Results and Observations Relating to the First Eight Years of Operation (1992-2000)

Prepared by:

S.J.Stewart PhD., P.Eng.
Project Engineer,
(604) 453-5155
stephen_stewart@translink.bc.ca

D.I.Gourley P.Eng.
Manager, Operations
(604) 453-5170
dave_gourley@translink.bc.ca

J.Wong B.A.Sc.
Engineering Assistant
(604) 453-5164
jimmy_wong@translink.bc.ca

Additional copies of this report are available from:

AirCare Administration Office
102-4705 Wayburne Drive
Burnaby, BC, V5G 3L1
Canada

This report may also be viewed at www.aircare.ca

AirCare is a community-based program represented by the following Federal, Provincial and Regional agencies:

Printed in Canada

Foreword

This report represents a comprehensive analysis of the first eight years of AirCare. Since its start-up in 1992, the program has experienced growing pains, interruptions and controversies. Nevertheless, the program has succeeded in achieving a 30% reduction in emissions from light-duty vehicles and enjoys the support of a majority of Lower Fraser Valley residents.

Vehicle emission testing programs impact the public more directly than virtually any other environmental regulation. Although most vehicle owners accept that their driving contributes to air pollution, it is sometimes difficult for them to understand that their own vehicle can make a difference. It is commonly believed that visible emissions from large trucks, industrial smokestacks, locomotives and aircraft are most responsible for poor air quality. However, the emission inventory for the Lower Fraser Valley shows that light-duty vehicles continue to account for more of the total smog-forming emissions released into the region's air than heavy-duty trucks, aircraft and rail combined.

AirCare works by counteracting the degradation of vehicle emissions due to a lack of preventative maintenance or the failure of emission control systems. If all vehicle owners conscientiously followed recommended service schedules, and repair facilities were diligent in checking for and correcting any problems found with the engine or emission controls, there would be no need for an emissions inspection program. However, this is not the case in practice. Often, maintenance is deferred until a serious problem develops. Similarly, causes of high emissions are frequently overlooked as long as the engine has no noticeable performance deficiencies. Inspection programs, like AirCare, identify vehicles with emission defects. Ensuring that these defects are corrected is the responsibility of the repair industry and the motoring public.

From the beginning, the AirCare program has employed state-of-the-art testing methods to identify excess-emitting vehicles. Once identified, the degree to which a vehicle's excess emissions can be reduced depends on the willingness of the owner to pay for repairs and the ability of the repair industry to isolate and correct any problems. These factors are critical to the success of the program but are beyond the ability of the program administration to control. Studies of inspection programs in other jurisdictions point to the same concerns about the response of the motoring public and the repair industry to emissions inspections.

On September 5, 2000, the AirCare program embarked on a new phase of its existence. Significant changes to the inspection centres, testing equipment and computer systems were completed over a 12-month period, while still providing the public with emission testing. As AirCare enters this second era, the inspection process has been improved yet again. More effort will be devoted in the coming years to ensuring that all high emitting vehicles are identified, and that the repairs performed are as effective as possible. In this way, the program will continue to be one of the best of its type in the world.

M.A. (Martin) Lay
Chief Executive Officer
Pacific Vehicle Testing Technologies

Pacific Vehicle Testing Technologies Ltd. is an operating subsidiary of Translink

1.0 EXECUTIVE SUMMARY

The AirCare vehicle emissions inspection and maintenance (I/M) program has been in operation in the Lower Fraser Valley since September of 1992. It was implemented by the provincial government on behalf of the Greater Vancouver and Fraser Valley Regional Districts as one of 54 emission reduction measures proposed in a comprehensive regional Air Quality Management Plan (AQMP). According to the 1990 emissions inventory, light-duty motor vehicles were estimated to account for 90% of the carbon monoxide, 35% of the oxides of nitrogen, and 43% of the volatile organic compounds released annually into the Lower Fraser Valley air shed. Thus, a vehicle emissions inspection and maintenance program was considered to be one of the most cost-effective approaches to reducing smog-forming pollutants in the region.

The AirCare program was designed according to a centralized, contractor-operated model. A private company, Ebco-Hamilton Partners, was contracted to build, staff and operate 12 inspection centres, located strategically throughout the region, with the capacity to perform up to 1.2 million inspections per year. A total of 42 lanes, each with identical testing equipment and lane operating software, were provided. The testing process was automated, with all the test data being transmitted electronically to a central database. The objective was to provide consistent and accurate tests, independently of the automotive repair sector. Since the inspection contractor would have no interest in the outcome of the inspection, the AirCare program would avoid the potential for conflict of interest that occurs in decentralized programs, where the person that does the test is the same one that repairs the vehicle if it fails. By separating the two functions, the testing contractor was able to focus on delivering quality inspections, leaving the repair industry to concentrate only on fixing vehicles with emission-related problems.

