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**SOURCE APPORTIONMENT OF VOLATILE ORGANIC
COMPOUNDS IN URBAN MICRO-ENVIRONMENTS**

BY

KEVIN C. O'LEARY

**A Thesis presented to
the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements
for the degree of
Master of Engineering*
Department of Civil and Environmental Engineering
Carleton University
Ottawa, Ontario
Canada**

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***The Master of Engineering program is a joint program with the University of
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The undersigned recommend to the Faculty of Graduate Studies and Research, acceptance of the thesis entitled Source Apportionment of Volatile Organic Compounds in Urban Micro-Environments submitted by Kevin O'Leary in partial fulfillment of the requirements for the degree of Master of Engineering.

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March 1, 1999

ABSTRACT

Source apportionment of volatile organic compounds at three urban micro-environments was successfully accomplished using the United States Environmental Protection Agency's Chemical Mass Balance Model CMB7. Three micro-environments were examined: underground garages, downtown urban roadways and residential homes with attached garages.

Underground garage source apportionment showed that tailpipe and evaporative emissions were significant contributors to total garage VOC loading. The results showed that the evaporative emissions were more significant in the interior of the garage in the morning. Tailpipe emissions were more significant at the entrance in the afternoon.

Urban roadway source apportionment showed that heavy and light duty tailpipe and evaporative emissions were significant. Minor contributions from liquefied petroleum gas and graphic arts were also seen. Source apportionment showed differences over the three sampling locations (two nose-level and one elevated and set back from road) and four sampling times.

Residential home results showed that cold start and hot soak vehicle emissions infiltrating from the garage are impacting the in-house air quality. The impact varied widely from house to house, but the degree of infiltration the two types of vehicle emissions showed reasonable agreement at each of the test homes.

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LIST OF NOMENCLATURE AND ABBREVIATIONS

AQIRP	Auto Air Quality Research Program
C/M	ratio of calculated to measured receptor concentration
C_i	measured receptor concentration of VOC species i
CMB	Chemical Mass Balance
CMB7	US EPA's Chemical Mass Balance model: Version 7
CNG	compressed natural gas
COLDST	cold start tailpipe emissions profile used in underground garage and residential garage study
COMPFUE	evaporative emissions profile used in Slater Street study
CPPI	Canadian Petroleum Products Institute
CS SCE	cold start source contribution estimate
CV	coefficient of variation
DNPH	dinitrophenylhydrazine
ELA	equivalent leakage area
ERMD	Emissions Research and Measurement Division (Environment Canada)
F_{ij}	measured source mass fraction of species i at source j
FTP	Federal Test Procedure
FUEL	whole gasoline profile used in underground garage study
GA	graphic arts
GM, HD, PT, MM, TR, JR	six homes investigated in attached garage study
HOTSOAK	evaporative emissions profile used in residential garage study
HOTST	hot stabilized tailpipe emissions profile used in underground garage study

HS SCE ..... hot soak source contribution estimate
 I ..... number of VOC species
 J ..... number of sources
 k ..... counter for number of iterations in CMB7's solution algorithm
 LDT ..... light duty trucks
 LDV ..... light duty automobiles
 LPG (FLPG) ..... liquefied petroleum gas
 MDL ..... minimum detection limit
 MPIN ..... normalized modified pseudo-inverse matrix
 NAPS network ..... National Air Pollution Surveillance network
 NMHC ..... non-methane hydrocarbons
 PAHs ..... polynuclear aromatic hydrocarbons
 PDP, TDC, XRX ..... three garages investigated in underground garage study
 R/U ..... measure of the number of uncertainty intervals by which the calculated
 and measured receptor concentrations differ
 RVP ..... Reid vapour pressure
 SAE ..... Society of Automotive Engineers
 SCE ..... source contribution estimate
 SHED ..... Sealed Housing Evaporative Determination
 S_j ..... source contribution of source j to the measured VOCs at the receptor
 SL1 ..... Slater Street nose-level sampling station
 SL2 ..... Slater Street nose-level sampling station
 TLROD ..... Atlanta, Georgia derived light duty gasoline tailpipe profile
 used in Slater Street study

TSTAT	t-statistic
TT94HD	Tuscarora Tunnel derived heavy duty diesel vehicle tailpipe emissions profile used in Slater Street study
TTFA	target transformation factor analysis
US EPA.....	United States Environmental Protection Agency
VAPOUR.....	evaporative emissions profile used in underground garage study
V_c	effective variance
$V_{c,ii}$	diagonal elements of the effective variance matrix
VOC(s).....	volatile organic compounds
χ^2	reduced chi-square
$\sigma(C)$	root mean square error for the concentration measured at the receptor
σ_{Ci}	one standard deviation C_i
σ_{Fij}	one standard deviation F_{ij}
σ_{Sj}	one standard deviation of S_j

1 INTRODUCTION

1.1 Overview

Air pollution models are often required to simulate the behavior of the atmosphere over a large range of scales; from small scale urban canyon air circulation models to global circulation models. Probably the most familiar of these models are atmospheric dispersion models which simulate the contaminant transport behaviour of a plume or puff released from a particular location to a point of impact. These dispersion models are effective when modeling relatively uniform terrain and atmospheric conditions. However, extrapolating the results of a dispersion model onto a highly irregular atmospheric environment such as the urban environment is impractical and prone to significant inaccuracies. Urban canyon dispersion models are still in the realm of academic research and have not seen much practical use in the real world environment. In addition, these models are not capable of modeling intra-city transport of pollutants. Even if they were capable of modeling transport from one part of the city to another, there are a very substantial number of sources such as individual automobiles or gasoline service station. Modeling these types of sources is very difficult in an urban environment. Alternative methods are required then to identify sources and to quantify the impact of these sources to a given receptor. These models are called receptor models and their focus is on the immediate environment surrounding the point of impact.

Receptor models are unique in that they do not require knowledge of the transport, dispersion or transformation processes that occur between point of release and point of impact. Receptor models instead use the measured pollutant concentrations at the point of impact (receptor) and use information regarding the chemical makeup of various sources to apportion the measured pollutant data amongst the contributing sources.

Receptor models have traditionally been used in such areas as helping to verify large scale volatile organic compound (VOC) emission inventories in regions where ground level ozone and other pollutants are a significant problem (Conner *et al*, 1994; Fujita *et al*, 1995; Wittorff *et al*, 1994). Apportioning measured particulate data has also been performed (Biegalski *et al*, 1998). With the exception of some tunnel studies (Wittorff *et al*, 1994), to date little work has been done in the area of applying receptor models to system scales much smaller than cities.

1.2 Objectives

In this thesis it is intended to show how receptor modeling techniques can be used in three urban micro-environments impacted by motor vehicle emissions to apportion measured volatile organic compounds using a chemical mass balance receptor model. The urban micro-environments considered are: underground parking garages, the ambient air at nose-level along a downtown street and residential homes with attached garages.

For the first two micro-environments noted above, the experimental study and preliminary modeling had been completed prior to the chemical mass balance (CMB) modeling performed for this thesis. For the third micro-environment, both the experimental study and CMB modeling was completed by the author. The experimental work included the characterization of emissions from a test vehicle and associated test gasoline and the collection of receptor data at six homes.

The contributions of the work being reported in this thesis to the three studies mentioned above can be summarized as follows:

Underground Garage

- CMB7 modeling was carried out for the data, refining the simplified chemical mass balance analysis of Graham *et al* (1995a)

Slater Street Nose-Level and NAPS

- The preliminary CMB modeling by Wong (1996) and Graham *et al* (1995b) was refined by introducing a locally derived gasoline source fingerprint and carrying out sensitivity analyses.
- A second receptor modeling technique (factor analysis) was introduced for analyzing the data and comparing results with CMB modeling.

Residential Homes

- Emissions from a test vehicle were measured and characterized in collaboration with Environment Canada's Emissions Research and Measurement Division (ERMD).
- The impact of vehicle emissions on VOC concentrations at six residences were measured in collaboration with ERMD, Canada Mortgage and Housing and Health Canada.
- CMB7 modeling was carried out for source apportionment of VOCs measured in six residences.

2 BACKGROUND

2.1 Air Pollution in Urban Micro-Environments

There are a number of sources of air pollution in the urban environment. Volatile organic compounds (VOCs) are one class of air pollution of interest because of toxicity effects and their role in ground-level ozone production. Sources of VOCs include various industrial processes (petroleum refineries, petrochemicals), fuel combustion (stationary combustion, power generation), solvent use (surface coatings, general use) and transportation (gasoline vehicle exhaust, diesel vehicle exhaust, spilled gasoline, evaporative emissions). The transportation sector constitutes the major source of VOC-related air pollution, contributing greater than 60% (in 1995) to the total inventory of VOCs as reported by Environment Canada (Environment Canada, 1991, 1996). In an urban environment where mobile sources (vehicles) are concentrated, the impact of transportation related VOCs has the potential to be much greater. Hence, a significant amount of research has been devoted to the study of motor vehicles and their role in air pollution in the urban environment. This research has focused on a broad range of topics, however, research regarding the impacts of motor vehicles in some urban micro-environments is not as prevalent.

The impacts of air quality on a smaller physical scale until recently has been largely ignored. Large scale urban air quality studies give only a general indication of the pollutant levels experienced by individuals. However various exposure studies show that people are exposed to a number of urban environments that may have significantly

elevated levels of pollutants (Andersson, 1997, Limassel, 1993, Backer, 1997). They show the importance of some types of micro-environments in being significant contributors to an individual's total exposure to VOCs.

In this thesis three such micro-environments will be examined. These are underground garages, urban roadways and residential homes.

2.1.1 Underground Garage

One micro-environment common in the urban centre are large underground parking garages. With the increased need for parking in downtown cores, these multi-level facilities are becoming larger and larger. With the increase in garage vehicle capacity, the potential exists for vehicle emissions to accumulate within the garage. Due to the enclosed nature of the garages, a forced ventilation system is required since natural ventilation systems can become inadequate. Ventilation systems are normally triggered at some carbon monoxide concentration set point. Carbon monoxide concentrations typically peak when the garage traffic is heaviest, that is, in the morning and afternoon rush. During these periods of high vehicle activity carbon monoxide levels may or may not reach the trigger points on these detectors. Even if the ventilation systems are activated they are running only during a short period of time. This triggered, intermittent pattern of ventilation would be adequate if the only emissions released from a vehicle were tailpipe since carbon monoxide concentrations would peak along with the other tailpipe emissions and be carried from the garage when the ventilation system was activated. However, the vehicles are parked after being driven some distance and the

engine is hot and may be releasing significant amounts of evaporative emissions (mainly from leaking fuel systems). Therefore the ventilation systems may not be triggered often enough to prevent other non-tailpipe vehicle emissions from accumulating within the garage. This means that garage patrons and personnel are subject to higher exposure of these toxic pollutants. In addition, underground garages are often attached to an office or other building complex. Infiltration of garage air into the buildings may occur through various conduits such as wiring, piping or tunnel/stairway access.

Receptor modeling of the VOC data from an underground parking garage will quantify the contribution of the various vehicle emission types (tailpipe and evaporative). Since vehicle activity changes over the course of the day, receptor modeling should be able to relate the changes in activity with changes in measured VOC emissions if samples were taken at appropriate times. Most important, receptor modeling would be able to quantify the role of evaporative emissions in the air quality of the underground garage which most current ventilation controls have no way of measuring or mitigating.

2.1.2 Urban Roadway

In an urban environment there are many users of the roadway systems. These include a wide range of motor vehicles, cyclists and pedestrians. Since drivers and pedestrians are in such close proximity to the main source of VOC emissions in a city, the exposure levels are usually significantly elevated. Pedestrian activity typically follows vehicle activity patterns, that is, the morning and afternoon vehicle traffic rushes are accompanied by higher pedestrian activity. One exception to this is the pedestrian lunch

hour activity. Since pedestrians can spend significant portions of their day at or near a roadway, mobile source emissions represent a major portion of their daily exposure to VOCs. Exposure studies are usually interested in total VOC exposure or exposure to a specific pollutant (e.g. benzene) and give no regard to the source of the measured exposure. Therefore, the goal of source apportionment in this project was to determine the fraction of nose-level VOCs that are attributable to mobile sources and to determine the split between tailpipe and evaporative emissions. Any trends in mobile source contributions could also be evaluated.

2.1.3 Residential Homes

In an effort to make Canadian homes more energy efficient, the degree of air exchange between the home and the outside has been significantly reduced. Newer homes were constructed using methods that significantly reduced the air flow passing through the building envelope. In Canadian homes during the winter, windows and doors are closed which makes the home even tighter. Heat recovery ventilation systems were installed to introduce fresh air into the home and to retain some of the thermal energy present in the outgoing stale house air. These units which may or may not be operating on a continuous basis can act to purge the indoor environment of VOCs from a number of sources such as combustion and solvent use. However, the homes still have pollution levels often several times greater than the outside ambient. The implications for the indoor environment is that with a lower air exchange rate in buildings, pollutants have the potential to accumulate. Since Canadians spend up to 70% of their time indoors (Health and Welfare

Canada, 1989) long term chronic exposure levels to indoor VOCs become a concern; especially those VOCs that are known or suspected carcinogens.

As more new homes are being constructed with attached garages, the role of the family vehicle as a potential source of residential VOCs has to be questioned. Most attached garages share at least one common wall and most times a door. Some garage/house configurations have even more common areas of attachments such as a garage that is below grade and tucked underneath a room above. A single vehicle family typically uses its car for the commute to and from work and for miscellaneous non-work trips in the evening and weekends. A second car in the family increases vehicle use and the potential for VOC infiltration from garage to home especially if the second car is used during the day for multiple non-work trips.

Receptor modeling in a residential home will quantify the contribution of the two main vehicle emission types (tailpipe and evaporative) while a test vehicle is operated in the attached garage. Two separate tests can be performed to investigate the infiltration and impacts of tailpipe and evaporative emissions.

2.2 Receptor Modeling

Investigating air quality issues involves identifying all pertinent contributors of the pollutant of interest, quantifying the emission rates from each source and obtaining an adequate understanding of the transport phenomena that occur between the source and receptor of interest. These transport phenomena include any physical or chemical

transformations that occur between source and receptor. The mathematical models developed to simulate the behavior of pollutants over their transport distance are called dispersion models. Although dispersion models are powerful and effective predictive tools, in many cases, the more complex models that have been developed are unable to model certain physical scenarios such as complex terrain. The urban centre probably is the most extreme case of complex terrain and obtaining accurate pollutant concentrations using dispersion models at the small scale is currently not feasible.

However, there are other types of models called receptor models whose focus is on the chemical characterization of the emission sources and receptors without quantifying the physical or chemical processes that may occur between source and receptor. Most of the receptor models in current use are based on the explicit assumption of mass conservation and the use of a mass balance analysis. That is, receptor models assume that there are a finite number of sources (or source categories) and all of the measured pollutant mass at the receptor can be attributed to the various contributions of these sources.

Multivariate models are a second class of receptor techniques that attempt to provide information regarding the composition of sources impacting a receptor. However, multivariate techniques are not based explicitly on the principle of conservation of mass. Multivariate receptor analysis requires that a consistent number of sources be contributing to the receptor over all measured samples and that measured samples reflect varying contributions of all sources. Multivariate techniques also differ in that they require no *a priori* knowledge of the sources contributing to the receptor. Instead they

use the correlations amongst the measured VOC species' concentrations in the receptor data to extract source related information.

These methods require a significant amount of receptor data measured over a number of samples to accurately develop the correlations between all of the species of interest. One of the guidelines given by two researchers (Henry *et al*, 1984; Ito *et al*, 1986) for the number of required samples was dependent on the degrees of freedom per variable (i.e. species). The number of degrees of freedom in the solution per species had to be greater than 30. Previously, multivariate analysis gave some insight only into the source composition but some work is being done to allow these receptor models to produce both source contribution and composition estimates. Two of these methods are target transformation factor analysis (TTFA) (Hopke, 1985, Henry, 1991) and factor analysis for the source composition followed by a regression analysis to estimate the contributions (Fung, 1995). Target transformation factor analysis has worked well using artificial data to reconstruct source profiles and source contributions. However, rigorous mathematical validation of these techniques are still underway.

Details regarding the factor analysis procedure used in this thesis have been presented elsewhere (O'Leary, 1997). The interpretation of the downtown street study with factor analysis are briefly presented in Chapter 5.

3 CHEMICAL MASS BALANCE MODEL

The use of receptor models and their first application to air quality measurements date back to the 1960's. Initially these models were applied to particulate data. The presence of a characteristic elemental composition pattern within a particulate sample was associated with a unique source. For example, road dust would show a particular relative composition pattern of elements including lead and those additives used to scavenge lead in the engines of the day (e.g. bromine compounds). However with the lack of an adequate database of source types only minimal information could be extracted from the measured data. With the increase of well characterized source types, the model could be extended to give a least-squares type of fit to estimate the contribution of each of these sources. It was not until the mid-1970's that receptor modeling techniques were performed on hydrocarbon sources. Again, as with the particulate data, as the size of the hydrocarbon source profile database grew so did the applicability of the chemical mass balance model. Currently the chemical mass balance model widely used is the US EPA's CMB7 model (CMB8 model has just recently been released). The physical and mathematical principles that define a chemical mass balance and the CMB7 solution algorithm are presented in this section.

3.1 Chemical Mass Balance Modeling

The central idea behind chemical mass balance modeling is to account for the chemical species measured at an ambient receptor. The relative abundance of each measured species is a function of both the contribution and composition of different sources. In

most cases, the sample material collected at a receptor has more than one source. Therefore chemical mass balance receptor models require chemical fingerprints (profiles) taken from a variety of appropriate sources to apportion the measured receptor species. To better explain the concepts of a chemical mass balance model a diagram of a three-source system is shown in Figure 1.

Using the chemical profiles of both receptor and source, a system of linear equations can be developed from mass balance principles. To keep this example simple, only three chemical species are used in the mass balance. Therefore this three-source three-species system gives three equations with three unknown variables.

$$\begin{aligned} C_1 &= S_1 F_{11} + S_2 F_{12} + S_3 F_{13} \\ C_2 &= S_1 F_{21} + S_2 F_{22} + S_3 F_{23} \text{ .....(1)} \\ C_3 &= S_1 F_{31} + S_2 F_{32} + S_3 F_{33} \end{aligned}$$

This system has three unknown source contribution estimates (S_1 , S_2 and S_3), three measured receptor concentrations (C_1 , C_2 and C_3) and nine measured mass fractions of the three chemicals at each of the three sources (F_{11} , F_{12} , F_{13} , F_{21} , F_{22} , F_{23} , F_{31} , F_{32} and F_{33}). This system when solved yields the source contribution estimates.

There are two options available for use in the CMB7 model to produce source contribution estimates. These options deal with how the receptor VOC profiles are used in the model: either in absolute concentration measurements or in normalized mass fractions. The source profiles always have to be normalized regardless as to how the

receptor data is utilized. The CMB7 model implementation presented in this thesis used normalized receptor profiles. The source contribution estimates that are produced using normalized receptor profiles are relative measures and are reported as a percent contribution. The other option, leaving the receptor profile measurements as absolute concentrations, produces source contribution estimates that are measured in units of concentration. For a hypothetical example, with normalized profiles, the source contribution estimate for light duty tailpipe emissions is 23%. If absolute receptor concentrations (given that the total VOC concentration of all VOC species used in CMB analysis is $200 \mu\text{g}/\text{m}^3$) are used then the source contribution would be calculated in terms of concentration and would be reported as $46 \mu\text{g}/\text{m}^3$. That is, of the $200 \mu\text{g}/\text{m}^3$ of measured VOC mass, $46 \mu\text{g}/\text{m}^3$ can be attributed to light duty tailpipe emissions. The two methods are identical except for the reporting of source contribution estimates and receptor profile use.

This is a very simple example but shows the basic principles behind receptor modeling. However, when dealing with a real system there are some major differences. The number of individual sources contributing to the local environment is extremely large. Modeling each individual source using a mass balance approach is therefore impractical. Consider an urban environment where volatile organic compounds are being investigated. There are a wide variety of individual vehicles each with different emission characteristics, a large number of point sources (paint shops, graphic art shops, gasoline stations, etc.) and unknown ubiquitous sources (gas stoves, leaking gas pipes, leaking vehicles). Characterizing these individual sources is prohibitive based on cost, time and

computational requirements. Instead, source categories are developed that represent the composite profile of all sources that belong to that source category. For example, a transit bus tailpipe emission profile can be developed by obtaining a representative selection of samples from the bus fleet serving the area where the receptor is located.

Another difference seen in an actual modeling scenario is that the number of chemical species quantified would typically be greater than the number of source categories. When using all species and all applicable sources, the corresponding system of equations becomes over-defined. This creates a situation where there are an infinite number of solutions that can mathematically, and with complete validity, describe the contribution of each source category to the receptor. To contend with the system's over-definition a mass balance analysis requires some modification. One obvious approach is to reduce the number of species used in the analysis to equal the number of sources. This will give a well-defined system but the analysis is then only using a portion of the measured data and the influence of errors on such a small amount of data can be significant. Another approach would be to include in the analysis the uncertainty measurements for both the receptor concentrations and source mass fractions. The analysis can then carry the measurement errors through the solution to give estimates of the errors in the source contributions. The method still has an infinite number of mathematically valid solutions. However a numerical method can be used to find the single solution that minimizes the error in source contribution estimates. This single solution to the CMB equations is then chosen as the "best" solution. It is a variation of this method that is used in the CMB7

model. In the next section, the background information and the solution method for the chemical mass balance equations is described.

3.2 CMB7 Background and Solution Algorithm

The CMB7 model calculates the solution to the set of mass balance equations such that the error in the set of source contribution estimates is minimized. There are a number of solution techniques that have been applied in the past which include:

- 1) tracer solutions
- 2) linear programming techniques
- 3) ordinary weighted least squares solution with or without an intercept
- 4) ridge regression weighted least squares solution with or without an intercept
- 5) effective variance least squares solution with or without an intercept

The development and comparison of these techniques are discussed in O'Leary (1997) and US EPA (1993). Currently the US EPA's CMB7 model uses the effective variance solution to the CMB equations which was developed by Watson *et al* (1984). This solution provides estimates of the source contributions and gives greater influence to those chemical species' concentrations that are known with greater precision in both the receptor and source profiles. The original solution was proposed by Britt and Luecke (1973) who derived the exact method. However Watson *et al* (1984) developed a simplification of the method. They showed that the effective variance solution can be derived by minimizing the weighted sums of the differences between the measured and

calculated mass concentrations at both the receptor and source. Using this minimization technique, the solution algorithm iteratively calculates a new set of source contribution estimates based on the previous set of source contribution estimates.

The CMB7 model requires uncertainty estimates in the receptor concentration and source mass fractions. The source mass fraction (F_{ij}) uncertainties are usually determined by obtaining multiple samples at the same source over a period of time. However, in many cases, the receptor sampling session produces only one sample hence the uncertainty in the receptor species concentration (C_i) cannot be calculated directly. The uncertainty must be calculated from empirical equations or “rules of thumb”. In other studies (Fujita *et al*, 1995; Conner *et al*, 1994), this uncertainty is calculated using the following equation.

$$\sigma(C) = \sqrt{(2 * MDL)^2 + (CV * C)^2} \dots\dots\dots(2)$$

where $\sigma(C)$: root mean square error for the concentration C

MDL: minimum detection limit for the analytical method (~ 0.2 ppb for most VOC species)

CV: coefficient of variation

Usually the minimum detection limit does not make a significant contribution to the uncertainty calculations since the concentrations are much larger. Therefore the uncertainty will be approximately equal to the following simplified equation.

$$\sigma(C) \cong CV * C \dots\dots\dots(3)$$

Fujita *et al* (1995) recommend that the coefficient of variation for ambient VOC samples should lie between 10 and 20%. It should be noted that artificially setting the coefficient of variation for both source mass fractions and receptor concentrations removes one of the prime reasons for using the CMB model. The weighted effective variance method cannot place different weighting to species since all species are known with the same artificial certainty. As seen in the solution algorithm in the next section, there is still some weighting being applied in the solution due to how the effective variance matrix is calculated (see step 2 below).

3.2.1 Solution Algorithm

The effective variance solution is derived by minimizing the weighted sums of the squares of the differences between the measured and calculated receptor concentration (C_i) and source profile fractions (F_{ij}). The effective variance matrix in step 2 below includes the error in measured receptor concentrations, source contribution estimates and the error in the species' measured source mass fraction. In simple terms, the CMB7 model produces a solution set that minimizes the difference between measured and calculated model values for two separate parameters: $(C_i)_{\text{MEASURED}} - (C_i)_{\text{CALCULATED}}$ and $(C_i - \sum_{\text{All Sources}} F_{ij} S_j)_{\text{MEASURED}} - (C_i - \sum_{\text{All Sources}} F_{ij} S_j)_{\text{CALCULATED}}$. The solution algorithm uses an iterative procedure which calculates a new set of source contribution estimate (S_j) based on the previous iteration's source contribution estimates. The iteration proceeds with the steps shown below shown in matrix notation where k represents the value of the variable

at the k^{th} iteration. The condensed form of the solution is presented below. The detailed derivation can be found in Watson *et al*, (1984).

1. Set initial estimate of the source contributions equal to zero.

$$S_j^{k=0} = 0 \quad j = 1, J \dots\dots\dots(4)$$

where j: one source, J: total number of sources

2. Calculate the diagonal components of the effective variance matrix (V_e).
All of the off-diagonal components of this matrix are equal to zero.

$$V_{ei}^k = \sigma_{Ci}^2 + \sum (S_j^k)^2 * \sigma_{Fij}^2 \dots\dots\dots(5)$$

3. Calculate the next iterative $(k+1)^{\text{th}}$ value of S_j .

$$S^{k+1} = (F^T (V_e^k)^{-1} F)^{-1} F^T (V_e^k)^{-1} C \dots\dots\dots(6)$$

4. Test the $(k+1)^{\text{th}}$ iteration of the S_j against the k^{th} iteration. If any one differs by more than one percent, then the algorithm performs the next iteration. If all differ by less than one percent then the algorithm terminates

$$\begin{array}{ll} \text{if } |S_j^{k+1} - S_j^k| / S_j^{k+1} > 0.01 & \text{go to step 2} \\ \text{if } |S_j^{k+1} - S_j^k| / S_j^{k+1} \leq 0.01 & \text{go to step 5} \end{array} \dots\dots\dots(7)$$

5. Assign the $(k+1)^{\text{th}}$ iteration to S_j and σ_{Sj} . All other calculations are performed using these final values.

$$\sigma_{Sj} = \left(\left(F^T (V_e^{k+1})^{-1} F \right)_{jj}^{-1} \right)^{0.5} \quad j = 1, J \dots\dots\dots(8)$$

where $C = (C_1 \dots C_I)^T$: a column vector with C_i as the i^{th} component : receptor concentration of component i where ^{T} indicates the transpose of the given matrix

$S = (S_1 \dots S_J)^T$: a column vector with S_j as the j^{th} component : source contribution estimate for all sources 1 to J

F = an I by J matrix of F_{ij} : the source composition matrix : source profile fraction of component i at source j

σ_{Ci} = standard deviation of the C_i measurement

σ_{Fij} = standard deviation of the F_{ij} measurement

σ_{Sj} = standard deviation of the S_j measurement

V_e = diagonal matrix of effective variances

3.2.2 Performance Measures and Output of the CMB7 Model

The CMB7 model results are presented with a number of performance measures that give some indication of the ability of the model to explain the experimental results. The main model output is seen in Table 1 a, b and c. Typically the model output combines Table 1 a, b and c, however for ease of discussion they have been separated. Further details can be found in the CMB7 model user's guide (US EPA, 1993).

- **Source contribution estimates:** Source contribution estimates are the main output of the CMB7 model. The sum of these contributions gives an approximation of the total mass concentration at the receptor. If the source and receptor profiles are expressed as mass percentages, the sum of the contributions gives the percent mass accounted for with the CMB model. The solution algorithm may drive some source contribution estimates to negative values when pursuing the minimization objective for the sum of the squares of the errors. Negative source contribution estimates (SCE) when they occur are not physically meaningful. They occur when either two or more source profiles are collinear or when a source contribution estimate is close to zero. Those species that give negative source contributions are removed from the CMB analysis for that particular sample.
- **Reduced chi-square:** The reduced chi-square is the weighted sum of squares of the differences between the calculated and measured fitting species concentration.

$$\chi^2 = \frac{1}{I-J} \sum_{i=1}^I \left[\frac{\left(C_i - \sum_{j=1}^J F_{ij} S_j \right)^2}{V_{cii}} \right] \dots\dots\dots (9)$$

The weighting is inversely proportional to the elements of the effective variance matrix $V_{c,ii}$, that is, the squares of the precisions in the source profiles and ambient data for each species. A value less than one indicates a very good fit to the data and those values of the chi-square less than two are acceptable. Chi-square values

exceeding four indicates that one or more of the species concentrations are not well explained by the source contribution estimates.

- R²: The R² is the fraction of the variance in the measured concentrations data which can be explained by the variance in the calculated species concentrations.

$$R^2 = 1 - \frac{(I - J)\chi^2}{\sum_{i=1}^I \frac{C_i^2}{V_{ci}}} \dots\dots\dots(10)$$

The R² is determined by performing a linear regression of the measured versus model values for the chemical species measured. R² ranges from 0 to 1 and when the R² is greater than 0.8 the source contribution estimates can explain the observations adequately.

- Percent Mass: The percent mass is the ratio (in percent) of the model calculated source contributions estimates to the measured mass concentration. This ratio should equal 100% but values ranging from 80 to 120 % are acceptable.
- T-statistic: The t-statistic is the ratio of the source contribution estimate to the standard error. A t-statistic value less than 2.0 indicates that the source contribution estimate is at or below a detection limit. Low t-statistic values for a number of source contributions may be caused by collinearities among their associated profiles.

Similarity/Uncertainty Clusters: The CMB model has a method to identify problems associated with excessive similarity between sources or high uncertainties in the individual source profiles. A similarity/uncertainty cluster is presented in Table 1 b). Clusters are formed when two or more sources are determined to be collinear (using eigen vectors) or a t-statistic is less than 2.

Each cluster is identified by the code numbers associated with its source profile. For example this cluster has problems associated with three source profiles: 2, 3 and 6. More information about this cluster may be obtained by looking at the other performance indicators. If the model run produces no clusters, it means that the source contributions can be adequately resolved.

Species Concentration Display: The species concentration display shows how well the individual ambient concentrations are reproduced by the source contribution estimates. This display may indicate which source may or may not belong in the calculation. When examining the measured and calculated species' concentrations they should agree. If they do not, this indicates that a source may be missing or a non-contributing source has been included in the analysis. For example, if measured propane is greater than calculated propane, a source of propane is most likely missing in the analysis. This is assuming that all the source profiles have been properly characterized, all analytical work was done correctly and all model assumptions have been met. A sample species concentration display is shown in Table 1 c).

The column labeled **RATIO R/U** shows the ratio of the signed difference between the calculated and measured concentrations (the residual) divided by the uncertainty of that residual (square root of the sum of the squares of the uncertainty in the calculated and measured concentrations). The **R/U** ratio shows the number of uncertainty intervals by which the calculated and measured concentrations differ. When the absolute value of **R/U** exceeds two, the residual is significant. If it is positive, then one or more of the profiles is contributing too much to that species. If it is negative then there is insufficient contribution to that species and a source may be missing. The column named **RATIO C/M** shows the ratio of calculated-to-measured concentration.

There are two main other diagnostics that do not need to be completely presented here but will be mentioned for completeness. Source contributions can be presented that shows the fraction of each species' calculated ambient concentration contributed by each source in the model fit. The sources that are major contributors to each species can be determined using output similar to Table 2.

The transpose of the normalized modified pseudo-inverse matrix (**MPIN**) shows the degree of influence each species concentration has on the contribution and standard of error of the corresponding source category. It generally gives an indication to those species that are influential and those that are not. The **MPIN** is

normalized so that values are between -1 and 1. Absolute values between 0.5 and 1 are associated with influential species. Non-influential species have an absolute value less than 0.3. The MPIN is determined as shown below and a sample MPIN matrix is also included.

$$\text{MPIN} = \left[F^T (V_E)^{-1} F \right]^{-1} F^T (V_e)^{-0.5} \dots\dots\dots(11)$$

The transpose of the sensitivity matrix is calculated using measured receptor data. The code does not normally produce a copy of this matrix for the data output. This matrix indicates the degree of influence each species concentration has on the contribution and the error of the corresponding source category.

3.2.3 Assumptions of the CMB Model

The CMB model has six assumptions that must be met to help ensure the validity of the analysis. These assumptions are summarized below.

1. Composition of source emissions are constant over the period of source and receptor sampling.
2. Chemical species do not react with each other and add linearly in the concentrations measured at the receptor.
3. All significant sources contributing to the receptor have been identified and their emissions have been characterized.
4. The source composition profiles are linearly independent of each other.

5. The number of source types is less than or equal to the number of chemical species.
6. Measurement uncertainties are random, normally distributed and are not correlated.

Dealing with assumptions 1, 3 and 5 are within the control of the modeler. It is the responsibility of the modeler to examine the ambient physical environment at the receptor location. Careful examination of the activities in the receptor area will help to identify potential contributors to the receptor. This would include businesses, vehicle traffic and any human activity (e.g. construction, painting, etc.) in the vicinity. Assumption 5 can be met by simply increasing the number of species measured in each profile. Assumption 1 is more difficult to meet when developing source and receptor profiles related to mobile source emissions. Vehicle emissions vary widely from vehicle to vehicle and depend on a large number of related factors (e.g. temperature, fuel type). Even though individual vehicles can vary, minimizing these effects can be performed by careful and representative sampling of enough of the individual sources to capture the range of emission rates and variability in composition. In effect, this produces a composite profile of the “average” vehicle that is impacting the receptor.

With respect to assumption 6 there are no real experimental results for the evaluation of the measurement uncertainties. The least squares solution requires random, normally distributed and uncorrelated errors. There is actually little known about the error distribution of source and receptor profile concentrations. Most likely the error

distribution follows a distribution close to log-normal since real-world concentrations cannot be negative. However for relatively small errors ($< 20\%$), the difference between log-normal and normal error distribution is not expected to be significant (Watson *et al*, 1992).

Assumptions 2 and 4 are out of the modeler's control although there are some things that can be done to alleviate the problems associated with the collinearity amongst profiles. The CMB7 model has some measure of the degree of collinearity and/or uncertainty. If clusters appear in the model output, one can determine if the cause is due to uncertainty or collinear profiles. The input profiles can be modified to artificially lower the uncertainty of the species' measurements. The model is then rerun. If the clusters disappear the cluster is due to the high uncertainty; otherwise the uncertainty is due to collinear profiles. If similarity is deemed to be the cause of the clusters there are some measures that can be taken.

- expansion of source profiles: the number of species used in the CMB analysis are usually limited to a manageable number for such reasons as to make the presentation of the results less cumbersome, the modeler is not dealing with pages and pages of data, etc. If two sources have problems with collinearity it may be eliminated by including additional species in the analysis which gives more points of comparison between sources
- combining source categories: some source categories that show collinear source profiles may be combined to form a composite source profile. After combining

profiles the model is no longer able to resolve the combined sources although there may be other methods available to get at the distribution of sources such as market use consumption surveys or industry surveys.

In situations where there is significant chemical reaction between source and receptor that would selectively alter the chemical composition, the second assumption would not be met. Scheff *et al* (1993) found that with less reactive species (e.g. no alkenes, alkynes) a travel time between source and receptor of less than four hours did not significantly affect the results of the CMB analysis. That is, under typical summertime conditions, if the time between release and receptor sampling did not exceed four hours, that photochemical reactions would not have sufficient time to alter the emissions profile. However when travel time is longer than four hours and/or more reactive species were included in the analysis, some accounting of the reactivity should be performed. If the more reactive species are to be retained in the analysis, the profiles should be artificially aged to reflect the removal of those species. Lin and Milford (1994) used a photochemical decay-adjusted chemical mass balance model with synthetic and actual data to successfully apportion the contributions of exhaust emissions and gasoline vapour for the 1990 Atlanta Ozone Precursor Monitoring Study.

Lin and Milford (1994) used first order rate reactions for various hydrocarbons reacting with $\text{OH}^\bullet$. They used an aging coefficient and the first order rate coefficient for $\text{OH}^\bullet$ to determine the decay factor yielding the “new” decay-adjusted source profiles. Each component within the profile was artificially aged using the decay factor to produce an

adjusted profile. These “new” source profiles were then used in the CMB model to determine the adjusted source contribution estimates. For most of the Atlanta data that they used to test this method, the agreement between CMB predicted and measured individual species contributions improved but the overall source contribution estimates did not change significantly. There were a few limitations and assumptions important in this method’s development. First, this method uses identical aging coefficients for each source category which means that the emissions are assumed to have similar temporal and spatial distributions which is not seen in the real-world situation. Second, the decay of reactive species is influenced by other oxidants such as ozone and NO₃ radicals. In areas where ozone is a significant problem, ozone rate coefficients would have to be developed as well as a method to account for the change in O₃ concentration during the day.

3.3 Source Profiles

Source profiles are required by the CMB model as part of the input data. Source profiles are chemical fingerprints of a particular source such as light duty gasoline automobile exhaust emissions or architectural coatings. When VOC modeling is performed on an urban centre, the profiles typically required are from mobile sources and their associated profiles (gasoline and gasoline vapour profiles) as seen in previous studies (Kenski *et al*, 1995; Fujita *et al*, 1995; Conner *et al*, 1994). However, other profiles are often required to account for that fraction of VOCs that is not related to vehicle operations. These include sources such as natural gas (heating and vehicles), propane sources (heating and vehicles), graphic arts (printing presses) and architectural coatings.

A number of VOC emission profiles have been published in recent years in connection with emission inventory development and/or chemical mass balance modeling studies. These emission profiles contain as many as 75 hydrocarbon species in the C₂ to C₁₀ range including saturates, unsaturates, cyclic and aromatics. Uncertainties in these profiles are sometimes given when multiple measurements were obtained in the original study. However, where uncertainties have not been supplied, a coefficient of variation can be applied to those species whose concentration is several times the species quantitation limit. Based on the Southern California study by Fujita *et al* (1994) a coefficient of variation of 10-20% has been suggested. The source profiles used in each of the three studies in this thesis are included in their respective chapters. Some of the profiles are based on literature profiles and some were developed locally. The uncertainty of the measurements in all source profiles used in this thesis is 15%.

3.3.1 Mobile Source Related Emission Profiles

For mobile source exhaust emissions, the source profiles are developed using two general approaches: measurements from vehicles on a dynamometer or tunnel/roadside sampling. These are discussed briefly below.

- chassis dynamometer method: a series of emission measurements are made on a representative cross section of vehicles that make up a typical vehicle fleet. The emissions are measured to capture the emissions from the three phases of a typical dynamometer test: cold start, hot stabilized and hot start emissions. A subset of these vehicle tests can be collected by model year, vehicle type and emission

control technologies and their speciated emissions can be combined to produce a composite profile of the three portions of the emissions test.

- tunnel/roadside method: emission measurements are taken in a tunnel or at a roadside site to collect the emissions released during vehicle transit. With careful traffic counts, the light and heavy duty emission rates can be determined through regression analysis. These types of measurements usually give a more accurate representation of the real-world hydrocarbon source profile.

Fuel-related source profiles can be developed by obtaining representative samples of the fuel that is locally available. Source profiles can be constructed by fuel grade and used directly in the CMB model. However, if the market split between fuel grades is known, a composite fuel profile can be produced thus reducing the number of profiles used in the CMB model. Note that using the three grades separately in the CMB analysis can provide an additional check on the results of the CMB analysis by comparing the split between the fuel grades shown in the model and the true market split. However, based on previous experience it is unlikely that the CMB model would be able to adequately distinguish between three grades of gasoline in an urban roadside environment.

Gasoline use in vehicles also gives rise to evaporative emissions. Evaporative emissions are the volatilized components of gasoline released from a vehicle's fuel and engine system components. Due to the number of vehicles in an urban environment, vapour sources can be a significant contributor to the urban atmosphere. Vehicles release two main types of evaporative emissions: diurnal breathing losses where the vehicle warms

and cools during the day and evaporative running losses where gasoline vapours are escaping the fuel system of the hot vehicle. If vehicle exhaust emission profiles are determined through roadside or tunnel sampling, running evaporative running losses are captured as part of the tailpipe emissions. Most tunnel sampling sessions undertaken to develop emission profiles only produce heavy duty and light duty emission profiles. The measured data is usually not capable of allowing the extraction of anything other than the composite tailpipe emissions profiles. In the CMB analysis, exhaust profiles therefore may have collinearity problems with vapour profiles. When required, the gas tank headspace vapour profiles can be obtained experimentally. Alternatively, it has been shown that using Raoult's law and the Antoine coefficients an accurate headspace profile can be constructed knowing the temperature and the liquid fuel profile (Reddy, 1989).

Of particular concern with VOC apportionment in an urban environment is that the results are somewhat dependent on the appropriateness of the profiles. In the ideal modeling situation, all of the profiles are developed using local information. For example, vehicle emission profiles are developed using the local vehicle fleet. Local in this case does not necessarily mean in the immediate geographical vicinity of the modeling environment. Local refers to that geographical area where the emissions could be considered similar. This area could be obtained by looking at provincial or national borders, refinery markets or other similar factors. For example, exhaust emission profiles obtained from a typical California light duty fleet would not be appropriate for use in other areas in the U.S. due to the stringent requirements placed on vehicles in that locale. Similarly, exhaust profiles developed using vehicles from the average US fleet would not

necessarily be appropriate for use in Canada. There are many reasons for this but two of the main reasons are that the fuel can be significantly different leading to significantly different emission profiles and that the vehicle's and associated emission control technologies are different, particularly on a model-year basis. This is because emission control equipment penetration rates and introduction years into the US market can be significantly different than that of the Canadian market. However, previous studies have shown that profiles can be used from one locale to the next without significant problems if the vehicle fleets and fuel used are similar.

Whole gasoline and headspace profiles are also more appropriate when developed using local gasolines. Sampling is time consuming and expensive if one wants to produce local profiles. However, gasoline composition is usually monitored by some industrial or governmental organization and details of hydrocarbon speciation can be obtained from this information. In Canada, the Canadian Petroleum Products Institute (CPPI) recently gathered information on typical gasolines and diesels by region across the country (CPPI, 1994). The report determined the gasoline composition (44 speciated hydrocarbons plus three naphthalenes and 1,3-butadiene) by region and by grade. This information can be used to produce reasonable profiles for Ontario.

3.3.2 Other VOC Profiles

In an urban environment there are a number of other potential sources of VOCs that may need to be characterized for use within the CMB model. This is especially important if the user is attempting to account for all of the VOCs measured at the receptor. Missing

sources show up in the model output as significant differences in total percent mass and differences in the measured versus calculated mass concentrations for some species. Some of the other VOC sources are discussed below.

- **Architectural Coatings:** Architectural coatings are those materials associated with painting and related solvent use. As with other source profiles, an architectural coatings profile should ideally be developed using data that is representative of the local conditions. However this can often be expensive and time consuming, so the work of other researchers has to be used. Potential problems with this method include outdated solvent/paint composition measurements as the formulation for paints and solvents can vary with time or region. In addition, the use of these solvents in one region may not necessarily reflect the usage pattern in the region of interest. However since the architectural coating usually accounts for a small portion of the VOC loading seen in an urban environment, errors in the source profiles can be tolerated to some degree or left out of the CMB analysis. However, at the micro-environment level certain receptor locations in an urban environment may be influenced highly by local sources of these hydrocarbons.

The architectural coatings profile can be developed using extensive surveys of product type consumption patterns in a particular region such as was done in the New York City-New Jersey Region (Leone *et al*, 1987). This data was in excellent agreement with the US EPA's national NMOC emissions per capita for architectural coatings emissions. Another architectural coatings profile was

developed by Scheff *et al* (1989). However, a large variety of formulations are used in surface coatings and thus it is unlikely that a typical profile can be developed to represent all coatings. In addition, coatings contain oxygenated compounds which may account for the majority of solvent content. The only thing that can be done is to develop a profile that captures the majority of the solvent use in a given area.

- **Graphic Arts:** Graphic arts are those materials used in printing presses and associated activities. As with other source profiles, a graphic arts profile should ideally be developed using data that is representative of the local conditions. However this can often be expensive and time consuming so the work of other researchers has to be used. Potential problems with this method include outdated solvent/ink composition measurements as the formulation for these materials can vary with time or region. In addition, the use of these solvents in one region may not necessarily reflect the use pattern in the region of interest. However, since the graphic arts profile usually accounts for a small portion of the VOC loading seen in an urban environment and that the majority of the profile is toluene, errors in the source profiles can be tolerated to some degree as seen with the architectural coatings or the profile can be omitted from the analysis. However at the micro-environment level certain receptor locations in an urban environment may be influenced highly by local sources of these hydrocarbons. A graphic arts profile was developed by Scheff *et al* (1989).

- **Natural Gas :** Natural gas normally comprises mainly methane which is generally left out of a CMB analysis. However there are other hydrocarbon components present in natural gas that would contribute to the NMHC loading seen in an urban environment like Ottawa where the majority of the homes and businesses use natural gas. Natural gas profiles have been developed and show a wide range of hydrocarbon species in their profiles (Fujita *et al*, 1994). A similar analysis of local natural gas supplies was performed by Environment Canada and was reported by Graham (1992) through personal communication.
- **Liquefied Propane Gas :** In a urban environment propane gas is used in heating, cooking and as a transportation fuel. In Ottawa, propane use as a heating and cooking fuel is expected to be minimal due to the infrastructure already in place for natural gas delivery. Propane however is used as a transportation fuel and therefore may be included as part of CMB analysis. As with the natural gas profile, liquefied propane gas profiles have been developed for other studies using their own data (Fujita *et al*, 1994).

3.3.3 Source Profile and Hydrocarbon Species Selection

Upon examining other studies and the downtown environment, a number of source profiles can be listed that could account for the majority of the VOCs measured in the downtown samples. These include light duty gasoline, light duty diesel, heavy duty gas, heavy duty diesel, whole liquid gasoline, whole diesel, natural gas, liquefied propane, gasoline vapours/evaporative emissions, architectural coatings and graphic arts.

Source profiles for use in CMB analysis should be chosen to closely match the conditions seen in the local modeling environment. That is, the receptor sites chosen for modeling should be investigated for all major sources of VOC pollution expected to impact the receptor. This involves looking at a number of factors including the local traffic conditions, identification of any refueling stations in the vicinity or other sources of raw fuel, any major industries that may be heavy solvent/paint users (printing shops, autobody shops) and activities that may involve hydrocarbon sources such as painting (architectural coatings). In addition, since the CMB model produces source contribution estimates based on samples taken over discrete time intervals (over the course of a few hours) the potential interferences caused by unknown transient emitters should be examined. These interferences are impossible to predict but can certainly invalidate a sampling run. For example, a sampling station placed outside a store front where the owner is going to have some minor painting done could seriously affect the results of that particular analysis. Another example is a vehicle idling near the sampling station. This would increase the exhaust emission source contribution estimate to excessive levels.

Just as important as source profile selection is the selection of species to be used in the source and receptor profiles. In the ideal case a large number of species would be used to increase the statistical confidence in the CMB results but a number of factors influence the species used in the modeling. Some of the important factors in species selection are mentioned below:

- **Source profile species:** the source profile with the least number of components normally controls which species are used in other sources. If the profiles are from other studies the modeler has no control over this factor.
- **costs:** measuring source profiles can be very expensive and if special analytical procedures are required to identify certain species the costs can escalate. The number of species required is normally chosen from those species that are known with the greatest accuracy or are known to be prevalent in similar source or receptor profiles and will give sufficient statistical confidence to the CMB results.
- **statistical accuracy required:** selection of the number of species has to allow for enough degrees of freedom in the results to give some confidence in the results. It is recommended that the modeling be performed so that there are at least 12 degrees of freedom (Conner *et al*, 1994).
- **accuracy and abundance of the species' measurements:** the source species must be known with some accuracy. The CMB model attaches more weight to those species that are known with greater accuracy and the accuracy of the results of the modeling depend on the accuracy of the input data. In addition to the accuracy, the abundance of the species within each emission source should be investigated. It would not be wise to model with those species that make up only a tiny fraction of the total emissions from each source. It is better to choose those species that are more abundant and make up the majority of the emissions from each source. This may not always be possible at each source. Some balance has to be struck between the abundance and accuracy of each species and the profiles constructed accordingly.

- **unique or distinct species:** some species may be present in significantly greater fractions in some sources than in others. If species such as this can be found in an emission source that is not as abundant in the others it should be chosen. This unique species would act similar to a tracer. For example if a particular isomer of octane made up 10% of a single source and the other sources consisted of minuscule amounts this isomer would be an ideal species.
- **reactivity:** some species are known to be reactive in the atmosphere especially in the presence of light or certain radicals. These species are usually not included in a CMB analysis since the profiles would change from the point of emission to the point of measurement. This would be acceptable if all the species possessed the same reactivity but in the real world some species are removed from the profile selectively. The reactivity is normally quantified based on the reactivity of the hydrocarbon with the hydroxide radical. This means that hydrocarbons with double or triple bonds are normally excluded from the species list as well as carbonyls and some larger hydrocarbon molecules. For example, on the basis of the reactivity of hydrocarbons to $\text{OH}^\bullet$, Conner *et al* (1994) excluded all alkenes, n-alkanes greater than or equal to C_8 alkanes, xylenes, trimethylbenzenes and methylheptanes from their study.

Figure 1: Simple Schematic of Receptor Model Scenario

- C_i measured concentration of chemical component i at the receptor
- F_{ij} measured fraction of chemical component i at source j
- S_j contribution of source j to the total concentration measured at receptor
- I number of chemical species
- J number of sources
- i chemical species i : 1 to I
- j source j : 1 to J

Table 2: Present Measured Source Contributions Command in CMB7 Model

INDIVIDUAL RATIO = $\frac{\text{CALC SPECIES (PER SOURCE)}}{\text{MEAS SPECIES (ALL SOURCES)}}$				
SPECIES	SOURCE NAME			
	TT94HD	FLPG	TLROD	COMPFU
TOT	.497	.063	.327	.096
ETHYL	.912	.000	.307	.000
AC+ET	.271	.044	.499	.000
PROPYL	.702	.069	.232	.000
PROPAN	.094	.838	.085	.000
ISOBUT	.257	.005	.259	.066
IS/1-B	1.559	.000	.429	.000
N-BUT	.453	.000	.535	.123
2M-BUT	.548	.000	.420	.128
N-PENT	.541	.000	.425	.242
23DMBU	.541	.000	.400	.162
2M-PEN	.481	.000	.319	.182
3M-PEN	.412	.000	.260	.159
N-HEX	.547	.000	.264	.193
M-CYCL	.515	.000	.290	.209
BENZEN	.672	.000	.361	.045
CYCLHE	.451	.000	.154	.079
ISO-OC	.661	.000	.686	.211
N-HEPT	.544	.000	.261	.190
TOLUEN	.268	.000	.216	.073
N-OCT	.729	.000	.237	.000
E-BENE	.306	.000	.266	.110
M&PXYL	.634	.000	.433	.194
O-XYLE	.531	.000	.348	.158
N-NONA	1.248	.000	.342	.000
124TMB	.628	.000	.345	.165

Table 3: Transpose of Sensitivity Matrix in CMB7 Model

SOURCE NAME					
SPECIES	TT94HD	FLPG	TLROD	GA	COMPFU
ETHYL	1.00	-.03	-.27	-.01	-.97
AC+ET	-.55	-.03	1.00	-.06	-1.00
PROPAN	.03	1.00	-.06	.00	.06
ISOBUT	-.15	-.02	.27	-.03	-.10
N-BUT	-.41	-.05	.60	-.06	-.22
2M-BUT	.01	-.02	.19	-.04	-.08
N-PENT	-.17	.01	.01	-.04	.75
23DMBU	-.01	-.01	.09	-.04	.21
2M-PEN	.01	.01	-.09	-.03	.54
3M-PEN	.04	.01	-.12	-.03	.53
N-HEX	.25	.02	-.33	-.03	.65
M-CYCL	.10	.02	-.25	-.03	.76
BENZEN	.48	-.04	.03	-.03	-.67
CYCLHE	.49	.01	-.31	-.01	.04
ISO-OC	-.39	-.04	.51	-.06	.04
N-HEPT	.25	.02	-.33	-.03	.64
TOLUEN	.00	.00	.00	1.00	.00
N-OCT	.90	-.03	-.26	-.01	-.84
E-BENE	-.13	-.01	.13	-.03	.21

4 ANALYSIS OF UNDERGROUND GARAGE VOC DATA

In response to health concerns associated with vehicle emissions, especially those that possess carcinogenic or toxic properties, the Environmental Health Directorate of Health Canada initiated a research program to investigate the air quality in underground parking facilities. This chapter describes the VOC apportionment of the collected data amongst the typical sources seen in underground garages. The Health Canada study (Graham *et al*, 1994) selected three garages in the Ottawa-Hull region to investigate air quality. The garages were selected to represent different designs and states of technologies common in Canada. The garages will be referred to as PDP, TDC and XRX. Preliminary chemical mass balance calculations were completed by Graham *et al* (1995) using a simplified spreadsheet implementation. In this study, the CMB7 model was applied using the profiles developed by Graham *et al* (1995).

Details regarding the garage physical characteristics can be found in Table 4. The table describes the garage vehicle capacity, number of levels, ventilation control, vehicle usage patterns and the average temperature during the sampling sessions. During these sessions the outside temperatures ranged from -5 to -20 °C. Note that there was very little variation in the vehicle distributions or garage usage from test to test since the majority of the patrons were monthly permit holders.

The winter season was chosen for this study because it represents the worse case scenario for emissions from vehicles. This is for two main reasons. In the winter more people tend

to drive to work because of the poorer weather. Second, winter gasoline has a higher Reid vapour pressure which can enhance evaporative emissions in an enclosed, heated garage.

Typical vehicle use patterns in an underground garage can be characterized by the amount and type of vehicle activity. On a given workday, underground parking facilities see peak activity during the morning rush as vehicles are arriving for the workday and as vehicles are leaving at the end of the day for the commute home. The remainder of the day sees relatively minor vehicle activity except at noontime when people are coming and going for lunch. The vehicles arriving in the morning have arrived after some length of commute and tailpipe emissions are expected to be characteristic of a hot vehicle. These hot vehicles are then parked for the day where they release evaporative emissions into the garage environment. Then at the end of the day these vehicles are started cold and leave the garage.

4.1 Sampling Protocol and VOC Data

A sampling program was set up at the three garages to obtain nine to twelve days of data. The sampling session occurred between December 1994 and January 1995. To capture the different types of vehicle activity, a total of four samples were collected from two sampling stations. One sampling station was established near the entrance in an area of high traffic activity (Location 1) and one further into the garage in an area of minor vehicle activity and was predominated by parked vehicles (Location 2). Two samples were taken at different times at each station to reflect the type of vehicle activity over the day. At Location 1, the morning sample captured vehicles that were arriving at the garage. At Location 2, the

morning sample captured vehicles that were parked and left hot when evaporative emissions would be highest. At Location 1, the afternoon sample captured vehicles that were leaving the garage after being parked for most of the day. At Location 2, the afternoon sample captured any remaining evaporative emissions and the initial vehicle start-up crank and tailpipe emissions of departing vehicles. The morning sample was taken from 07:30 to 09:30 and the afternoon sample was taken from 15:00 to 17:00.

Volatile hydrocarbon samples were collected in evacuated SUMMA™ canisters with attached critical flow assemblies to control the filling rate of the canisters. The flow assemblies consisted of a number of hollow stainless steel fittings placed together to form a hollow shaft approximately 10 centimeters long. The shaft was plugged at both ends using two Teflon plugs. A long narrow bore needle passed through both Teflon plugs. This allowed the sample to be drawn into the canister only through the needle. The needle was of narrow enough bore to create choked flow conditions thus ensuring a relatively constant flow rate over a wide range of pressure drops across the head assembly. To ensure that the flow remained constant over the required sampling period, the flow was measured in the laboratory prior to use.

Concentrations of the same 56 hydrocarbon species as seen in Table 7 from carbon number C₂ to C₁₀ were determined. Details regarding the analytical methods can be found in Graham *et al*, 1994. The quantitation limit using this method was approximately 0.05 µg/m³. These 56 compounds accounted for 80 to 95% of the total measured VOC mass. Methane was determined separately using a different direct injection technique. The quantitation limit for methane using this technique was approximately 0.09 ppm. Due to a

more limited list of species in the source profiles developed at Environment Canada's ERMD laboratories, only a subset of 17 species were used in the CMB analysis. The list of seventeen species is shown in Table 5.

4.2 Source Profiles

Although a number of source profiles related to motor vehicle emissions are available in the literature as described in Table 8, preliminary CMB runs for the underground garage data with these profiles gave poor performance indicators of percent mass, R^2 and χ^2 . These source profiles are developed from summer-time sampling session meaning that the gasoline grade in use by the fleet is summer grade. The poor fit between measured and calculated mass fractions was attributed mainly to butane, isobutane and other low molecular weight hydrocarbons. The concentration of these species were under-predicted by the model. The relative composition of these species in gasoline are adjusted by refineries to raise or lower the Reid vapour pressure (RVP). In winter time gasoline, the RVP of gasoline is increased by adding these low molecular weight, high volatility species. These species being more volatile assist the starting and operation of a colder vehicle. These changes in composition can be seen in a survey of Canadian gasolines that examined typical gasolines by grade, season and geographical region (CPPI, 1994).

With the change in gasoline composition comes changes in vehicle emissions. Most obvious is the change in evaporative emissions. As the liquid gasoline composition changes so does the gasoline vapour produced. Tailpipe emissions can also change when the composition of the fuel changes. The work of such research organizations as the Auto

Air Quality Research Program (AQIRP) and others have quantified the changes in tailpipe emissions (Koehl *et al*, 1991; Dempster *et al* 1990; Leppard *et al*, 1992; Schuetzle *et al*, 1994). Therefore winter time CMB analysis requires source profiles developed using appropriate fuel stocks.

A more representative set of mobile source profiles was developed at Environment Canada's ERMD laboratories using fuel representative of winter conditions seen in Canada (Graham *et al*, 1995). These profiles include seventeen hydrocarbon species as listed in Table 5. The source profiles used in the CMB analysis are shown Table 6. The source profile name and brief description is included. The normalized profiles are depicted graphically in Figure 2. Full details regarding the composition of the normalized profiles can be found in the appendices.

In an underground garage where evaporative emissions are expected to be significant, a representative profile is required. Although not provided in the original ERMD source profiles, an evaporative emissions profile (VAPOUR) was developed using Raoult's law and Antoine coefficient's gathered from literature sources (Dean, 1992). Constructing vapour profiles using the liquid gasoline profile has been shown to produce accurate vapour profiles as verified by other direct laboratory methods (Conner *et al*, 1994).

4.3 Receptor Profiles

The measured receptor profiles representing the results of the entire sampling session are depicted graphically in Figure 3 through Figure 5. The graphs represent the mean

measured receptor profiles. The same profiles are presented in tabular format in the appendices.

4.4 Choice of Source Profiles

As mentioned previously, the appropriate source profiles gathered from the literature were used in the initial screening CMB runs. They were unable to adequately account for the measured VOC mass in any of the garages. Therefore to perform an appropriate CMB analysis on the underground garage system, locally derived vehicle and gasoline related profiles were developed at Environment Canada's ERMD laboratories. In this study, the choice of vehicle emission related source profiles was limited to those developed in-house at ERMD laboratories unlike other studies that usually have a list of profiles to work with. Other relevant source profiles such as graphic arts and natural gas can still be used since they do not experience the same seasonal changes as gasoline.

4.5 Source Apportionment With Selected Source Profiles

Details regarding the CMB modeling runs with the ERMD profiles and mean receptor profiles are shown in the appendices. The first run used all available source profiles considered appropriate for the underground garage micro-environment. These source profiles were chosen based on the results of previous studies and an examination of the sources that are expected to impact an underground garage. They included the cold and hot tailpipe emission profiles, the liquid gasoline profile, the gasoline vapour profile, a natural gas, liquefied petroleum and graphic arts profile. Due to the enclosed nature of the garage,

the tailpipe and gasoline related profiles were expected to dominate. The main performance measures were acceptable showing a range of percent mass (98.4% - 105.0%), R^2 (0.93 – 0.98) and χ^2 (0.93 – 3.05). However, performance measures are not the only test of the sources' ability to fit the data. Many negative source contributions and low t-statistic values are given for compressed natural gas (CNG), liquefied petroleum gas (LPG), graphic arts (GA) and evaporative emissions given by the VAPOUR profile. The results do indicate however that the fuel, hot stabilized and cold start profiles are going to be the dominating sources in the underground garages.

At this point, source profiles that show negative contributions were removed. The liquefied petroleum profile was removed first and the results show that the large number of negative source contribution estimates and low t-statistics for the remaining sources improve slightly although there was room for significant improvement. The vapour profile was then removed and with a few exceptions the results improved. Even though the t-statistic values for some of the source profiles were flagged they are only marginally low ($1.5 < \text{t-statistic} < 2$). At this point either the natural gas profile or the hot stabilized profile could have been removed. Since other studies have shown that natural gas contributions are small (Fujita *et al* 1995; Conner *et al*, 1994) and some vehicles are expected to be operating in the hot mode, the natural gas profile was removed.

The results show that although six of the contributions are flagged, three of these have only marginally low t-statistic values. The flagged source contribution estimates are also significantly lower than the other more dominant profiles. At this point in the analysis the source contributions could be considered adequate. However, to investigate the importance

of these flagged source contribution estimates, another set of runs was performed that removed these sources. These results show that including or excluding these flagged sources affects the overall results only marginally. Both the source contribution estimates and performance measures fluctuate only slightly. Therefore these four sources will be carried throughout the remainder of the analysis.

There are some interactions or similarities between the source profiles that have to be examined. The most obvious of these is the VAPOUR and FUEL (whole gasoline) profiles. Figure 6 shows the whole gasoline profile and vapour profile at various temperatures and these profiles look very similar. The major difference between VAPOUR and FUEL is seen in the shift of the relative composition of the lighter hydrocarbons (isobutane through 2-methyl-pentane) towards higher mass fractions in the vapour phase. The VAPOUR and FUEL profiles are similar enough (based on the limited number of species) that their behavior in a CMB analysis show collinearity problems when used together in the same analysis. When the FUEL and VAPOUR profile were used individually there was some interaction between the FUEL or VAPOUR profile and the COLDST profile. The FUEL profile accounted for more of the measured VOC mass than the VAPOUR profile and the additional VOC mass was shifted away from the COLDST profile. In all samples, using the FUEL profile gives significantly improved performance measures as well as better results for the GA profile.

When the FUEL and VAPOUR profiles were used together, the other source contribution estimates for GA, COLDST and HOTST remained approximately the same. However the FUEL profile dominated over the VAPOUR profile and created negative source

contribution estimates and/or t-statistic problems for the VAPOUR contribution. In all cases there were similarity clusters indicating that the CMB model cannot adequately distinguish between the two profiles given the limited number of species used. In this study, the FUEL profile appeared to be accounting for both types of gasoline related emissions and thus will be used in the subsequent analysis.

Since these garages were expected to be dominated by exhaust profiles, the ability of only the HOTST and COLDST profiles to account for the measured VOC mass was tested. The results show that these profiles can account for a majority of the measured mass but cannot explain the observed profiles by themselves. The performance measures were poor and ranged from: percent mass (45.2% – 92.7%), R^2 (0.64 – 0.87) and χ^2 (3.53 – 12.00) suggesting that other sources were also contributing to the observed profiles.

The GA profile shows t-statistic problems in four of the twelve samples. In general, removing the GA profile improved the results of those CMB runs where the GA profile had a t-statistic problem. With no GA profile available, the other samples' performance measures degraded. Judging from the detailed results of the CMB analysis with and without the GA profile, GA was mainly accounting for the difference in toluene mass. This makes sense since the GA profile is 93% toluene.

Since the major source profiles identified in the garage study are COLDST, HOTST and FUEL, the role of the other minor profiles (CNG and LPG) were examined. These results showed that these profiles cannot be included in the analysis since their t-statistics were poor. In the case of the PDP garage, the CNG profile had a strong interaction with the

HOTST profile as seen by some uncertainty/similarity clusters. In other studies, these profiles have shown small, if not negligible, contributions to the ambient environment. In a confined space such as underground garages, the vehicle emissions are going to dominate the situation even stronger. Thus it is not surprising that these other minor sources were contributing little VOC mass to the measured profiles.

4.6 Sensitivity of Source Apportionment Results

To investigate the sensitivity of the CMB analysis, those species that are prevalent in the measured source profiles or are important in the given profiles (e.g. combustion related species for HOTST and COLDST) were removed. The results were then examined for large shifts in source contribution estimates or other changes in performance measures. The base CMB modeling scenario used all listed species and the COLDST, HOTST, FUEL and GA profiles. Those species whose mass fraction was ~5% or higher were removed from the analysis one at a time and the results were compared to the base run. In addition where the garage environment is heavily impacted by exhaust emissions, all species that are prevalent only in exhaust emissions were removed. Therefore ethylene, acetylene and propylene were removed as a group from the analysis.

Details regarding the sensitivity results are presented in the appendices. There were minor differences from run to run as species were removed but the relative magnitudes of each source's contribution was consistent. Two major points can be made from this sensitivity examination. First the contribution of GA was consistent across all the runs except for the run which removed toluene. When toluene was removed from the analysis, the

contribution increased from approximately 5% to between 5.3% and 55.8%. The GA profile represents a source class that is a heavy user of solvents. One of the largest components of this profile is toluene which has a mass fraction of 93%. Normally when a species is removed from the CMB analysis, the remaining species are capable of adequately representing the profile. However, in the case where toluene is removed, the CMB utilizes the other remaining species that make up only 7% of the mass of the profile. This means that the CMB model is utilizing minor components of the GA profile to perform the analysis. When examining the species-by-species details of the source apportionment, the measured mass fraction of toluene is less than half of the calculated mass fraction of toluene. All other species show fair agreement between measured and calculated mass fractions. By removing toluene from the analysis, the key species within the GA profile, a major constraint on the apportionment of GA is removed.

The second observation was seen when all of the combustion related profiles are removed. As in the case of the toluene in the GA profile, removing some of the key species from the analysis can have some effects on the apportionment. These combustion related species are not necessarily present in the largest fraction within these profiles, they are just key markers in the combustion related profile and therefore do not show up in other profiles. Removing these species decreases the contribution of FUEL, increases the contribution of COLDST and decreases the HOTST and GA contributions. Since these combustion species are key markers of the COLDST profile and they compose a significant fraction (>30% of VOC mass) their exclusion from the CMB analysis is detrimental. Like the toluene in the GA profile, combustion species serve an important role in constraining the apportionment of the COLDST profile. Without them the apportionment is performed utilizing the

remaining VOC mass which is not as capable of adequately representing the COLDST profile.

4.7 Interpretation of Final Source Apportionment

The overall results of the CMB7 modeling for the receptor profiles are presented in Figure 7. Numerical results in tabular form are also presented in the appendices. The bar charts in Figure 7 show the contribution of each source with the associated error calculated by the CMB7 model. Details regarding the species-by-species comparison of the model versus measured fit are shown in the appendices.

In the PDP garage, the COLDST contribution is the most significant except for the L2AM case. It shows higher contributions in the afternoon relative the morning while the FUEL profile, which is the second largest contributor, shows the reverse trend with decreasing contribution in the afternoon. In the TDC garage, the FUEL contribution is the dominant one except for the L1PM case. It is noticeably higher in contribution but with similar trends to PDP in terms of location and sampling session. The contribution of HOTST has increased in the TDC garage relative to other garages. In the XRX, garage the results are similar to the TDC garage although the difference between FUEL and COLDST are somewhat less pronounced.

Since the behaviour of the vehicles change over the course of the day, any trends in the contribution of the various vehicle emissions would be of interest. Visualizing trends from Figure 7 are not as obvious as they could be. Figure 8 shows the change in source

contribution estimates for FUEL and total tailpipe emissions as a function of sampling location and sample time individually. Figure 8 a) shows how the tailpipe source contribution estimate varies with sampling location. Figure 8 b) shows how the tailpipe source contribution estimate varies with sampling time. Figure 8 c) shows how the FUEL source contribution estimate varies with sampling location. Figure 8 d) shows how the FUEL source contribution estimate varies with sampling time.

