Attachment 1

AIRCARE PROGRAM TECHNICAL REVIEW
PHASE 1

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EXECUTIVE SUMMARY

INTRODUCTION

The Lower Fraser Valley (LFV) is a diverse region in terms of ecology, landscape and people and has a current population of over 2.4 million people, making it the third largest metropolitan area in Canada. The population in the region is growing rapidly, having seen a doubling in population in the past 35 years, with the potential for continued growth to 3.3 million people by 2026. To meet personal and commercial transportation needs, there are approximately 1.2 million light duty vehicles and 44,000 heavy duty vehicles licensed in the LFV.

The population growth, meteorology and topography of the LFV combine to make the airshed extending over the region one of high air pollution potential that experiences periods of noticeable degradation in summer months, in most years. Air movement is restricted by the Coast and Cascade mountains, which form barriers to air movement in the north and southeast. Together with the effects of having the ocean to the west, the region's natural features form a triangular basin where air pollutants can recirculate and build up over several days during stagnant summer weather conditions. With sustained poor ventilation conditions, air quality can degrade significantly, particularly in the eastern Lower Fraser Valley, and exposure to elevated ozone, fine particulate matter and other pollutants can increase human health risk, impair visibility and have other adverse effects.

PURPOSE OF THE REVIEW

This study is being completed in two phases. The goals of Phase 1 of the study are:

a) to evaluate the performance and cost effectiveness of the AirCare program and, considering air quality priorities in the Lower Fraser Valley, trends in vehicle emission control and inspection technologies, and other factors, to recommend whether or not the AirCare program should be continued and, if continued, which options should be considered in Phase 2 to improve the program; and

b) to evaluate the current heavy-duty vehicle program and to recommend options to enhance emission reductions.

AIR QUALITY IN THE GVRD AND FVRD

Air pollution and its effects on human health and the environment have been long-standing concerns in the Lower Fraser Valley, with a focus on ozone and fine particulate matter because of their more serious impacts to the young, the elderly and individuals with pre-existing illnesses. Episodes of high ozone concentrations can occur from reaction of nitrogen oxide (NOx), volatile organic compounds (VOCs) and other pollutants in the presence of sunlight, usually during hot summer days. For this reason, NOx and VOCs are called ozone precursors. Fine particulate ($PM_{2.5}$) and inhalable particulate matter (PM_{10}) are emitted directly from some sources and are also formed as a secondary pollutant from emitted gases, particularly ammonia, NOx and sulphur oxides (SOx).

Through the 1980s, air quality in the LFV was deteriorating as a result of increasing emissions from motor vehicles and other local sources, resulting in high concentrations of ozone, fine particulate matter and associated pollutants, largely during summer smog episodes. The Canadian Council of Ministers of the Environment (CCME) developed a national NOx and VOC management plan in 1988 to promote reductions in the emissions of these ozone precursors and designated the LFV as one of three ozone management regions in Canada. AirCare was implemented to address the largest source of ozone precursors in the LFV at that time and thereby reduce the potential for ozone formation.

The Greater Vancouver Regional District developed and implemented Canada's first comprehensive Air Quality Management Plan (AQMP), which was adopted in 1994 to maintain and improve air quality in the region. The AQMP's major objective, to reduce total emissions of common air contaminants by 38% between 1985 and 2000, was achieved a year ahead of schedule through implementation of tighter federal emission standards for motor vehicles, AirCare and a number of other emission reduction measures for mobile, point and area emission sources. All levels of government had a role in achieving these reductions.

The emission reductions achieved by the AQMP since its implementation have improved regional air quality substantially, while the region has grown in population and commercial activity. However, air quality continues to be degraded under certain weather conditions causing elevated ozone and fine particulate matter ($PM_{2.5}$) levels compared to standards. Ozone concentrations reached 90-100% of the Canada Wide Standard[1] at GVRD air quality monitoring stations in the eastern part of the LFV during 2001-2003, while other monitoring stations in the LFV were typically at 60-75% of this standard. Motor vehicles continue to be an important consideration in air quality planning in the LFV because they are a major source of all of the pollutants that contribute to ground-level ozone and fine particulate matter, as well as being a significant source of toxic and a variety of other air pollutants.

Air quality planning is an on-going process. The GVRD is in the formative stages of developing an updated Air Quality Management Plan. The goals guiding the creation of the second AQMP are:

- to minimize the risk to public health from air pollution;
- to improve visibility in the region; and
- to minimize the region's contribution to climate change.

Also, the FVRD intends to update its Air Quality Management Plan to address air quality concerns in the eastern LFV, considering options for reducing emissions and building on the experience with air quality management in the GVRD.

The AQMP and implementation of more stringent emission standards for light and heavy duty vehicles has had a beneficial effect on air quality in the LFV, as summarized in Table S-1. Short-term concentrations of common pollutants have declined, with moderate reductions for ozone and inhalable particulate matter (PM_{10}), and larger reductions in ozone precursors, carbon monoxide and sulphur dioxide. There has been moderate to large reductions in annual average pollutant levels for common pollutants, except ozone, which as shown a small increase. The small upward trend in the low average ozone concentration experienced in the LFV has been observed in other urban areas globally and is not a concern in terms of human health effects.

[1] 65 parts per billion by volume over an 8-hour averaging period, by the year 2010. Achievement is based on the 4th highest measurement annually, averaged over three consecutive years.

Table S- 1 1988-2002 Regional Ambient Air Quality Trends

Pollutant	Change in Average Annual Concentration	Change in Short-Term Peak Concentration
Sulphur Dioxide, SO_2	-50%	-50% (1-h average)
Carbon Monoxide, CO	-40%	-55% (1-h average)
Nitrogen dioxide, NO_2	-20%	-35% (1-h average)
Volatile Organic Compounds, VOC	-40%	-35% (1-h average)
Ozone, O_3	+5%	-15 to -20% (1-h average)
Inhalable particulate matter, PM_{10} (1994-2002)	-10%	-10% (24-h average)

Source: GVRD, 2004b

Notes:
- Based on the average of 7 regionally representative stations with long-term data.
- Monitoring of $PM_{2.5}$ does not go back 15 years and data is not sufficient to analyze long-term trends.