The first AirCare contract was for a period of seven years and expired on August 31, 1999. A renewal was negotiated with the same company, now called Envirotest Canada, in 1999. The new contract expires on August 31, 2006.

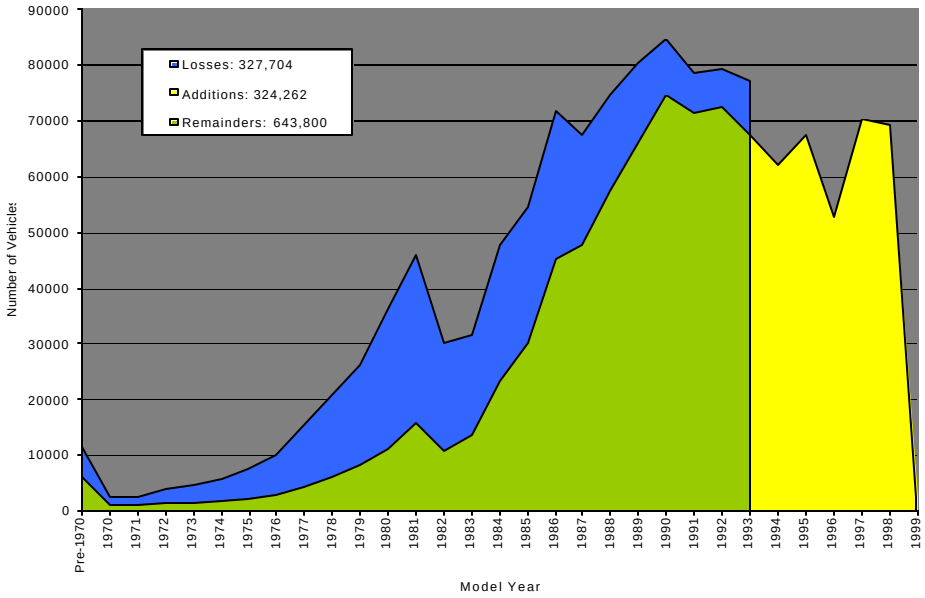
This report represents a review of the first eight years and four months of testing, from September 1, 1992 through December 31, 2000. Areas of analysis include changes in fleet composition, general inspection statistics, characterization of the failing vehicle fleet, discussion of the indicated effectiveness of repairs to failed vehicles and a calculation of estimated program benefits.

1.1 FLEET PROFILE

Approximately 1.2 million passenger cars and light trucks are registered in the Lower Fraser Valley of British Columbia. The age profile of the vehicle fleet changes over time as new vehicles are purchased and older vehicles are retired from use. In addition, used vehicles change hands, some vehicles move into the area from outside the region and some vehicles move out of the region. According to inspection data, about 75,000 new vehicles were introduced to the AirCare-tested fleet each year. This number has fluctuated since 1992 but has been showing a generally upward trend since 1996. The 1996 model year appears to have been a particularly poor sales year with only about 56,000 vehicles being added to the AirCare-tested fleet from that model year. The AirCare-tested fleet grew from 974,720 vehicles in 1994 to 1,047,969 in 1999. This represents a total growth of 73,249 vehicles in 5 years, or

approximately 1.4% per annum. The change between 1997 and 1998 was 1.9% and the growth between 1998 and 1999 was 1.7%.

The figure below illustrates the age profile of AirCare-tested fleet in calendar year 1994 (the first full year of testing) compared to calendar year 2000.



Age Profile of the Fleet in Calendar Year 1994 and 2000

327,704 vehicles disappeared from the fleet in 6 years. In the meantime, 324,262 vehicles were added, this number made up almost entirely of new vehicles.

There is a general trend towards a higher proportion of trucks in the active fleet. The fleet is dominated by the General Motors, Ford and Chrysler, particularly in the truck segment. The import brands with the highest market share were Honda and Toyota. Overall, these five manufacturers account for almost 80% of all the vehicles on the road in the AirCare testing region.

Approximately 18,000 diesel-powered light-duty vehicles are registered in the program area. Although the number has remained relatively constant, the composition of the diesel fleet has changed from mostly cars in 1992 to mostly trucks in 2000.

The propane and natural gas-powered fleet has decreased in size and increased in age since 1992. There are very few newer model-year vehicles being converted to operate on these fuels.

