

Evaluation Result: Low effectiveness, high practicality
Responsibility: Provincial government and TA (for Major Road Network in Metro Vancouver) (Leads)
Description: Within higher TRAP exposure areas along provincial roads, measures such as electronic tolls, signal synchronizations, and replacing stop signs with yield signs or roundabouts can be employed to avoid stop-and-go traffic. As shown in Figure 3 in section 2.2.3, having speed limits between 20 and 50 km/h (taking into consideration traffic dynamics) can also reduce TRAP emissions.
For Consideration: There have been studies in Ontario that have looked at the emission reductions achieved from the replacement of traffic signals and stop signs with roundabouts (Ontario Ministry of Transportation, 2007). In one study, replacing traffic signals and stop signs with roundabouts reduced CO emissions by 32%, NOx emissions by 34%, CO_2 emissions by 37%, and hydrocarbon emissions by 42%. When replacing traffic signals and stop signs with other traffic-calming measures, care should be taken not to create safety hazards.

#28 Designate truck traffic to specific times

Evaluation Result: Low effectiveness, high practicality
Responsibility: Provincial and municipal government (Leads); port authority (Support); involve the BC Trucking Association too
Description: Designate truck traffic on provincial roads to specific times such as encouraging off-hour deliveries to reduce congestion and daytime smog formation. For example, night-time deliveries were made during the 2010 Olympics in Vancouver to reduce vehicle congestion.
For Consideration: Alternative delivery times for truck traffic may be difficult to coordinate. There might be logistical issues regarding off-peak or evening deliveries, as well as concerns about noise pollution in the evenings.

4.2 CASE STUDIES / LESSONS LEARNED FROM BC AND OTHER AREAS

Examples where the strategies described in the previous section have been implemented at provincial / state or regional levels are presented in this section. A few examples are from within British Columbia, while most are from other areas. All of these strategies are related to transportation management or land use strategies, as most of the design and outreach strategies have been spearheaded by local government organizations.

Transportation Management Strategies

Commute Trip Reduction Programs

- In 1999 the state of Maryland passed a law giving employers a strong positive incentive to pay their employees extra for giving up their parking spot at work (VTPI, 2010a). The law, which went into effect in 2001, also extends tax credits to non-profit organizations such as schools or medical centers if they pay for employee transit benefits or other alternatives to driving. The tax credit is valued at half of whatever an employer pays toward an employee's transit or vanpool commuting costs, up to $30 each month. Supported by both business and environmental groups, the measures are helping to address traffic and air pollution problems.

- The San Joaquin Valley Air Quality Control District's *Rule 9410* requires employers with more than 100 eligible employees at a worksite to establish an Employer Trip Reduction Implementation Plan (ETRIP) to encourage employees to reduce single-occupancy vehicle trips, thus reducing commute trip pollutant emissions (VTPI, 2010a). Employers have the flexibility to choose the options that work best for their employees and work environments, and employers also have the option of suggesting measures that are not yet on the list. Each ETRIP measure has a point value, and an employer's ETRIP needs to meet the point targets specified in the rule.

Truck Licensing System (Federal example)

- In 2008, the Port of Metro Vancouver introduced a Container Truck Licensing System that ties environmental requirements to obtaining a license to deliver to the Port (Port of Metro Vancouver, 2011). The program addresses both trucks that are receiving a license for the first time, and to trucks that have been registered before. The focus of the system is to phase out older vehicles, and require improvements to other vehicles that are not meeting the opacity limits. The goal is to have the entire fleet at the equivalent particulate emissions of a 2007 or newer truck by 2017.

Land Use Strategies

Municipal Framework for Reducing Air Quality Exposure

- The Bay Area Air Quality Management is currently developing a Community Risk Reduction Plan (CRRP) guidance document, which will establish objectives, targets and a framework for creating a community-specific plan to reducing emissions and exposure to ambient air pollutants. The actions will focus on disproportionately exposed communities. In their final form, the Community Development Guidelines will provide municipalities with a list of best practices and actions that can be implemented to reduce exposure.

Smart Growth Policy

- The Portland, Oregon region is implementing a number of Smart Growth measures, including urban growth boundaries, extensive public transit service, and incentives for higher-density, infill development. The Region has adopted supportive land use policies to create transit-oriented development, and instead of funding highway projects, transportation funds are being used to rail development (VTPI, 2012b). As well, improvements to walking and cycling conditions and TDM measures have been implemented. A study conducted in 2008 suggested that the expansion in transit service and mixed land use made a significant contribution to the reduction of single occupancy vehicle trips (Jun, 2008).

Health Impact Assessments

- In Oregon, a Health Impact Assessment (HIA) was used to evaluate policies intended to reduce car use by reducing vehicle miles traveled (VMT) and greenhouse gas emissions. The HIA demonstrated that a combination of policies that decreased VMT, including creating neighborhoods with mixed-use, high density, good street connectivity and pedestrian/bicyclist-friendly infrastructures, and increasing transit coverage would maximize health benefits (APHA, n.d. and UCLA, n.d.).

Siting Restrictions for New Schools

- In 2003, the State of California passed legislation prohibiting schools from being located within 500 feet (150 m) of a freeway or other busy traffic corridor (Brauer et al., 2012). In a rural area, a busy traffic corridor is a roadway with an annual average daily traffic (AADT) volume greater than 50,000 vehicles, and in an urban area, a busy traffic corridor is a roadway with volumes greater than 100,000 AADT (N.B. this is not the same definition being used in this report, which considers a busy road as a roadway with 15,000 AADT or more).[11] Before a school site is approved, the school district must demonstrate that they are not within the 500 feet of a freeway, or if they are within 500 feet of a freeway, the school district must undertake risk assessment and air dispersion modeling to demonstrate that there are no significant short- or long-term

[11] For comparison, the southern section of Burrard Street has an AADT of 63,000.

health risks. However, if a school is required urgently, they may be exempt from having to meet these requirements.

Siting Restrictions for Childcare Centres

- Regional Public Health Service in Auckland, New Zealand, provides guidelines for the siting of early childcare centres (i.e., those that take care of children age 4 and under). The guidelines specify that such centres are not to be located either within 60 m of district or regional arterial roads, within 150 m of roadways (no traffic volume thresholds were provided), within enclosed parking facilities, within 300 m of industrial zones, or within 100 m of petrol stations. As a result, some new early childcare centres in Auckland have been refused licenses, while some are operating in the interim, but the Health Ministry is monitoring the air quality as there are air quality concerns (Brauer et al., 2012).

5. MUNICIPAL FRAMEWORK FOR REDUCING TRAP EXPOSURE

5.1 IS EXPOSURE TO TRAP A MUNICIPAL ISSUE?

Although municipalities in BC do not have direct authority over the management of air quality or the levels of emissions from vehicles, **municipalities do have authority over land use planning and urban design.** These areas impact vehicle travel distances (complete, compact communities have shorter vehicle trips), and the location of those emissions (vehicles on highways and major roadways) in relation to people's activities (residences and sensitive land uses).

Although regional air quality, as well as air emissions associated with point sources have been monitored and managed for decades in BC, the management of air emissions resulting from exposure to traffic on specific roadways is a new consideration for BC municipalities. It is only in the last decade that research has emerged demonstrating the links between increased risk of health problems and the levels of exposure to TRAP measured in BC municipalities.

The key areas where municipalities can influence exposure levels to traffic emissions are:

- land use planning (long-range and development)
- municipal road, cycling and pedestrian design and infrastructure
- traffic management
- parking management
- building design (in the case of the City of Vancouver)

Therefore, exposure to TRAP is an issue that municipalities increasingly need to be aware of, and consider the impacts of it when developing and undertaking policies and programs. This is an issue that should be considered alongside other planning considerations and community objectives. This chapter of the report provides guidance for municipalities to undertake the steps to characterize the levels of exposure in the community, and chart a course to reduce the levels where they are of concern.

5.2 COMMUNITIES WHERE TRAP IS A CONCERN

Any community that has residences or sensitive land uses adjacent to a major roadway that has over 15,000 average vehicles per day, or has major truck or bus routes may have elevated exposure to TRAP. In addition, if these high traffic corridors are being used by individuals undertaking susceptible activities such as cycling and walking, then these users may be exposed to higher levels of TRAP. In BC, these conditions are met in numerous municipalities of ranging

size and type, from rural areas to suburban areas, to urban centres. Duncan, Chilliwack, Prince George, Port Moody, Cranbrook, and every municipality in the Lower Mainland are examples of the variety of communities with high-enough volume traffic roadways to trigger potential concerns about TRAP exposure.

The characteristics of rural, suburban/general areas and urban centres are briefly described below.

Rural areas

Characteristics: low density residential connected by local streets, highways and major roads, and may be close to industrial or agricultural uses

Examples: rural areas of Prince George – there are many residential developments along Highways 97 and 16; rural areas of Chilliwack – there are some residential developments along Highway 1, such as near Evans Road

Receptors of concern: residents and individuals who spend a lot of time in traffic

Major Transportation Emission Sources: mostly light-duty vehicles and high-duty vehicles on highways and truck routes

Conditions or features that contribute to higher TRAP exposure: residences and / or sensitive land uses located close to highways and major truck routes; geographical conditions that trap air pollutants; locations where buses, trucks or cars idle; higher average commuting distances

Suburban / general urban areas

Characteristics: low / medium-density residential primarily with local-serving commercial connected by local streets, arterials, and major roads, and may be close to industrial uses

Examples: suburban or general urban areas of Surrey – Fraser Highway and King George are adjacent to sensitive land uses; and Richmond – Highway 99 runs alongside residential developments

Receptors of concern: residents, workers, and individuals who spend a lot of time in traffic

Major Transportation Emission Sources: mostly light-duty vehicles and some high-duty vehicles on major roads, truck routes, highways, and transit routes

Conditions or features that contribute to higher TRAP exposure: residents and / or sensitive land uses located close to distribution centres, major roads (including truck corridors) and highways, and frequent bus corridors; bus loops and exchanges; municipal heavy-duty vehicles operating in residential areas; locations where buses, trucks or cars idle; higher average commuting distances

Urban centres

Characteristics: established or emerging areas with medium or high-density residential and employment land uses connected by a major road network

Examples: Metro core (Vancouver centre), Surrey Metro core, regional city centres, municipal town centres such as New Westminster, and frequent transit development areas

Receptors of concern: residents, workers, and individuals who spend a lot of time in traffic

Major Transportation Emission Sources: mostly light-duty vehicles and some high-duty vehicles, including trucks and transit

Conditions or features that contribute to higher TRAP exposure: relatively high level of active transportation amongst residents; residents and / or sensitive land uses located close to distribution centres, major roads (including truck corridors) and highways, and frequent bus corridors; bus loops and exchanges; municipal heavy-duty vehicles operating in residential areas; locations where buses, trucks or cars idle

5.3 LOCATE THE CONCERN: IDENTIFYING POTENTIAL HIGHER TRAP EXPOSURE AREAS

Municipalities, with support from regional or provincial air quality authorities, should consider assessing their communities' traffic patterns relative to the location of residences, and sensitive populations and land uses to understand the levels of TRAP exposure in their communities. The following outlines key steps to take to create this baseline understanding:

- Contact the regional or provincial authority for air quality management in your region to find out what data (measured or modelled) is available for your community in relation to exposure to traffic emissions.
- Locate sensitive receptors on a map, including: residences, health-care facilities, schools and daycare facilities, parks and playgrounds, and cycle and pedestrian paths (existing and future where known). Lists of licensed community care facilities can be obtained from health authorities. Also consider areas that are expected to have significant new development or infill, as outlined in the community plan.
- Request technical support from your regional or provincial air quality, transportation and health authorities to identify higher TRAP exposure areas. This step will involve gathering traffic volume data and may involve air dispersion modelling and risk assessment expertise. Consider including this type of assessment as part of an Air Quality Management Planning process in collaboration with the Regional District, Province and local health authority.
- Based on this information, locate potential higher TRAP exposure areas on the same map. Also locate frequent diesel bus routes, and areas where vehicles spend significant time idling (border crossings, ports, distribution centres, bus loops, and major intersections). Locate any other point sources in the area to consider cumulative impacts across sources.

5.4 CONSIDER TRAP: AREAS OF MUNICIPAL INFLUENCE ON EXPOSURE LEVELS

As noted earlier, municipalities can have an important impact on the levels of exposure to traffic emissions through land use planning, urban design, and other transportation management activities. The most efficient and effective strategies for addressing TRAP will vary from community to community based on their unique combinations of receptors and sources, as well as the alignment with other local efforts around reducing air emissions or vehicle traffic.

This section provides a high-level picture of how different municipal departments can understand the implications of considering exposure to TRAP in their plans, policies and activities. Greater detail on several potential municipal strategies is provided in Chapter 6 of the report.

Long-range Planning Considerations

- How can the community be designed to reduce overall vehicle travel? This question is addressed in Official Community Plans (OCPs) throughout BC through smart growth policies including compact, infill, and mixed-use developments with good pedestrian and cycling connectivity, and good transit access and integration between different modes.
- Can mixed land uses (versus solely residential) be promoted within higher TRAP exposure areas?
- Can design guidelines be created to improve air circulation and prevent the trapping of pollutants in areas with multi-story buildings?

Development Planning Considerations

- Does a proposed location for a new building housing sensitive receptors fall within areas of concern? Can the building be located on a different property?
- Can buildings with sensitive receptors be located further away from major roadways or oriented on the property in a manner that reduces exposure to TRAP (e.g. locating building entrance and air intakes from major roadways and intersections and where vehicles idle)?
- Where buildings are within higher TRAP exposure areas, can air filtration units be installed in the new buildings?

Traffic Management Considerations

- Can speed limits be reduced to encourage steady traffic flow instead of stop-and-speed conditions, without creating more congestion?
- Can roundabouts be used in place of stop signs?

- Can traffic lights be adjusted to improve the flow of traffic, or to prevent idling adjacent to sensitive land uses?

Roadway Design and Active Transportation Infrastructure Considerations

- Can new roadways include separated pathways for pedestrians (e.g. sidewalks) and cyclists (e.g. bike lane)?
- How can existing roads be modified to include separated pathways for pedestrians and cyclists (using rights-of-way, reduced parking, land purchase)?
- Can transit-priority measures be introduced to make transit trip times more competitive with private automobiles, thereby reducing vehicle travel?

5.5 EMBED TRAP CONSIDERATIONS INTO COMMUNITY PLANNING

Once municipalities have a better understanding of the levels of TRAP exposure in their communities and particular areas of concern, the next step is to embed considerations for TRAP into various aspects of municipal activities, as relevant to each community. The following steps outline a method for doing this:

- Create community-specific objectives for reducing exposure to TRAP and aligning these exposure reduction objectives with other community objectives such as smart growth development
- Incorporate the objectives into Official Community Plans and area / neighbourhood plans N.B. As a part of the Healthy Families BC Communities initiative, provincial health authorities have been providing support to interested communities to develop plans to make their city or town healthier (BC Ministry of Health, 2011). More communities could take advantage of this initiative to develop plans to reduce exposure to TRAP.
- Incorporate considerations into design guidelines and infrastructure plans
- Identify appropriate reduction measures for specific areas
- Periodically monitor and reassess
- Support the local health authority, regional and provincial government, transportation authority, and other partners in communicating the health impacts of TRAP to residents, particularly vulnerable individuals, and steps individuals can take to reduce their exposure to TRAP

6. MUNICIPAL AND LOCAL ORGANIZATION STRATEGIES

As described in Chapter 5 above, there are numerous opportunities for municipalities to address exposure to TRAP, and many of these opportunities are aligned with objectives that BC municipalities are currently pursuing such as reduced traffic congestion, increased levels of active transportation, increased public transit use, and improved ambient air quality. This chapter outlines the key strategies that fall within the municipal realm of authority or influence, and identifies how certain strategies are more relevant to different contexts (e.g. urban, suburban and rural contexts). Opportunities for municipalities to roll out strategies may be accomplished with: plans and policies at a community-scale or neighbourhood-level (e.g. land use plans, transportation plans, area plans, and neighbourhood community plans), development and building regulations and guidelines, retrofit of existing sites and buildings, and stand-alone policies and projects.

See Chapter 4 for strategies that would be led by provincial or regional levels of government (N.B. there are some strategies where both provincial / regional and municipal / local organizations could take a lead).

6.1 OPPORTUNITIES FOR MUNICIPALITIES / LOCAL ORGANIZATIONS

6.1.1 Key Recommended Strategies

This section describes key recommended strategies for municipalities and local organizations. These strategies are considered to be highly effective in reducing exposure to TRAP, although some may be more difficult to implement. They also include supporting education / outreach strategies. For each key strategy described, the government agencies that could have a role in these initiatives are listed. In many cases, for successful and effective implementation, partnerships are required between multiple agencies, including partnerships with federal, provincial, regional governments and non-government organizations. Therefore, these agencies are also listed where appropriate, and the leading and supporting agencies have been suggested. In addition, it is recognized that these strategies also have co-benefits. As such, many of these benefits are also described.

Land Use Strategies

#1 Work with health authorities and other relevant agencies to develop a process for assessing health impacts of proposed new communities, infrastructure and transportation services, using an integrated approach that assesses the full range of health impacts, including quantification of air quality-health impacts

Evaluation Result: High effectiveness, high practicality

Responsibility: Municipal government and TA (for Major Road Network projects in Metro Vancouver) (Leads), Health authorities, Provincial and Regional government (Support)

Description: Strategy 4.2.4 in Metro Vancouver's Regional Growth Strategy states that "The role of municipalities is: Include policies within municipal plans or strategies, that may be referenced in the Regional Context Statements, which:" … "f) assess overall health implications of proposed new communities, infrastructure and transportation services, including air quality and noise, with input from public health authorities." Ideally, these assessments should be conducted before a project or plan is approved. If there are areas of concern and they can be reasonably mitigated, then these mitigation measures could be proposed.