Location 1 (near the entrance) is more heavily impacted by tailpipe emissions than location 2 (further into the garage). The impact of the tailpipe emissions is heaviest in the afternoon at location 1. of particular note is that the morning tailpipe emissions look more like cold emissions than hot stabilized emissions. It is expected that vehicles arriving at these garages from some time and distance of travel would be sufficiently warmed so that their exhaust would more closely resemble hot stabilized emissions. There are two main factors that can possibly explain this observation. First, the emission profiles were developed in the laboratory on an FTP (Federal Test Procedure) driving cycle (US EPA, TP 707J, 1996). The ability of this driving cycle to adequately represent the driving pattern experienced by the vehicles entering and leaving the garages has to be questioned. The FTP cycle was developed to represent the driving patterns seen in a typical Los Angeles commuting trip and thus represents a wide range of driving speeds and accelerations. The driving seen in the garage was dominated by slow speed stop-and-go driving up and down large grades.

Second, these profiles were developed from a limited number of vehicles and therefore only an approximation of the true vehicle fleet entering the garage. The profiles were constructed using only four vehicles which were chosen to be a representative sample of the

driving fleet. But vehicles entering the garage have a very wide range of ages and condition of their emission control technologies. Linked with the vehicle age distribution is the aging and type of emission control devices. As vehicles age, their emission control devices decrease in efficiency and older vehicles tend to have different emission control technologies, if any. Despite these limitations, these derived profiles are currently the best and only estimates for representing Ottawa wintertime vehicle populations. The summertime vehicle profiles found in the literature are completely incapable of adequately representing a wintertime vehicle fleet. There is currently no method of comparing the ERMD profiles to the work of other researchers.

At location 1, most of the remainder of the measured mass is accounted for by the FUEL profile. The source contribution estimate of FUEL is a measure of the evaporative emissions seen in each sample. The FUEL contribution at location 1 is highest in the morning sample. However, the magnitude of the contribution of evaporative emissions is large considering that this location should be seeing quite a large fraction of tailpipe emissions. Therefore some other factor must be working to increase the contribution. Since these are underground garages and hot air is less dense than the outside colder air, it is possible that the circulation patterns in the garage may be forcing internal garage air laden with these evaporative emissions out towards the entrance. The increase in the tailpipe emissions in the afternoon sample at both locations is due to a combination of two factors. The evaporative emission rates typically decrease over the course of the day as seen in Figure 9 (Graham and O'Leary, 1997) and the vehicles are leaving colder than when they arrived. That is, the samples are showing the effects of lowered evaporative

emission rates and elevated tailpipe emission rates. Figure 9 shows the measured evaporative emissions emission rate of the test vehicle used in the residential garage study.

Location 2 shows heavier contributions by fuel related emissions and the impact is larger in the morning. The larger impact of evaporative emissions was seen in the morning because the vehicles are being left hot in the garage when emission rates are highest. After the morning rush has passed the number of vehicles entering the garage levels off and the majority of the vehicles are left parked for the remainder of the day. The rate of release of evaporative emissions is much larger when the vehicle is hot. This can be seen from the results of an actual test vehicle in Figure 9. This graph shows that peak emission rates occur within 10 to 15 minutes of vehicle shut-off. Assuming that the vehicles parked in the garage behaved in a similar fashion, a significant amount of evaporative emissions is going to occur during the morning sampling session.

The other sources (CNG, LPG) do show up in some of the CMB runs but their statistical indicators show that including them in the final source contributions is insignificant. Although GA has some t-statistic problems they are included in the final apportionment because the results for GA at the TDC and XRX garage show that this profile can be distinguished.

PDP Garage

In the PDP garage, the COLDST profile accounts for the majority of the measured VOC mass except for the location 2 morning sample. The HOTST and GA profiles account for less than 9% in each sample with HOTST showing greater contributions except for one

case (location 1 afternoon). The FUEL profile accounted for the remainder of the measured mass and was the second highest contributor except in the location 2 morning sample where it was the largest. The other profiles LPG and CNG showed up in some of the other modeling runs but their contributions are low enough to be lost in the noise of the data and show up as negative source contribution estimates or have excessive errors. When the Ottawa environment is examined we know that these sources are present but in an enclosed environment such as the garages their effects are masked by the large contributions of the vehicle emissions. The performance measures range from percent mass (93.5% - 100.1%), R^2 (0.91 – 0.95) and χ^2 (1.66 – 3.29) which are all acceptable. The source contributions for GA show some t-statistic problems but they are not as extreme as seen by the other profiles (CNG, LPG). They are included because the other garages showed that the GA profile could be adequately resolved.

TDC Garage

In the TDC garage, the FUEL profile is the dominant profile except for the location 1 afternoon sample which showed the COLDST having the largest contribution. The COLDST profile showed the next largest contribution followed by HOTST and then GA. The performance measures range from: percent mass (99.6% - 108.1%), R^2 (0.86 – 0.94) and χ^2 (2.12 – 5.11) which are all acceptable except for the location 2 morning sample which gave a high χ^2 . Examining the species-by-species data from that individual sample shows that the fit between measured and calculated mass fractions are not as close as the other samples across all the species. No one species seems responsible for the poor fit in

the data. There were no t-statistic problems associated with the GA profile in any of the samples.

XRX Garage

The XRX garage results show similarities with the TDC results although the source contribution estimate shifts are not as pronounced. The location 1 afternoon sample still shows a larger contribution by COLDST. The performance measures range from: percent mass (99.6% - 102.3%), R^2 (0.95 – 0.97) and χ^2 (1.20 – 1.64) which are acceptable and are the best measures from all three garages.

4.8 Deviation From the CMB Model Assumptions

The basic assumptions of the chemical mass balance model are presented below.

1. Composition of source emissions are constant over the period of source and receptor sampling.
2. Chemical species do not react with each other and add linearly in the concentrations measured at the receptor.
3. All significant sources contributing to the receptor have been identified and their emissions have been characterized.
4. The source composition profiles are linearly independent of each other.
5. The number of source types is less than or equal to the number of chemical species.
6. Measurement uncertainties are random, normally distributed and are not correlated.

With respect to assumption 1, the four profiles used in the CMB analysis have to be examined individually. As mentioned previously, the composite source profiles used in this analysis are representing a very large vehicle fleet. It is hoped that with proper sampling that variations in an individual source can be accurately represented by a composite fleet profile which has accounted for these individual variations. The tailpipe emissions represented by HOTST and COLDST are composite profiles gathered over a limited number of laboratory tests. The receptor samples represent the time averaged concentrations gathered from a relatively large number of vehicles that are entering the garage. The basic requirement is that the source profiles adequately represent the tailpipe emissions of the sampled vehicles. In this study, the profiles do seem to fit the sampled vehicles in terms of total tailpipe emissions. The apportionment between cold and hot emissions may require more detailed laboratory profile development. In this study, the importance of distinguishing between the two types of tailpipe emissions is not as important as distinguishing between tailpipe and evaporative emissions.

When examining other tailpipe exhaust profiles, they show similarities in the middle to heavier end of their respective hydrocarbon regimes. The largest differences from profile to profile is seen in the lighter end of the profiles such as ethylene, propylene and acetylene. When these species are removed from the current CMB analysis some of the samples did show some changes in their source contribution estimates. However, with some exceptions, the relative magnitude of the source contribution estimates are consistent.

The FUEL profile was constructed using a limited number of samples from gasolines available at the filling stations in the Ottawa region. Although this is not a large

representative sample it has been shown that the gasolines from region to region are similar in terms of the major species analyzed (CPPI, 1994). This means that the measured profile should be adequate in representing the evaporative emissions from the composite fleet of vehicles in the garage study.

The reason for assumption 2 is that the VOCs released from their source must not change in relative composition as they are transported to the receptor. In an underground garage there is no direct sunlight which removes photochemistry as a significant factor. If any species are involved in any other chemical or physical process that selectively changes the relative concentration of one or more of the species, the CMB analysis becomes invalid. One factor that may become important however in the garage environment is the behaviour of some of the heavier compounds in colder weather. Since these compounds have low boiling points and vapour pressures they may be prone to adsorbing onto surfaces thus removing them from the ambient environment. At the observed temperatures (generally $>10^{\circ}\text{C}$) within the garage this may not be a problem. In the literature, the role of adsorption as a VOC sink has not been examined with regards to CMB modeling.

With respect to Assumption 3, the number and type of major sources in an environment such as an underground garage is not difficult to estimate. It appears from the performance measures that all of the significant sources in the garages have been included in the analyses.

With respect to Assumption 4, no problems with collinearity were evident in the profiles used in the final analyses.

With respect to assumption 5, the number of species retained in the analysis was always greater than the number of sources. In fact, the number of species used was always enough to maintain the degrees of freedom in the CMB solution greater than 12 as recommended by Conner *et al*, (1994).

With respect to Assumption 6, the randomness and distribution normality of the source and receptor measurements have yet to be studied. However, the importance of this assumption is not expected to be significant when the coefficient of variation in the measurements is not greater than 20% (Watson *et al*, 1994)

Figure 2: Source Profiles Used in the Underground Garage CMB Analysis

The characteristics of the source profiles labelled FUEL, COLDST, HOTST, CNG, LPG, GA and VAPOUR are described in Table 6. (FUEL: whole composite gasoline, COLDST: cold start tailpipe emissions, HOTST: hot stabilized tailpipe emissions, CNG: commercial natural gas, LPG: liquefied petroleum gas, GA: graphic arts and VAPOUR: gasoline headspace vapour)

Figure 3: CMB Receptor Profiles: PDP Garage, All Times, All Locations

Average of 9-12 measurements for each time/location combination. (L1: location near garage entrance/exit, L2: location within garage, AM: 07:30-09:30 hrs, PM: 15:00-17:00 hrs)

Figure 4: CMB Receptor Profiles: TDC Garage, All Times, All Locations

Average of 9-12 measurements for each time/location combination. (L1: location near garage entrance/exit, L2: location within garage, AM: 07:30-09:30 hrs, PM: 15:00-17:00 hrs)

Figure 5: CMB Receptor Profiles: XRXL Garage, All Times, All Locations

Average of 9-12 measurements for each time/location combination. (L1: location near garage entrance/exit, L2: location within garage, AM: 07:30-09:30 hrs, PM: 15:00-17:00 hrs)

Figure 6: Comparing the FUEL Profile and VAPOUR Profile Over Range of Temperatures

Whole gasoline profile (FUEL) plotted with corresponding gas tank headspace vapour profile calculated using Raoult's Law at temperatures of -10, 0, 10, 20 and 30 °C.

Figure 7: Final Source Contribution Estimates For Three Underground Garages

Final source apportionment for each garage/time/location combination. (PDP, TDC, XRX: three garages, L1: location near garage entrance/exit, L2: location within garage, AM: 07:30-09:30 hrs, PM: 15:00-17:00 hrs). The characteristics of the source profiles labelled FUEL, COLDST, HOTST and GA are described in Table 6. (FUEL: whole composite gasoline, COLDST: cold start tailpipe emissions, HOTST: hot stabilized tailpipe emissions and GA: graphic arts.)

Figure 8: Source Contribution Estimates of Evaporative and Tailpipe Emissions For Sampling Locations and Times

Trends in source contribution estimates for evaporative and vehicle (COLDST + HOTST) tailpipe emissions for garage/time/location combinations. (PDP, TDC, XRX: three garages, L1: location near garage entrance/exit, L2: location within garage, AM: 07:30-09:30 hrs, PM: 15:00-17:00 hrs). The characteristics of the source profiles labelled FUEL, COLDST and HOTST are described in Table 6. (FUEL: whole composite gasoline, COLDST: cold start tailpipe emissions, HOTST: hot stabilized tailpipe emissions and GA: graphic arts.)

Figure 9: Evaporative Emissions Release Rate from Test Vehicle Measured in SHED Test

Emissions from test vehicle measured in cold test cell maintained at -10°C . Taken from residential homes with attached garage study.

Table 4: Underground Garage (PDP, TDC and XRX) Descriptions

Vehicle distribution given as split between light duty automobiles (LDV) and light duty trucks (LDT).

	PDP	TDC	XRX
Vehicle Capacity	1655	626	263
Parking Levels	3	4	7
Ventilation Control	exhaust fans activated at 50 ppm CO, outdoor intake activated at 100 ppm, CO sensors on each level	exhaust fans activated at 50 ppm CO, outdoor intake activated at 100 ppm, CO sensors on each level	exhaust and outdoor intake, fans activated at 50 ppm CO, CO sensors on each level
Vehicle Distribution	83% LDV 17% LDT	86% LDV 14% LDT	85% LDV 15% LDT
Garage Use as % of Capacity	71%	81%	78%
Time Averaged Temperature (over 2-hr sample)	Location 1: 14 - 25 °C Location 2: 20 - 26 °C	Location 1: 16 - 24 °C Location 2: 20 - 25 °C	Location 1: 15 - 20 °C Location 2: 17 - 21 °C

Table 5: Species Used in Underground Garage CMB Analysis

ethylene	acetylene	benzene	toluene
propane	iso-butane	<i>ortho</i> -xylene	propylene
<i>normal</i> -pentane	2-methyl-pentane	ethane	2-methyl-butane
<i>normal</i> -butane	<i>normal</i> -hexane	3-methyl-pentane	<i>meta</i> & <i>para</i> -xylene
ethyl-benzene			

Table 6: ERMD Source Profiles and Published Source Profiles

Source Name	Description
FUEL	Liquid fuel profile for a winter grade fuel of RVP = 13.7 psi used in a testing program for light duty vehicles.
VAPOUR	Headspace vapour calculated at 0 °C for the gasoline represented by FUEL
COLDST	Tailpipe emission profiles from the first two phases of the FTP dynamometer test obtained from the composite of 4 vehicles test at 10 °C and -5 °C with the above mentioned fuel. Represents the cold start tailpipe emissions.
HOTST	Tailpipe emission profiles from the first two phases of the FTP dynamometer test obtained from the composite of 4 vehicles test at 10 °C and -5 °C with the above mentioned fuel. Represents the hot stabilized tailpipe emissions.
CNG	Compressed natural gas determined from samples taken in 1972 in Los Angeles and 1973 in El Monte California as reported by Fujita <i>et al</i> , 1994.
LPG	Liquefied Petroleum Gas as reported by Fujita <i>et al</i> , 1994.
GA	Graphics arts emissions profile. Composite profile obtained by usage patterns of lithographic, letter press, flexographic and rotogravure printing inks (Scheff <i>et al</i> , 1989).

5 SLATER STREET NOSE-LEVEL STUDY

The reduction of ground-level ozone levels has emerged as one of the most important challenges in urban air quality in most population centres in North America (Conner *et al*, 1994; Fujita *et al*, 1995; Gertler and Pierson, 1994). To this end, identifying pollutant sources and developing VOC inventories are important due to the role that these pollutants play in atmospheric photochemistry as ozone precursors. Measures taken to reduce urban ozone levels have failed in some instances partly due to the inaccuracy in the region's emission inventories (Gertler and Pierson, 1994; Fujita *et al*, 1995; Seinfeld, 1991). The largest error in these inventories was the significant underestimation of mobile source emissions that had been calculated using emission factor models that estimate the breakdown between tailpipe and non-tailpipe VOC emissions, in addition to estimates of tailpipe NO_x and CO (Fujita *et al*, 1995; Pierson *et al*, 1990; Pierson *et al*, 1996). Receptor modeling techniques such as CMB analysis allow locally measured VOC samples to be apportioned between tailpipe and non-tailpipe emissions, thus verifying or refuting the results of an emission factor model. Receptor models can also be used to indicate the contribution of motor vehicles as a whole to urban VOC pollution. In this way, some corroboration can be made between emission inventory estimates and actual ambient measurements.

This chapter demonstrates the source apportionment of two sets of ambient VOC data from downtown street locations using two different receptor models. The two receptor modeling techniques applied were the chemical mass balance model and factor analysis. The source of the first set of VOC data was a study carried out on a downtown Ottawa roadway (Slater

Street) where nose-level measurements were made at two stations located on each side of the road. Samples were obtained for two-hour periods during the morning, noon, afternoon and evening rush hours over 20 weekdays in August and September 1994 (Graham and Karman, 1995).

The second set of VOC data came from a continuous ambient monitoring station located two blocks away from the nose-level stations on the same street. This sampling station is part of the National Air Pollution Surveillance (NAPS) network (Environment Canada, 1995). This station samples for VOCs over 24-hour periods once every six days at a height of four metres above street level.

Preliminary work with CMB modeling using this data had been completed by Graham and Karman (1995) and Wong (1996). In this study, further CMB model runs were performed with local gasoline profiles that became available from a CPPI study (CPPI, 1994). Sensitivity of model results to uncertainties in source and receptor profiles were also assessed.

5.1 Slater Street Nose-Level VOC Data

The Slater Street nose-level data was obtained as part of a study by Environment Canada's ERMD to evaluate the pedestrian impact of street level pollution and the impact of motor vehicles to urban air quality. The study was entitled Contribution to Curbside Air Quality from Mobile Sources (Environment Canada-ERMD, 1994). Slater Street is a major roadway running east-west through the city and acts as a major bus transit route travelling

across the city. The purpose of this study was to obtain VOC, carbonyl, particulate and other data during times of high vehicle traffic and pedestrian activity. There were two sampling stations established on Slater Street. The sampling locations were chosen so that samples would reflect those exposure levels seen by a pedestrian. All inlets were located 1.5 metres from the ground to capture nose-level samples. In this thesis, Slater Street sampling station 1 is referred to as SL1 and Slater Street sampling station 2 is referred to as SL2.

Sampling station 1 was located 30 cm from the curb just in front of the bus stop. Sampling station 2 was located 2.5 m back from the curb. A simple map of the sampling area is shown in Figure 10. This figure shows the sampling locations indicated by “•”. The station number is next to the station marker.

Samples were obtained over a 20 day sampling session running from August through September 1994. Samples were analyzed for C₂ to C₁₀ hydrocarbons, C₁ to C₇ carbonyl compounds, particulate mass, trace metals, PAHs and soluble organic fraction of particulate mass.

The two-hour vehicle counts on Slater Street ranged from 1180 to 2120. This corresponds to a traffic volume between 10 and 18 vehicles per minute passing the samplers. of the total count, the light duty vehicles accounted for a minimum of 79%. Heavy duty vehicles comprised no more than 2% of the traffic volume. Buses made up the balance of the traffic volume and the split between coach style and articulated type was recorded.

Bus traffic was highest during the morning and afternoon intervals as expected. The number of coach style buses remained constant throughout the day. The number of articulated buses increased in the morning and afternoon periods to carry the increased demand. The number of light duty vehicles increased during the afternoon rush over the proportion observed during the morning rush. This would presumably be due to the number of errand-related stops on the commute home. These observed traffic patterns are typical of urban activity. It should be noted that from day to day, the observed traffic patterns were very consistent.

The samples were taken during the morning rush hour (7:30 AM – 9:30 AM), noontime (11:30 AM – 1:30 PM), afternoon rush hour (3:30 AM – 5:30 AM) and night time samples (10:00 PM – 12:00 AM). Some samples were not obtained on some days and/or times for a variety of reasons. The brief sampling methodologies for VOCs is presented briefly below.

Volatile organics were collected in 6 litre stainless steel SUMMA™ canisters and analyzed by standard laboratory techniques as described in the project report (Graham and Karman, 1995). This method gives a quantification limit of approximately $0.05 \mu\text{g}/\text{m}^3$ per component. Table 7 shows the hydrocarbons that were quantified in the curbside study.

The normalized receptor profiles for SL1 and SL2 are shown graphically in Figure 11 through Figure 18. These figures show all of the samples taken at a given location and time. These figures are meant to highlight the receptor profile patterns at and between each

sampling site and time. Samples that appear not to follow the predominant pattern are indicated by a label indicating the date. All other dates are not shown due to the number of samples contained in each figure. Numerical details regarding the corresponding absolute concentrations of those 25 species retained in the CMB analysis for the Slater Street nose-level and NAPS station data are shown in the appendices. The mass fraction receptor profiles for the CMB analysis are also shown in the appendices.

5.2 Slater Street NAPS Network VOC Data

The National Air Pollution Surveillance (NAPS) network was established in 1969 as a joint program between the provincial and federal governments. The main purpose of the NAPS project was to monitor and assess the quality of ambient air in urban environments across Canada. There are also a few rural sampling sites in such areas as Kejimikujik, Nova Scotia. The NAPS data has also served to establish a quality database to monitor temporal trends in air pollution levels and link these changes with air pollution abatement measures. There are currently 140 sampling stations located in 50 urban centres across Canada. The NAPS network has a sampling station on Slater Street that obtains samples every six days.

As part of the National Ambient Air Quality Objectives program pollutant concentrations of SO₂, CO, NO₂, ozone and suspended particulate matter are measured. In addition, as part of Canada's National Smog Management Program, nitrogen oxides, VOCs and ozone are measured and reported as part of the NAPS database. In the Acid Rain and Air Toxics priority program a number of particulate components (toxic metals, various organic anions/cations and inorganic cations) are measured as well. As of 1988, various organic

toxics are analyzed including aromatics, aldehydes, ketones, PAHs, dioxins and furans. These are measured at 40 urban and rural locations including the two NAPS stations in Ottawa. The NAPS station supplying the data for this CMB analysis is from the station located at 88 Slater Street which is two blocks away from the nose-level stations.

Twenty-four hour samples are obtained every six days at the Slater Street sampling station. The samples run from midnight to midnight. The samples are obtained using evacuated SUMMA™ canisters and are analyzed using gas chromatography with a flame ionization detector/mass spectrophotometer. The normalized receptor profiles are shown in Figure 19. Details regarding annual statistical measures, the data measured during the August-September sampling session and the normalized receptor profiles are shown in the appendices.

5.3 Source Profiles

The source apportionment along a busy downtown street will require many mobile source related profiles (Kenski *et al*, 1995; Fujita *et al*, 1995; Conner *et al*, 1994). Using these studies and examining the sources that may be present in the downtown environment, a number of source types would be required in the CMB model to account for the VOCs measured in the Slater Street samples. These profiles include light duty gasoline exhaust emissions, light duty diesel exhaust emissions, heavy duty gas exhaust emissions, heavy duty diesel exhaust emissions, whole gasoline, whole diesel, natural gas, liquefied propane, gasoline vapours, architectural coatings and graphic arts.

The tailpipe emission profiles developed in the literature do not distinguish between all of the noted tailpipe profile types. Typically, tailpipe emission profiles are broken into two main categories: light-duty gasoline and heavy-duty diesel. Even if the profiles were further refined to give the four types of exhaust profiles, it is very likely that they would be too similar for the CMB model to adequately apportion the measured VOC data. Most modeling efforts do not require that degree of resolution between tailpipe sources hence apportioning between heavy-duty diesel and light-duty gasoline is sufficient. The tailpipe profiles used in this study have been gathered from a number of literature sources and they reflect different development techniques and different vehicle fleets.

Gasoline related profiles (evaporative emissions and whole gasoline) are also a component of the measured VOC mass seen in previous studies. In this study, a locally developed gasoline profile was used in the source apportionment. Using the liquid gasoline profile developed from the CPPI report (CPPI, 1994), a vapour profile can be constructed using liquid/vapour equilibrium calculations. To investigate the sensitivity of the vapour profile to temperature, different profiles were generated using a range of typical summertime temperatures. There were not any significant differences between the vapour profiles at different temperatures therefore any of the vapour profiles could be used with no concern for the ambient temperature during sampling.

In addition, other source profiles may be required to account for that VOC fraction that is unrelated to motor vehicles such as those originating from graphic arts or architectural coatings sources. In this case, source apportionment has to be performed using profiles gathered from the literature. The relevant profiles were gathered from the literature and

compiled for use in a CMB analyses. The complete development details regarding each source profile will not be discussed. Brief descriptions of the profiles and the method of development are outlined in Table 8.

The actual concentrations measured and used to develop the source profiles will not be presented and are available in the original cited literature. Graphical representation of these source profiles are shown in Figure 20, Figure 21 and Figure 22. Figure 20 shows the whole gasoline and evaporative emissions profiles. Figure 21 shows the heavy duty tailpipe emission profiles. Figure 22 shows the light duty tailpipe emission profiles. The other source profiles are minor and will not be shown graphically. Numerical details regarding all of the normalized source profiles are shown in the appendices.

5.4 Source Apportionment With Selected Source Profiles

There were a large number of source profiles to consider as potential candidates for final source apportionment of the Slater Street VOC data. To perform every combination of source profiles would be inappropriate and time consuming. From previous studies, (Fujita *et al*, 1994; Conner *et al*, 1994) the predominant sources seen in an urban centre are light and heavy duty tailpipe emissions and evaporative emissions. The various combinations of these three types of emission profiles were tried with all appropriate source profiles. Those that showed the most promise of explaining the measured VOC data as indicated by the performance measures were retained for further analysis. Due to the volume of the resulting initial screening model runs, these results are not included. Instead the screening

runs using those promising profile combinations were the starting point in the more detailed analysis that follows.

The screening runs included the light duty, heavy duty and evaporative emission profiles found previously as well as other appropriate minor source profiles that have been used in other studies. Details regarding the CMB modeling runs using those profiles are shown in the appendices. The goal of this portion of the study was to find a set of source profiles that could adequately represent all of the measured profiles at the two nose-level stations and the NAPS station. All of the listed species were used in each run with the exception of propylene, *iso*-butane, the xylenes, *n*-nonane and 1,2,4-trimethyl-benzene. These were removed from the screening runs due to potential photochemical reactivity based on the recommendations of Conner *et al* (1994).

The results of the screening runs and the corroboration of the previous work from Wong (1994) showed that the following combination of core profiles gave the best results: TT94HD (heavy duty diesel tailpipe), TLROD (light duty gasoline tailpipe), COMFUE (composite whole liquid gasoline) and FLPG (liquefied petroleum gas). In addition, including the GA (graphic arts) profile also showed good preliminary results. At this point in the analysis, the core profiles appeared to have been established. The role of other minor contributing profiles have to be examined to complete this stage in the analysis.

Based on the results of previous studies, three other appropriate profiles were added to the core profiles and their impact on the CMB results examined. These additional profiles represent graphic art emissions, gasoline vapour and natural gas. To be included in this

step in the CMB analysis, individual model runs on each sample had to have a χ^2 less than 6 (just for screening purposes) and all positive source contribution estimates. This would eliminate those samples that were poorly represented by the chosen source profiles and would also give an indication to how well the source profiles represented all of the ambient samples. That is if only one sample in 80 could be adequately represented, that combination of source profiles would be considered inappropriate.

To be considered for further analysis, the source profiles must be able to adequately characterize the source contributions at all three sites (SL1, SL2 and NAPS). In total, eight different modeling runs were performed with the previously mentioned four core profiles and three other minor profiles. Five of the runs were not successful. Of the three remaining runs all of which showed adequate results, one had the best overall performance measures (highest R^2 , lowest χ^2 and percent mass nearest to 100%). This run (RUN2) included the profiles COMPFUE, FLPG, GA, TLROD and TT94HD.

It should be noted that across all runs, the source contribution estimates for the four core profiles remained close to their values obtained in the base run (RUN1). The largest changes were seen in the exhaust profiles. When the gasoline vapour was added to the core profiles the VOC mass was redistributed slightly. TLROD and COMPFUE dropped slightly while TT94HD increased slightly. When the graphic arts profile was added to the core profiles, there was very little change in the contribution estimates. The percent mass increased by 10% and the GA source contribution estimate was 13.5%. Since the performance measures all increased due to this profile addition, the GA profile seems to fill

a missing source. When the CNG profile was added to the core profiles, the number of valid samples retained dropped considerably. Since natural gas usually makes up a small contribution its presence can usually be neglected. Natural gas consists mainly of methane which is normally not included in CMB modeling. The small contribution, small number of species in the profile and the low levels of non-methane hydrocarbons (NMHC) associated with natural gas makes it probable that this profile can get “lost” in the noise of the data. Although there are other minor sources contributing to the ambient samples, the CMB model is not able to adequately resolve them. As seen in previous studies these contributors are small and can therefore be neglected.

5.4.1 Sensitivity Runs For CMB7

To examine the sensitivity of the apportionment to species selection, various combinations were modeled. As seen in previous studies, (Fujita *et al*, 1994) combustion related species and toluene are typical species used to investigate the stability of the apportionment. In addition, the species typically removed from a CMB analysis due to reactivity concerns will be reintroduced in to the model. Since chemical residence times are not expected to be greater than four hours, reactivity should not be a concern (Conner *et al*, 1994). If long range transport studies were being performed, the impact of photoreactivity would be important. Details regarding the sensitivity runs are shown in the appendices.

Two baseline runs are performed to form a starting point for the species sensitivity analysis. The two baseline runs were “BASE” and “ALL SPECIES”. The BASE analysis has the reactive species removed and the ALL SPECIES analysis reintroduces all 25 VOC species.

Introducing all the species reduces the number of valid runs (65 to 39). The percent mass decreases slightly. TT94HD and GA drops slightly and is redistributed to the TLROD profile. Details regarding the results of the analysis are outlined below.

ALL SPECIES:

- TOLUENE: SL1 & SL2: Removing toluene from the analysis has serious detrimental impact to the apportionment. Most obvious is the loss of valid runs (65 to 3). The loss of toluene most seriously impacts the TT94HD and GA profile both dropping by almost half. The percent mass drops from 104.9 to 80.2% which is interesting since toluene makes up approximately 20% of the measured mass in the ambient profiles. All of the performance measures drop when toluene is removed from the analysis. As seen in the residential and underground garage studies, toluene is an important constraint on the apportionment of the GA profile.
- TOLUENE: NAPS: Removing toluene from the analysis has a minor impact to the apportionment. Removing toluene substantially increases the contribution of the GA profile (4.3 to 15.2) while the other profiles remained the same. The difference in percent mass is due to the increase in the contribution of GA. R^2 remains the same, χ^2 increases and percent mass increases
- ETHYLENE: SL1 & SL2 & NAPS: Removing ethylene from the analysis does little to the contributions from all profiles. The biggest impact is seen in the χ^2 that increased slightly.
- 2M-BUTANE: SL1 & SL2 & NAPS: Removing 2-methyl-butane from the analysis does little to the contributions from all profiles. The χ^2 increased slightly.

- ACETYLENE + ETHANE: SL1 & SL2: Removing these two species has a slight effect on the contribution. A slight increase in TLROD is offset by a slight decrease in COMPFUE and TT94HD. The performance measures stayed relatively the same.
- ACETYLENE + ETHANE: NAPS: Removing these profiles had a detrimental effect on the number of retained samples.
- ACETYLENE + ETHANE & ETHYLENE: SL1 & SL2: Removing these three species resulted in a slight redistribution of contributions. The slight increase in TLROD is offset by a slight decrease in COMPFUE. The performance measures remained relatively the same.
- ACETYLENE + ETHANE & ETHYLENE: NAPS: Removing these profiles had a detrimental effect on the number of retained samples.
- PROPYLENE: SL1 & SL2: Very little change in any measures.
- PROPYLENE: NAPS: Some slight rearrangement in the contributions mainly a slight decrease in COMFUE.
- ACETYLENE + ETHANE, ETHYLENE, PROPYLENE: SL1 & SL2: Slight redistribution in the contributions. TLROD increased slightly. χ^2 increased slightly.
- ACETYLENE + ETHANE, ETHYLENE, PROPYLENE: NAPS: : Removing these profiles had a detrimental effect on the number of retained samples.

BASE SPECIES:

- TOLUENE: SL1 & SL2: Toluene could not be run. The developers of the CMB model (Desert Research Institute, Nevada) were contacted since the error message

supplied by the code and extensive input data checking proved ineffective in solving the problem. The developers stated that removing toluene in this particular model run left too many species with zero concentrations and an internal code subroutine did not allow the model to be run.

- TOLUENE: NAPS: As in TOLUENE: SL1 & SL2.
- ETHYLENE: SL1 & SL2: Excluding ethylene redistributes the contributions. TT94HD increased by almost half. The contributions increased in TLROD and COMPFUE. χ^2 increase and percent mass decreased. This pattern was also seen in Fujita *et al* (1994).
- ETHYLENE: NAPS: Removing ethylene from the analysis does little to the contributions from all profiles. The biggest impact is seen in the χ^2 that increased slightly
- 2M-BUTANE: SL1 & SL2 & NAPS: Little change in the contributions. Performance measures very similar.
- ACETYLENE + ETHANE: SL1 & SL2: Removing these two species involves a slight rearrangement of the contributions. TLROD increased while all others decreased slightly. Slight increase in performance measures.
- ACETYLENE + ETHANE: NAPS: Removing these profiles had a detrimental effect on the number of retained samples.
- ACETYLENE + ETHANE & ETHYLENE: SL1 & SL2: Increase in TT94HD, slight increase in TLROD and large decrease in COMPFUE. Percent mass increases slightly and χ^2 decreases slightly.

- ACETYLENE + ETHANE & ETHYLENE: NAPS: Removing these profiles had a detrimental effect on the number of retained samples.
- ISOBUTYLENE: SL1 & SL2: Slight rearrangement of contributions. Slight drop in χ^2 .

5.4.2 Discussion of Final Source Apportionment

The final source apportionment was performed using the following five source profiles: TT94HD, FLPG, TLROD, GA and COMPFUE. These were chosen on the basis of the screening and sensitivity analysis results. In addition, they represent the significant source profiles used in other studies. These studies consistently identified a heavy duty tailpipe, light duty tailpipe and an evaporative emissions profile. The remaining two sources have been seen in these studies and in this study they were significant enough to be resolved by the CMB model.

To ensure that photochemical reactivity does not influence the CMB results those reactive species identified in Conner *et al* (1994) were removed from the analysis. This includes all 25 species except propylene, *iso*-butylene/1-butene, the xylenes, *n*-nonane and 1,2,4-trimethyl-benzene.

The overall results of the CMB7 modeling for the mean receptor profiles are presented in this section. The results of the CMB source apportionment are shown in Figure 23. Tabulated results are found in the appendices. The figure shows the mean source contribution for each of the sources across all of the retained CMB runs. The figure shows

the mean source contribution of each source as well as the calculated CMB error for the NAPS station and the eight nose-level sampling locations and times. The samples are named in the table and figure using the sampling location and sample times (for nose-level). The sampling times are given by AM: morning, NO: noon, AF: afternoon and PM: evening sample. For example SL2AF is the afternoon samples at Slater Street nose-level sampling station SL2. Statistical summaries of the results are shown in the appendices.

The apportionment shows that the two exhaust profiles (TT94HD and TLROD) figure prominently in each sampling session followed closely by the whole gasoline profile (COMPFUE). The other two profiles, graphic arts (GA) and liquefied petroleum (FLPG) show smaller contributions except for some of the samples including both evening samples. The FLPG profile showed a consistent loading through all nose-level sampling sessions. The GA profile varied widely over the sampling sessions.

TT94HD was lower in the evening samples which corresponds to the lower heavy duty traffic volumes. Other profiles such as GA would therefore makeup a bigger contribution to the measured samples. TLROD seemed consistent except for one of the noon time samples.

Comparing the nose-level and NAPS sampling results shows that both are heavily impacted by heavy duty emissions. FLPG contributions are significantly lower in the nose-level profiles by almost a factor of 2. TLROD, COMPFUE and GA NAPS contributions are less than nose-level. The percent mass accounted for by the NAPS station is almost 20% less than the nose-level. The reason for this lower accounting of the sampled VOC mass is due

probably to the fact that the source profiles used do not account for the increased VOC “ambient background” the NAPS station would be sampling. The NAPS station will not be sampling as much of the vehicle emissions close to the source. Therefore, the background VOCs will make up a more significant contribution.

There are two main differences between the nose-level source contribution estimates. The most obvious are the heavy duty contributions. SL1 contributions are consistently larger than SL2. This is probably due to the proximity of the bus stop and the presence of a dedicated bus/taxi lane on Slater Street. The light duty profile is consistently lower in SL1 which is probably due to the larger heavy duty loadings which redistributes the contributions.

Trends in the major (heavy duty, light duty and evaporative emissions) are shown in Figure 24 and Figure 25. Figure 24 shows the comparison in source contribution estimates of from SL1 to SL2. The heavy duty profile shows a decrease in the source contribution estimate. This is probably due to the proximity of the bus stop to SL1. The light duty profile shows an increase from SL1 to SL2 which is the opposite of the heavy duty profile. Less light duty vehicles would be impacting the bus stop. The evaporative emissions decreases slightly from SL1 to SL2 were due probably to the proximity of SL1 to an above ground parking garage.

Figure 25 shows the trend in heavy duty, light duty and evaporative emissions over the four samples (AM-PM). The contributions are mirroring what is occurring with the traffic volumes. As traffic volumes peak in the morning and afternoon rush hours, the

contribution of vehicle exhaust should increase. The effect on the heavy duty contribution is more pronounced probably because the amount of heavy duty traffic (mainly buses) is highly dependent on ridership demand. The highest demands are in the morning and afternoon traffic rush. The effect on the light duty contribution is not as pronounced. Since Slater Street is a major east-west thoroughfare the off-peak traffic volumes stay relatively high thus reducing the shift in the contributions.

The poorer results of the NAPS results have to be addressed. There are two factors contributing to the poor performance. First these samples are 24 hours in duration. During the day they will be sampling similar VOCs as the nose-level but later into the evening the majority of the vehicles are gone. The samples at this point are mainly sampling whatever background VOCs may be present at that time of evening. The portion of the sample obtained at night serve both to dilute the daytime exhaust measurements and could possibly change the profiles enough to cause problems with CMB modeling using only motor vehicle related source profiles.

The second factor is that these samples are obtained from a height of four metres and are set back slightly from the roadway resulting in more dilution of the vehicle emissions before sampling. This dilution could enhance the impact of the “background” VOCs. Background in this sense refers to those VOCs whose source is located in another portion of the city. In the nose-level samples, the high concentrations of vehicle exhaust are probably dominating and the background VOCs are not as influential.

of the two previous factors, the impact of having samples obtained over a 24 hour period will have more impact on the CMB analysis. The second factor would only serve to slightly dilute whatever VOC mass that is measured directly at nose-level. The impact of any “background” VOCs would increase slightly but not to the degree that would be seen in the 24 hour sample.

5.5 Factor Analysis

As mentioned previously, a second receptor modeling technique utilizing multivariate analysis can be used to obtain information regarding the sources contributing to the receptor. A multivariate technique (factor analysis) was applied to the nose-level and NAPS VOC data to determine if a multivariate method could produce corroborating results when compared to the CMB7 model. The principals of multivariate factor analysis are presented in Reymont and Jöreskog (1993) and the application to the Slater Street VOC data was been documented in a detailed report (O’Leary 1997) so only the results will be briefly mentioned.

A factor analysis assumes that all of the measured receptor VOC concentrations are a combination of two key parameters: 1) factor loadings: the composition of the species that make up a factor (analogous to a source profile in the CMB model) and 2) factor scores: the relative magnitude of each factor present in each sample (analogous to source contributions in the CMB model). These measures (factor loadings and factor scores) are only relative measures (not directly proportional) and cannot be interpreted as true physical measures of source composition and contributions. A factor analysis examines the correlations between

species concentrations measured over all samples and extracts factor loadings. An example of a set of factor loadings extracted in the Slater Street analysis is shown in Table 9. The factor analysis study mainly examined the factor loadings for significant loadings in one or more species (loadings >0.4 or 0.7 : two levels of significance). Those species with high loadings in a particular pattern of species should match in some respects the CMB profiles. For example, factor loadings with high loadings in combustion related species would probably be a tailpipe emissions related factor. The results of the analysis are explained briefly below.

The Slater Street factor analysis did not produce results that clearly agreed with the CMB results. In most cases, five or six factors were extracted from the nose-level and NAPS data. In all cases, two strong combustion related factors were extracted that appeared to be the representation of the heavy and light duty emissions measured at the receptor. No clear distinction could be made between factors as to which was the heavy duty or light duty emissions related factor. A third factor was extracted from the nose-level measurements and it is proposed that it was due to the presence of evaporative emissions. All other factors from the nose-level data could not be identified as to belonging to a source type. It is presumed that the details of these factors get lost in the noise of the data and would require significantly more samples to increase the resolution of the analysis.

Although sufficient samples were taken to enable a multivariate technique to be performed the results were disappointing. The nature of the VOCs measured downtown may not allow the clear identification of sources with a factor analysis without the use of much more samples. The CMB model has a technique to deal with the error present in the measured

source and receptor profiles. However it is unclear how those errors would affect a multivariate analysis especially since the analysis was performed with just enough data. The results at this point however are somewhat promising for future analyses of urban VOC data if enough samples were obtained.

Figure 10: Map of Sampling Area Indicating Sampling Locations

Nose-level sampling locations Slater Street station 1 and 2 are indicated by “●”.

Figure 11: Slater Street Sampling Station 1: Daily Normalized Receptor Profiles: 7 AM

Symbols represent different days of sampling. The profiles are generally similar with the exception of two days: 19 Aug and 26 Aug.

Figure 12: Slater Street Sampling Station 2: Daily Normalized Receptor Profiles: 7 AM

Symbols represent different days of sampling. The profiles are generally similar with the exception of three days: 19 Aug, 22 Aug and 26 Aug.

Figure 13: Slater Street Sampling Station 1: Daily Normalized Receptor Profiles: 12 PM

Symbols represent different days of sampling. The profiles are generally similar with the exception of five days: 22 Aug, 23 Aug, 24 Aug, 26 Aug and 13 Sept.

Figure 14: Slater Street Sampling Station 2: Daily Normalized Receptor Profiles: 12 PM

Symbols represent different days of sampling. The profiles are generally similar with the exception of three days: 22 Aug, 23 Aug and 24 Aug.

Figure 15: Slater Street Sampling Station 1: Daily Normalized Receptor Profiles: 3 PM

Symbols represent different days of sampling. The profiles are generally similar with the exception of two days: 18 Aug and 19 Sept.

Figure 16: Slater Street Sampling Station 2: Daily Normalized Receptor Profiles: 3 PM

Symbols represent different days of sampling. The profiles are generally similar with the exception of two days: 18 Aug, 24 Aug and 19 Sept.

Figure 17: Slater Street Sampling Station 1: Daily Normalized Receptor Profiles: 10 PM

Symbols represent different days of sampling. The profiles are generally similar.

Figure 18: Slater Street Sampling Station 2: Daily Normalized Receptor Profiles: 10 PM

Symbols represent different days of sampling. The profiles are generally similar.

Figure 19: Slater Street NAPS Sampling Station: Aug. – Sept. Daily Normalized Receptor Profiles

Symbols represent different days of sampling. The profiles are generally similar with the exception of three days: 24 Aug, 5 Sept and 11 Sept.

Figure 20: Composite Whole Gasoline and Gasoline Vapour Profiles Used in the Slater Street CMB Analysis
 The characteristics of the source profiles labelled COMPFUE, TLPG, VAP20, VAP30 and VAP40 can be found in Table 8.

Figure 21: Heavy Duty Emission Profiles Used in the CMB Analysis

The characteristics of the source profiles labelled TT94HD, HDHDHS, HDCBD, HDNYCC, HDNYBC and CASSHD can be found in Table 8.

Figure 22: Light Duty Emission Profiles Used in the CMB Analysis

The characteristics of the source profiles labelled TT94LD, FLD801, FLDCCT, FLDCS, FLDST, FLDS, FLDAOAOC, TLROD and CASSLD can be found in Table 8.

Figure 23: Final Source Contribution Estimates : Slater Street Study

Average final source apportionment for all locations and sampling times using 20 days of measurements. (NAPS: National Air Pollution Surveillance network, SL1 and SL2: Slater Street nose-level sampling stations 1 and 2, AM: 07:30-09:30 hrs, NO: 11:30-13:30 hrs, AF: 15:30-17:30 hrs, PM: 22:00-00:00 hrs). The characteristics of the source profiles labelled TT94HD (Tuscarora Tunnel Heavy Duty), FLPG (liquefied petroleum gas), TLROD (Atlanta light duty), GA (graphic arts) and COMPFUE (Ontario composite winter gasoline) can be found in Table 8.

Figure 24: Trends in Heavy Duty, Light Duty and Evaporative Emissions Contributions Over SL1 & SL2

Differences between two nose-level samples showing the average source contribution of three significant vehicle related sources. (SL1 and SL2: Slater Street nose-level sampling stations 1 and 2, AM: 07:30-09:30 hrs, NO: 11:30-13:30 hrs, AF: 15:30-17:30 hrs, PM: 22:00-00:00 hrs). The characteristics of the source profiles labelled TT94HD (Tuscarora Tunnel Heavy Duty), TLROD (Atlanta light duty) and COMPFUE (Ontario composite winter gasoline) can be found in Table 8.

Figure 25: Temporal Trends in Contributions of Heavy & Light Duty and Evaporative Emissions at SL1 and SL2

Differences between two nose-level samples showing the average source contribution of three significant vehicle related sources. (SL1 and SL2: Slater Street nose-level sampling stations 1 and 2, AM: 07:30-09:30 hrs, NO: 11:30-13:30 hrs, AF: 15:30-17:30 hrs, PM: 22:00-00:00 hrs). The characteristics of the source profiles labelled TT94HD (Tuscarora Tunnel Heavy Duty), TLROD (Atlanta light duty) and COMPFUE (Ontario composite winter gasoline) can be found in Table 8.

Table 7: Hydrocarbons (C₂-C₁₀) Analyzed in Slater Street Samples

Naming convention: *n* (*normal*), *t* (*trans*), dm (*dimethyl*), *c* (*cis*), m (*methyl*), e (*ethyl*), *m&p* (*meta & para*) and *o* (*ortho*). Those species marked in bold were included in the CMB analysis.

ethylene	<i>c</i> -2-butene	<i>c/t</i> -4-m-2-pentene	cyclohexene
acetylene	3-m-1-butene	2-m-pentane	<i>iso</i>-octane
ethane	2-m-butane	3-m-pentane	<i>n</i>-heptane
propylene	2-m-1-butene	2-m-1-pentene/1-hexene	m-cyclohexane
propane	1-pentene	<i>n</i>-hexane	toluene
propyne	2-butyne	<i>t</i> -2-hexene	1-m-cyclohexene
<i>iso</i>-butane	<i>n</i>-pentane	2-m-2-pentene	<i>n</i>-octane
<i>iso</i>-butylene	<i>t</i> -2-pentene	<i>t</i> -3-m-2-pentene	<i>e</i>-benzene
1-butene	<i>c</i> -2-pentene	<i>c</i> -2-hexene	<i>m&p</i>-xylene
1,3-butadiene	2-m-2-butene	<i>c</i> -3-m-2-pentene	<i>o</i>-xylene
<i>n</i>-butane	2,2-dm-butane	m-cyclopentane	<i>n</i>-nonane
<i>t</i> -2-butene	cyclopentene	1-m-cyclopentene	1,2,4-tm-benzene
2,2-dm-propane	4-m-1-pentene	benzene	<i>n</i>-decane
1-butyne	cyclopentane	cyclohexane	

Table 8: Source Profiles Used in Slater Street CMB Study

Source Code	Description of Source
TT94LD	Light duty vehicle fleet average running emissions profile in hot stabilized mode of operation. Obtained by linear regression of 11 ambient profiles against vehicle counts. Samples gathered during the Tuscarora Tunnel Study of 1994. (Sagebiel <i>et al</i> , 1996)
TT94HD	Heavy duty vehicle fleet average running emissions profile in hot stabilized mode of operation. Obtained by linear regression of 11 ambient profiles against vehicle counts. Samples gathered during the Tuscarora Tunnel Study of 1994. (Sagebiel <i>et al</i> , 1996)
CTSHP	Headspace vapour profile constructed from a liquid fuel profile CTSLFP by liquid-vapour equilibrium calculations during the Cassiar Tunnel Study of 1993. (Wittorff <i>et al</i> , 1994, McLaren <i>et al</i> , 1996)
CTSLFP	Liquid fuel profile determined by weighting 24 liquid fuel sample profiles according to sales by vendor and grade during the Cassiar Tunnel study of 1993. (Wittorff <i>et al</i> , 1994, McLaren <i>et al</i> , 1996)
FLD801	Tailpipe emission profile obtained from FTP dynamometer tests on 46 in-use passenger vehicles of model years 1975-1982. This profile originally obtained by Sigsby <i>et al</i> , (1987) and later adjusted by Fujita <i>et al</i> (1994)
FLDCT	Light duty vehicle fleet average running emissions profile operating in hot stabilized mode. Obtained from 13 ambient samples during the Caldecott Tunnel study
FLDCS	Cold start tailpipe emission profiles from the Auto/Oil program for the 1989 light duty vehicle fleet using industry average gasoline as reported by Fujita <i>et al</i> (1994)
FLDST	Hot stabilized tailpipe emission profiles from the Auto/Oil program for the 1989 light duty vehicle fleet using industry average gasoline as reported by Fujita <i>et al</i> (1994)
FLDS	Hot start tailpipe emission profiles from the Auto/Oil program for the 1989 light duty vehicle fleet using industry average gasoline as reported by Fujita <i>et al</i> (1994)
FLDAOC	FTP composite profile for the Auto/Oil Program for 1983-1985 light duty vehicle fleet as reported by Fujita <i>et al</i> (1994)
FCNG	Compressed natural gas profile determined from samples taken in 1972 in Los Angeles and 1973 in El Monte, California as reported by Fujita <i>et al</i> (1994)
FLPG	Liquefied petroleum gas as reported by Fujita <i>et al</i> (1994)
TLROD	Light duty vehicle dominated fleet average running emissions profile in hot stabilized mode of operations. Determined from 9 roadside ambient samples during the 1990 Atlanta study by Conner <i>et al</i> (1994)
TLWG	Liquid fuel profile determined by weighting 18 liquid fuel sample profiles according to sales data by vendor and grade during the 1990 Atlanta study by Conner <i>et al</i> (1994)

TLH24C	Headspace vapour profile determined by weighting 24 °C headspace samples over 18 liquid fuel samples according to sales data by vendor and grade during the 1990 Atlanta study by Conner <i>et al</i> (1994)
TLH32C	Headspace vapour profile determined by weighting 32 °C headspace samples over 18 liquid fuel samples according to sales data by vendor and grade during the 1990 Atlanta study by Conner <i>et al</i> (1994)
HDHDHS	Heavy duty vehicle (Bus) emission profiles from Mobile Sources Emissions Division. (Rideout, 1991)
HDCBD	Heavy duty vehicle (Bus) emission profiles from Mobile Sources Emissions Division. (Rideout, 1991)
HDNYCC	Heavy duty vehicle (Bus) emission profiles from Mobile Sources Emissions Division. (Rideout, 1991)
HDNYBC	Heavy duty vehicle (Bus) emission profiles from Mobile Sources Emissions Division. (Rideout, 1991)
GA	Graphic arts emissions profile. Composite profile obtained by weighting contributions from lithographic, letter press, flexographic and rotogravure printing inks. (Scheff <i>et al</i> , 1989)
AC	Architectural coatings composite profile obtained by weighting contributions from solvent based coatings, thinning and cleanup solvents and water based coatings. (Scheff <i>et al</i> , 1989)
COMPFUE	Composite whole fuel profile of Ontario summer grade gasoline obtained using the Canadian Petroleum Products Institute's report (CPPI, 1994) and information regarding gasoline sales by grade from Statistics Canada
VAP20	Composite vapour profile from composite whole fuel profile of Ontario summer grade gasoline by liquid-vapour equilibrium calculations at a temperature of 20 °C.
VAP30	Composite vapour profile from composite whole fuel profile of Ontario summer grade gasoline by liquid-vapour equilibrium calculations at a temperature of 30 °C.
VAP40	Composite vapour profile from composite whole fuel profile of Ontario summer grade gasoline by liquid-vapour equilibrium calculations at a temperature of 40 °C.
CASSLD	Light duty emission profile developed from the Casmir Tunnel Study of 1993. (Wittorff <i>et al</i> , 1994)
CASSHD	Heavy duty emission profile developed from the Cassiar Tunnel Study of 1993. (Wittorff <i>et al</i> , 1994)
CNGLISA	Commercial natural gas profile obtained from Environment Canada's Emission Research and Measurement Division
MSEDBUS	Average composite profile (25% equal weighting applied to all four profiles) obtained from HDHDHS, HDCBD, HDNYCC and HDNYBC

LD_AVG	Average composite profiles (using equal weightings) of all listed light duty emission profiles
HD_AVG	Average composite profiles (using equal weightings) of all listed heavy duty emission profiles

Table 9: Factor Loadings: Slater Street Sampling Station 1

Factor Loadings (Varimax normalized) (slater_1.sta)						
Extraction: Maximum likelihood factors						
(Marked loadings are > .700000)						
Species	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
ETHYL	0.1248	0.3418	-0.0638		0.0196	0.1588
AC+ET	0.1312	0.2807			-0.1046	-0.0310
PROPYL	0.1129	0.3244	0.1743		-0.0545	0.0602
PROPAN	0.1461		0.1954		-0.1097	0.1779
ISOBUT	0.0389		0.1487	0.2160	0.1080	0.0395
IS/I-B	0.0822		0.1966		0.0924	0.0281
N-BUT	0.2711		0.0989	0.1960	-0.0097	-0.0281
2M-BUT	0.2863		0.1124	0.3969	0.0409	-0.0178
N-PENT			0.1417	0.3588	-0.1008	0.0271
23DMBU	0.1281		-0.1403		0.0166	0.1254
2M-PEN			0.1182		-0.0366	0.1192
3M-PEN	0.3260		0.1002		-0.0645	0.1136
N-HEX			0.1833		-0.1453	0.1823
M-CYCL			0.1620		-0.0507	0.1681
BENZEN			0.2154		-0.0774	0.1652
CYCLHE			0.2988		0.0487	
ISO-OC		0.1729	0.0542	0.0172	-0.1504	0.0645
N-HEPT		0.3038	0.2812		0.0025	0.1058
TOLUEN		0.1070	-0.0058	0.0462	0.0881	-0.0757
N-OCT	0.3715	0.2112		0.3286	0.0998	0.1593
E-BENE		0.1951	0.1976		0.3029	0.0498
M&PXYL		0.1838	0.1524		0.3113	-0.0165
O-XYLE		0.1963	0.2361		0.2444	-0.0073
N-NONA	0.0162	0.0707		0.0409	-0.0167	-0.0356
124TMB	0.2738	0.1359	0.2970		0.1077	-0.2760
Variance Explained	5.7982	5.9080	2.6049	7.3318	0.3969	0.5306
Fraction of Total	0.232	0.236	0.104	0.293	0.016	0.021

6 RESIDENTIAL HOME STUDY

The two previous chapters have presented the application of the chemical mass balance receptor model for VOC source apportionment to datasets that were obtained as part of other projects. Source apportionment was performed using VOC source profiles available in the literature and some locally derived source profiles. In this chapter, experimental and modeling work that was completed in the November 1997 – April 1998 period will be presented. The experimental work involved the characterization of VOC emissions from a test vehicle and the collection of ambient indoor and outdoor SUMMA™ canister samples from six homes where this particular vehicle was operated in the garages attached to these homes.

Research efforts are being undertaken in response to indoor air quality concerns becoming more prevalent in today's society. Figuring prominently in current media as sick building syndrome, indoor air quality is not just a concern in the typical office environment but is becoming more important in residential homes where people spend a large portion of their non-work related time. As more homes are being constructed with attached garages, the role of the family vehicle as a potential source of residential VOCs has to be questioned. Since most homes with attached garages share one common wall and often a doorway, infiltration of garage air laden with vehicle related VOCs becomes possible. Consider a typical residential vehicle use pattern where the vehicle is started in the morning and allowed to idle in the garage for a short period after which the garage door is closed and the vehicle departs. The vehicle then returns after the day's use and then is parked hot in the closed garage. The morning startup procedure would produce a relatively short burst of

tailpipe emissions while the parked hot vehicle slowly releases evaporative emissions over a longer period of time. The potential for increased VOC levels in the homes is even higher if there are multiple vehicles within the garage and/or one of the vehicles is used often during the day for non-work related trips.

To investigate the role that vehicles and attached garages play in residential indoor air quality, the Air Quality Section of Health Canada initiated a project to quantify and model vehicle emissions that reach the home from the garage and to quantify typical exposure levels seen by Canadian households. The overall project is entitled Contribution of Vehicle Emissions from an Attached Garage to Residential Indoor Air Pollution Levels. This project has the following objectives.

- To quantify cold start, hot start and evaporative emissions from a vehicle in a residential garage due to typical daily use of the vehicle.
- To quantify those vehicle emission products which reach an adjacent room in the residence via an attached garage through a common door, walls or attic of the home.
- To determine the concentrations of vehicle emission products in the attached garage relative to an adjacent room inside the house.
- To model movement/path of entry of vehicle emissions in an attached garage into the house.
- To determine the removal efficiency of vehicle emissions in the air of the house versus the air of the attached garage
- To assess the human exposure to levels of emissions found in the residences that have originated from the vehicle start-up and cool down in the attached garage.

A well characterized test vehicle was used as the source of vehicle emissions at these test homes. At Environment Canada's ERMD laboratories, the vehicle's tailpipe and evaporative emissions were determined. The vehicle was then brought to each test home and was parked or started in the garage depending on the type of test. Samples were taken at the test homes to capture the ambient background, in-house pre-test, in-garage during-test and in-house during-test VOC concentrations. Using the measured vehicle and house VOC data, source apportionment could be performed on the in-house and in-garage measurements.

This chapter details the experimental work and subsequent chemical mass balance analysis performed to address the first three project objectives outlined above.

6.1 Vehicle Characterization

In order to facilitate the identification of vehicle-related VOCs infiltrating into the test homes, a vehicle whose emissions were well known was required. The test vehicle used was a 1993 Buick Regal with a 3.8 litre engine. This vehicle was chosen in part because its engine and emissions were similar to those seen in a typical family car or minivan. The vehicle characterization was performed in the fall and winter of 1997 at Environment Canada's ERMD laboratories. There were two components of the vehicle characterization: quantify the evaporative emissions from a hot vehicle and the tailpipe emissions from both a cold and hot vehicle. A series of dynamometer tests in a cold cell using a specific driving schedule allowed the hot and cold start emission profiles to be developed at an ambient

temperature of -10°C . An airtight enclosure was constructed that allowed the evaporative emissions to be measured at an ambient temperature of -10°C . Details of the emission profile development including the gasoline used are discussed in the following sections.

6.1.1 Gasoline Used in Test Vehicle

The house tests were expected to stretch over the course of three or four months. Since vehicle emissions depend to some extent on gasoline composition, the gasoline used had to be identical from one test to the next. The test gasoline was purchased in bulk from one refinery lot in four 55-gallon drums. The drums were stored at the ERMD laboratories and kept sealed until required to ensure that the gasoline's composition was consistent over the course of the tests.

The gasoline samples were prepared for analysis by injecting $0.8\ \mu\text{L}$ of liquid gasoline into an evacuated cylinder followed by pressurization with ultra-pure nitrogen. The total gas volume in the canister was 11.0 litres at 25°C , 1 atmosphere pressure. Two canister samples were collected and analyzed for 163 hydrocarbon species using gas chromatography and flame ionization detection. The average VOC concentrations for the two samples are reported in Table 10 in mg/test. Since the CMB model requires only the relative species composition of sources the analytical results were reported as mass of VOCs per a given volume (e.g. SUMMA™ canister). These concentrations only reflect the relative composition of the hydrocarbons and not the true concentration found in the original gasoline. Figure 26 shows the graphical representation of the same concentrations. Note that the numbered species in Table 10 correspond to the species number in Figure 26.

6.1.2 Evaporative Emissions

Evaporative emissions were measured using slight modifications to the standard test procedure given in the Society of Automotive Engineer's Handbook (SAE J171, 1991-1992). Normally a permanent enclosure is constructed that is devoted solely to evaporative emission tests. Since this was a wintertime study requiring appropriate emission profiles, the test cell had to be kept cold. The ERMD laboratories have one test bay that is capable of being operated over a wide range of temperatures. Therefore, a temporary Sealed Housing Evaporative Determination (SHED) enclosure was constructed inside their cold cell which would allow the collection of emissions at the required ambient temperature of -10 °C.

The temporary SHED enclosure was constructed using a steel cage frame. This steel frame was underlaid with a heavy tarpaulin to help prevent punctures from tire wear and other traffic. The entire cell including the bottom was covered with Tedlar (polyvinylfluoride film) and sealed with aluminum duct tape. Tedlar is impermeable to hydrocarbons and other exhaust related compounds and does not act as an adsorbent onto which exhaust components can attach. The front portion of the SHED enclosure was constructed using Tedlar with Velcro™ strips to form movable flaps for vehicle entry/exit from the SHED enclosure. Once the vehicle was placed inside the cell, the seams could be sealed with aluminum duct tape.

The SHED enclosure was tested for hydrocarbon retention at a cell temperature of -10 °C using the standard Federal Test Procedure protocol (US EPA, TP 707J, 1996). A known mass of propane was injected into the sealed SHED enclosure. After three minutes of mixing, the initial concentration was determined. The concentration of propane was monitored over a four hour period using a hydrocarbon analyzer with flame ionization detection (Horiba Flame Ionization model FIA-23A 0-30, 0-300 ppm). This test was repeated with any required SHED enclosure alterations until the total propane leakage was less than 5% over a four hour period.

Samples during the evaporative emissions test were taken with Tedlar bags attached to a vacuum pump. The Tedlar bags were filled with the appropriate samples and analyzed. Samples were taken to obtain the SHED enclosure VOC background, initial (vehicle placed in SHED enclosure) and final concentrations. Samples were analyzed using high resolution gas chromatography with a flame ionization detection following cryogenic preconcentration. An Entech M7000 cryogenic preconcentrator was used at the inlet of the gas chromatograph. Using the preconcentrator allowed a relatively large sample volume of 50 mL to be injected onto the column. A Hewlett-Packard 5890 Series II gas chromatograph was used for the analysis. The preconcentrator does not allow concurrent determination of methane and C₂ hydrocarbons since they are not well retained in the trap. Simple gas loop injection was used to quantify these lighter hydrocarbons. The sample loop was flushed with sample from the Tedlar bag and was injected directly onto the capillary column. The minimum detection limits for the SHED enclosure tests are 2.3 mg/test for methane and approximately 0.05 mg/test for all other VOCs.

The vehicle was warmed up using the first two phases of the FTP driving cycle at an ambient temperature of -10°C . The vehicle was then pushed into the SHED enclosure as quickly as possible and sealed into the enclosure with aluminum tape. Since it is difficult to ensure that an exceptionally tight SHED enclosure door seal had been made, a tracer gas was used to determine the leakage for each test. A known quantity of sulphur hexafluoride (SF_6) was injected into the SHED enclosure just after the door was sealed and allowed to mix for three minutes. Corrections for leakage were determined using the percentage loss of SF_6 over the course of the test. A sample of the SHED enclosure atmosphere was taken before the vehicle was placed to determine the background VOC and SF_6 concentrations. Samples were then taken during the first 3 to 5 minutes of the SHED enclosure test and at the end of the two-hour test to determine the VOC emission rates and the SF_6 concentrations.

The collected samples were analyzed for 163 hydrocarbon species using gas chromatography and flame ionization detection. Figure 27 shows the graphical representation of the evaporative emissions profile measured as mg/test and represent the results from three evaporative emissions determinations on three different days. Details regarding the measured hydrocarbon concentrations are reported in the appendices.

6.1.3 Tailpipe Emissions

Tailpipe emissions were determined in the same cold test cell as the evaporative emissions. The cell was maintained at -10°C for each test. Tailpipe emissions in a residential garage are expected to come from two sources. The first is the small amount of tailpipe emissions

released as the vehicle is coming into the garage after the commute home. The second is the emissions generated from the vehicle upon start-up and during the vehicle warming time. The amount of emissions from the first case is expected to be insignificant. However, in the second case, on a cold morning most people allow their vehicles to warm in the garage before they leave for the commute to work. To simulate this warm-up behaviour, a special driving cycle was developed that approximated the maneuver of starting a vehicle, idling and then backing a vehicle out of a garage. The driving cycle was called the "Garage" cycle and it consisted of the vehicle start-up, some idling time followed by a 20 second backing up maneuver. Although backing out of a garage would typically not take 20 seconds, this length of time was required to collect adequate sample for the determination of the modal (maneuver related) emissions. On the dynamometer, the backing up procedure had to be done by driving the vehicle in the forward gear. Significant differences between driving the car forward or backwards over this small length of time and speed were not expected. The entire garage cycle is 300 seconds long and sampling begins just prior to the vehicle start-up until the end of the 300 seconds. The garage cycle is shown in Figure 28. For illustrative purposes, the measured total hydrocarbon concentration is shown concurrently with the garage cycle.

The entire exhaust emissions procedure requires that the vehicle be preconditioned in the test cell overnight at -10 °C. Before placement in the test cell, the vehicle was filled with test fuel to 40% fuel tank capacity and was operated on a standard vehicle pre-conditioning driving cycle. The entire test procedure used to measure garage related emissions follows this sequence of driving events: Garage cycle (cold start), 1370 second driving cycle (first two phases of FTP test), 10 minute cool down and then the Garage cycle (hot start).

Tailpipe emission samples were collected over each of the Garage cycles. Cold start and hot start emissions were collected separately. Tailpipe exhaust was quantified using a constant volume sampling system similar to the system described in the SAE Handbook under test number SAE J1094 (1990-91). The engine exhaust is mixed with outside ambient dilution air so that the total combined flow rate of exhaust and dilution air is nearly constant under all engine operating conditions. The principal component of this sampling system is a critical flow venturi which maintains constant flow through the sampling train. Samples are extracted upstream of the critical flow venturi and are pumped to Tedlar bags or an emissions analyzer bench depending on whether composite or modal emissions are required. A second venturi is used in the sample extraction line to control the filling rate of the Tedlar bag or the flow to the analyzer bench. Composite emissions collect the emissions over the entire driving cycle and represent the time averaged VOC concentrations. Modal emissions are concentrations measured in real-time and correlated to a specific driving mode. Figure 29 shows a simple schematic of the constant volume sampling system.

In this study, composite samples were collected in Tedlar bags and analyzed for 163 hydrocarbon concentrations using the same analytical equipment as in the evaporative emissions test. Graphical representations of these dilution-corrected cold start and hot soak emissions profiles are shown in Figure 30 and Figure 31. Details regarding these profiles are shown in the appendices.

6.1.4 Test Homes

A previous phase of the overall project had tested 25 volunteer homes and determined the airtightness characteristics of the house, garage and house/garage interfaces (Scanada Consultants, 1997). The airtightness characteristics were determined using fan depressurization tests. These tests involved removing one or more doors and sealing a large fan within the door frame. The fans were operated to induce an artificial and controlled pressure differential between the inside of the house and the outdoors. Two tests were performed to isolate the leakage through the garage/house interface. The first test depressurized the house leaving the main garage doors open. This allowed the house leakage characteristics through all surfaces including the leakage through the garage/house interface to be determined. The second airtightness test was performed while simultaneously depressurizing the garage to eliminate the air flow between the garage/house interface. This allowed the house leakage characteristics through all surfaces except the garage/house interface to be determined. The difference between the two tests allowed the leakage characteristics of the interface to be determined.

Another task of the airtightness tests was to determine a sampling location within the home that showed the greatest amount of leakage infiltrating from the garage. This location, being the area of highest amount of garage infiltration, should also give the highest concentrations of VOCs which would be coming from the garage. Other locations within the house would capture some of the vehicle-related emissions but the concentrations would not be as high, detection limits would become a greater issue and air circulation

patterns within the house would become an issue. With few exceptions, the majority of the air leaks from the garage into the home were found to be leading into the basement.

6.1.4.1 Test Home Descriptions

Although 25 homes had been characterized with air tightness tests, only six homes were identified for the actual vehicle emissions infiltration study during 1997/98. These six homes were chosen to maximize the variability in home types and house/garage configurations. The six homes are briefly described below in Table 11. To retain the privacy of the home owners, initials are used to designate the test homes.

