Appendix B

HAPEM4 Documentation

HAPEM4 Users Guide

The HAPEM4 User's Guide

Draft version

(Hazardous Air Pollutant Exposure Model - Version 4)

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1.1 INTRODUCTION

The Hazardous Air Pollutant Exposure Model, version 4 (HAPEM4) User's Guide is designed to assist exposure analysts with running and interpreting results from HAPEM4. Throughout the User's Guide, the input file names and file types are in lowercase italics and program names are in all uppercase letters for easier identification. Likewise, model variables are presented in bold italics. When presented, input and output data and program source codes will be presented in a single lined box, indicating that the text inside the box is shown exactly as it exists in its electronic form. In addition, shaded text boxes appear throughout the document providing useful information and tips to users.

1.2 ORGANIZATION OF THE USER'S GUIDE

The User's Guide is organized into seven chapters. Chapters 1 and 2 provide a general overview of the background functionality of HAPEM4, as well as basic instructions for running the model. The remaining chapters are designed to provide the user with more detailed information on the components of HAPEM4. These chapters are designed to be easily referenced without requiring the entire document to be read. We suggest, however, that the novice user read all of the chapters at least once to gain a better understanding of HAPEM4.

Chapter 1 Provides a brief introduction to HAPEM4 modeling fundamentals including a brief history of the development of HAPEM4.

Chapter 2 Provides an overview of the various components of HAPEM4 and basic information needed to run the model.

Chapter 3 Provides a description of the format, data, and options for each of HAPEM4 input files.

Chapter 4 Provides a description of the format and data associated with each of HAPEM4 output files.

Chapter 5 Provides a description of the purpose and oper, inputs, and outputs, including a brief description of the computer code, for each of HAPEM4 computer programs.

Chapter 6 References.

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1.3   BACKGROUND

The Hazardous Air Pollutant Exposure Model, version 4 (HAPEM4) is a screening-level exposure model appropriate for assessing average long-term

> A **microenvironment** is a three-dimensional space in which human contact with an environmental pollutant takes place and which can be treated as a well-characterized, relatively homogeneous location with respect to pollutant concentrations for a specified time period.

inhalation exposures of the general population, or a specific sub-population, over spatial scales ranging from urban[1] to national. HAPEM4 provides a relatively transparent set of exposure assumptions and approximations, as is appropriate for a screening level model.

HAPEM4 uses the general approach of tracking representatives of specified demographic groups as they move among indoor and outdoor microenvironments and among geographic locations. The estimated pollutant concentrations in each microenvironment visited are combined into a time-weighted average concentration, which is assigned to members of the demographic group.

HAPEM4 uses four primary sources of information: population data from the US Census, population activity data, air quality data, and microenvironmental data. These data will be discussed briefly below, and in greater detail later in this User's Guide.

1.3.1   Population data

The U.S. Census Bureau is the primary source of most population demographic data. The U.S. Census Bureau collects information on where people live, their demographic makeup (e.g., age, gender, ethnic group), and employment. The default population data for HAPEM4 uses 1990 US Census data reported at the spatial resolution of census tracts, which are small, relatively permanent statistical subdivisions of a county. Census tracts usually contain between 2,500 and 8,000 residents.

1.3.2   Activity data

HAPEM4 uses two types of population activity data: activity pattern data and commuting pattern data. Human activity pattern data are used to determine the frequency and duration of exposure for specific groups within various microenvironments. Activity pattern data are taken from

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[1] Urban refers to a scale that encompasses the size of a large city, and is generally on the order of tens of kilometers.

demographic surveys of individuals' daily activities, the amount of time spent engaged in those activities, and the locations where the activities occur.