HEALTH EFFECTS OF AIR CONTAMINANTS ASSOCIATED WITH MOTOR VEHICLE EMISSIONS

It is beyond the scope of this study to provide a detailed review of the current science for the effects of air contaminants on human health, however, an overview of these effects is very helpful background as reduction in health effects is one of the primary benefits of reducing regional emissions and their affects on ambient contaminant concentrations. Presented in Table S-2 is a summary of the definitive and probable health effects of air contaminants, as compiled by an expert panel struck under the auspices of the British Columbia Lung Association. This review focused on the principal common air contaminants that have long been associated with direct human health effects, which are germane to the evaluation in this study of the performance and benefits of the AirCare and AirCare OnRoad programs.

Table S- 2 Summary of Definite and Probable Health Effects of Air Contaminants Based on Current Knowledge

Contaminant	Definite Effects	Probable Effects
Fine Particles (PM_{10}, $PM_{2.5}$)	Association with increased respiratory and cardiac mortality. Aggravation of asthma. Increased hospital admissions for respiratory and cardiac conditions. Depressed lung function in school children. Increased prevalence of bronchitis. Increased risk of lung cancer. Increased school absences.	Aggravation of acute respiratory infections. Increased risk of wheezy bronchitis in infants. Decreased rate of lung growth in children. Tachycardia in the elderly. Reduced heart rate variability. Increased c-reactive protein. Increased blood vessel constriction.
Ozone	Increased hospital admissions for acute respiratory diseases. Aggravation of asthma. Increased bronchial responsiveness. Increased response to SO_2. Increased number of reduced activity days. Increased school absences for respiratory illness. Reduced lung function.	Effect on mortality. Increased sensitivity to allergens.
Sulphur dioxide (SO_2)	Acute bronchoconstriction in asthmatics. Increased chronic bronchitis.	Increased prevalence of lung cancer. Increased nasal congestion.
Nitrogen dioxide (NO_2)	Increased respiratory morbidity and infections. Aggravation of asthma in children. Lowered lung function. Increased response to ozone.	Chronic respiratory bronchiolitis.
Carbon monoxide (CO)	Increased cardiac ischemia.	Increased hospital cardiac admissions. Decreased birth weight.

Source: Adapted from BC Lung Association, 2003

BACKGROUND ON AIRCARE AND ACOR PROGRAMS

AirCare Program

The AirCare program for light duty vehicles (gross vehicle weight 5,000 kg, or less) and the AirCare OnRoad (ACOR) program for heavy duty diesel vehicles (gross vehicle weight more than 5,000 kg) were developed and implemented to reduce emissions from onroad motor vehicles. The contract for the AirCare program will expire on August 31, 2006, while the ACOR program has no expiry date.

Pacific Vehicle Testing Technologies (PVTT), an operating subsidiary of the Greater Vancouver Transportation Authority (GVTA), currently administers the contract between the GVTA and Envirotest Canada, the private contractor that tests vehicles, and has responsibility for implementation of the ACOR program.

Development of AirCare was initiated following a decision by the BC government and the Board of the Greater Vancouver Regional District in 1989 to control excess emissions from passenger cars and trucks in the LFV by establishing a motor vehicle inspection and maintenance program. Following detailed studies of options for this program, AirCare was implemented in 1992 using a centralized delivery model with testing at 12 inspection stations. An independent evaluation audit of the program was completed in 1994, which concluded that the program was reducing emissions substantially and identified a number of program improvements. In 1998, toward the end of the initial contract period, a detailed study was conducted of AirCare to evaluate its effectiveness, review trends in vehicle and inspection technologies and recommend improvements. The study concluded that AirCare was one of the most effective inspection and maintenance programs for light duty vehicles in North America. Results from this study were used as the basis for changes to AirCare that came into effect in January 2001 to improve emission reductions and cost effectiveness, with the key ones being for 1992 and newer vehicles, including a more rigorous emission test procedure and switching to biennial rather than annual testing.

PVTT publishes performance statistics and internal evaluations of the AirCare program, based on methods established by external reviews. These reports now cover the period from 1992 to 2002.

For a vehicle to pass an AirCare inspection, exhaust emissions must be below set standards for hydrocarbons, nitrogen oxides and carbon monoxide and standard equipment for control of evaporative emissions must be functional. Vehicles failing inspection have excess emissions above those of comparable, well maintained vehicles. Repair of these high-emitting vehicles will usually bring them into compliance with emission standards at a reasonable cost and thus achieve a reduction in emissions. Control of hydrocarbon emissions from motor vehicles will reduce chemically reactive volatile organic compounds (VOCs), as well as a significant source of carcinogenic pollutants, principally benzene, 1,3-butadiene and formaldehyde. The tests and operational features of the current AirCare program are summarized below in Table S-3.

Table S- 3 Features of the AirCare Program

	Vehicle Type and Model Years	Description
Pollutants measured	All gasoline vehicles.	Hydrocarbons (HC). Carbon monoxide (CO). Nitrogen oxides (NOx).
	Diesel vehicles.	Smoke opacity.
Tailpipe Test Procedure	1992 and newer gasoline vehicles.	IM240 Transient Test.
	1991 and older gasoline vehicles.	ASM/Idle Steady-State Test.
	All diesel vehicles.	D147 Transient Test.
Gas Cap	1972-1995 gasoline vehicles.	Pressure test to check for leakage.
Visual inspections	All	Gas cap.
	1988 and newer vehicles.	Catalytic converter.
On-board diagnostic check	1998 and newer vehicles.	Electronic scan of stored trouble codes, check for failure of evaporative emission control system and retention of vehicle data.
Test Frequency	1992 and newer.	Biennial.
	1991 and older.	Annual.
Model Year Exemptions (effective January 1, 2004).	No test required until the vehicle is 3 model years old.	i.e., a 2002 vehicle requires its first test in 2005; or a 2003 vehicle in 2006.
Test Fee (effective January 1, 2004).	1992 and newer – initial test.	$47/vehicle.
	1991 and older – initial test.	$23/vehicle.
	All – retest after fail.	$23/vehicle.

ACOR Program

Under the ACOR program, inspection teams observe onroad heavy duty diesel vehicles to identify smoking vehicles that appear to exceed the diesel emission standards stipulated by the Motor Vehicle Act Regulations. Smoking vehicles are stopped at roadside and a quick, screening-level inspection is conducted by checking the opacity of the exhaust during repeated rapid engine acceleration tests. Vehicles failing this screening test are then tested following a formal test procedure referred to as the SAE J1667 snap acceleration test, which is used widely in similar programs throughout North America. Operators of vehicles failing the test are issued a notice that the vehicle must be re-inspected within 30 days and demonstrate compliance with the emission standards. Vehicles that do not submit a passed re-inspection report are flagged in the ICBC motor vehicle registration database.