For Consideration: The University of California Los Angeles, the UK Association of Public Health Observatories Health Impact Assessment Gateway and the World Health Organization's Health Impact Assessment website provide useful resources.

#2 Work with health authorities and other relevant agencies to develop best management practices that will mitigate exposure to TRAP in *identified* higher TRAP exposure areas[12] as part of zoning and development permit processes

Evaluation Result: High effectiveness, high practicality

Responsibility: Municipal government (Lead); health authority and school district (Support)

Land Use Typology Suitability: Highly suitable for urban centres, suburban / general urban areas, and rural areas.

Description: Develop best management practices to mitigate exposure to TRAP in identified higher TRAP exposure areas as part of zoning, development permit areas (DPAs) and / or development permit processes. The following options could be considered for higher TRAP exposure areas:

- Promoting a mix of land uses (e.g., commercial, retail, etc.) and incorporate measures that mitigate air pollution-related health risks
- Particular siting considerations and designs for sensitive land uses (day cares, schools, hospitals, senior residences, and long term care facilities, with a focus on vulnerable populations - e.g. government-supported housing)
- For residential developments, best management practices for higher TRAP exposure areas (e.g., even small separations are still beneficial to reduce exposure to pollutants; also note different pollutants dissipate at different distances)
- Encouraging mitigation through building design and operation, ventilation and filtration (see strategy #6) if siting restrictions are impractical or not aligned with broader emission reduction / land use policies and plans - e.g. smart growth

[12] The process for identifying higher TRAP exposure areas is described in Section 5.3.

For Consideration: The approach and tools for mitigating exposure to traffic emissions may be similar to those used for mitigating noise through siting and design considerations. DPAs have not been used to consider air quality concerns to date and would need to be used with caution. If used, DPAs can provide more flexibility than a Zoning bylaw, and could contain requirements that a developer install best available emissions technology in the DPA (Gage and Saha, 2006). Zoning bylaws may be employed for defining development within higher TRAP exposure areas.

The South Coast Air Quality Management District (2005) in California developed a document that provides guidance for considering air quality issues when selecting school sites. The US Environmental Protection Agency (2011) has also recently developed school siting guidelines, which includes a section on how to evaluate the impact of nearby sources of air pollution.

#3 Review urban growth and infill strategies and plans to incorporate TRAP considerations

Evaluation Result: High effectiveness, high practicality
Responsibility: Municipal government (Lead)
Land Use Typology Suitability: Highly suitable for urban centres and suburban / general urban areas, and medium suitability for rural areas.
Description: Review urban growth and infill strategies and plans to incorporate TRAP considerations. The following options could be considered for higher TRAP exposure areas:

- Promoting a mix of land uses (e.g., commercial, retail, etc.) within higher TRAP exposure areas and incorporating measures that mitigate air pollution-related health risks. This option would still continue to promote smart growth, and also reduce exposure to TRAP and health care costs.
- Locating improved pedestrian and cycling infrastructure to avoid highest exposure locations (e.g. avoid benches at busy intersections with high stop-and-go traffic and move them away to mid-block or closer to buildings)
- Creating pedestrian and cycling links further away from heavy vehicular traffic (see strategy #5)
- Identifying most relevant VKT (vehicle-kilometres traveled) reduction and vehicle emission exposure reduction strategies for specific infill neighbourhoods or corridors (e.g. a corridor identified for high density residential along a frequent bus route could be prioritized for electric or other emission reduction technologies)
- Other strategies mentioned in this chapter. E.g. improved roadway connectivity (which reduces total travel and allows more walking and cycling trips), improved land use mix (which reduces total trip distances and allows more walking and cycling trips for local errands), improved walkability, improved transit service quality and access to transit, and efficient parking management.

#4 Use neighbourhood design guidelines to avoid or mitigate street canyon effects

Evaluation Result: High effectiveness, low practicality
Responsibility: Municipal government (Lead)

Land Use Typology Suitability: Highly suitable for urban centres, and low suitability for suburban / general urban areas and rural areas.
Description: Use neighbourhood design guidelines to mitigate street canyon effects by staggering the siting of buildings that are perpendicular to predominant wind direction, or develop tall buildings on only one side of the street when perpendicular to predominant wind direction (dispersion modelling may be required).

For Consideration: For municipalities with existing guidelines about building heights (often used for the purpose of preserving views), review potential for adverse air quality impacts through monitoring or modeling.

Design Strategies

#5 Locate designated pedestrian and cycling routes further away from busy roads (e.g. parallel roads, separated bike paths) wherever possible

Evaluation Result: High effectiveness, high practicality
Responsibility: Municipal government (Lead)
Land Use Typology Suitability: Highly suitable for urban centres, suburban / general urban areas, and rural areas.
Description: Locate designated pedestrian and cycling routes further away from busy roads, truck routes and areas with heavy stop-and-go traffic, while keeping travel time the same. The route could be located outside a higher TRAP exposure area, on an adjacent parallel minor road where practical, or on a bike path 1 to 2 m further away from vehicle traffic.
Connectivity of routes and to destinations along the busy roads will also be important to maintain.
For Consideration: As described in the context section of this report, different pollutants disperse at different distances. Pollutant levels will be lower with distance from roads. Hence, even a small separation, such as a bike lane, will reduce exposure. It also has the significant benefit of improved safety and comfort, thereby potentially shifting more trips from motor vehicles to bicycle.

#6 For development / permit applications promote best practices for indoor air quality management and if municipalities have the authority, implement these practices

Evaluation Result: High effectiveness, high practicality
Responsibility: Municipal government (Lead)
Description: For rezoning applications, encourage best practices for indoor air quality management to be followed. For the City of Vancouver, these practices could also be incorporated into the existing municipal building code. These practices would be suitable for larger commercial, institutional, and residential buildings. These practices could include:

- Requiring that buildings have ventilation systems with air intakes away from busy roads, areas where vehicles idle, and loading docks (municipalities may also need to implement and enforce anti-idling bylaws)
- In high exposure areas, requiring heating, ventilation, and air conditioning (HVAC) systems start earlier in the morning when outdoor pollutant concentrations are lower, and turn systems off from the beginning of the morning rush hour until the systems must be on for occupation of the building. N.B. This requirement may need to be included in the BC Building Code (see page Provincial Strategy #3).

- In high exposure areas and in sensitive land uses, requiring or encouraging new facilities to have high efficiency particulate air (HEPA) filters and, if possible, retrofitting existing facilities with HEPA filters. Centralized filtration is preferred, but single room air cleaners may also work. An incentive / rebate program could also be established to provide HEPA filters for these facilities.
- Requiring or encouraging all new buildings be airtight (i.e., they must meet be at or below a certain infiltration rate) so that filtration systems work more efficiently and / or require buildings be installed with ventilation systems that keep a slight positive pressure indoors in high exposure areas.
- In high exposure areas, requiring or encouraging buildings to be designed with common main entrance and exit doors (if possible, orient entrances away from major roadways) to reduce infiltration of TRAP.

For Consideration: This initiative could potentially be implemented in a series of phases, where sensitive land uses and new buildings are targeted first.

For new buildings, municipalities could request for a concept plan to be submitted to address mechanical systems for building operation based on location and outside uses and encourage a high-level assessment of mechanical systems as they are being designed to ensure indoor air quality is being considered.

It should also be noted that HEPA filters will not reduce exposure to gaseous air pollutants (e.g. CO, NOx, SO_2) (BC Ministry of Environment, 2012). Also, as HEPA filters increase air flow resistance (static pressure) and can make HVAC motors less efficient, thereby increasing energy consumption. Further research could be done to compare the benefits of reducing exposure with increasing energy consumption and costs.

Transportation Management Strategies

#7 Enhance pedestrian and cycling infrastructure

Evaluation Result: High effectiveness, high practicality

Responsibility: Municipal government (Lead); transportation authority (in Metro Vancouver) (Support)

Land Use Typology Suitability: Highly suitable for urban centres and suburban / general urban areas, medium to high suitability for rural areas.

Description: Enhance pedestrian and cycling infrastructure. Examples include:

- On-street infrastructure and crossings that increase road and path connectivity and provide safe and attractive walking and cycling infrastructure (e.g. intersection treatments, traffic signal phases for cyclists and leading pedestrian intervals, separated paths, traffic calming

on local streets to support increased walking and cycling away from major streets, and wayfinding signage)

- End-of-trip and off-street infrastructure (e.g. off-street paths, end-of-trip facilities, and bike-sharing program)
- Maintenance plans and protocols (e.g. winter management plans such as snow clearance and salting and/or sanding plans for sidewalks and bicycle paths)

A complete streets policy would be a helpful framework to ensure a municipality is consistently designing and building and retrofitting streets for all modes.
For Consideration: The health risks an individual assumes (e.g. exposure to air pollution and injury) when choosing active transportation are outweighed by the health benefits that an individual gains (e.g. physical activity, mental health, affordability and basic mobility) in active transportation.

Funding for cycling infrastructure is available through the BC Ministry of Transportation and Infrastructure's BikeBC program, which includes the Gateway Program Cycling Plan and Cycling Infrastructure Partnerships Program, TransLink's Municipal Bicycle Infrastructure Cost Sharing program (BC Ministry of Transportation, 2012a and 2012b).

#8 Expand ride-share programs

Evaluation Result: High effectiveness, high practicality
Responsibility: Municipal governments or transportation authority (in Metro Vancouver) (Lead); involve rideshare providers too
Land Use Typology Suitability: Highly suitable for suburban / general urban areas and rural areas, medium suitability for urban centres.
Description: Rideshare programs including vanpooling can be established for regional and municipal employees, and promoted to businesses and schools for trips to work, school, and events.
For Consideration: Ride-share programs lead to 3-9% reduction in overall vehicle-kilometres traveled (VTPI, 2012e). Local rideshare program providers such as Jack Bell Foundation would be important partners to engage.

#9 Introduce or enhance commute trip reduction programs

Evaluation Result: High effectiveness, high practicality
Responsibility: Municipal government or transportation authority (in Metro Vancouver) (Lead)
Land Use Typology Suitability: Highly suitable for urban centres and medium suitability for suburban / general urban areas and rural areas.
Description: Introduce or enhance commute trip reduction programs to give commuters resources and incentives to reduce their automobile trips (commute trip reduction programs typically include a variety of transportation demand management strategies), and establish Transportation Management Associations (TMAs) to support these programs.
For Consideration: This strategy requires involvement, initiative and cooperation of larger employers and business associations. The leading agency could start implementation with larger employers, such as hospitals, and work with large employers on the formation of TMAs.

#10 Limit private vehicles near schools and daycares

Evaluation Result: High effectiveness, high practicality
Responsibility: Municipal government (Lead); school districts (Support)
Land Use Typology Suitability: Highly suitable for urban centres and suburban / general urban areas, and medium suitability for rural areas.
Description: Limit private vehicles near schools and daycares, either by:

- Designating drop-off / pick-up areas at other locations along the perimeter of the school (i.e. disperse vehicles away from the main school entrance), or
- Restricting vehicles from roads within one block of schools / daycares during school hours and requiring guardians to drop off or pick up their children at least one block away from the school and along designated "best routes to school", and use non-motorized transport for the last / first leg of the trip to / from school.

For Consideration: Parking signage (e.g. NO STOPPING ANYTIME signage) and traffic calming (i.e. traffic diverters) strategies could be implemented to prevent motor vehicle access to a school property or school area.

#11 Implement parking management strategies that help reduce TRAP

Evaluation Result: High effectiveness, high practicality
Responsibility: Municipal government (Lead); R (Support)
Land Use Typology Suitability: Highly suitable for urban centres, medium suitability for suburban / general urban areas, and low suitability for rural areas.
Description: Implement a more efficient parking management strategy to reduce TRAP. This could include:

- Increasing parking pricing in all areas with commercial/retail, high employment centres, institutions, etc., not just in downtown areas, targeting high exposure areas. Communities can aim to achieve 85% parking occupancy all day using variable parking rates. A review of 16 studies conducted across four continents (including the United States), all examining how much time people spend looking for parking, found that the average time it took to find a curb space was eight minutes, and about 30% of the cars in traffic were cruising for parking (Shoup, 2007). With the increased cost of parking, more people would be encouraged to shift to other modes (i.e., reduce the total number of vehicles) and those who still choose to drive would not have to spend as much time looking for parking (i.e., reduce the vehicle kilometres driven).

- Encouraging businesses to implement parking cash-out programs (e.g. employees might be able to choose between a free parking space, a monthly transit pass, or $75 cash per month) or charge employees for parking

- Supporting projects that unbundle parking from property prices so that parking stalls / permits associated with commercial and residential developments are sold separately from the units themselves. Would probably have to start with new developments, so it would take some time to see positive effects.

- Reducing parking supply (e.g. set parking maximums rather than minimums, shared parking, counting street parking as part of parking requirement) to discourage driving to destinations where transit and non-motorized transportation options are viable, and to simultaneously create an urban form that is conducive to non-vehicular travel (e.g. compact urban form, continuous streetscape, etc.)

- Implementing comprehensive parking policies to designate short-term parking from all-day parking and only locate all-day parking on the periphery of a municipality and to provide preferential parking for low-emission vehicles. This would reduce VKT into the heart of the community where emission exposure would be higher.

For Consideration: Based on City of Vancouver's experience, unbundling parking from property prices may be easier to accomplish with rental development than market condominiums (City of Vancouver, 2012b). Market condominiums have legislative obstacles (*Strata Property Act*), market obstacles (development community) and programmatic ones (e.g. is parking permanently bundled after first purchase) that need to be resolved.

Municipalities have requested the authority to require unbundling parking in new developments, which would require a change in provincial legislation (City of Vancouver, 2010). At the time this report was published, the proposal has not yet been approved.

#12 Establish public idling restrictions and campaigns

Evaluation Result: High effectiveness, high practicality
Responsibility: Municipal government (Lead); R (Support)
Land Use Typology Suitability: Highly suitable for urban centres, suburban / general urban areas, and rural areas.
Description: Establish public idling restrictions and campaigns, particularly for high exposure areas and sensitive land uses (e.g. schools) and heavy-duty vehicles, and in locations where there is greater control over traffic (e.g. BC Ferries has implemented an idle free program at ferry terminals and there is a queuing idle prevention program at the Peace Arch border crossing on the Canadian side).
For Consideration: Effectiveness could be improved with targeted enforcement and education, particularly around schools and other locations with high pick-up / drop-off activity. School districts and other local organizations would be important partners to engage.

#13 Establish Enviro-Fleets for vehicles that operate in residential neighbourhoods

Evaluation Result: High effectiveness, high practicality
Responsibility: Municipal government (Lead)
Land Use Typology Suitability: Highly suitable for urban centres and suburban / general urban areas, and medium suitability for rural areas.
Description: Establish Enviro-Fleets for vehicles that operate in residential neighbourhoods such as garbage trucks and school buses. As part of the Enviro-Fleets program, also retrofit heavy-duty vehicles with particulate filters and diesel oxidation catalysts. This has done for urban transit buses (funding provided by Environment Canada, the BC provincial government, and the Canadian Urban Transit Association), school buses (funding provided by Environment Canada and the BC provincial government), municipal fleet vehicles (funding provided by Environment Canada), and the BC provincial heavy-duty diesel vehicle fleet.
For Consideration: When selecting alternative vehicle propulsion systems and fuels, it is also important to consider the life-cycle costs (e.g. financial and environmental cost of battery replacement) and other impacts of each option. If this includes transit vehicles, consideration must be given to cost trade-offs between purchasing low-emission technologies and investing in improved transit service with older technology, where the latter may provide a greater overall benefit in terms of motor vehicle trip reduction.

#14 Encourage a truck licensing program to be implemented at ports

Evaluation Result: High effectiveness, high practicality

Responsibility: Municipal government to provide encouragement (Lead), port authority (Federal) to implement the program

Description: A truck licensing program at ports can include requiring trucks to meet specified emission standards in order to have a license to operate at the ports, and banning older, more polluting trucks from port terminals.

For Consideration: Port Metro Vancouver has already implemented a truck licensing program. Municipalities could encourage the Port of Metro Vancouver to continue the program, and to enhance the vehicle emission requirements over time to ensure the truck fleet continues to incorporate the cleanest technology feasible. Expansion of this program to other ports in the province may be applicable and could be evaluated on a case-by-case basis (e.g. Prince Rupert, Nanaimo). Truck volume data from ports would be valuable to determine if such a program is warranted.

#15 Establish low emission zones

Evaluation Result: High effectiveness, low practicality

Responsibility: Municipal government (Lead); regional and provincial governments (Support)

Description: Establish low emission zones where vehicles that do not meet certain emission standards must pay a substantial fee for each day they operate in the zone (as has been done in London, Berlin, and Stockholm – see section 6.2 for more details).

For Consideration: International experience says there is a lot of public concern beforehand for such zones. However, these concerns disappear following implementation, especially when the benefits are seen by the public (City of Vancouver, 2012a). Also, the technology exists to read plates and charge accordingly, but care must be taken when deciding whether or not a vehicle has high emissions.

