Addendum

Comparison of Tested Vehicles to Overall Fleet

Preface
The Energy Solutions Centre held its second voluntary vehicle emissions testing clinic in Whitehorse in June 2009. The testing was conducted by Pacific Vehicle Testing Technologies Ltd (PVTT) of British Columbia. When PVTT staff submitted their report summarizing the test results, they suggested that the Energy Solutions Centre should try to discern how broadly the test results from the two clinics could be applied to the entire Yukon fleet. This could be accomplished by comparing the age and type profile of the tested vehicles (181 vehicles in 2007 and 161 vehicles in 2009) with that of the entire fleet of registered Yukon vehicles. The Yukon Government keeps records of the make, model and year of all registered vehicles, so a comparison was possible.

Due to the clinics being voluntary, the tested vehicles formed a self-selected sample of the Yukon fleet. The assumption was that this would not provide a representative sample of the fleet, but without conducting a comparison, one could not be sure of the degree to which this sample was unrepresentative. PVTT advised that they would expect the profile of the vehicles tested in the clinic to be somewhat biased towards older vehicles, and towards passenger vehicles.

The Yukon Government provided PVTT with the Yukon fleet vehicle data and PVTT conducted the comparison and analyzed the results. The comparison showed that the tested age profiles are clearly different from the licensed profile and that cars were over-represented and trucks were under-represented in the clinics. This means that the clinic results can not be simply applied to the entire Yukon fleet.

PVTT staff was able to identify three main areas of dissimilarity in the age profile of the test fleet compared to the entire Yukon fleet. This information could be used to attract certain groups of vehicles to future clinics so that although the clinic profile might not be the same as the entire Yukon fleet profile, it would still contain enough examples of each section of the fleet to allow the results to be reasonably mapped onto the Yukon fleet numbers, and thus draw much more definite deductions regarding the overall fleet.

Introduction
The vehicles presented for testing at a voluntary emissions clinic may not necessarily be representative of the overall fleet of in-use vehicles in the region. There are many factors that may make certain vehicles more or less likely to show up than others. One thing that can reduce the number of trucks is that they are very often used for work purposes and may be otherwise occupied during the times of the clinic. Another factor is the vehicle owner's own perception of why they might want to take a vehicle to the clinic. Experience has shown that some vehicles are brought because they are old and the owner wants to check if they are still working.
correctly. Others are brought because of known problems. And some very new vehicles are
brought just to demonstrate how good they are. As a rule of thumb we would expect the profile
of the vehicles tested in the clinic to be somewhat biased towards older vehicles, and towards
passenger vehicles.

The report already included comparisons of the group of vehicles tested in June 2009 with those
tested in September 2007. But we did not know whether the observed changes were
representative of overall fleet trends, and neither group was compared to the overall fleet of in-
use vehicles in Whitehorse. Since the report was completed, registration data for July 2009 has
been received from the Department of Highways & Public Works. This addendum compares the
profile of all in-use vehicles on July 29th to the sample tested on June 4th and 5th.

Registration Data

The registration data for the whole territory included 28,617 records on July 29th. The fields
provided were: vehicle style; make; model; year; VIN; postal code, and license start and end
dates. Only vehicles currently licensed were included. The vehicle style had 75 possible values,
so these were aggregated into just eight basic types of vehicle. The postal codes were split into
two groups: those within Whitehorse, and those not. The table shows the numbers of each
vehicle type in these two areas.

<table>
<thead>
<tr>
<th>vehicle type</th>
<th>Whitehorse</th>
<th>not Whitehorse</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>72 0%</td>
<td>34 0%</td>
<td>106 0%</td>
</tr>
<tr>
<td>Heavy Truck</td>
<td>1,517 7%</td>
<td>1,459 19%</td>
<td>2,976 10%</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>464 2%</td>
<td>119 2%</td>
<td>583 2%</td>
</tr>
<tr>
<td>Off Road</td>
<td>2,045 10%</td>
<td>732 9%</td>
<td>2,777 10%</td>
</tr>
<tr>
<td>Passenger Vehicle</td>
<td>4,484 22%</td>
<td>1,019 13%</td>
<td>5,503 19%</td>
</tr>
<tr>
<td>Recreational</td>
<td>319 2%</td>
<td>79 1%</td>
<td>398 1%</td>
</tr>
<tr>
<td>Light Truck</td>
<td>7,215 35%</td>
<td>2,785 36%</td>
<td>10,000 35%</td>
</tr>
<tr>
<td>Trailer</td>
<td>4,602 22%</td>
<td>1,579 20%</td>
<td>6,181 22%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20,718 73%</td>
<td>7,806 27%</td>
<td>28,524 100%</td>
</tr>
</tbody>
</table>

Almost three quarters (73%) of all vehicles in the territory are registered in Whitehorse.
However, only light-duty vehicles were eligible for the emissions clinic, so the following table
shows only passenger vehicles and light-duty trucks. Compared to other locations in Canada
the proportion of passenger vehicles (cars) is low. In the Vancouver area about 60% of all light-
duty vehicles are passenger vehicles (mostly cars). In the Yukon only 35% are passenger
vehicles. The percentage in Whitehorse is a bit higher at 38%; the rest of the territory is lower at
27%.