Table 1-1. HAPEM4 Microenvironments

MICRO – ENVIRONMENT No.	MICROENVIRONMENT		MICRO – ENVIRONMENT No.	MICROENVIRONMENT	
	SPECIFIC	GENERAL		SPECIFIC	GENERAL
1	Car	In vehicle	20	Manufacturing facility	Indoors
2	Bus	In vehicle	21	School	Indoors
3	Truck	In vehicle	22	Church	Indoors
4	Other	In vehicle	23	Shopping mall	Indoors
5	Public garage	Indoors	24	Auditorium	Indoors
6	Parking lot/garage	Outdoors	25	Health care facility	Indoors
7	Near road	Outdoors	26	Other public building	Indoors
8	Motorcycle	Outdoors	27	Other location	Indoors
9	Service station	Indoors	28	Not specified	Indoors
10	Service station	Outdoors	29	Construction site	Outdoors
11	Residential garage	Indoors	30	Residential grounds	Outdoors
12	Other repair shop	Indoors	31	School grounds	Outdoors
13	Residence - no gas stove	Indoors	32	Sports arena	Outdoors
14	Residence - gas stove	Indoors	33	Park/golf course	Outdoors
15	Residence - attached garage	Indoors	34	Other location	Outdoors
16	Residential - stove and garage	Indoors	35	Not specified	Outdoors
17	Office	Indoors	36	Train/subway	In vehicle
18	Store	Indoors	37	Airplane	In vehicle
19	Restaurant	Indoors			

In addition to recording the duration and location of a person's activities, these surveys also collect important demographic information about the person. The demographic information usually includes the person's age, gender, and ethnic group. Most activity pattern studies also try to collect information on other attributes of a respondent, such as highest level of education completed, number of people in their household, whether the person or anyone in their household is a smoker, employment status, and the number of hours spent outdoors.

The default population activity file for HAPEM4 is derived from a database of activity pattern surveys called the Consolidated Human Activity Database (CHAD) (Glen et al. 1997). The CHAD is currently comprised of over 22,000 person-days of activity pattern data, including 140 activities and 114 locations, collected and organized from twelve human activity pattern surveys. The CHAD contains the sequential patterns of activities for each individual, and each activity has a corresponding location code so that the microenvironment of each activity is known. The microenvironment categories currently incorporated into the default population activity file for HAPEM4 are presented in Table 1-1.

Because available activity data are not adequate to estimate the exposure of each individual in a population, HAPEM4 groups activity patterns data together for people with similar demographic characteristics that are expected to influence exposure to air pollutants (e.g., age, gender, race, work status), and makes exposure estimates for these groups. The activity profiles for each person in a demographic group have an equal chance of being selected from the activity database. (See discussion of stochastic elements below.) The result is that HAPEM4 provides an overall population-weighted average exposure for each demographic group.

HAPEM4 divides the population into 50 demographic groups, based on combinations of age (5 categories), race (5 categories), and gender. Activity pattern data are also separated into 3 day types: summer weekdays, other weekdays, and weekends.

The commuting data contained in the HAPEM4 default file was derived from a special 1990 US Census study that specifies the number of residents of each tract that work in that tract and every other US Census tract, i.e., the population associated with each home tract/work tract pair. HAPEM4 uses this data in coordination with the activity pattern data to place an individual either in the home tract or the work tract at each time step.

1.3.3   Air Quality Data

Previous versions of HAPEM relied on measured outdoor air pollutant data for the exposure calculations. This limited both the extent of the modeling domain and pollutants, because exposures

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could only be calculated for locations and pollutants with large monitoring networks. Typically, sufficient data were only available for large metropolitan areas and for the criteria pollutants[2].

HAPEM4, however, is capable of using model predictions of outdoor air quality data in addition to measured data. This added flexibility gives HAPEM4 the ability to model more pollutants and geographical areas than its predecessors.

HAPEM4 is able to estimate exposures over the entire U.S. at spatial scales as small as a US Census tract. For example, for the National Air Toxics Assessment program, annual average outdoor concentrations for each US Census tract were estimated with the **A**ssessment **S**ystem for **P**opulation **E**xposure **N**ationwide (ASPEN). In order to preserve any characteristic diurnal patterns in ambient concentrations that might be important in the estimation of population exposure, ASPEN annual average concentration estimates are stratified by time of day, with an annual average for each of (8) 3-hour time blocks. This stratification was preserved in HAPEM4 by combining the air quality data with similarly stratified activity data to estimate exposure concentrations.