The results of the air tightness tests at the six homes are shown in Table 12. The table shows the air exchange rate of the test homes during each of the two fan depressurization tests as well as the garage air exchange rate. These tests were performed at a pressure differential of 50 Pa. The air leakage from garage to house is shown as an equivalent leakage area (ELA) calculated at a pressure differential of 10 Pa. This area is the equivalent area of the size of hole between garage and house required to explain the air leakage at a pressure differential of 10 Pa. The fraction of total house air leakage that is occurring across the garage/house interface is also given.

6.1.4.2 Sampling Locations in Each Home

The sampling protocol for this project called for the collection of four samples: 1) ambient background sample, 2) pre-test in-home background sample, 3) during-test garage sample

and 4) during-test in-house sample. The locations for each sample at each home are summarized in Table 13. In addition, the sampling times required for each of the samples are shown at the bottom of the table.

The pre-test in-house sample and during-test in-house sampling locations were stipulated in Scanada's report (Scanada Consultants, 1997) and there is nothing particular to mention regarding these locations. However, there are some important factors to note in the placement of the outside ambient sampling systems. The ambient background sample had to be placed to reflect an accurate measure of the background concentration of the pollutants of interest. Since the samples being collected are for vehicle-related emissions, all other major interfering sources had to be accounted for during sample collection. This included other sources of vehicle exhaust, other combustion sources and other sources of hydrocarbons. The three largest interferences expected in this study were exhaust from the home's furnace and/or water heater, the exhaust from passing vehicles and other sources of hydrocarbons such as spilled gasoline. Given the home's configuration, the most "isolated" location was chosen such as the backyard. In all cases, there are no expected significant interferences. However, unexpected events can still occur. Snowblowers are the prime non-vehicle emission source during the winter and given their proximity to houses during their use, the weather and outdoor activity was monitored.

In this study, there were a finite number of placement options for the outdoor ambient sample given the home's layout and available window locations. The outdoor ambient sampling equipment had to remain indoors and sometimes the ambient background equipment had to be placed in the same location as the in-house sampling equipment. It

was important to avoid local dilution effects caused by the ambient air drawn by the carbonyl sampler (drawing at 1 L/min). To avoid drawing extra air into the room, the sampled outdoor ambient air was ported to the outside. The windows were sealed with multiple strips of aluminum foil duct tape.

6.2 Sampling Protocol for Cold Start and Hot Soak Tests

A sampling/data collection protocol was developed in collaboration with Health Canada and Canada Mortgage and Housing to collect real-time CO concentrations, garage/house interface differential pressures, furnace fan operation frequency and VOC and carbonyl concentrations. A brief description of the protocol follows.

6.2.1 Homeowner Pre-Interview

The purpose of the pre-interview is two-fold: 1) to explain the testing procedure to the homeowner and arrange a testing time and 2) to ensure that the home is still suitable for testing. It was important to determine that the conditions in the home at the time of selection had remained unchanged from the time of the air infiltration tests carried out some months before. These included the status of any smokers in the household, any activities that generated VOCs or other combustion related species and any home repairs that may have changed the infiltration patterns. After the homeowner was informed of the upcoming test, the vehicle was conditioned at the ERMD laboratories.

6.2.2 Vehicle Preconditioning

In brief, the vehicle's fuel tank was drained and then refueled to 40% capacity with fresh fuel from the same winter grade stock that had been used throughout this study. The vehicle was then run on the road on a pre-determined route for approximately 30 kilometers and then parked in the ERMD vehicle lot until taken to the test home. The time between preconditioning and use at the test home was minimal. The longest period of time that the vehicle spent between preconditioning and use at the test home was 24 hours.

6.2.3 Sampling Media

There are two main components of the sampling system not including the various tubing, connections and other minor components. These are the SUMMA™ canisters and carbonyl cartridges.

SUMMA™ canisters are stainless steel cylinders similar to propane tanks and are normally used to collect ambient VOC samples. The cylinders are typically under vacuum and allowed to fill passively on-site. Aside from grab samples, the filling rate is usually controlled using a critical flow device that maintains a constant flow into the canister. SUMMA™ canisters are capable of sampling for hydrocarbons in the C₁-C₁₂ carbon number range. To ensure minimal interference from previous samples, canisters are certified using a procedure similar to the US EPA TO-14 method (EPA, 1988). For this study, the canisters underwent repeated heating and evacuation with ultra-pure air until the residual hydrocarbon concentrations were low enough as determined through total

hydrocarbon concentration and comparison to the concentration seen in the source of ultra-pure air.

Canister filling rate was controlled using one of two devices. A needle assembly as described previously was used for the in-garage two hour samples. The other canisters used variable flow rate assemblies. These assemblies had an adjustable set screw that controlled the restriction valve and hence the flow rate. Since the head assemblies possessed no automatic shutoff valves, the sampling had to be stopped manually. The initial and final flow rates into the cylinder was determined using a digital flowmeter. Initial and final pressures of the cylinder was determined with a simple pressure gauge attached to the cylinder head assembly.

Cartridges for sampling carbonyls called C-18 Sep-Paks impregnated with 2,4-dinitro-phenylhydrazine (DNPH) were used. Sep-Paks are similar to liquid chromatography columns which in this case contain non-polar octadecylsilane packing. Any ketones and aldehydes drawn through the Sep-Pak with the ambient air react with DNPH in the presence of H_2SO_4 to form hydrazones and are held within the Sep-Pak until eluted later in the laboratory. At typical concentrations expected in this study a minimum sample time of 30 minutes was established to avoid problems with detection limits.

6.2.4 Setup and Sampling Protocol

At each of the six homes the following sequence of actions were undertaken. Both hot soak and cold start tests are described.

6.2.4.1 Cold Start Test

- 1) Complete homeowner pre-interview and arrange test session. Ensure that home is still suitable for testing. Explain test restrictions (no smoking, exhaust fans off, vehicles moved from garage, etc.).
- 2) Pre-condition test vehicle and prepare all sampling equipment. Ensure that proper outdoor ambient temperatures required for test to proceed are established.
- 3) Arrive at home. Setup equipment VOC/carbonyl sampling equipment.
  - a) Place garage sampling equipment at back of garage.
  - b) Place pre-test and during-test in-house sampling equipment at noted Scanada location.
  - c) Place ambient sampling equipment at appropriate location. Ensure that there are no possible interferences nearby.
  - d) Place differential pressure meter capillary tubing under door between house and garage.
- 4) Park vehicle in garage and leave overnight.
- 5) Arrive next morning and ensure equipment not tampered with. Ensure that house is setup properly to reflect the conditions measured in the airtightness tests (open flues, dryers not operating, etc). Obtain weather data from Environment Canada.
- 6) Start pre-test sample.
- 7) Prepare SF₆ syringe. Open garage, start vehicle and allow it to idle for 1 minute. Backup, park at end of driveway or street, re-enter garage and close door. Start mixing fan and inject SF₆ tracer. Allow 3 minutes for mixing and stop fan.

- 8) Start in-garage sample.
- 9) Leave garage through second garage door and remain outside and shake clothes to minimize any remnants of garage VOCs/SF₆ entering the house.
- 10) Start in-house during-test sample.
- 11) Start ambient background sample.
- 12) Monitor CO concentration, differential pressure and furnace fan operation. Obtain weather (especially temperature and wind measures) data at least at the end of the sampling session.
- 13) Clean up and return the vehicle for preconditioning for the next session.

6.2.4.2 Hot Soak Test

- 1) Complete homeowner pre-interview and arrange test session. Ensure that home is still suitable for testing. Explain test restrictions (no smoking, exhaust fans off, vehicles moved from garage, etc.).
- 2) Pre-condition test vehicle and prepare all sampling equipment. Ensure that proper outdoor ambient temperatures are established required for test to proceed.
- 3) Arrive at home. Setup equipment VOC/carbonyl sampling equipment.
  - a) Place garage sampling equipment at back of garage.
  - b) Place pre-test and during-test in-house sampling equipment at noted Scanada location.
  - c) Place ambient sampling equipment at appropriate location. Ensure that there are no possible interferences nearby.

- d) Place differential pressure meter capillary tubing under door between house and garage.
- 4) Ensure that house is setup properly to reflect the conditions measured in the airtightness tests (open flues, dryers not operating, etc). Obtain weather data from Environment Canada.
- 5) Start pre-test sample. Prepare SF₆ syringe.
- 6) Open garage. Warm vehicle using a half hour drive at an average running speed of 45-55 km/hr. Return to the home, park the vehicle in the garage shutting off the vehicle as quickly as possible and close door. Start mixing fan and inject SF₆ tracer. Allow 3 minutes for mixing and stop fan.
- 7) Start in-garage sample.
- 8) Leave garage through second garage door and remain outside and shake clothes to minimize any remnants of garage VOCs/SF₆ entering the house.
- 9) Start in-house during-test sample.
- 10) Start ambient background sample.
- 11) Monitor CO concentration, differential pressure and furnace fan operation. Obtain weather (especially temperature and wind measures) data at least at the end of the sampling session. At the appropriate time return to the garage and stop the canister sample.
- 12) Clean up and return the vehicle for preconditioning for the next session.

6.3 Selection of VOC Species for CMB Modeling

The principles of CMB modeling have been addressed in some detail in a previous section. One requirement of the model is that there be sufficient degrees of freedom (difference between the number of species and number of sources) to ensure the required confidence limits. It is generally recommended that there be at least 12 degrees of freedom remaining in the solution (Conner *et al*, 1994). However in this study there are enough species known well enough to allow additional species to be included in the model. The number of species retained in this study is 31 and are presented in Table 14.

These species were selected by comparing the concentration of each species in each of the source and receptor profiles. Those species that were significantly greater than their detection limits were chosen first. Then those species that were closer to their detection limits. Overall, only a few species had to be selected that were close to their detection limits in some samples. Retaining this number of species gives 26 to 28 degrees of freedom depending on the number of sources included with the CMB analysis. The source and receptor profiles are described in the next section.

6.4 Source Profiles

The vehicle and related profiles graphical profiles are shown in Figure 32 through Figure 36. Figure 32 shows the vehicle and whole gasoline profiles. Figure 33 shows the hot soak in-house profiles. Figure 34 shows the cold start in-house profiles. Figure 35 shows the hot soak ambient background profiles. Figure 36 shows the cold start ambient background profiles. The species number used in the graphical profiles are shown in Table 10 which

shows the results of the gasoline sample. Similar details for the other source profiles can be found in the appendices.

6.5 Receptor Profiles

The measured home receptor profiles are presented in this section. The graphical house receptor profiles are shown in Figure 37 through Figure 40. Figure 37 shows the normalized receptor profiles for the cold start in-house samples. Figure 38 shows the normalized receptor profiles for the cold start in-garage samples. Figure 39 shows the normalized receptor profiles for the hot soak in-house samples. Figure 40 shows the normalized hot soak in-garage samples. Tabular details regarding the profiles measured at each home can be found in the appendices.

6.6 Choice of Source Profiles

The residential garage was unique in receptor modeling studies. The modeling environment was very small and well contained and the primary source type was well characterized. With the proper selection of sampling methodology, the impact of extraneous sources can be eliminated. The primary source profile of interest was the vehicle emissions and they were well characterized in the laboratory. The behaviour of the vehicle from test to test was also known to be consistent. Using the background and in-house pre-test sample results as sources eliminated the effects of the other extraneous sources and lumped them into a composite source. Inside the house there are a number of sources of VOCs that would be impractical to model individually. Using the in-house pre-

test sample as a source combines all of these minor sources into one composite source. Since the modeling efforts were aimed at determining the contribution of the vehicle emission to the house air quality this, in effect, helps to “clean” the modeling results. The same holds true for the outside ambient sample. The outside sample creates a composite sample of all of the contributing sources such as passing vehicles, all of the other urban related VOCs being carried from other parts of the city and small localized intermittent sources.

Using composite source profiles derived on-site has another benefit. Since the in-house sample is accounting for the VOCs being generated inside the house, the change in VOC mass inside the house over the course of the test should be attributable only to the infiltration of VOCs from the garage. This assumes that the house related VOCs and the ambient background are not going to change over the course of the test. The CMB modeling setup was developed to help ensure that the only new source contributing to the in-house air quality would be the vehicle emissions remaining in the garage after the vehicle was started or left in the hot soak mode. Assuming that this holds true, this produces a check on the contribution of vehicle emissions as explained later in this chapter.

Although a whole gasoline profile was available to use in the CMB analysis, there is no physical basis to include it in the analysis. The vehicle was examined for any gross fuel leaks before and after all of the test sessions. In addition, any fuel related VOCs that are present in the house prior to introducing the vehicle will be captured by the in-house pre-test sample. Colinearity between whole gasoline and the associated evaporative emissions has also been shown in the underground garage study so using the whole gasoline profile is

not included in the reported CMB results. Therefore the CMB source profiles used in this study are the cold start tailpipe emissions profile (COLDST), hot soak evaporative emissions profile (HOTSOAK), ambient background and in-house pre-test.

6.7 Source Apportionment With Selected Source Profiles

The source apportionment of the residential home samples can be divided into four main categories: hot soak garage, hot soak house, cold start garage and cold start house. Although not directly part of the Health Canada objective, the garage samples can be apportioned to investigate how much of the initial garage VOC charge is attributable to the vehicle itself. The garage apportionment results are presented first. It should be noted that the source apportionment of the in-house measured VOC concentrations reflect the contribution of the given sources over the sampling interval. The in-house samples reflect the contribution of the various sources over a four hour period. The hot soak in-garage sample was over two hours and the cold start in-garage was a grab sample.

6.7.1 In-Garage Samples

All of the garage samples showed that the majority of the measured VOCs were due to the direct vehicle emissions, that is, hot soak or cold start emissions depending on the type of test being conducted on that day. The CMB results from each garage test are described below.

6.7.1.1 Cold Start Garage Results

The details of the screening CMB results for the cold start in-garage samples are contained in the appendices. The screening runs investigated the various combinations of source profiles and the associated model performance measures. The ability of the hot start emission profile to fit the measured VOC data was examined and the results showed very poor performance indicators. The reason for the poor performance can be seen by examining the similarity between the in-garage samples and the cold start emissions profile. By far, the in-garage samples, by visual inspection alone, most resembled the cold start vehicle profile.

The hot soak profile was expected to be seen in some of the cold start CMB analyses because the vehicle was placed in the garage overnight prior to the cold start test. This means that the hot soak emissions were being released slowly overnight and some small portion of the emissions may be seen in the garage sample.

The TR residence showed fair results when no hot soak profile was included. The results improved significantly with the introduction of the hot soak profile. Final source apportionment was performed using cold start, hot soak, background and pre-test source profiles. Performance measures gave percent mass (106.7%), R^2 (0.92) and χ^2 (2.87).

The PT residence showed fair results when no hot soak profile was included. A negative source contribution estimate was produced. With the introduction of the hot soak profile the results improved although the CMB model could not resolve the contributions of

background and pre-test. Final source apportionment was performed using cold start and hot soak profiles together with the pre-test or background to produce two final apportionments. These results showed that the background and pre-test sources are only minor contributors. Performance measures gave percent mass (98.15 - 99.0%), R^2 (0.93 - 0.94) and χ^2 (1.94 - 2.03).

The MM residence showed fair results when no hot soak profile was included. Negative source contribution estimates were seen. With the introduction of the hot soak profile, the results improved somewhat although the same source had a negative source contribution estimate. Final source apportionment was performed using the cold start, hot soak and background sources. Performance measures gave percent mass (108.7%), R^2 (0.94) and χ^2 (1.62).

The JR residence showed fair results when no hot soak profile was included. The results improved slightly when the hot soak profile was included. Final source apportionment was performed using the cold start, hot soak, pre-test and background sources. Performance measures gave percent mass (104.3%), R^2 (0.94) and χ^2 (1.70).

The HD residence showed fair results when no hot soak profile was included although negative source contribution estimates were seen. The inclusion of the hot soak profile showed only slight changes in the source contribution estimates and negative source contribution estimates were still seen. The pre-test source could not be resolved in any of the runs. The final apportionment could include or exclude the hot soak profile. Given the

results of the other homes, including the hot soak profile makes better physical sense. Performance measures gave percent mass (109.3%), R^2 (0.90) and χ^2 (2.75).

The GM residence showed fair results when no hot soak profile was included. The results improved slightly with the introduction of the hot soak profile although the background and the pre-test source could not be resolved. Final source apportionment used the cold start and hot soak with the pre-test and background sources individually. Performance measures gave percent mass (105.0 - 106.7%), R^2 (0.92) and χ^2 (2.17 - 2.36).

The cold start and hot soak profiles fit the measured VOC data well. However, in some cases the pre-test and background sample did not concurrently fit into the analysis. Since the pre-test and background contributions are small, the noise present in the data can cause problems in the apportionment leading to either negative source contributions or excessive relative errors in the contributions (low t-statistic values). In those cases both runs that include the pre-test and ambient background sample separately are included in the final source contribution estimates. This gives some indication to the upper limit of the contribution of each source. Tabular presentation of the final source contribution estimates are shown in the appendices.

The final source contribution estimates show the strong contribution of the cold start profile with relatively minor contributions of background and pre-test sources. The hot soak source contribution estimate varied from 5.1% to 29.8%. This remaining fraction of hot soak emissions is a function of the home's air exchange dynamics which is currently being

investigated by another researcher at Concordia University. The graphical representation of the source apportionment of the cold start garage data is shown in Figure 41. The species-by-species comparison of measured and CMB model results is shown in the appendices.

The cold start contribution was the most significant source by far in all cases. The hot soak contribution was next in significance. The pre-test and background sample made up very little of the measured garage VOCs accounting for less than 6% of the measured mass. The degree of similarity between all in-garage sample profiles should be noted. This gives more indication as to the consistency of the vehicle's behaviour.

6.7.1.2 Hot Soak Garage Results

The screening CMB results for the hot soak in-garage samples are contained in the appendices. The screening runs investigated the various combinations of source profiles and the associated model performance measures.

The PT residence showed fair results although the χ^2 values were all greater than four which shows that one or more of the species is not adequately being represented by the model fit. When examining the species-by-species comparison the major difference appears to be in the heavier hydrocarbons (mainly the xylenes). Final apportionment was performed using the hot soak and pre-test source profiles. Performance measures gave percent mass (95.6%), R^2 (0.85) and χ^2 (4.14).

The JR residence could not resolve the pre-test or background source profile when used simultaneously. The results when used separately were adequate. Final source apportionment was performed using two sets of sources: hot soak and pre-test or background sources. Performance measures gave percent mass (92.4% – 92.9%), R^2 (0.88) and χ^2 (3.12 – 3.20).

The HD residence showed results similar to the JR residence in its inability to resolve the pre-test and background sources. The results were adequate. Performance measures gave percent mass (95.1% – 96.9%), R^2 (0.87 – 0.88) and χ^2 (3.25 – 3.69).

The GM residence showed poor results all around. Negative source contribution estimates were seen. The final source apportionment was performed using pre-test and hot soak sources. A species-by-species comparison again showed poor fit in the heavier hydrocarbons beginning with toluene. The results suggest the possibility of another source perhaps solvent related. Performance measures gave percent mass (80.3%), R^2 (0.75) and χ^2 (7.15).

The results of the analysis again showed that the garage was impacted most heavily by the primary vehicle emissions mode, that is, hot soak emissions. Since the vehicle was driven into the garage after a 30 minute warm-up drive, exhaust emissions will be introduced into the garage. These emissions will only be emitted for a very short time between vehicle entry into the garage and vehicle shutoff. This time was no longer than five seconds in all tests. Since a hot stabilized emissions profile was not developed both cold start and hot

start profiles were tested in the CMB analysis. This showed that there were no significant contribution by these emission types and gave either negative source contribution estimates or very low source contribution estimates with very low t-statistic values. The garage door was open during this short period of time and most of the tailpipe emissions would have been carried outside. In addition, the garage sample was two hours long so the measured mass of evaporative emissions would far outweigh that fraction of the exhaust emitted in that short period of time.

The graphical representation of the hot soak garage source contribution estimates is shown in Figure 42. The species-by-species comparison and tabular presentation of the final source contribution estimates are shown in the appendices.

These CMB runs show that the majority of the measured VOC mass in the garage was vehicle related. The statistical indicators show that the goodness-of-fit for the garage samples are not as good as the cold start garage samples. This may be the result of changes in the evaporative emissions from the test vehicle at a different temperature and other operating conditions or the possible presence of other sources. However, the results still show that the hot soak profile makes up the majority of the measured VOC mass and the pre-test and background sample is only a minor contributor.

6.7.2 In-House Samples

The results of the in-house during-test sample are discussed in this section.

6.7.2.1 Cold Start In-House Results

The numerical details of the screening CMB results for the cold start in-house samples are contained in the appendices. The screening runs investigated the various combinations of source profiles and the associated model performance measures. The graphical representation of the source contribution estimates are shown in Figure 43.

The TR residence showed good results using all but the hot soak profile. Using the hot soak profile showed t-statistic problems. Final source apportionment was performed with cold start, background and pre-test sources. Performance measures gave percent mass (83.8%), R^2 (0.96) and χ^2 (1.34).

The PT residence showed good results using all but the hot soak profile. Using the hot soak profile showed negative source contribution estimates and t-statistic problems. Although better χ^2 values were obtained by dropping the background source, common sense dictates that some outside air would be contributing to the house air. Final source apportionment was performed using cold start, background and pre-test sources. Performance measures gave percent mass (93.3%), R^2 (0.94) and χ^2 (1.57).

The MM residence showed good results. The pre-test and background profiles could not be resolved when used simultaneously. Using the hot soak profile showed some minor t-statistic problems. The final source apportionment was performed with the cold start and pre-test sources. Performance measures gave percent mass (104.1%), R^2 (0.95) and χ^2 (1.35).

The JR residence behaved similar to the MM residence. Using the hot soak profile showed negative source contribution estimates. The pre-test and background sources could not be resolved simultaneously. The final source apportionment was performed with cold start and pre-test sources. Performance measures gave percent mass (97.6%), R^2 (0.88) and χ^2 (3.56).

The HD residence showed fair results. The pre-test and background sources could be resolved although one case was marginal. Although hot soak appears to give adequate results, for reasons explained in section 6.11, the hot soak profile should not be used in the in-house samples. The final source apportionment was performed with the cold start and the pre-test or the background sources. Performance measures gave percent mass (95.1 – 95.9%), R^2 (0.88) and χ^2 (3.34 – 3.45).

The GM residence showed fair results. The pre-test and background sources could be resolved. The hot soak profile can also be resolved by the CMB model but should not be included. Performance measures gave percent mass (95.7%), R^2 (0.91) and χ^2 (3.02).

The graphical representation of the hot soak garage data is shown in Figure 43. The final source contribution estimates are shown in the appendices as are the species-by-species comparison.

The cold start contribution in the homes varied widely ranging from 13.2% (PT residence) to 63.8% (HD residence). The contribution of cold start was examined in terms of garage/house airtightness. No clear pattern was observed although the heaviest cold start contribution at the HD residence was corroborated by the real-time CO concentration measured during the course of the test.

The pre-test sample was the next significant source. This source represents the VOC levels seen at the beginning of the test and assumes that no other new internal sources become active. The source contribution ranged from 7.5/8.7% (HD residence: two valid sample runs were retained) to 78.9% (MM residence). The background contributions ranged from 2.9% (HD residence) to 24.5% (GM residence). The background source contribution estimate could not be extracted at each test home.

6.7.2.2 Hot Soak In-House Results

The numerical details of the screening CMB results for the hot soak in-house samples are contained in the appendices. The screening runs investigated the various combinations of source profiles and the associated model performance measures.

The PT residence showed excellent results using the hot soak, background and pre-test sources. Performance measures gave percent mass (99.8%), R^2 (0.97) and χ^2 (0.87).

The JR residence showed good results using the hot soak, background and pre-test sources. Performance measures gave percent mass (89.1%), R^2 (0.92) and χ^2 (2.95).

The HD residence showed good results using the hot soak, background and pre-test sources. Performance measures gave percent mass (98.8%), R^2 (0.93) and χ^2 (2.22).

The GM residence showed fair results using the hot soak, pre-test and background sources although χ^2 values were high. The species-by-species comparison show that the difference is greatest for propane, 2-methyl-butane, o-xylene and 3 & 4-e-toluene and decane. Performance measures gave percent mass (95.9%), R^2 (0.85) and χ^2 (4.86).

The graphical representation of the hot soak garage data is shown in Figure 44. Tabular presentation of the final source contribution estimates and the species-by-species comparison is shown in the appendices.

The hot soak contribution at the homes varied from 34.7% (JR residence) to 69.4% (HD residence). The pre-test contribution at the homes varied from 10.8% (HD residence) to 47.8% (PT residence). The background contribution at the homes varied from 3.8% (PT residence) to 25.1% (JR residence).

6.8 Sensitivity Analysis of CMB Results

The next step in the CMB analysis was to investigate the sensitivity of the results to the inclusion/exclusion of various species used in the model. Previous studies dealing with exhaust emissions have removed some of the light alkenes and alkynes related directly to combustion, toluene and other significant (prevalent) species. Various combinations of

species removal are run in the CMB model and the results for each are shown in the appendices.

The CMB model runs for sensitivity were performed by removing the indicated species and recording the source contribution estimates and performance measures. The final run was performed by removing all noted species. The species to remove during the sensitivity analysis were chosen by their measured mass fractions in the in-house sample. If the mass fraction (using the 31 species) was greater than 5%, the species was included in the sensitivity analysis. Except where noted after the table the source contribution estimates and performance measures stayed relatively consistent throughout the sensitivity analysis for each test home.

6.8.1 Cold Start

- TR residence: source contribution estimates and performance measured stayed consistent except for the removal of combustion related and all noted species. As in the previous studies in this thesis, removing these species can affect the overall source apportionment.
- PT residence: source contribution estimates and performance measures stayed consistent except for when all combustion related and noted species are removed. Background contribution increases and pre-test decreases. Removing all the species removes almost half the measured VOC mass. Since the performance measures are good for the original run and possesses more degrees of freedom, the original runs appears to be more appropriate especially when considering all other runs.

- MM, JR, HD, GM residences: source contribution estimates and performance measures stayed consistent.

6.8.2 Hot Soak

- PT, HD, GM residences: source contribution estimates and performance measured stayed consistent.
- JR residence: source contribution estimates shifted although performance measures stayed consistent. Shifts seen in background and pre-test sources. Hot soak contribution stayed consistent.

6.9 Comparing Cold Start and Hot Soak Infiltration Results

To investigate whether the homes behave the same in both cold start and hot soak test Figure 45 was produced. This shows the final source contribution estimates for the house tests where the vehicle related source (COLDST or HOTSOAK) is represented by VEHICLE depending on the original test performed. With the exception of the PT residence, the vehicle contributions are similar for the two types of tests. Since the homes are tested under similar conditions, the overall vehicle contributions should be similar.

The pre-test and background contributions however show some dissimilarity between the two types of tests. These contributions depend heavily on the activity within the house in the period of time prior to the test. Such things as the opening/closing of doors and operation of dryers/exhaust fans can influence the air exchange rate of the house. However

the contribution of both the background and pre-test is unimportant in terms of vehicle infiltration.

6.10 Comparison of CMB Results With Total Hydrocarbon Concentrations

The CMB results show that the vehicle is a significant contributor to the measured in-house VOC concentrations. It is reasonable to assume that the in-house pre-test profile is not expected to change either in composition or emission rate over the course of the test. This is because there is minimal activity in the home at the time of the test. Therefore the in-house background VOC profile measured at the beginning of the test (in the pre-test sample) will be indicative of the background VOC levels in the home over the course of the test. The ambient background sample is not expected to change significantly over the course of the testing. Therefore it is a reasonable assumption to state that the increase in in-house VOC concentrations is approximately due only to the vehicle's activity. Note that this is only an approximation to see how close this method compares to the CMB results. To corroborate the CMB results, the total VOC measured mass both in the in-house pre-test sample and the during-test sample was used. Using the change in measured VOC mass, an approximation of the vehicle's contribution to the in-house environment can be made.

The top portion of Table 15 shows the measured VOC mass of all listed 31 species for all test homes, both hot soak and cold start tests and for the pre-test and during-test in-house sample. The measured mass in each sample is expressed in μg and was obtained by adding the concentrations of each listed species. The bottom portion of Table 15 shows the VOC mass ratios that expresses the increase in the in-house measured VOC mass. The

approximation of the vehicle's contribution to this measured mass is obtained by taking the difference of pre-test and during-test measured mass over the during-test measured mass. For ease of comparison the CMB results for cold start contributions (CS SCE) and hot soak contributions (HS SCE) are shown. These numbers reflect the CMB results obtained using a different list of VOC species in each test home. CMB results were examined to see if the species selection had serious impact on the source contribution estimates (SCE).

These results show that there is reasonable agreement between the CMB results and this approximation. The results are better for the hot soak test especially using the common species. The cold start results are reasonable except for the GM and TR residences. The TR residence CMB results indicate that the heavier hydrocarbons are under-predicted by the model indicating that there may be another source(s) unaccounted for. The higher fraction seen in the approximation shows that there is some mass unaccounted for by the CMB model.

6.11 Comparison of Cold Start: Hot Soak Contribution Ratios in Cold Start Test

The cold start: hot soak ratios in the house and garage cannot be directly compared. During the cold start test the vehicle is left in the garage overnight. The vehicle has the whole night to release evaporative emissions. The following morning the vehicle and the samples are started. At vehicle start-up it was shown that there were hot soak emissions still present in the garage. Within the in-garage sample there was some ratio of cold start and hot soak emissions. Assuming that the contaminant transport behaviour of all species is the same

from garage to the in-house sampling location, this same ratio should be measured in the in-house sample. This was not seen in the results.

The most probable reason for this is the nature of the samples themselves. In the cold start test, the in-house pre-test sample is measuring the VOC concentrations in the air just prior to the test. The location for this sample was identified by the Scanada report (Scanada Consultants, 1997) as showing the highest amount of air flow from garage to house. The pre-test sample would therefore be measuring whatever hot soak emissions are present in the house. Since the CMB analysis is being performed using the pre-test sample as a source, the hot soak emissions are effectively buried within the pre-test source profile. The pre-test source in this case is acting as a surrogate for any hot soak emissions that may be present and/or infiltrate into the home. Although no significant problems were seen in the CMB analysis, the true hot soak source contribution estimate was being affected by the hot soak emissions measured in the pre-test sample. For this reason, the hot soak profile was not used in the final source apportionment of the cold start in-house samples. In future studies, this effect could be removed by pushing the vehicle into the garage prior to the cold start test. The garage at this point would be free of test vehicle emissions and hot soak emissions would be removed from the cold start CMB analysis.

6.12 Deviations From the CMB Model Assumptions

The basic assumptions of the CMB model are as follows:

1. The composition of source emissions is constant over the period of source and receptor sampling.

2. Chemical species do not react with each other and add linearly in the concentrations measured at the receptor.
3. All significant sources contributing to the receptor have been identified and their emissions have been characterized.
4. The source composition profiles are linearly independent of each other.
5. The number of source types is less than or equal to the number of chemical species.
6. All measurement uncertainties are random, normally distributed and are not correlated.

The extent that these assumptions are met for the VOC source profiles and receptor data are discussed below.

With respect to assumption 1, the vehicle source profiles (cold start, hot start and hot soak) were characterized in the lab. From the laboratory results the behaviour of the vehicle appeared to behave consistently from one laboratory test to the next. The vehicle's behaviour may change when it is in the field but this has not been examined directly. It is assumed that the field conditions are close enough to the laboratory conditions that this is not a significant problem. Judging from the in-garage samples, the vehicle is behaving consistently in the field. The ambient background source profile may change slightly over the course of the 4 hour test and these changes have not been characterized. However the changes in the ambient background would be sampled in all canisters so the time average VOCs sampled would be similar from the indoor sample to the outdoor sample. The pre-test sample is performed just prior to the vehicle being placed in the garage. This requires the assumption that the background VOC levels in the home will not change significantly

over the four hour sample while the vehicle is either started or placed in the garage. Since the homeowner's activity in the home is slight or nil during the course of the test this is not too large an assumption.

One concern however is the behaviour of the vehicle emissions in the cold garage environment once they are released. In the cold start test, the garage is charged with emissions after a vehicle crank and start and one minute of idling. After this point in time the main garage door is closed and the samples are started. The initial grab sample in the garage would probably not be affected. However the remaining in-house sample is collected over a period of four hours. The VOC species in the garage consist of a large range of molecular weights and other associated properties. One potential sink of some of the heavier molecular weight hydrocarbons is through adsorption onto the cold surfaces within the garage. These heavier hydrocarbons, having higher boiling points, may preferentially be removed from the garage air thus changing the relative composition of the vehicle emissions. The potential impact of this phenomenon on CMB modeling and other related emissions measurements have not been investigated.

With respect to assumption 2, in the absence of sunlight the usual photochemical reactions associated with samples taken after significant outdoor travel time are significantly reduced. Therefore the lifetimes of the samples are adequate for this study. The reactions between these VOCs are virtually non-existent.

With respect to assumption 3, it appears from the performance measures (especially the percent mass) that all of the significant sources contributing to the indoor VOC

concentrations have been included in the analysis. Due to the nature of the micro-environment it is easy to determine and include all the sources contributing to the home's VOC levels.

With respect to assumption 4, at most five source profiles were used and 31 VOC species were used in the majority of the analysis.

With respect to assumption 5, there were very little uncertainty/collinearity clusters throughout the CMB analysis. When they occurred, it was when there was a source that had poor t-statistic scores. In the final source contribution estimates, there were no clusters except for one run which was marginal.

With respect to assumption 6, the effects of deviation from a normal distribution remains to be studied. The least squares solution requires random, normally distributed and uncorrelated errors (Watson *et al*, 1984). There is actually little known about the error distribution of source and receptor profile concentrations. Most likely the error distribution follows a distribution close to log-normal since real-world concentrations cannot be negative. However for relatively small errors (< 20%), the difference between log-normal and normal error distribution is not expected to be significant (Watson *et al*, 1992).

6.13 Discussion of Final Source Contribution Estimates

The garage samples all showed that the primary vehicle emissions composed the majority of the measured VOC mass. The cold start tests showed some degree of residual hot soak

emissions in the measured VOC mass. Since vehicles parked hot in a garage can produce evaporative emissions many hours after shut-off it is reasonable to expect some hot soak emissions to appear. The amount of remaining hot soak emissions is a function of the natural and forced ventilation dynamics of the house. The amount of hot soak emissions remaining was examined for any relation to the house/garage air tightness measures but no conclusive patterns were found. Intuitively, the tighter the house and garage and the smaller the equivalent leakage area across the house/garage interface the longer these hot soak emissions would remain in the garage. A concurrent dynamic modeling effort is being completed in an attempt to simulate the contaminant transport processes occurring in the homes. When comparing the cold start and hot soak contribution (TR and PT residence) two homes show the greatest retention of hot soak emissions. The other homes show some minor retention of hot soak emissions.

The in-house samples for both tests show varied impacts of the vehicle emissions infiltrating in from the garage. Even if the infiltration varies from house to house, this pilot project has shown that in these homes, having a directly attached garage increases the VOC loading to the homes. Health Canada is currently assessing the exposure risk and is expanding the pilot project to include more test homes. If the exposure of household members to these levels of pollutants is deemed to be significant, changes may be made to the building code to eliminate or reduce the infiltration of garage emissions.

Figure 26: Relative VOC Concentrations In Test Gasoline

Average relative measure of the concentrations in two replicate gasoline samples taken from SUMMA™ canisters. Species' numbers refer to the numbering system found in Table 10.

Figure 27: Mass Emissions of VOCs During the Evaporative Emissions Test

Average measure of the concentrations in three replicate evaporative emission tests. Species' numbers refer to the numbering system found in Table 10.

Figure 28: Garage Driving Cycle Showing Vehicle Speed and Total Hydrocarbon Emissions

Figure 29: Schematic of Constant Volume Sampling System

Figure 30: Mass Emissions of VOCs For the Cold Start Tailpipe Emissions Test

Average measure of the concentrations in three replicate cold start emissions tests. Species' numbers refer to the numbering system found in Table 10.

Figure 31: Mass Emissions of VOCs For the Hot Start Tailpipe Emissions Test

Average measure of the concentrations in three replicate hot start emissions tests. Species' numbers refer to the numbering system found in Table 10.

Figure 32: Vehicle Profiles Used In Residential House CMB Analysis

Normalized VOC profiles (Cold Start, Hot Start, Hot Soak: average of three samples; Whole Gasoline: average of two samples)

Figure 33: Hot Soak, In-House, Pre-Test Profiles Used In Residential House CMB Analysis

Mass fractions obtained from a single sample obtained at each residence (GM, HD, PT and JR). (HSPT: hot soak in-house pre-test sample)

Figure 34: Cold Start, In-House, Pre-Test Profiles Used In Residential House CMB Analysis

Mass fractions obtained from a single sample obtained at each residence (GM, HD, PT, JR, TR and MM). (CSPT: cold start in-house pre-test sample)

Figure 35: Hot Soak, Ambient Background Profiles Used In Residential House CMB Analysis

Mass fractions obtained from a single sample obtained at each residence (GM, HD, PT and JR). (HSB: hot soak ambient background sample)

Figure 36: Cold Start Ambient Background Profiles Used In Residential House CMB Analysis

Mass fractions obtained from a single sample obtained at each residence (GM, HD, PT, JR, TR and MM). (CSB: cold start ambient background sample)

Figure 37: Cold Start House Normalized Receptor Profiles

Mass fractions obtained from a single sample obtained at each residence (GM, HD, PT, JR, TR and MM). (CSH: cold start in-house during-test sample)

Figure 38: Cold Start Garage Normalized Receptor Profiles

Mass fractions obtained from a single sample obtained at each residence (GM, HD, PT, JR, TR and MM). (CSG: cold start in-garage during-test sample)

Figure 39: Hot Soak House Normalized Receptor Profiles

Mass fractions obtained from a single sample obtained at each residence (GM, HD, PT and JR). (HSH: hot soak in-house during-test sample)

Figure 40: Hot Soak Garage Normalized Receptor Profiles

Mass fractions obtained from a single sample obtained at each residence (GM, HD, PT and JR). (HSG: hot soak in-garage during-test sample)

Figure 41: Final Source Contribution Estimates for Cold Start Garage Samples

Source apportionment for the measured in-garage cold start test (CSG) for the six homes (TR, PT, MM, JR, HD and GM). Sources used were cold start tailpipe emissions (CS), hot soak evaporative emissions (HS), in-house pre-test (PT) and ambient background (B).

Figure 42: Final Source Contribution Estimates for Hot Soak Garage Samples

Source apportionment for the measured in-garage hot soak test (HSG) for the four homes (PT, JR, HD and GM). Sources used were hot soak evaporative emissions (HS), in-house pre-test (PT) and ambient background (B).

Figure 43: Final Source Contribution Estimates for Cold Start In-House Samples

Source apportionment for the measured in-house cold start test (CSH) for the six homes (TR, PT, MM, JR, HD and GM). Sources used were cold start tailpipe emissions (CS), in-house pre-test (PT) and ambient background (B).

Figure 44: Final Source Contribution Estimates for Hot Soak House Samples

Source apportionment for the measured in-house hot soak test (HSH) for the six homes (PT, JR, HD and GM). Sources used were hot soak evaporative emissions (HS), in-house pre-test (PT) and ambient background (B).

Figure 45: Comparing House Source Apportionment: Cold Start and Hot Soak

Source apportionment for the measured in-garage cold start test (CSG) for the six homes (TR, PT, MM, JR, HD and GM). Sources used were vehicle tailpipe source contribution estimates (VEH) for cold start tailpipe emissions (CS), hot soak evaporative emissions (HS), in-house pre-test (PT) and ambient background (B).

Table 10: Relative VOC Concentrations In Test Gasoline

Concentration represents the relative concentration of the test gasoline averaged over two replicate samples.

Number and Species		Average (mg/test)	Number and Species		Average (mg/test)
1	methane	0.00	42	t-3m2-pentene	144.23
2	ethylene	0.00	43	c2-hexene	83.20
3	acetylene	0.00	44	c-3m2-pentene	187.49
4	ethane	0.00	45	22-dm-pentane	0.00
5	propylene	0.00	46	m-cyclopentane	1846.35
6	propane	77.39	47	24-dm-pentane	247.79
7	propyne	0.00	48	223-tm-butane	17.67
8	isobutane	2041.22	49	1m-cyclopentene	11.40
9	isobutene/1-butene	633.01	50	benzene	1352.44
10	13-butadiene	7.11	51	33-dm-pentane	89.54
11	n-butane	4119.49	52	cyclohexane	340.40
12	t2-butene	402.39	53	2m-hexane	850.93
13	22-dm-propane	16.12	54	23-dm-pentane	280.12
14	1-butyne	0.00	55	11-dm-cyP	49.59
15	c2-butene	320.99	56	cyclohexene	17.43
16	12-butadiene	0.00	57	3m-hexane	890.17
17	3m1-butene	74.58	58	c-13-dm-cyP	169.84
18	2m-butane	4936.18	59	3e-pentane/t-13-dm-cyP	266.86
19	14-pentadiene	0.00	60	t-12-dm-cyP	0.00
20	2-butyne	0.00	61	224-tm-pentane/1-heptene	789.49
21	1-pentene	165.40	62	t3-heptene	48.81
22	2m1-butene	335.56	63	n-heptane	898.40
23	n-pentane	2415.11	64	c3-heptane	172.85
24	2m-13-butadiene	13.89	65	t2-heptene	45.27
25	t2-pentene	391.66	66	c2-heptene	53.13
26	c2-pentene	223.49	67	22-dm-hexane	11.79
27	2m2-butene	655.86	68	m-cyH/c12-dm-cyP/113-tm-cyP	349.72
28	22-dm-butane	596.52	69	12-dm-cyH	30.68
29	cyclopentene	83.77	70	25-dm-hexane/e-cyP	264.45
30	4m1 & 3m1-pentene	69.05	71	24-dm-hexane/223-tm-pentane	299.15
31	cyclopentane	439.91	72	33-dm-hexane/ctc-124-tm-cyP	100.86
32	23-dm-butane	639.28	73	ctc-123-tm-cyP	42.38
33	c/t-4m2-pentene	0.00	74	234-tm-pentane	287.65
34	2m-pentane	2671.95	75	toluene/233-tm-pentane	4862.21
35	3m-pentane	1694.83	76	23-dm-hexane/2m3e-pentane	182.51
36	2m1-pentene	0.00	77	112-tm-cyP	30.02
37	1-hexene	102.71	78	2m-heptane	427.40
38	n-hexane	1438.22	79	4m-C7/3m3e-C5/1m-cyHexene	158.36
39	c/t-3-hexene	98.93	80	34-dm-hexane	70.94
40	t2-hexene	143.80	81	3m-heptane	531.96
41	2m2-pentene	243.18	82	3e-hexane	0.00

Number and Species		Average (mg/test)	Number and Species		Average (mg/test)
83	cct-124-tm-cyP/c-13-dm-cyH	98.58	124	nb-cyP	62.98
84	t-14-dm-cyH	30.80	125	33-dm-octane	12.65
85	225-tm-hexane	67.94	126	np-benzene	252.39
86	11-dm-cyH	0.00	127	3e-toluene	672.46
87	1-octene	74.70	128	23-dm-octane	0.00
88	1e1m-cyP	46.35	129	4e-toluene	294.93
89	n-octane/t-12-dm-cyH	480.73	130	135-tm-benzene	399.12
90	224-tm-hexane	0.00	131	2m-nonane	69.80
91	t2-octene	44.09	132	3e-octane	15.46
92	ccc-123-tm-cyP	104.69	133	3m-nonane	0.00
93	244-tm-hexane	53.17	134	2e-toluene	315.19
94	c2-octene	0.00	135	124-tm&tb-benzene/1-decene	935.21
95	ip-cyP	26.22	136	ib-cyH	14.28
96	235-tm-hexane	27.01	137	n-decane	43.76
97	44&22-dm-heptane	16.59	138	ib-benzene	25.35
98	24-dm-heptane	85.39	139	sb-benzene	23.58
99	26-dm-heptane/c-12-dm-cyH	87.19	140	3-ip-toluene	0.00
100	np-cyP/ccc-135-tm-cyH/e-cyH	28.10	141	123-tm-benzene	30.71
101	25-dm-heptane	134.70	142	4-ip-toluene	212.52
102	33-dm-heptane	34.70	143	indan	8.99
103	114-tm-cyH	44.83	144	2-ip-toluene	117.11
104	e-benzene	923.40	145	13-de-benzene	0.00
105	ctt-124-tm-cyH	27.93	146	14-de-benzene	11.17
106	35-dm-heptane	36.37	147	3-np-toluene	44.44
107	m&p-xylene/23-dm-heptane	2911.72	148	4-np-toluene/nb-&13dm-5e-benz	175.67
108	34-dm-heptane/4m-octane	264.96	149	12-de-benzene	24.33
109	2m-octane/246-tm-hexane	209.63	150	2-np-toluene	12.18
110	ctc-124-tm-cyH	26.79	151	14-dm-2e-benzene	80.22
111	3m-octane/33-de-C5/3e-C7	0.00	152	13-dm-4e-benzene	53.05
112	o-xylene	1256.14	153	12-dm-4e-benzene	101.84
113	112-tm-cyH	0.00	154	13-dm-2e-benzene	39.17
114	1-nonene	54.55	155	n-undecane/12-dm-3e-benzene	26.27
115	t3-nonene	35.66	156	1245-ttm-benzene	22.98
116	ib-cyP	0.00	157	2mb-benzene	48.55
117	c3-nonene	27.57	158	tb-2m-benzene	7.87
118	n-nonane	143.80	159	1234-ttm-benzene	42.53
119	t2-nonene	13.40	160	n-pentylbenzene	47.21
120	c2-nonene	37.80	161	tb-35-dm-benzene	11.94
121	ip-benzene	92.01	162	tb-4e-benzene	0.00
122	22-dm-octane	30.64	163	n-dodecane	18.22
123	ip-cyH	67.31			

Table 11: Description of Test Homes

Finished refers to full gypsum board (drywall) coverage of all walls and all joints taped and/or crack-filled.

RESIDENCE	PT	JR	HD	MM	TR	GM
Constructed	1990	1968	1978	1969	1968	1991
Description	multi-level	two story	split-level	two story	split level	two story
Basement	partially finished	partially finished	part of basement finished	1/2 basement finished	most of basement finished	partially finished
Heating	Forced air intermittent fan	forced air continuous fan	forced air continuous fan	forced air intermittent fan	electric baseboard	forced air intermittent fan
Other Heating	wood fireplace	wood stove	wood fireplace	woodstove (never used)	wood stove	N/A
Garage	double car, partially finished	single car, partially finished	single car, finished	single car, finished	single car, finished	single car, finished
Garage/House Interface	one entire wall + two partial walls	one entire wall	one entire wall and ceiling	one entire wall + two partial walls	one entire wall	two entire walls + portion wall

Table 12: Infiltration Characteristics of the Six Test Homes

Test Home	Air Changes Per Hour @ 50 Pa Pressure Differential			Airtightness of Garage and House Common Surfaces: Equivalent Leakage Area (cm ²) @ 10 Pa	Percent of Air Leakage Through House/Garage Common Surfaces @ $\Delta P=50$ Pa
	House Airtightness Without Garage	House Airtightness With Garage/House $\Delta P=0$	Garage Airtightness With Garage/House $\Delta P=0$		
TR	6.41	5.53	29.95	30	13.7
JR	6.82	4.80	60.84	485	29.6
PT	3.84	3.46	38.12	2	9.7
MM	3.44	2.76	53.64	100	19.6
HD	3.98	3.58	12.14	56	10.1
GM	4.30	4.09	9.12	81	4.9

Table 13: Sampling Locations and Times for the Infiltration Study

	Ambient Background	Pre-Test In-House Background	During Test In-Garage	During Test In-House
9707-10-PT	South side of house near back of garage. Next to A/C unit. Sample line from laundry room.	In basement under the stairs next to small closet.	Near front wall in the garage near the centre.	In basement under the stairs next to small closet.
9707-09-JR	South side of house near entrance to garage. Sample line from workshop window.	In kitchen across from door to garage near pantry.	In centre of the garage opposite the garage/house door.	In kitchen across from door to garage near pantry.
9707-14-HD	South side of house near front door. Sample line from workshop window.	In laundry room under I-beam.	Near backwall of garage opposite the garage/house door.	In laundry room under I-beam.
9707-12-MM	East side of house near fence. Sample line from rec-room.	In laundry room on dryer across from door to garage.	Near backwall of garage in the centreline of the garage opposite the exit door to garage.	In laundry room on dryer across from door to garage.
9707-01-TR	North side of house near front door. Sample line from rec-room.	In laundry room near the dryers.	Near backwall of garage in front of the bench.	In laundry room near the dryers.
9707-21-GM	East side of the house near porch. Sample line from laundry room.	In laundry room near the dryers.	Near the outside wall of the garage ~ 2/3 into the length of the garage.	In laundry room near the dryers.
Cold Start - VOC	4 hr	grab	grab	4 hr
Hot Soak - VOC	4 hr	grab	2 hr	4 hr
Cold Start - Carb.	4 hr	30 min	30 min	4 hr
Hot Soak - Carb.	4 hr	30 min	2 hr	4 hr

Table 14: Species Included in CMB Analysis: Abbreviated and Full Name

ethylene	<i>n</i> -pentane	benzene	<i>t</i> -1,4-dm-cyclohexane	4 <i>e</i> -toluene
	<i>normal</i> -pentane		<i>trans</i> -1,4-dimethyl-cyclohexane	4-ethyl-toluene
acetylene	cyclopentane	2 <i>m</i> -hexane	<i>n</i> -octane/ <i>t</i> -1,2-dm-cyclohexane	<i>n</i> -decane
		2-methyl-hexane	<i>normal</i> -octane/ <i>trans</i> -1,2-dimethyl-cyclohexane	<i>normal</i> -decane
propylene	2 <i>m</i> -pentane & <i>t</i> -4 <i>m</i> 2-pentene	3 <i>m</i> -hexane & cyclohexene	<i>e</i> -benzene	3-isopropyl-toluene
	2-methyl-pentane & <i>trans</i> -4-methyl-2-pentene	3-methyl-hexane & cyclohexene	ethyl-benzene	
propane	3 <i>m</i> -pentane	2,2,4-trimethyl-pentane/1-heptene	<i>m</i> & <i>p</i> -xylene/2,3-dm-heptane	4-isopropyl-toluene
	3-methyl-pentane	2,2,4-trimethyl-pentane/1-heptene	<i>meta</i> & <i>para</i> -xylene/2,3-dimethyl-heptane	
isobutene /1-butene	<i>n</i> -hexane	<i>n</i> -heptane	<i>o</i> -xylene	<i>n</i> -undecane/1,2-dm-3 <i>e</i> -benzene
	<i>normal</i> -hexane	<i>normal</i> -heptane	<i>ortho</i> -xylene	<i>normal</i> -undecane/1,2-dimethyl-3ethyl-benzene
<i>n</i> -butane	<i>m</i> -cyclopentane	toluene/2,3,3-trimethyl-pentane	3 <i>e</i> -toluene & 2,3-dm-octane	<i>n</i> -dodecane
<i>normal</i> -butane	methyl-cyclopentane	toluene/2,3,3-trimethyl-pentane	3-ethyl-toluene & 2,3-dimethyl-octane	<i>normal</i> -dodecane
2 <i>m</i> -butane				
2-methyl-butane				

Table 15: Comparison of CMB Results With Change in Total Measured VOC Mass

Comparison of pre-test and during-test in-house total VOC masses at six homes (GM, HD, PT, JR, MM and TR). (CSPT: cold start in-house pre-test, CSH: cold start in-house during-test, HSPT: hot soak in-house pre-test, HSH: hot soak in-house during-test, TNMHC: total non-methane hydrocarbon, CS SCE: cold start source contribution estimate, HS SCE: hot soak source contribution estimate)

HOME	GM		HD		PT		JR		MM		TR	
SAMPLE	CSPT	CSH	CSPT	CSH	CSPT	CSH	CSPT	CSH	CSPT	CSH	CSPT	CSH
SUM TNMHC (µg)	58.2	181.7	314.2	2402.2	359.8	422.0	121.5	140.8	111.0	133.1	159.7	371.9
SAMPLE	HSPT	HSH	HSPT	HSH	HSPT	HSH	HSPT	HSH				
SUM TNMHC (µg)	78.3	175.1	133.7	817.6	175.9	318.2	105.9	187.3				

Mass Ratios	GM	HD	PT	JR	MM	TR
CSH/CSPT	3.12	7.65	1.17	1.16	1.20	2.33
HSH/HSPT	2.24	6.11	1.81	1.77		
(CSH-CSPT)/CSH	0.68	0.87	0.15	0.14	0.17	0.57
CS SCE	0.45	0.85	0.13	0.36	0.30	0.45
(HSH-HSPT)/HSH	0.55	0.84	0.45	0.43		
HS SCE	0.50	0.69	0.48	0.35		

7 CONCLUSIONS AND RECOMMENDATIONS

A method of source apportionment of measured ambient volatile organic compounds was presented using the US EPA's Chemical Mass Balance receptor model CMB7. Using source profiles gathered from the literature and some locally derived profiles, source apportionment was performed on three urban micro-environments. These micro-environments were an underground garage, urban roadway and residential homes with attached garages.

The general conclusions that can be drawn from this study is that chemical mass balance modeling can be successfully employed for the source apportionment of VOCs in urban micro-environments between heavy and light duty tailpipe emissions and evaporative emissions. Evaporative emissions were assessed to be a significant source of VOCs relative to tailpipe emissions in many of the cases studies. Specific conclusions about each of the studies that were analyzed are presented separately below.

7.1 Underground Garage Study

Samples at three underground garages had previously been obtained in the winter of 1994 at two locations (entrance and within garage) and two sampling times (morning and afternoon). The source apportionment results in the current work showed that the measured VOC mass could be successfully apportioned between four sources: cold start tailpipe emissions, hot stabilized emissions, evaporative emissions and a graphic arts source. In general, the evaporative emissions are the major source of VOCs followed by the cold start emissions. In some cases these two profiles exchanged their order of significance. The

other two profiles showed only minor contributions to the garage air quality. The results showed that the total tailpipe emissions decreased when going from the entrance to the interior of the garage and increased from the morning to the afternoon. Evaporative emissions showed the opposite trend and increased when going from entrance to interior and decreased from morning to afternoon.

7.2 Urban Roadway Study

Volatile organic compounds samples were obtained along a busy downtown roadway. Samples were obtained both at curbside nose-level and at a height of 4 metres and setback from the road. There were two nose-level samples: SL1 (next to a bus stop and parking structure) and SL2 (opposite side of street). The source apportionment results showed that the measured VOC mass could be successfully apportioned between four sources: heavy duty tailpipe emissions, light duty tailpipe emissions, evaporative emissions, graphic arts and liquefied petroleum gas.

In general, the heavy duty tailpipe emissions are most significant and the contribution ranged from 25.9% (PM sample) to 52.3% (NAPS sample). The light duty tailpipe emissions are next in significance and the contribution ranged from 14.5% (NAPS sample) to 32.9% (noon sample). The evaporative emissions contribution ranged from 7.9% (NAPS sample) to 25.2% (noon sample). The graphic arts contribution ranged from 4.8% (afternoon sample) to 23.1% (PM sample). The liquefied petroleum contribution ranged from 3.2% (afternoon sample) to 9.2% (NAPS sample).

The heavy duty tailpipe contributions mirrored the heavy duty traffic volume seen during peak traffic volumes. The light duty tailpipe contributions showed similar results but the correlation was not as pronounced. Nose-level samples showed a decrease in heavy duty and evaporative emissions contributions going from sampling station SL1 to SL2. This is due probably to moving away from the bus stop and the parking structure respectively. The light duty tailpipe contribution increased from SL1 to SL2 probably due to a combination of the proximity of the buses to station SL1 and light duty vehicles not passing close to the bus stop.

The NAPS source apportionment results showed poorer results than nose-level. This is probably due to a combination of the NAPS station samples being 24 hours in duration and the station was set back some distance from the roadway.

A factor analysis was also performed on the nose-level and NAPS samples. The results showed that up to six factors could explain the receptor data. Three of the six factors showed loadings in a large number of species. Two of the factors could be identified as tailpipe emissions from light duty and heavy duty vehicles. A third factor appears to be representing the evaporative emissions although the results of the CMB analysis assisted in the identification. The remaining factors are not identifiable and show significant factor loadings in only a few of the species.

7.3 Residential Homes Study

Volatile organic compound samples were obtained at residential homes with attached garages to investigate the degree of infiltration of vehicle emissions from the garage. Six homes were investigated using the vehicle in two modes of operation (cold start for tailpipe emissions and hot soak for evaporative emissions) during the winter of 1997. The source apportionment results showed that the measured VOC mass could be successfully apportioned between tailpipe and evaporative emission thus giving an estimate of the impact of vehicle emissions on indoor air quality.

The cold start results showed that for the four hour period after the vehicle was started in the garage, the tailpipe emissions accounted for an average of 41.1% of the in-house VOCs. The contribution of cold start emissions ranged from 13.2 to 87.2%. The hot soak results showed that for the four hour period after the vehicle was placed hot in the garage, the evaporative emissions accounted for an average of 50.7%. The contribution of evaporative emissions ranged from 34.7 to 69.4%. The cold start test was influenced by the hot soak emissions that were remaining in the garage after the vehicle was left to sit in the garage overnight prior to the test.

Although house and garage air tightness information was available, no correlations could be made at this time between vehicle emission contributions and air exchange rate information. Dynamic air exchange modeling being undertaken in a parallel may be able to corroborate the results obtained in the source apportionment.

7.4 Recommendations

Recommendations for any subsequent underground garage work include the development of vehicle tailpipe source profiles that include more vehicles in the laboratory samples. The other option could be to develop tailpipe profiles from roadside sampling. A more representative tailpipe profile could eliminate the question of cold start profiles adequately representing a supposed hot vehicle fleet. A more extensive survey of the gasolines used in the region could be used to increase the confidence in the characteristics of the fuel used in the vehicle fleet. The development of an extensive evaporative emissions profile may not be required if the gasoline survey is extensive since accurate vapour profiles can be generated from the liquid gasoline profiles.

Recommendations for further source apportionment of roadway data would be to develop source profiles representative of the typical Ottawa summertime heavy duty and light duty fleet. Although the nose-level results showed adequate performance measures, the results would improve significantly with the inclusion of these profiles.

Recommendations for residential homes include real-time monitoring of a tracer gas (e.g. SF₆) both in the garage and in-house during the course of the test. This would allow the direct calculation of air exchange parameters rather than relying on the results of previous tests which require the assumption of a number of parameters. In addition pushing the vehicle into the garage prior to the cold start test would eliminate the influence of hot soak emissions.

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UNDERGROUND GARAGE APPENDICES

Table 16: CMB7 Source Contribution Estimates for SL1, SL2 and NAPS Samples

Final source apportionment of three sampling station measurements. (NAPS: National Air Pollution Surveillance network, SL1 and SL2: Slater Street nose-level sampling stations 1 and 2, AM: 07:30-09:30 hrs, NO: 11:30-13:30 hrs, AF: 15:30-17:30 hrs, PM: 22:00-00:00 hrs). The characteristics of the source profiles labelled TT94HD (Tuscarora Tunnel Heavy Duty), TLROD (Atlanta light duty), FLPG (liquefied petroleum gas), GA (graphic arts) and COMPFUE (Ontario composite winter gasoline) can be found in Table 8.

SOURCE SAMPLE	TT94HD	FLPG	TLROD	GA	COMPFUE	Mass %
NAPS	52.3	9.2	14.5	4.8	7.9	88.7
SL1AM	42.7	5.1	25.7	12.0	20.3	105.8
SL2AM	33.7	4.1	30.2	17.1	20.0	105.1
SL1NO	41.8	5.1	17.8	14.9	25.2	104.8
SL2NO	26.6	4.3	32.9	16.1	22.7	102.6
SL1AF	51.2	3.2	25.7	9.9	16.0	106.0
SL2AF	48.3	3.9	28.7	10.2	13.4	104.5
SL1PM	32.1	5.4	25.7	23.1	17.2	103.5
SL2PM	25.9	3.4	29.4	22.1	23.5	104.3

Table 17: Final Source Contribution Estimates for Underground Garage Study

Final source apportionment for each garage/time/location combination. (PDP, TDC, XRX: three garages, L1: location near garage entrance/exit, L2: location within garage, AM: 07:30-09:30 hrs, PM: 15:00-17:00 hrs). The characteristics of the source profiles labelled FUEL, COLDST, HOTST and GA are described in Table 6.

	PDP	PDP	PDP	PDP	TDC	TDC	TDC	TDC	XRX	XRX	XRX	XRX
	L1-AM	L1-PM	L2-AM	L2-PM	L1-AM	L1-PM	L2-AM	L2-PM	L1-AM	L1-PM	L2-AM	L2-PM
FUEL (%)	35.6	17.6	53.3	33.5	69.3	40.3	71.0	61.2	56.4	35.3	67.6	49.7
COLDST (%)	55.5	77.1	36.7	53.3	23.2	50.5	20.1	21.7	35.8	58.2	26.8	41.7
HOTST (%)	4.2	2.3	6.2	5.8	10.0	5.7	11.2	12.8	4.9	2.1	4.9	4.2
GA (%)	2.8	3.1	2.1	0.9	4.6	5.2	5.8	3.8	3.3	4.1	2.9	3.9

Table 18: Source Profiles Used In CMB Analysis
Source profile descriptions found in Table 6.