The ACOR program was initiated in 1996 with a three-year pilot phase, which was followed from May 1999 through the end of 2001 by a mandatory testing program. Inspection activities were then scaled back until suspension of the program in August 2002. The ACOR program was re-launched by the Province in February 2004 and an agreement has now been reached for it to be jointly run by PVTT and the Ministry of Transportation.

Re-launching of the ACOR program is proceeding in phases, with the initial phase involving voluntary participation of vehicle operators. After this period, ACOR testing will become mandatory for vehicles stopped by inspectors and the same program design will be used as implemented successfully in the 1999-2001 period. Two 1-person inspection teams are delivering the program at road-side with assistance of a central co-ordinator.

The ACOR program is targeted at reducing smoke emissions from heavy duty diesel vehicles. This primarily reduces emissions of diesel particulate matter, however, emissions of other pollutants associated with poor engine combustion are all reduced, such as volatile organic compounds and nitrogen oxides.

ACOR inspectors observe 42,000 heavy duty diesel vehicles per year and stop and test 3,000 vehicles per year in the LFV. Based on previous results, approximately 230 heavy duty diesel vehicles will fail the initial emission test annually and have to be repaired and retested for compliance. Repairing vehicles failing inspections, as well as preventative repairs done by owners to avoid test failures, reduces diesel exhaust emissions.

EMISSIONS IN THE LFV

Inventories of emissions in the LFV are developed periodically by the GVRD, with the most recent one being for 2000. The GVRD has used the 2000 inventory to develop an emission forecast to 2025. The inventory distinguishes between point sources (large industrial sources), area sources (light industrial, commercial, institutional and residential sources), and mobile sources (light duty and heavy duty motor vehicles, aircraft, marine vessels, railways and other non-road equipment such as construction, lawn and garden equipment).

Figures S-1 shows the sum of key pollutants weighted roughly according to air quality impact[2] for the top five emission sectors in 2000. The emission forecasts are as reported for the LFV by the GVRD (2004a), except for light duty and heavy duty vehicles, which are from the updated emission forecast prepared in this study assuming continuation of the AirCare and ACOR programs. The trend curves clearly show that light duty motor vehicles are a major source of pollutants that contribute to the priority air quality concerns in the LFV, even with the emission reductions from AirCare. Emissions from heavy duty vehicles are forecast to decline substantially after 2007, such that they become the 12th ranked source in 2010 and are replaced in the top-five list of sources by other emission source sectors.

The emissions from light duty vehicles are forecast to decline due to the combined effect of tighter emission standards for new vehicles and the reduction in excess vehicle emissions achieved by the AirCare program. Stringent new vehicle emission standards will be instrumental in future emission reductions for this source sector, off-set somewhat by growth in number of vehicles and distances driven annually. Impact weighted emissions from marine vessels and nonroad equipment and vehicles are forecast to grow significantly in the future.

With AirCare implemented, light duty motor vehicles remain the largest source of impact-weighted emissions in 2005 and 2010, as shown in Figure S-2 by a comparison of the top ten emission sources. By 2015, tighter emission standards on 2004 model-year light duty vehicles, more rigorous certification requirements and the emission reductions from AirCare will combine to reduce these vehicles to the third largest sector. Marine vessels and other nonroad equipment will become the top two sources in the region by 2015.

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[2] Impact weighted emissions equal annual emissions summed as follows: $VOC+NOx+CO/7+25PM_{2.5}$. For motor vehicles, 94% of exhaust particulate matter emissions are $PM_{2.5.}$

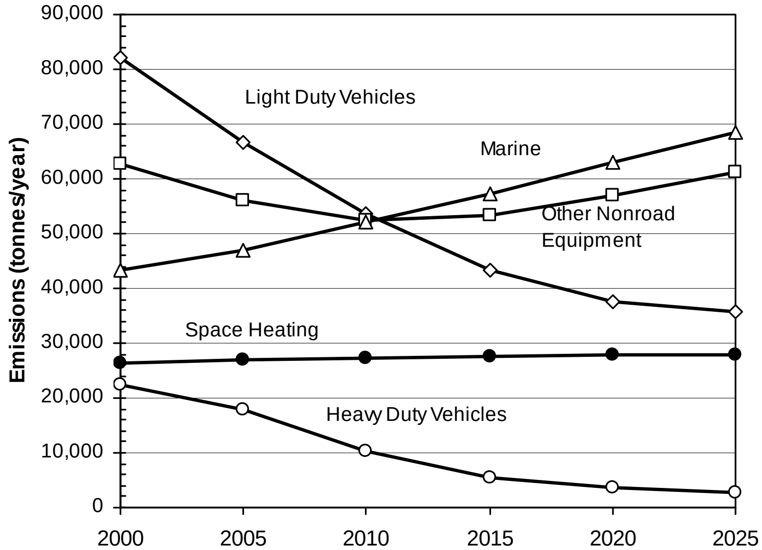
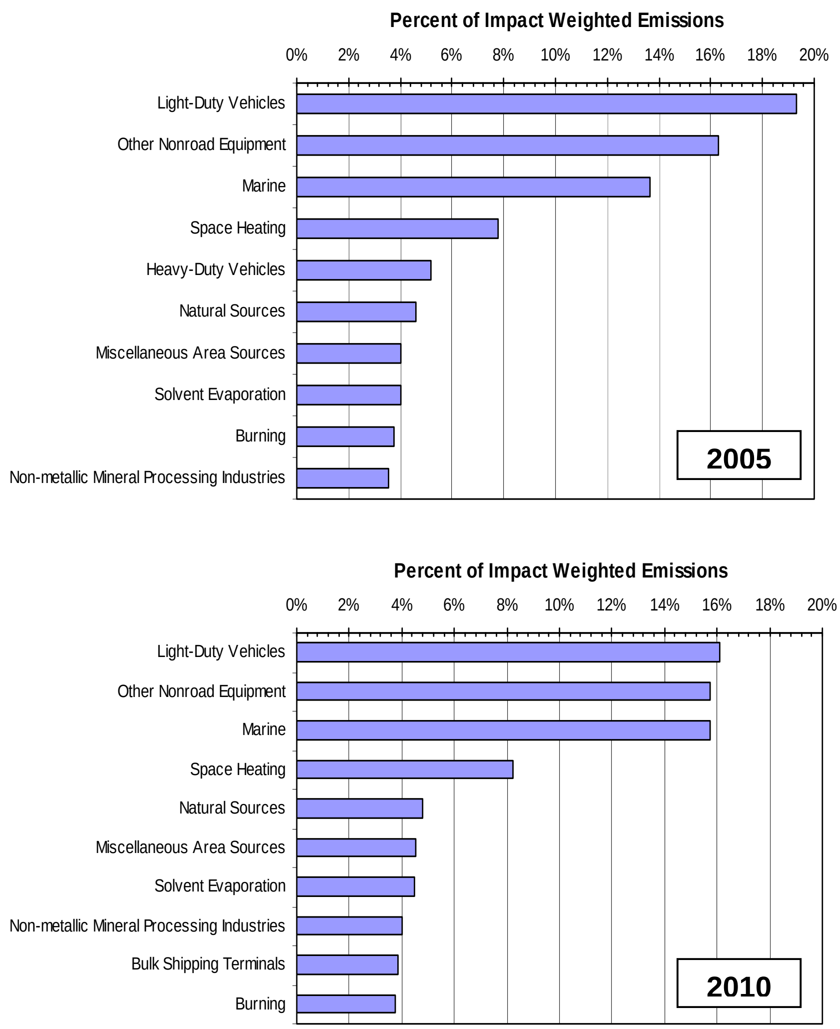
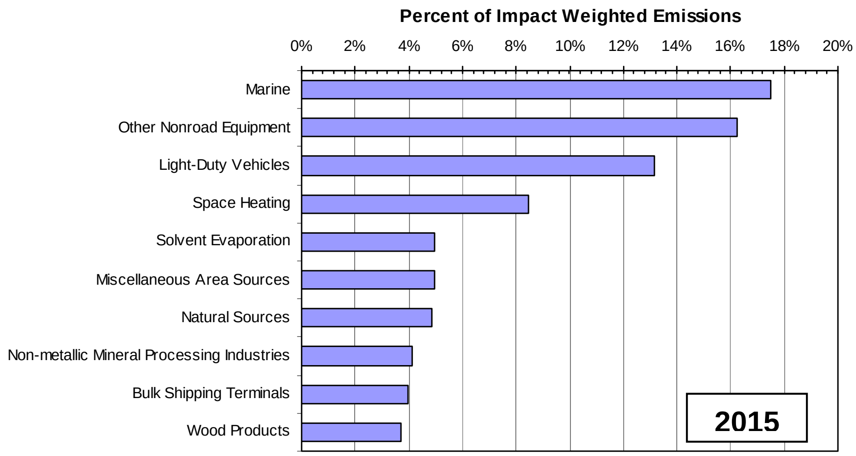