1.3.4   Microenvironmental data

In order to calculate the exposure concentration for each demographic group, an estimate is required of the concentration in each microenvironment (ME) specified by the activity pattern. In HAPEM4 these ME concentration estimates are derived from the outdoor concentration estimate for the geographic subdivision (e.g., US Census tract) and a set of 3 ME factors: *PEN*, *PROX*, and *ADD*. These account for penetration of outdoor air into the microenvironment, proximity of the microenvironment to the emission source, and emission sources within the microenvironment .

The ME factors are entered into the model as data from an input file. As is the case with all other HAPEM4 input files, these data can be modified by the user. The default *factors* files for HAPEM4 contain estimates for *PEN* and *PROX* for 33 pollutants. These were obtained from an extensive review of literature and databases on indoor/outdoor ratios of hazardous air pollutants (HAPs). There is currently no data for the *ADD* factors in the HAPEM4 data base. The ME factors can, and should, be updated as needed to reflect current knowledge, as available.

1.3.5   Stochastic elements

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[2] Criteria pollutants are those for which a National Ambient Air Quality Standard (NAAQS) has been set. They are ground-level ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, lead, and particulate matter.

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Although it would be difficult to accurately represent the activities of an individual due to day-to-day variation, the general behavior of population groups can be well represented using stochastic processes. This makes it possible for estimates of population exposure to be characterized as distributions rather than point estimates.

HAPEM4 incorporates two stochastic elements. The first is the selection of activity patterns to represent each demographic group. Because HAPEM4 estimates long-term average concentrations, but the available population activity data sequences are specified for 24-hour periods only, several of these patterns must be combined to represent the time allocation of activities over a full season or year. For each demographic group and day type HAPEM4 selects multiple activity patterns randomly (with replacement), and combines them to find the average fraction of time in each of the 37 microenvironments for each time block. One-hundred such annual activity patterns are created for each demographic group/day type combination. Then for each US Census tract, 30 of the 100 annual patterns are randomly selected (with replacement) to represent typical annual time allocations for group members in that tract for that day type. The results for each day type are combined to create a set of 30 annual exposure concentration estimates for each demographic group in each Census tract.

When selecting the multiple 24-hour activity patterns to construct an annual average pattern, patterns are combined that pertain to different individuals, so that day-to-day correlations in activity are not preserved. For example, for day 1 the pattern may specify a house with an attached garage, and for day 2 a house without an attached garage. As a result the aggregated activity pattern is more representative of a population average pattern for the demographic group, than an individual pattern. Thus, the distribution of exposure concentrations for the group estimated by HAPEM4 represents the uncertainty in the population average exposure concentration, rather than the variability of the individual exposure concentrations among members of the group.

Another stochastic process is applied in HAPEM4 for demographic groups whose activity patterns indicate time spent at work. For those groups a work district is selected at random from the set of work districts specified for that home district, using the proportion of workers commuting to each work tract for its selection probability.

1.4   STRENGTHS AND LIMITATIONS OF HAPEM4

All models have strengths and limitations. Therefore, for each application, it is important to carefully select the model that has the desired attributes. With this in mind, it is equally important to understand the strengths and weaknesses of the chosen model. The following sections provide a summary of the strengths and potential limitations of HAPEM4. However, this is not an exhaustive list and may not address features important for specific applications of an exposure model.

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1.4.1 Strengths

HAPEM has undergone many enhancements in recent years. The most recent of these is the ability to use air quality concentration estimates from the ASPEN modeling system. This capability allows exposure to population groups to be simulated at the census tract level, a much finer spatial resolution than was previously possible. It also means that estimation of population exposure no longer needs to rely solely on data from the limited (in both areal extent and pollutants measured) nationwide network of fixed-site monitors.

An important feature of HAPEM4 is its versatility. The model is designed so that input data specific to different applications can be used without having to rewrite the computer source code. This flexibility is possible because most specifications are not "hard wired" into the model's code. Instead, the necessary input data are entered through external databases and the modeling parameters are specified through an external file. This feature allows easier use of new data, or other information (e.g., microenvironmental factors) used by the model, as they become available.