CODE	NAME	ETHYLENE	ACETYLENE	ETHANE	PROPYLENE	PROPANE	ISOBUTANE	N-BUTANE	2M-BUTANE	N-PENTANE
1	FUEL	0.000	0.000	0.000	0.000	0.000	18.854	42.576	20.655	8.690
2	COLDST	17.760	10.282	2.450	6.059	0.977	0.755	10.513	7.081	4.049
3	HOTST	1.277	0.208	1.446	0.502	14.788	2.587	21.534	10.444	6.380
4	CNG	0.000	0.000	70.600	0.000	21.668	2.136	3.154	0.712	0.712
5	LPG	0.000	0.000	4.108	5.110	90.581	0.200	0.000	0.000	0.000
6	GA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	VAPOUR	0.000	0.000	0.000	0.000	0.000	35.657	52.549	8.523	2.659
CODE	NAME	2M-PENTANE	3M-PENTANE	N-HEXANE	BENZENE	TOLUENE	E-BENZENE	M&P-XYLENE	O-XYLENE	
1	FUEL	2.949	1.514	1.174	1.305	1.344	0.365	0.378	0.196	
2	COLDST	3.171	2.890	2.586	4.825	11.598	2.561	8.541	3.902	
3	HOTST	1.145	1.964	2.042	1.418	15.729	2.231	8.389	7.916	
4	CNG	0.305	0.102	0.407	0.000	0.203	0.000	0.000	0.000	
5	LPG	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
6	GA	0.000	0.000	0.000	0.000	93.090	0.000	6.910	0.000	
7	VAPOUR	0.316	0.144	0.085	0.050	0.014	0.001	0.001	0.000	

Table 20: VOC Concentrations and Normalized Profiles: PDP Garage, Location 1, PM (15:00-17:00) Sample

Afternoon ($\mu\text{g}/\text{m}^3$)	9-Jan-95	10-Jan-95	11-Jan-95	16-Jan-95	17-Jan-95	19-Jan-95	23-Jan-95	24-Jan-95	25-Jan-95	26-Jan-95	Min	Max	Mean	75th %ile	25th %ile
ETHYLENE	165.2	307.8	277.1	218.1	85.0	184.0	147.3	185.1	204.4	206.3	85.0	307.8	198.0	215.1	169.9
ACETYLENE	244.3	237.8	236.3	191.1	197.3	92.5	97.8	168.5	171.3	148.9	92.5	244.3	178.6	226.5	153.8
ETHANE	130.8	113.2	95.1	39.8	38.5	41.6	32.7	32.1	43.4	45.1	32.1	130.8	61.2	82.6	38.8
PROPYLENE	42.0	57.8	97.2	76.3	64.2	74.6	42.1	49.4	52.1	52.6	42.0	97.2	60.8	72.0	50.1
PROPANE	12.1	16.7	41.7	13.2	14.0	27.1	18.7	14.7	22.7	26.5	12.1	41.7	20.7	25.6	14.2
ISOBUTANE	31.1	76.7	106.5	77.9	72.0	153.5	131.5	93.7	147.6	122.5	31.1	153.5	101.3	129.3	77.0
N-BUTANE	135.0	290.4	366.3	235.1	210.7	447.5	312.0	250.0	362.3	271.0	135.0	447.5	288.0	349.7	238.9
2M-BUTANE	74.0	134.2	166.2	149.8	121.5	191.0	119.3	129.4	128.8	128.8	74.0	191.0	134.3	145.9	123.3
N-PENTANE	46.5	83.1	99.3	84.2	67.8	103.5	61.5	68.0	62.7	65.3	46.5	103.5	74.2	83.9	63.3
2M-PENTANE	42.4	70.8	85.4	85.9	62.8	84.0	56.5	62.9	55.7	61.0	42.4	85.9	66.7	80.7	57.6
3M-PENTANE	26.7	46.5	53.9	53.5	40.6	53.9	35.9	40.6	36.0	37.9	26.7	53.9	42.5	51.7	36.4
N-HEXANE	26.6	44.9	52.7	49.8	38.2	48.7	30.8	36.5	30.7	35.4	26.6	52.7	39.4	47.8	32.0
BENZENE	67.0	100.2	132.0	123.7	101.5	115.2	76.1	82.9	78.5	86.2	67.0	132.0	96.3	111.8	79.6
TOLUENE	154.9	244.2	317.4	299.5	233.6	258.1	175.9	202.0	184.4	202.4	154.9	317.4	227.2	254.6	188.8
E-BENZENE	31.5	50.5	76.7	56.7	44.4	50.8	33.1	39.1	39.9	38.9	31.5	76.7	46.2	50.7	38.9
M&P-XYLENE	106.3	165.1	226.1	197.4	154.1	183.1	118.4	136.0	127.5	128.4	106.3	226.1	154.3	178.6	127.8
O-XYLENE	51.3	69.4	95.4	86.0	62.6	69.7	49.6	56.2	54.7	54.0	49.6	95.4	64.9	69.6	54.2

Afternoon	10-Jan-95	11-Jan-95	12-Jan-95	13-Jan-95	17-Jan-95	19-Jan-95	23-Jan-95	24-Jan-95	25-Jan-95	26-Jan-95	Mean
ETHYLENE	11.90	14.59	10.97	10.70	5.28	8.44	9.57	11.24	11.34	12.06	10.61
ACETYLENE	17.60	11.27	9.36	9.38	12.26	4.24	6.35	10.23	9.50	8.70	9.89
ETHANE	9.43	5.37	3.77	1.95	2.39	1.91	2.12	1.95	2.41	2.64	3.39
PROPYLENE	3.03	2.74	3.85	3.75	3.99	3.42	2.74	3.00	2.89	3.07	3.25
PROPANE	0.87	0.79	1.65	0.65	0.87	1.24	1.22	0.89	1.26	1.55	1.10
ISOBUTANE	2.24	3.64	4.22	3.82	4.47	7.04	8.54	5.69	8.19	7.16	5.50
N-BUTANE	9.73	13.77	14.50	11.54	13.09	20.34	20.27	15.18	20.10	15.84	15.46
2M-BUTANE	5.33	6.36	6.58	7.35	7.55	8.76	7.75	7.86	7.15	7.53	7.22
N-PENTANE	3.35	3.94	3.93	4.13	4.21	4.75	4.00	4.13	3.48	3.81	3.97
2M-PENTANE	3.05	3.35	3.38	4.21	3.91	3.86	3.67	3.82	3.09	3.57	3.59
3M-PENTANE	1.92	2.20	2.13	2.62	2.53	2.48	2.33	2.46	1.99	2.21	2.29
N-HEXANE	1.92	2.13	2.09	2.44	2.37	2.24	2.00	2.22	1.70	2.07	2.12
BENZENE	4.83	4.75	5.23	6.07	6.31	5.29	4.94	5.03	4.35	5.04	5.18
TOLUENE	11.16	11.58	12.57	14.70	14.52	11.84	11.43	12.27	10.23	11.83	12.21
E-BENZENE	2.27	2.39	3.04	2.78	2.76	2.33	2.15	2.37	2.21	2.27	2.46
M&P-XYLENE	7.66	7.83	8.95	9.69	9.58	8.41	7.69	8.26	7.07	7.51	8.26
O-XYLENE	3.70	3.29	3.78	4.22	3.89	3.20	3.22	3.41	3.03	3.16	3.49

Table 23: VOC Concentrations and Normalized Profiles: TDC Garage, Location 1, AM (07:30-09:30) Sample

Morning (ug/m ³)	9-Dec-94	12-Dec-94	13-Dec-94	14-Dec-94	15-Dec-94	16-Dec-94	19-Dec-94	20-Dec-94	21-Dec-94	22-Dec-94	4-Jan-95	6-Jan-95	Min	Max	Mean	75th %ile	25th %ile
ETHYLENE	216.4	104.8	152.4	178.0	177.1	36.0	133.9	149.1	127.6	90.2	79.4	34.2	34.2	216.4	123.3	158.6	87.5
ACETYLENE	115.6	47.1	83.7	90.8	118.7	35.5	54.8	82.4	62.4	56.2	54.4	24.8	24.8	118.7	68.9	85.5	52.6
ETHANE	52.6	56.8	45.7	58.9	41.0	10.9	37.2	34.7	32.2	30.5	23.0	14.1	10.9	58.9	36.5	47.5	28.6
PROPYLENE	75.8	43.3	58.4	73.4	71.5	14.9	62.5	68.3	54.6	41.9	40.9	15.6	14.9	75.8	51.8	69.1	41.7
PROPANE	86.4	52.0	41.0	59.1	56.3	37.2	61.8	64.9	48.4	60.1	35.8	16.2	16.2	86.4	51.6	60.5	40.1
ISOBUTANE	926.5	490.3	438.7	646.2	644.1	218.5	641.7	733.7	589.7	680.1	369.2	174.9	174.9	926.5	546.1	654.7	421.3
N-BUTANE	1543.1	914.5	877.0	1444.1	1491.5	503.3	1619.2	1799.1	1573.8	1573.9	1226.6	497.5	497.5	1799.1	1255.3	1573.9	905.1
2M-BUTANE	703.2	392.5	404.6	621.7	603.2	284.1	600.8	637.6	566.5	562.2	400.8	188.9	188.9	703.2	497.2	607.9	398.8
N-PENTANE	336.1	190.3	209.1	331.5	301.7	136.0	286.7	312.5	281.7	270.7	210.3	99.4	99.4	336.1	247.2	304.4	204.4
2M-PENTANE	242.8	126.0	149.0	234.9	206.1	95.1	174.4	185.7	156.1	164.3	124.5	55.4	55.4	242.8	159.5	190.8	125.6
3M-PENTANE	145.7	76.1	92.0	140.5	123.2	58.2	106.9	115.5	94.4	99.1	73.2	33.0	33.0	145.7	96.5	117.4	75.4
N-HEXANE	127.6	65.7	82.7	134.3	110.5	53.5	89.4	100.7	84.8	87.9	67.7	29.1	29.1	134.3	85.8	103.2	67.2
BENZENE	185.9	116.5	144.7	210.6	210.6	83.2	163.1	188.6	140.9	151.2	104.8	48.5	48.5	210.6	145.7	186.6	113.5
TOLUENE	520.1	264.0	342.4	550.5	491.5	327.4	350.0	429.8	312.9	350.0	244.9	128.4	128.4	550.5	359.3	445.2	300.7
E-BENZENE	78.8	47.3	63.9	107.5	95.2	38.4	62.3	73.3	56.0	59.0	43.9	26.4	26.4	107.5	62.7	74.7	46.5
M&P-XYLENE	259.6	166.9	216.4	383.0	319.3	132.6	215.6	251.2	200.9	200.9	151.5	93.6	93.6	383.0	216.0	253.3	163.0
O-XYLENE	107.8	69.6	95.6	173.4	138.4	55.2	91.7	109.2	84.1	92.3	71.7	40.6	40.6	173.4	94.1	108.1	71.2
SUM	5729.9	3225.6	4447.3	7246.3	6799.9	2116.5	6751.9	7336.4	6067.0	6066.3	4136.5	1799.9	1799.9	7336.4	4136.5	5136.5	3136.5

Morning	9-Dec-94	12-Dec-94	13-Dec-94	14-Dec-94	15-Dec-94	16-Dec-94	19-Dec-94	20-Dec-94	21-Dec-94	22-Dec-94	4-Jan-95	6-Jan-95	Mean
ETHYLENE	3.78	3.25	4.36	3.27	3.41	1.70	2.82	2.79	2.86	1.98	2.39	2.25	2.90
ACETYLENE	2.02	1.46	2.39	1.67	2.28	1.67	1.15	1.54	1.40	1.23	1.64	1.63	1.67
ETHANE	0.92	1.76	1.31	1.08	0.79	0.51	0.78	0.65	0.72	0.67	0.69	0.93	0.90
PROPYLENE	1.32	1.34	1.67	1.35	1.38	0.70	1.32	1.28	1.22	0.92	1.23	1.03	1.23
PROPANE	1.51	1.61	1.17	1.09	1.08	1.76	1.30	1.22	1.08	1.32	1.08	1.06	1.27
ISOBUTANE	16.19	15.21	12.54	11.88	12.39	10.31	13.50	13.75	13.20	14.90	11.11	11.50	13.04
N-BUTANE	26.96	28.37	25.07	26.55	28.68	23.74	34.07	33.71	35.23	34.47	36.92	32.72	30.54
2M-BUTANE	12.29	12.18	11.57	11.43	11.60	13.40	12.64	11.95	12.68	12.31	12.06	12.42	12.21
N-PENTANE	5.87	5.90	5.98	6.10	5.80	6.42	6.03	5.86	6.31	5.93	6.33	6.54	6.09
2M-PENTANE	4.24	3.91	4.26	4.32	3.96	4.49	3.67	3.48	3.49	3.60	3.75	3.64	3.90
3M-PENTANE	2.55	2.36	2.63	2.58	2.37	2.75	2.25	2.17	2.11	2.17	2.20	2.17	2.36
N-HEXANE	2.23	2.04	2.36	2.47	2.13	2.52	1.88	1.89	1.90	1.82	2.04	1.91	2.10
BENZENE	3.25	3.61	4.14	3.87	4.05	3.92	3.43	3.53	3.15	3.31	3.15	3.19	3.55
TOLUENE	9.09	8.19	9.79	10.12	9.45	15.44	7.37	8.05	7.00	7.67	7.37	8.45	9.00
E-BENZENE	1.38	1.47	1.83	1.98	1.83	1.81	1.31	1.37	1.25	1.29	1.32	1.73	1.55
M&P-XYLENE	4.54	5.18	6.19	7.04	6.14	6.25	4.54	4.71	4.50	4.40	4.56	6.16	5.35
O-XYLENE	1.88	2.16	2.73	3.19	2.66	2.60	1.93	2.05	1.88	2.02	2.16	2.67	2.33
SUM	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 24: VOC Concentrations and Normalized Profiles: TDC Garage, Location 1, PM (15:00-17:00) Sample

Afternoon (µg/m ³)	9-Dec-94	13-Dec-94	14-Dec-94	15-Dec-94	19-Dec-94	20-Dec-94	21-Dec-94	3-Jan-95	4-Jan-95	5-Jan-95	Min	Max	Mean	75th %ile	25th %ile
ETHYLENE	304.6	243.4	251.1	247.8	214.0	266.7	261.9	192.8	172.6	210.2	172.6	304.6	236.5	259.2	211.1
ACETYLENE	243.8	181.8	201.2	195.9	128.6	194.3	191.6	141.9	122.2	153.1	122.2	243.8	175.4	195.5	144.7
ETHANE	61.8	61.2	37.7	39.9	39.1	46.0	41.5	33.5	32.0	35.6	32.0	61.8	42.8	44.9	36.1
PROPYLENE	123.5	108.1	113.7	113.4	98.8	125.5	122.7	93.3	85.7	101.0	85.7	123.5	108.6	120.4	99.3
PROPANE	57.7	46.4	47.5	38.3	33.7	47.8	29.9	51.2	40.7	125.9	29.9	125.9	51.9	50.4	38.9
ISOBUTANE	602.0	374.9	444.0	336.4	318.8	387.1	274.1	378.4	322.8	659.8	274.1	659.8	409.8	429.7	326.2
N-BUTANE	990.0	738.5	907.9	690.2	788.2	887.9	705.9	996.4	882.7	1790.8	690.2	1790.8	937.9	969.5	750.9
2M-BUTANE	551.9	311.5	468.1	327.7	382.4	369.1	333.7	400.5	287.6	508.8	287.6	551.9	394.1	451.2	329.2
N-PENTANE	286.0	161.8	277.0	172.4	214.3	195.5	181.2	221.9	152.6	264.7	152.6	286.0	212.7	254.0	174.6
2M-PENTANE	256.3	123.8	221.1	135.8	174.9	145.1	146.9	158.9	111.2	160.0	111.2	256.3	163.4	171.2	138.1
3M-PENTANE	161.4	77.2	134.3	85.8	108.8	90.2	89.1	96.3	68.0	98.1	68.0	161.4	100.9	106.2	86.6
N-HEXANE	151.0	72.3	133.4	80.0	100.6	86.5	82.9	94.7	63.2	97.8	63.2	151.0	96.2	99.9	80.7
BENZENE	253.1	177.6	237.7	189.8	190.6	202.0	199.8	178.2	139.1	179.2	139.1	253.1	194.7	201.4	178.5
TOLUENE	694.1	416.9	574.5	458.6	475.2	492.1	483.4	458.6	341.1	436.8	341.1	694.1	483.1	489.9	442.3
E-BENZENE	134.4	82.3	118.0	86.9	89.0	92.9	98.4	84.2	64.6	80.4	64.6	134.4	93.1	97.0	82.8
M&P-XYLENE	467.4	281.1	381.1	296.2	309.5	313.9	314.5	286.8	227.1	306.9	227.1	467.4	318.4	314.4	289.2
O-XYLENE	203.3	117.2	162.6	130.3	125.2	137.5	130.8	128.0	94.4	154.0	94.4	203.3	138.3	149.9	125.9

Afternoon	9-Dec	13-Dec	14-Dec	15-Dec	19-Dec	20-Dec	21-Dec	3-Jan	4-Jan	5-Jan	Mean
ETHYLENE	5.50	6.81	5.33	6.84	5.64	6.54	7.10	4.83	5.38	3.92	5.79
ACETYLENE	4.40	5.08	4.27	5.40	3.39	4.76	5.19	3.55	3.81	2.85	4.27
ETHANE	1.12	1.71	0.80	1.10	1.03	1.13	1.13	0.84	1.00	0.66	1.05
PROPYLENE	2.23	3.02	2.41	3.13	2.60	3.08	3.33	2.34	2.67	1.88	2.67
PROPANE	1.04	1.30	1.01	1.06	0.89	1.17	0.81	1.28	1.27	2.35	1.22
ISOBUTANE	10.86	10.48	9.42	9.28	8.41	9.49	7.43	9.47	10.06	12.30	9.72
N-BUTANE	17.86	20.65	19.27	19.04	20.79	21.76	19.14	24.94	27.52	33.39	22.44
2M-BUTANE	9.96	8.71	9.94	9.04	10.09	9.05	9.05	10.02	8.97	9.49	9.43
N-PENTANE	5.16	4.53	5.88	4.75	5.65	4.79	4.91	5.55	4.76	4.94	5.09
2M-PENTANE	4.63	3.46	4.69	3.74	4.61	3.56	3.98	3.98	3.47	2.98	3.91
3M-PENTANE	2.91	2.16	2.85	2.37	2.87	2.21	2.42	2.41	2.12	1.83	2.41
N-HEXANE	2.72	2.02	2.83	2.21	2.65	2.12	2.25	2.37	1.97	1.82	2.30
BENZENE	4.57	4.97	5.05	5.23	5.03	4.95	5.42	4.46	4.34	3.34	4.73
TOLUENE	12.52	11.66	12.19	12.65	12.53	12.06	13.11	11.48	10.64	8.14	11.70
E-BENZENE	2.43	2.30	2.50	2.40	2.35	2.28	2.67	2.11	2.01	1.50	2.25
M&P-XYLENE	8.43	7.86	8.09	8.17	8.16	7.69	8.53	7.18	7.08	5.72	7.69
O-XYLENE	3.67	3.28	3.45	3.59	3.30	3.37	3.55	3.20	2.94	2.87	3.32

Table 25: VOC Concentrations and Normalized Profiles: TDC Garage, Location 2, AM (07:30-09:30) Sample

Monitoring	9-Dec-94	12-Dec-94	13-Dec-94	14-Dec-94	15-Dec-94	16-Dec-94	19-Dec-94	20-Dec-94	21-Dec-94	22-Dec-94	4-Jan-95	6-Jan-95	Min	Max	Mean	75th %ile	25th %ile
ETHYLENE	154.7	71.5	82.3	80.0	57.7	72.2	42.7	73.2	53.1	59.0	43.8	138.8	42.7	154.7	77.4	80.6	56.5
ACETYLENE	106.7	47.1	49.0	52.1	43.6	52.0	25.8	55.0	37.7	47.4	26.9	63.0	25.8	106.7	50.5	52.8	42.1
ETHANE	97.5	93.7	53.4	57.8	17.0	22.7	22.4	26.8	18.3	20.9	16.4	29.6	16.4	97.5	39.7	54.5	20.2
PROPYLENE	92.1	31.5	34.8	29.7	23.0	29.6	16.7	33.2	22.9	25.3	20.1	50.2	16.7	92.1	34.1	33.6	23.0
PROPANE	246.7	51.2	57.7	34.2	22.8	30.8	28.7	41.7	22.5	28.1	25.1	37.9	22.5	246.7	52.3	44.1	27.4
ISOBUTANE	2882.2	538.0	885.3	340.8	278.8	334.4	311.4	500.2	179.4	282.4	212.5	422.2	179.4	2882.2	597.3	509.7	281.5
N-BUTANE	4899.2	1164.9	1966.9	691.9	593.7	725.5	670.0	1079.6	395.4	623.2	608.2	1428.6	395.4	4899.2	1237.3	1230.8	619.5
N-BUTANE	2109.6	458.5	1432.4	281.6	291.6	290.8	260.8	453.7	163.0	272.9	212.5	491.6	163.0	2109.6	559.9	466.7	269.9
N-PENTANE	1067.9	231.7	876.1	145.9	157.5	143.9	127.4	227.3	84.5	136.8	109.9	264.8	84.5	1067.9	297.8	239.9	134.5
2M-PENTANE	724.8	134.4	788.4	99.8	117.2	98.5	80.4	138.5	55.8	86.9	70.8	155.1	55.8	788.4	212.5	142.6	85.3
3M-PENTANE	429.3	80.5	472.9	61.3	70.8	62.0	48.8	83.6	34.4	53.9	42.1	96.4	34.4	472.9	128.0	86.8	52.7
N-HEXANE	387.3	72.8	444.9	55.4	66.6	55.7	42.8	70.8	30.0	44.9	38.3	89.9	30.0	444.9	116.6	77.1	44.4
BENZENE	474.7	112.0	419.5	100.3	102.1	105.0	74.1	113.7	60.0	79.5	66.7	156.0	60.0	474.7	155.3	124.3	78.2
TOLUENE	1143.4	261.6	1471.8	300.4	263.9	300.6	204.7	292.9	167.9	209.7	175.3	345.8	167.9	1471.8	428.1	311.9	208.4
E-BENZENE	183.9	49.6	256.3	73.1	48.4	58.4	41.0	58.8	37.2	42.4	32.7	61.0	32.7	256.3	78.6	64.0	42.1
M&P-XYLENE	609.2	173.5	934.4	239.7	168.4	206.8	145.2	214.8	128.8	143.7	117.1	204.9	117.1	934.4	273.9	221.0	144.8
O-XYLENE	249.5	73.0	406.8	112.3	75.1	88.8	68.6	93.0	58.5	67.4	51.9	92.4	51.9	406.8	119.8	97.8	68.3

Monitoring	9-Dec-94	12-Dec-94	13-Dec-94	14-Dec-94	15-Dec-94	16-Dec-94	19-Dec-94	20-Dec-94	21-Dec-94	22-Dec-94	4-Jan-95	6-Jan-95	Mean
ETHYLENE	0.98	1.96	0.77	2.90	2.40	2.70	1.93	2.06	3.43	2.65	2.34	3.36	2.29
ACETYLENE	0.67	1.29	0.46	1.89	1.82	1.94	1.17	1.55	2.44	2.13	1.44	1.53	1.53
ETHANE	0.61	2.57	0.50	2.10	0.71	0.85	1.01	0.75	1.18	0.94	0.88	0.72	1.07
PROPYLENE	0.58	0.86	0.33	1.08	0.96	1.11	0.75	0.93	1.48	1.14	1.07	1.22	0.96
PROPANE	1.56	1.41	0.54	1.24	0.95	1.15	1.30	1.17	1.45	1.26	1.34	0.92	1.19
ISOBUTANE	18.17	14.76	8.33	12.37	11.63	12.49	14.08	14.06	11.58	12.70	11.36	10.23	12.65
N-BUTANE	30.89	31.96	18.50	25.10	24.76	27.10	30.30	30.35	25.52	28.02	32.52	34.61	28.30
2M-BUTANE	13.30	12.58	13.47	10.22	12.16	10.86	11.79	12.76	10.52	12.27	11.36	11.91	11.93
N-PENTANE	6.73	6.35	8.24	5.29	6.57	5.37	5.76	6.39	5.45	6.15	5.87	6.41	6.22
2M-PENTANE	4.57	3.69	7.41	3.62	4.89	3.68	3.64	3.89	3.60	3.91	3.78	3.76	4.20
3M-PENTANE	2.71	2.21	4.45	2.22	2.95	2.32	2.21	2.35	2.22	2.42	2.25	2.34	2.55
N-HEXANE	2.44	2.00	4.18	2.01	2.78	2.08	1.94	1.99	1.94	2.02	2.05	2.18	2.30
BENZENE	2.99	3.07	3.95	3.64	4.26	3.92	3.35	3.20	3.87	3.58	3.56	3.78	3.60
TOLUENE	7.21	7.18	13.84	10.90	11.00	11.23	9.26	8.23	10.84	9.42	9.37	8.38	9.74
E-BENZENE	1.16	1.36	2.41	2.65	2.02	2.18	1.85	1.65	2.40	1.91	1.75	1.48	1.90
M&P-XYLENE	3.84	4.76	8.79	8.70	7.02	7.72	6.56	6.04	8.31	6.46	6.26	4.96	6.62
O-XYLENE	1.57	2.00	3.83	4.07	3.13	3.32	3.10	2.62	3.78	3.03	2.77	2.24	2.96

Table 27: VOC Concentrations and Normalized Profiles: XRZ Garage, Location 1, AM (07:30-09:30) Sample

Morning ($\mu\text{g}/\text{m}^3$)	31-Jan-95	1-Feb-95	2-Feb-95	3-Feb-95	6-Feb-95	8-Feb-95	9-Feb-95	14-Feb-95	15-Feb-95	16-Feb-95	21-Feb-95	22-Feb-95	Min	Max	Mean	75th %ile	25th %ile
ETHYLENE	257.5	235.8	226.1	121.6	155.4	158.5	128.7	114.2	119.7	109.1	142.3	134.0	109.1	257.5	158.6	175.4	121.1
ACETYLENE	151.4	152.1	186.3	53.1	105.3	89.9	79.5	81.1	56.9	92.9	105.3	116.9	53.1	186.3	105.9	125.5	80.7
ETHANE	41.4	39.6	31.9	16.2	23.0	21.9	15.7	16.0	15.2	20.6	23.9	28.9	15.2	41.4	24.5	29.6	16.2
PROPYLENE	91.2	67.6	66.8	34.0	40.4	41.7	37.1	37.5	25.2	35.9	43.5	66.5	25.2	91.2	49.0	66.6	36.8
PROPANE	38.0	45.5	72.1	26.4	24.2	21.2	19.1	25.1	20.5	14.6	27.7	42.2	14.6	72.1	31.4	39.1	21.0
ISOBUTANE	412.3	636.6	753.0	368.1	365.0	217.7	231.2	340.3	197.7	163.5	396.8	594.4	163.5	753.0	389.7	457.8	227.8
N-BUTANE	936.4	1585.8	1485.3	1094.2	670.3	599.6	675.5	1069.7	486.4	418.1	960.5	1153.5	418.1	1585.8	927.9	1109.0	632.7
2M-BUTANE	376.1	573.5	521.7	362.7	374.4	241.8	219.1	440.8	210.0	193.9	344.5	446.2	193.9	573.5	358.7	442.2	236.1
N-PENTANE	179.7	268.0	225.5	193.4	150.9	120.7	93.4	216.7	106.8	97.0	166.3	186.2	93.4	268.0	167.0	199.2	117.2
2M-PENTANE	125.8	169.1	140.2	92.7	118.9	79.0	59.0	158.4	70.0	66.1	108.7	126.3	59.0	169.1	109.5	129.7	76.7
3M-PENTANE	74.3	99.0	85.5	55.5	73.4	47.3	35.9	10.9	42.8	40.2	66.4	78.6	10.9	99.0	59.1	75.3	42.2
N-HEXANE	66.0	81.6	73.5	52.1	56.9	45.0	31.2	81.0	39.8	38.9	62.5	64.8	31.2	81.6	57.8	67.9	43.7
BENZENE	165.8	159.0	147.5	89.0	111.5	95.9	67.9	112.6	74.7	87.9	117.9	102.4	67.9	165.8	111.0	125.3	88.7
TOLUENE	321.0	337.0	291.6	203.2	257.3	203.7	154.4	321.9	174.2	207.0	284.7	251.8	154.4	337.0	250.7	298.9	203.6
E-BENZENE	56.2	54.9	50.1	38.1	43.7	39.1	28.0	61.6	32.6	34.5	50.2	44.7	28.0	61.6	44.5	51.4	37.2
M&P-XYLENE	201.6	204.1	185.0	136.2	163.9	138.4	99.0	208.8	111.1	117.3	179.2	155.1	99.0	208.8	158.3	189.2	131.5
O-XYLENE	86.5	88.2	76.1	60.3	71.3	61.1	44.3	91.8	50.5	53.2	79.1	68.0	44.3	91.8	69.4	81.0	58.6

Morning	31-Jan-95	1-Feb-95	2-Feb-95	3-Feb-95	6-Feb-95	8-Feb-95	9-Feb-95	14-Feb-95	15-Feb-95	16-Feb-95	21-Feb-95	22-Feb-95	Mean
ETHYLENE	7.19	4.91	4.90	4.06	5.54	7.13	6.37	3.37	6.53	6.09	4.50	3.66	5.35
ACETYLENE	4.23	3.17	4.03	1.77	3.75	4.04	3.94	2.39	3.10	5.19	3.33	3.19	3.51
ETHANE	1.16	0.83	0.69	0.54	0.82	0.99	0.78	0.47	0.83	1.15	0.76	0.79	0.82
PROPYLENE	2.55	1.41	1.45	1.13	1.44	1.88	1.84	1.11	1.37	2.01	1.38	1.82	1.61
PROPANE	1.06	0.55	1.56	0.88	0.86	0.95	0.95	0.74	1.12	0.82	0.88	1.15	0.99
ISOBUTANE	11.51	13.27	16.30	12.28	13.01	9.80	11.45	10.04	10.78	9.13	12.56	16.24	12.20
N-BUTANE	26.15	33.05	32.16	36.51	23.89	26.98	33.46	31.55	26.52	23.34	30.40	31.51	29.63
2M-BUTANE	10.50	11.95	11.30	12.10	13.34	10.88	10.85	13.00	11.45	10.83	10.91	12.19	11.61
N-PENTANE	5.02	5.59	4.88	6.45	5.38	5.43	4.63	6.39	5.82	5.41	5.26	5.09	5.45
2M-PENTANE	3.51	3.53	3.04	3.09	4.24	3.55	2.92	4.67	3.81	3.69	3.44	3.45	3.58
3M-PENTANE	2.07	2.06	1.85	1.85	2.62	2.13	1.78	0.32	2.33	2.25	2.10	2.15	1.96
N-HEXANE	1.84	1.70	1.59	1.74	2.03	2.03	1.54	2.39	2.17	2.17	1.98	1.77	1.91
BENZENE	4.63	3.31	3.19	2.97	3.97	4.31	3.36	3.32	4.07	4.91	3.73	2.80	3.72
TOLUENE	8.96	7.03	6.31	6.78	9.17	9.17	7.64	9.49	9.50	11.56	9.01	6.88	8.46
E-BENZENE	1.57	1.15	1.08	1.27	1.56	1.76	1.39	1.82	1.78	1.93	1.59	1.22	1.51
M&P-XYLENE	5.63	4.25	4.01	4.55	5.84	6.23	4.90	6.16	6.06	6.55	5.67	4.24	5.34
O-XYLENE	2.42	1.84	1.65	2.01	2.54	2.75	2.20	2.77	2.75	2.97	2.50	1.86	2.35

Table 28: VOC Concentrations and Normalized Profiles: XRX Garage, Location 1, PM (15:00-17:00) Sample

Afternoon ($\mu\text{g}/\text{m}^3$)	30-Jan-95	31-Jan-95	1-Feb-95	2-Feb-95	6-Feb-95	7-Feb-95	8-Feb-95	16-Feb-95	20-Feb-95	21-Feb-95	Mean	75th %ile	25th %ile
ETHYLENE	528.9	444.2	308.2	524.1	316.2	305.1	455.7	211.4	574.0	303.9	397.2	507.0	305.9
ACETYLENE	415.1	297.1	152.6	317.9	297.4	210.1	361.6	171.5	361.5	335.5	292.0	355.0	231.8
ETHANE	60.2	120.6	46.2	70.6	40.0	38.0	38.4	25.7	51.1	48.2	53.9	58.0	38.8
PROPYLENE	700.2	264.9	128.6	317.8	104.0	96.0	244.2	57.6	355.5	145.9	241.5	304.6	110.1
PROPANE	111.3	68.9	42.9	101.4	31.3	29.7	35.3	13.3	40.1	44.5	51.9	62.8	32.3
ISOBUTANE	1249.4	728.0	485.7	1027.5	221.3	295.7	260.0	168.3	461.9	441.3	533.9	667.4	268.9
N-BUTANE	3202.0	1771.7	1217.3	2301.7	582.3	783.7	759.6	507.4	1121.6	1188.2	1343.6	1633.1	765.7
2M-BUTANE	1331.1	656.1	500.4	689.2	271.0	328.7	309.5	242.4	431.5	555.4	531.5	630.9	314.3
N-PENTANE	620.4	329.9	235.0	329.3	144.5	162.6	163.9	136.8	238.1	267.9	262.8	313.9	162.9
2M-PENTANE	527.8	248.2	185.4	248.9	126.7	125.0	131.1	98.5	179.2	208.2	207.9	238.2	127.8
3M-PENTANE	325.4	151.0	116.7	152.2	78.6	78.8	80.1	61.6	114.0	129.6	128.8	145.7	79.1
N-HEXANE	296.0	137.5	102.1	145.2	75.8	74.8	79.7	61.9	125.7	123.7	122.3	134.6	76.8
BENZENE	541.3	329.3	233.2	334.9	194.4	183.0	198.2	130.2	258.0	204.4	260.7	311.5	195.3
TOLUENE	1398.2	756.9	507.9	760.8	446.8	430.6	473.8	306.2	635.8	489.2	620.6	726.6	453.5
E-BENZENE	212.9	138.9	92.9	129.4	84.2	78.5	86.4	52.4	105.0	91.2	107.2	123.3	84.7
M&P-XYLENE	735.8	460.7	311.6	434.6	293.4	263.8	297.2	183.9	366.3	317.4	366.5	417.6	294.4
O-XYLENE	305.9	194.6	133.9	184.8	128.3	115.6	127.0	77.9	157.0	135.5	156.0	177.8	127.3

Afternoon	30-Jan-95	31-Jan-95	1-Feb-95	2-Feb-95	6-Feb-95	7-Feb-95	8-Feb-95	16-Feb-95	20-Feb-95	21-Feb-95	Mean
ETHYLENE	4.21	6.26	6.42	6.49	9.20	8.48	11.11	8.43	10.29	6.04	7.69
ACETYLENE	3.30	4.19	3.18	3.94	8.65	5.84	8.82	6.84	6.48	6.67	5.79
ETHANE	0.48	1.70	0.96	0.87	1.16	1.06	0.94	1.03	0.92	0.96	1.01
PROPYLENE	5.57	3.73	2.68	3.94	3.03	2.67	5.95	2.30	6.38	2.90	3.91
PROPANE	0.89	0.97	0.89	1.26	0.91	0.83	0.86	0.53	0.72	0.88	0.87
ISOBUTANE	9.95	10.26	10.12	12.73	6.44	8.22	6.34	6.71	8.28	8.77	8.78
N-BUTANE	25.49	24.96	25.36	28.52	16.95	21.77	18.52	20.24	20.11	23.62	22.55
2M-BUTANE	10.60	9.24	10.42	8.54	7.89	9.13	7.55	9.67	7.74	11.04	9.18
N-PENTANE	4.94	4.65	4.89	4.08	4.21	4.52	4.00	5.46	4.27	5.33	4.63
2M-PENTANE	4.20	3.50	3.86	3.08	3.69	3.47	3.20	3.93	3.21	4.14	3.63
3M-PENTANE	2.59	2.13	2.43	1.89	2.29	2.19	1.95	2.46	2.04	2.58	2.25
N-HEXANE	2.36	1.94	2.13	1.80	2.21	2.08	1.94	2.47	2.25	2.46	2.16
BENZENE	4.31	4.64	4.86	4.15	5.66	5.08	4.83	5.19	4.63	4.06	4.74
TOLUENE	11.13	10.66	10.58	9.43	13.00	11.96	11.55	12.22	11.40	9.73	11.17
E-BENZENE	1.69	1.96	1.93	1.60	2.45	2.18	2.11	2.09	1.88	1.81	1.97
M&P-XYLENE	5.86	6.49	6.49	5.39	8.54	7.33	7.25	7.34	6.57	6.31	6.76
O-XYLENE	2.44	2.74	2.79	2.29	3.73	3.21	3.10	3.11	2.81	2.69	2.89

Table 30: VOC Concentrations and Normalized Profiles: XRX Garage, Location 2, PM (15:00-17:00) Sample

Afternoon ($\mu\text{g}/\text{m}^3$)	31-Jan-95	1-Feb-95	2-Feb-95	6-Feb-95	7-Feb-95	8-Feb-95	16-Feb-95	20-Feb-95	Min	Max	Mean	75th %-ile	25th %-ile
ETHYLENE	438.8	360.1	445.2	555.3	459.8	652.2	487.0	489.3	360.1	652.2	486.0	505.8	443.6
ACETYLENE	242.2	318.5	457.8	454.2	375.4	503.0	359.9	373.2	242.2	503.0	385.5	455.1	349.5
ETHANE	76.0	63.1	66.7	65.9	56.8	58.2	43.9	49.5	43.9	76.0	60.0	66.1	55.0
PROPYLENE	218.0	169.2	261.2	209.9	174.0	394.6	319.1	355.3	169.2	394.6	262.6	328.1	200.9
PROPANE	89.6	82.0	154.3	91.8	97.8	83.3	50.0	94.0	50.0	154.3	92.9	94.9	83.0
ISOBUTANE	1013.5	1030.6	1346.0	876.9	954.0	793.9	563.2	1254.9	563.2	1346.0	979.1	1086.6	856.1
N-BUTANE	2677.1	2528.1	3526.1	2637.6	2560.6	2511.4	1557.0	2688.4	1557.0	3526.1	2585.8	2679.9	2523.9
2M-BUTANE	1011.1	909.8	1121.8	844.4	1001.0	914.9	716.1	945.4	716.1	1121.8	933.1	1003.5	893.5
N-PENTANE	503.5	458.8	537.6	415.7	488.8	471.0	388.7	460.2	388.7	537.6	465.5	492.5	448.0
2M-PENTANE	323.8	313.7	347.8	301.6	345.4	311.9	294.1	340.6	294.1	347.8	322.4	341.8	309.3
3M-PENTANE	199.9	192.2	209.3	183.7	208.6	193.0	178.5	209.0	178.5	209.3	196.8	208.7	190.0
N-HEXANE	181.5	180.4	193.5	170.4	192.2	182.8	171.6	189.7	170.4	193.5	182.8	190.3	178.2
BENZENE	338.0	369.1	379.8	372.7	373.7	371.3	342.7	352.1	342.7	379.8	364.9	372.9	356.6
TOLUENE	834.1	831.8	877.0	878.2	845.6	856.7	853.5	872.4	831.8	878.2	856.2	873.6	842.7
E-BENZENE	138.1	137.2	134.9	147.9	145.6	145.8	149.0	142.9	134.9	149.0	142.7	146.3	137.8
M&P-XYLENE	464.4	469.9	468.3	515.1	493.5	499.8	491.5	472.6	464.4	515.1	484.4	495.1	469.5
O-XYLENE	195.5	197.5	199.7	221.5	211.2	216.7	213.6	203.7	195.5	221.5	207.4	214.4	199.1

Afternoon	31-Jan-95	1-Feb-95	2-Feb-95	6-Feb-95	7-Feb-95	8-Feb-95	16-Feb-95	20-Feb-95	Mean
ETHYLENE	4.89	4.18	4.15	6.21	5.12	7.12	6.78	5.15	5.45
ACETYLENE	2.70	3.70	4.27	5.08	4.18	5.49	5.01	3.93	4.29
ETHANE	0.85	0.73	0.62	0.74	0.63	0.64	0.61	0.52	0.67
PROPYLENE	2.43	1.97	2.44	2.35	1.94	4.31	4.44	3.74	2.95
PROPANE	1.00	0.95	1.44	1.03	1.09	0.91	0.70	0.99	1.01
ISOBUTANE	11.30	11.97	12.55	9.81	10.62	8.67	7.84	13.22	10.75
N-BUTANE	29.86	29.36	32.87	29.49	28.50	27.42	21.69	28.32	28.44
2M-BUTANE	11.28	10.56	10.46	9.44	11.14	9.99	9.97	9.96	10.35
N-PENTANE	5.62	5.33	5.01	4.65	5.44	5.14	5.41	4.85	5.18
2M-PENTANE	3.61	3.64	3.24	3.37	3.84	3.40	4.10	3.59	3.60
3M-PENTANE	2.23	2.23	1.95	2.05	2.32	2.11	2.49	2.20	2.20
N-HEXANE	2.03	2.09	1.80	1.91	2.14	2.00	2.39	2.00	2.04
BENZENE	3.99	4.29	3.54	4.17	4.16	4.05	4.77	3.71	4.09
TOLUENE	9.30	9.66	8.18	9.82	9.41	9.35	11.89	9.19	9.60
E-BENZENE	1.54	1.59	1.26	1.65	1.62	1.59	2.07	1.51	1.60
M&P-XYLENE	5.18	5.46	4.37	5.76	5.49	5.46	6.85	4.98	5.44
O-XYLENE	2.18	2.29	1.86	2.48	2.35	2.37	2.98	2.15	2.33

Table 31: CMB Runs Using Selected Source Profiles at PDP, TDC and XRX Garages

Source profile descriptions for FUEL, COLDST, HOTST, CNG, LPG, GA and VAPOUR are found in Table 6. (L1: location near garage entrance/exit, L2: location within garage, AM: 07:30-09:30, PM: 15:00-17:00). Source contribution estimates are given in percent.

Those source contribution estimates that are shown in bold and highlighted have either negative source contribution estimates and/or have low t-statistic values. Those source contribution estimates that are italicized have marginally low t-statistic values ($1.5 < t\text{-statistic} < 2$).

a)

	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	25.78	2.11	51.49	28.58	66.38	22.37	60.75	42.92	45.28	20.22	61.86	38.45
COLDST	48.81	76.01	30.38	53.16	18.89	47.13	14.98	20.71	33.96	62.32	24.96	45.54
HOTST	15.49	8.88	17.20	26.07	25.47	24.86	39.74	25.32	15.58	5.88	16.09	8.36
CNG	3.98	2.10	4.02	7.27	0.37	0.45	0.80	0.31	0.33	0.36	0.39	0.77
LPG	2.58	2.08	0.77	1.38	2.77	2.37	2.01	2.29	2.77	2.36	2.30	2.48
GA	7.57	1.37	1.38	1.38	2.47	2.28	2.01	2.29	2.77	2.36	2.30	2.48
VAPOUR	6.41	11.15	1.08	1.15	2.47	2.28	2.01	2.29	2.77	2.36	2.30	2.48
% Mass	99.5	100.6	99.3	98.4	104.1	102.7	105.0	101.3	100.9	102.3	100.4	101.3
R ²	0.96	0.98	0.96	0.98	0.95	0.96	0.93	0.95	0.97	0.98	0.97	0.97
χ ²	1.94	1.06	1.67	0.95	2.26	2.06	3.05	2.49	1.25	0.93	1.32	1.24

b)

	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	34.56	6.33	62.50	31.99	84.65	32.86	100.74	53.30	51.92	22.07	70.50	40.01
COLDST	55.86	80.40	35.86	57.01	21.68	54.15	17.81	23.13	37.72	64.27	28.24	47.08
HOTST	4.31	4.41	1.36	3.86	9.24	6.34	9.11	13.47	5.22	3.05	5.35	5.09
CNG	3.37	1.93	3.23	6.45	0.38	0.57	0.61	0.21	0.39	0.38	0.31	0.38
LPG												
GA	3.68	3.30	2.07	2.05	4.74	4.67	6.05	3.62	3.01	3.29	2.57	3.15
VAPOUR	3.11	2.00	4.63	4.80	16.54	5.66	20.05	8.28	3.67	10.70	6.50	6.99
% Mass	100.1	101.1	99.5	98.5	104.4	103.1	104.5	101.6	101.3	102.6	100.8	101.5
R ²	0.95	0.97	0.95	0.98	0.93	0.95	0.88	0.94	0.97	0.98	0.96	0.97
χ ²	2.05	1.00	2.19	0.94	2.93	2.22	4.92	2.72	1.39	0.85	1.61	1.12

c)

	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	37.95	18.99	56.05	36.44	70.23	38.93	73.17	60.07	55.28	33.57	65.75	46.94
COLDST	55.12	75.51	36.70	56.00	22.57	52.79	18.99	22.60	37.23	61.32	28.66	45.67
HOTST	0.34	0.43	1.27	3.00	9.44	6.33	9.55	13.30	5.22	3.05	5.37	5.11
CNG	3.39	2.16	3.19	6.51	0.38	0.57	0.56	0.15	0.37	0.37	0.36	0.78
LPG												
GA	3.73	3.30	2.07	2.05	4.78	4.78	6.22	3.63	3.01	3.29	2.57	3.15
VAPOUR												
% Mass	99.7	99.8	100.5	98.0	107.3	102.3	108.5	99.4	100.5	100.7	102.0	100.2
R ²	0.95	0.97	0.95	0.97	0.92	0.95	0.87	0.94	0.97	0.97	0.96	0.97
χ ²	1.90	1.25	2.05	0.90	2.96	2.08	5.30	2.50	1.29	0.97	1.51	1.08

d)

	PDP_LIAM	PDP_LIPM	PDP_L2AM	PDP_L2PM	TDC_LIAM	TDC_LIPM	TDC_L2AM	TDC_L2PM	XRX_LIAM	XRX_LIPM	XRX_L2AM	XRX_L2PM
FUEL	35.57	17.61	53.34	33.49	69.28	40.32	71.04	61.19	56.44	35.28	67.63	49.71
COLDST	55.47	77.07	36.68	53.34	23.22	50.49	20.09	21.72	35.81	58.17	26.81	41.74
HOTST	4.23	2.84	6.19	5.76	10.01	5.60	11.21	12.80	4.91	2.73	4.92	4.24
CNG												
LPG												
GA	2.85	3.06	2.85	2.85	4.59	5.21	5.77	3.84	3.28	4.72	2.91	3.94
VAPOUR												
% Mass	98.1	100.1	98.3	93.5	107.1	101.7	108.1	99.6	100.5	99.7	102.3	99.6
R ²	0.92	0.95	0.91	0.92	0.92	0.94	0.86	0.93	0.96	0.97	0.95	0.96
χ ²	2.91	1.66	3.29	2.84	2.78	2.12	5.11	2.40	1.28	1.20	1.64	1.54

e)

	PDP_LIAM	PDP_LIPM	PDP_L2AM	PDP_L2PM	TDC_LIAM	TDC_LIPM	TDC_L2AM	TDC_L2PM	XRX_LIAM	XRX_LIPM	XRX_L2AM	XRX_L2PM
FUEL												
COLDST	66.37	84.15	48.06	63.31	29.85	60.36	24.09	26.78	45.51	67.87	35.41	51.68
HOTST	3.86	2.88	6.02	5.68	12.33	5.59	18.81	16.31	4.75	2.74	4.95	4.02
CNG												
LPG												
GA	1.94	2.41	1.88	2.85	4.21	6.02	4.82	3.37	2.77	3.95	2.68	3.28
VAPOUR	26.39	13.11	40.24	25.21	51.70	29.94	47.15	55.72	46.58	27.36	54.42	39.78
% Mass	98.6	101.7	95.6	94.3	98.2	100.3	94.9	102.2	99.6	100.3	97.5	98.8
R ²	0.90	0.96	0.84	0.90	0.80	0.91	0.74	0.85	0.89	0.95	0.83	0.90
χ ²	3.42	1.20	5.52	3.37	7.50	3.23	9.96	5.51	3.85	1.77	6.01	3.41

f)

	PDP_LIAM	PDP_LIPM	PDP_L2AM	PDP_L2PM	TDC_LIAM	TDC_LIPM	TDC_L2AM	TDC_L2PM	XRX_LIAM	XRX_LIPM	XRX_L2AM	XRX_L2PM
FUEL	28.91	2.88	56.46	26.01	81.96	36.61	94.98	55.67	54.33	26.69	74.43	46.80
COLDST	57.21	82.91	36.31	55.15	22.59	51.22	19.07	22.06	36.28	59.98	26.29	42.19
HOTST	4.12	2.88	6.18	5.71	9.86	5.61	10.85	12.89	4.85	2.88	4.93	4.22
CNG												
LPG												
GA	2.73	2.83	2.88	2.79	4.52	5.17	5.62	3.85	3.25	4.01	2.87	3.91
VAPOUR	6.04	11.54	3.28	6.02	-14.41	3.00	35.98	6.02	2.31	8.31	2.01	3.96
% Mass	99.0	101.7	97.8	94.6	104.5	102.1	104.6	101.3	100.9	101.0	100.5	100.1
R ²	0.92	0.96	0.91	0.92	0.93	0.94	0.87	0.94	0.96	0.97	0.95	0.96
χ ²	3.06	1.31	3.56	2.98	2.78	2.28	4.91	2.61	1.38	1.18	1.70	1.67

g)

	PDP_LIAM	PDP_LIPM	PDP_L2AM	PDP_L2PM	TDC_LIAM	TDC_LIPM	TDC_L2AM	TDC_L2PM	XRX_LIAM	XRX_LIPM	XRX_L2AM	XRX_L2PM
FUEL												
COLDST	72.92	90.30	52.74	66.96	26.61	67.28	15.43	25.15	50.51	74.63	39.55	57.43
HOTST	4.23	2.85	6.81	6.62	25.61	6.48	51.05	26.78	5.38	2.88	5.65	4.52
CNG												
LPG												
GA												
VAPOUR												
% Mass	77.2	92.7	59.6	73.6	52.2	73.8	66.5	51.9	55.9	76.5	45.2	61.9
R ²	0.77	0.87	0.69	0.77	0.65	0.77	0.69	0.69	0.71	0.80	0.64	0.73
χ ²	6.84	3.53	10.02	6.93	12.00	7.08	10.28	10.58	9.24	5.70	11.86	8.29

h)

	PDP_LIAM	PDP_LIPM	PDP_L2AM	PDP_L2PM	TDC_LIAM	TDC_LIPM	TDC_L2AM	TDC_L2PM	XRX_LIAM	XRX_LIPM	XRX_L2AM	XRX_L2PM
FUEL	34.88	17.25	52.84	33.42	69.01	39.56	70.27	60.63	55.89	34.66	67.56	49.11
COLDST	57.58	78.92	37.97	53.62	24.10	52.80	20.85	22.22	37.48	60.37	27.93	43.59
HOTST	4.21	2.88	6.34	5.85	11.06	5.83	13.24	14.17	5.03	2.88	5.14	4.33
CNG												
LPG												
GA												
VAPOUR												
% Mass	96.7	98.5	97.2	92.9	104.2	98.2	104.4	97.0	98.4	97.1	100.6	97.0
R ²	0.92	0.95	0.91	0.92	0.91	0.93	0.84	0.92	0.96	0.96	0.94	0.95
χ ²	2.78	1.62	3.14	2.66	3.08	2.31	5.33	2.63	1.46	1.33	1.82	1.72

i)

	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	37.04	18.45	55.25	35.82	69.59	37.49	72.34	59.09	54.59	32.88	65.31	46.08
COLDST	57.56	77.84	38.40	57.36	23.74	55.38	20.02	23.34	38.91	63.48	29.99	47.77
HOTST	8.25	8.45	8.85	8.64	10.69	6.66	1.58	14.84	5.47	3.15	5.67	5.27
CNG	3.19	2.01	3.01	6.26	8.18	8.44	8.45	8.38	8.36	8.25	8.38	8.34
LPG												
GA												
VAPOUR												
% Mass	97.6	97.8	98.8	96.8	104.2	99.3	104.4	97.0	98.6	98.7	100.6	98.3
R ²	0.94	0.96	0.94	0.97	0.91	0.94	0.85	0.93	0.96	0.97	0.95	0.96
χ ²	1.95	1.30	2.09	0.91	3.31	2.21	5.69	2.67	1.42	1.07	1.62	1.20

j)

	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	31.52	16.69	48.37	33.65	57.91	32.15	51.22	53.14	50.58	32.01	60.83	46.10
COLDST	51.21	77.54	32.33	54.94	19.31	43.78	15.27	19.28	32.21	55.66	23.32	39.34
HOTST	15.60	4.56	18.40	8.36	29.81	26.75	44.31	26.24	17.64	10.81	18.01	12.88
CNG												
LPG	5.87	6.36	5.88	6.38	6.88	6.94	6.53	6.40	6.31	6.43	6.41	6.40
GA												
VAPOUR												
% Mass	96.5	98.4	97.0	93.2	103.6	99.1	105.4	96.0	98.2	97.1	99.8	96.8
R ²	0.92	0.95	0.91	0.92	0.94	0.95	0.93	0.94	0.97	0.96	0.96	0.95
χ ²	2.96	1.77	3.11	2.83	1.95	1.92	2.61	2.18	1.12	1.39	1.26	1.77

Table 32: Removing Flagged Source Contribution Estimates From FUEL, COLDST, HOTST and GA Results

Source profile descriptions for FUEL, COLDST, HOTST, CNG, LPG, GA and VAPOUR are found in Table 6. (L1: location near garage entrance/exit, L2: location within garage, AM: 07:30-09:30, PM: 15:00-17:00). Source contribution estimates are given in percent.

	PDP_ L1AM	PDP_ L1PM	PDP_ L2AM	PDP_ L2PM	XRX_ L1PM
FUEL	35.57	17.61	53.34	33.49	35.28
COLDST	55.47	77.07	36.68	53.34	58.17
HOTST	4.23	2.34	6.19	5.76	2.73
CNG					
LPG					
GA	2.85	3.06	2.85	2.85	4.22
VAPOUR					
% Mass	98.1	100.1	98.3	93.5	99.7
R ²	0.92	0.95	0.91	0.92	0.97
χ ²	2.91	1.66	3.29	2.84	1.20

PDP_ L1AM	PDP_ L1PM	PDP_ L1PM	PDP_ L2AM	PDP_ L2PM	XRX_ L1PM
34.89	17.53	17.18	52.84	33.43	34.49
57.59	80.66	82.42	37.98	53.63	63.48
4.21			6.35	5.86	
	5.06				
96.7	101.2	99.6	97.2	92.9	98.0
0.92	0.95	0.94	0.91	0.92	0.95
2.78	1.68	3.14	3.14	2.66	1.41

Table 33: Sensitivity of Underground Garage Source Apportionment

Source profile descriptions for FUEL, COLDST, HOTST and GA are found in Table 6. (L1: location near garage entrance/exit, L2: location within garage, AM: 07:30-09:30, PM: 15:00-17:00). Source contribution estimates are given in percent.

BASE	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	35.57	17.61	53.34	33.49	69.28	40.32	71.04	61.19	56.44	35.28	67.63	49.71
COLDST	55.47	77.07	36.68	53.34	23.22	50.49	20.09	21.72	35.81	58.17	26.81	41.74
HOTST	4.23	2.82	6.19	5.76	10.01	5.60	11.21	12.80	4.91	3.77	4.92	4.24
GA	2.00	3.06	2.00	2.00	4.59	5.21	5.77	3.84	3.28	2.91	2.91	3.94
% Mass	98.1	100.1	98.3	93.5	107.1	101.7	108.1	99.6	100.5	99.7	102.3	99.6
R ²	0.92	0.95	0.91	0.92	0.92	0.94	0.86	0.93	0.96	0.97	0.95	0.96
χ ²	2.91	1.66	3.29	2.84	2.78	2.12	5.11	2.40	1.28	1.20	1.64	1.54

-ETHYLENE	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	34.96	16.88	53.69	33.59	66.76	38.24	67.42	58.37	55.36	34.17	66.15	48.08
COLDST	57.09	80.08	36.08	53.06	27.29	55.85	26.23	26.05	37.66	61.22	28.80	44.91
HOTST	4.04	2.82	6.28	580.00	8.91	4.99	9.49	11.35	4.65	3.77	4.62	3.87
GA	2.00	2.00	2.00	2.00	4.23	4.60	5.23	3.53	3.00	2.91	2.91	3.92
% Mass	98.8	101.7	98.2	93.4	107.2	103.7	108.4	99.3	100.8	101.0	102.3	100.4
R ²	0.92	0.95	0.90	0.92	0.93	0.95	0.88	0.95	0.96	0.97	0.96	0.96
χ ²	3.07	1.62	3.59	3.08	2.48	1.77	4.54	1.99	1.28	1.07	1.56	1.38

-ACETYLENE	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	49.73	18.01	51.24	34.11	66.91	39.47	68.81	61.05	56.06	35.17	68.25	49.73
COLDST	41.72	75.02	40.57	51.61	27.19	52.76	24.03	21.99	36.48	58.49	25.98	41.72
HOTST	4.24	2.93	5.59	6.01	8.84	5.36	9.97	12.70	4.81	3.77	5.06	4.24
GA	3.93	3.90	1.66	1.11	4.25	4.96	5.45	3.82	3.20	2.91	2.99	3.93
% Mass	99.6	98.9	99.1	92.8	107.2	102.5	108.3	99.6	100.6	99.9	102.3	99.6
R ²	0.95	0.95	0.92	0.92	0.93	0.94	0.87	0.93	0.96	0.96	0.95	0.95
χ ²	1.67	1.73	3.17	3.03	2.52	2.15	5.00	2.59	1.37	1.29	1.76	1.67

-ISOBUTANE	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	47.89	10.63	53.76	30.68	70.01	36.94	73.18	57.21	54.56	31.42	69.04	47.89
COLDST	42.07	81.13	36.60	54.23	23.17	51.30	19.97	22.00	36.07	59.35	26.67	42.07
HOTST	4.23	2.82	6.19	5.77	9.98	5.67	11.13	12.97	4.92	3.77	4.92	4.23
GA	3.91	2.00	2.00	2.00	4.59	5.15	5.77	3.82	3.27	2.91	2.91	3.91
% Mass	98.1	96.6	98.6	91.5	107.8	99.1	110.1	96.0	98.8	96.9	103.5	98.1
R ²	0.95	0.96	0.90	0.92	0.92	0.94	0.85	0.93	0.96	0.97	0.95	0.95
χ ²	1.65	1.36	3.57	3.02	3.00	2.20	5.50	2.49	1.36	1.17	1.76	1.65

-N-BUTANE	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	48.52	18.03	52.24	32.18	71.59	41.32	75.94	60.40	55.96	34.63	66.98	48.52
COLDST	41.88	77.05	36.82	53.50	23.09	50.36	19.85	21.77	35.86	58.27	26.86	41.88
HOTST	4.22	2.82	6.17	5.73	10.01	5.67	11.19	12.79	4.91	3.77	4.92	4.22
GA	3.93	2.00	2.00	2.00	4.58	5.21	5.73	3.84	3.28	2.91	2.91	3.93
% Mass	98.6	100.5	97.3	92.4	109.3	102.6	112.7	98.8	100.0	99.2	101.7	98.6
R ²	0.95	0.95	0.90	0.92	0.92	0.94	0.86	0.93	0.96	0.96	0.95	0.95
χ ²	1.66	1.79	3.55	3.05	2.56	2.28	5.37	2.60	1.39	1.29	1.77	1.66

2M-BUTANE	PDP_L1AM	PDP_L1PM	PDP_L2AM	PDP_L2PM	TDC_L1AM	TDC_L1PM	TDC_L2AM	TDC_L2PM	XRX_L1AM	XRX_L1PM	XRX_L2AM	XRX_L2PM
FUEL	55.59	20.01	59.11	37.29	77.13	45.94	80.43	69.95	61.38	39.38	73.49	55.59
COLDST	41.23	77.71	36.10	53.03	22.84	50.10	19.72	21.27	35.43	57.93	26.43	41.23
HOTST	4.28	2.82	6.24	5.81	9.98	5.71	11.15	12.76	4.94	3.77	4.94	4.28
GA	3.91	2.00	2.00	2.00	4.53	5.17	5.68	3.77	3.25	2.91	2.86	3.91
% Mass	105.0	103.0	103.5	97.0	114.5	106.9	117.0	107.8	105.0	103.6	107.7	105.0
R ²	0.96	0.95	0.91	0.92	0.93	0.94	0.86	0.94	0.97	0.97	0.96	0.96
χ ²	1.42	1.56	3.35	2.90	2.67	2.01	5.09	2.12	1.21	1.09	1.56	1.42

-N-PENTANE	PDP_LIAM	PDP_LIPM	PDP_L2AM	PDP_L2PM	TDC_LIAM	TDC_LIPM	TDC_L2AM	TDC_L2PM	XXR_LIAM	XXR_LIPM	XXR_L2AM	XXR_L2PM
FUEL	53.22	18.73	56.13	34.97	74.03	42.59	75.88	67.63	60.27	37.77	71.61	53.22
COLDST	41.56	77.86	36.48	53.37	23.02	50.49	19.92	21.41	35.61	58.28	26.59	41.56
HOTST	4.28	2.33	6.24	5.81	10.06	5.71	11.28	12.94	4.96	2.70	4.95	4.28
GA	3.90	3.34	3.90	3.90	4.54	5.17	5.71	3.76	3.24	3.66	2.87	3.90
% Mass	103.0	101.9	100.9	95.0	111.7	104.0	112.8	105.7	104.1	102.3	106.0	103.0
R ²	0.96	0.95	0.91	0.92	0.92	0.94	0.86	0.94	0.97	0.97	0.95	0.96
χ ²	1.54	1.67	3.49	3.03	2.84	2.21	5.35	2.26	1.25	1.17	1.65	1.54

-BENZENE	PDP_LIAM	PDP_LIPM	PDP_L2AM	PDP_L2PM	TDC_LIAM	TDC_LIPM	TDC_L2AM	TDC_L2PM	XXR_LIAM	XXR_LIPM	XXR_L2AM	XXR_L2PM
FUEL	49.34	17.75	52.99	33.57	67.25	40.29	68.51	59.46	55.70	35.47	66.34	49.34
COLDST	40.12	74.85	35.36	52.33	22.24	48.35	19.10	20.80	34.61	56.02	25.97	40.12
HOTST	4.42	2.33	6.37	5.88	10.23	5.91	11.43	13.06	5.06	2.33	5.04	4.42
GA	4.14	3.34	3.34	3.34	4.73	5.48	5.91	3.95	3.43	2.40	3.02	4.14
% Mass	98.0	98.5	96.9	92.8	104.5	100.0	105.0	97.3	98.8	98.2	100.4	98.0
R ²	0.96	0.95	0.91	0.92	0.93	0.95	0.87	0.94	0.97	0.97	0.96	0.96
χ ²	1.37	1.69	3.47	3.06	2.56	1.95	4.99	2.21	1.10	1.05	1.55	1.37

-TOLUENE	PDP_LIAM	PDP_LIPM	PDP_L2AM	PDP_L2PM	TDC_LIAM	TDC_LIPM	TDC_L2AM	TDC_L2PM	XXR_LIAM	XXR_LIPM	XXR_L2AM	XXR_L2PM
FUEL	50.25	17.76	54.07	33.63	70.02	41.07	72.07	61.79	57.05	35.71	68.31	50.25
COLDST	40.67	75.72	35.41	52.98	22.32	48.71	19.07	20.81	34.69	56.99	25.53	40.67
HOTST	4.24	2.20	6.15	5.76	9.53	5.65	10.29	12.13	4.87	2.10	4.88	4.24
GA	3.80	3.00	3.00	3.00	34.40	41.99	55.76	34.34	23.34	22.00	25.86	23.06
% Mass	115.7	118.0	115.2	97.7	136.3	137.4	157.2	129.1	122.0	117.6	124.6	115.7
R ²	0.96	0.95	0.91	0.92	0.93	0.94	0.87	0.94	0.97	0.97	0.96	0.96
χ ²	1.59	1.76	3.48	3.08	2.60	2.04	4.75	2.18	1.19	1.23	1.48	1.59

-M&P-XYLENE	PDP_LIAM	PDP_LIPM	PDP_L2AM	PDP_L2PM	TDC_LIAM	TDC_LIPM	TDC_L2AM	TDC_L2PM	XXR_LIAM	XXR_LIPM	XXR_L2AM	XXR_L2PM
FUEL	50.25	17.76	54.07	33.63	70.02	41.07	72.07	61.79	57.05	35.79	68.31	50.25
COLDST	40.67	75.72	35.41	52.98	22.32	48.70	19.07	20.81	34.69	56.79	25.53	40.67
HOTST	4.24	2.20	6.15	5.76	9.53	5.65	10.29	12.13	4.87	2.20	4.88	4.24
GA	3.80	3.00	3.00	3.00	4.26	4.94	5.30	3.60	3.17	2.60	2.75	3.80
% Mass	99.0	98.9	97.7	93.3	106.2	100.4	106.7	98.3	99.7	98.1	101.5	9.0
R ²	0.96	0.95	0.91	0.92	0.93	0.94	0.97	0.94	0.97	0.97	0.96	0.96
χ ²	1.59	1.76	3.48	3.08	2.60	2.04	4.75	2.18	1.19	1.23	1.48	1.59

-ETHYLENE, ACETYLENE, PROPYLENE	PDP_LIAM	PDP_LIPM	PDP_L2AM	PDP_L2PM	TDC_LIAM	TDC_LIPM	TDC_L2AM	TDC_L2PM	XXR_LIAM	XXR_LIPM	XXR_L2AM	XXR_L2PM
FUEL	48.12	16.24	43.41	31.39	55.94	34.68	50.64	53.89	51.31	33.92	61.86	48.12
COLDST	44.89	84.47	56.89	59.46	45.81	65.75	57.44	34.09	44.86	61.97	34.92	44.89
HOTST	3.86	3.63	3.63	5.02	5.44	3.86	4.31	9.27	3.76	3.76	3.82	3.86
GA	3.86	3.63	3.63	5.02	5.44	3.86	4.31	9.27	3.76	3.76	3.82	3.86
% Mass	100.5	104.5	103.8	96.1	109.6	107.8	144.4	100.1	102.2	101.4	102.7	100.5
R ²	0.96	0.96	0.95	0.92	0.98	0.96	0.98	0.95	0.98	0.97	0.97	0.96
χ ²	1.63	1.47	1.52	2.99	0.73	1.45	0.80	1.85	0.96	1.26	1.19	1.63

Table 34: Sensitivity of Underground Garage Source Apportionment

Source profile descriptions for FUEL, COLDST, HOTST and GA are found in Table 6. (L1: location near garage entrance/exit, L2: location within garage, AM: 07:30-09:30, PM: 15:00-17:00). Source contribution estimates are given in percent.