Education / Outreach Strategies

#16 Encourage children and parents to walk and bike to school

Evaluation Result: Low effectiveness, high practicality

Responsibility: School districts (Lead); municipal government, transportation authority (in Metro Vancouver), and health authority (Support); involve other non-government organizations such as HASTeBC (Hub for Active School Travel in British Columbia) too

Description: Encourage children and parents to walk and bike to school through Safe / Best Routes to School programs or at least park a few blocks away from the schools and walk the rest of the way (to reduce school parking and air pollution problems, and encourage exercise). Using public transit is also another alternative, as parking along residential streets may require residential parking permits. Also encourage school bus drivers, parents, and students to choose school routes that avoid pollution hotspots unless the alternative route significantly increases travel distance.

For Consideration: The health risks an individual assumes (e.g. exposure to air pollution and injury) when choosing active transportation are outweighed by the health benefits that an

individual gains (e.g. physical activity, mental health, affordability and basic mobility) in active transportation.

A good source of information on how to implement this initiative is the HASTeBC website (www.hastebc.org).

#17 Encourage cyclists to choose low-traffic routes wherever possible

Evaluation Result: Low effectiveness, high practicality
Responsibility: Municipal government, transportation authority (in Metro Vancouver), and health authority (Leads); involve bicycle user groups too
Description: Encourage cyclists to choose low-traffic routes by making them aware of the potential health benefits. Encourage use of route planners that allow active commuters to choose 'least traffic pollution' in selecting route preferences (e.g. Cycling Metro Vancouver route planner), and engage cyclists through the route planners to identify barriers that cyclists face if they want to ride on routes with less traffic.

6.1.2 Additional Strategies

This section highlights additional strategies that municipalities and local organizations could consider. These strategies may not be as effective in reducing exposure when implemented on their own or may not be feasible in the short term. As noted in the provincial strategies, due to significant variations in how these strategies may be applied, their effectiveness and / or feasibility may be higher given certain conditions and could be considered where practical. They may also have a significant impact when implemented together and / or may be feasible in the longer term.

Design Strategies

#18 Create barriers between emission sources and higher TRAP exposure areas

Evaluation Result: Low effectiveness, high practicality
Responsibility: Municipal government (Lead)
Land Use Typology Suitability: Highly suitable for urban centres, suburban / general urban areas, and rural areas.
Description: Create barriers such as walls and landscaped boulevards and medians between emission sources and higher TRAP exposure areas.
For Consideration: Local meteorology and site design are critical factors affecting the effectiveness of barriers. Also, walls may be less feasible to build, while landscaping, medians are feasible depending on impacts on road users, business, etc.

#19 Build well-ventilated tunnels on municipal roads where there is higher TRAP exposure

Evaluation Result: Low effectiveness, low practicality

Responsibility: Municipal government and transportation authority (for Major Road Network in Metro Vancouver) (Leads)
Description: For higher TRAP exposure areas, build well-ventilated tunnels to enclose, capture and properly disperse emissions in enclosed areas and use surface to improve pedestrian connectivity.
For Consideration: It is likely difficult to justify the construction of a tunnel if the only reason is to reduce exposure to TRAP. It is more likely that a tunnel would be built to meet other objectives such as aesthetic reasons (preserving the above-ground view, landscape, and scenery), connectivity reasons (preserving above-ground connectivity of existing pathways. However, if a tunnel is built, then residents living near the tunnel would have the added benefit of reduced exposure to pollutants from vehicles operating within the tunnel.

Transportation Management Strategies

#20 Expand car-share programs

Evaluation Result: Low effectiveness, high practicality
Responsibility: Municipal government or transportation authority (in Metro Vancouver) (Lead)
Description: Car-share programs (e.g. Modo, Car2Go, Zipcar) can be established for regional and municipal employees, and promoted to businesses and schools for trips to work and school.
For Consideration: Motorists who shift from car ownership to car-sharing typically reduce their vehicle travel 30-60%, and car-sharing programs can lead to 1-2% reduction in overall vehicle-kilometres traveled (VTPI, 2012e). Data also show that each shared vehicle can replace 15-30 privately owned vehicles (Modo, 2012 and Zipcar 2011). Local car-sharing providers such as Modo, Zipcar, and Car2Go would be important partners to engage.

#21 Encourage part-time teleworking

Evaluation Result: Low effectiveness, high practicality
Responsibility: Municipal government or transportation authority (in Metro Vancouver) (Lead); involve business industry associations too
Land Use Typology Suitability: Highly suitable for urban centres, suburban / general urban areas, and rural areas.
Description: Encourage part-time teleworking where it is possible.
For Consideration: To implement strategy, a municipality could start with large employers where teleworking is feasible.

#22 Encourage organizations to manage vehicle fleets to reduce vehicle kilometres traveled

Evaluation Result: Low effectiveness, high practicality
Responsibility: Municipal government and / or transportation authority (in Metro Vancouver) (Leads); regional government (Support)
Description: Organizations can be encouraged to consolidate trips and find shorter routes where possible, and a municipal or regional government can implement a Clean Fleet Challenge where businesses are challenged to reduce their commercial fleet emissions by a specified percentage (e.g. 20% by 2020).

For Consideration: The leading agency can first find out who has the largest vehicle fleets with the largest impacts, and approach them directly to discuss options that would help reduce their VKTs and the benefits of these options, including reduced operating costs for businesses.

#23 Implement traffic calming measures

Evaluation Result: Low effectiveness, high practicality
Responsibility: Municipal government (Lead)
Land Use Typology Suitability: Highly suitable for urban centres and suburban / general urban areas, and medium to high suitability for rural areas.
Description: Traffic calming tends to reduce total vehicle travel in an area by reducing travel speeds and improving conditions for walking, cycling and transit use. However, traffic dynamics would need to be considered before implementing any traffic calming measures.
For Consideration: Traffic-calming measures may have the potential to divert traffic elsewhere and increase travel distances, as well as possibly concentrate more traffic on major roads, increasing TRAP exposure there.

#24 Promote enhanced electric vehicle infrastructure in all new developments

Evaluation Result: Low effectiveness, high practicality
Responsibility: Municipal government (Lead)
Land Use Typology Suitability: Highly suitable for urban centres, suburban / general urban areas, and rural areas.
Description: Requiring enhanced electric vehicle infrastructure in all new developments will enable those residents who are interested in switching to electric vehicles to do so.

#25 Provide more infrastructure for electric and other cleaner vehicle technologies / fuels for high emitting vehicles

Evaluation Result: Low effectiveness, high practicality
Responsibility: Municipal government and port authority (federal) (Leads); provincial government (Support)
Description: Infrastructure for electric vehicles and other cleaner vehicle technologies / fuels (e.g. compressed natural gas) can be installed at ports and distribution centres for trucks. This would provide encouragement to truck drivers to plug-in while loading and unloading their vehicles or use other cleaner vehicle technologies / fuels.
For Consideration: The Plug-In Vehicle project in BC has included the development of Electric Vehicle Charging Infrastructure Deployment Guidelines, and City of Vancouver has a Charge and Go Vancouver electric vehicle infrastructure trial. These programs can be expanded to include the installation of electric vehicle infrastructure at ports and distribution centres.

Also, in 2010, the Natural Gas Use in the Canadian Transportation Sector Deployment Roadmap initiative, which was facilitated by Natural Resources Canada, was launched (Natural Gas in Transportation Roundtable, 2010). The roadmap focuses on expanding the use of natural gas in the Canadian transportation sector through a number of strategies such as addressing information gaps, de-risking investment and early adoption, increasing capacity (by developing standards and codes, training materials, etc.), and ensuring on-going competitiveness (e.g. by increasing

research and development funding). If this initiative is successful, the number of CNG vehicles may increase in the near future.

#26 Establish Municipal Green Fleets

Evaluation Result: Low effectiveness, high practicality
Responsibility: Municipal government (Lead)
Land Use Typology Suitability: Highly suitable for urban centres, suburban / general urban areas, and rural areas.
Description: Establish Municipal Green Fleets and lead by example by procuring cleaner vehicle technologies, right-sizing vehicles, and encouraging carpooling (e.g. both Cities of Vancouver and Surrey have invested in low or no-carbon vehicles and energy efficient technologies for their municipal fleet).
For Consideration: When selecting alternative vehicle propulsion systems and fuels, it is also important to consider the life-cycle costs (e.g. financial and environmental cost of battery replacement) of each option.

#27 Condition or filter air in buses (school and transit)

Evaluation Result: Low effectiveness, high practicality
Responsibility: School districts and transportation authority (Leads)
Description: Public and school buses can be fitted with air filtration units to reduce exposure to air pollutants.
For Consideration: The positive impact of filtration can easily be confounded if buses have operable windows. Filtration is only effective for particulate matter, but not for gaseous pollutants (NOx, CO, SO_2).

#28 Within higher TRAP exposure areas along municipal roads, consider implementing or expanding vehicle speed management strategies (e.g. strategies that reduce stop-and-go traffic or reduce vehicle speed)

Evaluation Result: Low effectiveness, high practicality
Responsibility: Municipal government (Lead)
Description: Within higher TRAP exposure areas along municipal roads, measures such as electronic tolls, signal synchronizations, and replacing stop signs with yield signs or roundabouts can be employed to avoid stop-and-go traffic. As shown in Figure 3 in section 2.2.3, having speed limits between 20 and 50 km/h (taking into consideration traffic dynamics) can also reduce TRAP emissions.
For Consideration: There have been studies in Ontario that have looked at the emission reductions achieved from the replacement of traffic signals and stop signs with roundabouts (Ontario Ministry of Transportation, 2007). In one study, replacing traffic signals and stop signs with roundabouts reduced CO emissions by 32%, NOx emissions by 34%, CO_2 emissions by 37%, and hydrocarbon emissions by 42%. When replacing traffic signals and stop signs with other traffic-calming measures, care should be taken not to create safety hazards.

#29 Designate truck traffic to specific times

Evaluation Result: Low effectiveness, high practicality

Responsibility: Municipal and provincial government (Leads); port authority (Support); involve the BC Trucking Association too

Description: Designate truck traffic to specific times such as encouraging off-hour deliveries to reduce congestion and daytime smog formation. For example, night-time deliveries were made during the 2010 Olympics in Vancouver to reduce vehicle congestion.

For Consideration: Alternative delivery times for truck traffic may be difficult to coordinate. There might be logistical issues regarding off-peak or evening deliveries, as well as concerns about noise pollution in the evenings.

#30 Design bus shelters to reduce exposure to air pollutants

Evaluation Result: Low effectiveness, high practicality

Responsibility: Municipal government (Lead); transportation authority (Support)

Description: Design bus shelters to reduce exposure to air pollutants (e.g. orient a bus shelter such that the opening is away from the roadway). As most bus shelters within the Lower Mainland have panels only on one or two sides, allowing greater airflow, this recommendation may be more suitable for other parts of the province where bus shelters are more enclosed. Transparent panels should be considered to maintain visibility.

- **For Consideration:** A study in Portland, Oregon found that the orientation of a bus shelter can play an important role in how much exposure transit users have to particulate matter (Moore and Figliozzi, 2011). When a bus shelter faced the roadway (i.e., the panels are oriented to form an opening facing the roadway), measurements of particulate matter inside the shelter were, on average, 17.5% greater than measurements outside the shelter. In comparison, when the shelter faced away from the roadway, measurements inside the shelter were 23.8% less than measurements outside the shelter. When a bus shelter faces the road, particulate matter is trapped in an enclosed area so dispersion does not immediately take place. When shelters face away from the roadway, particulates do not immediately enter the shelter, allowing time and distance for dispersal. It was also noted that increased air flow through a shelter that faces the roadway could allow pollutants to disperse more quickly.

#31 Re-route heavy duty truck and freight routes away from residential and mixed-use residential areas

Evaluation Result: Low effectiveness, low practicality

Responsibility: Municipal government (Lead); transportation authority (in Metro Vancouver) (Support)

Description: To reduce residents' exposure to traffic emissions, truck routes could be designed such that trucks operate away from residential and mixed-use residential areas.

For Consideration: In urban areas, most arterial streets have residences. Therefore, this strategy may be more applicable in rural settings.

#32 Implement circulation changes that would re-route through-traffic away from residential and mixed-use residential areas

Evaluation Result: Low effectiveness, low practicality
Responsibility: Municipal government (Lead); transportation authority (in Metro Vancouver) (Support)
Description: Implement circulation changes that would re-route through-traffic, especially trucks, and reduce the volume of traffic on streets programmed for residential or mixed-use residential use.
For Consideration: In urban areas, most arterial streets have residences. Therefore, this strategy may be more applicable in rural settings.

6.2 CASE STUDIES / LESSONS LEARNED FROM BC AND OTHER AREAS

This section provides some examples of strategies that have been undertaken by municipalities and other local organizations, both within BC and other areas. Where possible, emphasis has been placed on examples where results have been documented. In some cases (e.g. the construction of a tunnel), while the primary motivation for the change may not be to reduce exposure or emissions, these are co-benefits that have resulted from the change made.

Transportation Management Strategies

Enhanced Pedestrian and Cycling Infrastructure

- In 2007, the New York Department of Transportation transformed Ninth Avenue in Manhattan into a "complete street" (VTPI, 2012c). The design includes a separated bicycle lane located between the parking lane and the sidewalk, shortened pedestrian crossings (through refuge islands and curb bulges), and separated signal phases for cyclists and motorists. This resulted in dramatically improved safety conditions for pedestrians and cyclists.

- The City of Vancouver has numerous pedestrian and cycling initiatives underway. For example, along many arterial streets within the City of Vancouver, the City is working towards providing wider sidewalks when a redevelopment occurs. Examples include the Broadway corridor and the Kingsway corridor (City of Vancouver, 2012a). City is also working with Vancouver General Hospital, which is located on 10th Avenue just north of Broadway, to develop a Wellness Walkway around the hospital. The Wellness Walkway will feature more pedestrian lighting, benches, and more landscaping (e.g. small gardens, public art, and trees) which would often mean there would be increased separation from traffic.

  As well, along the city's designated bikeways such as 10th Avenue, the City has implemented a number of traffic calming measures to reduce traffic volumes and speeds, and installed additional signage and pavement markings (e.g. green paint) to improve safety. The City also plans to launch a public bike share system in 2013 (City of

Vancouver, 2012c). As mentioned previously, the City also introduced separated bike lanes and they have worked with private businesses to install more bicycle racks and corrals around the city.

- The City of Surrey has recently adopted a Cycling Plan to improve cycling in the coming years (City of Surrey, 2012). which consists of three main principles:

  - Making Connections (on and off street cycling network);
  - Providing Door to Door Service (improved end of trip facilities);
  - Managing and Maintaining the Network (keeping network safe, visible and in optimum condition)

- The plan addresses a range of factors that are important to make cycling a safe, attractive, and viable transportation option. In addition to separated bike lanes, it includes measures to improve safety at intersections, providing more public bike racks, and enhancing signage.

- The City of Kelowna recently received recognition for updating its design guidelines to prioritize sustainable transportation. The new guidelines include (City of Kelowna, 2012):

  - including pedestrian and cycling paths on all new roads
  - separating pedestrian and cycling paths from higher speed limit roads
  - priorities for creating enough space for separated paths – e.g. where the right-of-way is insufficient, remove on-street parking
  - improved design of intersections to improve safety

  These guidelines may be helpful to other municipalities throughout BC who are interested in prioritizing active transportation infrastructure in new and existing roadways.

Congestion Pricing

- London's well-known Congestion Charging Scheme (CCS), which was introduced in 2003, limits the number of vehicles entering central London each day. This strategy has significantly reduced traffic volumes within the congestion zone – approximately 20% reduction compared to before (Brauer et al., 2012). Meanwhile, traffic volumes outside the congestion zone have not been reduced. Also, one 2008 study estimated that NO2 and PM concentrations were reduced compared to surrounding areas (Ibid).

  That being said, a more recent evaluation found that reduction in TRAP concentrations due to the CCS and Low Emission Zone (see below) may not have been as significant as projected, as there is a shift from personal gasoline-fueled vehicles towards diesel-fueled taxis and buses (Ibid). It should also be noted that emissions outside a congestion zone could increase as a result of the introduction of a congestion zone.

- In 2006, Stockholm also tested a congestion tax, and in 2007, this tax became permanent. It was found that emissions have declined faster than what they would have without the tax (Stockholm Environment and Health Administration, 2010 and Börjesson et al., 2011). This is due to a shift from gasoline-powered vehicles to alternative fuel vehicles, as alternative fuel vehicles were exempt from the congestion tax until January 2012, as well as a shift to other modes (24% of car work trips changed to transit and 21% of car non-work trips shift to other modes). Traffic volumes have also been reduced during periods with the congestion tax.

Low Emission Zones

- When London implemented Congestion Charging Scheme, it also introduced a Low Emission Zone (LEZ). The LEZ includes greater London and is in effect 24 hours per day, all-year round. Vehicles that do not meet Euro emission standards must pay a substantial fee for each day they operate in the zone.

- Berlin has also restricted travel in its inner city Environmental Zone to low emission vehicles since 2008.

    - According to the brochure, Stage 2 of the environmental zone will virtually halve the fine particle emissions from diesel exhausts (Impacts, 2007).
    - More pre-program info can be found on the Impacts website (2007).

- Stockholm requires the rationalization of heavy truck traffic before it enters the city centre.

    - "In 1996 access restrictions for the city centre for diesel driven trucks and buses over 3.5 tons was introduced. Only vehicles not older than eight years are exempted from these access restrictions. The results of this measure are positive; noise peaks have been reduced and air pollution has decreased" (European Commission, 2002).
    - Pilot program to run electric-diesel hybrid heavy-duty vehicles – electric mode while delivering within the city centre; switch to diesel mode if needed outside city centre. Operate from an Urban Distribution Centre (UDC) that provides appropriate charging stations etc.