Figure S- 1 Top Five Impact Weighted Emission Sources in the LFV in 2000



Note: Includes emission reductions from AirCare and ACOR for years shown.

Figure S- 2 Share of Impact-Weighted Emissions for Major Sources in the LFV



Note: Includes emission reductions from AirCare and ACOR for years shown.

Figure S-2 Share of Impact-Weighted Emissions for Major Sources in the LFV (continued)

Trends in Vehicle and Emission Testing Technologies

Based on a comprehensive review of light duty vehicle inspection and maintenance programs it is clear that AirCare is using state-of-the-art methods to measure tailpipe emission levels for pre-1998 vehicles. Later model cars in Canada are equipped with the second generation of onboard diagnostic systems (OBDII). Unlike AirCare, most U.S. inspection and maintenance programs inspect OBDII equipped vehicles by plugging into the OBDII system and determining the status of the vehicle's emissions control system. OBDII tests alone have been found to achieve equal or greater emissions reductions to the IM240 tests alone. It is also easier and less expensive to inspect OBDII equipped vehicles in this way rather than to conduct an IM240 emission test as now done by AirCare.

Although OBDII inspections achieve equal or greater emissions reductions to IM240 tests, requiring 1998 and newer vehicles to pass both tailpipe emissions and OBDII standards provides the potential for greater benefits than subjecting them to only an OBDII inspection or a tailpipe test alone. Some jurisdictions are investigating OBDII screening tests that require vehicles with known OBDII deficiencies or that show diagnostic trouble codes to receive tailpipe and OBDII tests, which provide the same benefits as subjecting all vehicles to OBDII and tailpipe tests. Innovative owner-testing of OBDII systems at kiosks is being pursued in Oregon and this approach also has merit for consideration in the LFV to reduce cost and provide improved access and user convenience.

Using remote sensing devices (RSD) to identify high emitting vehicles or to identify clean vehicles that can be exempted from inspection and maintenance tests has been extensively tested in North America, but do not appear to be a cost effective enhancement to these programs. To date, there has been limited success with using remote sensing instead of conventional vehicle tests to reduce excess emissions from light duty vehicles.

A number of trends in the use and design of light duty vehicles will affect future emissions in the LFV, as follows:

	Emissions Increase	Emissions Decrease
Growth in vehicle population	✓	
Increase in fraction of SUVs and trucks in fleet	✓	
Growth in average distance driven annually per vehicle	✓	
Tier 2 emissions standards (2004 model year)		✓
Improved durability of emission controls		✓
Sales of hybrid/fuel cell/alternative fuel vehicles	Depends on technology	

Hybrid vehicles are expected to have a minor effect on emissions in the LFV by 2015. Pollutant emissions from hybrid vehicles could be the same as future gasoline vehicles or could be lower depending on the approach taken by the manufacturer. The fuel consumption and greenhouse gas emissions of current hybrid vehicle designs are lower than conventional designs by 30-50% for small passenger cars to 10-15% for trucks. Hybrids are anticipated to have limited market penetration in the near to medium term. A recent forecast by the National Energy Board anticipates hybrid vehicles having 2% of the new passenger vehicle market by 2010 with business as usual policies and up to 13% with incentive policies.