Another strength of HAPEM4 is its ability to estimate the exposures of workers in the geographic area where they work, in addition to the geographic area where they live, since the pollutant concentrations in these locations may be very different.

Another important feature of HAPEM4 is the incorporation of stochastic processes for the selection activity patterns, so that at least some of the uncertainty in the exposure estimates can be captured.

Exposure assessment with HAPEM4 has also been facilitated by development of default input files derived from the databases discussed above: national US Census population and commuting information, CHAD activity data, and ME factors for more than 30 HAPs.

1.4.2 Limitations

HAPEM4 calculates long-term average exposure concentrations in order to address exposures to pollutants with carcinogenic and other long-term effects. Thus, HAPEM4 does not preserve the time-sequence of exposure events when sampling from the time/activity databases. The result is that information used to evaluate possible correlations in exposures to different pollutants due to activities that are related in time is not preserved.

HAPEM4 only estimates exposures experienced through inhalation. For certain HAPs, inhalation might not be the major route of exposure, and therefore, HAPEM4 may underestimate

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exposures in these instances.   Also, although HAPEM4 is an inhalation exposure model, it does not include any measures of the ventilation rate associated with an activity, so there is no ability to calculate the potential dose received when engaging in various activities.

The default files for HAPEM4 currently do not account for inhalation exposures from indoor emission sources, such as passive smoking, which can be a significant source of inhalation exposure for many HAPs.

Uncertainty and variability of input data other than activity data is not considered, so that the resulting uncertainty information provided by the prediction distributions is an underestimate of the overall uncertainty. Some of these additional uncertainties are as follows.

- The US Census population data incorporated into HAPEM4 was collected in 1990, and thus is likely to understate the current population in most US Census tracts. In addition, it may not reflect recent changes in spatial patterns of population, e.g., increased population density in formerly suburban fringe areas.
- The population activity pattern data is limited. Only one of the 12 studies in CHAD was national in scope; therefore, the combined data set does not constitute a representative sample, at least with respect to geographic region. See **???** for a more detailed discussion.
- Commuting pattern data was derived from the 1990 US Census, and therefore may not reflect current commuting patterns. Moreover, the commuting data addresses only home-to-work travel. The population not employed outside the home is assumed to always remain in the residential Census tract. Further, although several of the HAPEM4 microenvironments account for time spent in travel, the travel is assumed to always occur either in the home or work tract. No provision is made for the possibility of passing through other tracts during travel.
- The ME factors incorporated into HAPEM4 were derived from reported measurement studies. The data available was quite limited. As a result most factors were not derived from a representative sample of measurements, and many were inferred on the basis of measurements of different pollutants and/or MEs that would be expected to be similar (see **???**). In addition the derivation of the *PEN* factors was based on the assumption that measured I/O ratios of 1.0 or less indicate the absence of indoor emission sources. Because this assumption is unlikely to be uniformly valid, *PEN* factors are likely to overestimate penetration by some unknown amount.
- Air quality data from modeling studies are uncertain, due to simplifications incorporated into modeling algorithms and limitations of input data (e.g., emissions, meteorology). Air quality measurements are also uncertain due to limitations of measurement technology

(e.g., minimum detection limits) and unknown representativeness of monitoring
locations.

1.5   APPLICABILITY

HAPEM4 is a screening-level exposure model appropriate for assessing **average long-term**
inhalation exposures of the general population, or a specific sub-population, over spatial scales ranging
from urban to national. Due to its design features, HAPEM4 is not appropriate for modeling short-term
(*e.g.*, hourly or daily) exposure events, nor should the model be used to assess the exposure of
individuals. Furthermore, the model is designed to look at the average inhalation exposures of different
groups, and thus it should not be used to quantify exposures of episodic "high-end" inhalation exposure
that results from high localized pollutant concentrations and/or activities that, by their nature, could result
in potentially high exposures. Furthermore, HAPEM4 cannot address cumulative exposure from
multiple pollutants nor pollutant mixtures.