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<td>5,503 35%</td>
</tr>
<tr>
<td>Light Truck</td>
<td>7,215 62%</td>
<td>2,785 73%</td>
<td>10,000 65%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>11,699 75%</td>
<td>3,804 25%</td>
<td>15,503 100%</td>
</tr>
</tbody>
</table>
Of light-duty vehicles, 75% are registered in Whitehorse. The clinic tested 77 (48%) passenger vehicles and 84 (52%) trucks, compared to 38% and 62% of the overall Whitehorse fleet, so cars were over-represented and trucks under-represented in the clinic.

The following chart plots the numbers of passenger vehicles and light-trucks in Whitehorse against their model years. In general the proportions of cars and trucks seems to be about the same each model year, and if we assume that the original sales were in the same proportions, we can conclude that the rate of loss of old trucks and old cars is also about the same. Or, in other words, cars and trucks both deteriorate and are retired from use at about the same rate. This observation is also true for the rest of the territory.

One important conclusion is that the age profile of the fleet is not likely to have changed between 2007 and 2009, or in fact for the past decade or two. This is indicated by the fairly consistent slope of the lines. Although some year-to-year variation is natural, there are no indications of any major changes in the numbers of vehicles registered by model year, other than the expected reduction as vehicles age and are retired. This was not apparent from the clinic test results, because a clinic can only test those vehicles that show up.

The next chart combines the numbers tested in 2007 and in 2009 with the numbers licensed in Whitehorse in July 2009. To allow comparison the numbers for each model year are normalized and presented as percentages of the totals. The tested profiles are clearly different from the licensed profile.

There are three areas of dissimilarity. The first is around model years 1988 to 1993 where the numbers tested (especially in 2007) were more predominant in the clinic sample than they are in the overall fleet. The second area is for model years 1999 to 2003 where the numbers tested (especially in 2009) were disproportionate than their representation in the fleet. The third area is
from 2004 and newer; these years account for a large part of the fleet, but a relatively small part of those vehicles tested.

We do not actually know why a greater number of older vehicles were brought for testing in 2007 than in 2009. One could only speculate as to why this was, but the reason is more probably associated with behavioural responses to the opportunity for testing than being in any way related to the vehicle fleet make up.

### Failure rates

The difference between the age profiles does indicate that the overall failure rates observed in the clinics can not be simply applied to the whole fleet. Ideally we would look at the tested failure rates by vehicle type and by model year, and then apply those to the fleet numbers by vehicle type and model year, and finally aggregate the results to give an overall rate at which the fleet could be expected to fail if they were all tested. Unfortunately there are not enough clinic tests to make this really viable – this was why the clinic failure rates were only reported in two age groups (1997 and older, and 1998 and newer). However there is some merit in expanding this to three age groups, to better reflect the technology milestones. The 1995 and older group are almost all Tier Zero\(^1\) vehicles. The 1996 to 2003 vehicles are almost all Tier One\(^2\). And all vehicles from 2004 onwards are Tier Two\(^3\). The following table shows the numbers tested in 2007 and 2009, and tailpipe failure rates by these age groups.

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\(^1\) Tier Zero refers to the emissions standards that were in place in Canada from model year 1988 to model year 1995. It allowed maximum passenger vehicle emission rates of HC=0.41 g/m; CO=3.4 g/m and NOx=1.0g/m

\(^2\) Tier One emission standards applied in Canada from model year 1996 to model year 2003. For passenger vehicles the allowable maximum emissions rates were HC=0.25 g/m; CO=3.4 g/m and NOx=0.4g/m
The complete lack of failures in the newest age group (2004 and newer) is as expected. In the Vancouver region these vehicles are exempt from mandatory AirCare testing. Although they do sometimes develop faults, there is little chance of a problem vehicle showing up in such small test groups as were tested.

In the middle age group (1996-2003) the failure rates seem quite different for passenger vehicles and trucks and for 2007 versus 2009. This could be just an artifact of the small numbers causing large step changes in the percentages. Overall the average failure rate for this age group was 6%. But the difference between cars (9.3%) and trucks (1.4%) may reflect a real difference. The increased failure rate from 2007 to 2009 may also be real.

For the oldest vehicles (pre-1996) the failure rates for cars and trucks are quite similar. What does appear significant is the big decrease from 2007 (38.9%) to 2009 (17.5%).

It is clear that even aggregating the test data by age groups instead of by model years still doesn’t give a really reliable indication of the failure profile, and we can not be certain that the failure rates observed in 2007 or in 2009 were actually representative of the fleet at large. It is likely that behavioural factors had an effect on which vehicles were brought in for testing.