Electronic Toll Payment

- Introducing an electronic toll collection along the New Jersey Turnpike to reduce congestion was associated temporally and spatially with reductions in incidence of prematurity and low birth weight among mothers living near toll plazas (Currie, 2009).

- The Province of BC has introduced electronic tolls on their two new bridges, Golden Ears Bridge, and Port Mann Bridge, to fund the cost of building the bridges.

Metered Parking

- In Redwood City, California, meter rates are set to achieve an 85% occupancy rate for curb parking downtown (Shoup, 2007). The rates differ by location and time of day, depending on demand. This means that visitors can easily find a space and avoid cruising around, which generates unnecessary vehicle emissions. The city returns the revenue for added public services in the metered district, such as increased police protection and clean sidewalks. When the merchants and property owners learned that the revenue would pay for community services in the downtown business district, they supported the new policy and the city council adopted it unanimously.

- Old Pasadena's downtown in California had a similar experience. After they started charging for on-street parking, they found that there was a higher turnover of vehicles and the revenues from the meters and the fines could be used to fund public improvement projects and operations to revitalize the downtown (VTPI, 2011b). These improvements included new street furniture and trees, more police patrols, better street lighting, more street and sidewalk cleaning, pedestrian facility improvements and marketing.

Parking Policy

- Due to increasing congestion and air quality concerns, in 1999 the City of Perth in Australia developed a comprehensive parking policy and license fee for the urban core (Brauer et al., 2012). The policy included maximum levels of parking for new non-residential development within the city. It also established three parking zones to control public parking – a pedestrian priority zone where no parking is permitted; a short stay zone; and a general parking zone, where all-day parking is permitted, which is on the perimeter of the city. After ten years, the City has seen a significant shift from private automobiles to public transit and a significant reduction in traffic within the City and on roads leading to the city.

Limiting Private Vehicles around Schools

- L'Ecole Bilingue Elementary School in the City of Vancouver has implemented a "NO STOPPING" zone along the front of the school in favor of walking and cycling. The school initiated this strategy in consultation with staff. Motor vehicle access however was maintained at the sides and rear of the school (City of Vancouver, 2012a).

Commute Trip Reduction Programs

- At four British hospitals, commute travel plans have been implemented. Table 6 summarizes the changes in commute travel by employees as a response to the implementation of these plans. The results indicate an average 17-point mode shift from driving to alternative modes, resulting in an average 24.5% reduction in automobile commuting (VTPI, 2010a).

Table 6: Hospital Commute Mode Split

HOSPITAL	Mode	Before	After	Change (points)
Addenbrookes, Cambridge	Car	74%	49%	**-25**
	Bus	4%	19%	+15
	Walk	4%	6%	+2
John Radcliffe, Oxford	Car	58%	54%	**-4**
	Bus	7%	9%	+2
	Walk	12%	14%	+2
Derriford Hospital, Plymouth	Car	78%	54%	**-24**
	Bus	8%	15%	+7
Nottingham City Hospital	Car	72%	55%	**-17**
	Bus	11%	19%	+8
	Walk	8%	9%	+1

- The Vancouver International Airport's Green Commuter Program encouraged staff to make green commuting choices and reduces parking demand by offering employees $50 per month if they car-pool, cycle, walk or take public transit to work (VTPI, 2010a). All employees (full-time, part-time and contract) qualify. Employees must use a green transport choice at least 16 times out of each 22 day work period. Participants are allowed to expense a taxi ride home for personal or family emergency. The program works on the honor system. After two years of operation:

  - The program has 90 employees enrolled, representing 22.5% of Airport Authority employees.
  - Eliminating the lowest and highest participation months (January at 28 and May at 56), an average of 49 employees participated in the program each month.
  - 84% of program participants commute by car-pool, while 16% commute by bus, and 1% bicycle or walk.
  - 61% of participants changed their commuting mode as a result of the program.
  - Program participation continues to grow.

Municipal Green Fleet

- The City of Vancouver has implemented a four-pillar approach to reduce the emissions of their vehicle fleets (City of Vancouver, 2012a). The first pillar involves using new vehicle technologies such as hybrid-electric drivetrains and auxiliary power units that allow hybrid vehicles to operate vehicle accessories (e.g. boom cranes) without having to turn on the engine. The second is the use of alternative fuels including biodiesel. 100% of the municipal vehicle fleet uses a biodiesel blend. The third pillar involves providing on-going driver training on fuel efficiency. According to the City, on-going training and education is required to maintain the positive benefits of such a program. The fourth and last pillar is the Green Operations Program, where all municipal departments with fleet vehicles are required to set emission reduction targets and develop a proposal of strategies on how they will meet those targets. On a monthly basis, fuel consumption information is collected to determine how they are progressing in their initiatives.

- The City of Kelowna has also initiated a number of measures to reduce their vehicle fleet emissions (City of Kelowna, 2012). These measures include: a three-minute idling policy; equipping all vehicles with GPS units to monitor idling and to assist in route management (to reduce VKTs and maintenance costs); using biodiesel, smart cars, and hybrid-electric vehicles; and installing solar-assist systems to power vehicle hazard lights, thereby reducing the need to idle. According to the City, the use of hybrid vehicles has been of particular benefit to residents, as vehicles no longer have to idle to operate their vehicle equipment when doing maintenance / repair work.

Electrical Vehicle Infrastructure

- To accommodate electric vehicles and support early adopters of electric vehicles, the City of Vancouver now requires all new single family homes and off-street bicycle storage rooms to have dedicated electric plug-in outlets and 20% of all parking stalls in all new condo buildings to have charging infrastructure (City of Vancouver, 2012b).

Logistics Program

- In Germany, approximately 80 cities have set up "City Logistic" projects where shipments are consolidated outside the city and better coordinated within the city (VTPI, 2011a). A trans-shipment facility and a new company that coordinates the delivery services within the city are set up by the municipality, chambers of commerce and large haulers. The service uses vehicles with air and noise emission reduction features. These projects have resulted in less spending on roads, less noise and pollution, and reduced costs for manufacturers.

Land Use and Related Strategies

Municipal General Plan that Contains an Air Quality Section

- The City of San Francisco has developed an Air Quality section in the General Plan that identifies six objectives in the following areas: (1) adherence to air quality standards, (2)

improvements related to mobile sources, (3) land use planning, (4) public awareness, (5) reduction of dust, and (6) energy conservation. Objective 3 states: "Decrease the air quality impacts of development by coordination of land use and transportation decisions" and it is supported by nine policies. Policy 3.7 explicitly links building design and sensitive land uses near freeways:

> *POLICY 3.7 Exercise air quality modeling in building design for sensitive land uses such as residential developments that are located near the sources of pollution such as freeways and industries.* (City of San Francisco, 2012)

Design Strategies

Tunnels

- When a new tunnel was constructed in Sydney, a study found that there were significant decreases in NO2, NOx, and PM10 concentrations in the area immediately adjacent to the bypassed main road (Cowie et al., 2012). If people worked, lived or played near this road, it is likely that the tunnel reduced their exposure to local NO2, NOx, and PM10 emissions.

Separated Bicycle Routes

- Evidence in a study of cyclists in Vancouver and Toronto confirmed an earlier finding (Teschke et al., in press), which suggests that separated routes for cyclists could be a "win-win", reducing both risk of injury and TRAP exposure (Brauer et al., 2012). In the case Vancouver, after the Dunsmuir separated bike lane was completed in June 2010, cycling volumes in June 2011 were 50% higher than the June 2010 levels (City of Vancouver, 2011). The same study also found that the percentage of women cycling on the Hornby separated bike lane also increased from 28% to 32% and the percentage of children cycling on weekdays increased from 0.14% to 0.41% (Ibid).

Municipal Bylaw Requiring Filtration Systems

- The City of San Francisco implemented Article 38 of the Health Code entitled *Air Quality Assessment and Ventilation Requirement for Urban Infill Residential Developments* that requires all new buildings with 10 or more units located within defined "potential exposure zones" to undertake an Air Quality Assessment for levels of PM2.5 derived from local traffic sources (City of San Francisco, 2008). If the levels measure higher than 0.2

ug/m^3 then the applicant must either move or reorient the building on the site to a location that measures less than this prescribed level, or must submit a ventilation plan for approval. The ventilation plan must remove more than 80% of the particulate matter inside the residential units.

Filtration Systems

- Two elementary schools and one high school in Las Vegas, Nevada, received funding from the transportation authority to install enhanced filtration systems (Sonoma Technology, 2010). The original ventilation system removed approximately 45% to 75% of the black carbon observed at the outdoor air intake, but the enhanced filtration systems removed about 77% to 98% of the outdoor black carbon concentrations.

Education / Outreach Strategies

Active and Safe School Transportation

- The Cities of Surrey, Vancouver, Kelowna, New Westminster, Langley, and Vernon, as well as a number of other communities are implementing active and safe school transportation programs. These programs include improving pedestrian and cycling infrastructure, as well as encouraging students and their families to walk or cycle to school (HASTE, 2012 and City of Kelowna, 2012). In New Westminster, it was found that a combination of traffic calming, safety education, an in-class Cool Routes to School program, along with safe route maps for all elementary schools made a significant difference. At Richard McBride elementary, there was an 18% increase in walking and at Ecole Glenbrook middle school, which has a larger catchment area, walking increased by 9%. At Queensborough middle school, the number of students driven to school dropped by 17%.

  Similarly, the City of Surrey has seen positive results from their program. In 2011 / 2012, a unique Student-Led Active School Travel Program was piloted at two schools. This program provided a small group of grade seven students at each school with guidance from a School Travel Facilitator and the opportunity to develop and deliver their own safe and active school travel program. Within a school year, the percentage of students cycling at Beaver Creek Elementary more than tripled, and the percentage of students cycling at Ecole Riverdale, which has a larger catchment area, increased from 0.5% to 2.5% (Stantec, 2012).

Community Partnership, Assessment, Outreach, and Development of Culturally Appropriate Education Modules

- A multi-year project in six freeway-adjacent neighbourhoods of Boston, Massachusetts called CAFEH (Community Assessment of Freeway Exposure and Health) is a community-based participatory research project that has full participation of the community partners in all aspects of the science including: developing the proposal, leading the study, collecting, analyzing and interpreting the data. The aim is to assess the association between exposure to air pollutants emanating from highway traffic and cardiac health in communities near highways. They are collecting and comparing measurements of highway-generated air pollution including ultrafine particulates (UFP) less than a millionth of a meter in diameter, with measures of health including blood pressure and C-reactive protein (CRP), a measure of systemic inflammation in adults. They are measuring changes in air pollution levels and health impacts as a function of distance from highways in six communities in greater Boston.

- Another important aim of the study is been to investigate the community and cultural understanding of the effects of air pollution on health among people living in neighborhoods adjacent to major highways. Building on this work, they will develop and field test culturally appropriate, educational modules that will raise awareness of risks and countermeasures (from CAFEH website http://sites.tufts.edu/cafeh/project-description/cafeh-study/).

Public Information about Higher TRAP Exposure Areas

- The City of San Francisco has developed a map of Potential Roadway Exposure Zones which is published on the City's website to inform the public about exposure near freeways and other major roadways (see http://www.thehdmt.org/indicators/view/40). This allows residents to understand the potential risks of choosing to reside in various areas of the city. The map is used as part of a program that determines whether new buildings require additional air filtration to reduce exposure. If considered locally within BC, the leading agency should investigate the liability issues of publicizing such information.

Traffic Pollution Outreach Program at Museum

- As part of the CAFEH project (see above), leaders and participants surveyed museum visitors regarding pollution in their communities, presented maps of traffic pollution in the greater Boston area, oversaw an air pollution puzzle contest and made pinwheels with younger visitors to demonstrate the impacts to lung function associated with traffic pollution. A podcast produced during the event can be downloaded from the Museum of Science website at: http://www.mos.org/events_activities/podcasts&d=4838.

7. RECOMMENDED ENGAGEMENT STRATEGY

Through the course of this document, numerous opportunities for reducing exposure to traffic-related air pollutants have been identified. These opportunities do not fall within one organization's authority or realm of influence, but rather across organizational and jurisdictional boundaries. Therefore, undertaking a comprehensive strategy for minimizing current and potential future exposure levels will involve identifying and engaging a cross-section of organizations, and people within the organizations, to:

- create a common language for communicating about TRAP;
- raise awareness about the impact of each organization's initiatives on exposure to TRAP;
- align with related initiatives and objectives; and
- create a partnership to maintain ongoing dialogue and share information about new research.

7.1 CREATE A COMMON LANGUAGE

Due to the diversity of organizations that can influence the levels of exposure to TRAP, it will be essential to create clear messages using a common language. The audience ranges from municipal and regional planners and transportation engineers, to fleet operators, school districts, industry, and politicians. A first step will be creating a "Toolbox" of factsheets to ensure consistency in the message that is communicated to the different audiences, but that is tailored to their areas of influence.

Through the course of this study, representatives from several BC municipalities were interviewed to assess their understanding of the issue of exposure to TRAP, and to gauge whether current practices are aligned with the objectives of reducing exposure. Consistently across all municipalities interviewed, there was limited to no awareness or attention given directly to the objective of reducing exposure to TRAP. This is in part due to a lack of information and understanding of the health impacts of TRAP and the implications of different transportation, land use, and design measures on exposure to TRAP. However, all of the municipalities interviewed have undertaken and have plans to undertake further measures to reduce vehicle kilometres travelled in their communities, with the objectives of mitigating climate change impacts, promoting more active mobility choices, improving overall air quality and numerous other community sustainability and health objectives. Further, there was interest from all municipalities in further understanding the impacts of TRAP in their communities, and understanding what measures can be undertaken to mitigate those.

Therefore, it is important to make this information available to municipalities in an easily understandable manner. To assist with this, provincial/regional governments plan to develop a fact

sheets for distribution to local governments summarizing key information. It is recommended that these sheets answer the following questions:

- What is TRAP?
- Where is exposure to TRAP a concern?
- How can exposure to TRAP be reduced?
    i. In local government land use planning and urban design
    ii. In local government transportation planning and infrastructure design
    iii. In fleet operations

A further opportunity for incorporating considerations of TRAP into municipal and regional government policies and programs is through provision of presentations and / or workshops through professional organizations (e.g. Planning Institute of BC, Association of Professional Engineers and Geoscientists), and community sustainability conferences (e.g. Federation of Canadian Municipalities Sustainable Communities conference, Union of BC Municipalities annual conference).

7.2 IDENTIFY KEY ORGANIZATIONS AND ALIGN WITH EXISTING INITIATIVES

Strategies for reducing exposure to TRAP are often aligned with objectives that have been identified by organizations across BC such as improving ambient air quality, reducing impacts on climate change, improving the health of our communities and residents, and increasing the safety, accessibility and health of our mobility options. Many initiatives to achieve these objectives are already planned or underway, and many successes have already been achieved in BC. In particular, it should be a high priority to align with initiatives that are related to the vulnerable populations identified in this study (e.g. children, elderly, lower socio-economic neighbourhoods, etc.) or initiatives that are related to reducing emissions from high polluting vehicles. Aligning with these initiatives provides two opportunities:

- communicating the benefits of reducing TRAP exposure can lend further support and priority to these initiatives; and
- influencing the development of the initiatives to ensure mitigation measures are incorporated where an adverse effect of the initiative has the potential to increase TRAP exposure.

Both of these opportunities can be addressed through the communication material and presentations described in section 7.1 above. In addition to local governments, there are other organizations that can be engaged to both communicate the benefits of reducing TRAP, and influence the inclusion of mitigation measures in other initiatives. This study has been guided by a steering committee made up of several organizations that will be valuable to continue to engage, including:

- BC Ministry of Environment
- BC Ministry of Health
- BC Ministry of Transportation and Infrastructure
- Metro Vancouver and Fraser Valley Regional Districts

- TransLink
- Fraser Health Authority
- Vancouver Coastal Health
- BC Lung Association
- UBC School of Population and Public Health
- Cities of Vancouver, New Westminster, and Surrey

A number of other potential partners have also been identified to engage moving forward, including:

- Industry associations (e.g. BC Trucking Association, HVAC professional associations and engineering associations)
- Utilities (e.g. BC Hydro)
- Non-government organizations (e.g. Fraser Basin Council, Better Environmentally Sustainable Transportation – BEST, and HUB, formerly the Vancouver Area Cycling Coalition)
- Health professionals
- Rideshare program providers and car co-ops
- Facility planners for School districts and Health authorities

7.3 CREATE PARTNERSHIP FOR AIR QUALITY PROTECTION TO MAINTAIN DIALOGUE

The idea of reducing exposure to TRAP is a relatively new concept, particularly in the realm of local planning in BC. As communities around the world begin to address this issue, new information will become available about the most effective mitigation measures for addressing TRAP. Further, academic research will continue to identify more information about sources, links to health concerns, and potential new mitigation opportunities. To encourage an on-going dialogue around reducing exposure to TRAP that continually incorporates all of this new information, a regional or provincial multi-agency partnership for air quality protection (similar to the national Partnership for Climate Protection) could be established. Within this partnership, local governments can come together and discuss their experiences, challenges, and solutions to reducing exposure to TRAP and to keep abreast of the most recent research findings.

8. AREAS FOR FURTHER RESEARCH

In completing this study, a number of areas where information is lacking or incomplete have been identified. Further research into these areas would enable: organizations to have a better understanding of air pollution and exposure levels within their communities; the strategies identified in this study to be evaluated at a more detailed level; and organizations to select strategies that are suitable for their communities and will help achieve multiple community objectives. This section describes some of these areas for further research.