1.2 VEHICLE ANNUAL MILEAGE

Odometer readings are collected at the time of inspection, providing a means of tracking annual mileage. Since this has a direct influence on the amount of emissions generated by a vehicle in a year, it is an important piece of information. Analysis of inspection data suggests that the median annual kilometres travelled ranges from 18,000 km for the newest vehicles on the road to about 10,000 km for 16 year-old vehicles. AirCare data suggest that vehicles used for daily transportation continue to accumulate significant annual mileages, despite increasing age.

1.3 INSPECTION STATISTICS

1.3.1 Annual Test Volumes and Frequency of Inspection

In the first 8 program years, the total number of inspections performed was 8,534,984. There were 1,876,123 individual vehicles tested at least once. The table below shows the number of vehicles tested in each program year compared to projected volumes based on an initial fleet size of 950,000 vehicles and a 3% annual growth rate.

Projected and Actual Number of Vehicles Inspected by Program Year

Program Year	Projected	Actual
1992-1993	950,000	507,616
1993-1994	978,500	1,016,528
1994-1995	1,007,855	1,002,566
1995-1996	1,038,091	550,668
1996-1997	1,069,233	1,060,344
1997-1998	1,101,310	1,022,874
1998-1999	1,134,349	1,042,874
1999-2000	1,093,379*	999,007
Total	**8,372,717**	**7,202,477**

* Adjusted to reflect exemption of 1999 model year vehicles

Start-up adjustments and a labour dispute that lasted from April through July of 1993 make it impossible to compare the first program year to any others. A second labour dispute in 1996 resulted in nearly 500,000 vehicles being exempt from testing in program year 4. The program has operated without interruption since September of 1996.

1994 was the first full calendar year for the AirCare program. Of the 974,720 vehicles tested in that first full calendar year, 97,100 were never seen again in any subsequent year. Of these, 75.7% passed the inspection. It is not known where these vehicles went or why they did not re-appear in later years.

Of the 1,876,123 vehicles tested at some point during the review period, 425,436 were tested in 1994 and have been seen in every year since then. Another 454,803 have missed only one year since 1994, mostly due to the strike in 1996. There have been 211,669 that have missed two years and 130,734 that have missed three years.

The table below shows the irregularity of inspection frequency for calendar years 1992 through 2000.

In every year, there are large numbers of vehicles that appear for the first time, made up mostly of new vehicles that have become eligible for testing for the first time. There appear to be about

200,000 vehicles that skip inspection in any given year, however, this number is offset by approximately 100,000 vehicles not seen in the previous year that return to the program.

Irregularity of Inspecton Frequency

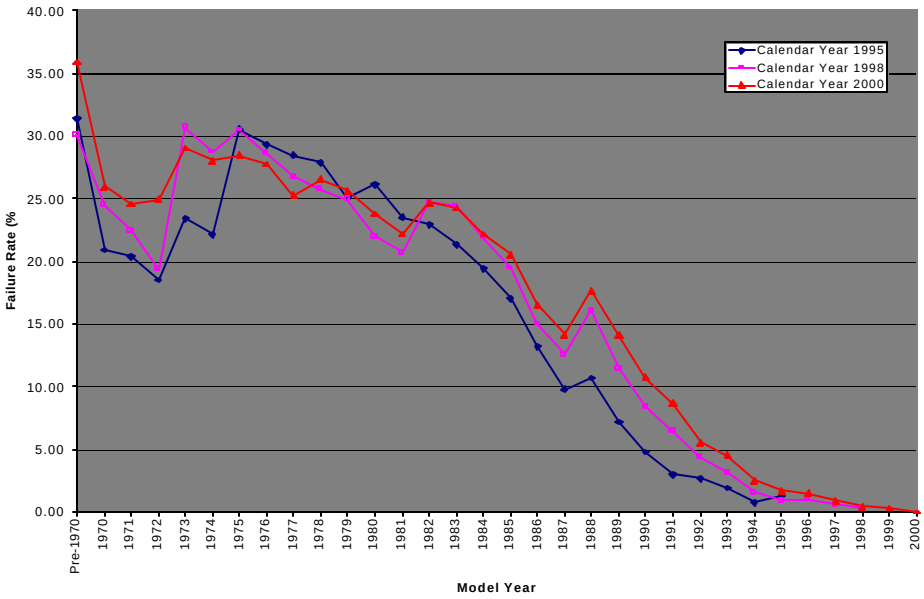
Calendar Year	# Vehicles Tested	# Seen First Time	# Tested in Previous Year but Not Seen in Current Year	# Returning for Annual Inspection as Expected	# Tested at Some Point Prior to Previous Year
1992	244,823	244,823	N/A	N/A	N/A
1993	751,755	599,917	92,985	151,838	N/A
1994	974,720	380,917	205,077	546,678	47,125
1995	1,002,604	141,529	212,372	762,348	98,727
1996	644,611	80,822	494,707	507,897	55,802
1997	1,011,112	142,614	164,154	480,457	388,041
1998	1,030,648	119,325	209,294	801,818	109,505
1999	1,047,969	112,527	203,779	826,869	108,573
2000	968,135	53,659	237,240	810,729	101,747