1.6   BRIEF HISTORY OF THE HAZARDOUS AIR POLLUTANT EXPOSURE MODEL

In 1985, the EPA's Office of Mobile Sources (OMS)[3] developed a model for estimating
human exposure to nonreactive pollutants emitted by mobile sources. This model was similar to the
probabilistic NAAQS Exposure Model (pNEM) in that both simulated the movements of population
groups between home and work locations and through various microenvironments. They differed,
however, in several respects. The pNEM provided minute-by-minute exposure estimates which could
be averaged over longer time periods, whereas HAPEM provided annual average exposure estimates.
The pNEM included stochastic processes for estimating uncertainty and variability, while HAPEM
provided only point estimates. HAPEM also included the ability to estimate cancer incidence through
the use of risk factors developed by EPA, a capability not available to pNEM.

The OMS extended the modeling methodology in 1991 to estimate annual average carbon
monoxide (CO) exposures in urban and rural areas under specified control scenarios. The model was
renamed the Hazardous Air Pollutant Exposure Model for Mobile Sources (HAPEM-MS). HAPEM-
MS used the estimated annual average CO exposures to estimate annual average exposures to various
HAPs associated with mobile sources. This was achieved by assuming the annual average exposure to
each HAP was linearly proportional to the annual average CO exposure. The model was limited by the
fact that it could only be run for specified urban areas with ambient fixed-site CO monitors.

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[3] The EPA changed this name to the Office of Transportation and Air Quality in 1999.

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Shortly after, EPA's Office of Research and Development (ORD) developed an enhanced version of HAPEM-MS, called HAPEM-MS2. HAPEM-MS2 sub-divided the annual exposures by calendar quarter (*i.e.*, 3-month periods) to more accurately estimate exposures to mobile sources as a function of outdoor air temperature. HAPEM-MS2 also increased the number of microenvironments from 5 to 37, increased the number of demographic groups from 11 to 23, and increased the size of the activity pattern database.

In 1996, ORD further enhanced HAPEM by creating another generation of the model called HAPEM-MS3. These enhancements included adding the ability to customize the demographic groups, updating the census data using the 1990 U.S. census, and developing an algorithm for estimating ambient impacts in residences with attached garages.

Until the spring of 1998, HAPEM-MS3 could only be run on an EPA mainframe computer. During early model development, use of the mainframe was necessary, because the model required the storage of large data files and the calculation of large internal arrays. After 1998, with advances in computing technology, it became possible for HAPEM-MS3 to be executed on a "workstation." To this end, in the spring of 1998, HAPEM-MS3 was migrated (*i.e.*, transferred) to the UNIX operating system on a workstation. During the migration, further enhancements to the model were made, including a new time-activity database derived from CHAD, a new air quality program that automatically selects air pollutant monitoring sites, and a more efficient implementation of the commuting algorithm.

Immediately after the release of the UNIX-version of HAPEM-MS3, ORD, in association with the EPA's Office of Air Quality Planning and Standards (OAQPS), again made substantial improvements to the model. The newer model had two distinct improvements over the 1998 UNIX-version. First, the flexibility of the model was expanded to allow the use of modeled air quality data as well as measured data. This added functionality allowed the second improvement, expanding the areal extent of the model to include the entire contiguous U.S. at the census tract levels. With these improvement, the model was able to **directly** estimate exposures to HAPs, and hence the model was again renamed by dropping the mobile source (-MS) acronym.

This latest version of the model, called HAPEM4, has other enhancements as well. These include broader flexibility in defining the study area (this can range from a single Census tract up to the entire contiguous U.S.), population and commuting data for all census tracts in the country, a database of ME factors for more than 30 HAPs, stochastic selection of activity data, and the ability to allow the user to change internal modeling parameters such as the number of microenvironments.