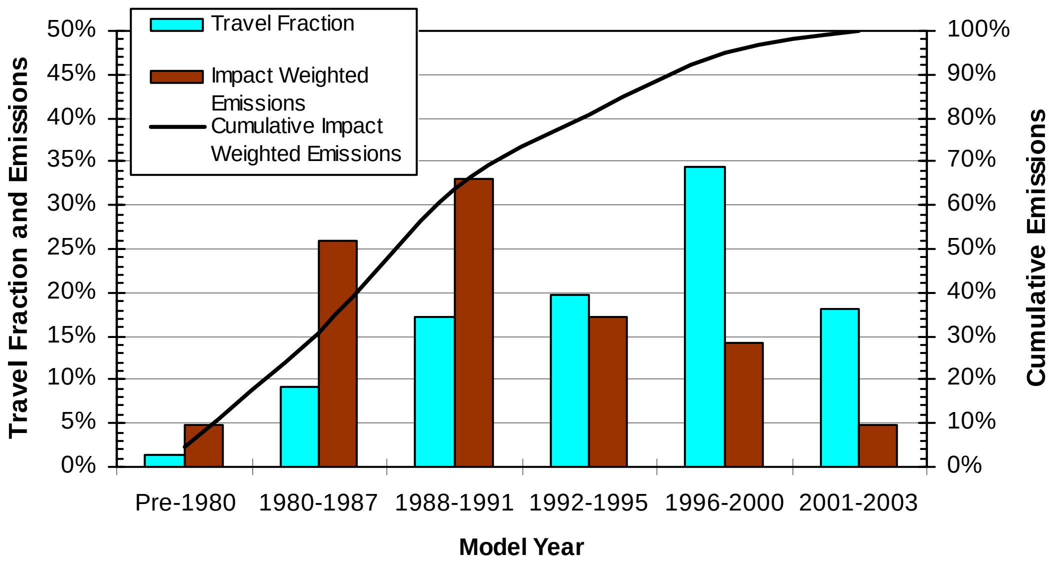
Fuel cell vehicles have essentially no emissions, however, emission may occur from hydrogen production, depending on the process used. Fuel cell vehicles are unlikely to be commercially available in significant numbers until beyond 2015 based on the pace of development of vehicle technology and refueling infrastructure.

AirCare Program

Program Performance and Effectiveness

Vehicle emission testing data for 2002 and 2003 was used to determine the emission reductions currently achieved by AirCare and to calibrate forecasts of emission reductions for 2010 and later years developed using an emission model. A two-year period was considered to capture data for a complete test cycle.

A significant fraction of the vehicle fleet (15%) continues to emit at well above emission standards. AirCare identifies the vast majority of these emissions (>90%) and requires high emitting vehicles be repaired or receive conditional passes before being eligible for re-licensing. As illustrated below, 1991 and older model year vehicles are responsible for 64% of impact weighted emissions from the fleet and yet are used for only 28% of distance travel by the vehicle fleet. The situation is reversed for 1992-2000 model year vehicles, which are responsible for 31% of impact weighted emissions, while accumulating 54% of the distance traveled by the fleet. The best results are shown for 2001-2003 model year vehicles, as they emit only 5% of the total impact weighted pollutants and are used for 18% of the travel.



Repairs that bring vehicles into compliance with AirCare standards achieve close to the best achievable emission reductions. On the other hand, vehicles that receive waivers show little to no emissions reductions. Overall, the analysis shows one cycle of the current program reduces hydrocarbons by 25%, carbon monoxide by 24% and nitrogen oxides by 11%. At these levels, AirCare remains one of the most effective programs in North America. The emission reductions from AirCare are close to the maximum estimated to be achievable by prevention of excess vehicle emissions.

The cost effectiveness of AirCare was determined as the cost per tonne of emission reduction, based upon observed emission reductions and the cost for operating the program and assuming it is fully funded by test fees. The costs and savings included in the calculation of cost effectiveness are inspection costs, vehicle repair costs and fuel savings. AirCare had a cost effectiveness in 2003 of approximately $7,000/tonne of impact weighted emissions reduced (HC+NOx+CO/7). This reflects the current policy of exempting the first 3 years for new vehicles. The cost effectiveness of AirCare if the current design is continued is $7,000/tonne of impact weighted pollutants in 2005 and will rise in later years as vehicles become cleaner to $10,900/tonne in 2010 and $13,200/tonne in 2015.

The current cost effectiveness of AirCare is in line with the cost effectiveness of stationary emission control measures implemented under the AQMP, in which the lowest-cost group are under $10,000/tonne reduced. The cost effectiveness of AirCare is also similar to that for California's light duty vehicle Smog Check program at CDN$6,400/tonne reduction in impact weighted emissions, after conversion to Canadian currency and adjustment to reflect the average vehicle repair cost observed in the AirCare program. Also, the study of options for AirCare II in 1998 estimated the same $/tonne cost effectiveness for the currently implemented AirCare design as was found in this study.

The cost effectiveness of AirCare could be improved in the future if 1998 and newer vehicles were tested by an OBDII test, instead of receiving the IM240 test that is currently performed. Other options were also identified that could maintain high emission reductions from motor vehicles while reducing costs.

AirCare is using state-of-the-art methods to measure tailpipe emissions for pre-OBDII equipped vehicles (i.e., pre-1998 vehicles) and should continue to use these test methods.

Further study of possible combinations of OBDII inspections and IM240 tests of 1998 and newer vehicles is needed to determine the optimum program design for emission reductions and cost effectiveness. AirCare should also consider extending the new car exemption and evaluate the exemption that would be best for the program.

Emission Reductions

Emission reductions from AirCare were determined in five year intervals beginning in 2000 assuming the program remains similar in design to that used today, but taking into account the effects of fleet turnover with new vehicles and legislated future vehicle emission standards and fuel sulphur content on future emissions.

AirCare achieves large reductions in emissions of common pollutants and air toxics, as well as a smaller reduction in emissions of greenhouse gases in terms of tonnes per year and percentage, as summarized in Table S-4. Emissions from light duty vehicles without AirCare will decline over the forecast period due to the stringent emission standards that new vehicles are required to meet, starting with the 2004 model year. Even with this improvement, AirCare would continue to achieve large reductions in CO and VOC emissions and substantial NOx reductions, resulting in an 18-21% decrease in annual impact-weighted emissions for the 2005-2015 forecast period. AirCare currently reduces emissions of carcinogenic pollutants from light duty vehicles by 25% and this is forecast to increase to 27% by 2015.

Table S- 4 Summary of Annual Emissions in the LFV From Light Duty Vehicles Without and With AirCare

Year and Pollutant	Emissions Without AirCare*	Emissions With AirCare*	Emission Reduction	
	(tonnes/year)	(tonnes/year)	(tonnes/year)	%
2005				
VOC	21,174	15,907	5,267	25%
NOx	19,057	17,052	2,005	11%
CO	286,384	217,737	68,647	24%
Impact weighted pollutants**	**81,143**	**64,064**	**17,079**	**21%**
Benzene-equivalent toxics	1,612	1,230	382	24%
Greenhouse gases (CO_2)	4,942,151	4,939,186	2,965	0.06%
2010				
VOC	15,228	11,895	3,333	22%
NOx	14,086	12,596	1,490	11%
CO	226,712	183,686	43,027	19%
Impact weighted pollutants	**61,702**	**50,732**	**10,970**	**18%**
Benzene-equivalent toxics	1,026	786	240	23%
Greenhouse gases (CO_2)**	5,298,995	5,295,815	3,180	0.06%
2015				
VOC	10,252	7703	2548	25%
NOx	9,997	8927	1069	11%
CO	201,763	163,463	38,300	19%
Impact weighted pollutants	**49,072**	**39,983**	**9,089**	**19%**
Benzene-equivalent toxics	717	526	192	27%
Greenhouse gases (CO_2)**	5,691,512	5,688,102	3,410	0.06%

* Gasoline and diesel motor vehicles with a GVWR of 5,000 kg or less.