The reasons for irregularity in testing frequency are not evident from the data but it is suspected that change-of-ownership may account for much of it. According to DesRosiers [1], the annual used car sales volume range from 2.5 to 3.0 million, which corresponds to between 16% and 19% of the total vehicle population. This would suggest 160,000 to 190,000 sales transactions in the AirCare fleet. These transactions usually alter the vehicle's license renewal date, placing it on a different inspection cycle.

1.3.2 Inspection Results

The purpose of inspecting the in-use fleet is to identify vehicles with abnormally high emissions. The AirCare test procedure subjects vehicles to a loaded dynamometer test to measure HC, CO and NO_x emissions, followed by an idle test that checks tailpipe levels of HC and CO. Vehicles whose emissions exceed specified "cut points" fail the inspection and must be repaired. The cut points are established from the analysis of AirCare test data and are set so that any vehicle exceeding them would have emissions higher than certification standards if it were tested according to the Federal Test Procedure (the official test that must met before a new vehicle can be sold). Studies of in-use vehicles suggest that a minority will have excess emissions compared to the normal group and a subset of the high-emitter group will have very high emissions. It has been reported that 10% of vehicles account for 50% of pollutants [2].

AirCare inspection data confirm an increasing failure rate with vehicle age, ranging from less than 1% for the newest vehicles tested to 30% or more for older vehicles. The rate of increase in the failure rate appears to be much lower for vehicles less than 5 years old, otherwise the rate increases with age to a maximum of about 30%. The next figure shows the trend in failure rate vs. model year for all vehicle types for three calendar years.



Vehicle Failure Rate vs. Model Year for All Vehicle Types

The next table shows the average Passing and Failing Idle and ASM test results for four different age groups of vehicles based on data from program year 8.

Average Inspection Results by Age Group

		Idle		ASM		
Result	**Age Group**	**HC (ppm)**	**CO (%)**	**HC (ppm)**	**CO (%)**	**NO_x (ppm)**
FAIL	pre -1975	856	5.14	289	3.16	805
	1975 - 1987	419	2.60	180	1.75	1234
	1988 - 1993	214	1.21	122	1.19	946
	1994 and later	156	0.80	81	0.80	620
PASS	pre -1975	297	2.40	108	1.20	1110
	1975 - 1987	85	0.58	68	0.38	1022
	1988 - 1993	25	0.06	25	0.11	345
	1994 and later	10	0.03	13	0.06	135

The data show that advances in emission control technology over time have measurably improved emissions performance. The substantial reduction in NO_x emissions for passing vehicles in the 1988 and 1994 model years coincide with changes in the federal standards. In fact, the average ASM readings for 1994-and-later model year vehicles that fail are better than the average passing readings for pre-1975 vehicles. The emissions of failing vehicles are higher than passing vehicles in all age groups except for NO_x for the pre-1975 age group. This is expected, as NO_x and CO emissions are inversely related and most pre-1975 vehicles fail for

excessive CO emissions. The failing vehicles therefore have suppressed NO_x levels relative to normal vehicles in their age group.

1.3.3 Inspection Accuracy

Throughout the review period, the program administration audited all of the inspection centres and test lanes at least once per month using certified reference gases traceable to the National Institute of Science and Technology (NIST). Although on occasion, the analyzer reading for one of the three gases fell outside the permitted ±5% tolerance from the stated gas bottle value, the errors were in the negative direction in all but 3 cases out of more than 3000 audits.

Vehicle variability is an unavoidable phenomenon in all emission testing programs. Although a vehicle in good mechanical condition with all of its emission control devices operating properly will produce fairly consistent results when tested repeatedly, vehicles with emission-related defects can produce very different results in back-to-back testing. Due to this effect, some portion of the failing vehicle fleet has been able to achieve a passing result without repairs simply by attempting another test. The exact number is impossible to determine from the inspection data.