FUEL	BASE	-ETHYLENE	-ACETYLENE	-ISOBUTANE	-N-BUTANE	2M-BUTANE	-N-PENTANE	-BENZENE	-TOLUENE	-MAP-XYLENE	-ETHYLENE, ACETYLENE, PROPYLENE
PDP L1AM	35.57	34.96	49.73	47.89	48.52	55.59	53.22	49.34	50.25	50.25	48.12
PDP L1PM	17.61	16.88	18.01	10.63	18.03	20.01	18.73	17.75	17.76	17.76	16.24
PDP L2AM	53.34	53.69	51.24	53.76	52.24	59.11	56.13	52.99	54.07	54.07	43.41
PDP L2PM	33.49	33.59	34.11	30.68	32.18	37.29	34.97	33.57	33.63	33.63	31.39
TDC L1AM	69.28	66.76	66.91	70.01	71.59	77.13	74.03	67.25	70.02	70.02	55.94
TDC L1PM	40.32	38.24	39.47	36.94	41.32	45.94	42.59	40.29	41.07	41.07	34.68
TDC L2AM	71.04	67.42	68.81	73.18	75.94	80.43	75.88	68.51	72.07	72.07	50.64
TDC L2PM	61.19	58.37	61.05	57.21	60.40	69.95	67.63	59.46	61.79	61.79	53.89
XRX L1AM	56.44	55.36	56.06	54.56	55.96	61.38	60.27	55.70	57.05	57.05	51.31
XRX L1PM	35.28	34.17	35.17	31.42	34.63	39.38	37.77	35.47	35.71	35.79	33.92
XRX L2AM	67.63	66.15	68.25	69.04	66.98	73.49	71.61	66.34	68.31	68.31	61.86
XRX L2PM	49.71	48.08	49.73	47.89	48.52	55.59	53.22	49.34	50.25	50.25	48.12

COLDST	BASE	-ETHYLENE	-ACETYLENE	-ISOBUTANE	-N-BUTANE	2M-BUTANE	-N-PENTANE	-BENZENE	-TOLUENE	-MAP-XYLENE	-ETHYLENE, ACETYLENE, PROPYLENE
PDP L1AM	55.47	57.09	41.72	42.07	41.88	41.23	41.56	40.12	40.67	40.67	44.89
PDP L1PM	77.07	80.08	75.02	81.13	77.05	77.71	77.86	74.85	75.72	75.72	84.47
PDP L2AM	36.68	36.08	40.57	36.60	36.82	36.10	36.48	35.36	35.41	35.41	56.89
PDP L2PM	53.34	53.06	51.61	54.23	53.50	53.03	53.37	52.33	52.98	52.98	59.46
TDC L1AM	23.22	27.29	27.19	23.17	23.09	22.84	23.02	22.24	22.32	22.32	45.81
TDC L1PM	50.49	55.85	52.70	51.30	50.36	50.10	50.49	48.35	48.71	48.70	65.75
TDC L2AM	20.09	26.23	24.03	19.97	19.85	19.72	19.92	19.10	19.07	19.07	57.44
TDC L2PM	21.72	26.05	21.99	22.00	21.77	21.27	21.41	20.80	20.81	20.81	34.09
XRX L1AM	35.81	37.66	36.48	36.07	35.86	35.43	35.61	34.61	34.69	34.69	44.86
XRX L1PM	58.17	61.22	58.49	59.35	58.27	57.93	58.28	56.02	56.99	56.79	61.97
XRX L2AM	26.81	28.80	25.98	26.67	26.86	26.43	26.59	25.97	25.53	25.53	34.92
XRX L2PM	41.74	44.91	41.72	42.07	41.88	41.23	41.56	40.12	40.67	40.67	44.89

HOTST	BASE	-ETHYLENE	-ACETYLENE	-ISOBUTANE	-N-BUTANE	2M-BUTANE	-N-PENTANE	-BENZENE	-TOLUENE	-MAP-XYLENE	-ETHYLENE, ACETYLENE, PROPYLENE
PDP L1AM	4.23	4.04	4.24	4.23	4.22	4.28	4.28	4.42	4.24	4.24	3.86
PDP L1PM	2.34	2.05	2.55	2.23	2.35	2.33	2.35	2.55	2.42	2.42	1.62
PDP L2AM	6.19	6.28	5.59	6.19	6.17	6.24	6.24	6.37	6.15	6.15	3.63
PDP L2PM	5.76	5.80	6.01	5.77	5.73	5.81	5.81	5.88	5.76	5.76	5.02
TDC L1AM	10.01	8.91	8.84	9.98	10.01	9.98	10.06	10.23	9.53	9.53	5.44
TDC L1PM	5.60	4.99	5.36	5.67	5.67	5.71	5.71	5.91	5.65	5.65	3.86
TDC L2AM	11.21	9.49	9.97	11.13	11.19	11.15	11.28	11.43	10.29	10.29	4.31
TDC L2PM	12.80	11.35	12.70	12.97	12.79	12.76	12.94	13.06	12.13	12.13	9.27
XRX L1AM	4.91	4.65	4.81	4.92	4.91	4.94	4.96	5.06	4.87	4.87	3.76
XRX L1PM	2.13	1.85	2.11	2.09	2.12	2.16	2.16	2.33	2.18	2.20	1.78
XRX L2AM	4.92	4.62	5.06	4.92	4.92	4.94	4.95	5.04	4.88	4.88	3.82
XRX L2PM	4.24	3.87	4.24	4.23	4.22	4.28	4.28	4.42	4.24	4.24	3.86

GA	BASE	-ETHYLENE	-ACETYLENE	-ISOBUTANE	-N-BUTANE	2M-BUTANE	-N-PENTANE	-BENZENE	-TOLUENE	-MAP-XYLENE	-ETHYLENE, ACETYLENE, PROPYLENE
PDP L1AM	2.85	2.67	3.93	3.91	3.93	3.91	3.90	4.14	20.56	3.80	3.57
PDP L1PM	3.06	2.71	3.30	2.63	3.06	2.94	2.94	3.34	22.08	3.01	2.19
PDP L2AM	2.06	2.12	1.65	2.06	2.05	2.04	2.03	2.21	19.50	2.01	-0.12
PDP L2PM	0.92	0.95	1.11	0.84	0.90	0.89	0.88	1.03	5.29	0.91	0.24
TDC L1AM	4.59	4.23	4.25	4.59	4.58	4.53	4.54	4.73	34.40	4.26	2.36
TDC L1PM	5.21	4.60	4.96	5.15	5.21	5.17	5.17	5.48	41.99	4.94	3.47
TDC L2AM	5.77	5.23	5.45	5.77	5.73	5.68	5.71	5.91	55.76	5.30	2.01
TDC L2PM	3.84	3.53	3.82	3.82	3.84	3.77	3.76	3.95	34.34	3.60	2.81
XRX L1AM	3.28	3.07	3.20	3.27	3.28	3.25	3.24	3.43	25.34	3.11	2.28
XRX L1PM	4.12	3.76	4.08	4.02	4.12	4.09	4.06	4.40	22.69	4.02	3.67
XRX L2AM	2.91	2.69	2.99	2.91	2.91	2.86	2.87	3.02	25.86	2.75	2.04
XRX L2PM	3.94	3.57	3.93	3.91	3.93	3.91	3.90	4.14	20.56	3.80	3.57

Figure 46: CMB Results: Species-By-Species Comparison: PDP Garage

L1: location and garage entrance/exit, L2: location within garage, AM: 07:30-09:30, PM: 15:00-17:00

Figure 47: CMB Results: Species-By-Species Comparison: TDC Garage

L1: location and garage entrance/exit, L2: location within garage, AM: 07:30-09:30, PM: 15:00-17:00

Figure 48: CMB Results: Species-By-Species Comparison: XRX Garage

L1: location and garage entrance/exit, L2: location within garage, AM: 07:30-09:30, PM: 15:00-17:00

Figure 49: CMB Results: Performance Indicators for Garages PDP, TDC and XRX

L1: location and garage entrance/exit, L2: location within garage, AM: 07:30-09:30, PM: 15:00-17:00

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Figure 49: CMB Results: Performance Indicators for Garages PDP, TDC and XRX

L1: location and garage entrance/exit, L2: location within garage, AM: 07:30-09:30, PM: 15:00-17:00

Table 35: Slater Street Sampling Station 1: 7 AM: VOC Concentrations ($\mu\text{g}/\text{m}^3$)

CURB 7 AM	19-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	7-Sep	8-Sep	9-Sep	12-Sep	13-Sep	14-Sep	16-Sep	19-Sep	20-Sep	21-Sep	MEAN	ST DEV	75th %ile	Max	Min	25th %ile
ethylene	0.47	7.42	8.61	16.68	14.23	16.21	9.89	10.38	10.32	10.12	14.23	10.76	21.58	10.79	13.64	19.71	12.19	5.06	14.72	21.58	0.47	10.06
acetylene + ethane	17.64	2.39	3.58	12.35	8.92	11.13	6.73	7.15	6.81	7.30	9.20	6.31	15.11	8.12	7.96	10.43	8.83	3.62	10.60	17.64	2.39	6.79
propylene	5.65	3.11	2.68	9.11	9.14	8.73	5.11	5.36	5.80	3.98	8.14	5.31	12.08	5.63	7.76	10.39	6.75	2.67	8.82	12.08	2.68	5.26
propane	11.05	6.53	4.31	21.81	18.26	17.78	7.44	10.91	10.65	6.47	14.24	9.37	21.63	14.46	8.87	19.98	12.74	5.71	17.90	21.81	4.31	8.51
isobutane	4.76	1.99	2.36	13.12	11.74	11.79	4.01	4.11	4.88	3.58	10.56	3.19	8.22	5.68	6.55	9.77	6.46	3.60	8.80	13.12	1.99	3.90
isobutylene	2.69	1.54	1.64	4.44	4.11	4.38	2.22	2.49	2.55	2.33	4.78	2.40	4.58	2.42	4.62	3.87	3.19	1.15	4.39	4.78	1.54	2.38
n-butane	8.65	4.45	6.57	24.11	19.35	24.40	6.77	7.42	8.94	7.93	22.25	7.06	14.23	20.76	12.27	12.01	12.95	6.95	19.70	24.40	4.45	7.33
Zm-butane	20.76	9.36	14.49	46.19	38.69	0.00	16.98	19.05	20.73	21.57	46.49	17.52	34.79	39.29	27.20	28.22	25.08	13.16	35.77	46.49	0.00	17.38
n-pentane	6.96	3.72	5.94	15.27	12.69	0.00	5.04	6.72	6.81	7.74	15.63	6.33	10.53	16.41	9.45	9.84	8.69	4.55	11.07	16.41	0.00	6.23
2,2-dim-butane	0.00	0.00	3.51	3.48	2.99	3.26	1.67	1.86	2.02	2.02	3.80	1.67	3.46	2.20	2.15	2.48	2.28	1.14	3.31	3.80	0.00	1.81
Zm-pentane	6.45	4.37	4.98	15.01	11.89	13.94	5.62	8.06	7.38	8.42	13.94	6.48	12.00	12.79	9.89	10.17	9.46	3.47	12.20	15.01	4.37	6.48
3m-pentane	4.30	2.82	3.62	10.75	7.56	11.79	3.51	6.02	5.62	5.30	8.56	4.73	10.50	7.95	5.95	6.66	6.60	2.72	8.11	11.79	2.82	4.62
n-hexane	3.76	2.95	3.47	7.09	7.13	8.45	3.58	5.41	4.87	6.16	8.45	3.90	6.77	9.31	5.41	5.70	5.78	1.97	7.10	9.31	2.95	3.87
m-cyclopentane	2.48	1.94	1.91	5.77	3.95	4.76	2.17	3.32	2.50	4.13	4.93	2.32	4.51	5.28	3.27	3.67	3.56	1.26	4.57	5.77	1.91	2.44
benzene	6.56	3.83	5.13	13.51	10.62	12.31	5.49	7.57	6.92	8.70	12.24	7.40	12.37	12.50	9.77	10.72	9.10	3.06	12.26	13.51	3.83	6.83
cyclohexane	0.91	0.52	0.59	2.58	1.69	1.64	0.80	1.14	1.06	1.77	1.98	0.86	1.62	1.71	1.39	1.21	1.34	0.56	1.70	2.58	0.52	0.90
iso-octane	3.40	4.45	6.27	12.11	8.41	9.83	2.42	15.81	6.65	8.98	11.44	5.60	7.17	18.28	9.31	8.31	8.65	4.25	10.23	18.28	4.45	6.10
n-heptane	2.42	1.42	1.89	3.40	3.38	4.37	1.47	3.22	2.41	4.17	4.33	2.33	4.04	4.79	3.49	3.13	3.14	1.06	4.07	4.79	1.42	2.39
n-octane	15.44	17.28	22.68	40.60	44.43	50.94	10.04	65.50	34.86	60.44	88.10	47.50	35.62	124.87	72.39	43.28	49.62	30.49	67.22	124.87	10.04	31.81
e-benzene	4.11	0.74	1.15	2.42	2.06	2.28	0.93	1.98	1.74	3.22	2.57	1.39	2.52	2.37	2.45	2.29	2.14	0.85	2.46	4.11	0.74	1.65
m,p-xylene	4.29	2.67	2.59	5.91	4.94	5.91	2.79	5.74	3.88	9.00	7.77	4.55	6.66	7.15	6.97	6.09	5.43	1.89	6.74	9.00	2.59	4.19
o-xylene	8.61	6.05	6.49	12.67	10.46	13.46	5.74	14.39	8.92	20.04	17.65	11.52	14.96	17.04	16.02	13.77	12.36	4.36	15.23	20.04	5.74	8.84
n-nonane	4.14	2.47	3.15	5.03	4.30	7.06	2.89	5.96	4.21	7.11	6.89	4.77	7.06	6.05	6.36	5.87	5.21	1.56	6.49	7.11	2.47	4.19
1,2,4-tri benzene	7.68	0.83	0.83	1.05	1.36	1.67	0.61	1.44	1.32	2.03	1.56	1.00	1.73	1.16	1.65	1.57	1.67	1.68	1.66	7.68	0.83	1.04
SUM	9.69	3.24	4.58	6.90	5.45	8.89	4.77	8.04	6.40	9.34	8.04	5.65	10.39	6.55	7.49	8.64	7.13	2.04	8.71	10.39	3.24	5.60
Below Detection Limit (0.05 mg/m ³)	162.9	95.3	123.0	311.4	267.8	255.0	118.7	229.0	178.2	251.8	347.8	180.1	284.1	363.6	262.3	254.8	230.4	80.5				
Below Detection Limit and reported as 0																						

Table 36: Slater Street Sampling Station 2: 7 AM: VOC Concentrations ($\mu\text{g}/\text{m}^3$)

CURB 7 AM	19-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	7-Sep	8-Sep	9-Sep	12-Sep	13-Sep	14-Sep	16-Sep	19-Sep	20-Sep	21-Sep	MEAN	ST DEV	75th %ile	Max	Min	25th %ile
ethylene	0.00	0.00	7.79	12.95	8.27	14.46	12.95	12.48	12.95	12.25	15.16	13.06	17.96	12.48	10.79	15.28	11.18	5.01	13.41	17.96	0.00	10.16
acetylene + ethane	0.00	0.00	3.32	11.82	6.17	11.87	8.74	7.90	8.50	9.27	10.76	8.65	17.39	8.45	6.50	8.95	8.03	-3.34	9.64	17.39	0.00	6.42
propylene	0.00	0.00	3.50	7.68	4.21	8.54	6.71	6.71	7.48	7.08	8.59	8.06	10.68	7.13	6.10	8.68	6.32	3.00	8.18	10.68	0.00	5.63
propane	0.00	0.00	4.62	16.54	11.42	15.77	9.92	7.19	12.21	9.55	11.48	10.28	16.33	13.93	7.19	14.68	10.07	5.21	14.12	16.54	0.00	7.19
isobutane	5.41	1.39	2.03	13.10	8.41	14.14	3.91	4.47	4.18	3.48	7.27	4.18	7.66	4.42	5.53	7.59	6.07	3.55	7.61	14.14	1.39	4.11
isobutylene	3.57	1.12	1.44	4.36	3.19	4.80	2.73	2.68	2.77	2.84	3.70	3.21	3.74	2.91	2.64	3.35	3.07	0.93	3.61	4.80	1.12	2.72
n-butane	9.69	2.90	5.65	22.86	16.89	33.10	6.55	7.90	7.61	7.59	15.27	9.57	12.71	11.98	10.05	13.85	12.14	7.42	14.20	33.10	2.90	7.61
2m-butane	21.66	9.42	13.41	47.39	31.79	0.00	18.09	22.26	20.70	20.97	36.29	23.17	32.69	28.19	22.62	31.49	23.77	11.18	31.57	47.39	0.00	20.04
n-pentane	7.32	2.61	5.37	14.52	10.86	0.00	5.61	7.59	6.69	7.71	11.97	7.95	9.99	12.60	7.80	10.29	8.05	3.70	10.43	14.52	0.00	6.42
2,2-dm-butane	0.00	0.00	2.93	3.35	2.04	4.05	1.95	2.30	2.17	1.93	3.05	2.10	3.21	1.79	1.73	2.39	2.19	1.07	2.96	4.05	0.00	1.89
2m-pentane	6.74	3.24	4.37	13.94	8.67	17.41	6.81	9.60	8.10	8.17	11.89	7.74	11.28	10.96	7.77	11.25	9.25	3.52	11.26	17.41	3.24	7.51
n-hexane	4.62	2.76	2.82	8.99	5.41	10.57	4.26	6.13	5.88	5.30	7.24	5.52	7.38	6.77	4.76	6.81	5.95	2.04	6.91	10.57	2.76	4.73
3m-pentane	3.76	2.86	3.21	7.85	5.12	10.03	3.90	5.41	4.84	5.05	8.17	4.51	5.41	8.06	4.62	5.62	5.53	2.00	6.18	10.03	2.86	4.36
m-cyclopentane	2.62	1.65	1.71	4.44	3.17	4.44	2.47	3.23	2.83	2.89	4.23	2.88	4.83	4.02	2.69	3.33	3.29	1.09	4.08	5.60	1.65	2.67
benzene	7.40	3.38	4.64	10.65	7.57	12.83	6.75	8.77	7.92	9.32	11.85	8.74	14.58	12.40	7.53	9.12	8.97	2.97	10.95	14.58	3.38	7.40
cyclohexane	1.24	0.54	0.52	1.51	1.07	2.14	0.95	1.22	1.07	1.14	1.74	1.00	2.35	1.62	1.01	1.24	1.28	0.50	1.54	2.35	0.52	1.01
n-octane	3.68	4.66	6.36	12.77	7.74	11.78	2.70	16.91	6.89	8.07	13.58	9.40	7.31	16.76	8.41	11.49	9.28	4.28	12.03	16.91	2.70	6.76
n-heptane	2.11	0.84	1.58	3.29	2.43	4.06	1.74	3.29	2.18	2.68	3.59	2.46	5.04	4.33	2.76	2.69	2.82	1.08	3.37	5.04	0.84	2.17
toluene	16.89	16.59	23.90	42.13	41.75	57.46	11.84	74.31	38.69	86.95	94.99	59.37	38.69	127.55	63.97	47.88	52.68	31.58	66.55	127.55	11.84	34.99
n-octane	1.35	1.00	0.73	1.70	1.31	1.91	1.13	1.64	1.40	1.43	1.72	1.25	1.94	1.88	1.34	1.47	1.45	0.34	1.70	1.94	0.73	1.29
n-nonane	3.21	2.16	2.48	5.43	3.74	5.96	3.49	6.75	4.50	6.40	7.72	5.56	7.06	7.55	5.43	5.91	5.21	1.76	6.49	7.72	2.16	3.68
m,p xylene	7.15	4.50	5.61	11.39	7.50	11.65	7.19	16.29	9.97	15.45	16.82	12.58	15.67	17.35	12.76	12.36	11.51	4.17	15.50	17.35	4.50	7.43
o-xylene	2.95	1.81	2.20	4.68	3.09	4.46	2.99	6.00	4.16	5.21	6.37	4.99	6.05	5.61	4.41	4.85	4.36	1.39	5.31	6.27	1.81	3.07
n-nonane	0.86	0.58	0.58	0.58	0.58	1.27	0.76	0.71	0.68	0.83	0.83	0.60	0.89	0.65	0.58	0.76	0.58	0.37	0.78	1.27	0.01	0.44
1,2,4-tri benzene	3.95	2.57	3.02	6.10	3.74	5.30	4.32	7.35	5.85	5.45	7.30	6.35	8.69	5.30	5.45	6.70	5.46	1.66	6.43	8.69	2.57	4.23
SUM	116.19	66.04	113.45	290.00	205.61	269.15	137.69	249.22	190.23	246.84	321.49	223.37	269.52	334.70	214.43	248.04	218.50	77.16				
Below Detection Limit (0.05 mg/m^3)																						
Below Detection Limit and reported as 0																						

Table 37: Slater Street Sampling Station 1: 12 PM: VOC Concentrations ($\mu\text{g}/\text{m}^3$)

CURB 12 PM	19-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	7-Sep	8-Sep	9-Sep	12-Sep	13-Sep	14-Sep	15-Sep	16-Sep	19-Sep	20-Sep	21-Sep	MEAN	ST DEV	75th %ile	Max	Min	25th %ile
ethylene	7.01	6.18	0.00	6.71	10.02	12.13	9.35	7.63	8.11	9.05	13.76	7.74	16.56	18.08	8.62	9.66	10.95	9.40	4.15	10.95	18.08	0.00	7.63
acetylene	2.93	2.06	13.44	4.53	7.51	8.29	5.05	5.78	3.60	2.86	6.58	2.80	8.73	13.01	5.64	5.20	7.04	5.13	3.19	7.51	13.44	2.06	3.60
propylene	2.42	2.38	4.76	4.36	5.31	6.73	4.78	4.00	4.31	4.45	6.85	5.30	8.28	10.36	5.18	5.38	5.73	5.33	1.95	5.73	10.36	2.38	4.36
propane	5.32	4.00	6.25	5.76	10.56	14.96	8.69	5.11	8.23	7.02	27.50	5.79	15.45	21.08	7.59	6.47	14.08	10.23	6.44	14.08	27.50	4.00	5.79
isobutane	3.58	1.40	4.64	4.59	7.73	8.07	2.97	3.96	2.88	4.74	4.08	3.09	17.03	8.02	3.26	4.86	15.80	6.22	4.44	8.02	17.03	1.40	3.26
isobutylene	2.33	1.31	3.54	2.73	2.82	3.24	2.09	2.03	2.18	2.60	2.58	3.08	5.32	4.56	2.03	2.42	3.85	2.87	1.00	3.24	5.32	1.31	2.18
n-butane	6.79	2.92	7.95	45.91	13.65	10.87	5.32	7.66	5.63	9.09	7.97	8.14	27.79	14.47	10.00	9.40	26.58	12.95	10.86	13.65	45.91	2.92	7.66
2m-butane	14.25	5.07	19.53	62.99	28.67	23.64	14.25	20.91	16.29	24.77	20.91	17.46	57.29	35.99	22.53	23.85	49.19	26.92	15.77	28.67	62.99	5.07	17.46
n-pentane	4.80	2.49	5.94	0.00	8.46	7.23	4.38	6.42	5.16	7.20	6.90	5.76	14.22	10.98	9.30	7.44	11.58	6.96	3.39	8.46	14.22	2.49	5.94
22-dm-butane	0.00	4.44	1.41	1.63	2.07	1.96	1.59	2.11	1.74	2.12	2.18	1.39	3.98	3.73	1.58	2.05	2.86	2.17	1.07	2.18	4.44	0.00	1.59
2m-pentane	4.19	3.45	6.95	14.29	8.42	7.31	5.41	7.85	6.63	8.38	7.52	5.80	12.29	12.83	8.56	7.99	10.03	8.11	2.92	8.56	14.29	3.45	6.63
3m-pentane	2.74	1.88	8.74	9.31	6.05	4.48	3.29	5.12	4.41	5.66	4.94	6.41	7.81	8.31	5.27	4.87	6.31	5.62	2.07	6.41	9.31	1.88	4.48
n-hexane	2.37	2.01	3.39	0.00	4.80	4.73	3.45	4.51	3.76	4.26	4.33	3.05	5.30	6.13	5.88	4.01	3.94	3.88	1.49	4.73	6.13	2.01	3.39
m-cyclopentane	1.61	1.35	2.78	3.57	2.61	2.60	1.89	2.72	2.43	2.79	2.82	2.17	3.85	4.55	3.01	2.83	2.97	2.74	0.78	2.97	4.55	1.35	2.43
benzene	4.38	2.84	6.14	7.47	6.98	8.77	5.36	6.17	5.72	7.01	7.50	5.72	9.77	11.11	8.38	6.88	6.85	6.89	1.96	7.50	11.11	2.84	5.72
cyclohexane	0.66	0.37	0.88	1.29	0.97	2.11	0.75	1.09	0.86	0.98	1.04	0.64	1.28	1.80	1.16	0.94	0.88	1.04	0.42	1.16	2.11	0.37	0.88
iso-octane	2.32	2.80	5.13	0.00	4.34	4.61	2.20	6.98	3.65	4.57	4.99	5.27	4.63	6.03	13.72	6.17	4.44	4.83	2.85	5.27	13.72	2.80	5.13
n-heptane	1.32	1.00	1.88	3.16	2.04	2.44	1.47	2.23	1.91	2.15	2.28	1.67	2.69	3.41	3.04	2.51	2.00	2.19	0.65	2.51	3.41	1.00	1.88
toluene	11.76	12.41	21.83	0.00	23.40	27.66	9.54	38.30	22.94	55.54	46.35	44.82	35.97	32.29	85.42	49.80	29.15	32.19	20.55	44.82	85.42	12.41	21.83
n-octane	1.27	0.53	1.22	1.54	1.12	3.15	0.85	1.26	0.96	1.24	1.36	1.01	1.74	1.97	1.33	1.29	1.19	1.36	0.57	1.36	3.15	0.53	1.22
p-benzene	3.12	1.81	4.16	3.78	3.66	5.16	2.98	4.81	3.85	4.94	5.21	4.55	5.52	7.19	5.65	5.30	4.34	4.47	1.24	5.52	7.19	1.81	3.78
m,p-xylene	7.19	4.00	10.72	8.56	7.50	10.37	6.00	10.59	8.25	11.92	11.39	11.21	13.51	15.05	13.15	11.87	9.05	10.02	2.87	11.87	15.05	4.00	8.25
o-xylene	2.93	1.60	7.37	3.57	4.03	4.81	2.67	4.26	3.37	4.26	4.40	4.46	5.61	5.91	4.35	4.46	3.65	4.22	1.31	4.46	7.37	1.60	3.57
n-nonane			0.84	0.73		3.85							1.10	0.86			0.54	0.48	0.95	0.73	3.85	0.00	0.01
1,24-tm benzene	4.46	2.04	7.10	4.13	5.30	0.00	3.89	5.95	4.59	4.89	5.35	5.30	7.20	7.54	4.53	5.80	6.10	4.95	1.86	5.95	7.54	0.00	4.46
SUM	99.8	70.4	156.6	205.6	178.3	189.1	108.2	167.5	131.5	192.5	208.8	162.7	292.9	265.3	239.2	191.4	239.1	182.3	59.0				
Below Detection Limit (0.05 mg/m ³)																							
Below Detection Limit and reported as 0																							

Table 38: Slater Street Sampling Station 2: 12 PM: VOC Concentrations ($\mu\text{g}/\text{m}^3$)

CURB 12 PM	19-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	7-Sep	8-Sep	9-Sep	12-Sep	13-Sep	14-Sep	15-Sep	16-Sep	19-Sep	20-Sep	21-Sep	MEAN	ST DEV	75th %ile	Max	Min	25th %ile
ethylene	4.42	5.43	0.00	2.64	6.89	6.23	8.36	9.95	10.17	9.45	11.58	7.52	6.27	12.83	8.71	9.20	7.67	7.49	3.20	9.45	12.83	0.00	6.23
acetylene + ethane	0.99	2.85	6.13	1.85	4.49	4.39	5.27	6.57	2.57	2.84	9.75	6.82	4.79	9.55	6.60	5.77	5.25	5.10	2.44	6.57	9.75	0.99	2.85
propylene	2.96	2.10	6.06	1.64	4.18	3.18	4.65	5.26	5.36	4.73	7.30	6.26	3.65	7.21	5.43	5.46	4.35	4.69	1.62	5.46	7.30	1.64	3.65
propane	5.46	3.43	5.30	2.93	7.55	7.30	7.55	7.17	8.69	10.39	16.33	4.93	8.67	18.70	9.68	7.11	9.15	8.26	4.07	9.15	18.70	2.93	5.46
isobutane	3.60	2.07	4.45	3.14	7.22	4.76	3.91	4.20	3.41	3.50	6.62	3.60	11.65	7.03	3.38	4.42	12.81	5.28	2.97	6.62	12.81	2.07	3.50
isobutylene	1.63	1.98	3.61	1.30	2.73	1.68	2.27	2.47	2.38	2.40	2.93	3.24	3.78	2.88	2.16	2.33	3.35	2.55	0.70	3.24	3.78	1.30	2.16
n-butane	5.82	3.96	7.64	9.69	12.44	9.67	10.51	8.12	7.18	6.77	23.15	9.62	19.02	12.01	10.44	9.01	22.45	11.03	5.50	12.01	23.15	3.96	7.64
2m-pentane	10.83	9.63	17.07	0.00	24.50	18.33	24.89	21.60	18.42	18.63	36.29	18.33	37.79	28.31	23.31	21.99	43.10	21.95	10.60	24.89	43.10	9.63	17.07
n-pentane	3.72	2.77	5.34	0.00	7.29	6.18	7.23	6.90	5.70	5.76	11.76	6.18	8.82	8.73	9.84	7.17	10.38	6.69	2.87	8.73	11.76	2.77	5.34
2,2-dim-butane	0.00	4.66	1.13	0.72	1.68	1.19	1.72	2.26	1.87	1.67	2.02	1.31	2.34	2.82	1.60	1.81	2.42	1.84	0.99	2.26	4.66	0.00	1.13
2m-pentane	3.07	2.79	5.48	0.00	6.74	5.19	6.84	8.10	6.77	6.48	8.85	6.20	8.13	9.85	8.81	7.85	8.92	6.48	2.57	8.13	9.85	0.00	5.48
n-pentane	1.80	2.96	3.27	4.73	7.92	3.15	4.05	5.41	4.87	4.73	5.48	3.14	8.56	7.45	5.45	4.73	6.27	4.94	1.85	5.48	7.92	1.80	3.27
n-hexane	1.81	2.17	2.91	0.00	3.69	3.10	4.08	4.73	3.94	4.51	5.52	2.89	4.44	5.45	6.38	4.12	4.01	3.75	1.51	4.51	6.38	0.00	2.91
m-cyclopentane	1.04	1.33	1.95	1.93	3.20	2.16	2.18	2.80	2.39	2.92	2.88	1.79	2.88	3.43	3.25	2.71	2.90	2.46	0.68	2.90	3.43	1.04	1.95
benzene	3.04	2.94	5.98	2.56	5.52	4.84	5.16	6.92	6.59	6.79	8.09	5.68	5.49	8.18	9.16	6.82	5.81	5.87	1.83	6.82	9.16	2.56	5.98
cyclohexane	0.56	0.41	0.66	0.44	1.10	0.71	0.84	1.07	0.86	0.91	1.15	0.62	0.92	1.37	1.27	0.96	0.87	0.86	0.28	1.07	1.37	0.41	0.66
iso-octane	1.63	4.59	5.56	0.00	6.03	4.46	5.56	8.31	4.72	4.84	14.29	7.17	4.60	6.17	13.91	7.27	5.89	6.18	3.57	7.17	14.29	0.00	4.46
n-heptane	2.34	1.22	1.90	0.83	2.51	1.16	1.59	2.34	2.02	2.10	2.69	1.58	2.06	2.74	3.47	2.48	1.80	2.05	0.66	2.48	3.47	0.83	1.59
toluene	8.01	15.36	23.40	0.00	21.37	27.73	12.03	43.28	26.70	59.37	69.33	47.11	32.56	30.87	99.21	58.99	33.55	35.82	25.01	47.11	99.21	0.00	21.37
n-octane	0.66	0.64	1.64	0.48	0.85	0.89	1.06	1.36	1.00	1.01	1.34	0.91	1.42	1.60	1.59	1.34	1.07	1.11	0.35	1.36	1.64	0.48	0.89
p-benzene	1.49	2.17	3.41	1.88	2.90	3.35	2.81	5.34	4.06	4.94	5.78	4.29	3.89	6.09	6.53	5.91	4.38	4.07	1.54	5.34	6.53	1.49	2.90
m,p xylene	3.12	4.85	7.41	3.57	6.58	6.89	5.74	11.92	8.78	11.52	13.90	10.90	10.68	13.33	15.27	13.02	9.18	9.22	3.74	11.92	15.27	3.12	6.58
o-xylene	1.31	2.18	3.19	2.18	4.85	2.96	2.36	4.81	3.65	4.18	5.03	3.66	5.52	5.65	5.08	4.81	3.94	3.84	1.31	4.85	5.65	1.31	2.96
n-nonane	0.05	0.77	0.77	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
1,2,4-trim benzene	1.56	3.06	4.86	2.82	4.07	0.00	3.64	6.70	5.35	5.20	6.20	4.67	11.79	7.69	5.30	6.10	6.40	5.02	2.61	6.20	11.79	0.00	3.06
SUM	70.9	85.6	129.1	45.3	156.4	129.5	134.5	187.6	147.7	185.7	278.3	168.5	211.3	220.7	265.9	201.4	216.2	166.7	64.4	265.9	220.7	166.7	64.4
Below Detection Limit (0.05 mg/m ³)																							
Below Detection Limit and reported as 0																							

Table 43: Annual Statistical Measures NAPS Slater Street Data: VOC Concentrations ($\mu\text{g}/\text{m}^3$)

	Annual Mean	Standard Deviation	25th Percentile	75th Percentile	Maximum	Minimum
ethylene	6.27	3.45	3.88	8.03	17.63	1.27
ethane + acetylene	8.62	4.01	5.61	10.68	22.95	2.52
propylene	2.65	1.60	1.55	3.46	8.70	0.42
propane	8.17	4.69	5.38	11.23	24.19	1.29
isobutane	4.34	2.78	2.48	5.89	13.65	0.54
isobutylene	2.10	1.18	1.42	2.59	6.05	0.24
n-butane	7.59	6.18	3.43	9.12	35.71	0.90
2m-pentane	8.00	4.47	5.09	10.80	21.46	1.84
n-pentane	3.55	2.05	2.33	4.46	11.25	0.76
22dm-butane	0.70	0.37	0.47	0.87	1.78	0.17
2m-pentane	3.30	1.66	2.30	4.03	8.26	0.75
3m-pentane	2.02	1.07	1.32	2.49	5.35	0.50
n-hexane	1.86	1.11	1.12	2.34	5.33	0.34
m-cyclopentane	1.06	0.56	0.68	1.31	2.66	0.25
benzene	3.73	1.94	2.55	4.75	10.34	0.90
cyclohexane	0.32	0.19	0.20	0.40	1.07	0.05
iso-octane	0.68	0.44	0.41	0.87	2.52	0.12
n-heptane	0.82	0.44	0.51	1.04	2.12	0.17
toluene	8.53	5.44	4.97	10.42	26.94	1.70
n-octane	0.36	0.19	0.23	0.47	0.93	0.10
e-benzene	1.75	0.96	1.09	2.25	5.05	0.34
m&p-xylene	4.99	2.83	2.87	6.66	15.42	0.80
o-xylene	1.93	1.07	1.18	2.61	5.64	0.35
nonane	0.45	0.29	0.28	0.51	1.89	0.09
1,2,4-trimethylbenzene	1.83	1.16	1.10	2.39	5.87	0.00

Table 45: Slater Street Sampling Station 1: Daily Normalized Receptor Profiles: 7 AM

CURB 7 AM	19-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	7-Sep	8-Sep	9-Sep	12-Sep	13-Sep	14-Sep	16-Sep	19-Sep	20-Sep	21-Sep	MEAN	ST.DEV.
ethylene	0.29	7.79	7.00	5.36	5.31	6.36	8.33	4.53	5.79	4.02	4.09	5.98	7.59	2.97	5.20	7.74	5.52	2.08
acetylene + ethane	10.83	2.51	2.91	3.97	3.33	4.36	5.67	3.12	3.82	2.90	2.65	3.61	5.32	2.23	3.03	4.09	4.02	2.05
propylene	3.47	3.27	2.18	2.93	3.41	3.42	4.31	2.34	3.25	1.58	2.34	2.95	4.25	1.55	2.96	4.08	3.02	0.85
propane	6.79	6.85	3.50	7.01	6.82	6.97	6.27	4.76	5.98	2.57	4.10	5.20	7.61	3.98	3.38	7.84	5.60	1.68
isobutane	2.92	2.09	1.92	4.21	4.39	4.62	3.38	1.79	2.74	1.42	3.04	1.77	2.89	1.56	2.50	2.66	2.74	1.00
isobutylene	1.65	1.61	1.34	1.42	1.53	1.72	1.87	1.09	1.43	0.92	1.38	1.33	1.61	0.67	1.76	1.52	1.43	0.32
n-butane	5.31	4.67	5.34	7.74	7.23	9.57	5.70	3.24	5.02	3.15	6.40	3.92	5.01	5.71	4.68	4.71	5.46	1.66
2m-butane	12.74	9.82	11.78	14.83	14.45	0.00	14.31	8.32	11.63	8.56	13.37	9.73	12.24	10.81	10.37	11.08	10.88	3.52
n-pentane	4.27	3.90	4.83	4.90	4.74	0.00	4.25	2.93	3.82	3.07	4.49	3.51	3.71	4.51	3.60	3.86	3.78	1.17
22-dim-butane	0.00	0.00	2.85	1.12	1.12	1.28	1.40	0.81	1.13	0.80	1.09	0.92	1.22	0.60	0.82	0.97	1.01	0.64
2m-pentane	3.96	4.59	4.05	4.82	4.44	5.47	4.74	3.52	4.14	3.34	4.01	3.60	4.22	3.52	3.77	3.99	4.14	0.57
3m-pentane	2.64	2.96	2.94	3.45	2.82	4.62	2.96	2.63	3.16	2.11	2.46	2.63	3.69	2.19	2.27	2.62	2.88	0.63
n-hexane	2.31	3.09	2.82	2.28	2.66	3.32	3.02	2.36	2.73	2.45	2.43	2.17	2.38	2.56	2.06	2.24	2.56	0.36
m-cyclopentane	1.52	2.03	1.55	1.85	1.48	1.87	1.83	1.45	1.40	1.64	1.42	1.29	1.59	1.45	1.25	1.44	1.57	0.22
benzene	4.03	4.02	4.17	4.34	3.97	4.83	4.62	3.30	3.88	3.46	3.52	4.11	4.35	3.44	3.73	4.21	4.00	0.43
cyclohexane	0.56	0.55	0.48	0.83	0.63	0.64	0.67	0.50	0.59	0.70	0.57	0.48	0.57	0.47	0.53	0.47	0.58	0.10
iso-octane	2.08	4.67	5.10	3.89	3.14	3.85	2.04	6.90	3.73	3.56	3.29	3.11	2.52	5.03	3.55	3.26	3.73	1.23
n-heptane	1.49	1.50	1.54	1.09	1.26	1.72	1.24	1.40	1.35	1.65	1.25	1.29	1.42	1.32	1.33	1.23	1.38	0.17
toluene	9.48	18.13	18.43	13.04	16.59	19.98	8.46	28.60	19.56	31.94	25.33	26.37	12.54	34.35	27.60	16.99	20.46	7.83
n-octane	2.52	0.77	0.93	0.78	0.77	0.90	0.78	0.86	0.98	1.28	0.74	0.77	0.89	0.65	0.93	0.90	0.97	0.44
e-benzene	2.64	2.80	2.11	1.90	1.85	2.32	2.35	2.51	2.18	3.58	2.23	2.52	2.35	1.97	2.66	2.39	2.40	0.42
m&p xylene	5.28	6.35	5.27	4.07	3.91	5.28	4.83	6.28	5.00	7.96	5.08	6.40	5.27	4.69	6.11	5.40	5.45	0.99
o-xylene	2.54	2.59	2.56	1.62	1.61	2.77	2.44	2.60	2.36	2.82	1.98	2.65	2.49	1.66	2.42	2.30	2.34	0.40
n-nonane	4.71	3.40	0.68	0.34	0.51	0.65	0.51	0.63	0.74	0.81	0.45	0.56	0.61	0.32	0.63	0.62	0.80	1.06
124-m benzene	5.95	3.40	3.72	2.21	2.03	3.49	4.02	3.51	3.59	3.71	2.31	3.13	3.66	1.80	2.86	3.39	3.30	0.98
SUM	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00		
Below Detection Limit (0.05 µg/m³)																		
Below Detection Limited and reported as 0.																		

Table 48: Slater Street Sampling Station 2: Daily Normalized Receptor Profiles: 12 PM

CURB 12 PM	19-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	7-Sep	8-Sep	9-Sep	12-Sep	13-Sep	14-Sep	15-Sep	16-Sep	19-Sep	20-Sep	21-Sep	MEAN	ST DEV
ethylene	6.23	6.35	0.00	5.81	4.41	4.81	6.22	5.30	6.89	5.09	4.16	4.46	2.97	5.81	3.28	4.57	3.55	4.70	1.66
acetylene + ethane	1.40	3.33	4.74	4.07	2.87	3.39	3.92	3.50	1.74	1.53	3.50	4.05	2.27	4.32	2.48	2.87	2.52	3.09	1.00
propylene	4.18	2.45	4.70	3.62	2.67	2.46	3.45	2.81	3.63	2.55	2.62	3.72	1.73	3.27	2.04	2.71	2.01	2.98	0.81
propane	7.70	4.01	4.10	6.47	4.83	5.63	5.62	3.82	5.88	5.60	5.87	2.93	4.10	8.47	3.64	3.53	4.23	5.08	1.52
isobutylene	5.08	2.42	3.44	6.93	4.62	3.67	2.91	2.24	2.31	1.89	2.38	2.14	5.51	3.19	1.27	2.20	5.92	3.42	1.63
isobutylene	2.30	2.31	2.80	2.87	1.75	1.30	1.69	1.32	1.75	1.29	1.05	1.93	1.79	1.30	0.81	1.16	1.55	1.70	0.59
n-butane	8.21	4.63	5.91	21.37	7.96	7.46	7.81	4.33	4.86	3.64	8.32	5.71	9.00	5.44	3.93	4.47	10.38	7.26	4.15
2m-butane	15.27	11.25	13.22	0.00	15.67	14.15	18.51	11.51	12.47	10.03	13.04	10.88	17.89	12.83	8.77	10.92	19.98	12.73	4.51
n-pentane	5.24	3.24	4.14	0.00	4.66	4.77	5.37	3.68	3.86	3.10	4.23	3.67	4.17	3.95	3.70	3.56	4.80	3.89	1.20
22-dm-butane	0.00	5.44	0.88	1.58	1.07	0.92	1.28	1.20	1.27	0.90	0.72	0.78	1.11	1.28	0.60	0.90	1.12	1.24	1.14
3m-pentane	4.32	3.27	4.25	0.00	4.31	4.01	5.09	4.32	4.58	3.49	3.18	3.68	3.85	4.46	3.31	3.90	4.13	3.77	1.10
3m-pentane	2.54	3.46	2.53	10.43	5.06	2.43	3.01	2.88	3.30	2.55	1.97	1.86	4.05	3.38	2.05	2.35	2.90	3.34	2.00
n-hexane	2.55	2.53	2.25	0.00	2.36	2.39	3.04	2.52	2.67	2.43	1.98	1.71	2.10	2.47	2.40	2.05	1.86	2.19	0.65
m-cyclopentane	1.47	1.56	1.51	4.27	2.05	1.67	1.62	1.49	1.62	1.57	1.03	1.06	1.36	1.55	1.22	1.34	1.34	1.63	0.72
benzene	4.28	3.43	4.63	5.65	3.53	3.74	3.98	3.69	4.46	3.66	2.91	3.37	2.60	3.71	3.44	3.39	2.69	3.71	0.75
cyclohexane	0.78	0.47	0.51	0.97	0.70	0.55	0.62	0.57	0.58	0.49	0.41	0.37	0.44	0.62	0.48	0.47	0.40	0.56	0.15
iso-octane	2.30	5.37	4.30	0.00	3.86	3.44	4.13	4.43	3.19	2.61	5.14	4.26	2.18	2.80	5.23	3.61	2.72	3.50	1.35
n-heptane	3.30	1.43	1.47	1.83	1.60	0.90	1.18	1.25	1.37	1.13	0.97	0.94	0.97	1.24	1.31	1.23	0.83	1.35	0.57
toluene	11.29	17.95	18.13	0.00	13.67	21.41	8.94	23.08	18.08	31.98	24.91	27.96	15.41	13.99	37.32	29.29	15.52	19.35	9.18
n-octane	0.94	0.74	1.27	1.07	0.54	0.69	0.79	0.73	0.68	0.54	0.48	0.54	0.67	0.73	0.60	0.66	0.50	0.72	0.21
e-benzene	2.10	2.53	2.64	4.14	1.85	2.59	2.09	2.85	2.75	2.66	2.08	2.55	1.84	2.76	2.46	2.94	2.02	2.52	0.55
m&p xylene	4.40	5.67	5.74	7.87	4.21	5.32	4.27	6.35	5.95	6.20	5.00	6.47	5.05	6.04	5.74	6.46	4.25	5.59	0.99
n-xylene	1.85	2.55	2.47	4.80	3.11	2.29	1.75	2.56	2.47	2.25	1.81	2.17	2.61	2.56	1.91	2.39	1.82	2.43	0.71
n-nonane	0.07	0.59	0.59	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.75	0.35	0.00	0.00	0.00	0.12	0.22
124-4m benzene	2.20	3.57	3.77	6.23	2.60	0.00	2.71	3.57	3.62	2.80	2.23	2.77	5.58	3.49	1.99	3.03	2.96	3.12	1.38
SUM	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Below Detection Limit (0.05 µg/m³)																			
Below Detection Limited and reported as 0.																			

Table 49: Slater Street Sampling Station 1: Daily Normalized Receptor Profiles: 3 PM

CURB 3 PM	18-Aug	19-Aug	22-Aug	23-Aug	24-Aug	25-Aug	7-Sep	8-Sep	9-Sep	13-Sep	14-Sep	15-Sep	16-Sep	19-Sep	20-Sep	21-Sep	MEAN	ST. DEV.
ethylene	4.10	9.44	9.92	7.12	6.99	6.96	8.17	6.65	8.62	7.41	7.69	7.39	5.68	4.84	5.34	8.83	7.20	1.63
acetylene + ethane	2.67	3.55	4.67	4.87	4.24	5.34	4.71	3.74	2.14	5.51	5.60	5.11	4.44	3.64	3.31	5.07	4.29	1.02
propylene	2.02	3.29	2.88	4.79	4.06	4.11	5.04	2.30	5.13	4.29	4.44	4.47	3.49	3.06	3.44	4.95	3.86	0.97
propane	6.10	5.21	3.31	3.30	6.32	4.33	7.48	2.60	4.94	5.73	2.80	3.90	6.08	3.35	3.56	5.01	4.63	1.45
isobutane	0.00	3.11	1.93	2.02	2.11	2.44	2.45	2.49	1.92	2.55	1.78	2.70	3.28	1.47	2.56	2.33	2.16	0.74
isobutylene	1.08	2.35	1.81	2.41	2.00	1.78	2.12	1.73	1.96	1.71	1.81	1.75	1.55	1.18	1.45	1.79	1.78	0.36
n-butane	17.10	5.67	4.36	4.53	4.64	5.32	4.39	4.87	3.85	4.65	3.97	4.23	6.34	3.99	4.85	4.57	5.46	3.17
2m-butane	24.37	12.96	12.05	13.39	10.47	13.38	13.83	12.13	11.95	13.00	11.67	11.52	13.79	9.78	13.10	11.22	13.04	3.24
n-pentane	0.00	4.46	3.81	4.39	3.50	4.12	3.98	3.86	3.66	3.94	3.66	3.48	4.14	3.66	3.99	3.55	3.64	1.01
22-dim-butane	0.00	0.00	3.57	0.00	0.91	1.09	1.42	1.15	1.33	1.36	1.25	1.24	1.34	0.73	1.18	1.13	1.11	0.83
2m-pentane	5.92	4.30	4.48	5.11	3.89	4.69	5.16	4.40	4.80	4.52	4.38	4.44	4.45	3.62	4.75	4.34	4.58	0.53
3m-pentane	3.51	2.78	2.82	2.96	3.65	5.17	3.35	3.42	4.11	2.98	3.42	3.14	3.65	2.34	3.14	2.87	3.33	0.65
n-hexane	0.00	2.58	2.51	3.07	2.09	2.54	2.94	2.74	2.22	2.24	2.09	2.49	2.35	2.40	2.29	1.93	2.28	0.68
m-cyclopentane	1.69	1.73	1.84	1.76	1.90	1.57	1.80	1.56	1.67	1.60	1.59	1.84	1.54	1.38	1.70	1.39	1.66	0.15
benzene	2.78	4.50	4.63	4.82	5.02	4.52	4.81	4.36	5.04	4.18	4.51	4.24	3.83	3.83	3.68	4.31	4.32	0.58
cyclohexane	0.87	0.76	0.46	0.55	0.61	0.75	0.72	0.60	0.67	0.63	0.61	0.65	0.66	0.51	0.64	0.53	0.64	0.10
iso-octane	0.00	2.69	2.96	3.09	3.56	2.57	1.71	3.22	2.47	1.77	2.14	2.24	2.15	3.78	2.65	2.28	2.46	0.88
n-heptane	1.14	1.71	1.42	1.54	1.48	1.49	1.17	1.45	1.30	1.18	1.21	1.26	1.21	1.30	1.42	1.14	1.34	0.17
toluene	12.88	10.36	14.25	14.01	15.35	12.08	8.61	19.14	14.60	15.99	16.84	17.16	11.79	30.83	20.11	15.13	15.57	5.07
n-octane	0.65	1.57	0.86	1.06	0.96	0.90	0.93	0.79	0.86	0.76	0.75	0.83	0.81	0.67	0.89	0.83	0.88	0.21
e-benzene	1.89	3.09	2.97	2.91	2.65	2.61	2.71	3.04	3.05	2.64	3.11	2.85	2.91	2.66	3.09	2.80	2.81	0.30
m&p xylene	4.56	5.41	6.33	6.14	5.43	5.14	5.51	6.44	6.29	5.71	6.52	6.45	6.20	6.07	6.56	6.03	5.92	0.57
o-xylene	1.99	2.78	2.55	2.55	2.94	2.88	2.81	2.74	2.81	2.23	3.46	2.65	3.23	2.07	2.50	2.56	2.67	0.38
n-nonane	0.78	0.87		0.42	0.83	0.35	0.41	0.39	0.42	0.35	0.30	0.50	0.38	0.26	0.35	0.54	0.45	0.22
124-tm benzene	3.89	4.83	3.58	3.21	4.41	3.86	3.77	4.20	4.20	3.05	4.42	3.98	4.70	2.56	3.44	4.87	3.94	0.66
SUM	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00		
Below Detection Limit (0.05 µg/m³)																		
Below Detection Limited and reported as 0.																		

Table S1: Slater Street Sampling Station 1: Daily Normalized Receptor Profiles: 10 PM

CURB 10 PM	15-Sep	16-Sep	19-Sep	20-Sep	MEAN	ST.DEV.
ethylene	5.79	4.26	3.46	5.12	4.66	1.01
acetylene + ethane	4.52	3.87	2.67	3.41	3.62	0.78
propylene	3.06	2.47	2.04	2.83	2.60	0.45
propane	8.94	6.71	3.60	4.69	5.99	2.36
isobutane	1.89	2.31	1.03	1.98	1.80	0.55
isobutylene	1.08	1.39	0.76	1.21	1.11	0.26
n-butane	4.38	6.89	2.76	4.19	4.56	1.72
2m-butane	10.27	12.63	6.99	10.60	10.12	2.34
n-pentane	3.65	4.69	3.03	3.88	3.81	0.69
22-dm-butane	0.84	0.85	0.53	0.85	0.77	0.16
2m-pentane	3.77	3.73	2.78	3.83	3.53	0.50
3m-pentane	2.85	2.27	1.78	2.28	2.30	0.44
n-hexane	1.99	1.96	2.07	2.37	2.10	0.19
m-cyclopentane	1.35	1.93	1.08	1.42	1.44	0.36
benzene	3.60	3.24	3.22	3.41	3.37	0.18
cyclohexane	0.55		0.41	0.47	0.37	0.23
iso-octane	3.78	3.68	4.84	4.01	4.08	0.53
n-heptane	1.31	1.24	1.24	1.17	1.24	0.06
toluene	20.42	20.70	40.88	27.22	27.30	9.58
n-octane	0.80		0.59	0.62	0.51	0.35
c-benzene	2.93	2.63	2.80	2.88	2.81	0.13
m&p xylene	6.34	6.12	6.75	6.37	6.39	0.26
o-xylene	2.55	2.48	2.23	2.30	2.39	0.15
n-nonane	0.33				0.11	0.15
124-tm benzene	2.98	3.86	2.45	2.86	3.04	0.59
SUM	100.00	100.00	100.00	100.00		
Below Detection Limit (0.05 µg/m ³)						
Below Detection Limited and reported as 0.						

Table 52: Slater Street Sampling Station 2: Daily Normalized Receptor Profiles: 10 PM

CURB 10 PM	15-Sep	16-Sep	19-Sep	20-Sep	MEAN	ST DEV
ethylene	4.46	3.42	3.52	4.58	4.00	0.61
acetylene + ethane	4.84	3.58	2.48	3.09	3.50	1.00
propylene	2.75	3.62	2.06	2.57	2.75	0.65
propane	3.67	5.48	4.02	4.00	4.29	0.81
isobutane	1.97	2.82	1.22	1.99	2.00	0.65
isobutylene	1.13	1.74	0.83	1.07	1.20	0.39
n-butane	5.42	6.99	3.22	4.76	5.10	1.56
2m-butane	13.03	12.31	7.78	10.24	10.84	2.36
n-pentane	4.50	4.44	3.22	3.80	3.99	0.60
22-dm-butane	1.01	0.62	0.50	0.82	0.74	0.23
2m-pentane	4.66	3.40	3.28	3.51	3.72	0.64
3m-pentane	3.07	1.96	1.99	2.36	2.34	0.52
n-hexane	2.42	1.83	2.36	2.38	2.25	0.28
m-cyclopentane	1.69	1.11	1.25	1.49	1.38	0.26
benzene	3.79	2.90	3.21	3.33	3.31	0.37
cyclohexane	0.58		0.51	0.49	0.40	0.24
iso-octane	4.87	3.31	4.32	4.35	4.21	0.65
n-heptane	1.42	2.23	1.25	1.15	1.51	0.49
toluene	20.00	19.45	38.81	28.62	26.72	9.09
n-octane	0.75	1.06	0.60	0.61	0.76	0.22
e-benzene	2.67	2.55	2.72	2.93	2.72	0.16
m&p xylene	5.81	5.95	6.47	6.53	6.19	0.36
o-xylene	2.31	2.46	2.11	2.42	2.33	0.16
n-nonane		1.21			0.32	0.60
124-tm benzene	3.15	5.52	2.26	2.87	3.45	1.43
SUM	100.00	100.00	100.00	100.00		
Below Detection Limit (0.05 µg/m ³)						
Below Detection Limited and reported as 0.						

Table 53: Slater Street NAPS Sampling Station: Aug. – Sept. Daily Normalized Receptor Profiles

Concentration (mg/m ³)	18-Aug	24-Aug	30-Aug	5-Sep	11-Sep	17-Sep	23-Sep	29-Sep
ethylene	7.32	6.72	8.37	7.64	8.03	7.89	8.82	9.09
ethane + acetylene	9.59	7.06	9.49	12.41	14.80	12.88	10.80	9.56
propylene	2.69	2.61	3.16	2.44	2.77	2.44	2.98	3.27
propane	7.92	8.30	7.49	7.31	8.57	8.66	9.08	10.86
isobutane	3.07	3.46	3.73	3.27	2.22	3.15	3.05	3.44
isobutylene	2.11	2.02	2.58	2.52	2.56	2.21	2.36	2.57
n-butane	5.43	5.76	5.54	5.14	3.70	5.78	5.47	5.70
2m-pentane	11.02	11.20	11.50	10.67	7.94	9.79	10.09	9.94
n-pentane	4.20	4.01	4.03	3.84	3.13	4.10	4.09	3.92
22dm-butane	0.91	0.95	0.96	0.95	0.71	0.89	0.88	0.83
2m-pentane	4.89	4.27	4.39	7.51	10.13	4.87	4.93	3.87
3m-pentane	2.67	2.69	2.72	2.56	2.06	2.31	2.42	2.42
n-hexane	2.27	2.31	1.97	2.01	1.41	2.09	1.85	1.97
m-cyclopentane	1.39	1.38	1.50	1.43	1.15	1.25	1.32	1.29
benzene	4.25	3.89	4.81	4.86	4.82	4.17	4.62	4.35
cyclohexane	0.37	0.37	0.46	0.39	0.34	0.35	0.40	0.39
iso-octane	0.81	0.71	0.71	0.67	0.50	0.67	0.80	0.79
n-heptane	1.00	1.04	1.07	0.96	0.91	0.95	0.96	0.95
toluene	10.10	17.98	10.08	9.41	9.03	9.60	10.34	10.40
n-octane	0.46	0.48	0.49	0.41	0.40	0.45	0.51	0.47
e-benzene	2.55	2.00	2.28	1.99	2.17	2.25	2.19	2.17
m&p-xylene	7.31	5.77	6.67	5.70	6.55	6.85	6.32	6.28
o-xylene	2.58	2.09	2.39	2.06	2.36	2.38	2.40	2.36
nonane	1.81	0.48	0.56	0.43	0.44	0.48	0.49	0.54
1,2,4-trimethylbenzene	3.28	2.47	3.05	3.42	3.30	3.56	2.82	2.57
SUM	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Below Detection Limit (0.05 mg/m ³)								
Below Detection Limit and Reported as 0.								

Table 54: Normalized Source Profiles Used in Slater Street CMB Analysis

Source profile descriptions are found in Table 8.

NAME	ETHYL	AC+ET	PROPYL	PROPAN	ISOBUT	IS/I-B	N-BUT	2M-BUT	N-PENT	23DMBU	2M-PEN	3M-PEN	N-HEX
TT94LD	0.11578	0.05922	0.04636	0.00470	0.00765	0.04211	0.04026	0.11583	0.04366	0.01120	0.03816	0.02376	0.01896
TT94HD	0.14286	0.03212	0.06563	0.01278	0.01229	0.04744	0.03851	0.12451	0.03749	0.01291	0.04052	0.02483	0.02491
CTSHIP	0.00000	0.00000	0.00000	0.00324	0.07370	0.00869	0.25846	0.33268	0.15960	0.01583	0.04970	0.00221	0.02945
CTSLFP	0.00000	0.00000	0.00000	0.00017	0.00739	0.00103	0.03817	0.13119	0.08528	0.01874	0.06568	0.04213	0.05502
FLD801	0.15062	0.08596	0.04762	0.00654	0.01400	0.01308	0.09798	0.07500	0.03362	0.01232	0.02906	0.02084	0.01400
FLDCT	0.09640	0.04483	0.04123	0.00540	0.01050	0.02564	0.04258	0.11679	0.04093	0.01334	0.04753	0.02774	0.02579
FLDCS	0.12809	0.09303	0.06433	0.00000	0.00071	0.00594	0.05302	0.04567	0.03591	0.01753	0.04906	0.02573	0.01089
FLDST	0.02341	0.14237	0.00000	0.00000	0.00000	0.00000	0.22236	0.14964	0.04113	0.00000	0.04193	0.01443	0.01954
FLDS	0.11705	0.07480	0.02489	0.00000	0.00034	0.00000	0.08667	0.07240	0.06269	0.01919	0.07308	0.03483	0.03357
FLDAOC	0.10951	0.12641	0.04005	0.00373	0.00279	0.00479	0.10379	0.07558	0.05442	0.02542	0.06574	0.03407	0.03154
FCNG	0.00000	0.69540	0.00000	0.21343	0.02104	0.00000	0.03106	0.00701	0.00701	0.00000	0.00301	0.00100	0.00401
FLPG	0.00000	0.04108	0.05110	0.90582	0.00200	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
TLROD	0.07296	0.08994	0.03295	0.01765	0.01883	0.01985	0.06909	0.14525	0.04472	0.01451	0.04092	0.02384	0.01829
TLWG	0.00012	0.00046	0.00082	0.00155	0.01163	0.00249	0.06273	0.14312	0.05360	0.01709	0.05593	0.03476	0.02913
TLH24C	0.00009	0.00195	0.00175	0.00128	0.06763	0.00116	0.28741	0.36783	0.09756	0.01964	0.04654	0.02544	0.01582
TLH32C	0.00013	0.00250	0.00150	0.01119	0.06095	0.01132	0.26325	0.35394	0.09477	0.02040	0.04805	0.02646	0.01645
HHDHHS	0.14665	0.29207	0.08029	0.06177	0.00575	0.00000	0.03012	0.02371	0.00956	0.00255	0.00699	0.00681	0.02237
HDCBD	0.12611	0.23963	0.06781	0.04982	0.02138	0.00000	0.06531	0.08040	0.02940	0.00456	0.01423	0.01236	0.01112
HIDNYCC	0.00490	0.34460	0.07603	0.04256	0.01678	0.01101	0.05254	0.06714	0.02517	0.00325	0.01173	0.00991	0.01538
HIDNYBC	0.15395	0.21631	0.08361	0.03040	0.01172	0.01112	0.03859	0.05362	0.02117	0.00344	0.01114	0.00801	0.01283
GA	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
AC	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
COMPTUE	0.00000	0.00000	0.00000	0.00000	0.01632	0.00000	0.05445	0.15047	0.08700	0.02006	0.07947	0.04984	0.04560
VAP20	0.00000	0.00000	0.00000	0.00000	0.012967	0.00000	0.29246	0.29839	0.13245	0.01324	0.04707	0.02641	0.01912
VAP30	0.00000	0.00000	0.00000	0.00000	0.12297	0.00000	0.28142	0.29988	0.13514	0.01398	0.05022	0.02830	0.02082
VAP40	0.00000	0.00000	0.00000	0.00000	0.11692	0.00000	0.27108	0.30067	0.13737	0.01466	0.05318	0.03008	0.02246
CASSLD	0.13473	0.08589	0.06649	0.11598	0.01657	0.04099	0.04753	0.07390	0.04622	0.00785	0.03183	0.02158	0.02725
CASSHD	0.22294	0.10612	0.04697	0.00000	0.01164	0.01566	0.00656	0.07427	0.06303	0.00897	0.04643	0.03774	0.03693
CNGLISA	0.00000	0.93574	0.00000	0.05622	0.00402	0.00000	0.00402	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

NAME	M-CYCL	BENZEN	CYCLHE	ISO-OC	N-HEPT	TOLUEN	N-OCT	E-BENE	M&PXYL	O-XYLE	N-NONA	124TMB
TT94LD	0.01520	0.07377	0.00435	0.03101	0.00765	0.11428	0.00330	0.02261	0.08457	0.03231	0.00075	0.04256
TT94HD	0.01536	0.05625	0.00537	0.02675	0.01246	0.09030	0.00975	0.01627	0.07047	0.02807	0.00865	0.04351
CTSHIP	0.01778	0.01207	0.00208	0.00376	0.00273	0.01648	0.00584	0.00091	0.00337	0.00104	0.00000	0.00039
CTSLFP	0.03662	0.03628	0.00602	0.02235	0.01771	0.17039	0.00774	0.02734	0.12397	0.04763	0.00206	0.05708
FLD801	0.01400	0.05949	0.00335	0.04427	0.01187	0.10802	0.00669	0.01202	0.05051	0.03378	0.00472	0.05066
FLDCT	0.02654	0.08126	0.00435	0.02384	0.01394	0.12399	0.00480	0.02249	0.08921	0.03688	0.00000	0.03403
FLDCS	0.01089	0.07041	0.00028	0.03945	0.00000	0.10985	0.00820	0.04524	0.11000	0.03832	0.00085	0.03662
FLDST	0.00000	0.13760	0.00000	0.08079	0.00000	0.10499	0.00000	0.00000	0.02182	0.00000	0.00000	0.00000
FLDS	0.00948	0.08599	0.00000	0.05527	0.01073	0.10312	0.00286	0.03266	0.06498	0.02250	0.00000	0.01290
FLDAO	0.01144	0.05429	0.00226	0.04711	0.01025	0.06840	0.00559	0.02355	0.05975	0.02023	0.00146	0.01584
FCNG	0.01002	0.00000	0.00000	0.00301	0.00200	0.00200	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
FLPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
TLROD	0.01316	0.04589	0.00279	0.04220	0.00908	0.11078	0.00481	0.02152	0.07313	0.02794	0.00360	0.03631
TLWG	0.02136	0.02971	0.00484	0.05476	0.01651	0.15749	0.00876	0.03496	0.12234	0.05049	0.00418	0.08117
TLH24C	0.01068	0.01129	0.00161	0.01305	0.00274	0.01661	0.00044	0.00138	0.00426	0.00233	0.00010	0.00141
TLH32C	0.01132	0.01223	0.00161	0.01974	0.00352	0.02435	0.00082	0.00248	0.00777	0.00282	0.00021	0.00223
HDHDS	0.00502	0.05418	0.00172	0.01173	0.00540	0.05065	0.01100	0.01173	0.03960	0.01801	0.00643	0.09590
HDCBD	0.00398	0.04793	0.00238	0.01297	0.00507	0.04371	0.01129	0.01008	0.02373	0.02117	0.00785	0.08772
HDNYCC	0.00485	0.04905	0.00254	0.01161	0.00444	0.04997	0.00943	0.01101	0.04076	0.02230	0.00452	0.10854
HDNYBC	0.00442	0.04971	0.00230	0.01116	0.00425	0.04855	0.00905	0.01095	0.03915	0.02149	0.00482	0.13826
GA	0.00000	0.00000	0.00000	0.00000	0.00000	0.93090	0.00000	0.00000	0.06910	0.00000	0.00000	0.00000
AC	0.00000	0.00282	0.00000	0.00000	0.00000	0.81012	0.00000	0.01408	0.08352	0.08946	0.00000	0.00000
COMPFUE	0.03236	0.01935	0.00491	0.04439	0.02254	0.12846	0.00000	0.03032	0.11200	0.04328	0.00000	0.05920
VAP20	0.01232	0.00503	0.00132	0.00592	0.00276	0.00969	0.00000	0.00074	0.00242	0.00073	0.00000	0.00030
VAP30	0.01341	0.00563	0.00146	0.00676	0.00321	0.01148	0.00000	0.00093	0.00306	0.00094	0.00000	0.00041
VAP40	0.01447	0.00623	0.00160	0.00760	0.00367	0.01338	0.00000	0.00115	0.00379	0.00117	0.00000	0.00054
CASSLD	0.01504	0.05494	0.00371	0.00959	0.00894	0.07979	0.00283	0.01657	0.04731	0.02027	0.00044	0.02376
CASSHD	0.01030	0.06905	0.00442	0.00455	0.00990	0.07574	0.00000	0.02034	0.06758	0.02462	0.00562	0.03064
CNGLISA	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 55: Initial Slater Street CMB7 Screening Runs

Source apportionment using all samples. Source profile descriptions are found in Table 8. (SL1, SL2: Slater Street nose-level sampling stations, NAPS: National Air Pollution Surveillance network sampling station, SCE: source contribution estimate). The presentation of these results is different than the other two studies comprising this thesis. Included in the table are the performance measures used to indicate the fit of the model to the ambient data. These measures are the percent mass, R^2 , χ^2 , presence of similarity/uncertainty clusters and the presence of negative source contributions. The table shows the modeling runs across the columns using the various source profiles. The source profile combination used in each run is indicated by an asterisk. The three main performance indicators are provided and show the median, minimum, maximum, 5th, and 95th percentile value for each of R^2 , χ^2 and percent mass accounted for. The relative number of negative source contribution estimates in each run are indicated on a relative scale of none, few, some, majority or all. This was used to give an indication of how realistic the model runs were even if the other performance measures showed good results.