** Impact weighted emissions =VOC+NOx+CO/7. AirCare is estimated to have no effect on direct PM_{10} emissions.

AirCare reduces fleet gasoline consumption by an estimated 0.06%, which will reduce greenhouse gas emissions by 2,965 tonnes/year in 2005, rising to 3,400 tonnes/year in 2015. This benefit reduces total owner's costs for fuel by about $1.1 million per year (at $0.90/L).

The reduction in impact weighted emissions is equivalent to removing 240,000 gasoline passenger cars from the road, based on the average emissions per kilometer and distance travelled for the current fleet. The emission reduction benefits of AirCare are forecast to continue to 2015 and beyond, which is the equivalent of removing 220,000 cars from the road in 2010, and 250,000 cars in 2015.

The forecast of emissions from light and heavy duty vehicles without and with inspection and maintenance programs were combined with the forecast of emissions from other sources in the LFV prepared previously by the GVRD. The reduction in impact weighted emissions from AirCare and ACOR amounts to 5% of total regional emissions in 2005, and 3% in 2010 and 2015, as summarized in Table S-5. These are substantial reductions from a single large source sector considering the total inventory from all sources. The no-AirCare and no-ACOR baseline declines over this period due to implementation of more stringent vehicle emission standards, which contributes to a decline in the emission reductions achieved by AirCare.

Table S- 5 Total Emissions from All Sources in the LFV Without and With AirCare and ACOR

Pollutant	Emission Source or Reduction	2005		2010		2015	
		tonnes/year	%	tonnes/year	%	tonnes/year	%
CO	Emissions without AirCare or ACOR	407,609		357,346		341,329	
	AirCare Reduction	68,647	16.8	43,027	12.0	38,300	11.2
	ACOR Reduction	0	0.0	0	0.0	0	0.0
	Total Reduction	**68,647**	**16.8**	**43,027**	**12.0**	**38,300**	**11.2**
	Net Emissions wIth AirCare & ACOR	338,961		314,320		303,029	
NOx	Emissions without AirCare or ACOR	78,004		69,695		64,404	
	AirCare Reduction	2,005	2.6	1,490	2.1	1,069	1.7
	ACOR Reduction	43	0.1	25	0.0	13	0.0
	Total Reduction	**2,048**	**2.6**	**1,515**	**2.2**	**1,082**	**1.7**
	Net Emissions wIth AirCare & ACOR	75,956		68,180		63,322	
VOC	Emissions without AirCare or ACOR	69,322		63,480		59,881	
	AirCare Reduction	5,267	7.6	3,333	5.3	2,548	4.3
	ACOR Reduction	8	0.0	5	0.0	5	0.0
	Total Reduction	**5,275**	**7.6**	**3,338**	**5.3**	**2,554**	**4.3**
	Net Emissions wIth AirCare & ACOR	64,047		60,142		57,328	
$PM_{2.5}$	Emissions without AirCare or ACOR	6,260		6,362		6,575	
	AirCare Reduction	0	0	0	0	0	0
	ACOR Reduction	6	0.10	2	0.04	1	0.02
	Total Reduction	**6**	**0.10**	**2**	**0.04**	**1**	**0.02**
	Net Emissions wIth AirCare & ACOR	6,254		6,359		6,573	
Impact Weighted*	Emissions without AirCare or ACOR	362,064		343,264		337,417	
	AirCare Reduction	17,079	4.7	10,970	3.2	9,089	2.7
	ACOR Reduction	212	0.1	91	0.0	54	0.0
	Total Reduction	**17291**	**4.8**	**11061**	**3.2**	**9144**	**2.7**
	Net Emissions wIth AirCare & ACOR	344,773		332,203		328,273	

* Impact weighted regional emissions= VOC +NOx +CO/7+25$PM_{2.5}$.

Emission reductions from the AirCare and ACOR programs improve local and regional air quality and reduce health risks from exposure to ozone, fine particulate and other common pollutants, as well as carcinogenic air pollutants, such as benzene and diesel particulate matter. AirCare strongly supports the goals of the GVRD and FVRD Air Quality Management Plans, having contributed the largest reduction in emissions of the range of measures implemented by the GVRD. This large contribution to emission reductions in the LFV is projected to continue in the near future.

While emissions from light and heavy duty vehicles will decrease by 2015, in spite of forecast growth in numbers and usage of motor vehicles, emissions will increase substantially from marine and more modestly from point and area sources, causing a resumption of growth in regional emissions beyond 2015. This resumption of emission increases will adversely affect air quality and visibility in the region if allowed to persist.

Overall Evaluation

An assessment of the AirCare program was conducted using an evaluation framework that considered environmental, economic and program effectiveness criteria. For this analysis, AirCare was assumed to continue with a design similar to that of the current program. The results for AirCare are summarized in Table S-6.

Table S- 6 Evaluation of the AirCare Program

Evaluation Parameters	2005	2010	2015	Overall Rating
Environmental				
Change in emissions from light duty vehicles				
Health impact weighted pollutants	-21%	-18%	-19%	**++**
Greenhouse gases	~0.1%	~0.1%	~0.1%	**O**
Toxic pollutants	-24%	-23%	-27%	**++**
Change in regional emissions (all sources)				
Health impact weighted pollutants	-5%	-3%	-3%	**++**
Toxic pollutants	-8%	-6%	-4%	**++**
Change in health effects from pollutant exposure.	**++**	**++**	**+**	**+/++**
Achievement of GVRD and FVRD environmental goals and objectives.	**++**	**++**	**+**	**+/++**
Economic				
Cost-effectiveness 2004$/tonne impact weighted emissions (VOC+NOx+CO/7)	7,000	10,900	13,200	**–**
Program Effectiveness				
Customer convenience (waiting time)	**– /O**	**– /O**	**– /O**	**– /O**
Process based I/M effectiveness (detection of excess emitters)	**++**	**++**	**++**	**++**
Quality indicators: results, enforcement and waiver administration.	**++**	**++**	**++**	**++**

Rating scale:

– – Strongly negative; **–** Negative; **O** Neutral; **+** Positive; **++** Strongly positive.