1.4 VEHICLES THAT FAILED INSPECTION

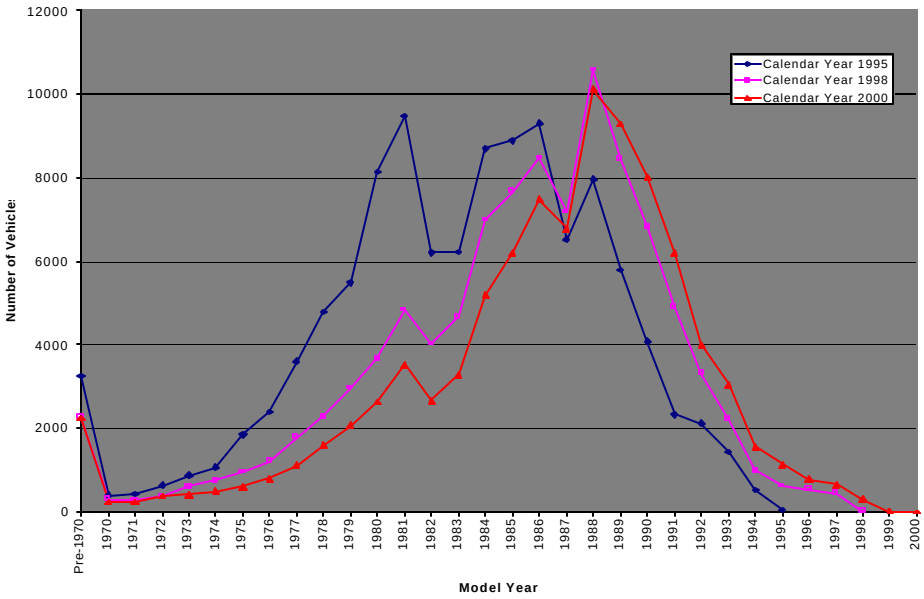
During the review period, the failure rate on initial inspection ranged from 9.64% to 14.72%, representing between 100,000 and 150,000 excess-emitting vehicles per year.

During periods when the pass/fail limits remained constant, the failure rate decreased from year to year. Significant changes were made to the pass/fail limits in September of 1995 and again in September of 2000. The failure rate increased noticeably following each of these changes. In 1995, the changes caused the failure rate to increase from 9.8% to 15%. However, by the end of August 2000, the failure rate had once again dropped to 10%.

The next figure shows the distribution of failed vehicles by model year. Most of the failing vehicles fall into the 1980-1992 model year range. The 1988 model year produced the most failures in calendar years 1998 and 2000. The number of failures of vehicles older than 1988 is decreasing over time. The number of failures among vehicles newer than 1988 is increasing.

Of the 1,876,123 individual vehicles tested at some point during the review period, there were 509,242 vehicles that failed at least once. Of these, 56.2% failed in only one annual cycle.

239,997 of the vehicles that failed did so on their first ever inspection. Another 66,130 failed the second year they were inspected. Investigation revealed that most of these “first-time-failures” (that were not during the programs start-up years) occurred on vehicles that were new to the area. This suggests that the vehicles operated within the AirCare region are better maintained than vehicles operated in areas with no inspection programs.



Number of Failed Vehicles vs. Model Year for All Vehicles Types

Each year, between 6.5% and 8.5% of failing vehicles did not return for any form of re-inspection. Overall, it is estimated that the number of "disappeared" failing vehicles was 79,000 during the review period, or 15.5% of the total number of vehicles failed.

In calendar year 1999, the top six failure modes were:

	Failure Mode
1	ASM NO_x Only
2	Idle HC Only
3	ASM CO Only
4	Idle CO Only
5	Idle HC and CO
6	ASM HC Only

These six failure modes accounted for 70.65% of all failures.

1.5 REPAIRS TO FAILING VEHICLES

The process of testing vehicles and failing excess emitters does not, in itself, produce any emissions benefit. In order to produce emission reductions, excess-emitting vehicles must be competently repaired. The designers of the AirCare program were well aware of the importance of the repair industry to its success. As a result, a repair industry certification and monitoring program was devised and put in place alongside the inspection process. The objective was to provide the motoring public with access to a well-trained and well-equipped repair industry that could repair emission-related problems with maximum effectiveness at minimum cost.

Collecting repair data from these facilities would also allow for better understanding of the types of faults responsible for excess emissions in the in-use fleet.

There were two key incentives for motorists to choose a certified shop over a non-certified one:

1. Repairs could be limited to a total cost defined by a set of repair cost limits established by government. The intent of repair cost limits was to ease the financial burden on motorists facing high costs to bring their vehicles into compliance with AirCare limits.