Profile \ Run	1	2	3	4	5	6	7	8	9	10
TT94LD			*				*			
TT94HD			*		*	*		*		*
FLPG										*
TLROD				*	*			*	*	*
GA										
AC										
COMPFUE	*	*	*	*	*	*	*	*	*	*
VAP30	*	*	*	*	*	*	*	*	*	*
CASSLD		*				*				
CASSHD		*		*			*		*	
CNGLISA	*	*	*	*	*	*	*		*	
MSEDBUS										
LD_AVG										
HD_AVG										
SL1 & SL2										
Median R^2	0.65	0.86	0.87	0.87	0.89	0.91	0.82	0.89	0.86	0.93
Min R^2	0.00	0.04	0.04	0.00	0.04	0.04	0.00	0.00	0.00	0.04
Max R^2	0.73	0.92	0.92	0.93	0.93	0.96	0.86	0.93	0.91	0.98
5th Percentile R^2	0.05	0.52	0.62	0.52	0.62	0.63	0.51	0.62	0.45	0.63
95th Percentile R^2	0.68	0.91	0.91	0.91	0.92	0.95	0.86	0.92	0.90	0.96
Median χ^2	12.2	5.4	4.7	4.1	4.6	4.0	6.0	4.5	5.0	3.0
Min χ^2	8.4	2.3	2.5	1.9	2.5	1.6	4.1	2.7	2.4	1.0
Max χ^2	44.2	44.1	44.1	44.1	44.1	44.1	44.1	44.5	44.5	44.0
5th Percentile χ^2	11.1	3.2	2.9	2.5	2.9	2.2	4.7	3.2	3.3	1.8
95th Percentile χ^2	35.4	18.6	15.4	20.5	13.0	15.1	21.1	13.8	24.6	13.8
Median % Mass	70.2	88.7	92.2	98.5	93.6	91.3	96.8	92.2	92.0	94.6
Min % Mass	0.0	2.6	2.5	0.0	2.4	2.4	0.0	0.0	0.0	3.5
Max % Mass	82.3	107.5	111.8	116.2	109.5	109.3	110.8	107.8	108.2	109.2
5th Percentile % Mass	6.3	56.6	63.8	53.6	64.6	62.8	46.1	63.5	46.1	64.8
95th Percentile % Mass	79.2	103.4	105.0	109.6	105.8	104.8	108.4	103.8	104.8	106.6
Negative SCE	NO	Almost All	Majority	Almost All	Most	Some	Majority	Few	Majority	Few
NAPS										
Median R^2	0.64	0.93	0.86	0.83	0.86	0.94	0.83	0.81	0.84	0.87
Min R^2	0.61	0.89	0.80	0.80	0.81	0.89	0.80	0.73	0.79	0.80
Max R^2	0.66	0.95	0.87	0.85	0.87	0.96	0.85	0.81	0.85	0.88
5th Percentile R^2	0.62	0.90	0.81	0.80	0.82	0.90	0.80	0.75	0.80	0.81
95th Percentile R^2	0.66	0.95	0.87	0.85	0.87	0.96	0.85	0.81	0.85	0.88
Median χ^2	12.7	2.5	5.6	6.9	4.5	2.4	7.4	7.5	6.0	5.2
Min χ^2	12.3	1.5	5.3	6.1	4.3	1.6	6.6	6.8	5.3	4.5
Max χ^2	14.3	3.7	8.0	8.7	6.1	3.7	9.0	9.5	7.8	7.3
5th Percentile χ^2	12.1	1.6	5.4	6.1	4.3	1.7	6.6	6.9	5.4	4.6
95th Percentile χ^2	13.8	3.5	7.4	8.5	5.8	3.6	8.8	9.0	7.6	6.8
Median % Mass	67.1	100.3	86.3	88.7	88.3	99.0	88.5	78.8	88.3	85.9
Min % Mass	61.9	93.9	79.9	81.1	82.7	92.6	80.5	66.0	80.9	73.6
Max % Mass	70.3	103.4	89.6	91.0	91.8	100.8	91.1	84.4	91.9	89.9
5th Percentile % Mass	62.5	94.8	80.5	82.1	83.0	93.1	82.0	69.5	81.3	77.0
95th Percentile % Mass	69.8	103.1	89.3	91.0	91.4	100.8	91.0	83.4	91.7	89.9
Negative SCE	None	Majority	Few	Majority	All	Majority	Some	Some	Majority	Some

Profile \ Run	11	12	13	14	15	16	17	18	19	20
TT94LD						*		*		
TT94HD	*	*	*	*		*				
FLPG	*	*	*	*	*	*	*	*	*	*
TLROD	*	*	*	*			*			
GA		*	*	*	*	*	*			*
AC										
COMPFUE	*	*	*	*	*	*	*	*	*	*
VAP30		*		*	*	*	*			
CASSLD					*					
CASSHD					*		*			
CNGLISA				*						
MSEDBUS								*		
LD_AVG									*	*
HD_AVG									*	*
SL1 & SL2										
Median R^2	0.92	0.95	0.94	0.96	0.90	0.94	0.91	0.87	0.88	0.90
Min R^2	0.66	0.04	0.00	0.08	0.05	0.04	0.05	0.00	0.03	0.00
Max R^2	0.96	0.98	0.97	0.98	0.93	0.97	0.95	0.92	0.94	0.95
5th Percentile R^2	0.05	0.63	0.10	0.70	0.63	0.63	0.56	0.10	0.12	0.07
95th Percentile R^2	0.95	0.97	0.97	0.97	0.93	0.96	0.94	0.91	0.92	0.94
Median χ^2	3.2	2.2	2.4	2.1	2.1	2.6	4.0	4.8	4.8	3.9
Min χ^2	1.7	1.1	1.3	1.0	1.5	1.1	1.8	3.0	2.4	1.7
Max χ^2	45.9	41.0	44.5	41.3	40.5	40.9	40.5	44.5	44.5	44.5
5th Percentile χ^2	1.8	1.4	1.5	1.2	1.7	1.6	2.5	3.4	3.0	2.2
95th Percentile χ^2	38.2	14.4	35.9	13.6	9.1	13.9	20.5	34.5	35.7	34.3
Median % Mass	93.9	105.4	104.3	105.5	107.5	105.8	101.3	93.7	98.0	94.8
Min % Mass	0.0	7.4	0.0	11.0	8.2	7.4	8.2	0.0	3.5	0.0
Max % Mass	109.0	109.9	109.7	111.4	121.9	113.3	108.6	107.5	109.9	110.3
5th Percentile % Mass	8.4	77.5	30.9	82.7	83.7	81.1	58.5	14.1	29.7	11.2
95th Percentile % Mass	106.2	109.0	108.4	109.1	111.5	109.9	106.6	104.4	104.7	107.0
Negative SCE	Few	Some	Few	Some	Majority	Some	Majority	Few	Some	Few
NAPS										
Median R^2	0.82	0.88	0.83	0.95	0.94	0.88	0.89	0.86	0.91	0.82
Min R^2	0.77	0.81	0.77	0.88	0.87	0.81	0.85	0.82	0.88	0.78
Max R^2	0.84	0.89	0.85	0.96	0.95	0.90	0.91	0.88	0.92	0.84
5th Percentile R^2	0.78	0.82	0.78	0.90	0.89	0.82	0.86	0.83	0.88	0.79
95th Percentile R^2	0.84	0.89	0.85	0.96	0.95	0.90	0.91	0.88	0.92	0.84
Median χ^2	6.9	5.0	7.0	1.7	1.9	5.4	4.6	5.4	3.0	7.3
Min χ^2	6.0	4.3	6.3	1.3	1.3	4.5	3.6	4.7	2.7	6.3
Max χ^2	8.5	7.2	8.8	3.8	3.8	8.4	6.1	7.2	3.8	9.0
5th Percentile χ^2	6.0	4.4	6.3	1.4	1.4	4.6	3.7	4.6	2.7	6.3
95th Percentile χ^2	8.3	6.8	8.6	3.3	3.4	7.9	5.7	6.8	3.6	8.7
Median % Mass	82.8	90.5	86.5	97.7	103.2	91.5	98.0	94.5	102.2	83.3
Min % Mass	72.7	76.5	74.8	89.4	92.9	76.8	88.9	85.7	94.6	74.1
Max % Mass	87.4	97.6	92.1	101.5	106.6	97.6	100.6	97.4	104.1	88.6
5th Percentile % Mass	75.3	79.8	77.1	91.5	95.7	80.1	91.5	86.8	96.6	76.3
95th Percentile % Mass	87.4	96.1	91.1	100.6	106.1	96.6	100.4	96.9	104.1	88.5
Negative SCE	None	Majority	None	All	All	Majority	Majority	None	All	All

Profile \ Run	21	22	23	24	25	26	27	28	29	30
TT94LD	*		*							
TT94HD	*							*		
FLPG	*	*	*	*		*	*	*	*	*
TLROD				*		*				
GA										
AC										
COMPFUE	*	*	*	*		*	*	*	*	*
VAP30										
CASSLD		*					*			
CASSHD		*	*	*					*	
CNGLISA										
MSEDBUS						*	*			*
LD_AVG								*	*	*
HD_AVG										
SL1 & SL2										
Median R^2	0.89	0.86	0.89	0.86	0.90	0.89	0.85	0.91	0.86	0.86
Min R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max R^2	0.93	0.93	0.93	0.93	0.96	0.93	0.93	0.95	0.89	0.91
5th Percentile R^2	0.39	0.09	0.14	0.09	0.11	0.12	0.10	0.05	0.29	0.11
95th Percentile R^2	0.92	0.91	0.92	0.91	0.95	0.93	0.91	0.94	0.89	0.89
Median χ^2	4.3	3.1	4.2	3.1	3.8	3.8	5.4	3.7	5.4	5.4
Min χ^2	2.5	1.5	2.3	1.5	1.6	2.1	2.8	1.5	3.7	3.5
Max χ^2	44.5	44.5	44.5	44.5	44.5	44.5	44.5	46.1	44.5	44.5
5th Percentile χ^2	3.1	1.7	2.9	1.7	1.8	2.5	3.5	2.2	4.4	4.1
95th Percentile χ^2	25.2	34.1	34.8	34.1	33.6	32.6	34.2	38.0	25.6	33.4
Median % Mass	92.9	96.2	88.6	96.2	91.5	94.1	87.6	91.8	85.2	87.6
Min % Mass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max % Mass	105.8	115.5	106.0	115.5	110.2	107.2	106.1	109.1	99.2	110.7
5th Percentile % Mass	44.5	11.1	21.7	11.1	15.0	14.0	15.4	5.7	28.8	14.3
95th Percentile % Mass	104.3	110.5	102.5	110.5	105.6	103.5	100.8	105.2	96.7	99.3
Negative SCE	Few	Majority	Majority	Some	Some	Some	Some	Few	Some	Some
NAPS										
Median R^2	0.83	0.92	0.82	0.92	0.92	0.88	0.92	0.81	0.81	0.88
Min R^2	0.79	0.87	0.80	0.87	0.87	0.85	0.88	0.77	0.79	0.85
Max R^2	0.85	0.94	0.85	0.94	0.94	0.89	0.94	0.84	0.85	0.90
5th Percentile R^2	0.80	0.88	0.80	0.88	0.88	0.85	0.88	0.78	0.79	0.85
95th Percentile R^2	0.85	0.94	0.85	0.94	0.94	0.89	0.94	0.84	0.85	0.90
Median χ^2	6.8	1.6	7.2	1.6	2.4	4.0	2.5	7.0	7.2	4.0
Min χ^2	5.8	1.1	5.8	1.1	2.0	3.3	2.0	6.2	6.1	3.3
Max χ^2	7.6	3.2	8.4	3.2	3.6	4.9	3.6	8.5	8.4	4.9
5th Percentile χ^2	5.9	1.2	5.9	1.2	2.0	3.4	2.0	6.2	6.1	3.3
95th Percentile χ^2	7.6	2.9	8.1	2.9	3.6	4.8	3.6	8.3	8.2	4.8
Median % Mass	88.9	102.8	90.4	102.8	100.8	98.3	100.7	82.1	89.3	98.8
Min % Mass	82.1	92.8	84.5	92.8	91.4	91.4	92.3	72.6	83.1	92.5
Max % Mass	93.7	106.3	95.1	106.3	103.4	100.6	103.7	86.3	91.7	101.5
5th Percentile % Mass	83.6	95.7	84.8	95.7	93.0	91.8	93.7	75.1	83.4	92.6
95th Percentile % Mass	93.6	105.9	95.1	105.9	103.1	100.2	103.6	86.3	91.6	101.2
Negative SCE	None	All	Few	Some	All	All	All	None	Few	All

Run	11	12	13	14	15	16	17	18	19	20
Profile										
TT94LD						*		*		
TT94HD	*	*	*	*		*				
FLPG	*	*	*	*	*	*	*	*	*	*
TLROD	*	*	*	*			*			
GA		*	*	*	*	*	*			*
AC										
COMPFUE	*	*	*	*	*	*	*	*	*	*
VAP30		*		*	*	*	*			
CASSLD					*					
CASSHD					*		*			
CNGLISA				*						
MSSEBUS								*		
LD_AVG									*	*
HD_AVG									*	*
SL1 & SL2										
Median R^2	0.92	0.95	0.94	0.96	0.90	0.94	0.91	0.87	0.88	0.90
Min R^2	0.00	0.04	0.00	0.08	0.05	0.04	0.05	0.00	0.03	0.00
Max R^2	0.96	0.98	0.97	0.98	0.93	0.97	0.95	0.92	0.94	0.95
5th Percentile R^2	0.05	0.63	0.10	0.70	0.63	0.63	0.56	0.10	0.12	0.07
95th Percentile R^2	0.95	0.97	0.97	0.97	0.93	0.96	0.94	0.91	0.92	0.94
Median χ^2	3.2	2.2	2.4	2.1	2.1	2.6	4.0	4.8	4.8	3.9
Min χ^2	1.7	1.1	1.3	1.0	1.5	1.1	1.8	3.0	2.4	1.7
Max χ^2	45.9	41.0	44.5	41.3	40.5	40.9	40.5	44.5	44.5	44.5
5th Percentile χ^2	1.8	1.4	1.5	1.2	1.7	1.6	2.5	3.4	3.0	2.2
95th Percentile χ^2	38.2	14.4	35.9	13.6	9.1	13.9	20.5	34.5	35.7	34.3
Median % Mass	93.9	105.4	104.3	105.5	107.5	105.8	101.3	93.7	98.0	94.8
Min % Mass	0.0	7.4	0.0	11.0	8.2	7.4	8.2	0.0	3.5	0.0
Max % Mass	109.0	109.9	109.7	111.4	121.9	113.3	108.6	107.5	109.9	110.3
5th Percentile % Mass	8.4	77.5	30.9	82.7	83.7	81.1	58.5	14.1	29.7	11.2
95th Percentile % Mass	106.2	109.0	108.4	109.1	111.5	109.9	106.6	104.4	104.7	107.0
Negative SCE	Few	Some	Few	Some	Majority	Some	Majority	Few	Some	Few
NAPS										
Median R^2	0.82	0.88	0.83	0.95	0.94	0.88	0.89	0.86	0.91	0.82
Min R^2	0.77	0.81	0.77	0.88	0.87	0.81	0.85	0.82	0.88	0.78
Max R^2	0.84	0.89	0.85	0.96	0.95	0.90	0.91	0.88	0.92	0.84
5th Percentile R^2	0.78	0.82	0.78	0.90	0.89	0.82	0.86	0.83	0.88	0.79
95th Percentile R^2	0.84	0.89	0.85	0.96	0.95	0.90	0.91	0.88	0.92	0.84
Median χ^2	6.9	5.0	7.0	1.7	1.9	5.4	4.6	5.4	3.0	7.3
Min χ^2	6.0	4.3	6.3	1.3	1.3	4.5	3.6	4.7	2.7	6.3
Max χ^2	8.5	7.2	8.8	3.8	3.8	8.4	6.1	7.2	3.8	9.0
5th Percentile χ^2	6.0	4.4	6.3	1.4	1.4	4.6	3.7	4.6	2.7	6.3
95th Percentile χ^2	8.3	6.8	8.6	3.3	3.4	7.9	5.7	6.8	3.6	8.7
Median % Mass	82.8	90.5	86.5	97.7	103.2	91.5	98.0	94.5	102.2	83.3
Min % Mass	72.7	76.5	74.8	89.4	92.9	76.8	88.9	85.7	94.6	74.1
Max % Mass	87.4	97.6	92.1	101.5	106.6	97.6	100.6	97.4	104.1	88.6
5th Percentile % Mass	75.3	79.8	77.1	91.5	95.7	80.1	91.5	86.8	96.6	76.3
95th Percentile % Mass	87.4	96.1	91.1	100.6	106.1	96.6	100.4	96.9	104.1	88.5
Negative SCE	None	Majority	None	All	All	Majority	Majority	None	All	All

Table S6: Source Profile Combinations Around Four Core Profiles

Source apportionment using all samples. Source profile descriptions are found in Table 8. (SL1, SL2: Slater Street nose-level sampling stations, NAPS: National Air Pollution Surveillance network sampling station, N: number of samples).

RUN1: SL1 & SL2						
	TT94HD	FLPG	TLROD	COMPFUE	% Mass	
Mean	41.2	4.5	27.7	20.0	93.3	
Stand Dev ^a	14.9	1.9	10.4	7.4	N	
Median	39.6	4.1	27.5	20.2	80	
Minimum	11.4	1.7	1.2	5.1		
Maximum	77.4	13.3	55.3	39.9		
5 th Percentile	18.0	2.2	9.5	9.5		
25 th Percentile	31.1	3.1	21.3	13.7		
75 th Percentile	51.6	5.4	33.0	25.0		
95 th Percentile	68.3	7.6	46.9	31.8		
	R ²	χ^2	% Mass			
Mean	0.92	3.16	93.3			
Median	0.93	2.93	95.3			
Min	0.86	1.75	68.6			
Max	0.96	5.99	109.0			
5 th Percentile	0.87	1.84	76.2			
95 th Percentile	0.95	5.43	106.3			

RUN2: SL1 & SL2						
	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	39.7	4.3	26.2	13.5	19.9	103.7
Stand Dev ^a	13.0	1.9	9.9	8.9	7.0	N
Median	39.3	3.8	26.1	11.2	20.2	75
Minimum	13.3	1.7	0.9	1.9	4.9	
Maximum	77.1	13.4	51.9	37.1	39.1	
5 th Percentile	18.5	2.1	8.6	2.7	9.8	
25 th Percentile	30.3	3.0	20.1	7.2	14.6	
75 th Percentile	49.6	5.3	31.6	20.8	24.5	
95 th Percentile	60.1	7.5	44.5	30.6	31.0	
	R ²	χ^2	% Mass			
Mean	0.94	2.68	103.7			
Median	0.95	2.30	104.7			
Min	0.87	1.25	83.3			
Max	0.97	5.59	109.7			
5 th Percentile	0.89	1.43	94.9			
95 th Percentile	0.97	4.81	108.7			

RUN1: NAPS						
	51.6	8.9	13.9	8.1	% Mass	
Mean	3.1	1.3	5.1	3.2	82.5	
Stand Dev ^a	51.9	8.9	14.2	8.4	N	
Median	47.0	7.5	5.7	4.4	8	
Minimum	57.0	11.7	20.7	11.7		
Maximum	47.3	7.5	7.0	4.4		
5 th Percentile	50.2	8.0	10.3	4.8		
25 th Percentile	52.9	9.2	17.4	11.4		
75 th Percentile	55.6	10.9	20.2	11.6		
95 th Percentile						
	R ²	χ^2	% Mass			
Mean	0.82	7.03	82.5			
Median	0.82	6.95	82.8			
Min	0.77	5.98	72.7			
Max	0.84	8.49	87.4			
5 th Percentile	0.78	6.00	75.3			
95 th Percentile	0.84	8.27	87.4			

RUN2: NAPS						
	52.4	9.0	11.5	4.1	% Mass	
Mean	3.0	1.3	4.8	3.1	85.2	
Stand Dev ^a	52.7	9.0	12.0	3.0	N	
Median	47.9	7.5	3.8	2.5	4.5	
Minimum	57.6	11.7	17.8	11.6	11.5	
Maximum	48.3	7.6	5.1	2.6	4.6	
5 th Percentile	51.1	8.1	8.1	2.8	5.0	
25 th Percentile	53.6	9.2	15.0	3.4	11.4	
75 th Percentile	56.4	10.9	17.3	8.8	11.5	
95 th Percentile						
	R ²	χ^2	% Mass			
Mean	0.82	7.28	85.2			
Median	0.83	6.95	86.5			
Min	0.77	6.32	74.8			
Max	0.85	8.81	92.1			
5 th Percentile	0.78	6.32	77.1			
95 th Percentile	0.85	8.62	91.1			

RUN3: SL1 & SL2

	TT94HD	FLPG	TLROD	COMPEUE	VAP30	% Mass
Mean	44.3	4.8	23.3	16.9	5.7	95.1
Stand Dev ⁿ	15.5	2.0	9.0	7.0	6.1	N
Median	44.7	4.4	23.4	16.6	3.6	70
Minimum	17.2	1.7	1.8	3.7	0.0	
Maximum	79.7	13.5	48.6	31.0	27.8	
5 th Percentile	21.9	2.7	8.1	5.1	0.4	
25 th Percentile	32.8	3.3	17.8	11.9	1.7	
75 th Percentile	55.1	5.6	28.2	22.2	8.3	
95 th Percentile	73.5	7.8	37.8	28.2	18.3	
	R ²	χ^2	% Mass			
Mean	0.93	2.90	95.1			
Median	0.94	2.71	96.8			
Min	0.87	1.04	71.7			
Max	0.98	5.89	109.2			
5 th Percentile	0.88	1.68	76.3			
95 th Percentile	0.96	5.03	107.4			

RUN4: SL1 & SL2

	TT94HD	FLPG	TLROD	COMPEUE	CNGLISA	% Mass
Mean	56.3	4.6	20.0	16.3	1.5	98.7
Stand Dev ⁿ	12.0	1.9	9.6	3.7	1.0	N
Median	57.4	4.3	21.2	16.6	1.7	20
Minimum	36.6	1.8	2.1	5.7	0.1	
Maximum	79.3	7.7	32.8	21.6	3.6	
5 th Percentile	38.3	2.0	2.8	11.8	0.2	
25 th Percentile	48.9	3.1	13.9	14.6	0.6	
75 th Percentile	62.5	6.1	28.4	18.9	2.4	
95 th Percentile	76.3	7.6	31.5	20.8	2.7	
	R ²	χ^2	% Mass			
Mean	0.94	2.51	98.7			
Median	0.95	2.21	99.5			
Min	0.88	1.68	76.7			
Max	0.96	5.49	109.1			
5 th Percentile	0.91	1.74	80.4			
95 th Percentile	0.96	4.03	108.8			

RUN3: NAPS

	59.8	8.7	2.2	3.6	13.4	% Mass
Mean	4.8	0.8	1.4	3.0	1.0	87.7
Stand Dev ⁿ	59.3	8.7	1.5	3.6	13.3	N
Median	55.5	7.7	1.3	0.4	12.2	4
Minimum	65.2	9.6	4.3	6.9	14.5	
Maximum	55.6	7.8	1.3	0.7	12.3	
5 th Percentile	56.0	8.2	1.3	1.5	12.7	
25 th Percentile	63.2	9.1	2.3	5.7	14.0	
75 th Percentile	64.8	9.5	3.9	6.7	14.4	
95 th Percentile						
	R ²	χ^2	% Mass			
Mean	0.87	5.05	87.7			
Median	0.87	5.02	87.5			
Min	0.86	4.67	85.9			
Max	0.88	5.50	89.9			
5 th Percentile	0.86	4.71	85.8			
95 th Percentile	0.88	5.44	89.8			

RUN4: NAPS

NO SOURCES WITH ALL POSITIVE CONTRIBUTIONS

RUN5: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPEUE	VAP30	% Mass
Mean	43.0	4.6	21.9	13.0	16.3	6.2	105.0
Stand Dev ⁿ	13.1	2.0	8.5	8.0	6.4	6.6	N
Median	43.4	4.1	21.4	10.9	15.6	4.2	65
Minimum	19.6	1.7	0.3	2.5	2.8	0.2	
Maximum	78.1	13.7	44.0	34.4	29.3	29.6	
5 th Percentile	23.1	2.4	8.3	3.3	4.6	0.6	
25 th Percentile	33.5	3.2	17.0	6.8	12.6	1.8	
75 th Percentile	53.0	5.5	26.0	19.1	20.9	7.4	
95 th Percentile	63.0	7.7	37.8	30.1	26.9	20.2	
	R ²	χ^2	% Mass				
Mean	0.95	2.29	105.0				
Median	0.96	2.03	105.6				
Min	0.90	1.16	93.6				
Max	0.97	4.65	109.9				
5 th Percentile	0.91	1.39	99.1				
95 th Percentile	0.97	4.16	109.1				

RUN5: NAPS

	63.7	9.7	0.5	4.7	0.3	13.2	% Mass
R ²		χ^2					92.1
0.88	4.56	92.1					N
							1

RUN6: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPEUE	CNGLISA	% Mass
Mean	49.6	4.0	18.8	13.7	17.5	1.2	104.7
Stand Dev ⁿ	10.9	1.6	7.8	10.7	3.7	1.0	N
Median	49.0	3.9	19.0	9.6	17.6	0.8	24
Minimum	30.9	1.8	5.0	2.1	6.4	0.2	
Maximum	65.7	7.6	31.1	37.2	24.6	2.8	
5 th Percentile	32.2	2.1	7.7	2.2	13.5	0.2	
25 th Percentile	40.4	2.7	11.5	5.4	15.4	0.3	
75 th Percentile	59.1	5.2	25.9	22.6	20.3	1.9	
95 th Percentile	63.9	7.0	27.8	33.7	21.7	2.8	
	R ²	χ^2	% Mass				
Mean	0.94	2.59	104.7				
Median	0.95	2.22	105.1				
Min	0.89	1.42	100.5				
Max	0.97	4.79	109.2				
5 th Percentile	0.90	1.47	100.8				
95 th Percentile	0.97	4.54	108.5				

RUN6: NAPS

NO SOURCES WITH ALL POSITIVE CONTRIBUTIONS

RUN7: SL1 & SL2

	TT94HD	FLPG	TLROD	COMPEUE	VAP30	CNGLISA	% Mass
Mean	59.2	5.1	11.2	15.9	7.1	1.7	100.1
Stand Dev ⁿ	10.6	1.9	8.2	5.5	5.9	1.1	N
Median	63.1	4.9	10.4	17.3	5.4	1.7	17
Minimum	43.0	1.8	0.1	5.0	1.4	0.2	
Maximum	71.8	8.3	26.7	24.9	25.6	3.6	
5 th Percentile	43.1	2.4	0.4	6.0	1.6	0.3	
25 th Percentile	47.5	4.2	4.9	14.8	3.8	0.8	
75 th Percentile	68.1	6.3	17.6	19.8	8.3	2.8	
95 th Percentile	71.2	7.8	24.1	21.7	16.8	3.2	
	R ²	χ^2	% Mass				
Mean	0.94	2.45	100.1				
Median	0.95	2.24	100.3				
Min	0.89	1.66	93.8				
Max	0.96	4.58	105.3				
5 th Percentile	0.92	1.68	94.3				
95 th Percentile	0.96	3.46	105.2				

RUN7: NAPS

NO SOURCES WITH ALL POSITIVE CONTRIBUTIONS

RUN8: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPEUE	VAP30	CNGLISA	% Mass
Mean	50.5	4.9	15.7	12.0	16.4	5.4	0.9	105.9
Stand Dev ⁿ	11.8	2.6	9.2	8.0	6.0	6.2	1.0	N
Median	50.1	4.5	14.4	10.6	16.4	4.0	0.6	26
Minimum	22.9	1.8	2.3	3.6	3.6	0.2	0.1	
Maximum	73.3	13.7	41.1	34.6	29.4	27.6	3.8	
5 th Percentile	32.9	2.2	2.9	4.6	6.8	0.5	0.1	
25 th Percentile	47.2	3.2	8.6	6.7	13.7	1.3	0.3	
75 th Percentile	57.4	5.7	20.9	12.5	19.9	5.7	1.2	
95 th Percentile	68.9	8.7	30.3	31.2	26.6	15.8	3.4	
	R ²	χ^2	% Mass					
Mean	0.96	2.17	105.9					
Median	0.96	1.95	105.9					
Min	0.90	1.24	100.5					
Max	0.97	4.80	109.2					
5 th Percentile	0.92	1.34	102.7					
95 th Percentile	0.97	4.09	109.0					

RUN8: NAPS

NO SOURCES WITH ALL POSITIVE CONTRIBUTIONS

Table 57: Sensitivity Runs in the CMB Analysis

Source apportionment using all samples. Source profile descriptions are found in Table 8. (SL1, SL2: Slater Street nose-level sampling stations, NAPS: National Air Pollution Surveillance network sampling station, N: number of samples).

BASE: SL1 & SL2						
	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	40.9	4.3	27.0	13.1	19.5	104.9
Stand Dev ⁿ	12.7	2.0	10.3	8.1	6.9	N
Median	39.8	3.9	27.2	11.2	19.7	65
Minimum	13.3	1.7	0.9	1.9	4.9	
Maximum	77.1	13.4	51.9	33.2	39.1	
5 th Percentile	21.0	2.1	8.4	2.5	10.0	
25 th Percentile	32.3	2.9	23.2	7.4	14.3	
75 th Percentile	50.0	5.3	32.4	20.0	24.3	
95 th Percentile	61.0	7.5	45.7	28.6	30.7	
	R ²	χ^2	% Mass			
Mean	0.94	2.37	104.9			
Median	0.95	2.17	104.9			
Min	0.91	1.25	98.2			
Max	0.97	3.94	109.7			
5 th Percentile	0.91	1.39	100.0			
95 th Percentile	0.97	3.75	108.8			

ALL SPECIES: SL1 & SL2						
	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	31.3	4.5	32.7	10.4	19.3	98.2
Stand Dev ⁿ	10.2	1.8	9.9	6.5	5.0	N
Median	30.3	4.3	32.6	9.1	19.2	39
Minimum	15.2	1.8	2.5	1.5	9.0	
Maximum	59.8	8.9	53.8	26.9	30.8	
5 th Percentile	19.5	2.2	17.0	2.2	13.3	
25 th Percentile	23.6	3.1	28.2	5.7	15.4	
75 th Percentile	36.0	5.5	39.0	15.6	22.2	
95 th Percentile	49.6	7.8	44.2	21.5	27.4	
	R ²	χ^2	% Mass			
Mean	0.94	2.26	98.2			
Median	0.95	2.19	98.4			
Min	0.90	1.50	93.2			
Max	0.96	3.85	102.0			
5 th Percentile	0.92	1.52	95.1			
95 th Percentile	0.96	3.10	100.5			

BASE: NAPS						
	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	52.4	9.0	11.5	4.1	8.2	85.2
Stand Dev ⁿ	3.0	1.3	4.8	3.1	3.2	N
Median	52.7	9.0	12.0	3.0	8.5	8
Minimum	47.9	7.5	3.8	2.5	4.5	
Maximum	57.6	11.7	17.8	11.6	11.5	
5 th Percentile	48.3	7.6	5.1	2.6	4.6	
25 th Percentile	51.1	8.1	8.1	2.8	5.0	
75 th Percentile	53.6	9.2	15.0	3.4	11.4	
95 th Percentile	56.4	10.9	17.3	8.8	11.5	
	R ²	χ^2	% Mass			
Mean	0.82	7.28	85.2			
Median	0.83	6.95	86.5			
Min	0.77	6.32	74.8			
Max	0.85	8.81	92.1			
5 th Percentile	0.78	6.32	77.1			
95 th Percentile	0.85	8.62	91.1			

ALL SPECIES: NAPS						
	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	47.0	8.5	10.3	4.3	12.0	82.2
Stand Dev ⁿ	3.3	1.2	5.1	3.0	3.2	N
Median	46.5	8.5	11.3	3.4	12.2	8
Minimum	42.0	7.2	1.8	2.8	7.3	
Maximum	52.6	11.2	15.9	11.7	15.8	
5 th Percentile	42.8	7.3	3.2	2.9	8.0	
25 th Percentile	45.5	7.7	6.3	3.0	9.6	
75 th Percentile	48.9	8.8	14.4	3.6	14.9	
95 th Percentile	51.7	10.4	15.8	8.9	15.5	
	R ²	χ^2	% Mass			
Mean	0.85	5.77	82.2			
Median	0.85	5.75	84.3			
Min	0.81	4.88	73.8			
Max	0.87	6.67	87.1			
5 th Percentile	0.82	4.94	75.2			
95 th Percentile	0.87	6.60	86.8			

ALL SPECIES - TOLUENE: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPUE	% Mass
Mean	23.0	3.4	27.1	5.5	21.2	80.2
Stand Dev ⁿ	2.9	1.0	4.7	5.0	4.8	N
Median	22.7	3.4	27.3	5.0	23.1	3
Minimum	20.4	2.3	22.2	0.8	15.8	
Maximum	26.0	4.4	31.6	10.8	24.7	
5 th Percentile	20.6	2.5	22.7	1.2	16.5	
25 th Percentile	21.5	2.9	24.8	2.9	19.4	
75 th Percentile	24.4	3.9	29.5	7.9	23.9	
95 th Percentile	25.7	4.3	31.2	10.2	24.5	
	R ²	χ^2	% Mass			
Mean	0.93	2.99	80.2			
Median	0.93	2.96	80.5			
Min	0.90	2.06	78.2			
Max	0.95	3.96	82.0			
5 th Percentile	0.90	2.15	78.4			
95 th Percentile	0.95	3.86	81.9			

ALL SPECIES - ETHYLENE: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPUE	% Mass
Mean	33.4	4.4	32.4	9.9	18.1	98.2
Stand Dev ⁿ	10.8	1.8	10.6	6.3	5.8	N
Median	32.3	4.2	32.4	7.7	18.2	44
Minimum	15.7	1.8	2.4	1.5	4.9	
Maximum	60.0	8.9	56.4	26.9	31.5	
5 th Percentile	20.0	2.2	14.7	2.3	8.5	
25 th Percentile	28.1	3.0	27.2	5.7	15.0	
75 th Percentile	39.0	5.5	39.4	12.4	21.8	
95 th Percentile	54.0	7.7	44.0	21.3	27.3	
	R ²	χ^2	% Mass			
Mean	0.94	2.59	98.2			
Median	0.94	2.36	98.5			
Min	0.80	1.56	85.8			
Max	0.96	8.10	108.4			
5 th Percentile	0.89	1.61	91.4			
95 th Percentile	0.96	4.60	103.3			

ALL SPECIES - TOLUENE: NAPS

	TT94HD	FLPG	TLROD	GA	COMPUE	% Mass
Mean	47.0	8.6	10.2	15.2	11.8	
Stand Dev ⁿ	3.3	1.2	5.1	8.2	3.2	92.8
Median	46.5	8.5	11.3	13.8	12.1	N
Minimum	42.0	7.2	1.8	3.6	7.0	8
Maximum	52.6	11.2	15.8	27.2	15.7	
5 th Percentile	42.8	7.3	3.2	4.6	7.7	
25 th Percentile	45.5	7.7	6.2	10.8	9.2	
75 th Percentile	48.8	8.8	14.2	22.1	14.4	
95 th Percentile	51.7	10.4	15.8	25.7	15.3	
	R ²	χ^2	% Mass			
Mean	0.84	6.05	92.8			
Median	0.84	6.02	95.8			
Min	0.81	5.13	78.6			
Max	0.87	6.94	103.0			
5 th Percentile	0.82	5.19	79.8			
95 th Percentile	0.87	6.88	101.0			

ALL SPECIES - ETHYLENE: NAPS

	TT94HD	FLPG	TLROD	GA	COMPUE	% Mass
Mean	46.5	8.6	10.0	4.3	12.5	
Stand Dev ⁿ	3.2	1.3	5.0	3.0	3.0	81.9
Median	45.6	8.5	11.3	3.4	12.2	N
Minimum	42.2	7.2	1.5	2.8	8.1	8
Maximum	52.6	11.2	15.3	11.7	16.3	
5 th Percentile	43.0	7.3	2.9	2.9	8.8	
25 th Percentile	44.7	7.7	6.0	3.0	10.3	
75 th Percentile	48.0	8.9	14.2	3.6	15.0	
95 th Percentile	51.4	10.5	15.2	8.9	16.1	
	R ²	χ^2	% Mass			
Mean	0.84	6.09	81.9			
Median	0.84	6.05	84.0			
Min	0.81	5.18	73.4			
Max	0.87	7.05	87.2			
5 th Percentile	0.82	5.24	74.8			
95 th Percentile	0.87	6.96	86.7			

ALL SPECIES - 2M-BUTANE: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPUE	% Mass
Mean	31.3	4.5	32.4	10.2	19.2	97.6
Stand Dev ⁿ	9.9	1.8	9.8	6.4	4.9	N
Median	30.3	4.3	32.8	8.8	19.1	41
Minimum	15.5	1.8	2.5	1.6	9.0	
Maximum	59.8	8.8	54.2	26.8	30.9	
5 th Percentile	19.6	2.2	18.4	2.3	13.7	
25 th Percentile	24.8	3.2	28.2	5.5	15.5	
75 th Percentile	35.7	5.5	38.3	14.6	21.8	
95 th Percentile	48.3	7.8	44.8	21.4	27.4	
	R ²	χ^2	% Mass			
Mean	0.94	2.47	97.6			
Median	0.94	2.43	98.3			
Min	0.89	1.56	79.9			
Max	0.96	4.75	102.8			
5 th Percentile	0.90	1.59	92.5			
95 th Percentile	0.96	3.92	100.8			

ALL SPECIES - AC+ET: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPUE	% Mass
Mean	29.3	4.4	37.8	10.1	17.6	99.2
Stand Dev ⁿ	12.0	1.8	12.4	6.3	4.4	N
Median	28.6	4.3	37.3	8.5	17.9	38
Minimum	6.9	1.7	15.4	1.7	6.1	
Maximum	52.7	8.8	68.6	27.0	25.1	
5 th Percentile	10.2	2.3	17.4	1.9	10.6	
25 th Percentile	21.1	3.0	30.0	5.4	15.8	
75 th Percentile	36.8	5.6	44.4	13.3	21.4	
95 th Percentile	48.5	7.8	56.3	21.4	24.3	
	R ²	χ^2	% Mass			
Mean	0.94	2.25	99.2			
Median	0.94	2.22	99.4			
Min	0.92	1.44	94.5			
Max	0.96	3.05	102.7			
5 th Percentile	0.93	1.54	95.4			
95 th Percentile	0.96	3.02	102.0			

ALL SPECIES - 2M-BUTANE: NAPS

	TT94HD	FLPG	TLROD	GA	COMPUE	% Mass
Mean	47.4	8.6	9.3	4.4	12.2	
Stand Dev ⁿ	3.2	1.2	4.9	3.0	3.2	
Median	46.8	8.5	9.8	3.4	12.4	
Minimum	42.6	7.2	1.9	2.9	7.4	
Maximum	53.0	11.2	15.2	11.9	16.0	
5 th Percentile	43.4	7.3	2.8	3.0	8.1	
25 th Percentile	45.8	7.7	5.3	3.1	9.6	
75 th Percentile	49.1	8.8	13.2	3.6	15.0	
95 th Percentile	52.0	10.5	15.1	9.1	15.7	
	R ²	χ^2	% Mass			
Mean	0.84	6.05	81.8			
Median	0.84	6.00	83.9			
Min	0.81	5.14	73.8			
Max	0.87	7.02	86.4			
5 th Percentile	0.82	5.21	75.0			
95 th Percentile	0.87	6.94	86.3			

ALL SPECIES - AC+ET: NAPS

	TT94HD	FLPG	TLROD	GA	COMPUE	% Mass

No Samples With All Positive SCE
 All -ve in TLROD

ALL SPECIES - AC+ET-ETHYLENE: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	30.8	4.3	38.4	9.8	16.6	100.0
Stand Dev ⁿ	12.3	1.8	12.5	6.3	5.3	N
Median	30.4	4.1	37.6	8.3	17.2	38
Minimum	7.3	1.7	15.4	1.6	0.0	
Maximum	53.3	8.9	68.6	27.0	25.1	
5 th Percentile	11.0	2.3	17.5	1.9	8.3	
25 th Percentile	21.8	2.8	30.6	5.2	13.1	
75 th Percentile	39.8	5.5	45.2	12.2	20.7	
95 th Percentile	51.6	7.8	58.1	21.4	23.3	
	R ²	χ^2	% Mass			
Mean	0.94	2.34	100.0			
Median	0.94	2.32	100.0			
Min	0.92	1.52	94.5			
Max	0.96	3.19	111.8			
5 th Percentile	0.92	1.61	95.2			
95 th Percentile	0.96	3.17	103.7			

ALL SPECIES - PROPYLENE: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	30.8	4.5	32.8	10.4	19.5	98.0
Stand Dev ⁿ	10.2	1.8	9.9	6.5	4.7	N
Median	29.6	4.3	32.7	9.0	19.5	39
Minimum	14.6	1.8	3.3	1.5	9.7	
Maximum	57.1	8.8	54.0	26.9	28.6	
5 th Percentile	18.2	2.2	17.0	2.2	13.6	
25 th Percentile	23.7	3.1	28.2	5.7	15.9	
75 th Percentile	37.0	5.5	39.3	15.6	22.6	
95 th Percentile	50.7	7.7	44.6	21.5	27.9	
	R ²	χ^2	% Mass			
Mean	0.94	2.34	98.0			
Median	0.94	2.29	97.7			
Min	0.90	1.49	93.6			
Max	0.96	3.97	102.5			
5 th Percentile	0.92	1.57	94.6			
95 th Percentile	0.96	3.07	101.0			

ALL SPECIES - AC+ET-ETHYLENE: NAPS

TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass

No Samples With All Positive SCE
All -ve in TLROD

ALL SPECIES - PROPYLENE: NAPS

TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	50.8	9.0	11.5	4.2	9.3
Stand Dev ⁿ	3.0	1.3	5.1	3.0	2.8
Median	50.6	9.0	12.3	3.2	9.9
Minimum	45.5	7.6	3.2	2.6	5.0
Maximum	55.9	11.7	17.7	11.6	12.6
5 th Percentile	46.9	7.6	4.5	2.7	5.6
25 th Percentile	49.8	8.1	7.8	2.9	7.1
75 th Percentile	51.8	9.3	15.3	3.4	11.6
95 th Percentile	55.0	11.0	17.5	8.8	12.3
	R ²	χ^2	% Mass		
Mean	0.85	5.69	84.8		
Median	0.85	5.64	87.0		
Min	0.81	4.82	76.2		
Max	0.87	6.67	89.3		
5 th Percentile	0.82	4.86	77.7		
95 th Percentile	0.87	6.56	89.1		

ALL SPECIES-ETHYLENE-PROPYLENE-AC+ET: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	30.2	4.4	38.0	9.9	17.1	99.6
Stand Dev ⁿ	12.0	1.8	12.3	6.3	4.8	N
Median	31.2	4.2	36.8	8.5	17.6	41
Minimum	7.1	1.7	15.6	1.6	6.0	
Maximum	57.1	8.8	68.1	27.0	24.9	
5 th Percentile	10.3	2.3	17.5	2.0	9.4	
25 th Percentile	21.7	3.0	30.4	5.2	13.9	
75 th Percentile	38.3	5.5	44.0	12.6	20.9	
95 th Percentile	49.8	7.7	58.2	21.4	23.0	
	R ²	χ^2	% Mass			
Mean	0.94	2.42	99.6			
Median	0.94	2.43	99.6			
Min	0.92	1.54	93.6			
Max	0.96	3.37	105.5			
5 th Percentile	0.93	1.64	94.1			
95 th Percentile	0.96	3.11	105.1			

BASE SPECIES-ETHYLENE: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	59.3	4.2	21.2	13.7	12.1	110.4
Stand Dev ⁿ	12.1	2.0	10.4	9.0	6.3	N
Median	59.9	3.7	20.5	11.5	11.3	65
Minimum	25.5	1.5	1.3	1.6	0.7	
Maximum	82.0	13.3	51.9	36.8	32.0	
5 th Percentile	41.9	2.0	6.9	2.4	3.2	
25 th Percentile	51.3	2.8	13.6	7.1	6.9	
75 th Percentile	68.5	5.2	26.9	20.6	16.1	
95 th Percentile	78.1	7.4	39.8	31.3	21.8	
	R ²	χ^2	% Mass			
Mean	0.95	2.07	110.4			
Median	0.96	1.87	110.7			
Min	0.91	1.03	100.8			
Max	0.97	3.75	116.4			
5 th Percentile	0.92	1.15	104.8			
95 th Percentile	0.97	3.28	114.7			

ALL SPECIES-ETHYLENE-PROPYLENE-AC+ET: NAPS

TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass

No Samples With All Positive SCE
All -ve in TLROD

BASE SPECIES-ETHYLENE: NAPS

	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	53.7	8.9	11.9	4.0	7.4	
Stand Dev ⁿ	2.9	1.4	4.8	3.0	2.5	85.9
Median	53.1	8.9	12.9	3.0	7.3	N
Minimum	50.2	7.5	3.6	2.5	4.1	8
Maximum	60.1	11.8	18.0	11.5	10.5	
5 th Percentile	50.9	7.5	5.1	2.5	4.5	
25 th Percentile	52.2	8.0	8.4	2.7	5.4	
75 th Percentile	54.1	9.2	15.3	3.4	9.5	
95 th Percentile	58.3	10.9	17.3	8.7	10.3	
	R ²	χ^2	% Mass			
Mean	0.82	7.73	85.9			
Median	0.83	7.29	87.5			
Min	0.76	6.75	74.5			
Max	0.84	9.52	94.5			
5 th Percentile	0.77	6.79	77.2			
95 th Percentile	0.84	9.26	92.8			

BASE SPECIES-2M-BUTANE: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPFEUE	% Mass
Mean	41.8	4.4	27.6	12.4	19.1	105.3
Stand Dev ⁿ	12.9	2.0	10.3	7.3	6.6	N
Median	42.5	3.9	27.9	11.1	19.0	68
Minimum	14.2	1.7	0.8	1.9	4.8	
Maximum	78.0	13.4	51.9	30.0	30.9	
5 th Percentile	20.1	2.1	8.4	2.5	9.9	
25 th Percentile	32.9	2.9	23.6	7.4	13.2	
75 th Percentile	50.4	5.3	32.5	19.1	24.4	
95 th Percentile	63.0	7.6	44.8	23.2	30.4	
	R ²	χ^2	% Mass			
Mean	0.95	2.40	105.3			
Median	0.95	2.28	105.2			
Min	0.92	1.34	97.2			
Max	0.97	3.77	111.9			
5 th Percentile	0.92	1.49	100.1			
95 th Percentile	0.97	3.58	109.6			

BASE SPECIES-AC+ET: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPFEUE	% Mass
Mean	38.7	4.3	34.6	11.9	17.1	106.6
Stand Dev ⁿ	17.4	2.0	17.0	7.3	5.1	N
Median	39.1	4.1	31.0	10.3	17.4	65
Minimum	3.9	1.6	7.2	1.9	3.2	
Maximum	74.4	13.6	77.6	29.9	30.5	
5 th Percentile	10.1	2.2	10.5	2.3	8.3	
25 th Percentile	25.4	2.8	23.8	6.5	13.9	
75 th Percentile	52.2	5.3	46.2	18.9	20.0	
95 th Percentile	63.8	7.5	69.3	24.1	26.3	
	R ²	χ^2	% Mass			
Mean	0.95	2.24	106.6			
Median	0.95	2.13	106.5			
Min	0.91	1.23	100.4			
Max	0.97	3.86	113.9			
5 th Percentile	0.92	1.43	102.0			
95 th Percentile	0.97	3.46	110.8			

BASE SPECIES-2M-BUTANE: NAPS

	TT94HD	FLPG	TLROD	GA	COMPFEUE	% Mass
Mean	52.5	9.0	10.7	4.1	8.4	84.8
Stand Dev ⁿ	3.0	1.3	4.8	3.1	3.2	N
Median	52.8	9.0	10.7	3.1	8.8	8
Minimum	48.2	7.6	3.8	2.6	4.6	
Maximum	57.7	11.8	17.6	11.8	11.8	
5 th Percentile	48.5	7.6	4.7	2.7	4.6	
25 th Percentile	51.2	8.1	7.2	2.9	5.0	
75 th Percentile	53.6	9.3	13.9	3.4	11.6	
95 th Percentile	56.5	10.9	17.1	8.9	11.8	
	R ²	χ^2	% Mass			
Mean	0.81	7.84	84.8			
Median	0.82	7.50	85.9			
Min	0.76	6.81	74.8			
Max	0.84	9.49	91.3			
5 th Percentile	0.77	6.81	76.9			
95 th Percentile	0.84	9.27	90.5			

BASE SPECIES-AC+ET: NAPS

	TT94HD	FLPG	TLROD	GA	COMPFEUE	% Mass

No Samples With All Positive SCE
All -ve in TLROD

BASE SPECIES -AC+ET-ETHYLENE: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	55.8	4.1	29.5	13.1	9.6	112.1
Stand Dev ⁿ	17.6	1.9	18.0	9.0	3.8	N
Median	56.1	3.7	25.3	10.6	10.2	41
Minimum	4.6	1.4	3.5	1.7	1.2	
Maximum	90.3	13.5	83.3	36.9	23.2	
5 th Percentile	29.5	2.1	6.3	2.1	3.0	
25 th Percentile	43.3	2.8	18.4	6.0	7.3	
75 th Percentile	67.8	5.1	40.6	19.8	11.6	
95 th Percentile	80.1	7.3	64.8	30.9	14.6	
	R ²	X ²	% Mass			
Mean	0.95	2.02	112.1			
Median	0.96	1.81	112.1			
Min	0.91	1.04	103.2			
Max	0.98	3.73	119.4			
5 th Percentile	0.92	1.18	105.8			
95 th Percentile	0.97	3.44	118.1			

BASE SPECIES -ISOBUTYLENE: SL1 & SL2

	TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	38.0	4.4	30.1	10.6	16.7	99.8
Stand Dev ⁿ	10.3	1.8	8.5	6.5	5.2	N
Median	37.4	4.2	30.3	9.2	16.6	38
Minimum	19.8	1.7	1.4	1.5	5.4	
Maximum	64.8	8.5	48.9	26.9	27.2	
5 th Percentile	25.2	2.1	17.3	2.2	9.1	
25 th Percentile	29.6	3.0	24.9	5.8	13.5	
75 th Percentile	42.0	5.4	35.8	16.1	19.4	
95 th Percentile	55.9	7.8	41.7	21.5	25.9	
	R ²	X ²	% Mass			
Mean	0.95	2.11	99.8			
Median	0.95	2.05	100.0			
Min	0.91	1.26	93.8			
Max	0.97	3.45	104.6			
5 th Percentile	0.93	1.40	95.9			
95 th Percentile	0.96	2.99	103.1			

BASE SPECIES -AC+ET-ETHYLENE: NAPS

TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass

BASE SPECIES -ISOBUTYLENE: NAPS

TT94HD	FLPG	TLROD	GA	COMPFUE	% Mass
Mean	47.5	8.5	10.2	4.3	11.8
Stand Dev ⁿ	3.0	1.2	5.1	3.0	3.1
Median	47.0	8.5	11.3	3.3	11.8
Minimum	43.2	7.2	1.8	2.8	7.2
Maximum	53.2	11.2	15.9	11.7	16.2
5 th Percentile	43.9	7.3	3.2	2.9	7.8
25 th Percentile	46.1	7.7	6.3	3.0	9.7
75 th Percentile	48.9	8.8	14.0	3.6	14.1
95 th Percentile	52.1	10.5	15.8	9.3	15.8
	R ²	X ²	% Mass		
Mean	0.84	6.05	82.4		
Median	0.84	6.00	84.8		
Min	0.81	5.13	73.5		
Max	0.87	7.05	87.5		
5 th Percentile	0.82	5.18	74.9		
95 th Percentile	0.87	6.93	87.1		

No Samples With All Positive SCE
All -ve in TLROD

Table 58: Statistical Summary of CMB Results: NAPS Samples

Source apportionment using all samples. Source profile descriptions are found in Table 8. (SL1, SL2: Slater Street nose-level sampling stations, NAPS: National Air Pollution Surveillance network sampling station).

NAPS		R ²		χ ²		% Mass		R ²		χ ²		% Mass		TT94HD		Error	TSTAT	FLPG	Error	TSTAT	TLROD	Error	TSTAT	GA	Error	TSTAT	COMPFUE	Error	TSTAT
0.84	6.94	85.1	Median	0.83	6.95	86.55		0.83	6.95	86.55		0.83	6.95	47.9	8.8	5.4	8.2	1.8	4.5	14.5	10.2	1.4	2.9	1.9	1.5	11.5	5.4	2.1	
0.84	6.82	92.1	Mean	0.82	7.28	85.19		0.82	7.28	85.19		0.82	7.28	48.9	8.6	5.7	8.8	1.9	4.6	11.3	9.3	1.2	11.6	3.5	3.3	11.4	5.1	2.2	
0.83	6.97	88.0	Min	0.77	6.32	74.80		0.77	6.32	74.80		0.77	6.32	57.6	9.9	5.8	7.6	1.7	4.5	12.6	10.6	1.2	2.7	1.9	1.4	7.5	5.7	1.3	
0.85	6.32	89.0	Max	0.85	8.81	92.10		0.85	8.81	92.10		0.85	8.81	54.1	9.7	5.6	9.4	2.1	4.5	17.8	10.6	1.7	3.1	2.0	1.6	4.5	5.6	0.8	
0.85	6.32	89.2	5th	0.78	6.32	77.15		0.78	6.32	77.15		0.78	6.32	53.1	9.5	5.6	11.7	2.5	4.7	16.4	10.3	1.6	3.4	2.0	1.7	4.6	5.4	0.9	
0.80	8.27	81.5	25th	0.81	6.70	81.73		0.81	6.70	81.73		0.81	6.70	52.4	9.1	5.8	7.6	1.7	4.5	7.5	10.5	0.7	2.6	1.8	1.4	11.5	5.6	2.1	
0.77	8.81	74.8	75th	0.84	7.91	89.05		0.84	7.91	89.05		0.84	7.91	53.4	8.7	6.1	9.1	2.0	4.6	3.8	9.5	0.4	3.4	1.8	1.9	5.2	5.2	1.0	
0.81	7.79	81.8	95th	0.85	8.62	91.08		0.85	8.62	91.08		0.85	8.62	51.8	9.1	5.7	9.2	2.0	4.6	8.3	10.5	0.8	3.0	1.8	1.6	9.6	5.4	1.8	

Table 59: Statistical Summary of CMB Results: SL1 & SL2: AM (07:30-09:30) Samples

Source apportionment using all samples. Source profile descriptions are found in Table 8. (SL1, SL2: Slater Street nose-level sampling stations, NAPS: National Air Pollution Surveillance network sampling station).

SL1-AM													
R ²	χ ²	% Mass	Median	R ²	χ ²	% Mass	TT94HD	Error	TSTAT	FLPG	Error	TSTAT	TLROD
0.93	2.90	104.3	Median	0.94	2.54	106.0	29.7	7.2	4.1	3.6	0.9	4.1	23.3
0.97	1.48	106.5	Mean	0.94	2.51	105.9	45.1	9.0	5.0	4.7	1.1	4.1	23.2
0.96	1.81	107.5	Min	0.91	1.47	102.0	53.8	10.8	5.0	7.1	1.7	4.3	31.4
0.93	3.03	103.9	Max	0.97	3.94	109.7	40.3	8.6	4.7	2.7	0.7	3.8	23.3
0.97	1.47	106.9	5th	0.91	1.47	102.9	52.4	10.4	5.1	7.3	1.7	4.3	27.6
0.95	1.93	109.7	25th	0.93	1.84	104.4	53.2	10.0	5.3	2.7	0.7	3.7	17.6
0.92	3.38	105.4	75th	0.96	3.01	107.4	32.7	9.1	3.6	6.4	1.5	4.2	38.8
0.93	2.96	104.5	95th	0.97	3.69	108.8	39.7	8.7	4.6	6.4	1.5	4.3	25.6
0.91	3.94	102.0					37.2	7.8	4.8	4.4	1.0	4.2	17.9
0.95	2.17	107.8					43.3	9.5	4.6	5.4	1.3	4.2	28.0
SL2-AM													
R ²	χ ²	% Mass	Median	R ²	χ ²	% Mass	TT94HD	Error	TSTAT	FLPG	Error	TSTAT	TLROD
0.96	1.88	105.5	Median	0.94	2.32	104.5	34.5	7.5	4.6	3.3	0.8	4.0	24.6
0.95	2.04	106.2	Mean	0.95	2.42	105.2	27.3	7.4	3.7	2.9	0.8	3.9	32.2
0.97	1.35	104.9	Min	0.91	1.32	102.1	32.3	8.1	4.0	3.9	1.0	4.0	35.0
0.94	2.81	107.5	Max	0.97	3.86	109.1	44.2	10.4	4.2	5.3	1.3	4.1	41.9
0.91	3.86	104.2	5th	0.92	1.34	102.4	29.7	6.4	4.6	3.9	0.9	4.2	16.6
0.94	2.57	104.2	25th	0.94	1.83	103.8	33.1	7.6	4.3	2.7	0.7	3.8	26.1
0.95	2.08	104.1	75th	0.96	2.90	106.5	32.8	8.4	3.9	5.3	1.3	4.1	35.7
0.96	1.67	109.1	95th	0.97	3.64	108.9	44.5	9.0	5.0	3.4	0.9	3.9	23.3
0.94	2.76	102.7					17.5	8.0	2.2	5.1	1.2	4.1	47.2
0.92	3.46	102.1					24.2	7.1	3.4	5.1	1.2	4.2	30.3
0.93	3.19	103.0					38.5	7.9	4.9	2.3	0.6	3.7	20.1
0.97	1.32	108.7					46.2	9.6	4.8	5.9	1.4	4.2	29.5
Error													
GA	17.4	4.9	3.5	30.3	4.3	7.0	TSTAT	3.4	3.4	17.4	4.9	3.5	30.3
GA	19.2	5.2	3.7	14.3	4.7	3.1	TSTAT	2.9	2.9	19.2	5.2	3.7	14.3
GA	2.8	2.3	1.2	12.3	5.7	2.2	TSTAT	3.1	3.1	2.8	2.3	1.2	12.3
GA	20.6	5.5	3.8	17.0	4.5	3.8	TSTAT	3.1	3.1	20.6	5.5	3.8	17.0
GA	8.3	3.2	2.6	11.2	5.3	2.1	TSTAT	3.1	3.1	8.3	3.2	2.6	11.2
GA	8.8	3.4	2.5	27.3	5.4	5.1	TSTAT	2.3	2.3	8.8	3.4	2.5	27.3
GA	2.8	2.4	1.2	24.6	5.1	4.8	TSTAT	4.0	4.0	2.8	2.4	1.2	24.6
GA	7.4	3.1	2.4	25.5	4.9	5.2	TSTAT	3.1	3.1	7.4	3.1	2.4	25.5
GA	22.2	5.7	3.9	20.3	4.3	4.7	TSTAT	2.6	2.6	22.2	5.7	3.9	20.3
GA	10.7	3.7	2.9	20.5	5.1	4.1	TSTAT	3.2	3.2	10.7	3.7	2.9	20.5
Error													
GA	29.7	7.3	4.1	13.2	4.1	3.2	TSTAT	3.3	3.3	29.7	7.3	4.1	13.2
GA	22.3	5.9	3.8	21.5	4.3	5.0	TSTAT	4.0	4.0	22.3	5.9	3.8	21.5
GA	19.3	5.3	3.7	14.5	4.4	3.3	TSTAT	4.1	4.1	19.3	5.3	3.7	14.5
GA	4.6	2.7	1.7	11.5	5.6	2.0	TSTAT	3.7	3.7	4.6	2.7	1.7	11.5
GA	33.2	7.9	4.2	20.9	3.7	5.6	TSTAT	2.8	2.8	33.2	7.9	4.2	20.9
GA	23.1	6.0	3.9	19.2	4.2	4.5	TSTAT	3.5	3.5	23.1	6.0	3.9	19.2
GA	10.6	3.6	2.9	19.7	4.7	4.2	TSTAT	4.0	4.0	10.6	3.6	2.9	19.7
GA	12.0	4.0	3.0	25.9	5.0	5.2	TSTAT	3.0	3.0	12.0	4.0	3.0	25.9
GA	4.4	2.7	1.6	28.5	5.0	5.8	TSTAT	4.6	4.6	4.4	2.7	1.6	28.5
GA	11.6	3.8	3.0	30.9	4.5	6.9	TSTAT	3.8	3.8	11.6	3.8	3.0	30.9
GA	23.3	6.0	3.9	18.8	4.3	4.4	TSTAT	2.8	2.8	23.3	6.0	3.9	18.8
GA	11.7	3.9	3.0	15.4	5.1	3.0	TSTAT	3.2	3.2	11.7	3.9	3.0	15.4

Table 61: Statistical Summary of CMB Results: SL1 & SL2: Afternoon (15:30-17:30) Samples

Source apportionment using all samples. Source profile descriptions are found in Table 8. (SL1, SL2: Slater Street nose-level sampling stations, NAPS: National Air Pollution Surveillance network sampling station).

SL1-AF													
R ²	χ ²	% Mass	Median	R ²	χ ²	% Mass	TT94HD	Error	TSTAT	FLPG	Error	TSTAT	TLROD
0.94	2.34	105.3	Median	0.95	2.08	105.6	53.8	10.4	5.2	5.1	1.2	4.1	27.6
0.96	1.80	102.7	Mean	0.95	2.07	105.9	54.6	10.4	5.2	1.8	0.6	3.1	28.1
0.96	1.91	105.8	Min	0.94	1.73	102.7	56.4	10.6	5.3	3.1	0.8	3.7	24.8
0.95	2.26	105.4	Max	0.96	2.40	109.3	34.2	7.9	4.4	2.7	0.7	3.8	26.0
0.94	2.40	104.9	5th	0.94	1.75	103.5	42.6	8.9	4.8	2.9	0.8	3.9	21.6
0.96	1.79	109.3	25th	0.95	1.80	105.2	62.7	11.5	5.4	2.2	0.7	3.3	27.2
0.95	2.30	106.2	75th	0.96	2.31	106.5	56.0	10.8	5.2	5.7	1.4	4.2	25.0
0.96	1.73	107.4	95th	0.96	2.38	108.6	49.5	9.8	5.0	1.7	0.5	3.2	24.9
SL2-AF													
R ²	χ ²	% Mass	Median	R ²	χ ²	% Mass	TT94HD	Error	TSTAT	FLPG	Error	TSTAT	TLROD
0.95	1.92	104.8	Median	0.95	1.92	104.8	50.4	10.1	5.0	6.3	1.5	4.3	30.5
0.97	1.45	105.4	Mean	0.95	2.04	104.5	46.1	10.1	4.6	2.1	0.6	3.3	36.9
0.96	1.75	103.7	Min	0.92	1.45	101.9	33.3	9.2	3.6	2.5	0.7	3.5	43.8
0.92	3.51	101.9	Max	0.97	3.51	106.9	44.0	9.4	4.7	4.3	1.1	4.1	27.9
0.96	1.85	106.9	5th	0.93	1.55	102.4	44.1	9.0	4.9	4.1	1.0	4.1	24.4
0.95	2.00	105.2	25th	0.95	1.75	103.7	50.0	9.8	5.1	3.8	1.0	4.0	23.3
0.96	1.69	103.2	75th	0.96	2.05	105.2	43.8	10.0	4.4	3.5	0.9	3.8	40.1
0.95	2.12	104.9	95th	0.97	2.95	106.3	63.3	11.1	5.7	4.3	1.1	4.0	19.0
0.95	2.05	104.7					59.6	10.1	5.9	4.2	1.0	4.1	12.4
				GA	Error	TSTAT	COMPFUE	Error	TSTAT	GA	Error	TSTAT	TSTAT
				7.1	3.0	2.8	11.8	5.5	2.4	8.2	3.1	2.6	2.1
				8.0	3.2	2.9	10.3	5.5	2.5	10.3	3.6	2.9	1.9
				8.2	3.2	2.6	13.3	5.6	2.5	11.2	3.8	3.0	2.5
				24.2	6.2	3.3	18.3	4.4	3.9	5.5	2.7	2.0	4.0
				11.2	3.8	3.0	26.6	5.0	3.8	21.0	5.6	3.8	2.8
				4.2	2.7	2.8	16.4	5.0	3.1	11.7	3.8	3.1	3.3
				6.3	2.9	2.7	5.9	5.0	2.8	9.9	3.5	2.8	1.2
				13.2	5.5	2.2	15.9	5.7	2.2	2.5	2.3	1.1	2.8
				21.4	5.3	2.9	16.6	5.1	3.1	11.9	3.8	3.1	3.2

Table 63: Statistical Summary: Source Contribution Estimates: NAPS

Source apportionment using all samples. Source profile descriptions are found in Table 8. (NAPS: National Air Pollution Surveillance network sampling station).

NAPS	TT94HD	ERROR	TSTAT	FLPG	ERROR	TSTAT	TLROD	ERROR	TSTAT	GA	ERROR	TSTAT	COMPFUE	ERROR	TSTAT
Median	53.1	9.5	5.6	8.8	1.9	4.5	14.5	10.3	1.4	3.1	2.0	1.6	7.5	5.4	1.3
Mean	52.3	9.3	5.6	9.2	2.0	4.6	14.5	10.2	1.4	4.8	2.3	1.9	7.9	5.4	1.5
Min	47.9	8.6	5.4	7.6	1.7	4.5	11.3	9.3	1.2	2.7	1.9	1.4	4.5	5.1	0.8
Max	57.6	9.9	5.8	11.7	2.5	4.7	17.8	10.6	1.7	11.6	3.5	3.3	11.5	5.7	2.2
5th	48.1	8.7	5.4	7.7	1.7	4.5	11.6	9.5	1.2	2.7	1.9	1.4	4.6	5.1	0.8
25th	48.9	8.8	5.6	8.2	1.8	4.5	12.6	10.2	1.2	2.9	1.9	1.5	4.6	5.4	0.9
75th	54.1	9.7	5.7	9.4	2.1	4.6	16.4	10.6	1.6	3.4	2.0	1.7	11.4	5.6	2.1
95th	56.9	9.9	5.8	11.3	2.4	4.6	17.5	10.6	1.7	10.0	3.2	3.0	11.5	5.7	2.2

Table 65: Statistical Summary: Source Contribution Estimates: SL1 & SL2: Noon (11:30-13:30) Samples

Source apportionment using all samples. Source profile descriptions are found in Table 8. (SL1, SL2: Slater Street nose-level sampling stations, NAPS: National Air Pollution Surveillance network sampling station).

SL1-NO													
	TT94HD	ERROR	TSTAT	FLPG	ERROR	TSTAT	TLROD	ERROR	TSTAT	GA	ERROR	TSTAT	TSTAT
Median	38.2	8.3	5.1	4.2	1.0	4.1	15.7	7.1	2.5	14.5	4.4	3.3	5.8
Mean	41.8	8.3	5.0	5.1	1.2	4.1	17.8	7.2	2.4	14.9	4.5	3.1	5.5
Min	27.5	6.2	3.8	2.4	0.6	3.7	7.5	5.0	1.2	3.4	2.4	1.4	3.4
Max	61.4	10.5	5.8	13.4	3.0	4.5	36.7	9.6	3.8	30.0	7.4	4.1	6.8
5th	28.7	6.6	3.8	2.5	0.7	3.8	7.8	5.3	1.2	5.0	2.7	1.8	3.7
25th	32.1	7.6	4.3	2.8	0.7	4.0	8.6	6.6	1.4	8.6	3.3	2.6	4.6
75th	51.3	9.0	5.7	5.5	1.3	4.2	23.0	7.7	3.2	19.0	5.2	3.6	6.4
95th	59.5	10.2	5.8	10.8	2.4	4.4	34.0	9.1	3.7	26.9	6.7	4.0	6.7
SL2-NO													
	TT94HD	ERROR	TSTAT	FLPG	ERROR	TSTAT	TLROD	ERROR	TSTAT	GA	ERROR	TSTAT	TSTAT
Median	28.0	7.4	4.1	3.9	0.9	4.1	30.6	8.5	3.5	16.2	4.7	3.5	5.0
Mean	26.6	7.6	3.5	4.3	1.0	4.0	32.9	8.2	3.9	16.1	4.7	3.1	5.1
Min	13.3	6.0	1.9	2.0	0.6	3.3	18.9	6.0	3.2	3.7	2.5	1.4	2.6
Max	36.9	9.0	4.3	8.2	1.9	4.4	51.9	9.6	5.4	32.1	7.7	4.1	8.1
5th	13.6	6.4	1.9	2.3	0.7	3.5	20.5	6.3	3.2	3.9	2.6	1.5	3.0
25th	22.0	7.2	3.0	3.1	0.8	3.9	24.2	7.3	3.4	10.8	3.7	2.8	4.3
75th	32.7	8.1	4.2	5.1	1.2	4.2	38.9	9.3	4.4	21.3	5.7	3.8	5.7
95th	36.7	8.8	4.3	7.2	1.7	4.3	50.0	9.5	5.2	28.7	7.1	4.0	7.5
											COMPFUE	ERROR	TSTAT
											22.7	4.4	5.0
											22.7	4.4	5.1
											10.8	3.7	2.6
											39.1	5.1	8.1
											12.4	3.8	3.0
											20.7	4.1	4.3
											24.1	4.8	5.7
											33.9	5.0	7.5

Table 66: Statistical Summary: Source Contribution Estimates: SL1 & SL2: Afternoon (15:30-17:30) Samples

Source apportionment using all samples. Source profile descriptions are found in Table 8. (SL1, SL2: Slater Street nose-level sampling stations, NAPS: National Air Pollution Surveillance network sampling station).

SL1-AF													
TT94HD													
	ERROR	TSTAT	FLPG	ERROR	TSTAT	TLROD	ERROR	TSTAT	GA	ERROR	TSTAT	COMPFUE	TSTAT
Median	54.2	10.4	5.2	2.8	0.7	3.8	25.5	9.4	2.8	8.1	3.2	13.2	2.4
Mean	51.2	10.0	5.1	3.2	0.8	3.7	25.7	9.1	2.8	9.9	3.6	16.0	3.1
Min	34.2	7.9	4.4	1.7	0.5	3.1	21.6	7.8	2.6	4.2	2.7	10.3	1.9
Max	62.7	11.5	5.4	5.7	1.4	4.2	28.1	9.9	3.3	24.2	6.2	26.6	5.4
5th	37.2	8.2	4.5	1.7	0.5	3.1	22.7	7.8	2.6	4.9	2.7	10.8	2.0
25th	47.8	9.6	5.0	2.1	0.7	3.3	24.9	8.4	2.8	6.9	3.0	12.6	2.1
75th	56.1	10.7	5.2	3.6	0.9	3.9	27.3	9.7	2.9	10.2	3.6	19.1	4.1
95th	60.5	11.3	5.4	5.5	1.3	4.2	27.9	9.8	3.2	19.6	5.4	24.8	4.9
SL2-AF													
TT94HD													
	ERROR	TSTAT	FLPG	ERROR	TSTAT	TLROD	ERROR	TSTAT	GA	ERROR	TSTAT	COMPFUE	TSTAT
Median	46.1	10.0	4.9	4.1	1.0	4.0	27.9	9.1	3.1	10.3	3.6	13.2	2.8
Mean	48.3	9.9	4.9	3.9	1.0	3.9	28.7	9.2	3.1	10.2	3.6	13.4	2.6
Min	33.3	9.0	3.6	2.1	0.6	3.3	12.4	7.6	1.6	2.5	2.3	5.9	1.2
Max	63.3	11.1	5.9	6.3	1.5	4.3	43.8	10.6	4.1	21.0	5.6	20.2	4.0
5th	37.5	9.1	3.9	2.3	0.7	3.4	15.1	7.9	1.9	3.7	2.5	7.3	1.4
25th	44.0	9.4	4.6	3.5	0.9	3.8	23.3	8.3	2.8	8.2	3.1	10.0	1.9
75th	50.4	10.1	5.1	4.3	1.1	4.1	36.9	10.0	3.6	11.7	3.8	16.4	3.2
95th	61.8	10.7	5.8	5.5	1.3	4.2	42.3	10.5	4.1	17.3	4.9	18.8	3.7

Table 67: Statistical Summary: Source Contribution Estimates: SL1 & SL2: PM (22:00-00:00) Samples

Source apportionment using all samples. Source profile descriptions are found in Table 8. (SL1, SL2: Slater Street nose-level sampling stations, NAPS: National Air Pollution Surveillance network sampling station).

SL1-PM													
	TT94HD	ERROR	TSTAT	FLPG	ERROR	TSTAT	TLROD	ERROR	TSTAT	GA	ERROR	TSTAT	COMPFUE
Median	32.0	7.7	4.2	4.2	1.0	4.2	27.7	7.8	3.6	20.0	5.4	3.7	16.0
Mean	32.1	7.6	4.3	5.4	1.3	4.2	25.7	7.6	3.3	23.1	6.0	3.7	17.2
Min	27.9	6.1	4.1	3.3	0.8	4.1	16.1	5.8	2.8	12.4	3.9	3.2	14.7
Max	36.3	8.9	4.6	8.8	2.0	4.4	33.5	9.2	3.6	37.1	8.6	4.3	20.8
5th	28.3	6.3	4.1	3.4	0.8	4.1	17.3	6.0	2.9	13.2	4.1	3.2	14.8
25th	30.0	6.9	4.1	3.7	0.9	4.2	21.9	6.8	3.2	16.2	4.6	3.4	15.4
75th	34.1	8.3	4.4	6.5	1.5	4.3	30.6	8.5	3.6	28.5	7.0	4.0	18.4
95th	35.9	8.8	4.5	8.3	1.9	4.4	32.9	9.0	3.6	35.4	8.3	4.2	20.4
SL2-PM													
	TT94HD	ERROR	TSTAT	FLPG	ERROR	TSTAT	TLROD	ERROR	TSTAT	GA	ERROR	TSTAT	COMPFUE
Median	28.5	7.2	3.9	3.5	0.9	4.0	27.1	7.5	3.6	21.6	5.7	3.8	23.1
Mean	25.9	7.3	3.7	3.4	0.8	4.0	29.4	7.9	3.5	22.1	5.9	3.6	23.5
Min	20.2	6.3	2.4	2.9	0.8	3.7	14.8	5.7	2.6	10.3	3.8	2.7	20.2
Max	29.0	8.4	4.6	3.8	0.9	4.3	46.1	10.4	4.4	34.3	8.1	4.2	27.1
5th	21.0	6.4	2.6	2.9	0.8	3.7	16.0	5.9	2.7	11.4	4.0	2.8	20.5
25th	24.4	6.7	3.2	3.2	0.8	3.9	21.0	6.6	3.1	15.9	4.7	3.3	21.7
75th	28.7	7.8	4.3	3.6	0.9	4.1	36.6	9.0	4.0	27.9	6.9	4.0	25.1
95th	28.9	8.3	4.6	3.7	0.9	4.2	44.2	10.1	4.3	33.1	7.9	4.2	26.7
											ERROR	TSTAT	
											4.2	5.5	
											4.3	5.4	
											3.6	5.3	
											5.1	5.6	
											3.7	5.3	
											3.9	5.4	
											4.7	5.5	
											5.1	5.6	

RESIDENTIAL GARAGE APPENDICES

Table 68: Cold Start Garage: Final Source Contribution Estimates

Final apportionment of cold start garage (CSG) samples at six homes (TR, PT, MM, JR, HD and GM). Sources used for the apportionment are cold start tailpipe emissions (CS), ambient background (B), in-house pre-test (PT) and hot soak evaporative emissions (HS).