8.1 ASSESSMENT OF HIGHER TRAP EXPOSURE AREAS AND ON-GOING MONITORING

As identified in Chapter 4, it may be helpful to municipalities outside of Metro Vancouver for the provincial government to conduct a province-wide high-level assessment of higher TRAP exposure areas. Inputs for this assessment could include traffic count data, household location data, data on the location of sensitive land uses such as hospitals, schools, and other long term care facilities (this might require a separate study), data on other point sources, and results from local land use regression or dispersion modelling. This information should be shared with local governments to help them understand which areas are of particular concern, and assist them in identifying context-sensitive strategies to mitigate exposure. It should be noted that much of this information has already been compiled for the Metro Vancouver region.

Related to a high-level assessment, on-going monitoring of air pollutants (from on-road traffic as well as other sources) across the province should continue and be expanded so that trends in pollutant levels can be closely monitored and the impact of pollution reduction strategies can be measured. This information should also be shared with municipal and regional governments to help them understand how pollution levels are changing at the local level. Equipped with this information, local governments would also be in a better position to pro-actively address air quality and implement measures to reduce residents' exposure to air pollution.

8.2 EXPOSURE TO TRAP FOR SUSCEPTIBLE ACTIVITIES

Exposure to TRAP for susceptible activities along high traffic corridors such as cycling, walking, commuting for long durations of time, or occupations such as truck drivers also warrant further research. Much of the research within the Lower Fraser Valley and BC has focused on individuals with physiological characteristics that make them more susceptible to exposure to TRAP, but not as much research has been done to study those who partake in activities that make them more

susceptible to TRAP. As mentioned earlier, Health Canada is planning to conduct a study in 2013 to characterize personal air pollution exposures during commutes by light rail, bus, and private car transportation methods in Vancouver. This study should provide some valuable information.

8.3 FULL IMPACTS OF EMISSION AND EXPOSURE REDUCTION STRATEGIES

To complete a more detailed evaluation of the strategies described in this report, further work is required to better understand the full impacts of the strategies. It is also important to understand their place in the overall regional and municipal planning processes. This analysis should indicate how much actual emission reduction these strategies provide, as well as any increase in emissions and other costs that result. For example, if some strategies have the potential to increase total vehicle travel (for example, freight vehicles may need to drive longer distances as they are prevented from using the most direct route because it passes through residential areas, and locating daycares and hospitals in less central areas where pollution levels are lower might result in additional driving), then these potential costs should be assessed.

Also, a better understanding of the emission reductions from small changes in location design would be valuable. For example, it would be important and valuable to know how much exposure reduction results from locating a building a certain distance away from an arterial road, changing street designs to avoid canyon effects, and from relocating building air intake locations.

As well, further work could be conducted to gain a better understanding of how much additional impact and emission reductions can be achieved by strategies that have already been introduced but could be expanded. For example, anti-idling campaigns already exist, so work could be done to understand how much additional impact could be achieved if they were expanded.

9. CONCLUSION

This study has provided evidence of how traffic-related air pollutants impact human health, and the factors that lead to higher levels of exposure and vulnerability. Specifically, evidence from research work conducted within BC and the Lower Fraser Valley has been included, and the results indicate that there are areas within the region and province that have higher levels of exposure and people and activities that are particularly vulnerable or susceptible to TRAP.

Protecting air quality and minimizing the health impacts of exposure to air pollutants requires the cooperation of government agencies at all levels. There are many factors that influence air quality and exposure to air pollutants, and these areas are under the authority of different levels of government. As such, this study has provided a framework and identified TRAP exposure reduction opportunities that are specifically within the sphere of influence of each level of government. Further, this study has provided a high-level evaluation of these opportunities, which range from transportation management strategies, to land use, design, and education / outreach strategies. The study has recommended strategies that contribute to communities' existing strategies and plans for vibrant, compact communities, and also address the apparent dilemma that can exist between TRAP exposure reduction and smart growth infill development objectives. These strategies have been evaluated in terms of their effectiveness in reducing exposure to TRAP, political and technical feasibility, and effectiveness in achieving co-benefits such as increasing physical activity, generating economic development, and encouraging community cohesion.

While there are still many areas that warrant further research, in the short term it is recommended that organizations take the steps identified in this report to reduce exposure to TRAP, as there is sufficient confidence about these results to justify action. There are many private and public partners to engage, and consistent and clear communication with these partners on how they can work together to achieve exposure reduction and other related community objectives will be key. Thus, as a next step, it is recommended that a "Toolbox" of factsheets be created and that they be tailored to different audiences. As well, efforts could be made to establish a regional or provincial partnership for air quality protection to enable local governments to share their knowledge, experiences, challenges, and solutions to reducing exposure to TRAP.

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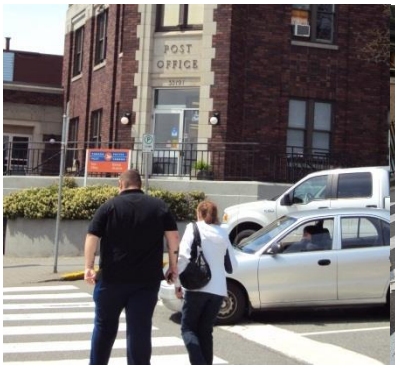



APPENDICES

APPENDIX A: EXPOSURE LEVELS WITHIN LOWER FRASER VALLEY AND BRITISH COLUMBIA

Spatial Variability within Lower Fraser Valley and BC

The Lower Fraser Valley (LFV) airshed is comprised of Metro Vancouver, the Fraser Valley Regional District (FVRD), and Whatcom County in the United States. Within the Canadian portion of the LFV, there is significant difference between Metro Vancouver and the FVRD. While Metro Vancouver is the most densely populated region in BC and walkability is relatively high when compared to other North American regions, the FVRD is mainly comprised of agricultural and rural communities, and has relatively lower walkability.

In addition, the LFV is a constrained air basin surrounded by the Coast Mountains in the north and the Cascade Mountains in the south. Generally, weather systems approach the region from the west. However, they may also approach from the southwest and northwest depending on the season (Environment Canada, 2004). During the summer, there is also limited vertical mixing. Thus, in the summertime, levels of air pollutants such as ozone and particulate matter can become elevated throughout the LFV (Fraser Valley Regional District, n.d.).

Across the region, there are also differences in traffic volumes and congestion levels. As a result there are local differences in TRAP levels. At the University of British Columbia, researchers have monitored levels of traffic-related nitrogen oxides in Metro Vancouver and completed a land use regression model, where air quality measurements are linked to geographical features describing land use, traffic and topography. Their results confirm that distance from major roads and highways is a significant determinant of TRAP levels within the region. The following figures show the results of their monitoring and modeling work in 2003 and 2010. Figure 9 shows that annual average levels of nitrogen oxides have been reduced between 2003 and 2010. As the Metro Vancouver annual objective for NO_2 is 22 ppb, these maps indicate that annual ambient NO_2 levels are below the annual objective. They also show that levels of both pollutants have been reduced between 2003 and 2010. However, emissions of several traffic-related air pollutants are predicted to increase over the next decade due to continued growth in population, international trade and transportation (see next section). It is also important to remember that health effects also occur when air pollutant concentrations are below Metro Vancouver's ambient air quality objectives.

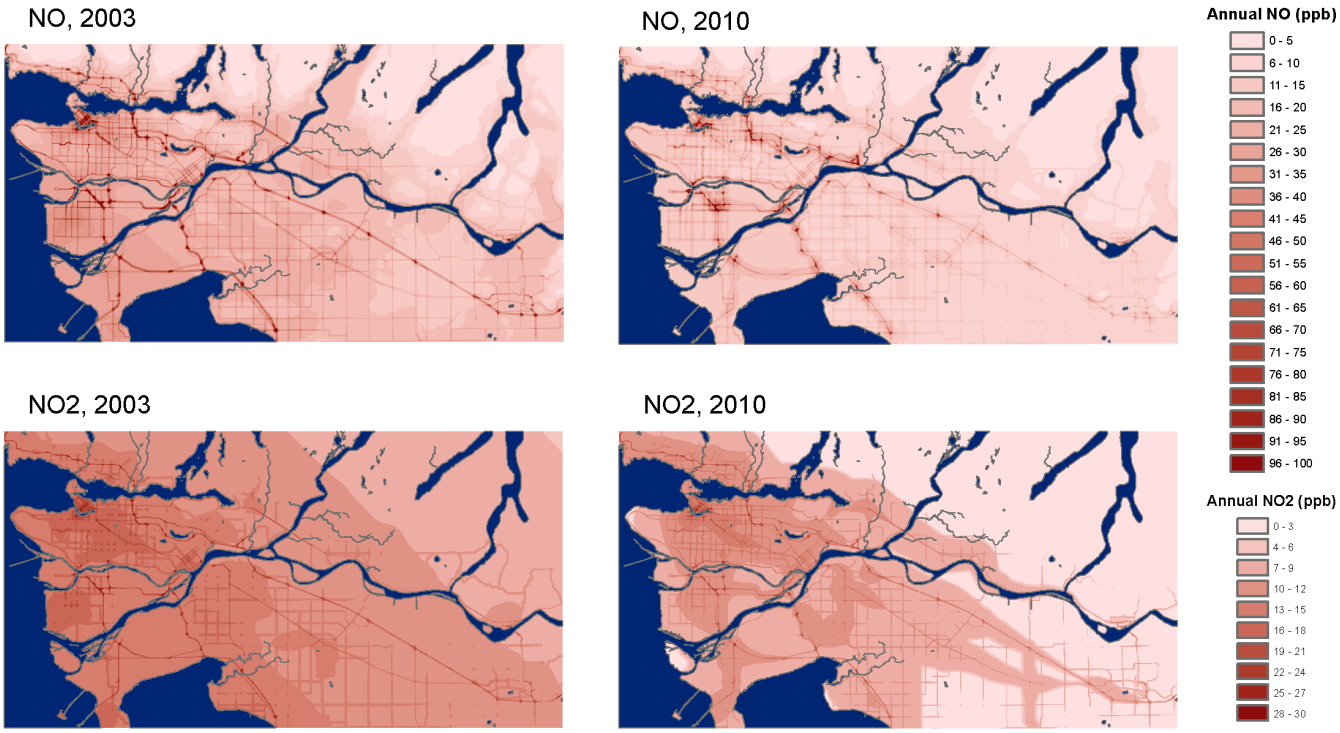

Figure 9: NO and NO_2 Levels within Metro Vancouver, 2003 and 2010

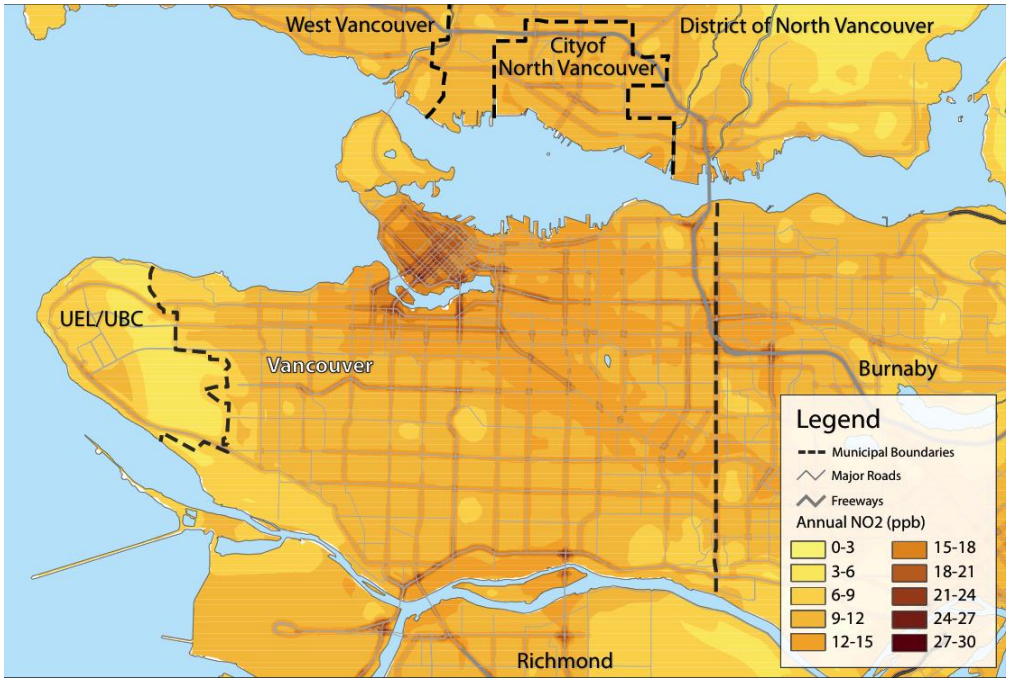

Figure 10: NO_2 Levels within City of Vancouver in relation to Highways and Major Roads, 2010

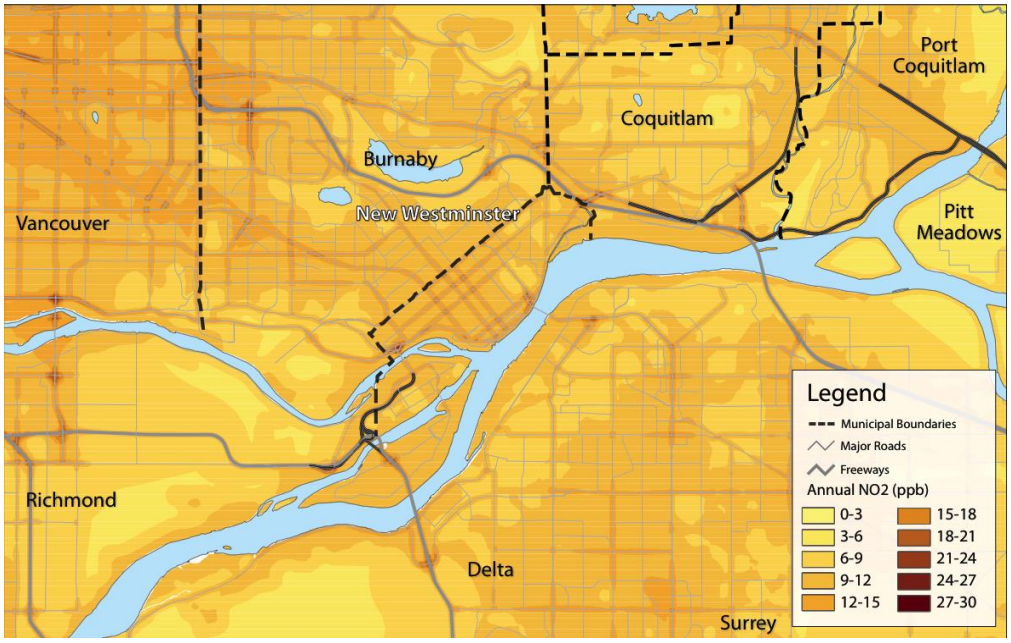

Figure 11: NO_2 Levels within City of New Westminster in relation to Highways and Major Roads, 2010

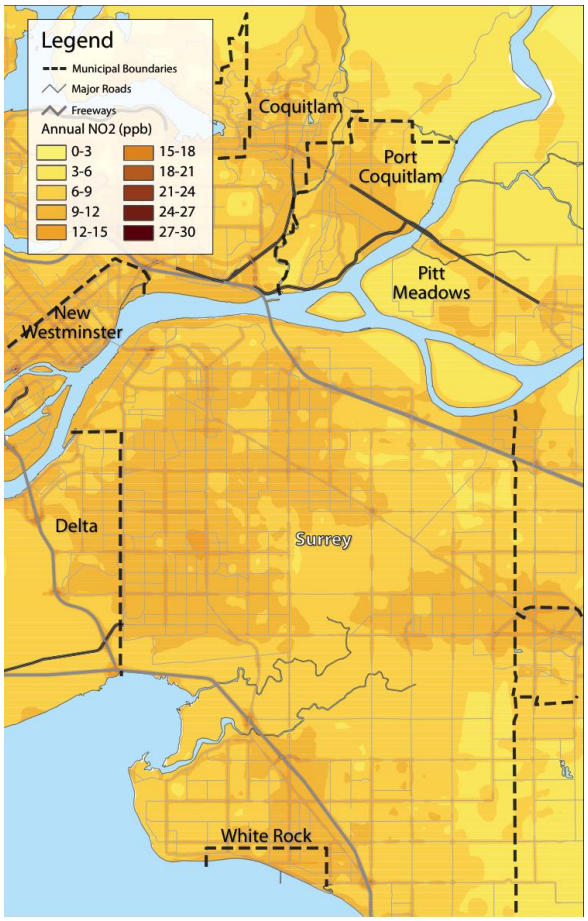

Figure 12: NO_2 Levels within City of Surrey in relation to Highways and Major Roads, 2010

Source for Figures 9 to 12: Wang (2011).

In other parts of BC, development patterns are also less densely populated than Metro Vancouver. In cities and regions such as Prince George, the Bulkley Valley, and the Okanagan Valley, geographical conditions also create restricted air basins, trapping air pollutants and creating poor air quality conditions.