2. Regardless of the amount spent on repairs, any vehicle submitting a completed repair data form at the time of re-inspection was automatically eligible for a Conditional Pass, allowing the vehicle owner to re-license their vehicle for up to a year, even though it still didn't pass.

1.5.1 Certified Repairs

In any given program year, fewer than half of the vehicles that failed returned for re-inspection with completed Repair Data Forms, suggesting an unexpected preference for non-certified shops by the motoring public.

Overall, 367,154 Repair Data Forms were endorsed by certified repair facilities and turned in at the time of re-inspection through August 31, 2000. Of these repairs performed by certified shops, 108,056 (29.43%) resulted in a Conditional Pass at the time of re-inspection.

There were 86,559 vehicles that received a Conditional Pass at some point, representing 17% of all failing vehicles. Most of the vehicles that received a Conditional Pass received only one. Only 1 vehicle received the maximum possible 8 Conditional Passes and only 3804 vehicles have received more than 2 Conditional Passes, suggesting that this provision is not widely used as a means of avoiding complete repairs.

Approximately 500 repair shops have been AirCare-certified in any given year. In total, 942 auto repair businesses have been certified at some point during the review period, but many decided not to renew their certification. A total of 228 shops have been certified continuously since September 1992.

The number of active AirCare-certified technicians has remained relatively stable at about 1200. There are 1900 technicians that were certified at one time but have allowed their certification to lapse.

The rate of return of Repair Data Forms has been declining in recent years. The reason for this is not clearly understood. It may be that technicians are hesitant to have certain repairs count towards their average REI and therefore do not complete and endorse the forms or it may be that fewer motorists are patronising AirCare-certified repair shops.

In the first few years of operation, the most commonly-reported parts replacements concerned basic tune-up items such as air filters, spark plugs, distributor caps and ignition wires. In more recent years, there has been a trend towards the replacement of more substantive components such as oxygen sensors and catalytic converters. As far as repair actions are concerned, carburetor air-fuel mixture adjustments and idle speed adjustments tend to dominate, even in the most recent program year. This reflects the high proportion of carbureted vehicles among vehicles that fail the test.

The Repair Effectiveness Index (REI) introduced in 1996 has indicated that the effectiveness of repairs performed to vehicles that fail an AirCare inspection has been improving. The average REI for the overall certified industry has increased from 0.29 to 0.37 between 1996 and 2000.

1.5.2 Non-Certified Repairs

The AirCare program was designed to encourage motorists to use certified repair facilities. Therefore, the database was designed in such a way that only those tests involving a completed RDF were designated as re-inspections. All other tests were designated as initial tests. As a result, it is difficult to identify non-certified re-inspections within the database. Also, because there is no repair data submitted in these cases, it is impossible to determine what repairs, if any, were performed. Simply trying a second test without making repairs may appear as a successful repair, even though no actual corrective maintenance was performed.

Vehicles not repaired by certified AirCare repair facilities must pass the re-inspection, regardless of the cost or number of repeat attempts required. Otherwise they cannot be re-licensed in the AirCare area.

1.5.3 Overall Repair Effectiveness

The table below shows the average ASM and Idle emissions from program year 8 for vehicles repaired at certified repair shops compared to vehicles with unknown repair actions. The sample is broken down into four different age groups, consistent with the table, "Average Inspection Result by Age Group", shown earlier.

Re-inspection Results by Type of Repair

		Idle		ASM		
	Age Group	**HC (ppm)**	**CO (%)**	**HC (ppm)**	**CO (%)**	**NO_x (ppm)**
Certified Repair	pre -1975	435	2.92	172	2.20	912
	1975 - 1987	161	1.00	105	0.99	1000
	1988 - 1993	82	0.32	59	0.39	589
	1994 and later	51	0.16	42	0.22	359
Other Repair	pre -1975	325	2.42	115	1.44	987
	1975 - 1987	105	0.78	74	0.48	1020
	1988 - 1993	40	0.11	35	0.14	451
	1994 and later	26	0.07	24	0.11	266

The table shows that certified repairs appear to be less effective. This is a result of the 30% of vehicles that obtain Conditional Passes.

A supplementary measure of repair effectiveness is available from a sample of 957 vehicles tested according to the HOT 505 test in the AirCare Research Centre. The HOT 505 test gives a more complete picture of a vehicle's actual emissions output under normal urban driving

conditions. The results are expressed in units of grams/kilometre rather than in parts per million or percent. Average pre- and post-repair HOT 505 test results are shown in the table below.