	TR-CSG	PT-CSG	PT-CSG	MM-CSG	MM-CSG	JR-CSG	HD-CSG	GM-CSG	GM-CSG
SOURCE	Final Source Contribution Estimates								
CS	70.26	82.31	79.69	98.02	96.69	92.46	102.09	97.31	99.34
B	5.86	3.46		2.22		1.43	2.07		1.62
PT	0.75		4.22		1.09	1.17		1.11	
HS	29.83	13.23	14.18	8.51	11.14	9.20	5.10	6.59	5.87
% Mass	106.7	99.0	98.1	108.7	108.9	104.3	109.3	105.0	106.8
R ²	0.92	0.94	0.93	0.94	0.92	0.94	0.90	0.92	0.92
χ^2	2.87	1.94	2.03	1.62	2.33	1.70	2.75	2.17	2.36

Table 69: Hot Soak Garage: Final Source Contribution Estimates

Final apportionment of hot soak garage (HSG) samples at four homes (PT, JR, HD and GM). Sources used for the apportionment are ambient background (B), in-house pre-test (PT) and hot soak evaporative emissions (HS).

	PT-HSG	JR-HSG	JR-HSG	HD-HSG	HD-HSG	GM-HSG
SOURCE	Final Source Contribution Estimates					
CS						
B		2.06			6.52	
PT	0.90		1.39	3.15		0.45
HS	94.74	90.30	91.54	93.73	88.55	79.82
% Mass	95.6	92.4	92.9	96.9	95.1	80.3
R ²	0.85	0.88	0.88	0.88	0.87	0.75
χ^2	4.14	3.20	3.12	3.25	3.69	7.15

Table 70: Cold Start House: Final Source Contribution Estimates

Final apportionment of cold start in-house (CSH) samples at six homes (TR, PT, MM, JR, HD and GM). Sources used for the apportionment are cold start tailpipe emissions (CS), ambient background (B) and in-house pre-test (PT).

	TR-CSH	PT-CSH	MM-CSH	JR-CSH	HD-CSH	HD-CSH	GM-CSH
SOURCE	Final Source Contribution Estimates						
CS	45.55	13.19	25.15	36.55	84.71	87.20	40.05
B	7.31	8.56					24.45
PT	25.54	70.53	78.94	61.04	7.48	8.74	31.21
HS							
% Mass	78.4	92.3	104.1	97.6	95.1	95.9	95.7
R ²	0.75	0.94	0.95	0.88	0.88	0.88	0.91
χ^2	8.74	1.74	1.35	3.56	3.45	3.34	3.01

Table 71: Hot Soak House: Final Source Contribution Estimates

Final apportionment of hot soak in-house (HSH) samples at six homes (PT, JR, HD and GM). Sources used for the apportionment are ambient background (B), in-house pre-test (PT) and hot soak evaporative emissions (HS).

	PT-HSH	JR-HSH	HD-HSH	GM-HSH
SOURCE	Final Source Contribution Estimates			
CS				
B	3.81	25.06	18.66	11.61
PT	47.81	29.30	10.77	33.83
HS	48.21	34.72	69.36	50.42
% Mass	99.8	89.1	98.8	95.9
R ²	0.97	0.92	0.93	0.85
χ^2	0.87	2.95	2.22	4.86

Table 72: Mass Emissions of VOCs During the Evaporative Emissions Test

Relative concentrations are reported that represent the mass contained in a 6 L SUMMA™ canister. Two replicates were taken. Blank cells represent those species below their respective detection limits.

Number and Species	Average (mg/test)	Std. Dev. (mg/test)	Number and Species	Average (mg/test)	Std. Dev. (mg/test)
1 methane	15.41	5.04	42 t-3m2-pentene	0.35	0.05
2 ethylene	0.32	0.2	43 c2-hexene	0.25	0.05
3 acetylene	0.09	0.03	44 c-3m2-pentene	0.49	0.08
4 ethane	0.21	0.05	45 22-dm-pentane		
5 propylene	0.15	0.07	46 m-cyclopentane	4.09	0.56
6 propane	2.32	4.02	47 24-dm-pentane	0.38	0.04
7 propyne			48 223-tm-butane	0.01	0.02
8 isobutane	6.75	1.46	49 1m-cyclopentene		
9 isobutene/1-butene	3.73	0.81	50 benzene	10.53	1.08
10 13-butadiene	0.09	0.1	51 33-dm-pentane	0.14	0.01
11 n-butane	17.99	3.21	52 cyclohexane	0.75	0.13
12 t2-butene	3.19	0.73	53 2m-hexane	1.49	0.14
13 22-dm-propane	0.03	0.03	54 23-dm-pentane	0.40	0.04
14 1-butyne			55 11-dm-cyP	0.08	0.01
15 c2-butene	2.19	0.46	56 cyclohexene	0.08	
16 12-butadiene			57 3m-hexane	1.46	0.13
17 3m1-butene	0.21	0.07	58 c-13-dm-cyP	0.31	0.03
18 2m-butane	11.72	1.51	59 3e-pentane/t-13-dm-cyP	0.50	0.05
19 14-pentadiene	0.09	0.16	60 t-12-dm-cyP		
20 2-butyne			61 224-tm-pentane/1-heptene	1.04	0.19
21 1-pentene	0.78	0.1	62 t3-heptene	0.14	0.01
22 2m1-butene	1.39	0.25	63 n-heptane	1.97	0.18
23 n-pentane	7.81	1.11	64 c3-heptane	0.32	0.04
24 2m-13-butadiene	0.10	0.03	65 t2-heptene	0.15	0
25 t2-pentene	1.99	0.31	66 c2-heptene	0.14	0.01
26 c2-pentene	1.05	0.16	67 22-dm-hexane		
27 2m2-butene	2.63	0.4	68 m-cyH/c12-dm-cyP/113-tm-cyP	0.74	0.23
28 22-dm-butane	0.79	0.1	69 12-dm-cyH	0.03	0.02
29 cyclopentene	0.45	0.06	70 25-dm-hexane/e-cyP	0.44	0.05
30 4m1 & 3m1-pentene	0.11	0.1	71 24-dm-hexane/223-tm-pentane	0.42	0.04
31 cyclopentane	1.37	0.2	72 33-dm-hexane/ctc-124-tm-cyP	0.12	0
32 23-dm-butane	0.99	0.11	73 ctc-123-tm-cyP	0.09	0.01
33 c/t-4m2-pentene			74 234-tm-pentane	0.60	0.15
34 2m-pentane	5.24	0.58	75 toluene/233-tm-pentane	23.84	0.36
35 3m-pentane	3.18	0.35	76 23-dm-hexane/2m3e-pentane	0.19	0.33
36 2m1-pentene			77 112-tm-cyP		
37 1-hexene	0.38	0.09	78 2m-heptane	0.67	0.08
38 n-hexane	3.71	0.46	79 4m-C7/3m3e-C5/1m-cyHexene	0.23	0.03
39 c/t-3-hexene	0.28	0.04	80 34-dm-hexane	0.11	0.02
40 t2-hexene	0.45	0.04	81 3m-heptane	0.73	0.1
41 2m2-pentene	0.65	0.09	82 3e-hexane		

Number and Species		Average (mg/test)	Std. Dev. (mg/test)	Number and Species		Average (mg/test)	Std. Dev. (mg/test)
83	cct-124-tm-cyP/c-13-dm-cyH	0.16	0.03	124	nb-cyP	0.05	0.04
84	t-14-dm-cyH	0.08	0.01	125	33-dm-octane		
85	225-tm-hexane	0.14	0.02	126	np-benzene	0.58	0.06
86	11-dm-cyH			127	3e-toluene	1.5	0.18
87	1-octene	0.16	0.01	128	23-dm-octane		
88	ic1m-cyP	0.09	0	129	4e-toluene	0.48	0.41
89	n-octane/t-12-dm-cyH	0.77	0.05	130	135-tm-benzene	0.74	0.08
90	224-tm-hexane			131	2m-nonane	0.1	0.09
91	12-octene	0.11	0.01	132	3e-octane		
92	ccc-123-tm-cyP	0.14	0.02	133	3m-nonane		
93	244-tm-hexane	0.09	0.01	134	2e-toluene	0.58	0.15
94	c2-octene			135	124-tm&1b-benzene/1-decene	1.71	0.12
95	ip-cyP			136	ib-cyH	0.05	0.09
96	235-tm-hexane	0.04	0.04	137	n-decane	0.03	0.04
97	44&22-dm-heptane	0.06	0.04	138	ib-benzene		
98	24-dm-heptane	0.15	0.01	139	sb-benzene		
99	26-dm-heptane/c-12-dm-cyH	0.14	0.02	140	3-ip-toluene	0.09	0.11
100	np-cyP/ccc-135-tm-cyH/e-cyH	0.05	0.05	141	123-tm-benzene		
101	25-dm-heptane	0.14	0.05	142	4-ip-toluene	0.26	0.2
102	33-dm-heptane	0.03	0.05	143	indan		
103	114-tm-cyH	0.02	0.04	144	2-ip-toluene	0.21	0.23
104	e-benzene	3.69	0.34	145	13-de-benzene		
105	cti-124-tm-cyH	0.18	0.16	146	14-de-benzene	0	0.01
106	35-dm-heptane			147	3-np-toluene	0.08	0.07
107	m&p-xylene/23-dm-heptane	10.67	0.22	148	4-np-toluene/nb-&13dm-5e-benz	0.2	0.03
108	34-dm-heptane/4m-octane	0.31	0.02	149	12-de-benzene		
109	2m-octane/246-tm-hexane	0.17	0.06	150	2-np-toluene		
110	ctc-124-tm-cyH	0.06	0.1	151	14-dm-2e-benzene	0.09	0.08
111	3m-octane/33-de-C5/3e-C7			152	13-dm-4e-benzene		
112	o-xylene	3.94	0.13	153	12-dm-4e-benzene	0.11	0.11
113	112-tm-cyH			154	13-dm-2e-benzene		
114	1-nonene	0.08	0.01	155	n-undecane/12-dm-3e-benzene	0.07	0.12
115	13-nonene			156	1245-ttm-benzene		
116	ib-cyP			157	2mb-benzene	0.03	0.06
117	c3-nonene			158	tb-2m-benzene		
118	n-nonane	0.11	0.1	159	1234-ttm-benzene		
119	12-nonene	0.03	0.06	160	n-pentylbenzene	0.11	0.19
120	c2-nonene	0.02	0.02	161	tb-35-dm-benzene	0.08	0.14
121	ip-benzene	0.14	0.09	162	tb-4e-benzene		
122	22-dm-octane			163	n-dodecane	0.17	0.26
123	ip-cyH	0.02	0.04				

Table 73: Mass Emissions of VOCs For the Cold Start Tailpipe Emissions Test

Relative concentrations are reported that represent the mass contained in a Tedlar sample collection bag. Three samples were taken. Blank cells (or "0") represent those species below their respective detection limits.

Number and Species	Average (mg/test)	Std. Dev. (mg/test)	Number and Species	Average (mg/test)	Std. Dev. (mg/test)
1 methane	393.7	106.01	42 t-3m2-pentene	6.03	1.27
2 ethylene	499.94	121.79	43 c2-hexene	4.51	1.25
3 acetylene	270.14	65.92	44 c-3m2-pentene	8.33	1.04
4 ethane	59.54	9.62	45 22-dm-pentane	0	
5 propylene	234.63	55.13	46 m-cyclopentane	127.95	38.75
6 propane	0		47 24-dm-pentane	13.46	3.33
7 propyne	24.92	7.42	48 223-tm-butane	1.32	0.22
8 isobutane	74.6	16.52	49 1m-cyclopentene	0.82	0.71
9 isobutene/1-butene	103.96	22.73	50 benzene	266.14	68.84
10 13-butadiene	50.27	5.01	51 34-dm-pentane	6.08	1.64
11 n-butane	156.27	36.46	52 cyclohexane	25.82	7.94
12 t2-butene	27.38	6.7	53 2m-hexane	61.59	18.24
13 22-dm-propane	0.8	0.13	54 23-dm-pentane	19.17	5.34
14 1-butyne	0.95	0.17	55 11-dm-cyP	3.9	0.93
15 c2-butene	25.32	7.51	56 cyclohexene	2.02	0.53
16 12-butadiene	0		57 3m-hexane	64.32	19.02
17 3m1-butene	6.85	1.55	58 c-13-dm-cyP	13.02	3.64
18 2m-butane	212.35	55.94	59 3e-pentane/t-13-dm-cyP	21.49	6.14
19 14-pentadiene	1.78	0.58	60 t-12-dm-cyP	3.44	5.96
20 2-butyne	1.72	0.34	61 224-tm-pentane/1-heptene	43.78	18.05
21 1-pentene	12.74	2.95	62 t3-heptene	3.61	1.19
22 2m1-butene	17.69	3.43	63 n-heptane	70.01	21.51
23 n-pentane	112.98	31.04	64 c3-heptane	8.88	2.66
24 2m-13-butadiene	12.30	2.73	65 t2-heptene	3.52	1.17
25 t2-pentene	20.15	4.64	66 c2-heptene	3.29	0.95
26 c2-pentene	11.46	2.72	67 22-dm-hexane	1.02	0.3
27 2m2-butene	26.36	2.9	68 m-cyH/c12-dm-cyP/113-tm-cyP	29.37	8.45
28 22-dm-butane	33.15	8.24	69 12-dm-cyH	2.55	0.79
29 cyclopentene	2.19	3.73	70 25-dm-hexane/c-cyP	20.99	6.61
30 4m1 & 3m1-pentene	4.11	0.93	71 24-dm-hexane/223-tm-pentane	22.31	7.18
31 cyclopentane	23.38	6.93	72 33-dm-hexane/c1c-124-tm-cyP	8.76	2.54
32 23-dm-butane	34.67	9.98	73 c1c-123-tm-cyP	3.83	0.99
33 c/t-4m2-pentene	0		74 234-tm-pentane	20.23	4.86
34 2m-pentane	154.02	44.27	75 toluene/233-tm-pentane	782.96	242.89
35 3m-pentane	100.56	29.53	76 23-dm-hexane/2m3e-pentane	0.78	0.21
36 2m1-pentene	3.58	3.36	77 112-tm-cyP	2.06	0.77
37 1-hexene	5.29	1.28	78 2m-heptane	38.65	12.23
38 n-hexane	95.36	28.23	79 4m-C7/3m3e-C5/1m-cyHexene	14.49	4.69
39 c/t-3-hexene	5.72	1.39	80 34-dm-hexane	6.08	1.78
40 t2-hexene	8.05	2.24	81 3m-heptane	48.45	15.49
41 2m2-pentene	11.95	2.39	82 3e-hexane	0	

Number and Species		Average (mg/test)	Std. Dev. (mg/test)	Number and Species		Average (mg/test)	Std. Dev. (mg/test)
83	cct-124-tm-cyP/c-13-dm-cyH	9.44	2.92	124	nb-cyP	12.33	3.58
84	t-14-dm-cyH	2.78	0.82	125	33-dm-octane	1.31	0.37
85	225-tm-hexane	6.3	2.06	126	np-benzene	45.59	15.7
86	11-dm-cyH	0		127	3e-toluene	147.27	49.41
87	1-octene	7.06	2.19	128	23-dm-octane	0	
88	1e1m-cyP	3.41	1.41	129	4e-toluene	63.05	21.7
89	n-octane/t-12-dm-cyH	47.74	15.52	130	135-tm-benzene	79.42	26.58
90	224-tm-hexane	0		131	2m-nonane	11.41	3.59
91	12-octene	3.76	1.3	132	3e-octane	2.76	0.77
92	ccc-123-tm-cyP	9.83	3.41	133	3m-nonane	0	
93	244-tm-hexane	3.28	0.91	134	2e-toluene	65.76	20.07
94	c2-octene	1.63	0.65	135	124-tm&tb-benzene/1-decene	211.75	72.36
95	ip-cyP	2.52	0.89	136	ib-cyH	0.25	0.35
96	235-tm-hexane	2.49	0.88	137	n-decane	6.04	1.26
97	44&22-dm-heptane	1.63	0.68	138	ib-benzene	4.48	2.35
98	24-dm-heptane	8.58	3	139	sb-benzene	3.93	1.81
99	26-dm-heptane/c-12-dm-cyH	9.19	3.21	140	3-ip-toluene	0.73	1.03
100	np-cyP/ccc-135-tm-cyH/e-cyH	2.91	1.11	141	123-tm-benzene	8.33	5.9
101	25-dm-heptane	15.64	4.68	142	4-ip-toluene	43.68	19.16
102	33-dm-heptane	4.19	1.39	143	indan	0.83	0.52
103	114-tm-cyH	4.69	1.37	144	2-ip-toluene	25.11	14.15
104	e-benzene	165.51	54.08	145	13-de-benzene	0	
105	crt-124-tm-cyH	4.09	1.03	146	14-de-benzene	21.43	10.67
106	35-dm-heptane	3.10	2.99	147	3-np-toluene	8.42	2.18
107	m&p-xylene/23-dm-heptane	533.89	186.01	148	4-np-toluene/nb-&13dm-5e-benz	36.3	15.3
108	34-dm-heptane/4m-octane	32.82	11.12	149	12-de-benzene	3.86	1.49
109	2m-octane/246-tm-hexane	25.38	8.53	150	2-np-toluene	0.59	0.83
110	cic-124-tm-cyH	29.72	6.96	151	14-dm-2e-benzene	18.44	10.28
111	3m-octane/33-de-C5/3e-C7	0.96	1.67	152	13-dm-4e-benzene	13.14	6.43
112	o-xylene	224.15	79.32	153	12-dm-4e-benzene	21.62	10.34
113	112-tm-cyH	0		154	13-dm-2e-benzene	7.16	3.17
114	1-nonene	6.94	2.41	155	n-undecane/12-dm-3e-benzene	1.74	2.47
115	t3-nonene	4.13	1.62	156	1245-ttm-benzene	4.76	1.96
116	ib-cyP	0		157	2mb-benzene	9.43	4.86
117	c3-nonene	2.96	1.11	158	tb-2m-benzene	1.22	0.01
118	n-nonene	19.85	6.55	159	1234-ttm-benzene	6.69	3.08
119	t2-nonene	1.93	0.72	160	n-pentylbenzene	7.1	3.63
120	c2-nonene	4.45	1.31	161	tb-35-dm-benzene	1.14	0.54
121	ip-benzene	14.52	4.42	162	tb-4e-benzene	0	
122	22-dm-octane	4.98	1.74	163	n-dodecane	0.73	1.04
123	ip-cyH	8.87	3.18				

Table 74: Mass Emissions of VOCs For the Hot Start Tailpipe Emissions Test

Relative concentrations are reported that represent the mass contained in a Tedlar sample collection bag. Three samples were taken. Blank cells (or "0") represent those species below their respective detection limits.

Hot Start					
Number and Species		Average (mg/test)	Std. Dev. (mg/test)	Number and Species	
1	methane	62.79	2.58	42	t-3m2-pentene
2	ethylene	31.95	12.23	43	c2-hexene
3	acetylene	3.53	0.4	44	c-3m2-pentene
4	ethane	16.86	1.93	45	22-dm-pentane
5	propylene	10.3	14.57	46	m-cyclopentane
6	propane	0.85	0.28	47	24-dm-pentane
7	propyne	0		48	223-tm-butane
8	isobutane	6.05	1.39	49	1m-cyclopentene
9	isobutene/1-butene	7.73	3.21	50	benzene
10	1,3-butadiene	1.57	2.22	51	33-dm-pentane
11	n-butane	12.07	3.66	52	cyclohexane
12	c2-butene	1.86	0.91	53	2m-hexane
13	22-dm-propane	0.17	0.08	54	23-dm-pentane
14	1-butyne	0		55	11-dm-cyP
15	c2-butene	1.94	0.96	56	cyclohexene
16	1,2-butadiene	0		57	3m-hexane
17	3m1-butene	0.44	0.21	58	c-13-dm-cyP
18	2m-butane	11.78	3.4	59	3e-pentane/t-13-dm-cyP
19	1,4-pentadiene	0.36	0.34	60	t-12-dm-cyP
20	2-butyne	0		61	224-tm-pentane/1-heptene
21	1-pentene	0.57	0.27	62	i3-heptene
22	2m1-butene	1.01	0.48	63	n-heptane
23	n-pentane	6.01	2.4	64	c3-heptane
24	2m-1,3-butadiene	1.02	0.34	65	i2-heptene
25	i2-pentene	1.01	0.44	66	c2-heptene
26	c2-pentene	0.57	0.24	67	22-dm-hexane
27	2m2-butene	1.65	0.76	68	m-cyH/c12-dm-cyP/113-tm-cyP
28	22-dm-butane	2.14	0.73	69	12-dm-cyH
29	cyclopentene	0.43	0.19	70	25-dm-hexane/c-cyP
30	4m1 & 3m1-pentene	0.11	0.05	71	24-dm-hexane/223-tm-pentane
31	cyclopentane	1.1	0.41	72	33-dm-hexane/cic-124-tm-cyP
32	23-dm-butane	1.66	0.75	73	cic-123-tm-cyP
33	c/t-4m2-pentene	0		74	234-tm-pentane
34	2m-pentane	7.35	3.31	75	toluene/233-tm-pentane
35	3m-pentane	4.77	2.06	76	23-dm-hexane/2m3e-pentane
36	2m1-pentene	0		77	112-tm-cyP
37	1-hexene	0.2	0.08	78	2m-heptane
38	n-hexane	4.26	1.82	79	4m-C7/3m3e-C5/1m-cyHexene
39	c/t-3-hexene	0.25	0.12	80	34-dm-hexane
40	i2-hexene	0.31	0.06	81	3m-heptane
41	2m2-pentene	0.53	0.21	82	3e-hexane

Number and Species		Average (mg/test)	Std. Dev. (mg/test)	Number and Species		Average (mg/test)	Std. Dev. (mg/test)
83	cct-124-tm-cyP/c-13-dm-cyH	0.71	0.38	124	nb-cyP	0.75	0.64
84	t-14-dm-cyH	0.35	0.22	125	33-dm-octane	0.13	0.18
85	225-tm-hexane	0.57	0.52	126	np-benzene	2.55	1.32
86	11-dm-cyH	0		127	3e-toluene	5.3	0.08
87	1-octene	0.71	0.33	128	23-dm-octane	0	
88	1e1m-cyP	0.52	0.52	129	4e-toluene	1.83	0.44
89	n-octane/t-12-dm-cyH	2.19	0.55	130	135-tm-benzene	2.54	0.14
90	224-tm-hexane	0		131	2m-nonane	0.26	0.37
91	t2-octene	0.2	0.08	132	3e-octane	0	
92	ccc-123-tm-cyP	0.38	0.54	133	3m-nonane	0	
93	244-tm-hexane	0		134	2e-toluene	1.82	2.58
94	c2-octene	0		135	124-tm&tb-benzene/1-decene	6.02	0.54
95	ip-cyP	0.09	0.12	136	ib-cyH	0.00	
96	235-tm-hexane	0		137	n-decane	0.38	0.05
97	44&22-dm-heptane	0.03	0.04	138	ib-benzene	0	
98	24-dm-heptane	0.62	0.32	139	sb-benzene	0.49	0.69
99	26-dm-heptane/c-12-dm-cyH	0.52	0.08	140	3-ip-toluene	0.52	0.74
100	np-cyP/ccc-135-tm-cyH/e-cyH	0		141	123-tm-benzene	0.00	
101	25-dm-heptane	0.52	0.06	142	4-ip-toluene	1.97	0.72
102	33-dm-heptane	0		143	indan	1.81	2.56
103	114-tm-cyH	0.09	0.13	144	2-ip-toluene	0.66	0.94
104	e-benzene	8.09	0.37	145	13-de-benzene	0	
105	ctt-124-tm-cyH	0.57	0.42	146	14-de-benzene	2.53	2.19
106	35-dm-heptane	0.28	0.4	147	3-np-toluene	0.78	0.13
107	m&p-xylene/23-dm-heptane	21.47	2.32	148	4-np-toluene/nb-&13dm-5e-benz	0.83	1.18
108	34-dm-heptane/4m-octane	0.96	1.36	149	12-de-benzene	0.84	1.18
109	2m-octane/246-tm-hexane	1.16	0.09	150	2-np-toluene	1.33	1.87
110	ctc-124-tm-cyH	0.97	0.57	151	14-dm-2e-benzene	0.39	0.55
111	3m-octane/33-de-C5/3e-C7	0		152	13-dm-4e-benzene	1.17	1.17
112	o-xylene	9.41	1.89	153	12-dm-4e-benzene	1.42	1.03
113	112-tm-cyH	0		154	13-dm-2e-benzene	1	0.87
114	1-nonene	0.12	0.17	155	n-undecane/12-dm-3e-benzene	1.11	1.09
115	t3-nonene	0		156	1245-ttm-benzene	0.68	0.96
116	ib-cyP	0		157	2mb-benzene	0.5	0.09
117	c3-nonene	0		158	tb-2m-benzene	0	
118	n-nonane	0.78	0.03	159	1234-ttm-benzene	0.48	0.68
119	t2-nonene	0		160	n-pentyibenzene	0.56	0.44
120	c2-nonene	0		161	tb-35-dm-benzene	0.09	0.13
121	ip-benzene	0.61	0.09	162	tb-4e-benzene	0.6	0.84
122	22-dm-octane	0		163	n-dodecane	2.99	3.3
123	ip-cyH	0.19	0.27				

Table 75: Normalized Source Profiles Used In Residential House CMB Analysis

	Cold Start	Hot Start	Hot Soak Evaporative Emissions	Whole Gasoline	GM RESIDENCE	GM RESIDENCE	HD RESIDENCE	HD RESIDENCE	PT RESIDENCE	PT RESIDENCE	JR RESIDENCE	JR RESIDENCE
ethylene	0.1082	0.1248	0.0028	0.0000	HSPT	HSPT	HSPT	HSPT	HSPT	HSPT	HSPT	HSPT
acetylene	0.0385	0.0138	0.0007	0.0000	0.0261	0.0388	0.0183	0.0503	0.0305	0.0255	0.0342	0.0342
propylene	0.0508	0.0402	0.0012	0.0000	0.0282	0.0328	0.0110	0.0571	0.0827	0.0163	0.0284	0.0284
propene	0.0000	0.0033	0.0187	0.0000	0.0578	0.0156	0.0120	0.1920	0.0117	0.0247	0.0128	0.0128
isobutylene/1-butene	0.0225	0.0302	0.0301	0.0172	0.0897	0.0575	0.0307	0.0410	0.0289	0.0768	0.0810	0.0810
n-butane	0.0338	0.0471	0.1452	0.1119	0.1176	0.0137	0.0234	0.0000	0.0090	0.0666	0.0098	0.0098
2m-butane	0.0480	0.0480	0.0948	0.1341	0.1021	0.0752	0.0910	0.0892	0.0888	0.2155	0.0832	0.0832
n-pentane	0.0245	0.0235	0.0830	0.0858	0.0000	0.0202	0.0276	0.0000	0.0351	0.0890	0.0482	0.0482
cyclopentane	0.0051	0.0043	0.0111	0.0120	0.0109	0.0083	0.0050	0.0048	0.0059	0.0081	0.0030	0.0030
2m-pentane & 1-4m2-pentene	0.0333	0.0287	0.0423	0.0128	0.0515	0.0414	0.0224	0.0249	0.0348	0.0387	0.0418	0.0418
3m-pentane	0.0218	0.0188	0.0257	0.0480	0.0185	0.0082	0.0152	0.0284	0.0200	0.0107	0.0118	0.0118
n-hexane	0.0208	0.0168	0.0289	0.0391	0.0174	0.0129	0.0128	0.0134	0.0143	0.0162	0.0111	0.0111
m-cyclopentane	0.0277	0.0210	0.0330	0.0502	0.0170	0.0091	0.0149	0.0095	0.0171	0.0140	0.0095	0.0095
benzene	0.0576	0.0876	0.0850	0.0387	0.0450	0.0000	0.0289	0.0385	0.0247	0.0308	0.0274	0.0274
2m-hexane	0.0133	0.0119	0.0120	0.0231	0.0087	0.0000	0.0082	0.0105	0.0089	0.0102	0.0110	0.0110
3m-hexane & cyclohexene	0.0144	0.0138	0.0124	0.0084	0.0082	0.0053	0.0103	0.0132	0.0141	0.0178	0.0211	0.0211
224-1m-pentane/1-heptene	0.0095	0.0091	0.0084	0.0215	0.0159	0.0000	0.0081	0.0106	0.0082	0.0081	0.0070	0.0070
n-heptane	0.0152	0.0125	0.0159	0.0244	0.0084	0.0108	0.0079	0.0101	0.0085	0.0113	0.0180	0.0180
toluene/233-1m-pentane	0.1695	0.2501	0.1924	0.1321	0.0743	0.0578	0.3597	0.2386	0.0766	0.1052	0.1839	0.1839
1-14-dm-cyl	0.0008	0.0014	0.0008	0.0008	0.0215	0.0480	0.0087	0.0183	0.0020	0.0245	0.0422	0.0422
n-octane/12-dm-cyl	0.0103	0.0088	0.0082	0.0131	0.0078	0.0083	0.0042	0.0058	0.0174	0.0082	0.0088	0.0088
n-benzene	0.0358	0.0316	0.0288	0.0251	0.0334	0.0083	0.0042	0.0058	0.0174	0.0082	0.0140	0.0140
m,p-xylene/23-dm-heptane	0.1158	0.0838	0.0861	0.0791	0.0334	0.0150	0.0278	0.0380	0.0249	0.0138	0.0140	0.0140
o-xylene	0.0485	0.0387	0.0318	0.0341	0.0131	0.0448	0.0085	0.0889	0.0883	0.0528	0.0575	0.0575
3e-toluene & 23-dm-octane	0.0319	0.0207	0.0121	0.0183	0.0115	0.0198	0.0392	0.0483	0.0481	0.0223	0.0285	0.0285
4e-toluene	0.0138	0.0071	0.0039	0.0080	0.0457	0.0088	0.0205	0.0428	0.0206	0.0183	0.0340	0.0340
n-decane	0.0013	0.0015	0.0002	0.0012	0.0098	0.1779	0.0114	0.0227	0.0430	0.0203	0.0191	0.0191
3-p-toluene	0.0002	0.0020	0.0007	0.0000	0.0128	0.0128	0.0085	0.0071	0.0285	0.0278	0.0288	0.0288
4-p-toluene	0.0085	0.0077	0.0021	0.0058	0.0282	0.0848	0.0082	0.0140	0.0277	0.0409	0.0841	0.0841
n-undecane/12-dm-3e-benzene	0.0004	0.0043	0.0008	0.0007	0.0128	0.0292	0.0252	0.0549	0.0081	0.0104	0.0217	0.0217
n-dodecane	0.0002	0.0117	0.0014	0.0005	0.0000	0.0148	0.0084	0.0129	0.0000	0.0185	0.0343	0.0343
					0.0000	0.0148	0.0032	0.0063	0.0000	0.0047	0.0115	0.0115

	GM RESIDENCE		GM RESIDENCE		HD RESIDENCE		HD RESIDENCE		PT RESIDENCE		PT RESIDENCE		JR RESIDENCE		JR RESIDENCE		TR RESIDENCE		TR RESIDENCE		MM RESIDENCE		MM RESIDENCE	
	CSB	CSPT	CSB	CSPT	CSB	CSPT	CSB	CSPT	CSB	CSPT	CSB	CSPT	CSB	CSPT	CSB	CSPT	CSB	CSPT	CSB	CSPT	CSB	CSPT	CSB	CSPT
ethylene	0.0416	0.0229	0.0633	0.0127	0.0200	0.0032	0.0371	0.0227	0.0366	0.0238	0.0366	0.0238	0.0371	0.0227	0.0366	0.0238	0.0366	0.0238	0.0366	0.0238	0.0269	0.0161	0.0269	0.0161
acetylene	0.0377	0.0205	0.0518	0.0258	0.0144	0.0027	0.0338	0.0209	0.0323	0.0173	0.0323	0.0173	0.0338	0.0209	0.0323	0.0173	0.0323	0.0173	0.0323	0.0173	0.0313	0.0091	0.0313	0.0091
propylene	0.0684	0.0000	0.0437	0.0066	0.0175	0.0016	0.0244	0.0082	0.0148	0.0117	0.0148	0.0117	0.0244	0.0082	0.0148	0.0117	0.0148	0.0117	0.0148	0.0117	0.0481	0.0041	0.0481	0.0041
propane	0.0821	0.0740	0.0550	0.1885	0.0229	0.0131	0.1004	0.0558	0.0438	0.0347	0.0438	0.0347	0.1004	0.0558	0.0438	0.0347	0.0438	0.0347	0.0438	0.0347	0.0715	0.1208	0.0715	0.1208
isobutene/1-butene	0.0703	0.0284	0.0340	0.0093	0.0259	0.0186	0.0536	0.0000	0.0885	0.0182	0.0885	0.0182	0.0536	0.0000	0.0885	0.0182	0.0885	0.0182	0.0885	0.0182	0.1389	0.0513	0.1389	0.0513
n-butane	0.1136	0.0884	0.1231	0.0818	0.0433	0.0483	0.1628	0.0758	0.1380	0.0832	0.1380	0.0832	0.1628	0.0758	0.1380	0.0832	0.1380	0.0832	0.1380	0.0832	0.1389	0.0513	0.1389	0.0513
2m-butane	0.0562	0.0552	0.0585	0.0271	0.0428	0.0201	0.0433	0.0281	0.1017	0.0114	0.1017	0.0114	0.0433	0.0281	0.1017	0.0114	0.1017	0.0114	0.1017	0.0114	0.0582	0.0607	0.0582	0.0607
n-pentane	0.0000	0.0344	0.0351	0.0183	0.0189	0.0187	0.0132	0.0247	0.0597	0.0208	0.0597	0.0208	0.0132	0.0247	0.0597	0.0208	0.0597	0.0208	0.0597	0.0208	0.0409	0.0252	0.0409	0.0252
cyclopentane	0.0000	0.0147	0.0137	0.0025	0.0052	0.0067	0.0060	0.0042	0.0101	0.0046	0.0101	0.0046	0.0060	0.0042	0.0101	0.0046	0.0101	0.0046	0.0101	0.0046	0.0045	0.0053	0.0045	0.0053
2m-pentane & 1-4m2-pentene	0.0452	0.0239	0.0460	0.0127	0.0516	0.0611	0.0408	0.0140	0.0855	0.0204	0.0855	0.0204	0.0408	0.0140	0.0855	0.0204	0.0855	0.0204	0.0855	0.0204	0.0321	0.0281	0.0321	0.0281
3m-pentane	0.0324	0.0133	0.0112	0.0109	0.0424	0.0548	0.0188	0.0103	0.0298	0.0128	0.0298	0.0128	0.0188	0.0103	0.0298	0.0128	0.0298	0.0128	0.0298	0.0128	0.0089	0.0121	0.0089	0.0121
n-hexane	0.0184	0.0170	0.0176	0.0104	0.0521	0.0763	0.0131	0.0152	0.0214	0.0123	0.0214	0.0123	0.0131	0.0152	0.0214	0.0123	0.0214	0.0123	0.0214	0.0123	0.0151	0.0128	0.0151	0.0128
m-cyclopentane	0.0145	0.0154	0.0124	0.0081	0.0235	0.0281	0.0097	0.0113	0.0211	0.0095	0.0211	0.0095	0.0097	0.0113	0.0211	0.0095	0.0211	0.0095	0.0211	0.0095	0.0055	0.0138	0.0055	0.0138
benzene	0.0468	0.0436	0.0580	0.0287	0.0452	0.0688	0.0338	0.0286	0.0339	0.0080	0.0339	0.0080	0.0338	0.0286	0.0339	0.0080	0.0339	0.0080	0.0339	0.0080	0.0345	0.0414	0.0345	0.0414
2m-hexane	0.0067	0.0075	0.0125	0.0097	0.0239	0.0215	0.0087	0.0287	0.0105	0.0079	0.0105	0.0079	0.0087	0.0287	0.0105	0.0079	0.0105	0.0079	0.0105	0.0079	0.0050	0.0070	0.0050	0.0070
3m-hexane & cyclohexene	0.0111	0.0180	0.0288	0.0123	0.0584	0.0873	0.0087	0.0287	0.0087	0.0079	0.0087	0.0079	0.0087	0.0287	0.0087	0.0079	0.0087	0.0079	0.0087	0.0079	0.0050	0.0070	0.0050	0.0070
224-1m-pentane/1-heptene	0.0161	0.0041	0.0163	0.0115	0.0084	0.0057	0.0114	0.0070	0.0073	0.0081	0.0073	0.0081	0.0114	0.0070	0.0073	0.0081	0.0073	0.0081	0.0073	0.0081	0.0114	0.0054	0.0114	0.0054
n-heptane	0.0079	0.0158	0.0108	0.0078	0.0386	0.0630	0.0114	0.0285	0.0073	0.0079	0.0114	0.0285	0.0114	0.0285	0.0073	0.0079	0.0114	0.0285	0.0073	0.0079	0.0079	0.0059	0.0079	0.0059
toluene/23-1m-pentane	0.0713	0.1368	0.0851	0.2076	0.0791	0.0868	0.0605	0.1313	0.0585	0.1002	0.0585	0.1002	0.0605	0.1313	0.0585	0.1002	0.0585	0.1002	0.0585	0.1002	0.0484	0.0981	0.0484	0.0981
1-14-dm-cyH	0.0041	0.0537	0.0132	0.0127	0.0379	0.0273	0.0038	0.0487	0.0000	0.0083	0.0038	0.0487	0.0038	0.0487	0.0000	0.0083	0.0038	0.0487	0.0000	0.0083	0.0208	0.0545	0.0208	0.0545
n-octane/12-dm-cyH	0.0089	0.0087	0.0086	0.0067	0.0112	0.0108	0.0053	0.0058	0.0000	0.0066	0.0053	0.0058	0.0053	0.0058	0.0000	0.0066	0.0053	0.0058	0.0000	0.0066	0.0059	0.0051	0.0059	0.0051
e-benzene	0.0133	0.0288	0.0253	0.0363	0.0225	0.0207	0.0134	0.0161	0.0173	0.0258	0.0173	0.0258	0.0134	0.0161	0.0173	0.0258	0.0173	0.0258	0.0173	0.0258	0.0332	0.0777	0.0332	0.0777
m,p-xylene/23-dm-heptane	0.0374	0.0746	0.0544	0.0805	0.0713	0.0738	0.0484	0.0848	0.0422	0.0858	0.0422	0.0858	0.0484	0.0848	0.0422	0.0858	0.0422	0.0858	0.0422	0.0858	0.0099	0.0227	0.0099	0.0227
o-xylene	0.0184	0.0298	0.0280	0.0406	0.0332	0.0309	0.0488	0.0307	0.0288	0.0397	0.0288	0.0397	0.0488	0.0307	0.0288	0.0397	0.0288	0.0397	0.0288	0.0397	0.0083	0.0324	0.0083	0.0324
3e-toluene & 23-dm-octane	0.0130	0.0242	0.0112	0.0293	0.0247	0.0402	0.0000	0.0307	0.0000	0.0626	0.0000	0.0626	0.0000	0.0307	0.0000	0.0626	0.0000	0.0626	0.0000	0.0626	0.1873	0.0258	0.1873	0.0258
4e-toluene	0.0859	0.0136	0.0491	0.0154	0.0603	0.0154	0.0881	0.1037	0.0889	0.0624	0.0889	0.0624	0.0881	0.1037	0.0889	0.0624	0.0889	0.0624	0.0889	0.0624	0.1873	0.0258	0.1873	0.0258
n-decane	0.0121	0.0127	0.0069	0.0180	0.0233	0.0308	0.0103	0.0631	0.0000	0.0624	0.0103	0.0631	0.0103	0.0631	0.0000	0.0624	0.0103	0.0631	0.0000	0.0624	0.1873	0.0258	0.1873	0.0258
3-ip-toluene	0.0810	0.0781	0.0183	0.0140	0.0354	0.0239	0.0584	0.0401	0.0110	0.0165	0.0584	0.0401	0.0110	0.0165	0.0584	0.0401	0.0110	0.0165	0.0584	0.0401	0.0530	0.0324	0.0530	0.0324
4-ip-toluene	0.0000	0.0134	0.0073	0.0274	0.0155	0.0144	0.0185	0.0201	0.0000	0.1041	0.0185	0.0201	0.0185	0.0201	0.0000	0.1041	0.0185	0.0201	0.0000	0.1041	0.0000	0.0324	0.0000	0.0324
n-undecane/12-dm-3e-benzene	0.0076	0.0116	0.0000	0.0118	0.0251	0.0209	0.0044	0.0800	0.0000	0.0484	0.0044	0.0800	0.0044	0.0800	0.0000	0.0484	0.0044	0.0800	0.0000	0.0484	0.0184	0.0183	0.0184	0.0183
n-dodecane	0.0000	0.0110	0.0000	0.0052	0.0080	0.0080	0.0000	0.0198	0.0000	0.0102	0.0000	0.0102	0.0000	0.0198	0.0000	0.0102	0.0000	0.0102	0.0000	0.0102	0.0126	0.0112	0.0126	0.0112

Table 76: Raw VOC Data For House Samples: Hot Soak: GM and HD Residence

(HSB: hot soak ambient background sample, HSPT: hot soak in-house pre-test sample, HSH: hot soak in-house during-test sample, HSG: hot soak in-garage during-test sample)

	GM HSB ($\mu\text{g}/\text{m}^3$)	GM HSPT ($\mu\text{g}/\text{m}^3$)	GM HSH ($\mu\text{g}/\text{m}^3$)	GM HSG ($\mu\text{g}/\text{m}^3$)	HD HSB ($\mu\text{g}/\text{m}^3$)	HD HSPT ($\mu\text{g}/\text{m}^3$)	HD HSH ($\mu\text{g}/\text{m}^3$)	HD HSG ($\mu\text{g}/\text{m}^3$)
methane	1380.85	1789.63	2105.05	1469.84	1463.08	1345.06	1558.45	1500.19
ethylene	0.90	3.04	3.41	1.72	6.94	2.45	6.55	8.36
acetylene	1.01	2.55	1.74	1.24	3.96	2.51	3.52	4.61
ethane	1.88	0.37	0.58	0.68	0.73	0.15	0.31	0.57
propylene	1.99	1.22	1.89	1.24	4.32	1.02	4.77	4.48
propane	2.41	4.51	10.91	15.34	11.04	2.43	12.00	13.14
propyne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
isobutane	0.00	3.79	18.83	157.28	29.49	6.06	55.21	110.75
1-butene & isobutene	4.06	1.08	5.94	0.00	8.41	0.28	19.74	0.00
1,3-butadiene	0.00	0.25	0.80	2.02	1.98	0.24	1.03	2.34
n-butane	3.52	5.89	15.13	496.04	32.71	11.92	114.22	384.47
1,2-butene & 2,2-dm-propane	0.43	0.00	2.09	79.88	2.64	0.00	15.15	58.42
1-butyne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c2-butene	0.00	0.00	2.07	55.43	1.71	0.78	10.46	40.27
3m1-butene	0.00	0.00	0.00	7.07	0.00	0.00	1.45	5.39
2m-butene	2.06	4.30	7.02	292.92	15.09	4.68	59.75	219.51
1-pentene	0.00	0.00	0.71	29.32	1.39	0.98	4.07	15.93
2m1-butene	0.00	0.00	1.05	40.48	0.75	0.55	8.26	29.66
n-pentane	0.00	1.58	5.93	214.48	9.93	2.92	42.50	156.40
2m1,3-butadiene	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2-pentene	0.20	0.19	1.73	59.59	2.22	0.96	11.55	43.85
c2-pentene	0.00	0.00	5.33	31.53	0.00	0.48	6.09	23.52
2m2-butene	0.85	0.00	0.00	82.91	5.79	1.86	16.30	61.69
2,2-dm-butane	0.30	0.00	0.89	21.86	1.25	0.53	5.34	15.55
cyclopentene	0.35	0.25	2.28	13.07	0.64	0.00	2.44	9.85
4m1&3m1-pentene	0.00	0.00	0.00	5.50	0.00	0.00	1.14	3.88
cyclopentane	0.38	0.65	1.84	39.49	1.78	0.62	7.23	27.29
2,3-dm-butane	0.29	0.00	0.87	30.17	1.65	0.69	6.53	22.68
2m-pentane & t-4m2-pentene	1.78	3.24	7.41	154.02	8.05	3.33	32.90	116.75
MTBE & c-4m2-pentene	0.49	0.00	0.49	8.55	0.89	0.35	2.49	5.98
3m-pentane	0.57	0.49	4.63	96.31	5.46	1.85	19.53	73.47
1-hexene & 2m1-pentene	0.00	0.20	0.00	20.00	0.00	0.00	8.94	15.22
n-hexane	0.60	1.01	3.09	106.85	4.53	1.79	22.64	83.93
1,2-hexene	0.00	0.00	2.14	17.60	0.59	0.25	3.40	13.19
2m2-pentene & 2e1-butene	0.00	0.00	0.00	13.14	0.28	0.00	3.90	9.62
c2-hexene	0.00	0.00	0.00	9.73	0.44	0.00	2.11	7.22
c/t-3m2-pentene	0.00	0.00	0.47	18.86	0.70	0.25	3.33	13.73
2,2-dm-pentane	0.00	0.00	0.32	2.59	0.00	0.00	0.69	2.36
m-cyclopentane	0.59	0.71	3.41	122.87	5.37	1.27	21.60	83.26
2,4-dm-pentane	0.00	0.66	1.11	13.70	0.79	0.43	3.19	11.75
2,2,3-dm-butane	0.00	0.25	0.93	1.14	0.29	0.00	0.03	0.61
1m-cyclopentene	0.00	1.77	0.00	16.84	0.61	0.00	2.99	14.69
benzene	1.55	0.00	7.53	238.53	10.41	5.28	43.51	169.87
3,3-dm-pentane	0.00	0.00	0.00	6.04	0.43	0.24	1.37	4.80
cyclohexane	0.21	0.32	0.82	25.50	0.92	0.29	4.57	17.31
2m-hexane	0.34	0.00	2.06	54.05	2.96	1.40	11.78	41.97
2,3-dm-pentane	0.00	0.00	0.00	15.36	1.19	0.63	4.26	13.53
1,1-dm-cyP	0.00	0.83	0.59	3.10	0.00	0.00	0.53	2.03
3m-hexane & cyclohexene	0.22	5.11	4.83	57.43	3.71	1.76	13.23	44.58
c-1,3-dm-cyP	0.00	0.00	0.00	12.30	0.59	0.29	2.41	8.50
t-1,3-dm-cyP & 3e-pentane	0.34	0.00	0.00	18.16	0.85	0.42	3.57	12.98
t-1,2-dm-cyP	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00
2,2,4-trim-pentane & 1-heptene	0.55	0.00	5.20	30.49	2.92	1.42	8.18	24.82
c3-heptene	0.00	0.24	1.27	5.97	0.39	0.00	1.03	4.72
n-heptane	0.31	0.85	2.07	52.70	2.83	1.35	11.46	40.64
1,3-heptene	0.00	0.00	1.30	20.39	0.66	0.00	3.28	14.52
1,2-heptene	0.00	0.00	1.45	6.34	0.00	0.00	1.00	4.50
c2-heptene	1.52	0.00	3.01	6.36	1.19	1.06	1.04	4.03
m-cyH & 2,2-dmC6	0.00	0.31	0.82	24.34	1.15	0.62	5.04	16.94
2,5-dm-C6 & e-cyP	0.17	0.21	0.66	5.36	0.40	0.27	0.70	4.45
2,4-dm-C6 & 2,2,3-trim-C5	0.00	0.00	0.48	15.53	1.09	0.44	1.77	11.16
ctc-1,2,4-trim-cyP	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.00
ctc-1,2,3-trim-cyP	0.00	0.00	0.00	3.06	0.00	0.00	0.50	2.86
2,3,4-trim-pentane	0.34	0.32	2.95	12.73	1.66	0.66	3.14	11.06
toluene	2.56	4.52	20.87	795.56	129.34	32.04	170.16	612.32

2m-heptane	0.00	0.00	0.82	19.49	1.31	0.70	4.03	14.83
4m-heptane & 1m-cyhexene	0.00	0.00	0.00	11.57	0.62	0.28	2.09	8.46
3m-C7 & 3e-C6	0.00	0.45	2.92	25.84	1.65	0.62	5.13	20.26
cct-124-tm-cyP & c-13-dm-cyH	0.00	0.00	0.00	5.43	0.34	0.23	1.15	4.08
t-14-dm-cyH	0.74	3.84	6.48	4.47	3.12	2.45	2.54	2.81
225-tm-C6	0.00	0.00	0.00	2.85	0.00	0.00	0.58	2.62
1-octene	0.00	0.41	0.87	1.61	0.00	0.42	0.00	4.11
1e-1m-cyP	0.00	0.00	0.60	4.28	0.00	0.24	0.00	5.56
n-octane & t-12-dm-cyH	0.27	0.65	1.43	20.80	1.50	0.77	4.04	19.45
12-octene	0.00	0.00	0.00	2.97	1.36	0.00	0.35	7.96
ccc-123-tm-cyP	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00
??t-13-dm-cyH & c-14-dm-cyH	0.00	0.65	2.36	4.75	0.78	0.45	0.33	30.38
c2-octene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.09
ip-cyP	0.74	0.00	1.36	1.17	0.00	0.00	0.00	0.00
c-12-dm-cyH	0.00	0.00	0.00	1.84	0.00	0.00	0.51	1.95
np-cyP	0.00	0.00	1.52	2.42	0.00	0.00	0.73	1.30
25-dm-heptane	0.00	0.00	0.85	6.01	0.00	0.56	1.63	4.94
33-dm-heptane	0.00	0.00	0.00	0.76	0.00	0.00	0.47	0.00
114-tm-cyH	0.00	0.00	1.51	2.76	0.00	0.00	0.00	2.35
e-benzene	1.15	1.17	4.34	136.74	10.04	5.08	26.75	109.84
cct-124-tm-cyH & 35-dm-C7	0.00	0.34	1.34	1.52	0.00	0.00	0.53	1.36
m&p-xylene & 23-dm-heptane	1.79	3.51	11.79	425.50	31.82	14.56	75.63	336.93
34-dm-C7 & 4m-C8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2m-octane	0.57	1.55	6.45	6.79	0.79	0.43	1.96	6.84
3m-octane & ctc-124-tm-cyH	0.56	0.00	0.00	3.07	0.00	0.63	0.00	1.66
styrene	1.39	0.79	6.47	4.51	2.04	0.58	2.25	3.72
o-xylene	0.45	1.55	6.00	175.82	14.09	6.46	31.95	137.55
1-nonene & 112-tm-cyH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t3-nonene	0.00	0.00	0.00	1.34	0.00	0.00	0.00	2.59
c3-nonene & ib-cyP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13
n-nonane	0.00	0.63	1.08	4.94	2.49	1.86	3.92	4.22
12-nonene	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.75
c2-nonene	0.00	0.00	1.81	1.45	0.34	0.60	0.99	0.94
ip-benzene	0.00	0.00	0.73	8.09	0.84	0.95	2.08	6.44
ip-cyH	0.00	0.00	0.55	1.43	0.83	0.68	1.36	1.20
nb-cyP	0.00	0.24	1.06	1.38	1.74	1.52	2.77	1.51
33 & 36- dm-octane	1.68	1.54	0.00	3.86	2.11	0.26	7.27	2.75
np-benzene	0.00	0.56	0.72	27.59	2.17	1.72	5.78	21.94
3e-toluene & 23-dm-octane	0.40	0.69	3.98	78.43	7.36	5.72	15.31	63.28
4e-toluene	1.58	13.93	7.48	43.63	4.10	3.03	14.54	30.49
135-tm-benzene & 2m-nonane	0.00	0.00	0.00	27.29	3.89	3.03	7.75	23.02
3e-octane	0.00	0.65	1.43	0.00	0.00	1.26	0.00	0.00
3m-nonane	0.00	0.00	0.00	1.67	0.90	0.65	1.31	1.44
2e-toluene	0.00	0.76	2.20	25.68	2.22	1.88	5.37	21.26
1-decene & ib-cyH	0.59	1.24	8.65	0.62	0.74	1.15	0.00	1.44
124-tm-benzene & tb-benzene	0.49	2.51	21.29	109.78	64.94	8.99	26.47	94.75
n-decane	0.34	1.00	8.03	2.25	2.34	3.55	6.36	2.35
ib-benzene	0.00	0.38	2.18	1.19	0.00	0.00	0.00	1.87
sb-benzene	0.00	0.00	7.89	1.14	0.00	0.00	0.00	1.23
3-ip-toluene	1.95	6.64	5.06	5.53	2.22	1.87	3.86	7.71
4-ip-toluene & 123-tm-benzene	0.44	2.29	3.10	22.95	9.04	7.34	6.76	18.98
indan	0.00	0.68	0.00	0.61	0.66	0.88	3.46	0.49
2-ip-toluene	0.46	12.83	0.00	1.55	1.33	2.92	2.28	14.02
3-np-toluene & 13de-benzene	0.00	0.86	1.39	3.57	0.65	1.10	0.23	3.11
4-np-tol/nb&13dm5e&14de-benz	0.00	0.45	6.56	15.13	2.37	1.97	2.91	13.98
12-de-benzene	0.00	1.73	4.60	0.00	0.58	0.58	0.63	0.00
2-np-toluene	0.00	0.62	0.55	2.84	0.96	1.11	1.29	2.92
14-dm-2e-benzene	0.00	0.63	0.00	4.96	0.49	0.51	0.86	0.47
12-dm-4e-benzene	0.00	0.76	1.05	10.13	1.29	1.15	1.96	8.82
13-dm-2e-benzene	1.89	6.80	5.91	4.32	0.00	7.94	0.56	2.81
n-undecane	0.00	1.14	1.09	2.38	3.01	1.73	3.48	2.08
1245-tm-benzene	0.00	0.00	0.67	1.83	0.00	0.00	0.60	1.60
2mb-benzene	0.00	0.82	0.33	4.49	0.80	0.63	0.98	4.38
tb-2m-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00
n-pentylbenzene	0.38	0.00	0.00	6.87	18.68	1.07	1.31	7.87
tb-35dm-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50
tb-4e-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
naphthalene	0.45	3.16	2.61	12.85	1.41	2.56	2.50	10.93
n-dodecane	0.00	1.16	1.41	3.11	1.16	0.85	1.14	3.11
135-te-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
124-te-benzene	0.00	0.00	1.34	0.00	0.00	0.00	0.00	0.00
n-hexylbenzene	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00
n-tridecane	0.00	1.00	1.07	0.00	0.69	0.58	0.00	0.00

Table 77: Raw VOC Data For House Samples: Hot Soak: PT and JR Residence

(HSB: hot soak ambient background sample, HSPT: hot soak in-house pre-test sample, HSH: hot soak in-house during-test sample, HSG: hot soak in-garage during-test sample)

	PT HSB ($\mu\text{g}/\text{m}^3$)	PT HSPT ($\mu\text{g}/\text{m}^3$)	PT HSH ($\mu\text{g}/\text{m}^3$)	PT HSG ($\mu\text{g}/\text{m}^3$)	JR HSB ($\mu\text{g}/\text{m}^3$)	JR HSPT ($\mu\text{g}/\text{m}^3$)	JR HSH ($\mu\text{g}/\text{m}^3$)	JR HSG ($\mu\text{g}/\text{m}^3$)
methane	1604.99	1459.45	1528.69	1339.88	1678.18	2221.21	1843.96	1430.69
ethylene	3.78	5.36	4.71	6.26	2.74	3.63	2.75	3.35
acetylene	4.30	11.02	7.01	6.69	1.76	2.79	2.06	3.02
ethane	4.34	0.25	0.29	0.49	0.74	0.28	0.43	0.70
propylene	14.45	2.05	4.57	3.15	2.66	1.36	1.37	1.58
propane	3.09	5.25	6.26	10.46	8.24	6.46	11.23	10.01
propyne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
isobutane	0.00	0.00	11.32	109.47	7.39	0.00	12.73	55.66
1-butene & isobutene	0.00	1.59	6.00	0.00	1.79	1.05	3.07	37.53
1,3-butadiene	0.51	0.48	0.47	2.06	0.00	0.26	0.30	1.05
n-butane	7.44	15.62	33.85	348.90	23.18	6.90	40.89	184.59
t2-butene & 2,2-dm-propane	0.47	0.69	0.00	51.88	0.00	0.00	0.00	29.29
1-butyne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c2-butene	0.33	0.51	2.54	36.87	0.61	0.00	1.23	20.16
3m1-butene	0.00	0.00	0.46	5.27	0.00	0.00	0.00	2.56
2m-butane	5.48	3.99	18.07	221.54	7.42	5.21	11.10	111.38
1-pentene	1.54	0.84	1.29	15.29	0.00	0.31	0.00	7.56
2m1-butene	0.70	0.99	2.49	29.41	0.61	0.60	1.23	14.17
n-pentane	0.00	6.17	16.16	154.92	2.71	1.66	5.52	77.13
2m1,3-butadiene	2.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t2-pentene	0.51	1.20	3.74	40.18	0.00	0.00	0.00	0.00
c2-pentene	0.41	0.47	2.31	21.94	0.00	0.00	1.39	11.28
2m ² -butene	0.97	3.52	8.91	55.86	1.23	0.44	1.81	31.50
2,2-dm-butane	0.73	1.11	1.91	16.83	0.00	0.00	0.57	7.16
cyclopentene	0.00	0.32	0.87	8.47	0.50	0.00	0.67	4.48
4m1&3m1-pentene	0.00	0.00	0.00	3.97	0.00	0.00	0.00	1.93
cyclopentane	0.52	1.04	3.20	29.05	0.66	0.32	1.46	14.05
2,3-dm-butane	0.74	1.11	2.32	23.35	0.42	0.34	0.76	10.08
2m-pentane & t-4m ² -pentene	4.19	6.08	11.62	118.43	4.16	4.43	5.86	53.63
MTBE & c-4m ² -pentene	0.00	0.00	1.32	6.39	0.00	0.00	0.00	3.41
3m-pentane	1.99	3.52	6.44	74.67	1.15	1.25	3.43	32.31
1-hexene & 2m1-pentene	0.00	0.00	6.86	16.11	5.07	5.94	8.12	11.58
n-hexane	1.35	2.51	7.07	81.39	1.74	1.17	2.96	38.40
t2-hexene	0.20	0.37	1.10	13.00	0.00	0.00	0.42	6.33
2m ² -pentene & 2e1-butene	0.20	1.27	0.60	9.35	1.07	1.45	2.30	4.90
c2-hexene	0.27	0.39	0.82	7.23	0.00	0.00	0.50	3.77
c/t-3m ² -pentene	0.25	0.27	1.25	13.14	0.00	0.00	0.44	6.33
2,2-dm-pentane	0.00	0.00	0.00	2.00	0.00	0.00	0.36	0.81
m-cyclopentane	1.59	3.00	8.56	93.47	1.51	1.01	3.17	42.40
2,4-dm-pentane	0.24	1.20	1.55	9.76	0.55	2.40	1.17	4.54
2,2,3-dm-butane	0.00	0.72	0.75	1.03	0.10	0.27	0.41	0.32
1m-cyclopentene	0.17	0.00	1.19	11.04	0.00	0.00	0.00	5.69
benzene	3.08	4.35	14.08	175.47	3.32	2.90	7.00	88.08
3,3-dm-pentane	0.00	0.00	0.76	4.74	0.00	0.00	0.00	2.43
cyclohexane	0.46	0.67	1.77	19.63	0.84	0.55	1.04	8.44
2m-hexane	0.87	1.56	3.94	43.07	1.10	1.17	1.86	18.79
2,3-dm-pentane	0.44	0.56	1.21	12.36	0.37	0.62	0.59	5.12
1,1-dm-cyP	0.00	0.00	0.00	2.42	0.00	0.00	0.00	1.02
3m-hexane & cyclohexene	1.15	2.48	4.68	45.81	1.92	2.24	3.57	20.66
c-1,3-dm-cyP	0.62	0.56	1.09	9.85	0.36	0.40	0.51	4.23
t-1,3-dm-cyP & 3e-pentane	0.46	0.53	1.43	14.50	0.58	0.34	0.78	6.45
t-1,2-dm-cyP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2,4-tm-pentane & 1-heptene	1.26	1.09	2.68	25.29	0.87	0.74	1.42	10.36
c3-heptene	0.00	0.00	0.00	4.45	0.00	0.00	0.00	2.07
n-heptane	0.78	1.50	4.07	41.02	1.22	1.69	2.09	18.82
t3-heptene	0.00	0.00	0.86	14.31	0.00	0.00	0.00	6.66
t2-heptene	0.00	0.00	0.00	4.88	0.00	0.00	0.00	2.13
c2-heptene	0.00	0.63	0.61	4.30	0.00	0.35	0.00	2.05
m-cyH & 2,2-dmC6	0.52	0.75	1.91	19.78	0.90	0.94	1.30	8.69
2,5-dm-C6 & e-cyP	0.35	0.53	0.66	4.78	0.86	4.15	0.00	1.88
2,4-dm-C6 & 2,2,3-tm-C5	0.37	0.57	1.96	12.66	0.00	0.00	0.00	5.40
ctc-1,2,4-tm-cyP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ctc-1,2,3-tm-cyP	0.00	0.00	0.00	2.49	0.00	0.00	0.00	0.99
2,3,4-tm-pentane	0.36	1.07	1.08	8.11	0.80	0.64	0.97	4.35
toluene	5.68	13.48	41.59	606.97	11.32	19.46	25.01	308.90

2m-heptane	0.40	0.35	1.11	16.08	0.26	0.45	0.41	6.90
4m-heptane & 1m-cyhexene	0.17	0.00	0.52	9.15	0.00	0.00	0.00	3.90
3m-C ₇ & 3e-C ₆	0.49	1.28	2.25	21.16	0.26	0.57	1.21	9.04
cct-124-tm-cyP & c-13-dm-cyH	0.00	0.00	0.00	4.73	0.00	0.00	0.00	1.59
t-14-dm-cyH	0.15	10.49	6.51	2.37	2.64	4.47	5.41	1.41
225-tm-C ₆	0.15	1.30	1.75	2.34	0.00	0.00	0.00	0.53
1-octene	0.32	0.94	1.28	1.39	0.00	0.00	0.00	1.34
1e-1m-cyP	0.00	0.38	0.62	2.42	0.00	0.00	0.00	0.51
n-octane & t-12-dm-cyH	0.51	3.06	4.25	16.36	0.67	0.72	1.18	6.81
t2-octene	0.00	0.56	0.97	2.12	0.11	0.26	0.36	0.67
ccc-123-tm-cyP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
??t-13-dm-cyH & c-14-dm-cyH	0.00	0.97	1.14	4.38	0.00	0.50	0.58	1.26
c2-octene	0.00	0.48	0.74	0.00	0.00	0.00	0.00	0.00
ip-cyP	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.92
c-12-dm-cyH	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.74
np-cyP	0.00	0.41	0.00	1.48	0.00	0.00	0.00	1.07
25-dm-heptane	0.00	0.87	1.02	5.12	0.73	0.46	0.00	2.69
33-dm-heptane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
114-tm-cyH	0.00	0.00	0.00	1.30	0.00	0.00	0.00	0.00
e-benzene	1.27	4.39	8.61	109.13	1.46	1.48	3.37	53.01
ctt-124-tm-cyH & 35-dm-C ₇	0.00	0.63	0.76	1.40	0.00	0.50	0.59	0.00
m&p-xylene & 23-dm-heptane	3.52	17.29	28.46	337.62	5.68	6.08	11.87	164.40
34-dm-C ₇ & 4m-C ₈	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2m-octane	0.24	0.39	1.08	5.65	0.97	0.90	1.26	3.20
3m-octane & ctc-124-tm-cyH	0.00	2.04	0.54	1.79	0.62	0.71	0.00	1.29
styrene	0.00	1.59	1.87	2.86	0.62	0.72	1.44	1.59
o-xylene	1.55	8.47	12.88	140.93	2.40	3.02	5.40	67.65
1-nonene & 112-tm-cyH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t3-nonene	0.00	0.66	0.00	1.02	0.40	0.64	0.62	0.00
c3-nonene & ib-cyP	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00
n-nonane	0.31	1.60	1.43	4.46	2.05	3.02	3.46	2.36
t2-nonene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c2-nonene	0.00	0.83	1.02	1.18	0.00	0.33	0.55	0.76
ip-benzene	0.00	0.69	0.94	6.59	0.58	0.44	0.57	3.27
ip-cyH	0.24	0.59	0.80	1.37	0.52	0.53	0.68	0.68
nb-cyP	0.26	1.55	1.36	1.84	1.15	0.98	1.03	0.88
33 & 36-dm-octane	0.78	0.00	0.00	3.67	4.82	6.20	9.76	0.31
np-benzene	0.35	1.73	2.43	22.15	0.67	0.70	1.20	10.67
3e-toluene & 23-dm-octane	0.95	8.49	10.49	60.56	2.08	3.60	0.00	29.59
4e-toluene	3.23	2.87	3.85	29.21	2.19	2.03	12.89	14.82
135-tm-benzene & 2m-nonane	0.00	2.97	3.20	20.38	1.72	2.21	2.76	9.83
3e-octane	0.00	1.22	0.00	0.00	0.00	0.00	0.00	0.00
3m-nonane	0.27	0.86	0.88	1.63	0.63	0.73	0.47	0.61
2e-toluene	0.48	1.64	2.08	20.26	0.60	0.65	1.05	9.71
1-decene & ib-cyH	0.36	13.99	3.05	0.00	0.68	0.67	0.94	0.00
124-tm-benzene & tb-benzene	3.26	9.37	9.87	83.41	12.55	1.33	97.30	44.28
n-decane	0.53	5.01	4.90	2.42	2.99	3.03	0.00	1.35
ib-benzene	0.00	0.49	0.47	1.54	0.00	0.22	0.00	0.00
sb-benzene	0.00	0.00	0.00	0.92	0.00	0.00	0.00	1.73
3-ip-toluene	2.08	12.61	21.01	4.27	4.40	8.90	3.71	2.30
4-ip-toluene & 123-tm-benzene	0.46	4.34	5.48	15.94	1.12	2.30	2.24	8.35
indan	0.00	0.73	0.80	0.00	0.00	0.73	0.66	0.00
2-ip-toluene	0.00	0.00	3.94	12.44	2.82	6.61	6.29	7.30
3-np-toluene & 13de-benzene	0.00	0.81	0.80	2.51	0.00	0.82	0.93	0.74
4-np-to/nb&13dm5e&14de-benz	0.00	2.17	2.28	10.32	0.76	1.07	0.67	7.37
12-de-benzene	0.00	0.86	0.00	0.00	0.19	0.54	0.00	1.35
2-np-toluene	0.00	1.22	1.05	1.99	0.22	0.50	0.58	1.44
14-dm-2e-benzene	0.00	0.56	1.00	0.37	0.27	0.48	0.57	1.94
12-dm-4e-benzene	0.00	1.40	1.29	6.41	0.00	0.35	0.45	3.63
13-dm-2e-benzene	0.00	0.94	1.24	2.30	0.55	0.51	0.80	2.71
n-undecane	0.00	4.69	4.53	1.28	1.99	3.63	4.09	1.17
1245-ttm-benzene	0.00	0.88	0.98	1.19	0.00	0.00	0.55	0.57
2mb-benzene	0.00	1.11	0.80	2.37	0.26	0.10	0.27	1.76
tb-2m-benzene	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00
n-pentylbenzene	0.00	1.71	0.00	4.03	2.12	0.00	5.48	12.08
tb-35dm-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
tb-4e-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
naphthalene	0.00	1.91	2.04	4.38	0.60	0.82	3.39	4.76
n-dodecane	0.00	2.53	2.67	0.00	0.50	1.22	1.33	0.00
135-te-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
124-te-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-hexylbenzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-tridecane	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00