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The EPA is using HAPEM4 in its National Air Toxics Assessment (NATA) program. This program is designed to address the air toxics problem in the U.S. and is an important part of EPA's Integrated Urban Air Toxics Strategy. As part of the NATA program, HAPEM4 will continue to be enhanced and tested.

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2.   GETTING STARTED — AN OVERVIEW OF HAPEM4

This chapter provides the user the basic information needed to run HAPEM4. The topics addressed in this chapter include the functions of the programs that comprise the HAPEM4, the contents of the various input and output files, and the meanings of parameter values. The chapter has been separated into the following sections.

> *Section 2.1*   Describes the general structure of HAPEM4, the input and output files, and the parameter settings.

> *Section 2.2*   Discusses considerations for changing parameter settings.

> *Section 2.3*   Provides instructions for setting up and running HAPEM4.

Figure 2-1 presents a graphical overview of the HAPEM4 model, including the types of data needed and the types of output produced by the model. The user should refer back to the figure while reading this chapter to understand how all the pieces of the model fit together.

2.1   MODEL STRUCTURE

Five programs comprise HAPEM4. These are:

1.   DURAV
2.   INDEXPOP
3.   COMMUTE
4.   AIRQUAL
5.   HAPEM

Because several output files of these programs are used as input to other programs of the set, it is important to execute them in the order presented. Program 3, COMMUTE, is omitted if commuting is not included in the exposure assessment.

For a given modeling domain (e.g., a state, a set of states, entire US) the first three of these programs need to be executed only once, even if several different air quality scenarios/pollutants are evaluated. Programs 4 and 5 need to be executed one time each for each air quality scenario/pollutant. The modeling domain for running programs 4 and 5 must be included in the modeling domain used for running Programs 1- 3, but may be smaller. For example, if programs 1- 3 are run for the entire US, the output files from these runs may then be used by programs 4 and 5 for evaluating a single state or set of states.

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The HAPEM4 programs use six user-supplied input data files, and one or more *parameter* files. All are in ASCII format. A *parameter* file identifies the user-supplied input files, the output files available to the user, and specifies the parameter settings for a model run.

2.1.1 Parameter file

The required *parameter* file information for running each of the 5 HAPEM programs is presented in Table 2-1 as user defined files and user defined parameters. The contents of each of the user defined files is described below. Any information in the *parameter* file in addition to that required will be ignored by the program. Therefore, although a separate *parameter* file may be used for each

> We recommend that the user prepare a separate parameter file for each air quality scenario/pollutant evaluation. Using distinct files, rather than re-using the same file repeatedly (*i.e.*, by editing it between runs), will assist the user in keeping track of the differences between various model runs, because the parameter file serves as a record of the job settings.

program in the HAPEM set, it is possible to use the same parameter file for running more than one program by aggregating all the information needed for each program in the file. If only one air quality scenario/pollutant is evaluated, we recommend using a single *parameter* file for running all 5 programs, to avoid errors in duplicating information used by more than one program. If multiple air quality scenarios/pollutants are evaluated for the same modeling domain, we recommend using one *parameter* file for running programs 1 - 3, and a separate *parameter* file for each set of program 4 - 5 runs. The name of the *parameter* file is specified in the OPEN statement for unit 10 in the source code of each program. These statements should be modified to specify the correct *parameter* file name for each program as appropriate before compiling.

In order for a record in the *parameter* file to be processed by the program it must contain an equal sign, i.e., "=". Other records in the file are ignored by the program. The left side of the equal sign contains a user supplied key word or phrase for each user defined file and parameter, as indicated in Table 2-1. Note that the word "file" is part of the file key phrase, e.g., "activity file". On the right side of the equal sign a full file path name (all files except the final exposure output files), a path name (the final exposure output files), or a parameter value is specified. As currently configured HAPEM4 creates two exposure output files for each state/pollutant combination. The names of these files are constructed by the program based on the pollutant SAROAD code and the state FIPS code, so that the user need not supply names for these files in the *parameter* file. However, the user must supply the SAROAD code for the pollutant in the *parameter* file of HAPEM as the value for the parameter *sarod*.