Substantial decreases in average emission output are evident in all cases but one. An increase in average NO_x emissions of 4.5% was observed among the oldest vehicles. The newest vehicles tended to show the highest percentage reductions, but the absolute emission levels from these vehicles are quite low, meaning that a small reduction appears as a large percentage.

Pre-Repair and Post-Repair Emission Levels from HOT 505 Test

		Failing (g/km)			Repaired (g/km)			% Change		
Age Group	**Number**	**HC**	**CO**	**NO_x**	**HC**	**CO**	**NO_x**	**HC**	**CO**	**NO_x**
Pre-1975	29	4.45	48.79	2.01	2.70	35.18	2.10	-39.3%	-27.9%	+4.5%
1975-1987	564	1.77	23.02	1.80	1.25	15.90	1.56	-29.3%	-30.9%	-13.3%
1988-1993	344	0.82	12.61	0.95	0.43	6.56	0.73	-47.6%	-48.0%	-23.2%
1994 and later	20	0.19	3.11	0.52	0.15	1.70	0.29	-21.0%	-45.4%	-63.5%

To demonstrate how these data can be used to calculate program benefits, assume the case of a 1988-1993 vehicle that experiences a reduction in HC emissions of 0.39 grams/km. If such a vehicle is driven 15,000 km per year, the act of repairing it would result in (0.39*15,000) grams of HC emission reduction, or 5.85 kg (about 7.5L of gasoline) for that one vehicle. Repeating these calculations in tens of thousands of cases yields the total annual fleet reduction.

1.6 CALCULATION OF PROGRAM BENEFITS

The effect of an emissions inspection and maintenance program may be defined as the difference between the total vehicle-generated emissions in a given geographic area with an I/M program, compared to what the total would be for the same area without an I/M program

Ideally, the calculation of the non-AirCare case would be based on a control group identical in all respects to the AirCare-tested group. This would require a control situation comprising an exact duplicate of the Lower Fraser Valley except for the AirCare program. Obviously, such a control situation does not exist, so it necessary to rely on in-program data to estimate what would have happened without a program.

The methodology used in this review is different to that used previously. It does not require many of the assumptions built into the previous assessments. Its ability to model what actually happened has been radically improved, and its modelling of the effectiveness of individual repairs is much more precise.

1.6.1 The "With-AirCare" Scenario

This is the scenario that actually happened. To assess how the inventory has decreased, it is only necessary to consider the initial condition of the fleet in each year it was inspected. The first inspection on each vehicle in each year was used to calculate what the inventory would be in that year if no further repairs were effected. This assessment does not require any model of

previous repair effectiveness or longevity, or of fleet turnover or retirement rates. It simply examines what the actual emission output of the fleet was, when it was initially inspected in each year. When compared with the previous year, the actual inventory reduction can be assessed. This automatically takes into account all the causes that have contributed to the reduction, but it obviously does not enable any assessment of their comparative contributions.

1.6.2 The "Without-AirCare" Scenario

This hypothetical scenario is important because it enables comparison of what was achieved in the previous "with-AirCare" scenario, to what would have been achieved anyway. To model this scenario it is necessary to assess the amount of reduction achieved by performing repairs to excess-emitting vehicles in each year, then compare this to the total reduction that was achieved between that year and the next.

To calculate the direct AirCare-related emission reductions in a single year, the emission reduction attributable to each repaired vehicle, in grams per kilometre, is multiplied by the mileage that the vehicle would be expected to drive in a year. Subtracting the total direct-from-AirCare benefits from the year-to-year change calculated in section 1.6.1, gives an assessment of how much reduction would have been achieved without the program.

Using this method, the incremental benefits directly attributable to AirCare repairs in any given year range from 3.33% to 9.72% for HC emissions, 2.65% to 8.98% for CO and 0.91% to 2.20% for NO_x. Although the annual, incremental reductions may appear small, the cumulative effects of the program become very significant over time.

Table below shows the total inventory reductions that were achieved over the eight years, including cumulative benefits.

Total Inventory Reductions over Eight Years of AirCare

	HC	CO	NO_x
Overall 8 Years	**63.6%**	**53.2%**	**48.2%**
Due to Repairs	34.3%	38.4%	10.3%
Other	29.3%	14.8%	38.0%

By combining the three percentage reductions, weighted by their actual mass assessments in the inventory, it was estimated that the emissions attributable to the light-duty vehicle fleet declined by 57.4% due to fleet turnover, repairs related to AirCare, accelerated vehicle retirement, etc. Calculations indicate that in the absence of the AirCare program, the reduction over the same period would have been only 23.7%, indicating a significant benefit due to the program.