Overall the AirCare program is functioning very effectively and contributing to achievement of the goals of the GVRD and FVRD to continue to improve air quality in the airshed and to avoid and reduce adverse health impacts associated with people's exposure to ground-level ozone, fine particulate matter, toxic chemicals and other air pollutants. The program achieves a large and beneficial reduction in pollutants that is significant regionally. The current cost of AirCare in dollars per tonne of impact weighted emissions reduced is comparable to other control options implemented or being considered under the AQMP, however, the cost effectiveness ratio will increase as baseline emissions decline unless changes are made to the program's testing costs. Steps should be taken to reduce testing cost and optimize the cost effectiveness if it is continued beyond 2006 and options for doing so are identified in this study.

ACOR PROGRAM

Program Performance and Effectiveness

ACOR inspects approximately 3000 heavy duty vehicles per year and reduces emissions due to the repair of vehicles failing the test, as well as repairs made voluntarily by vehicle owners to avoid test failures. This means that about 10-11% of the heavy duty diesel fleet is being inspected. The emission reduction benefits achieved by the program increase roughly in proportion to the percentage of the vehicle fleet inspected. The percent of the fleet inspected in the LFV is low compared to California where combined roadside and self-inspection of vehicles by owners is close to 55%.

ACOR currently reduces emissions from heavy duty diesel vehicles as follows: VOC, 2.2%; NOx, 0.5%; and PM_{10}, 3%. These emission reductions are achieved cost effectively, with an estimated cost per impact weighted tonne of emission reduction of $2,100/tonne ($VOC+NOx+25PM_{10}$). The cost effectiveness will increase to about $4,900/tonne impact weighted emission reductions by 2010 as emissions from the fleet decrease, assuming the same program cost.

The test procedure and standards used in the ACOR program are suitable for identifying vehicles with high particulate emissions and are consistent with methods used to test these vehicles in Ontario, California, Washington State and many other US jurisdictions.

Changes to the program will be needed as vehicles equipped with advanced emission control and OBD systems that meet the 2007 emission standards are deployed in the market place and the on-going modernization of the vehicle fleet makes the snap acceleration test increasingly less effective for checking vehicles for excess emissions.

Emission Reductions

Baseline emissions from heavy duty vehicles will decrease from the introduction of new diesel vehicles meeting the stringent 2007 emission standards. These standards will be phased-in between 2007 and 2010. ACOR reduces these baseline emissions in proportion to the fraction of the onroad vehicles inspected, which is currently about 10-11% and will decline to about 7% by 2010 with growth in the fleet. ACOR is forecast to reduce emissions from the heavy duty vehicle fleet, as shown in Table S-7.

Table S- 7 Summary of Emissions from Heavy Duty Vehicles Without and With ACOR for Diesel Vehicles

Year and Pollutant	Emissions Without ACOR	Emissions With ACOR	Emission Reductions	
	(tonnes/year)	(tonnes/year)	(tonnes/year)	%
2005				
VOC	425	417	8	1.9%
NOx	8,711	8,668	43	0.5%
PM_{10}	234	227	7	3.0%
Impact weighted pollutants*	**15,407**	**15,181**	**225**	**1.5%**
Greenhouse gases (CO_2)	-	-	1,770	0.1%
2010				
VOC	314	309	5	1.5%
NOx	5,189	5,163	25	0.5%
PM_{10}	116	113	3	2.3%
Impact weighted pollutants	**8,634**	**8,538**	**96**	**1.1%**
Greenhouse gases (CO_2)	-	-	1,680	0.1%
2015				
VOC	253	248	5	2.1%
NOx	2,559	2,546	13	0.5%
PM_{10}	54	52	2	3.0%
Impact weighted pollutants	**4,278**	**4,220**	**58**	**1.3%**
Greenhouse gases (CO_2)	-	-	1,680	0.1%

* Impact weighted emissions= VOC+NOx+25PM_{10}. ACOR is estimated to have no effect on CO emissions.

ACOR reduces fuel use by 0.1%, yielding a cost saving to operators in 2005 of up to $382,800/year and a reduction in greenhouse gas emissions of up to 1,770 tonnes of CO_2equivalent per year in 2005. This fuel saving was not included in the cost effectiveness estimate due to uncertainty in the fuel economy benefit.

The forecast emissions from heavy duty vehicles without and with inspection and maintenance programs were combined with the regional emissions prepared by the GVRD for the LFV. These results are shown earlier in Table S-5. The reduction in impact weighted emissions from ACOR is small regionally, amounting to only about 0.1% of the baseline impact weighted emissions from all sources without ACOR or AirCare.

The emission reductions achieved by ACOR could be increased by adding a self-inspection program for owners with two or more heavy duty diesel vehicles and requiring installation of low-NOx engine control software already available from engine manufacturers for 1993-1998 model year vehicles. A self-inspection program would add to the existing coverage of the local onroad diesel fleet to reach a total of approximately 40%. The installation of low-NOx rebuild software would correct NOx defeat devices installed on 1993-1998 engines that improved fuel economy at the expense of higher NOx emissions. There is presently no requirement for vehicle owners to install this software in Canada, although this is a requirement in the United States when engines are rebuilt. Implementation of these two enhancements would increase emission reductions for heavy duty diesel vehicles in 2010 to 13% for PM_{10}, 9% for VOC and 5% for NOx. The effect on emissions from all heavy duty vehicles would be lower since emissions from gasoline vehicles would not be affected.

With addition of a self-inspection program for owners of fleet vehicles and a requirement for installation of low-NOx engine control software, ACOR is forecast to reduce impact weighted emissions by 963 tonnes/year (6.3%) in 2005, 653 tonnes/year (7.6%) in 2010 and 245 tonnes/year (5.7%) in 2015, as compared to the emission reductions forecast for the current ACOR program shown in Table S-7.

Overall Assessment

The overall assessment of the ACOR program is summarized in Table S-8 using the same evaluation framework used for AirCare. The reduction in emissions achieved by ACOR has a minor effect on regional emissions of common and toxic pollutants due to the combined effect of the small percentage of vehicles inspected and the small share of regional impact weighted emissions from this sector (5% in 2005 and 2% by 2015). Emission reductions from ACOR in the form of smoke and common pollutants primarily address important localized air quality problems near intersections and in road corridors where there is a high volume of truck and bus traffic. In these areas, the impact of diesel vehicles on pollutant concentrations and human health is much higher than suggested by emission results on a regional basis.