Table 78: Raw VOC Data For House Samples: Cold Start: GM and HD Residence

(CSB: cold start ambient background sample, CSPT: cold start in-house pre-test sample, CSH: cold start in-house during-test sample, CSG: cold start in-garage during-test sample)

	GM CSB ($\mu\text{g}/\text{m}^3$)	GM CSPT ($\mu\text{g}/\text{m}^3$)	GM CSH ($\mu\text{g}/\text{m}^3$)	GM CSG ($\mu\text{g}/\text{m}^3$)	HD CSB ($\mu\text{g}/\text{m}^3$)	HD CSPT ($\mu\text{g}/\text{m}^3$)	HD CSH ($\mu\text{g}/\text{m}^3$)	HD CSG ($\mu\text{g}/\text{m}^3$)
methane	1317.78	1636.59	1836.29	1872.14	1395.78	1610.98	2026.06	3043.27
ethylene	1.48	1.33	11.39	729.80	3.25	3.99	272.95	1047.27
acetylene	1.34	1.19	9.85	503.12	2.66	8.04	191.45	1380.61
ethane	2.50	0.23	0.57	123.90	1.66	0.22	0.00	160.72
propylene	3.85	0.00	6.15	345.51	2.25	2.08	146.22	834.96
propane	2.21	4.30	8.59	11.59	2.83	59.23	42.25	28.12
propyne	0.00	0.00	0.00	38.32	0.00	0.25	13.81	107.82
isobutane	2.32	0.00	20.56	10 ⁴ .13	2.74	281.63	228.02	321.29
1-butene & isobutene	2.50	1.65	0.00	0.00	1.75	2.93	0.00	0.00
1,3-butadiene	0.00	0.00	1.76	106.34	0.00	0.42	28.64	0.00
n-butane	4.03	5.61	11.86	295.42	6.32	25.72	141.63	886.20
t2-butene & 2,2-dm-propane	0.00	0.52	1.40	62.43	0.41	1.76	23.10	0.00
1-butyne	0.00	0.00	0.00	7.46	0.00	0.00	0.95	7.15
c2-butene	0.53	0.73	1.19	38.35	0.43	1.05	0.00	101.68
3m1-butene	0.00	0.00	0.00	13.27	0.00	0.00	4.73	32.08
2m-butane	2.00	3.21	23.43	342.59	3.00	8.52	143.10	991.23
1-pentene	0.00	0.00	0.74	32.35	0.00	3.11	8.40	65.23
2m1-butene	0.00	0.00	1.00	50.43	0.40	1.18	19.64	126.32
n-pentane	0.00	2.00	5.98	208.83	1.80	5.74	83.94	602.71
2m1,3-butadiene	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t2-pentene	0.00	0.51	1.41	43.78	0.24	1.48	17.54	119.93
c2-pentene	0.00	0.00	0.57	24.92	0.00	3.85	12.33	68.85
2m ² -butene	0.36	0.00	4.89	65.04	0.00	0.00	22.69	180.24
2,2-dm-butane	0.00	0.00	1.25	46.03	0.00	0.77	18.79	130.77
cyclopentene	0.00	0.56	0.47	15.57	1.46	0.35	5.34	37.89
4m1 & 3m1-pentene	0.00	0.00	0.00	9.14	0.00	0.00	3.18	0.00
cyclopentane	0.00	0.85	1.48	40.52	0.71	0.78	16.54	113.59
2,3-dm-butane	0.23	0.25	1.28	59.04	0.40	1.08	23.19	168.95
2m-pentane & t-4m ² -pentene	1.50	1.39	6.39	259.64	2.36	3.99	101.41	764.94
MTBE & c-4m ² -pentene	0.00	0.64	1.02	9.96	0.80	0.00	4.33	24.33
3m-pentane	1.15	0.77	4.17	170.60	0.57	3.42	67.43	503.86
1-hexene & 2m1-pentene	0.00	4.90	5.17	15.55	0.00	0.00	13.71	77.90
n-hexane	0.65	0.99	3.73	153.57	0.90	3.26	59.76	466.16
t2-hexene	0.00	0.00	0.44	20.71	0.00	0.00	7.44	59.49
2m ² -pentene & 2el-butene	0.00	0.28	0.71	20.30	0.00	1.37	5.55	63.32
c2-hexene	0.00	0.00	0.43	10.92	0.64	0.34	4.32	36.68
c/t-3m ² -pentene	0.00	0.00	0.41	22.69	0.00	0.46	8.77	66.02
2,2-dm-pentane	0.00	0.00	0.00	9.29	0.00	0.00	4.37	27.68
m-cyclopentane	0.52	0.90	4.24	190.77	0.64	2.86	74.31	579.02
2,4-dm-pentane	0.00	0.98	1.37	33.11	0.00	1.41	12.02	95.05
2,2,3-dm-butane	0.00	0.01	0.09	16.70	0.63	0.33	1.71	7.94
1m-cyclopentene	0.00	0.00	0.54	0.00	0.00	0.00	5.51	57.45
benzene	1.66	2.53	8.18	393.37	2.98	8.40	132.87	1156.77
3,3-dm-pentane	0.00	0.00	0.28	14.23	0.00	0.49	5.64	41.83
cyclohexane	0.15	0.29	1.15	41.73	0.32	0.59	16.73	128.13
2m-hexane	0.24	0.44	2.81	128.14	0.64	3.04	49.99	404.90
2,3-dm-pentane	0.00	0.00	0.84	41.22	0.24	1.78	16.99	126.62
1,1-dm-cyP	0.00	0.00	0.00	8.38	0.00	0.00	3.46	23.41
3m-hexane & cyclohexene	0.40	1.05	3.66	140.72	1.47	3.86	55.00	441.57
c-1,3-dm-cyP	0.43	0.00	0.66	26.82	0.00	0.51	10.70	83.26
t-1,3-dm-cyP & 3e-pentane	0.00	0.00	0.99	41.56	0.68	0.67	16.38	127.56
t-1,2-dm-cyP	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2,4-tm-pentane & 1-heptene	0.57	0.24	1.98	102.82	0.84	3.63	41.18	317.51
c3-heptene	0.00	0.00	0.00	9.10	0.17	1.67	3.76	27.06
n-heptane	0.28	0.92	2.87	110.73	0.55	2.44	41.51	351.82
t3-heptene	0.00	0.00	0.48	32.61	0.00	0.68	12.35	97.85
t2-heptene	0.00	0.00	0.00	9.97	1.48	0.49	3.77	29.94
c2-heptene	0.70	0.99	1.45	10.51	0.33	0.00	4.12	24.99
m-cyH & 2,2-dmC6	0.00	0.82	1.25	61.71	0.22	0.98	24.05	187.81
2,5-dm-C6 & e-cyP	0.00	0.22	0.47	22.55	0.29	0.84	8.52	69.85
2,4-dm-C6 & 2,2,3-tm-CS	0.00	0.00	1.15	45.54	0.15	1.10	17.43	142.18
etc-1,2,4-tm-cyP	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00
etc-1,2,3-tm-cyP	0.00	0.00	0.00	8.71	0.00	0.33	3.36	25.75

234-tm-pentane	0.75	0.60	1.62	30.77	0.49	1.67	12.44	97.20
toluene	2.53	7.96	19.94	925.33	4.37	65.22	317.64	2879.49
2m-heptane	0.00	0.42	1.09	65.27	0.20	1.32	23.39	211.00
4m-heptane & 1m-cyhexene	0.00	0.35	0.47	32.09	0.00	0.70	11.38	100.54
3m-C ₇ & 3e-C ₆	0.00	0.00	1.89	88.32	0.18	1.80	31.22	284.54
cct-124-tm-cyP & c-13-dm-cyH	0.00	0.00	0.29	17.89	0.00	0.00	6.63	56.56
t-14-dm-cyH	0.14	3.12	3.07	5.98	0.68	3.99	4.73	17.15
225-tm-C ₆	0.00	0.00	0.00	10.20	0.00	0.30	3.98	31.55
1-octene	0.26	0.00	0.00	16.56	0.46	1.06	6.86	52.34
1e-1m-cyP	0.00	0.00	0.00	3.56	0.00	0.83	3.80	28.41
n-octane & t-12-dm-cyH	0.32	0.51	1.57	61.18	0.49	2.11	20.72	201.82
t2-octene	0.00	0.00	0.00	7.75	0.00	0.81	3.50	23.75
ccc-123-tm-cyP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
??t-13-dm-cyH & c-14-dm-cyH	0.00	0.42	0.78	12.80	0.00	1.10	4.57	43.28
c2-octene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.45
ip-cyP	0.00	0.00	0.00	7.18	0.30	1.04	2.84	14.20
c-12-dm-cyH	0.00	0.00	0.00	13.46	0.00	0.26	4.90	41.04
np-cyP	0.00	0.00	0.00	4.80	0.00	0.00	1.82	15.44
25-dm-heptane	0.00	0.00	0.52	26.13	0.00	0.00	9.08	84.28
33-dm-heptane	0.00	0.00	0.00	5.04	0.00	0.38	2.11	16.25
114-tm-cyH	0.00	0.00	0.00	6.75	0.00	0.00	2.32	20.78
e-benzene	0.47	1.56	3.58	220.30	1.30	11.39	59.33	674.73
ctt-124-tm-cyH & 35-dm-C ₇	1.22	0.00	0.00	3.54	0.00	5.02	1.34	11.69
m&p-xylene & 23-dm-heptane	1.33	4.34	11.61	705.83	2.79	28.44	183.42	2251.80
34-dm-C ₇ & 4m-C ₈	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.64
2m-octane	0.00	0.47	0.88	30.74	0.82	0.78	10.21	106.05
3m-octane & ctc-124-tm-cyH	0.32	0.00	0.00	5.30	0.68	0.00	0.00	17.51
styrene	0.00	1.36	3.55	58.08	0.00	1.12	10.67	156.74
o-xylene	0.58	1.74	5.08	295.27	1.44	12.76	74.51	919.63
1-nonene & 112-tm-cyH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t3-nonene	0.00	0.00	0.00	5.58	0.00	0.31	1.70	17.44
c3-nonene & ib-cyP	0.00	0.00	0.00	3.69	0.00	0.00	0.00	0.00
n-nonane	0.39	0.41	0.83	20.80	0.29	2.94	8.76	74.01
t2-nonene	0.00	0.00	0.00	2.91	0.00	0.26	0.70	8.91
c2-nonene	0.00	0.00	0.00	5.93	0.00	0.53	2.26	19.11
ip-benzene	0.00	0.00	0.00	20.20	0.00	1.15	5.21	62.60
ip-cyH	0.00	0.00	0.00	7.38	0.00	0.84	2.51	23.81
nb-cyP	0.15	0.00	0.00	8.50	0.00	1.49	4.35	25.19
33 & 36- dm-octane	0.80	19.72	24.32	1.22	1.04	7.57	11.36	6.54
np-benzene	0.42	0.00	1.12	52.16	0.00	2.81	11.64	158.93
3e-toluene & 23-dm-octane	0.46	1.41	2.88	174.57	0.57	9.19	35.14	511.90
4e-toluene	2.34	0.79	8.71	73.89	2.52	4.83	15.49	215.46
135-tm-benzene & 2m-nonane	0.00	0.00	0.97	72.29	0.41	4.97	15.72	209.54
3e-octane	0.00	0.00	0.00	2.81	0.00	1.95	0.80	7.97
3m-nonane	0.00	0.00	0.00	9.99	0.00	0.99	2.87	32.04
2e-toluene	0.33	0.54	1.24	59.97	0.00	3.80	11.76	172.24
1-decene & ib-cyH	0.33	3.25	1.73	20.02	0.27	2.81	1.94	40.26
124-tm-benzene & tb-benzene	0.34	13.12	18.21	247.38	2.40	41.05	45.75	685.06
n-decane	0.43	0.74	1.37	8.59	0.36	5.98	7.21	26.16
ib-benzene	0.00	0.52	0.41	4.13	0.36	0.00	1.90	0.00
sb-benzene	0.00	0.00	0.00	4.04	0.00	1.06	0.71	0.00
3-ip-toluene	2.17	4.55	3.75	8.40	0.94	4.40	3.75	20.67
4-ip-toluene & 123-tm-benzene	0.00	0.78	1.17	48.57	0.37	8.62	13.96	129.82
indan	0.00	6.95	5.58	3.54	0.00	0.00	0.00	9.05
2-ip-toluene	0.00	0.00	0.00	27.82	0.00	25.66	104.34	77.28
3-np-toluene & 13de-benzene	0.00	0.78	0.86	11.78	0.00	1.13	1.86	28.39
4-np-tol/nb&13dm5e&14de-benz	0.00	0.66	0.78	46.47	0.00	1.04	7.69	110.37
12-de-benzene	0.00	0.00	0.92	4.28	0.00	1.02	0.87	10.93
2-np-toluene	0.00	0.55	0.54	10.92	0.00	1.39	2.07	26.94
14-dm-2e-benzene	0.00	0.54	0.53	17.46	0.00	1.02	2.18	39.28
12-dm-4e-benzene	1.22	0.00	0.00	28.72	0.00	2.80	4.01	64.36
13-dm-2e-benzene	1.21	0.00	0.60	6.88	0.00	2.82	1.73	12.37
n-undecane	0.27	0.68	1.36	7.87	0.00	3.71	3.60	16.01
1245-ttm-benzene	0.00	0.00	0.00	7.04	0.00	1.56	0.81	14.37
2mb-benzene	0.00	0.00	1.22	13.07	0.00	1.55	1.67	26.29
tb-2m-benzene	0.00	0.00	0.00	2.99	0.00	0.37	0.76	6.16
n-pentylbenzene	0.67	0.00	0.00	8.08	1.17	19.94	2.33	39.98
tb-35dm-benzene	0.61	0.00	0.00	1.95	0.00	0.00	0.00	5.91
tb-4e-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
naphthalene	0.54	0.81	3.76	31.33	0.00	2.56	2.62	56.65
n-dodecane	0.00	0.64	0.84	9.15	0.00	1.65	1.19	15.18
135-te-benzene	0.00	0.00	0.00	1.53	0.00	0.00	0.00	0.89
124-te-benzene	0.00	0.00	0.00	1.45	0.00	0.00	0.00	1.92
n-hexylbenzene	0.00	0.00	0.00	2.00	0.00	0.00	0.00	3.12
n-tridecane	0.00	0.63	0.00	0.85	0.00	1.11	0.00	1.25

Table 79: Raw VOC Data For House Samples: Cold Start: TR and PT Residence

(CSB: cold start ambient background sample, CSPT: cold start in-house pre-test sample, CSH: cold start in-house during-test sample, CSG: cold start in-garage during-test sample)

	TR CSB ($\mu\text{g}/\text{m}^3$)	TR CSPT ($\mu\text{g}/\text{m}^3$)	TR CSH ($\mu\text{g}/\text{m}^3$)	TR CSG ($\mu\text{g}/\text{m}^3$)	PT CSB ($\mu\text{g}/\text{m}^3$)	PT CSPT ($\mu\text{g}/\text{m}^3$)	PT CSH ($\mu\text{g}/\text{m}^3$)	PT CSG ($\mu\text{g}/\text{m}^3$)
methane	1399.57	1400.65	1473.98	1610.46	1939.97	2026.04	2171.72	1877.90
ethylene	2.55	3.77	14.16	147.70	4.05	1.14	8.52	128.70
acetylene	2.25	2.76	13.18	104.30	2.92	0.97	5.67	70.32
ethane	2.45	0.16	0.36	0.00	0.79	0.25	0.44	1.47
propylene	1.03	1.87	8.52	61.82	3.54	0.59	4.53	76.60
propane	3.06	5.54	10.19	15.44	4.65	4.72	4.82	4.28
propyne	0.00	0.00	0.00	7.67	0.00	0.00	0.00	7.78
isobutane	2.85	0.00	7.02	29.02	5.27	5.15	6.85	21.99
1-butene & isobutene	6.73	2.59	9.49	0.00	5.18	6.68	6.18	15.35
1,3-butadiene	0.31	0.61	2.37	21.81	1.04	0.00	1.46	24.65
n-butane	9.63	10.09	20.89	89.70	8.78	17.40	11.40	59.69
t2-butene & 2,2-dm-propane	0.69	3.90	2.58	14.27	1.09	2.53	1.72	13.49
1-butyne	0.00	0.00	0.00	0.57	0.00	0.00	0.00	0.45
c2-butene	0.00	1.79	2.18	9.24	0.52	0.00	6.01	8.44
3m1-butene	0.00	0.00	0.41	3.21	0.00	0.00	0.00	2.94
2m-butane	7.10	1.82	13.31	95.20	8.68	7.23	10.62	69.26
1-pentene	1.61	0.00	1.91	8.17	0.00	0.00	0.51	4.80
2m1-butene	0.00	0.31	2.11	14.56	0.68	0.83	0.90	10.74
n-pentane	4.17	3.29	10.20	57.45	3.82	7.07	6.07	41.47
2m1,3-butadiene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t2-pentene	0.46	1.03	2.72	12.96	0.66	1.80	1.11	9.26
c2-pentene	0.38	0.53	0.68	7.21	0.36	0.84	0.43	5.49
2m ² -butene	0.34	7.28	7.58	19.27	0.00	0.00	2.18	0.00
2,2-dm-butane	0.68	0.51	2.16	12.84	1.16	2.04	2.86	9.43
cyclopentene	0.29	0.26	0.41	3.93	0.00	0.26	0.52	3.48
4m1&3m1-pentene	0.00	0.00	0.85	2.61	0.00	0.00	0.00	2.33
cyclopentane	0.70	0.73	1.99	11.20	1.04	2.39	1.82	8.46
2,3-dm-butane	0.97	0.60	2.30	16.23	1.65	3.58	4.93	12.07
2m-pentane & t-4m ² -pentene	4.57	3.26	11.55	71.72	10.44	21.97	30.34	60.36
MTBE & c-4m ² -pentene	0.00	0.32	0.88	4.06	0.00	0.34	0.00	3.44
3m-pentane	2.06	2.04	7.98	47.09	8.58	19.64	26.75	35.37
1-hexene & 2m1-pentene	0.00	1.40	4.55	4.73	0.00	0.00	0.00	4.32
n-hexane	1.49	1.97	7.19	41.64	10.55	27.45	36.62	31.67
t2-hexene	0.00	0.26	0.84	6.27	0.26	0.74	0.77	6.64
2m ² -pentene & 2e1-butene	0.00	0.57	3.20	5.75	0.90	0.89	2.29	2.29
c2-hexene	0.00	0.21	0.62	3.54	0.43	0.49	0.56	2.22
c/t-3m ² -pentene	0.00	0.31	0.81	6.88	0.35	1.75	0.94	4.50
2,2-dm-pentane	0.00	0.00	0.33	2.48	1.17	3.02	3.91	1.79
m-cyclopentane	1.47	1.51	6.84	51.17	4.76	9.40	11.66	38.16
2,4-dm-pentane	0.00	0.00	1.75	9.11	2.07	3.81	5.64	6.72
2,2,3-dm-butane	0.00	0.00	0.61	2.94	0.41	0.71	0.81	1.00
1m-cyclopentene	0.00	0.00	0.00	5.91	0.45	0.23	0.46	5.00
benzene	2.37	14.20	12.86	99.54	4.84	7.75	8.17	77.06
3,3-dm-pentane	0.00	0.00	0.00	4.26	1.32	3.38	4.61	2.86
cyclohexane	0.33	0.45	1.76	11.67	0.57	1.17	1.44	8.15
2m-hexane	0.80	1.27	4.47	36.19	9.15	24.76	32.72	25.10
2,3-dm-pentane	0.34	0.41	1.81	11.95	3.48	9.24	12.30	8.12
1,1-dm-cyP	0.00	0.00	0.00	2.53	0.00	0.60	0.77	1.55
3m-hexane & cyclohexene	0.73	1.55	5.15	39.68	11.83	31.41	41.48	28.10
c-1,3-dm-cyP	0.20	0.30	0.99	8.12	0.61	1.36	1.56	5.15
t-1,3-dm-cyP & 3e-pentane	0.28	0.38	1.39	12.18	0.00	0.00	0.00	7.94
t-1,2-dm-cyP	0.00	0.00	0.00	0.00	1.79	4.57	5.85	0.00
2,2,4-tm-pentane & 1-heptene	0.76	0.97	3.48	29.97	1.30	2.05	3.39	19.42
c3-heptene	0.00	0.31	0.58	3.03	0.00	0.00	0.00	1.75
n-heptane	0.51	1.27	3.89	30.27	7.83	22.66	29.24	20.82
t3-heptene	0.00	0.37	1.17	9.77	0.48	0.00	1.69	6.13
t2-heptene	0.00	0.00	0.85	3.15	0.00	0.00	1.86	1.71
c2-heptene	5.41	0.00	0.83	3.68	3.34	0.96	0.75	1.62
m-cyH & 2,2-dmC6	0.00	0.62	1.91	18.33	0.65	0.08	2.51	11.43
2,5-dm-C6 & e-cyP	0.00	0.00	0.68	6.23	0.48	0.86	1.20	4.16
2,4-dm-C6 & 2,2,3-tm-C5	0.46	0.00	2.16	13.15	1.02	2.02	2.49	8.45
ctc-1,2,4-tm-cyP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ctc-1,2,3-tm-cyP	0.00	0.00	2.72	2.67	0.00	0.61	0.38	1.57
2,3,4-tm-pentane	0.41	0.44	2.85	9.91	0.45	0.62	1.20	5.64
toluene	4.08	16.00	35.85	232.43	16.04	31.22	27.32	190.04

2m-heptane	0.23	0.57	2.18	18.01	1.08	1.24	2.29	12.27
4m-heptane & 1m-cyhexene	0.00	0.22	0.83	8.82	0.41	0.50	1.04	6.02
3m-C ₇ & 3e-C ₆	0.42	0.56	3.60	24.50	1.62	1.95	3.28	12.89
cct-124-tm-cyP & c-13-dm-cyH	0.00	0.00	0.00	5.12	0.00	1.07	0.00	3.16
t-14-dm-cyH	0.00	1.32	6.00	3.45	7.69	9.82	9.63	1.77
225-tm-C ₆	0.00	0.00	1.07	3.05	0.56	1.73	1.50	1.92
1-octene	0.00	0.00	5.92	1.06	0.00	0.57	1.57	4.03
1e-1m-cyP	0.00	0.00	5.36	2.14	0.00	1.24	0.71	0.00
n-octane & t-12-dm-cyH	0.00	1.06	41.50	16.24	2.26	3.87	5.03	11.69
t2-octene	0.00	0.00	7.32	2.54	0.00	0.44	0.91	1.38
ccc-123-tm-cyP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
?t-13-dm-cyH & c-14-dm-cyH	0.00	2.40	50.42	3.71	0.64	2.74	1.51	2.31
c2-octene	0.00	0.00	8.57	0.00	0.00	0.52	1.54	0.00
ip-cyP	0.00	0.00	1.21	2.39	0.00	0.00	0.00	0.00
c-12-dm-cyH	0.00	0.35	0.00	3.64	0.00	0.00	0.39	2.36
np-cyP	0.00	0.17	0.00	1.70	0.00	0.00	0.98	0.00
25-dm-heptane	0.00	0.36	0.00	6.90	0.82	1.32	1.54	4.85
33-dm-heptane	0.00	0.08	0.00	1.36	0.00	0.31	0.58	0.00
114-tm-cyH	0.00	0.14	0.86	1.88	0.00	0.00	0.00	0.00
c-benzene	1.21	4.13	7.82	51.96	4.55	7.44	9.82	44.46
ctt-124-tm-cyH & 35-dm-C ₇	0.00	0.58	0.00	0.95	0.38	0.00	0.61	0.44
m&p-xylene & 23-dm-heptane	2.95	13.71	26.62	170.35	14.44	26.55	24.12	144.71
34-dm-C ₇ & 4m-C ₈	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2m-octane	0.75	0.55	14.00	7.93	0.68	0.78	1.96	5.23
3m-octane & ctc-124-tm-cyH	0.00	0.00	0.00	0.00	0.00	0.00	2.17	0.00
styrene	0.00	1.18	1.50	13.35	1.41	1.78	2.68	16.21
o-xylene	2.08	6.34	11.21	70.92	6.73	11.11	10.72	63.31
1-nonene & 112-tm-cyH	0.00	0.00	0.00	0.00	0.00	1.14	0.00	0.00
t3-nonene	0.00	0.40	1.51	1.35	0.00	0.57	0.75	1.18
c3-nonene & ib-cyP	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.70
n-nonane	0.00	2.90	7.11	5.19	2.11	3.05	2.37	4.26
t2-nonene	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.64
c2-nonene	0.00	1.44	3.80	1.62	0.99	1.31	1.25	1.40
ip-benzene	0.00	0.68	1.65	4.67	0.45	0.59	0.75	4.01
ip-cyH	0.00	1.16	2.73	1.77	0.70	0.83	0.86	1.45
nb-cyP	0.00	2.85	6.50	2.51	1.43	2.19	2.09	1.69
33 & 36- dm-octane	0.00	0.41	59.73	4.66	0.00	0.00	0.00	5.59
np-benzene	0.00	1.94	3.56	11.42	1.88	2.41	2.65	10.65
3e-toluene & 23-dm-octane	0.00	10.00	11.46	38.29	5.01	14.45	22.33	37.69
4e-toluene	6.07	8.35	3.59	21.30	12.22	5.53	0.00	16.78
135-tm-benzene & 2m-nonane	0.52	2.88	4.83	16.49	3.16	4.23	4.19	15.55
3e-octane	0.00	2.01	1.75	0.00	1.98	2.26	1.78	0.00
3m-nonane	0.00	1.62	3.45	2.15	0.90	1.38	1.20	1.95
2e-toluene	0.00	1.67	2.28	12.87	1.51	2.22	2.16	12.99
1-decene & ib-cyH	0.00	0.00	11.33	2.35	12.77	2.69	7.48	4.90
124-tm-benzene & tb-benzene	1.35	10.23	32.65	51.54	41.09	10.61	10.07	54.46
n-decane	0.65	9.97	21.85	2.50	4.72	11.07	10.49	2.31
ib-benzene	0.57	1.27	2.51	0.87	0.48	2.12	1.65	0.00
sb-benzene	0.00	0.00	2.03	0.55	0.00	0.00	0.00	0.00
3-ip-toluene	0.77	2.63	18.43	4.31	7.17	8.60	8.18	2.48
4-ip-toluene & 123-tm-benzene	0.00	16.63	5.98	10.46	3.14	5.18	4.83	11.70
indan	0.00	1.20	0.00	0.74	0.00	0.85	0.69	2.21
2-ip-toluene	0.00	1.76	17.80	6.06	1.62	3.02	2.14	6.34
3-np-toluene & 13de-benzene	0.00	1.37	3.18	2.14	0.62	0.84	0.83	2.57
4-np-tol/nb&13dm5e&14de-benz	0.00	2.15	4.84	8.68	0.61	3.26	3.12	11.11
12-de-benzene	0.00	1.44	4.19	0.00	0.93	1.28	1.02	0.00
2-np-toluene	0.00	1.23	3.05	1.99	1.02	1.61	1.43	2.14
14-dm-2e-benzene	0.00	0.37	5.36	3.10	0.41	1.23	0.59	3.87
12-dm-4e-benzene	0.00	0.57	2.77	5.01	0.97	1.55	1.53	6.62
13-dm-2e-benzene	0.00	0.79	1.37	2.04	2.86	3.39	2.57	2.57
n-undecane	0.00	7.40	14.46	1.39	5.08	7.52	7.36	1.82
1245-ttm-benzene	0.00	1.05	2.66	0.84	0.38	0.67	1.34	1.23
2mb-benzene	0.00	1.36	2.70	2.09	0.65	1.34	0.94	3.13
tb-2m-benzene	0.00	0.24	2.73	1.62	0.88	0.28	0.95	0.65
n-pentylbenzene	0.00	1.47	0.42	2.47	11.15	1.09	3.91	2.73
tb-35dm-benzene	0.00	0.63	0.53	0.00	0.00	0.00	0.00	0.68
tb-4e-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
naphthalene	0.00	2.63	1.02	6.55	3.11	3.88	1.69	9.86
n-dodecane	0.00	1.63	1.77	1.32	1.61	2.17	2.17	2.52
135-te-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39
124-te-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-hexylbenzene	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00
n-tridecane	0.00	0.00	0.00	0.00	0.62	1.08	0.00	1.03

Table 80: Raw VOC Data For House Samples: Cold Start: MM and JR Residence

(CSB: cold start ambient background sample, CSPT: cold start in-house pre-test sample, CSH: cold start in-house during-test sample, CSG: cold start in-garage during-test sample)

	MM CSB ($\mu\text{g}/\text{m}^3$)	MM CSPT ($\mu\text{g}/\text{m}^3$)	MM CSH ($\mu\text{g}/\text{m}^3$)	MM CSG ($\mu\text{g}/\text{m}^3$)	JR CSB ($\mu\text{g}/\text{m}^3$)	JR CSPT ($\mu\text{g}/\text{m}^3$)	JR CSH ($\mu\text{g}/\text{m}^3$)	JR CSG ($\mu\text{g}/\text{m}^3$)
methane	1323.36	2511.77	2752.18	1650.82	1776.56	1252.14	1715.46	1477.62
ethylene	1.12	1.78	3.65	367.24	2.37	2.76	6.47	227.99
acetylene	1.30	1.01	2.96	254.72	2.14	2.54	5.22	117.38
ethane	0.90	0.54	0.65	0.00	2.11	0.37	0.69	1.72
propylene	1.91	0.45	2.59	164.49	1.56	1.00	3.12	105.41
propane	2.97	13.41	12.88	10.14	6.41	6.76	7.98	7.26
propyne	0.00	0.00	0.30	18.93	0.00	0.00	0.00	11.37
isobutane	2.20	19.11	18.52	103.57	2.80	0.00	0.00	31.38
1-butene & isobutene	1.99	5.70	3.81	0.00	3.42	0.00	1.67	0.00
1,3-butadiene	0.00	0.00	0.38	51.00	1.63	0.00	1.02	34.68
n-butane	5.77	6.93	9.52	275.85	10.39	9.21	10.24	88.94
1,2-butene & 2,2-dm-propane	0.28	0.77	1.10	42.85	0.30	0.77	0.97	19.00
1-butyne	0.00	0.00	0.00	4.54	0.00	0.00	0.00	0.78
c2-butene	0.00	0.00	0.00	28.62	2.70	0.44	0.58	11.06
3m1-butene	0.00	0.00	0.00	8.39	0.00	0.00	0.00	4.20
2m-butane	2.42	6.74	9.64	277.43	2.77	3.17	1.88	99.33
1-pentene	0.89	0.45	0.72	16.52	1.40	0.00	0.92	9.27
2m1-butene	0.00	0.49	0.55	32.44	0.00	0.42	1.11	16.70
n-pentane	1.70	2.80	4.38	163.00	0.84	3.00	4.09	60.42
2m1,3-butadiene	0.00	0.00	0.00	0.00	3.91	0.00	0.00	0.00
1,2-pentene	0.00	0.65	0.95	31.49	0.00	0.00	0.72	13.56
c2-pentene	0.00	0.00	0.00	18.03	0.00	0.00	0.19	7.57
2m2-butene	0.00	0.00	0.00	47.74	0.73	0.76	1.04	21.48
2,2-dm-butane	0.00	0.43	0.54	33.83	0.26	0.14	0.57	13.14
cyclopentene	0.00	0.85	0.32	9.45	0.00	0.16	0.53	4.89
4m1&3m1-pentene	0.00	0.00	0.00	5.93	0.00	0.00	0.00	2.76
cyclopentane	0.19	0.59	0.74	30.15	0.38	0.51	0.81	12.29
2,3-dm-butane	0.22	0.32	0.59	42.32	0.45	0.40	0.71	17.08
2m-pentane & 1,4m2-pentene	1.33	3.12	4.38	182.65	2.60	1.70	4.78	76.01
MTBE & c-4m2-pentene	0.27	0.00	0.00	6.99	0.00	0.00	0.00	3.26
3m-pentane	0.37	1.35	2.79	118.97	1.20	1.25	2.66	49.76
1-hexene & 2m1-pentene	0.00	1.70	2.02	9.10	0.00	4.55	4.82	9.33
n-hexane	0.63	1.40	2.14	104.30	0.84	1.84	2.66	45.67
1,2-hexene	0.00	0.00	0.00	12.55	0.00	0.00	0.26	6.54
2m2-pentene & 2e1-butene	0.00	0.00	0.00	10.83	0.00	5.77	5.07	6.37
c2-hexene	1.10	0.00	0.00	7.52	0.00	0.00	0.41	3.48
c/t-3m2-pentene	0.00	0.33	0.99	15.22	0.00	0.00	0.00	7.07
2,2-dm-pentane	0.00	0.00	0.33	5.95	0.00	0.00	0.00	2.77
m-cyclopentane	0.23	1.51	2.51	129.31	0.62	1.37	2.41	55.30
2,4-dm-pentane	0.00	1.22	2.02	21.20	0.22	0.00	1.79	10.32
2,2,3-dm-butane	0.89	0.15	0.38	6.99	0.00	0.00	0.09	4.36
1m-cyclopentene	0.00	0.00	0.00	11.19	0.00	0.00	0.00	0.42
benzene	1.43	4.59	5.55	228.52	2.16	3.23	5.57	122.70
3,3-dm-pentane	0.00	0.00	0.00	6.98	0.00	0.00	0.19	4.58
cyclohexane	0.00	0.39	0.59	26.28	0.20	0.64	0.90	12.31
2m-hexane	0.21	0.77	1.28	106.74	0.59	1.80	2.51	51.97
2,3-dm-pentane	0.00	0.25	0.43	0.00	0.34	0.73	0.98	0.00
1,1-dm-cyP	0.00	0.00	0.00	4.36	0.00	0.00	0.00	2.83
3m-hexane & cyclohexene	0.00	1.44	2.24	88.26	0.55	3.61	4.16	43.27
c-13-dm-cyP	0.85	0.48	0.60	16.28	0.46	0.42	0.60	8.11
t-13-dm-cyP & 3e-pentane	0.00	0.00	0.42	25.92	0.32	0.67	0.92	12.73
t-12-dm-cyP	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00
2,2,4-tm-pentane & i-heptene	0.48	0.60	1.07	63.82	0.67	0.85	1.54	32.16
c3-heptene	0.00	0.00	0.00	5.25	0.00	0.00	0.00	2.09
n-heptane	0.33	0.65	1.11	70.29	0.73	3.46	3.46	44.11
t3-heptene	0.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00
1,2-heptene	0.00	0.22	0.40	5.76	0.00	0.00	0.00	3.39
c2-heptene	0.00	3.91	2.53	5.62	0.00	0.29	0.00	3.42
m-cyH & 2,2-dmC6	0.00	0.08	0.62	36.28	0.33	1.38	1.56	18.07
2,5-dm-C6 & e-cyP	0.00	0.26	0.67	15.30	0.00	0.00	0.00	1.12
2,4-dm-C6 & 2,2,3-tm-C5	0.00	0.00	0.00	25.55	0.00	0.00	0.00	20.59
ctc-12,4-tm-cyP	0.00	0.11	0.00	0.29	0.00	0.00	0.00	0.00
ctc-12,3-tm-cyP	0.00	0.00	0.00	4.73	0.00	0.00	0.00	2.80
2,3,4-tm-pentane	0.00	0.28	0.70	18.81	0.24	0.49	0.54	9.63
toluene	1.93	10.67	12.96	600.48	3.86	15.96	18.61	301.02

2m-heptane	0.00	0.32	0.30	62.09	0.19	0.00	0.64	20.65
4m-heptane & 1m-cyhexene	0.00	0.15	0.00	0.00	0.00	0.00	0.28	10.08
3m-C7 & 3e-C6	0.35	0.47	1.06	55.90	0.25	0.00	0.74	27.85
cct-124-tm-cyP & c-13-dm-cyH	0.00	0.00	0.00	9.94	0.00	0.00	0.00	5.76
t-14-dm-cyH	0.86	6.05	7.02	3.74	0.24	5.91	6.60	2.02
225-tm-C6	0.00	0.00	0.00	5.35	0.00	0.29	0.38	3.41
1-octene	0.00	0.66	0.57	9.12	0.00	0.00	0.00	1.30
1e-1m-cyP	0.00	0.16	0.00	1.98	0.00	0.00	0.00	2.53
n-octane & t-12-dm-cyH	0.25	0.57	1.54	39.49	0.34	0.71	1.05	19.55
t2-octene	0.00	0.70	0.70	3.73	0.00	0.20	0.37	2.59
ccc-123-tm-cyP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
?n-13-dm-cyH & c-14-dm-cyH	0.00	0.83	3.44	7.12	0.00	0.61	0.64	4.06
c2-octene	0.00	0.00	0.00	1.19	0.00	0.00	0.00	0.81
ip-cyP	0.00	0.00	0.00	2.14	0.00	0.00	0.00	1.61
c-12-dm-cyH	0.00	1.24	0.00	1.88	0.00	0.00	0.28	4.55
np-cyP	0.00	0.56	0.45	2.60	0.00	0.00	0.00	1.57
25-dm-heptane	0.00	0.59	0.79	16.13	0.00	0.00	0.51	8.28
33-dm-heptane	0.00	0.00	0.35	2.48	0.00	0.00	0.36	1.59
114-tm-cyH	0.00	0.00	0.00	3.21	0.00	0.00	0.00	2.15
c-benzene	0.41	2.52	3.35	146.15	0.85	1.96	2.69	73.99
ctt-124-tm-cyH & 35-dm-C7	0.00	0.40	0.35	2.05	1.84	0.45	0.89	1.09
m&p-xylene & 23-dm-heptane	1.38	8.63	9.97	494.05	2.96	7.87	8.44	241.28
34-dm-C7 & 4m-C8	0.00	0.65	0.98	1.86	0.00	0.00	1.31	0.00
2m-octane	0.16	0.25	0.98	19.83	0.48	0.97	0.92	10.06
3m-octane & ctc-124-tm-cyH	0.00	0.00	0.00	3.01	2.88	2.01	0.86	2.45
styrene	0.76	0.88	1.29	35.22	0.00	1.47	1.36	19.95
o-xylene	0.26	3.60	4.83	203.18	3.18	3.73	4.19	101.72
1-nonene & 112-tm-cyH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t3-nonene	0.00	0.00	0.00	3.60	0.00	0.35	0.46	1.74
c3-nonene & ib-cyP	0.00	0.00	0.00	2.45	0.00	0.00	0.00	1.12
n-nonane	0.29	0.83	1.01	14.22	0.78	0.00	3.70	7.05
t2-nonene	0.00	0.00	0.00	1.87	0.00	0.00	0.00	0.83
c2-nonene	0.00	0.38	0.44	3.44	0.00	0.52	0.43	1.66
ip-benzene	0.00	0.25	0.38	13.86	0.00	0.00	0.64	6.68
ip-cyH	0.00	0.19	0.27	5.01	0.00	0.65	0.63	2.28
nb-cyP	0.00	0.42	0.59	5.65	0.00	1.26	1.44	3.17
33 & 36-dm-octane	2.52	3.75	12.90	1.53	0.40	9.23	8.49	2.17
np-benzene	0.38	0.98	0.99	36.83	0.35	1.08	1.02	17.76
3e-toluene & 23-dm-octane	0.00	5.62	5.02	170.84	0.00	0.00	3.72	61.91
4e-toluene	8.20	2.86	3.55	0.00	6.26	12.60	2.44	27.99
135-tm-benzene & 2m-nonane	0.00	1.68	1.27	50.32	0.40	3.26	1.79	25.71
3e-octane	0.00	1.44	0.72	2.49	0.00	0.17	0.00	1.05
3m-nonane	0.00	0.31	0.20	6.96	0.00	0.82	0.64	3.39
2e-toluene	0.36	1.22	1.28	40.53	0.27	0.81	0.75	21.24
1-decene & ib-cyH	0.26	2.56	3.59	11.25	0.00	2.26	1.55	6.26
124-tm-benzene & tb-benzene	0.52	5.11	48.38	167.04	0.67	17.72	4.18	88.96
n-decane	0.49	2.19	0.00	6.31	0.66	7.67	6.41	3.54
ib-benzene	0.00	0.41	0.00	3.34	0.47	1.11	0.76	1.69
sb-benzene	0.00	0.00	0.00	2.37	0.00	0.36	0.00	1.08
3-ip-toluene	2.20	6.49	4.05	6.24	3.79	4.88	4.62	3.85
4-ip-toluene & 123-tm-benzene	0.00	3.60	3.73	32.04	1.18	2.44	2.63	17.81
indan	0.00	0.86	0.69	2.30	0.00	0.38	0.21	1.24
2-ip-toluene	0.00	1.97	47.15	19.14	0.00	1.00	12.36	9.69
3-np-toluene & 13de-benzene	0.00	1.12	1.26	7.29	0.00	0.39	0.44	4.17
4-np-tol/nb&13dm5e&14de-benz	0.00	1.47	1.61	30.14	0.00	0.29	1.21	16.58
12-de-benzene	0.00	0.94	0.66	1.76	0.00	0.77	0.82	1.60
2-np-toluene	0.00	1.31	1.28	7.11	0.00	0.88	0.82	3.64
14-dm-2e-benzene	0.00	0.33	0.25	10.72	2.51	0.30	0.95	6.29
12-dm-4e-benzene	0.00	1.21	0.80	17.73	0.00	0.61	0.83	10.37
13-dm-2e-benzene	0.65	2.45	4.16	3.70	0.63	0.97	0.86	1.78
n-undecane	0.68	2.15	2.13	4.95	0.28	7.29	5.92	2.91
1245-ttm-benzene	0.00	0.64	0.78	4.07	1.12	0.72	0.44	2.42
2mb-benzene	0.70	0.79	2.27	7.64	1.99	1.13	0.92	4.76
tb-2m-benzene	0.00	0.24	0.49	1.73	0.00	0.54	0.00	0.91
n-pentylbenzene	0.00	0.63	1.52	5.31	1.17	7.51	1.00	6.64
tb-35dm-benzene	0.00	1.37	0.00	1.86	0.96	0.00	0.00	1.11
tb-4e-benzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
naphthalene	2.64	2.86	2.94	20.02	0.00	2.90	1.45	11.52
n-dodecane	0.52	1.25	1.65	4.24	0.00	2.40	2.22	3.18
135-te-benzene	0.00	0.00	0.00	1.17	0.00	0.00	0.00	0.41
124-te-benzene	0.00	0.14	0.00	0.78	0.00	0.00	0.00	0.00
n-hexylbenzene	0.00	0.19	0.00	0.61	0.00	0.00	0.00	0.00
n-tridecane	0.00	2.98	1.73	1.48	0.56	1.20	1.01	0.72

Table 81: Normalized Receptor Profiles Used In Residential House CMB Analysis

(GM, HD, PT, JR, TR, MM: six residential homes, CSH: cold start in-house during-test sample, CSG: cold start in-garage during-test sample, HSH: hot soak in-house during-test sample, HSG: hot soak in-garage during-test sample)

SAMPLE	ETHYL	ACETYL	PROPYL	N-C3	IBUTENE	N-C4	2M-C4	N-C5	CYC-C5	2M-C5	3M-C5	N-C6	MCYC-C5	BENZENE	2M-C6	3M-C6
GM-CSH	6.2681	5.4234	3.3854	4.7291	0.0000	6.5280	12.8971	3.2893	0.8161	3.5188	2.2951	2.0532	2.3312	4.5044	1.5436	2.0170
GM-CSG	10.9372	7.5399	5.1780	0.1737	0.0000	4.4274	5.1342	3.1296	0.6072	3.8911	2.5566	2.3014	2.8590	5.8952	1.9203	2.1088
HD-CSH	11.3625	7.9698	6.0867	1.7589	0.0000	5.8959	5.9569	3.4943	0.6885	4.2215	2.8071	2.4878	3.0933	5.5310	2.0810	2.2894
HD-CSG	5.5851	7.3628	4.4529	0.1500	0.0000	4.7261	5.2863	3.2143	0.6058	4.0795	2.6871	2.4860	3.0879	6.1691	2.1593	2.3549
PT-CSH	2.0183	1.3435	1.0737	1.1412	1.4643	2.7004	2.5161	1.4380	0.4306	7.1900	6.3385	8.6778	2.7628	1.9365	7.7530	9.8302
PT-CSG	9.5936	5.2417	5.7104	0.3190	1.1444	4.4499	5.1632	3.0915	0.6306	4.4992	2.6367	2.3605	2.8450	5.7441	1.8711	2.0947
JR-CSH	4.5942	3.7070	2.2196	5.6689	1.1868	7.2778	1.3387	2.9088	0.5719	3.3928	1.8865	1.8886	1.7105	3.9584	1.7849	2.9518
JR-CSG	10.8530	5.5874	5.0179	0.3458	0.0000	4.2339	4.7285	2.8760	0.5852	3.6180	2.3686	2.1739	2.6322	5.8407	2.4737	2.0599
TR-CSH	3.8088	3.5451	2.2918	2.7400	2.5522	5.6188	3.5787	2.7442	0.5351	3.1056	2.1466	1.9322	1.8394	3.4579	1.2024	1.3852
TR-CSG	8.9246	6.3024	3.7353	0.9330	0.0000	5.4200	5.7523	3.4715	0.6765	4.3334	2.8450	2.5160	3.0917	6.0147	2.1865	2.3976
MM-CSH	2.7448	2.2265	1.9483	9.6800	2.8644	7.1575	7.2424	3.2956	0.5586	3.2956	2.0946	1.6076	1.8880	4.1703	0.9596	1.6802
MM-CSG	8.4470	5.8588	3.7835	0.2333	0.0000	6.3448	6.3812	3.7492	0.6934	4.2012	2.7365	2.3991	2.9742	5.2563	2.4552	2.0300
GM-HSH	1.9449	0.9916	1.0785	6.2315	3.3915	8.6388	4.0108	3.3883	1.0509	4.2314	2.6459	1.7647	1.9460	4.3024	1.1750	2.7573
GM-HSG	0.0466	0.0337	0.0337	0.4154	0.0000	13.4323	7.9320	5.8080	1.0693	4.1707	2.6079	2.8933	3.3272	6.4591	1.4637	1.5551
HD-HSH	0.8014	0.4303	0.5839	1.4678	2.4147	13.9697	7.3074	5.1974	0.8839	4.0240	2.3891	2.7685	2.6417	5.3211	1.4408	1.6176
HD-HSG	0.2937	0.1620	0.1575	0.4621	0.0000	13.5164	7.7171	5.4984	0.9593	4.1044	2.5828	2.9508	2.9270	5.9720	1.4755	1.5672
PT-HSH	1.4809	2.2026	1.4349	1.9688	1.8872	10.6379	5.6795	5.0802	1.0056	3.6527	2.0227	2.2214	2.6889	4.4250	1.2367	1.4720
PT-HSG	0.2231	0.2385	0.1121	0.3726	0.0000	12.4313	7.8935	5.5199	1.0349	4.2197	2.6605	2.8999	3.3303	6.2520	1.5344	1.6320
JR-HSH	1.4662	1.0994	0.7326	5.9980	1.6394	21.8302	5.9235	2.9454	0.7820	3.1279	1.8330	1.5826	1.6906	3.7349	0.9905	1.9056
JR-HSG	0.2348	0.2119	0.1111	0.7021	2.6324	12.9456	7.8116	5.4094	0.9855	3.7611	2.2657	2.6929	2.9733	6.1775	1.3177	1.4490

SAMPLE	224TMC5	N-C7	TOLUENE	DMCVCC6	N-C8	E-BENZ	M&P-XYL	O-XYL	3E-TOLU	4E-TOLU	N-C10	3IP-TOL	4IP-TOL	N-C11	N-C12
GM-CSH	1.0898	1.5780	10.9734	1.6875	0.8628	1.9684	6.3881	2.7988	1.5865	4.7930	0.7523	2.0646	0.6419	0.7495	0.4638
GM-CSG	1.5410	1.6595	13.8674	0.0896	0.9169	3.3015	10.5779	4.4251	2.6162	1.1074	0.1287	0.1258	0.7280	0.1180	0.1372
HD-CSH	1.7144	1.7280	13.2225	0.1968	0.8626	2.4699	7.6354	3.1018	1.4626	0.6450	0.3000	0.1562	0.5812	0.1497	0.0494
HD-CSG	1.6933	1.8763	15.3564	0.0915	1.0763	3.5984	12.0089	4.9044	2.7300	1.1490	0.1395	0.1102	0.6923	0.0854	0.0809
PT-CSH	0.8043	6.9285	6.4741	2.2831	1.1913	2.3278	5.7152	2.5402	5.2914	0.0000	2.4868	1.9386	1.1455	1.7435	0.5147
PT-CSG	1.4480	1.5524	14.1662	0.1320	0.8714	3.3143	10.7875	4.7192	2.8096	1.2511	0.1723	0.1848	0.8719	0.1360	0.1875
JR-CSH	1.0934	2.4574	13.2191	4.6885	0.7489	1.9085	5.9957	2.9801	2.6396	1.7336	4.5555	3.2796	1.8708	4.2067	1.5754
JR-CSG	1.5311	2.0999	14.3290	0.0961	0.9305	3.5222	11.4854	4.8421	2.9471	1.3322	0.1685	0.1835	0.8479	0.1384	0.1514
TR-CSH	0.9365	1.0467	9.6392	1.6125	11.1590	2.1016	7.1582	3.0151	3.0803	0.9634	5.8755	4.9560	1.6070	3.8873	0.4758
TR-CSG	1.8106	1.8291	14.0442	0.2087	0.9813	3.1393	10.2931	4.2855	2.3138	1.2867	0.1512	0.2605	0.6323	0.0838	0.0795
MM-CSH	0.8056	0.8334	9.7426	5.2729	1.1585	2.5180	7.4938	3.6296	3.7737	2.6677	0.0000	3.0476	2.8018	1.6009	1.2400
MM-CSG	1.4678	1.6167	13.8117	0.0860	0.9084	3.3617	11.3638	4.6733	3.9296	0.0000	0.1452	0.1435	0.7369	0.1140	0.0976
GM-HSH	2.9677	1.1846	11.9178	3.7001	0.8145	2.4805	6.7352	3.4275	2.2748	4.2706	4.3860	2.8920	1.7721	0.6225	0.8049
GM-HSG	0.8255	1.4271	21.5430	0.1211	0.5631	3.7027	11.5223	4.7610	2.1239	1.1815	0.0610	0.1497	0.6214	0.0645	0.0843
HD-HSH	1.0002	1.4019	20.8116	0.3111	0.4939	3.2712	9.2503	3.9073	1.8729	1.7782	0.7775	0.4717	0.8273	0.4255	0.1399
HD-HSG	0.8726	1.4288	21.5270	0.0988	0.6838	3.8615	11.8453	4.8358	2.2248	1.0719	0.0828	0.2710	0.6674	0.0731	0.1092
PT-HSH	0.8413	1.2786	13.0722	2.0446	1.3356	2.7072	8.9447	4.0490	3.2971	1.2085	1.5400	6.6025	1.7215	1.4224	0.8377
PT-HSG	0.9011	1.4615	21.6262	0.0843	0.5828	3.8882	12.0294	5.0213	2.1578	1.0408	0.0863	0.1520	0.5680	0.0455	0.0000
JR-HSH	0.7606	1.1171	13.3513	2.8905	0.6284	1.8004	6.3377	2.8831	0.0000	6.8795	0.0000	1.9819	1.1953	2.1849	0.7075
JR-HSG	0.7265	1.3200	21.6643	0.0991	0.4776	3.7180	11.5296	4.7445	2.0752	1.0391	0.0950	0.1615	0.5858	0.0823	0.0000

Note that those cells that are shaded represent either a negative source contribution or a t-statistic value less than two. Those values that are shaded and in italics represent those sources that have marginally low t-statistic values ($1.5 < t\text{-statistic} < 2$).

Table 82: Screening Runs - CMB Results: TR Residence: Cold Start Garage Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TR-CSG		
SOURCE	Source Contribution Estimates	
CS	92.35	70.26
B	11.20	5.86
PT	0.84	0.75
HS		29.83
% Mass	104.4	106.7
R ²	0.86	0.92
χ ²	4.11	2.87

Table 83: Screening Runs - CMB Results: PT Residence: Cold Start Garage Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

PT-CSG					
SOURCE	Source Contribution Estimates				
CS	95.49	94.86	81.51	82.31	79.69
B	5.82	4.15		3.46	
PT					4.22
HS			13.67	13.23	14.18
% Mass	99.6	99.0	98.8	99.0	98.1
R ²	0.90	0.90	0.94	0.94	0.93
χ ²	2.62	2.74	2.06	1.94	2.03

Table 84: Screening Runs - CMB Results: MM Residence: Cold Start Garage Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

MM-CSG				
SOURCE	Source Contribution Estimates			
CS	105.76	104.76	95.04	98.02
B	7.04	2.97	5.51	2.22
PT				
HS			12.38	8.51
% Mass	110.3	107.7	110.8	108.7
R ²	0.94	0.93	0.96	0.94
χ ²	1.32	1.79	1.14	1.62

Table 85: Screening Runs - CMB Results: JR Residence: Cold Start Garage Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

JR-CSG		
SOURCE	Source Contribution Estimates	
CS	101.05	92.46
B	2.25	1.43
PT	1.11	1.17
HS		9.20
% Mass	104.4	104.3
R ²	0.93	0.94
χ^2	1.88	1.70

Table 86: Screening Runs - CMB Results: HD Residence: Cold Start Garage Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

HD-CSG					
SOURCE	Source Contribution Estimates				
CS	105.62	104.42	94.05	102.09	101.89
B	2.82	3.20	3.07	2.07	
PT					
HS			12.79	5.10	8.98
% Mass	108.6	107.6	109.1	109.3	111.1
R ²	0.90	0.90	0.91	0.90	0.89
χ^2	2.82	2.74	2.64	2.75	3.10

Table 87: Screening Runs - CMB Results: GM Residence: Cold Start Garage Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

GM-CSG				
SOURCE	Source Contribution Estimates			
CS	103.07	98.16	97.31	99.34
B	1.22			1.62
PT	0.80	0.83	1.11	
HS		5.83	6.59	5.87
% Mass	105.1	105.4	105.0	106.8
R ²	0.91	0.92	0.92	0.92
χ^2	2.43	2.24	2.17	2.36

Figure 50 a-c: Cold Start Garage CMB Results: Species-By-Species Comparison
(PT: TR: residential homes, CSG: cold start garage sample)

d)

e)

f)

d-f: Cold Start Garage CMB Results: Species-By-Species Comparison

(MM: JR: residential homes, CSG: cold start garage sample)

g)

h)

i)

g-i: Cold Start Garage CMB Results: Species-By-Species Comparison

(GM: HD: residential homes, CSG: cold start garage sample)

Table 88: Screening Runs - CMB Results: PT Residence: Hot Soak Garage Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

PT-HSG				
SOURCE	Source Contribution Estimates			
CS				
B				
PT	0.90	0.90		
HS	94.59	94.74	104.33	102.70
% Mass	95.5	95.6	104.3	102.9
R ²	0.85	0.85	0.82	0.82
χ ²	4.31	4.14	4.63	4.82

Table 89: Screening Runs - CMB Results: JR Residence: Hot Soak Garage Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

JR-HSG			
SOURCE	Source Contribution Estimates		
CS			
B		2.06	
PT			1.39
HS	90.85	90.30	91.54
% Mass	92.5	92.4	92.9
R ²	0.89	0.88	0.88
χ ²	3.25	3.20	3.12

Table 90: Screening Runs - CMB Results: HD Residence: Hot Soak Garage Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

HD-HSG			
SOURCE	Source Contribution Estimates		
CS			
B			6.52
PT	2.76	3.15	
HS	93.00	93.73	88.55
% Mass	96.6	96.9	95.1
R ²	0.88	0.88	0.87
χ ²	3.40	3.25	3.69

Table 91: Screening Runs - CMB Results: GM Residence: Hot Soak Garage Sample
 (CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

GM-HSG			
SOURCE	Source Contribution Estimates		
CS			
B			
PT	1.77	0.45	
HS	86.92	79.82	90.63
% Mass	86.8	80.3	90.3
R ²	0.81	0.75	0.75
χ^2	5.01	7.15	6.47

Figure 51 a-c: Hot Soak Garage CMB Results: Species-By-Species Comparison
(PT, JR,GM: HD: residential homes, HSG: hot soak garage sample)

d)

e)

f)

d-f: Hot Soak Garage CMB Results: Species-By-Species Comparison

g)

g: Hot Soak Garage CMB Results: Species-By-Species Comparison

Table 92: Screening Runs - CMB Results: TR Residence: Cold Start In-House Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TR-CSH	
SOURCE	Source Contribution Estimates
CS	45.55
B	7.31
PT	25.54
HS	
% Mass	78.4
R ²	0.75
χ ²	8.74

Table 93: Screening Runs - CMB Results: PT Residence: Cold Start In-House Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

PT-CSH			
SOURCE	Source Contribution Estimates		
CS	13.19	14.82	16.58
B	8.56		
PT	70.53	78.51	87.62
HS			
% Mass	92.3	93.3	96.3
R ²	0.94	0.94	0.96
χ ²	1.74	1.57	1.00

Table 94: Screening Runs - CMB Results: MM Residence: Cold Start In-House Sample

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

MM-CSH				
SOURCE	Source Contribution Estimates			
CS	24.36	25.15	21.32	22.61
B				
PT	75.73	78.94	68.66	73.40
HS			9.03	
% Mass	103.6	104.1	103.2	104.0
R ²	0.96	0.95	0.96	0.96
χ ²	1.37	1.35	1.38	1.37

Table 95: Screening Runs - CMB Results: JR Residence: Cold Start In-House Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

JR-CSH				
SOURCE	Source Contribution Estimates			
CS	34.36	36.55	36.51	37.77
B			4.82	
PT	59.18	61.04	59.86	61.96
HS				
% Mass	97.3	97.6	97.9	98.1
R ²	0.88	0.88	0.88	0.88
χ ²	3.80	3.56	3.80	3.60

Table 96: Screening Runs - CMB Results: HD Residence: Cold Start In-House Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

HD-CSH			
SOURCE	Source Contribution Estimates		
CS	84.71	87.20	63.83
B			3.45
PT	7.48	8.74	5.60
HS			21.54
% Mass	95.1	95.9	94.4
R ²	0.88	0.88	0.90
χ ²	3.45	3.34	3.52

Table 97: Screening Runs - CMB Results: GM Residence: Cold Start In-House Sample

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

GM-CSH		
SOURCE	Source Contribution Estimates	
CS	40.05	30.06
B	24.45	24.36
PT	31.21	27.79
HS		15.17
% Mass	95.7	97.4
R ²	0.91	0.92
χ ²	3.02	2.97

d)

e)

f)

d-f: Cold Start House CMB Results: Species-By-Species Comparison

g)

g: Cold Start House CMB Results: Species-By-Species Comparison

Table 98: Screening Runs - CMB Results: PT Residence: Hot Soak In-House Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

PT-HSH	
SOURCE	Source Contribution Estimates
CS	
B	3.81
PT	47.81
HS	48.21
% Mass	99.8
R ²	0.97
χ^2	0.87

Table 99: Screening Runs - CMB Results: JR Residence: Hot Soak In-House Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

JR-HSH	
SOURCE	Source Contribution Estimates
CS	
B	25.06
PT	29.30
HS	34.72
% Mass	89.1
R ²	0.92
χ^2	2.95

Table 100: Screening Runs - CMB Results: HD Residence: Hot Soak In-House Sample
(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

HD-HSH	
SOURCE	Source Contribution Estimates
CS	
B	18.66
PT	10.77
HS	69.36
% Mass	98.8
R ²	0.93
χ^2	2.22

Table 101: Screening Runs - CMB Results: GM Residence: Hot Soak In-House Sample

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

GM-HSH	
SOURCE	Source Contribution Estimates
CS	
B	11.61
PT	33.83
HS	50.42
% Mass	95.9
R ²	0.85
χ^2	4.86

Figure 53 a-c: Hot Soak House CMB Results: Species-By-Species Comparison
(PT, JR, GM: HD: residential homes, HSH: hot soak house sample)

d)

d: Hot Soak House CMB Results: Species-By-Species Comparison

NOTE: The sensitivity analysis started from the baseline CMB analysis using all 31 species minus those species indicated in the list marked "base" at the bottom of each table. These species were removed due to obvious errors in the VOC data (zero species concentration). Leaving the species in the analysis caused the CMB model to calculate source contribution estimates that were very inaccurate based on the species-by-species results.

Table 102: TR-CSH: Sensitivity of CMB Results to Removing Fitting Species

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TEST	TR-CSH							
	base	n-butane	toluene	octane	n-decane	3-ip-toluene	ethylene/acetylene/propylene	ALL
Species Removed								
CS	45.54	46.78	46.27	44.99	48.76	47.78	53.03	60.52
B	7.32	5.79	7.03	7.62	6.98	6.59	5.03	2.39
PT	25.54	25.09	25.59	25.43	20.95	23.76	23.57	17.7
% Mass	78.4	77.7	78.9	78.1	76.7	77.7	81.6	80.6
R ²	0.75	0.74	0.74	0.78	0.75	0.77	0.73	0.79
χ ²	8.74	9.03	9.04	7.61	8.58	7.89	9.65	7.21

Table 103: PT-CSH: Sensitivity of CMB Results to Removing Fitting Species

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TEST	PT-CSH											
	base	2-m-pentane	3-m-pentane	hexane	ethylene, acetylene, propylene	2-m-hexane	3-m-hexane	heptane	toluene	m&p-xylene	3-e-toluene	ALL
Species Removed												
CS	13.19	13.04	13.02	12.94	1.37	12.95	12.98	12.86	14.59	13.85	12.47	9.02
B	8.56	9.75	10.13	10.77	-4.84	10.91	10.77	11.22	4.09	6.47	12.37	24.52
PT	70.53	68.37	67.92	67.23	95.2	67.04	67.16	66.82	75.89	73.43	65.79	48.34
% Mass	92.3	91.2	91.1	90.9	91.7	90.9	90.9	90.9	94.6	93.8	90.6	81.9
R ²	0.94	0.94	0.94	0.94	0.95	0.94	0.94	0.94	0.95	0.94	0.95	0.97
χ ²	1.74	1.75	1.74	1.75	1.18	1.75	1.75	1.77	1.57	1.68	1.72	1.18

base: 4-ethyl-toluene

Table 104: MM-CSH: Sensitivity of CMB Results to Removing Fitting Species

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TEST	MM-CSH							
	base	propane	butane	2-m-butane	toluene	m&p-xylene	ethylene, acetylene, propylene	ALL
Species Removed								
CS	25.15	25.24	25.43	25.28	25.69	25.50	30.40	35.39
B								
PT	78.93	78.75	77.84	78.08	79.26	79.44	74.97	70.83
% Mass	104.1	104.0	103.3	103.4	105.0	104.9	105.4	106.2
R ²	0.95	0.95	0.95	0.95	0.95	0.95	0.96	0.96
χ ²	1.35	1.4	1.37	1.37	1.34	1.35	1.3	1.35

base: n-decane

Table 105: JR-CSH: Sensitivity of CMB Results to Removing Fitting Species

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TEST	JR-CSH						
	base	propane	n-butane	toluene	meta & para-xylene	ethylene, acetylene, propylene	ALL
Species Removed							
CS	36.55	38.02	36.87	36.68	37.74	37.95	42.3
B							
PT	61.04	57.81	59.79	61.23	61.43	60.19	56.01
% Mass	97.6	95.8	96.7	97.9	99.2	98.1	98.3
R ²	0.88	0.88	0.88	0.88	0.88	0.82	0.87
χ^2	3.56	3.6	3.7	3.67	3.52	3.93	4.23

Table 106: HD-CSH: Sensitivity of CMB Results to Removing Fitting Species

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TEST	HD-CSH							
	base	n-butane	2-methyl-butane	benzene	toluene	meta & para-xylene	acetylene, propylene, ethylene	ALL
Species Removed								
CS	87.20	85.83	85.76	86.89	88.52	89.43	82.88	81.85
B								
PT	8.73	8.66	8.77	8.75	8.73	8.68	8.93	8.87
% Mass	95.9	94.5	94.5	95.6	97.2	98.1	91.8	90.7
R ²	0.88	0.80	0.88	0.88	0.88	0.88	0.87	0.86
χ^2	3.34	3.33	3.42	3.48	3.37	3.27	3.63	3.92

base: isobutene/1-butene

Table 107: GM-CSH: Sensitivity of CMB Results to Removing Fitting Species

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TEST	GM-CSH						
	base	acetylene, propylene, ethylene	butane	2-m-butane	toluene	m&p-xylene	ALL
Species Removed							
CS	40.05	38.70	39.62	39.70	41.02	41.78	40.94
B	24.48	29.55	2512.00	23.70	24.02	23.67	28.49
PT	31.21	28.98	31.37	30.99	31.39	31.32	29.09
% Mass	95.7	97.3	96.1	94.5	96.4	96.8	98.5
R ²	0.91	0.91	0.91	0.93	0.91	0.91	0.92
χ^2	3.02	3.90	3.11	2.53	3.09	3.06	2.78

base: isobutene/1-butene

Table 108: PT-HSH: Sensitivity of CMB Results to Removing Fitting Species

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TEST	PT-HSH								
	base	meta & para xylene	toluene	3-isopropyl- toluene	n-butane	benzene	2-methyl- butane	n-pentane	ALL
Species Removed									
CS									
B	3.81	3.81	3.81	3.97	3.81	3.82	3.82	3.84	4.00
PT	47.81	47.92	47.79	45.57	47.78	47.30	47.69	47.82	44.60
HS	48.21	48.23	48.28	49.60	48.67	49.86	48.52	47.84	53.27
% Mass	99.8	99.9	99.9	99.1	100.3	101.0	100.0	99.5	101.9
R ²	0.97	0.97	0.97	0.98	0.97	0.97	0.97	0.92	0.98
χ ²	0.87	0.91	0.91	0.64	0.90	0.86	0.90	0.90	0.72

Table 109: JR-HSH: Sensitivity of CMB Results to Removing Fitting Species

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TEST	JR-HSH							
	base	propane	n-butane	2-methyl- butane	toluene	meta & para xylene	benzene	ALL
Species Removed								
CS								
B	25.06	20.58	16.62	25.55	23.88	25.20	23.99	10.16
PT	29.30	31.32	35.30	28.93	30.26	29.18	29.62	38.85
HS	34.72	36.11	35.53	37.98	35.29	34.49	36.32	39.06
% Mass	89.1	88.0	87.5	89.5	89.4	88.9	89.9	88.1
R ²	0.92	0.92	0.92	0.91	0.91	0.91	0.92	0.92
χ ²	2.95	2.93	2.64	3.05	3.04	3.06	3.01	2.89

base: 3-ethyl-toluene, n-decane

Table 110: HD-HSH: Sensitivity of CMB Results to Removing Fitting Species

(CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TEST	HD-HSH							
	base	n-butane	2-methyl- butane	n-pentane	benzene	toluene	meta & para xylene	ALL
Species Removed								
CS								
B	18.66	18.73	18.56	18.68	17.55	19.60	18.65	18.40
PT	10.77	10.77	10.78	10.77	11.17	10.32	10.77	10.71
HS	69.36	68.88	69.72	69.27	71.44	69.36	69.16	71.56
% Mass	98.8	98.4	99.1	98.7	100.2	99.3	98.6	100.7
R ²	0.93	0.93	0.93	0.97	0.93	0.93	0.93	0.92
χ ²	2.22	2.30	2.30	2.30	2.22	2.29	2.30	2.70

Table 111: GM-HSH: Sensitivity of CMB Results to Removing Fitting Species
 (CS: cold start, B: ambient background, PT: in-house pre-test, HS: hot soak)

TEST	GM-HSH					
	base	propane	n-butane	toluene	meta & para xylene	ALL
Species Removed						
CS						
B	11.61	10.76	11.52	11.55	11.64	10.65
PT	33.83	32.98	33.87	33.82	33.82	33.32
HS	50.42	50.67	51.97	50.75	50.20	52.66
% Mass	95.9	94.4	97.4	96.1	95.7	96.6
R ²	0.85	0.85	0.85	0.85	0.85	0.84
χ^2	4.86	4.82	4.94	5.03	5.04	5.29