The names of the other user defined input and output files should consist of two parts, separated by a dot ("."). The part of the name preceding the dot, including the path, is the root and the part following the dot is the extension. Note that the maximum record length in the parameter file that

will be processed by the program is 120 characters, including the key word/phrase, the equal sign, and the file name/path or parameter value. The number of spaces between the keywords and the "=" signs and between the "=" signs and the file names are not

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Figure 2-1. Overview of HAPEM4

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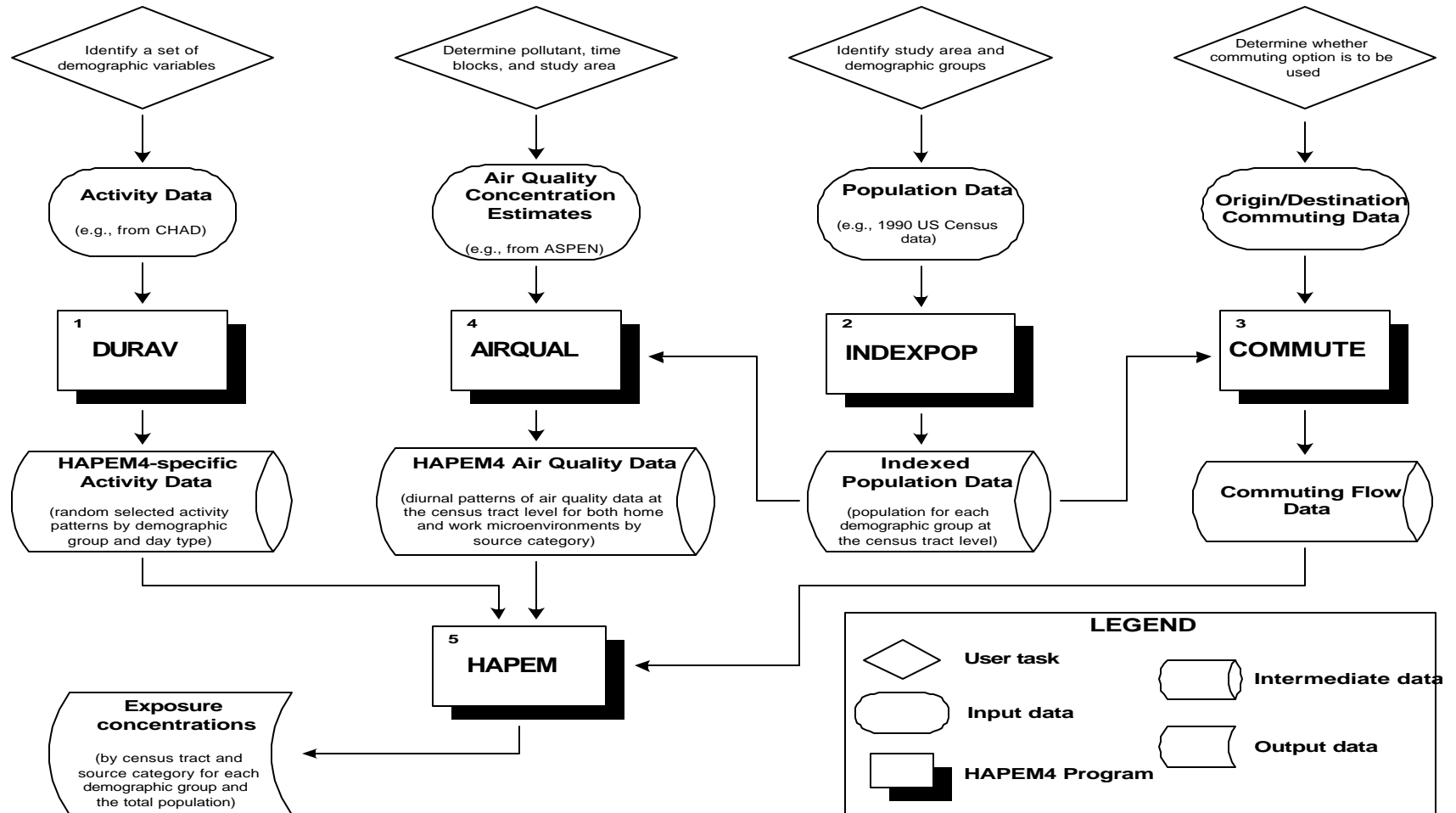
Figure 2-2. Example *parameter* file

```
INPUT FILES:
  activity file          =          /hapemin/durhw.txt
  population file        =          /hapemin/census.txt
  commuting file         =          /hapemin/comm.txt
  air quality file  =      /hapemin/benzout.txt
  factors file      =      /hapemin/factors.txt
  statefip file          =          /hapemin/statefip.dat



OUTPUT FILES:
  log file        =       log.txt
  counter file    =       counter.dat
  mistract file   =       mistract.dat
  afile           =       /hapemout/
  bfile           =       /hapemout/

PARAMETER SETTINGS:
  comm    = YES
  region1    = 1
  region2    = 53
  sarod      = 45201


  backg     = 0.00
  nmicro   = 37           ! Number of microenvironments
  nblock   = 24           ! Number of time blocks/day in activity file
  hblock   = 8            ! Number of time blocks/day for analysis
  ntype    = 3            ! Number of day types
  ngroup   = 50           ! Number of demographic groups
  nsource  = 4            ! Number of source categories
```