Emission Growth in Lower Fraser Valley

As indicated above, while the LFV airshed typically experiences good air quality relative to other urban areas, it does not always meet Metro Vancouver's ambient air quality objectives.[13] Furthermore, as mentioned earlier, health effects still occur when air pollutant concentrations are below these objectives. With growth in population, international trade, and transportation, it is also predicted that the emission of some air contaminants such as particulate matter, greenhouse gases, and several ozone and particulate matter precursors (SOx, NH_3, and VOC) will increase over the next decade (Metro Vancouver, 2011). Although new and existing federal emission standards and other initiatives (such as the AirCare Program) for on-road vehicles, marine

[13] Metro Vancouver's ambient air quality objectives are based on current knowledge about air quality and health science, and takes into consideration other relevant objectives developed world-wide and local achievability (Metro Vancouver, 2011).

vessels, and non-road engines / equipment will help reduce emissions from the transportation sector, transportation will continue to be a major contributor of these and other air pollutants. In fact, light-duty vehicles were the largest source of smog-forming pollutants in the region in 2005.

Higher TRAP Exposure Areas, Vulnerable Individuals and Susceptible Activities within LFV and BC

In an earlier section, the various ways that an individual can have a higher chance of being exposed to and / or experiencing health effects from traffic-related air pollution have been defined. Higher TRAP exposure areas include locations with large numbers of vehicles, and vulnerable individuals include pregnant mothers and their fetuses, children, elderly, low-income individuals, people with respiratory conditions. Individuals who spend a lot of time in traffic such as taxi, bus, and truck drivers, and transit and active transportation users can also be more susceptible to TRAP exposure. This section provides some examples of these higher TRAP exposure areas and individuals within the Lower Fraser Valley and BC.

HIGHER TRAP EXPOSURE AREAS

As described above, exposure to TRAP varies signficantly with distance from major roadways and highways. Figure 13 (taken from Brauer et al., 2012) shows "TRAP influence zones" - distances of 500 m from highways and 100 m from major roadways. The national road network provided by DMTI CanMap® Street was used to create this map. The expressway, primary and secondary highway DMTI classifications represented "highways" and the major road classification represented "major roads".

Figure 13: TRAP Influence Zones* in Metro Vancouver

Source: adapted from Brauer et al. (2012).

*TRAP Influence Zones = distances of 500 m from highways and 100 m from major roadways

Using data collected by Statistics Canada and TRAP influence zones shown in Figure 13, it was determined that in 2006, 37% of the BC population lived within 500 m of a highway or 100 m of a major road (Brauer et al., 2012). Another study has also concluded that in 2006, 74% of the Metro Vancouver population lived within 500 m of a major road, and 49% lived within 250 m, 21% lived within 100 m, and 11% lived within 50 m of a major road (Evans et al., 2011).[14] Interpolating these results, it is estimated that in 2006, approximately 28% of the region's residents lived within 150 m of a major road or higwhay (the distance recommended in the BC *Develop with Care 2012* guidelines, especially for sensitive land uses).

In addition, many bus routes in the Lower Fraser Valley and in the rest of BC are served by diesel buses. Diesel-exhaust particles are the most harmful vehicle related pollutant and a harmful human carcinogen. As such, transit users can be exposed to higher levels of air pollution while

[14] These distances represent the space between the centreline of a roadway to the extent of the distance specified. Property lines that fall within these distances are included in these figures. For highways, there is a centreline for each direction of travel.

waiting at bus stops (especially if the transit route is also a major roadway) and bus exchanges, and while they are on the bus. That said, both TransLink and BC Transit are employing vehicle technologies and fuels to reduce air emissions. These include trolleybuses, hybrid-electric buses, hydrogen fuel cell buses, CNG buses, biodiesel, and emission control devices such as diesel particulate filters and diesel oxidation catalysts.[15] As described earlier, enhanced transit services may encourage people to shift from private automobiles to public transit, which can provide overall air pollutant emission reductions and more opportunities for physical activity.

As trucks are a major source of TRAP and diesel-exhaust particles are a special concern for human health, a number of complaints about air quality from residents living along truck routes have been received by Metro Vancouver, municipalities and TransLink. This is an indication that there is some concern amongst the public about exposure to TRAP, particularly from diesel vehicles. See Figure 14 for a map of the truck routes in the Lower Mainland.

[15] TransLink completed a Bus Technology & Alternative Fuel Demonstration Project that tested the effectiveness of CNG, biodiesel, hybrid-electric vehicles, and diesel particulate filters on diesel buses in reducing exhaust emissions and/or increasing vehicle energy efficiency compared to the use of standard baseline diesel engines and fuel (M.J. Bradley & Associates, 2009). The results showed that all of these tested alternative bus technologies performed equal or better than the baseline diesel buses with regards to particulate matter, GHG emissions and fuel costs. However, some technologies had lower fuel economies and higher maintenance costs than the baseline buses.

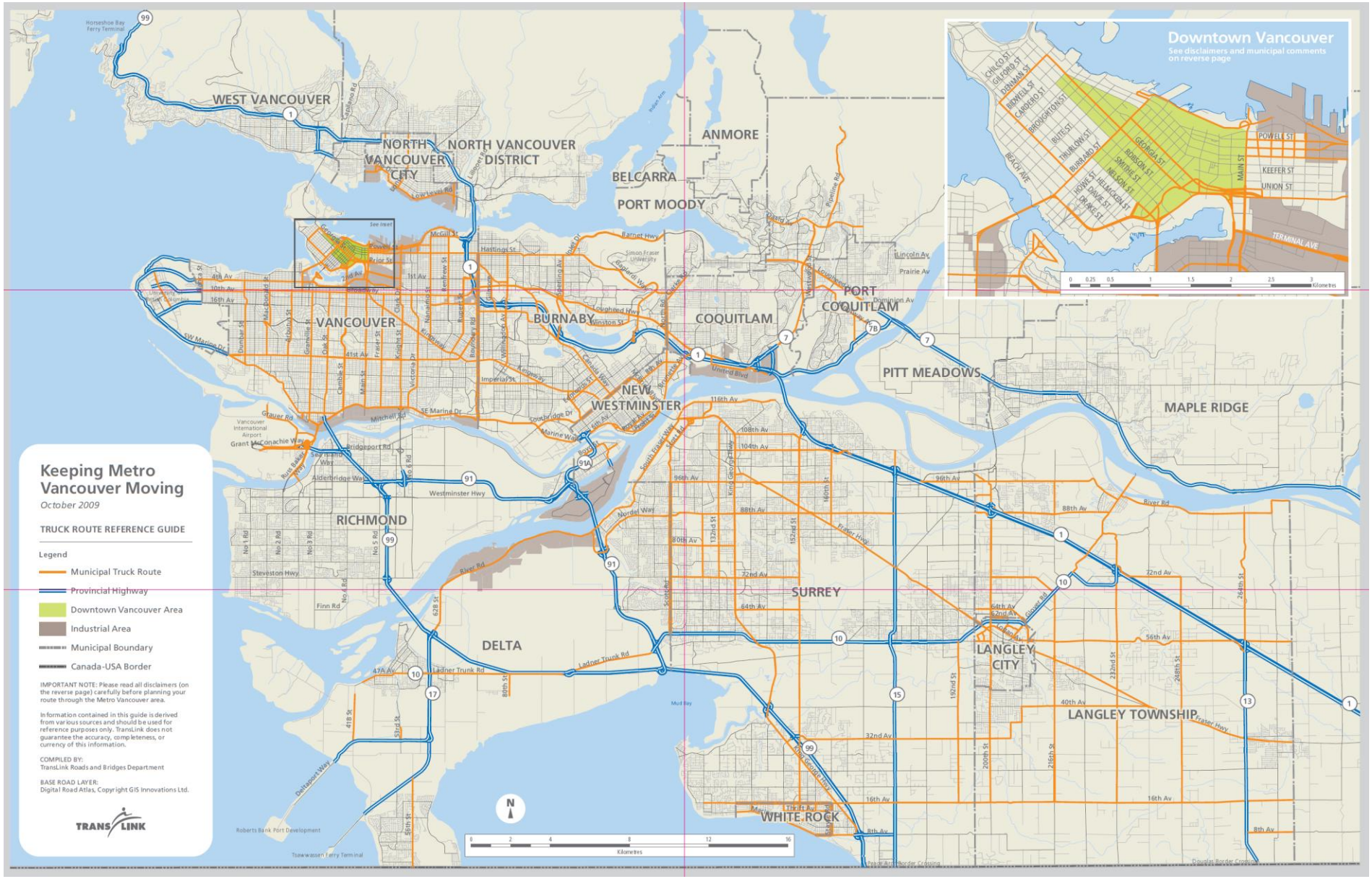

Figure 14: Truck Routes in Metro Vancouver, 2009

Source: TransLink (2009).

As well, distribution centres where hundreds of trucks can be entering or leaving the premises on a daily basis are also a significant source of TRAP. Such distribution centres are often found in industrial areas such as those in Surrey, Richmond, and many other communities within Metro Vancouver, but these areas may be upwind of residences or sensitive land uses such as senior and long term care facilities.

Another source of TRAP are land uses and locations where vehicles often idle and people are exposed to the resulting emissions. Examples include elementary schools during pick-up and drop-off periods (which is a common occurrence in communities across LFV), border crossings between BC and the United States, and ferry terminals such as those operated by BC Ferries.

It should also be noted that individuals residing or spending time in locations immediately adjacent to and downwind of the sources described above are at greatest risk of exposure to air pollution. However, as windspeeds are relatively low in the Lower Mainland, being downwind of these sources is likely more of a concern in other parts of BC.

In terms of the street canyon effect in the LFV and BC, it is most common in areas with taller buildings on both sides of the street, such as downtown Vancouver. In these areas, dilution rates are reduced and pollutant concentrations are higher (Wehner et al., 2002). For example, Metro Vancouver found that in 2009 a downtown monitoring station located in a dense urban environment and very near a busy street had elevated pollutant levels and exceeded the annual objective for NO_2 (Metro Vancouver, 2010).

VULNERABLE AND SUSCEPTIBLE INDIVIDUALS ACTIVITIES

As explained earlier, children are a segment of the population that is more sensitive to air pollution. A study in 2011 (Amram et al.) found that 55% of schools in the City of Vancouver are located within 200 m of major roadways, with a disproportionate number of these located in low-income areas. Moreover, parents often idle their vehicles when they are picking up and dropping off their children at schools and daycare facilities (although some schools have implemented idle-free campaigns). This is a concern, as many studies within Metro Vancouver have shown that traffic-related pollutants are associated with the highest risks of asthma diagnosis in children and with physician visits and hospitalizations for bronchiolitis among infants (BC Ministry of Environment, 2012).

For pregnant mothers (and the fetuses they carry), another vulnerable population, a study in Metro Vancouver has found that there are associations between exposure to NO, NO_2, and $PM_{2.5}$ during the whole pregnancy, as well as residence within 50 m of a highway, and low birth weights (Brauer et al., 2008). The same study also found associations between exposure to specific traffic-related pollutants, preterm births, and, perhaps an increased risk of the child developing asthma.

Studies in Vancouver have also shown a causal association between cardiovascular mortality and exposure to TRAP, particularly black carbon and traffic noise (BC Ministry of Environment, 2012). A study showed that when individuals moved away from TRAP proximity zones (defined as within 150m of a highway or within 50m of a major road), their risk of coronary heart

disease mortality was reduced by up to 40% (Gan et al., 2010). Thus, individuals with pre-existing cardiovascular conditions make up another vulnerable population.

In addition, a study conducted by Marshall et al. (2009) found that in Metro Vancouver, lower-income areas tend to have higher nitric oxide (NO) concentrations (a marker for direct vehicle emissions) and walkability (Marshall et al., 2009). This suggests that increased concentration of activities can have benefits and costs. Thus communities should consider implementing strategies to ensure communities are walkable and at the same time residents are not adversely affected by increased exposure to air pollution.

In the same study, it was found that neighbourhoods with higher ozone levels tend to be middle income. Ozone is a regional, secondary pollutant that is formed in the atmosphere, so higher concentrations tend to occur regionally downwind of the highest density areas such as suburbs. The researchers also found that "sweet-spot" neighborhoods (lower pollution, high walkability) are concentrated near but not at the city centre and are occupied by higher income individuals, while "sour-spot" neighbourhoods (higher pollution and low walkability) are mainly occupied by middle-income individuals, although the other income groups are also found in these areas. These results suggest it is also important to look at exposure levels in suburbs and middle-income neighbourhoods, and not just low-income neighbourhoods. Figure 15 is map showing the sweet-spots and sour-spots identified by the researchers.

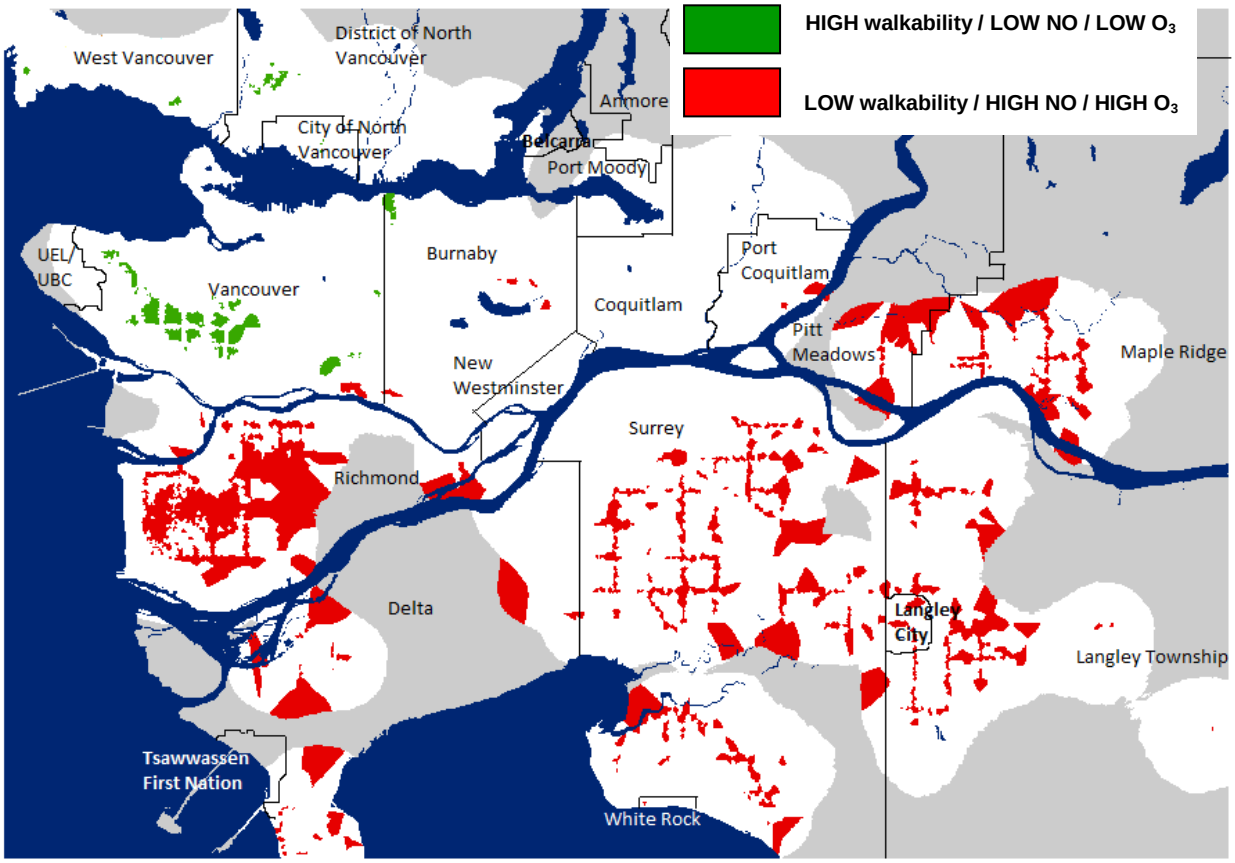

Figure 15: "Sweet-Spots" and "Sour-Spots" within Metro Vancouver

Source: Marshall et al. (2009).

As mentioned earlier, cyclists can also be exposed to peaks of TRAP, particularly when riding along major roadways. Within Metro Vancouver, approximately 21% of designated bike routes are along the Major Road Network, which is comprised of most of the region's arterial roads not owned by the provincial government (TransLink, 2012), and within the City of Vancouver, 20-25% of bike routes are along primary and secondary arterials (City of Vancouver, 2012a).

A study for the northwestern portion of Vancouver examined the level of pollution to which cyclists are exposed (Thai, 2007). It found that on high-traffic routes, cyclists would be exposed to higher levels of ultrafine particulates than when riding on roads with less traffic. Examples from the study included Burrard Street, the Burrard Bridge (at the time of the study, cyclists were often less than a metre away from vehicles), and West Georgia Street (which leads to the Lions Gate Bridge and the primary route into downtown Vancouver for many residents of the North Shore). According to traffic data collected by the City of Vancouver, the average daily traffic volumes are approximately 23,000 along the southern sections of Burrard Street (data from 2004, 2006, and 2008), 63,000 on the Burrard Bridge (2008-2009), and 24,000 on some sections of West Georgia (data from 2004 to 2010). Therefore, all of these roads would be considered as busy or major roads.

Meanwhile, the study found that cyclists using streets with less traffic or a bicycle lane further away from vehicular traffic would experience less personal exposure to ultrafine particulates. In northwestern Vancouver, these streets include Cardero Street (with average daily traffic volumes of approximately 2,000), the Cambie Bridge (which had a wider bicycle lane further away from traffic than Burrard Bridge at the time of the study), and the Seaside and Chilco bicycle routes. These results indicate that providing separate routes or lanes for cyclists can be an effective way to reduce their personal exposure to traffic-related air pollutants.

Similar to cyclists, pedestrians can also be exposed to peaks of TRAP when walking along busy roads within the region and province. In addition, other vulnerable populations include individuals who spend a significant amount of time in traffic, such as taxi drivers, truck drivers, and commuters who travel long distances to get to and from work or school.