1.7 PROGRAM RESULTS

Over its first 8 years of operation, the program has performed millions of inspections, of which more than 1 million have generated a result of "FAIL". Thus, it has been effective in identifying many vehicles that appear to be high emitters. On the repair industry side, the program has created a demand for emission-related repairs. The industry has responded by voluntarily becoming AirCare-certified, purchasing the necessary diagnostic equipment and reference

materials. Repair technicians have responded by submitting to written exams and taking training courses to improve their skills in emissions diagnosis and repair. Prior to the start-up of AirCare, very few repair shops had exhaust gas analyzers or any experience in interpreting tailpipe emissions readings. Increased public awareness of what vehicles emit and how good maintenance is important in preventing excess emissions has also resulted from the program.

However, the AirCare inspection process cannot produce environmental benefits on its own. Once a vehicle has been identified as a high emitter in the inspection lanes, the owner must take appropriate action. The motivation could come from a strong environmental awareness but more often comes from the fact that vehicle licensing will be denied until the vehicle has passed or conditionally passed. Thus, the owners of vehicles that fail the inspection are "forced" to spend money on their vehicles to comply with the program rules. This is not popular with everyone and some may go to extraordinary means to avoid repair and re-inspection costs. Persons committed to circumventing the inspection/repair process have various means at their disposal to do so. Such means include registering their vehicle outside of the AirCare area, making temporary adjustments to achieve a passing result without really correcting the problem or trying additional tests with the hope that the vehicle may pass on its own, despite no repairs.

Hopefully, only a small number of motorists employ any of these methods of avoiding an inspection failure. However, with fewer than half of the repairs being documented, it is difficult to quantify what actions were taken on the part of motorists who simply re-appeared for a second or subsequent test without any information about what might have been done to the vehicle since the last test. A significant portion of failing vehicles simply "disappear". Whether these vehicles are actually taken out of the program area is not certain. All that is known is that they no longer appeared for inspection.

Another potential problem concerns the repair industry. Misdiagnoses and incomplete repairs prevent all of the available emission reductions from being realized. Of the repairs that are confirmed by data, only about 70% of cases result in the vehicle achieving a passing inspection result. This is not to say that the other 30% are mistakes by the repair industry, as the existence of repair cost limits prevents them from making full repairs in all cases. However, a portion of these unsuccessful repairs is not limited by cost, pointing to incomplete or incorrect diagnoses. Sometimes, the goal of the repair is to "get the vehicle through", rather than to restore the vehicle to FTP-passing condition. This may meet the customer demands but does not satisfy the environmental goals of the program.

To sum up, the AirCare program is more than a technical exercise of testing and repairing vehicles. Human attitudes and responses have a great deal to do with the program's success and many of these factors are beyond the ability of program designers and administrators to control. The analysis contained in this report confirms that the AirCare program has been effective in reducing emissions from motor vehicles in its first 8 years of operation. It appears that the AirCare-attributable benefits slightly outweigh those from the introduction of new, more effective emission controls.

Improvements in effectiveness can be achieved be increasing the proportion of failing vehicles that are fully repaired to achieve their lowest possible emissions. At the moment, it is apparent that 15% of failing vehicles receive a Conditional pass rather than a full pass. Of the approximately 40% of failing vehicles that simply return for re-inspection but do not supply any repair information, some portion have either not been repaired or have been made "clean for a day". The exact number cannot be determined from the data but anecdotal accounts of passing

the test despite no repairs and making temporary adjustments to “get through the test” are frequent enough to suggest that these actions do occur.

Understanding and quantifying vehicle owner's responses to I/M regulations is a very difficult task. A recently published review of inspection and maintenance program evaluation techniques identified the inability to quantify human response as a common deficiency in all I/M program and concluded that further study is required to determine the extent of old-vehicle-scrapping in response to I/M, and of program avoidance and other types of non-compliance among different socioeconomic groups. [3]

A. REFERENCES

1 "The Used Vehicle Market in Canada" DesRosiers Automotive Consultants Inc., December 2000

2 "Playing with Fire. Science and Politics of air Pollution from Cars" D.H. Stedman, University Lecture, University of Denver, March 29, 1995. http://www.du.edu/news/Univ_Lecture/ULECTscience.html

see also Smog Check Program, Bureau of Automotive Repair, California. http://smogcheck.ca.gov/000001.htm

3 "Evaluating vehicle Emissions Inspection and Maintenance Programs" National Academy Press, 2001