What the failure rates do indicate is the probable range of failure rates that might be expected in a clinic of this type and of this size. The rates from the table can be compared to the AirCare failure rates for vehicles in the Vancouver region in 2009, which are plotted below.

In making such a comparison it is first necessary to understand the different tests used in the clinics and in the AirCare inspections. The clinics necessarily used an unloaded two-speed idle (TSI) test, and measured tailpipe concentrations of HC, CO and CO₂. The Pass/Fail decision was based on comparing the HC and CO readings to standards that AirCare derived for vehicles that have to be tested with an idle test because they can not be tested on a

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Tier Two applies to vehicle model years from 2004 onwards. Its average requirements for light-duty vehicles are maximum emission rates of HC=0.09 g/m; CO=4.2 g/m and NOx=0.07g/m, and it requires these standards to be met for a much longer vehicle life than previous standards.
The tests actually used by AirCare are usually loaded tests, during which the vehicle is driven on a dynamometer. For vehicles up to and including model year 1991, this is a steady-speed loaded test at 40 km/h known as ASM2525, during which the tailpipe concentrations of HC, CO, NO\textsubscript{x} and CO\textsubscript{2} are measured. It is followed by a curb idle during which HC, CO and CO\textsubscript{2} concentrations are measured. For model years 1992 to 1997 the test is an IM240 test, which requires a transient driving cycle lasting up to 240 seconds, and which gives a result expressed in units of gram/km for HC, CO, NO\textsubscript{x} and CO\textsubscript{2}. Until fairly recently this IM240 test was also used for newer vehicles, but it has now been replaced for 1998 and newer vehicles by an inspection that relies entirely on downloading information from the On Board Diagnostics system. However, the failure rates for IM240 and OBD-II inspections are quite similar, as can be deduced from the reasonable continuity of the blue and orange lines in the chart.

All the AirCare inspection test methods are more demanding, and therefore more difficult to pass, than the two-speed idle test used in the clinic. (It is also clear from the discontinuity between 1991 and 1992 model years that the ASM+idle test is not as demanding as the IM240 test.) If the Lower Fraser Valley vehicles were tested using just a two-speed idle their failure rates would be much lower than those shown in the chart.

For the pre-1996 vehicle the clinic TSI failure rates were 38% in 2007 and 18% in 2009. This range is almost entirely above the range of ASM+idle and IM240 failure rates observed by AirCare in the LFV in 2009 for the same age of vehicles, even though the two-speed idle test is much less demanding.

For the 1996 to 2003 vehicles the clinic TSI failure rates averaged about 6%, which is similar to the AirCare IM240 and OBD rates. But, again, the TSI is much easier to pass.
For 2004 and newer vehicles it does not matter much what method is used to test them, because they are almost all still working exactly as originally intended, and at present they are all exempt from AirCare Program requirements.

**Overall Incidence of High-Emitters**
The comparison of Whitehorse TSI failure rates with AirCare ASM+idle and IM240 failure rates suggests that the incidence of high-emitting vehicles in Whitehorse is likely to be at least double their incidence in the Lower Fraser Valley. This is to be expected, because the vehicles in the LFV have been subject to regular AirCare inspection requirements ever since 1992, but, to date, there has been little or no effort to correct in-use vehicle emission problems in the Yukon. In the LFV the average AirCare failure rates at present mean that about 6.1% of the entire light-duty fleet vehicles are high-emitters. In other words one in every 16 or 17 vehicles has a problem that causes its emissions to be higher than they should be. In Whitehorse, by extension, it is likely that at least one out of every 8 vehicles is a high-emitter. For a total Whitehorse fleet size of 11,699 light-duty vehicles this means there are 1,419 high emitters. And in the entire territory light-duty fleet of 15,503 vehicles there are probably 1,881 or more high-emitters.

In considering failure rates it is also important to realize that the Pass/Fail standards reflect what the vehicles of any particular model year should be capable of. As vehicle technology has progressed it means that the normal, acceptable, emission levels from vehicles have decreased (see footnotes on earlier page). Therefore the standard to which an old vehicle is tested is much easier than the standard for a newer vehicle. Even those old vehicles which pass the tests will typically have emissions much higher than a new vehicle; and a new vehicle that fails might still be a lot cleaner than an old vehicle that passes. The overall effect is that a hugely disproportionate amount of the total vehicle emissions in a region come from those older vehicles that have problems. In the Vancouver area, after 17 years of mandatory emissions testing and repairs, about 46% of all light-duty vehicle emissions comes from 1995 and older vehicles. This is even though their ASM+idle or IM240 failure rates now average only about 19%. In the Yukon the incidence of high-emitters is much higher -- maybe one in every 8 vehicles, which is 12.5% of the vehicle fleet. But these high-emitters probably contribute at least half of the total vehicle emissions in the territory. So, the effect of correcting all their problems would not be just a 12.5% reduction in the emissions problem, but more like a 50% reduction.