Overall the ACOR program is presently contributing to achievement of the goals of the GVRD and FVRD to reduce exposure to diesel particulate matter (a probable carcinogen) and fine particulate matter. The cost effectiveness of emission reductions is attractive compared to alternatives being implemented in the LFV. Advances in vehicle technology after 2007 and declining emissions from cleaner vehicles will make it necessary to redesign the program before 2010.

Table S- 8 Evaluation of the ACOR Program

Evaluation Parameters	2005	2010	2015	Overall Rating
Environmental				
Change in emissions from light duty vehicles				
Impact Weighted Pollutants	-1.5%	-1.1%	-1.4%	**+**
Greenhouse gases (CO_2)	-0.1%	-0.1%	-0.1%	**O**
Toxic pollutants (diesel particulate matter)	-3%	-2%	-3%	**+**
Change in regional emissions (all sources)				
Health impact weighted pollutants	-0.1%	<-0.1%	< -0.1%	**O/+**
Toxic pollutants (diesel particulate matter)	~ 0%	~0%	~ 0%	**O/+**
Change in health effects from pollutant exposure.	**+**	**+**	**+/O**	**+**
Achievement of GVRD and FVRD environmental goals and objectives.	**+**	**+**	**+/O**	**+**
Economic				
Cost-effectiveness 2004$/tonne impact weighted emissions ($VOC+NOx+25PM_{10}$)	2,100	4,900	?	**–**
Program Effectiveness				
Customer convenience (waiting time/delays)	**– /O**	**– /O**	**– /O**	**– /O**
Process based I/M effectiveness (detection of excess emitters)	**+**	**+**	**+**	**+**
Quality indicators: results, enforcement	**+**	**+**	**+**	**+**

Rating scale:

– – Strongly negative; **–** Negative; **O** Neutral; **+** Positive; **++** Strongly positive.

FINDINGS

Light Duty Vehicle I/M Program

- A light duty vehicle I/M program should be continued to the 2010-2015 period, in conjunction with periodic reviews and improvements in the design of the program to maintain the current high level of emission reduction, while keeping the cost per tonne of impact weighted emissions attractive in future years. The exact date should be determined as part of Phase 2 of this study. Options for improving the future program as vehicle emissions decline are identified in this study and include using an OBDII inspection rather than the currently used IM240 test on 1998 and newer vehicles, increased exemptions for new vehicles and self-service kiosks for OBDII inspections.
- The future light duty vehicle I/M program should continue to test 1992 through 1997 vehicles using the IM240 cycle and pre-1992 vehicles using the ASM cycle, which are currently state-of-the-art methods to measure tailpipe emissions for pre-OBDII equipped vehicles. Reviews of the methods used to measure vehicle emissions should be conducted in conjunction with periodic reviews of the I/M Program.
- Currently, AirCare requires 1998 and newer vehicles with OBDII systems to pass an IM240 tailpipe test. Inspecting the vehicle's OBDII system is easier, less expensive and achieves equal or greater emissions reductions to the IM240 test. It is recommended that OBDII inspections should be used in any future I/M program for most 1998 and newer vehicles to improve the cost effectiveness and reduce the waiting time for the program, while maintaining a high level of emission reduction.
- If it is decided to continue a light duty vehicle I/M program, Phase 2 of the study should include evaluating design options, considering performance, benefits and costs of:
  - Setting-up self-service kiosks to perform OBDII inspections on 1998 and newer vehicles to improved convenience and provide reduced cost testing for vehicles that pass.
  - Testing of 1998 and newer vehicles using a hybrid testing program starting with an OBDII screening test that would include screening criteria and pass/fail criteria. With this hybrid scenario, approximately 85% of the 1998 and newer vehicles would only get OBDII inspections and emission reductions would be greater than performing only OBDII inspections on 1998 and newer vehicles.
  - Increasing the exemption period for testing of new cars, in combination with changes noted above.
  - Evaluate program design options with the goal of maintaining the cost effectiveness of the program at below $10,000/tonne (2004 dollars) for reduction of emissions of impact weighted pollutants, as future emissions from the vehicle fleet decline.
- Investigate ways to test older vehicles (greater than 10-15 years old) to identify those with fuel leaks. A liquid leak test is estimated to reduce hydrocarbon emissions by 4%.

Heavy Duty Vehicle I/M Program

- The ACOR program should be continued for random roadside testing of heavy duty vehicles using the present format of 2 teams of 1 person each to perform SAE J1667 snap acceleration tests and conduct visual inspections of emission control systems. The opacity cut points for diesel vehicles should remain at the current levels of 55% for pre-

1990 vehicles and 40% for 1991 and newer vehicles, as the same cut points are used in California and most other jurisdictions and they will identify most vehicles with excess particulate matter emissions.

- Periodic analysis and reports of ACOR's performance and effectiveness should be completed and disseminated to the public once the re-launched program is fully operational.
- Public and industry awareness of the program should be increased using an outreach program and by making information easily available.
- Because of high cost, inconvenience to vehicle operators and low emission benefit, expansion of ACOR to include 2-speed idle testing of heavy duty gasoline vehicles at AirCare testing stations is not recommended.
- Options should be investigated in consultation with industry to promote or require installation of low-NOx rebuild computer software in 1993-1998 model year heavy duty diesel vehicles during normal vehicle servicing or on recall to reduce NOx emissions. The ACOR program should include a check for installation of this software during roadside inspections.
- In consultation with the trucking industry, fleet managers and government agencies, investigate the feasibility of implementing a periodic fleet inspection program that would require owners of two or more onroad heavy duty diesel vehicles to test their vehicles (private or owner tested) using the same test protocol used in the ACOR program for roadside testing. Vehicle owners would be required to have vehicles that fail this test repaired and to report such tests and repairs to AirCare. Existing roadside testing should continue to provide verification that onroad vehicles registered locally or in other jurisdictions meet the diesel emission requirements of the Motor Vehicle Act Regulations. The expanded program would include approximately 40% of the locally registered onroad diesel fleet.
- The ACOR program should be reviewed and redesigned prior to 2010 to take into account effects of the forecast decline in vehicle emissions on cost effectiveness, inspection requirements for new vehicle emission control and OBD systems, and vehicle equipment failure, deterioration and tampering that may occur.