APPENDIX B: CURRENT POLICY AND REGULATORY CONTEXT

The conditions that lead to exposure to traffic emissions are created through a combination of factors that are regulated or influenced by a multitude of agencies, including all levels of government. The following section outlines key regulations, strategic plans and policies that control or influence these exposure levels. The section is organized by the scale of the regulation or initiative (e.g. federal, provincial, regional or airshed, municipal). The majority of the following initiatives are primarily focused on overall air quality improvements in relation to transportation emissions. The degree of impact of these initiatives on exposure levels are discussed where appropriate.

Federal

Air Quality Standards, Objectives and Indices

The federal government has identified air quality standards and objectives for certain pollutants. In 2000, **Canada-Wide Standards** (CWS) were set for particulate matter ($PM_{2.5}$) and ozone. The province of BC committed to achieving the CWS in all regions by 2010. **National Ambient Air Quality Objectives** (NAAQOs) have also been identified for sulphur dioxide, carbon monoxide, nitrogen dioxide, total suspended particulates and ground-level ozone. These provide guidance for decision-making and setting provincial objectives. All of these initiatives provide benchmarks for the state of the air throughout Canada. The objectives and standards provide an indication of exposure to emissions at the locations that data are collected; however, these tools do not directly measure or evaluate the level of exposure experienced by the population (who may be moving around, going inside and outside, etc.).

Vehicle Emission Regulations

Since 2004, all new vehicles sold in Canada must comply with the ***On-Road Vehicle and Engine Emission Regulations*** defined in the *Canadian Environmental Protection Act* (*CEPA*). This regulation focused on reducing nitrogen oxide by up to 95%, and volatile organic compounds by up to 84% from new vehicles (Environment Canada, 2010). Sulphur emissions have also been addressed through the ***Sulphur in Gasoline Regulations*** and the ***Sulphur in Diesel Regulations*** defined in *CEPA, 1999* and *2006* respectively. Benzene and Lead have also been controlled under other regulations, leading to the successful removal of Lead from virtually all gasoline sold in Canada since 1990.

In 2010, the Federal government proposed new ***Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations*** with the goal of reducing GHG emissions from new vehicles. The updated regulation is proposed to align with the United States and requires automobile manufacturers to meet fleet average improvements in efficiency from the 2011 model year onward,

reaching average fleet emission reductions of approximately 25% in 2016 compared to 2008 average fleet emissions on a per-kilometre basis (Environment Canada, 2011). Although this regulation is targeting GHG emission reductions, the improvements in fuel efficiency may have positive co-benefits for reducing emissions of air pollutants (i.e., NOx, particulate matter and VOCs) on a per-kilometre basis (Canada Gazette, 2010).

In April 2012, the Federal government announced the newest set of **emission standards for heavy-duty vehicles** (Canada Gazette, Vol. 146, No. 15, 2012). The proposed changes are focused on reducing GHG emissions from heavy-trucks between the 2014 and 2018 model years resulting in anticipated average fleet emission reductions of 23% compared to the 2010 model year. The improvements in fuel efficiency may have positive co-benefits for reducing emissions of air pollutants on a per-kilometre basis. However, trends toward increasing the use of trucks to transport goods (Steenhof, 2006) may result in no overall benefits, or possibly an overall increase in air pollutants.

Other Areas of Influence

The Federal government may also influence exposure to traffic emissions in relation to federally regulated roadways, border crossings, and activities at ports. The federal government is also a key funding partner for transportation infrastructure projects. In addition, Transport Canada developed the **ecoTRANSPORT** Strategy which aims to reduce the environmental and health effects through three initiatives: ecoFREIGHT (improving freight technology), ecoMOBILITY (improving transit), and ecoTECHNOLOGY for vehicles (improving vehicle technology).

Provincial

Air Quality Objectives and Monitoring

The provincial government does not directly regulate traffic emissions, however, maintaining and improving air quality is core to the BC Ministry of Environment's functions. BC committed to meeting the Canada-Wide Standards for $PM_{2.5}$ and ozone for all communities by 2010. Furthermore, the Province has **adopted ambient air quality objectives** for $PM_{2.5}$, PM_{10}, ozone, sulphur dioxide, nitrogen dioxide, and carbon monoxide as a guide for air quality management and decisions. The BC Ministry of Environment also runs a **province-wide air quality monitoring network** (outside the Lower Fraser Valley) and reports this data to the public through a website (www.bcairquality.ca). Using the monitored data, the Province calculates an Air Quality Health Index (AQHI) and provides smog advisories to airsheds that are exceeding specified objectives or standards.

Cleaner Gasoline Regulation

In 1995, the provincial government set standards for gasoline to significantly reduce emissions of pollutants, such as volatile organics, nitrogen oxides, sulphur oxides and toxics (BC Laws, 2011).

Climate Change Regulations

Since 2007, the provincial government has placed considerable focus on the reduction of greenhouse gases from all sectors, including transportation. These regulations will have positive co-benefits for the reduction of traffic emissions. Key regulations include:

- ***Greenhouse Gas Reduction Targets Act*** (Bill 44, 2007), which sets province-wide GHG emission reduction targets of 33% by 2020 and 80% by 2050, relative to 2007 levels.
- ***Green Communities amendment to the Local Government Act*** (Bill 27, 2008), which requires every local government in BC to incorporate GHG reduction targets, policies and actions into Official Community Plans and Regional Growth Strategies.
- ***Carbon Tax Act*** (2008) adds a revenue-neutral tax to all fossil fuels sold in BC, with the goal of incentivising increased efficiency and / or reduced use of fossil fuels.
- ***Renewable and Low Carbon Fuel Requirements*** (2008) sets minimum requirements for the percentage of renewable content in gasoline and diesel sold in BC beginning in 2010.

BC Building Code

The provincial government also has jurisdiction over the **BC Building Code** which governs the construction of buildings, including air intake and ventilation requirements. Currently, there are no Code requirements linked to outdoor air quality or proximity to traffic emissions.

Air Quality Programs and Initiatives

In addition to monitoring air quality and regulations related the GHG emissions, the Province has undertaken a number of initiatives to improve air quality and reduce human health impacts. These include:

- ***BC Air Action Plan*** (http://www.bcairsmart.ca/, 2008), which outlines 28 actions for the Province to improve air quality across BC with a focus on clean transportation, clean industry, and clean communities. Initiatives identified include investing in transit, cycling and pedestrian infrastructure, expanding the vehicle Scrap-it program, building an anti-idling program, retrofiting government heavy-duty vehicles and transit vehicles, supporting airshed planning, and funding research on air quality and health.
- ***Develop with Care*** (BC Ministry of Environment, 2006 and 2012), which provides voluntary guidelines for municipal planning authorities about best practices for urban and rural development in relation to environmental management, including air protection. Air protection guidelines are focused on reducing exposure for vulnerable populations, and for areas where people spend large amounts of time. Guidelines include location / siting of buildings, outdoor characteristics around buildings, and building design features.
- ***Provincial Transit Plan*** (2008) is a plan to double transit ridership by investing in rapid transit infrastructure and RapidBus services along major routes and in high growth centres. The plan also targets emission reductions from buses through the use of new low-emission technology.

BC Transit

Transit services provided to BC communities outside of Metro Vancouver are under the jurisdiction of BC Transit, an agency of the provincial government. BC Transit's long-term strategy is set out in ***Shaping our Future: 2030 Strategic Plan***. Transit services are typically planned and operated as a joint venture between BC Transit and the local government. All communities in FVRD are serviced by BC Transit and are currently reviewing the draft routes and services for the ***Central Fraser Valley Transit Future Plan***. BC Transit can also affect exposure levels through transit vehicle selection and operation, and transit routes and service levels.

Other Areas of Influence

The provincial government may also influence exposure to traffic emissions in relation to the design and operation of provincial roadways, funding and operation of public transportation and other transportation infrastructure, and activities related to rail transportation.

Regional and Airshed

Airshed Planning

Air quality planning and management is occurring at a regional or airshed scale in several regions throughout BC. These are typically multi-stakeholder processes that identify management initiatives specific to the air quality concerns of the region. Airshed management plans have been developed (or are currently being developed) for 13 regions in BC, including the Sea-to-Sky airshed, Metro Vancouver, the Fraser Valley Regional District, Merritt, the Regional Districts of Okanagan-Similkameen, Central Okanagan and North Okanagan, Grand Forks, Williams Lake, Quesnel, Prince George and the Bulkley Valley-Lakes District (BC Ministry of Environment, n.d.). These initiatives generally focus on achieving Canada-Wide Standards and BC Objectives through general emission reductions, as opposed to targeting specific exposure reduction opportunities.

Regional Districts: Metro Vancouver and the Fraser Valley Regional District (FVRD)

Regional districts are responsible for policy development and service delivery at the regional scale for their member municipalities. Metro Vancouver and FVRD have each adopted ***Regional Growth Strategies*** (RGS), in 2011 and 2004 respectively, that provide the long-term policy direction for land use planning in their regions. The goals identified in the *Metro Vancouver RGS* are well-aligned with reducing overall traffic-related air pollutants through the creation of compact, complete communities and the development of sustainable transportation choices.

Metro Vancouver RGS Strategy 3.3

Encourage land use and transportation infrastructure that reduce energy consumption and greenhouse gas emissions, and improve air quality

Under the provincial *Environmental Management Act*, Metro Vancouver is given authority to **regulate air pollution control** (N.B. no other regional district has this authority in BC, including FVRD). With respect to transportation emissions, Metro Vancouver has undertaken regulatory activities such as:

- The **AirCare** program to track emission performance of all registered vehicles. This program continues to operate under TransLink.

- Effective January 2012, Metro Vancouver also requires all **Non-Road Diesel Engines** to be registered and labelled.

Unlike Metro Vancouver, the FVRD has no regulatory or enforcement authority in the air quality management context. The FVRD is currently exploring the possibility of requesting that authority from the Province. Any such change would be reflected in the FVRD ***Air Quality Management Plan***, which is currently being updated and will include **ambient air quality objectives.**

IAQGGMP Action 1.1.4
Work with municipalities, health authorities, the Provincial government, and TransLink to develop air quality-focused land use planning and urban design guidelines that will minimize resident exposure to diesel emissions and other traffic-related air pollution.

In 2011 Metro Vancouver adopted a new ***Integrated Air Quality and Greenhouse Gas Management Plan.*** This plan identifies 12 strategies to implement over 10 years, with a focus on actions that can provide co-benefits between GHG and air quality management. The plan also identifies health-based **ambient air quality objectives** that are as or more stringent than the provincial objectives and Canada-wide Standards.
Metro Vancouver operates the **Lower Fraser Valley Air Quality Monitoring Network** in partnership with the Fraser Valley Regional District, BC Ministry of Environment, Environment Canada and other partners. The network currently consists of 26 air quality monitoring stations from Horseshoe Bay to Hope. In addition to the fixed monitoring network stations, Metro Vancouver periodically deploys its Mobile Air Monitoring Unit or portable air quality instruments to conduct specialized monitoring studies. Metro Vancouver plans to initiate a roadside monitoring study starting in 2013 in partnership with Environment Canada's National Air Pollution Surveillance network.

TransLink (South Coast Regional Transportation Authority)
TransLink is the regional transportation authority for Metro Vancouver. In collaboration with Metro Vancouver and municipalities, TransLink is responsible for transit, the Major Road Network (MRN) which includes roads and bridges, regional cycling, and managing the AirCare program. TransLink's long-term strategy is outlined in ***Transport 2040.*** Goals from this strategy include aggressively reducing GHG emissions and prioritizing walking, cycling and transit as the primary modes of getting around. These align with an objective of overall traffic emission reductions. TransLink also has a *10-Year Transportation and Financial Plan* which includes an outline of funded and planned strategic initiatives, programs and services.

Additionally, TransLink can affect air pollution exposure in several important ways including:

- Strategic transport planning, such as whether to expand highways and transit services;
- Transit vehicle selection and operation (e.g., changing from diesel buses to electric trolleys);
- Walk / bike route locations (away from major highways); and
- Bus waiting area design (e.g. investigate bus stop designs that would reduce the concentration of air pollutants to which transit users are exposed while waiting for their bus – see Chapter 4 for an example).

Health Authorities

The five regional health authorities in BC are responsible for delivering health care services according to province-wide goals and standards. The Provincial Health Services Authority coordinates and / or provides programs across the province. One community program is the Healthy Families BC Communities Initiative. The initiative supports collaborative action between local governments, health authorities and community leaders to encourage physical activity, healthy built environments, priority populations, and other areas where local governments can have an influence on the health of the community.

In addition to offering programs about health, health authorities are responsible for planning the location and design of new health care facilities. This presents an opportunity to incorporate TRAP exposure considerations when siting and designing new facilities. This could have significant impact on TRAP reduction for vulnerable populations with medical conditions, because these individuals often spend extended time at care facilities.

Municipal and Neighbourhood

Municipalities

There are significant opportunities for reducing exposure to air emissions at the municipal scale. Municipalities have authority over numerous factors that impact exposure to traffic emissions, including: land use planning; siting of buildings; local transportation planning; location, size and design of roads; cycling and pedestrian infrastructure; landscaping of road right-of-ways; and bylaws to regulate idling. As described earlier, municipalities across BC are undertaking these activities using a Smart Growth approach that reduces overall TRAP emissions, while achieving numerous other sustainability goals.

As discussed above, air quality management planning for the Lower Fraser Valley occurs at a regional scale; therefore, there are no municipalities that have plans dedicated solely to air quality. However, several municipalities in the LFV have completed, or are in the process of completing, integrated sustainability and / or community energy and emissions plans that target changes in transportation that have co-benefits for reducing air emissions from vehicles. The City of Chilliwack has created an Integrated Air Quality, Energy and Greenhouse Gas Management Plan where the vision, goals and actions in the plan incorporate improvements in all three of these areas. Other examples include:

- *City of Surrey's Sustainability Charter* (2008)
- *City of Vancouver's Greenest City Action Plan* (2011), including a strategy for Air Quality Improvement for Vulnerable Populations
- *City of New Westminster's Community Energy and Emissions Plan* (2011)
- *City of Chilliwack's Integrated Air, Energy and Greenhouse Gas Management Plan* (2011)

Municipalities in the LFV have also undertaken various programs that reduce traffic emissions, both broadly across the community and in a more targeted manner. Examples of these programs include:

- Idling reduction bylaws, including: City of Abbotsford (2003), District of West Vancouver (2004), District of North Vancouver (2004), City of North Vancouver (2005), City of Vancouver (2006)
- Transportation Demand Management program in the Cities of New Westminster and Surrey
- Requirements for Electric Vehicle plug-ins in all new single-family homes and in 20% of parking spaces in new condos in the City of Vancouver
- Charge And Go Vancouver electric vehicle infrastructure trial (launched in 2012) – plans to install over 67 charging stations throughout the city
- Separated bike lanes to promote increased cycling in the City of Vancouver
- Numerous programs to reduce emissions from local government fleets through vehicle right-sizing, shared vehicles, use of hybrid technology, driver training, and retro-fitting diesel vehicles with diesel oxygen catalysts
- Surrey is pursuing a policy to ensure new and redeveloped gas station sites are required to provide alternative fuels. Options include Level 3 electric vehicle recharging stations, Hydrogen, fast fill natural gas, and propane.

School Districts

School districts have the opportunity to reduce TRAP exposure for children attending schools through considerations in busing, school locations, school design and renovation, and policies about parking and idling at school drop-off locations. With respect to busing, school districts can participate in the provincial Diesel School Bus Retrofit Program that aims to reduce PM emissions by retrofitting existing buses with emission-reduction technology. Numerous school districts have already completed the retrofits, and most others are currently involved in the program.

Also, similar to health authorities, school districts are responsible for planning the location and design of new schools in BC. Because young children are more vulnerable to the effects of TRAP exposure, school districts can consider TRAP when determining the location of new facilities, as well as when designing those facilities. An additional opportunity to reduce TRAP exposure would be at the time of renovation of older schools in higher TRAP exposure areas.

Finally, schools can influence the way children arrive at school by promoting walking, cycling and transit use. For children that arrive by vehicle, schools can also create policies that encourage parents and buses to turn off engines during drop-off and pick-up times. Several school districts have undertaken these initiatives throughout the province. The non-profit organization HASTeBC has worked with numerous schools and communities to develop and support active modes to school ("Cool Routes to School") and idle free programs ("Idle Free Cookbook").

APPENDIX C: EVALUATION MATRIX AND RESULTS, AND EVALUATION CRITERIA DEFINITIONS

Provincial / Regional Strategies

		Responsibility	Evaluation Result [1]	Co-Benefit [2]	Suitability for Urban Centres	Suitability for Suburban / General Urban Areas	Suitability for Rural Areas
	Key Recommended Strategies						
	Land Use Strategies						
1	Adopt a policy to require new large-scale transportation infrastructure projects and plans involving provincial roads or the Major Road Network in Metro Vancouver to quantify air quality-health benefits and costs through Health Impact Assessments prior to approval	P and TA (for Major Road Network projects in Metro Vancouver) (Leads)	High effectiveness, high practicality	Low	High	High	High
2	Adopt siting considerations (and designs) for medical, health, and long-term care facilities	HA (Lead)	High effectiveness, high practicality	Low	High	High	High
	Design Strategies						
3	a) Update BC Building Code to require indoor air quality management practices that reduce levels of outdoor pollutants and/or b) investigate whether municipalities/regional districts already have the authority to require indoor air quality management practices using powers granted in the Community Charter and Local Government Act and if necessary provide municipalities with authority to require such practices (N.B. City of Vancouver already has this authority)	P (Lead)	High effectiveness, high practicality	Low	High	High	High
	Transportation Management Strategies						
4	Improve transit service quality	TA (Lead); P and M (Support)	High effectiveness, high practicality	High	High	High	Medium
5	Increase fuel prices	P or F (Lead)	High effectiveness, high practicality	Medium	High	High	High
6	Implement or expand targeted mandated inspection and maintenance programs for cars, buses, trucks, and older vehicles	R or P (Lead)	High effectiveness, high practicality	Low	High	High	High
7	Expand ride-share programs, including vanpooling, for trips to work, school, and events	TA (in Metro Vancouver) or M (Lead); involve rideshare providers too	High effectiveness, high practicality	Low	Medium	High	High
8	Introduce or enhance commute trip reduction programs	TA (in Metro Vancouver) or M (Lead)	High effectiveness, high practicality	High	High	Medium	Medium
9	Implement pay-as-you-drive insurance	P (Lead), including Insurance Corporation of British Columbia	High effectiveness, low practicality	High	High	High	High
10	Introduce vehicle registration fees based on size of vehicle or emission rate	P (Lead), including Insurance Corporation of British Columbia	High effectiveness, low practicality	Medium	High	High	High
11	Implement a logistics program to reduce the number of loaded and empty truck trips in high exposure areas, or by increasing vehicle load factors	P (Lead); M and PA (Support); involve BC Trucking Association too	High effectiveness, low practicality	Medium	High	High	Medium
12	Implement alternatives to transporting goods from ports by truck	F (Lead); P and PA (Support)	High effectiveness, low practicality	Medium	High	High	Medium
13	Develop or expand electric or zero-emission transit systems	TA (Lead); F and P (Support)	High effectiveness, low practicality	High	High	Low-Medium	Low
14	Implement congestion pricing on provincial and / or arterial roads	P and / or TA (in Metro Vancouver) (Lead), depending on road type; M (Support)	High effectiveness, low practicality	Medium	Low	Medium	High
	Education / Outreach Strategies						
15	Educate the general public about health impacts of transportation decisions	P, R, HA (Leads); M (Support)	Low effectiveness, high practicality	Low	High	High	High
16	Encourage cyclists to choose low-traffic routes wherever possible	HA, TA (in Metro Vancouver) and M (Leads); involve bicycle user groups too	Low effectiveness, high practicality	Medium	High	Medium	Medium
17	Develop a fact sheet and / or workshop module on reducing exposure to TRAP	P and/or R (Leads), and HA (Support); involve BC Lung	Low effectiveness, high practicality	Low	High	High	High

		Responsibility	Evaluation Result [1]	Co-Benefit [2]	Suitability for Urban Centres	Suitability for Suburban / General Urban Areas	Suitability for Rural Areas
		Association too					
18	Where feasible, educate vulnerable individuals regarding the risk of living, working and exercising in higher TRAP exposure areas	HA (Lead), M (Support)	Low effectiveness, high practicality	Low	High	High	High
19	Educate the trucking community about exposure to TRAP	HA (Lead), R (Support); involve BC Trucking Association too	Low effectiveness, high practicality	Low	High	High	High
	Additional Strategies						
	Land Use Strategy						
20	Develop sample Official Community Plan (OCP) policy guidelines to reduce exposure to TRAP	R (Lead)	Low effectiveness, high practicality	Low	High	High	High
	Design Strategy						
21	Build well-ventilated tunnels on provincial roads or the Major Road Network in Metro Vancouver where there is higher TRAP exposure	P or TA (for Major Road Network in Metro Vancouver) (Lead)	Low effectiveness, low practicality	Medium	High	Low	Low
	Transportation Management Strategies						
22	Expand car-share programs	TA (in Metro Vancouver) or M (Lead)	Low effectiveness, high practicality	Low	High	Low-Medium	Low
23	Encourage part-time teleworking	TA (in Metro Vancouver) or M (Lead); involve business industry associations too	Low effectiveness, high practicality	Medium	High	High	High
24	Implement or expand U-pass program	TA (Lead); support from post-secondary institutions	Low effectiveness, high practicality	Medium	High	Medium	Low
25	Encourage organizations to manage vehicle fleets to reduce vehicle kilometres traveled	TA (in Metro Vancouver) and / or M (Leads); R (Support)	Low effectiveness, high practicality	Low	High	Medium	Low
26	Condition or filter air in buses (school and transit)	TA and SD (Leads)	Low effectiveness, high practicality	Low	High	High	High
27	Within higher TRAP exposure areas along provincial roads and the Major Road Network in Metro Vancouver, consider implementing or expanding vehicle speed management strategies (e.g. strategies to reduce stop-and-go traffic or reduce vehicle speeds)	P and TA (for Major Road Network in Metro Vancouver) (Leads)	Low effectiveness, high practicality	Low	High	Medium	Low
28	Designate truck traffic to specific times	P and M (Leads); PA (Support); involve the BC Trucking Association too	Low effectiveness, high practicality	Medium	High	High	Medium

TA = Transportation authority
PA = Port authority
M = Municipal government
R = Regional government
P = Provincial government
F = Federal government
SD = School district
ICBC = Insurance Corporation of British Columbia

Notes

[1] The evaluation results are based on each strategy's effectiveness to reduce exposure to traffic-related air pollutants and the overall technical and political feasibility of the strategy (see page 104 for a description of the individual criteria and scales of measurement used)

- High effectiveness, high practicality: Strategies that are moderately to highly effective in reducing exposure to traffic emissions and likely practical to implement
- High effectiveness, low practicality: Strategies that are moderately to highly effective in reducing exposure to traffic emissions but may be difficult to implement

- Low effectiveness, high practicality: Strategies that are moderately effective in reducing exposure to traffic emissions and likely practical to implement
- Low effectiveness, low practicality: Strategies that are not very effective in reducing exposure to traffic emissions and may be difficult to implement

[2] The co-benefit results are based on each strategy's ability to achieve other human health, environmental, economic, and social benefits (see page 104 for a description of the individual criteria and scales of measurement used)

Municipal / Local Strategies (see notes on page 101)

		Responsibility	Evaluation Result [1]	Co-Benefit [2]	Suitability for Urban Centres	Suitability for Suburban / General Urban Areas	Suitability for Rural Areas
	Key Recommended Strategies						
	Land Use Strategies						
1	Work with health authorities and other relevant agencies to develop a process for assessing health impacts of proposed new communities, infrastructure and transportation services, using an integrated approach that assesses the full range of health impacts, including quantification of air quality-health impacts	M and TA (for Major Road Network projects in Metro Vancouver) (Leads), HA, P and R (Support)	High effectiveness, high practicality	Low	High	High	High
2	Work with health authorities and other relevant agencies to develop best management practices that will mitigate exposure to TRAP in *identified* higher TRAP exposure areas as part of zoning and development permit processes	M (Lead), HA and SD (Support)	High effectiveness, high practicality	Low	High	High	High
3	Review urban growth and infill strategies and plans to incorporate TRAP considerations	M (Lead)	High effectiveness, high practicality	Medium	High	High	Medium
4	Use neighbourhood design guidelines to avoid or mitigate street canyon effects	M (Lead)	High effectiveness, low practicality	Low	High	Low	Low
	Design Strategies						
5	Locate designated pedestrian and cycling routes further away from busy roads (e.g. parallel roads, separated bike paths) wherever possible	M (Lead)	High effectiveness, high practicality	Medium	High	High	High
6	For development / permit applications, promote best practices for indoor air quality management that reduce levels of outdoor pollutants and if municipalities have the authority, implement these practices	M (Lead)	High effectiveness, high practicality	Low	High	High	High
	Transportation Management Strategies						
7	Enhance pedestrian and cycling infrastructure	M (Lead); TA (in Metro Vancouver) (Support)	High effectiveness, high practicality	High	High	High	Medium-High
8	Expand ride-share programs, including vanpooling, for trips to work, school, and events	M or TA (in Metro Vancouver) (Lead); involve rideshare providers too	High effectiveness, high practicality	Low	Medium	High	High
9	Introduce or enhance commute trip reduction programs	M or TA (in Metro Vancouver) (Lead)	High effectiveness, high practicality	High	High	Medium	Medium
10	Limit private vehicles near schools and daycares	M (Lead); SD (Support)	High effectiveness, high practicality	Medium	High	High	Medium
11	Implement parking management strategies that help reduce TRAP (goal is to reduce vehicle kilometres traveled and the amount of time spent idling and driving around looking for parking)	M (Lead); R (Support)	High effectiveness, high practicality	Medium	High	Medium	Low
12	Establish public idling restrictions and campaigns	M (Lead); R (Support)	High effectiveness, high practicality	Low	High	High	High
13	Establish Enviro-Fleets for vehicles that operate in residential neighbourhoods	M (Lead)	High effectiveness, high practicality	Low	High	High	Medium
14	Encourage a truck licensing program to be implemented at ports (Port Metro Vancouver has already implemented a truck licensing program)	M (to encourage PA to implement the program) (Lead); PA to implement program	High effectiveness, high practicality	Low	High	High	High
15	Establish low emission zones where vehicles that do not meet certain emission standards must pay a substantial fee for each day they operate in the zone	M (Lead); R and P (Support)	High effectiveness, low practicality	Low	High	Low	Low
	Education / Outreach Strategies						
16	Encourage children and parents to walk and bike to school	SD (Lead); M, TA (in Metro Vancouver), and HA (Support); involve other non-government organizations such as HASTeBC too	Low effectiveness, high practicality	Medium	High	Medium-High	Medium-High
17	Encourage cyclists to choose low-traffic routes wherever possible	M, HA, and TA (in Metro Vancouver) (Leads); involve bicycle user groups too	Low effectiveness, high practicality	Medium	High	Medium	Medium

		Responsibility	Evaluation Result [1]	Co-Benefit [2]	Suitability for Urban Centres	Suitability for Suburban / General Urban Areas	Suitability for Rural Areas
	Additional Strategies						
	Design Strategies						
18	Create barriers between emission sources and higher TRAP exposure areas.	M (Lead)	Low effectiveness, high practicality	Low	High	High	High
19	Build well-ventilated tunnels on municipal roads where there is higher TRAP exposure	M and TA (for Major Road Network in Metro Vancouver) (Leads)	Low effectiveness, low practicality	Medium	High	Low	Low
	Transportation Management Strategies						
20	Expand car-share programs (e.g. Modo, Car2Go, Zipcar)	M or TA (in Metro Vancouver) (Lead)	Low effectiveness, high practicality	Low	High	Low-Medium	Low
21	Encourage part-time teleworking.	M or TA (in Metro Vancouver) (Lead); involve business industry associations too	Low effectiveness, high practicality	Medium	High	High	High
22	Encourage organizations to manage vehicle fleets to reduce vehicle kilometres traveled	M and / or TA (in Metro Vancouver) (Leads); R (Support)	Low effectiveness, high practicality	Low	High	Medium	Low
23	Implement traffic calming measures	M (Lead)	Low effectiveness, high practicality	Medium	High	High	Medium-High
24	Promote enhanced electric vehicle infrastructure in all new developments	M (Lead)	Low effectiveness, high practicality	Low	High	High	High
25	Provide more infrastructure for electric vehicles and other cleaner vehicle technologies / fuels for high emitting vehicles	M and PA (Leads); P (Support)	Low effectiveness, high practicality	Low	High	High	High
26	Establish Municipal Green Fleets	M (Lead)	Low effectiveness, high practicality	Low	High	High	High
27	Condition or filter air in buses (school and transit)	SD and TA (Leads)	Low effectiveness, high practicality	Low	High	High	High
28	Within higher TRAP exposure areas along municipal roads, consider implementing or expanding vehicle speed management strategies (e.g. strategies that reduce stop-and-go traffic or reduce vehicle speed)	M (Lead)	Low effectiveness, high practicality	Low	High	Medium	Low
29	Designate truck traffic to specific times	M and P (Leads); PA (Support); involve the BC Trucking Association too	Low effectiveness, high practicality	Medium	High	High	Medium
30	Design bus shelters to reduce exposure to air pollutants	M (Lead); TA (Support)	Low effectiveness, low practicality	Medium	High	High	Medium
31	Re-route heavy duty truck and freight routes away from residential and mixed use residential areas	M (Lead); TA (in Metro Vancouver) (Support)	Low effectiveness, low practicality	Low	Low	Medium	High
32	Implement circulation changes that would re-route through-traffic and reduce the volume of traffic on streets programmed for residential or mixed-use residential use	M (Lead); TA (in Metro Vancouver) (Support)	Low effectiveness, low practicality	Low	High	High	High

EVALUATION CRITERIA

EFFECTIVENESS IN REDUCING EXPOSURE TO TRAP

1. Level of TRAP exposure reduction

High

- Reduces VKT for general vehicle traffic by greater than 5%, OR
- High potential to reduce emissions from high-emitting vehicles.
- Removes exposure (e.g. through siting or re-routing).
- Targets reductions in higher TRAP exposure areas.
- Expect significant uptake of measure (e.g. where a strategy targets diesel bus emissions, expect more than half of diesel buses will perform the measure). High uptake typically requires regulation or significant cost savings for the targeted individuals.

Medium

- Reduces VKT by 1 to 5% for general vehicle traffic, OR
- Moderate potential to reduce emissions from high-emitting vehicles.
- Reduces exposure by removing pollutants (e.g. air filtration).
- Expect moderate uptake of measure (e.g. expect 10 to 50% uptake of measure). Moderate uptake typically requires strong financial incentives.
- May result in significant decrease in overall exposure (e.g. overall reduction in VKT >5%), but potential increase in exposure for a subset population (e.g. increased emissions from running more diesel buses on specific routes).

Low

- Reduces VKT for general vehicle traffic by less than 1%, OR
- Low potential to reduce emissions from high-emitting vehicles.
- Expect low uptake of measure (e.g. less than 10% of targeted population performs the measure). Lower uptake is typically associated with broad education and communication campaigns not linked to incentives or regulations.

2. Proportion of population benefitting from reduced exposure as a result of implementing the strategy

High

- More than 50% of the population

Medium

- 10 to 50% of the population

Low

- Less than 10% of the population

3. Specifically benefits vulnerable populations in terms of their health

Yes

- Strategy targets emission reductions in Higher TRAP Exposure Areas where vulnerable populations spend significant time, including:
    - Elementary or secondary school
    - Health care facility (hospitals, hospices, long-term care, etc.)
    - Low-income neighbourhood or housing development
    - Traffic (where the vulnerable population is individuals that spend significant amounts of time in traffic)
    - Transit stops and inside diesel buses
    - Active transportation pathways

Neutral

- Strategy addresses emission reductions for the general population (which may or may not include vulnerable populations).

4. Specifically benefits areas with high density in terms of reduced exposure

Yes

- The area is primarily made up of multi-family residential units

Neutral

- The area may contain a mix of residential forms, but is primarily single-family units on larger lots

OVERALL PRACTICALITY OF STRATEGY

5. Feasibility / ease of implementation (political, etc.)

High

- The strategy will be led and primarily implemented by one organization.
- The strategy is within current "realm" of implementing agency – e.g. does not require changes in legislative authority, though may include enacting a regulation using current powers.
- The strategy has high potential for proponents or champions.
- The strategy aligns with other strategic initiatives or policies already in place.
- Does not require significant new infrastructure or rely on new technology.

Medium

- The strategy is a joint effort between two organizations.
- The strategy introduces a type of regulation that has not been implemented widely elsewhere.
- May require surmounting some technical challenges, such as building new infrastructure that does not create significant disruptions to the transportation network.

Low

- The strategy requires collaboration among numerous organizations.
- The strategy has high potential for opponents.
- Requires a change in legal authority or powers of the implementing agency, or first jurisdiction to "test" a new type of regulation.

- Technology may be new or untested.
- Requires significant infrastructure to be built.

6. Cost of implementation (opportunities for cost recovery considered) for lead government agency

High cost

- Large, capital-intensive projects that require significant funding beyond annual government budgets, or
- Significant impact on annual government operating costs.
- Little opportunity for cost recovery.

Medium cost

- Projects that may require additional budget above standard operating costs, but can be planned for in annual budgeting processes.
- May be able to recover some cost, or all of the cost over a long period of time.

Low cost

- Projects can be completed within typical annual budgets.
- Considering cost recovery, a high implementation cost may recover costs within reasonable timeframe.
- N.B. Projects that have overall high implementation costs may be ranked as "low cost", if these costs are not borne by the implementing government agency (e.g. a municipal re-zoning requirement to include HEPA filters in new buildings in higher TRAP areas may be expensive for the building developer, but relatively low cost for the municipality).

EFFECTIVENESS IN ACHIEVING CO-BENEFITS

7. GHG emissions

High

- Reduces VKT for general vehicle traffic by greater than 5%.
- Reduces short-lived climate forcers (black soot and methane)

Medium

- Reduces VKT by 1 to 5% for general vehicle traffic.

Low

- Reduces VKT for general vehicle traffic by less than 1%.

8. Creates sense of community (community cohesion), and enhances / maintains livable vibrant communities

Yes / Neutral

9. Benefits transport users (or travelers) in terms of their personal travel experience (comfort, convenience, etc.)

Yes / No / Neutral

10. Enhances affordability for transport users (i.e., overall cost of living)

Yes / No / Neutral

11. Increases active transportation trips (transit, biking, walking)

Yes / No / Neutral

12. Supports Economic Development (employment and productivity)

Yes / No / Neutral