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fixed, and therefore can be any reasonable number. Figure 2-2 presents an example *parameter* file. Note that the input and output file names must be listed before the parameter settings.

The HAPEM programs also create several intermediate output files that are used as input to other programs in the HAPEM set, but are not directly useful for the user. The HAPEM4 programs generate the names of the intermediate output files by changing the filename extensions (*i.e*., the text after the dot) of the input file names. An example set of filenames, including the intermediate files generated by the programs, is shown in Table 2-1, with example user defined filenames in parentheses.

Besides the input and output files, the HAPEM4 programs create a set of user defined diagnostic output files. The main one is a *log* file which records information about the execution of the programs, including some error messages. Another is a *counter* file that keeps track of the numbers of elements in various processed files, some of which are used by subsequent programs. A third diagnostic file is the *mistract* file. This file keeps track of tracts in the *population* file that are not matched by tracts in the *commuting* file, tracts in the *population* file that are not matched by tracts in the *air quality* file, and of tracts in the *commuting* file that are not matched by tracts in the *air quality* file. Only tracts included in both the *population* and *air quality* files are processed by HAPEM4, since both these pieces of information about a tract (population and air quality) are needed to make an exposure estimate. If commuting is included in the simulation and tract is missing from the *commuting* file, it is assumed that all workers residing in that tract stay in the home tract for work.

2.1.2   DURAV and the Activity File

The DURAV program performs two main functions.

• It categorizes population activity data extracted from CHAD into demographic groups and day types (season, day-of-week).

• It creates 100 annual average activity patterns for each demographic group/day type combination by random sampling to be used in HAPEM.

The *activity* file is the primary input file for the DURAV program. The default file, *durhw.txt*, contains data extracted from CHAD, describing the amount of time spent in various microenvironments by individuals. Each record in the *activity* file consists of one person-day (*i.e.*, 1,440 minutes of data for an individual) of activity data. This information is not an activity sequence, rather it is the total

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number of minutes spent in each microenvironment during each block of time throughout the day (*i.e.*, the time increments used per twenty-four hour period).   For example, in the default *activity* file, *durhw.txt*, there are 37 microenvironments, (24) one- hour time blocks, and 2 exposure districts (home and work), resulting in a total of 1,776 duration values. The duration in each of the 37 microenvironments for the first hour comes first in the *activity* file, followed by the 37 durations for the second hour, etc. This pattern is repeated for all twenty-four hours for the home exposure district, and then for the 24 hours and 37 microenvironments of the work district.

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Table 2-1. Keywords for parameter files and example file names

User/Model Defined	Inputs	Outputs
DURAV.f90		
User defined files Ý	*activity* file (e.g., *durhw.txt*)	*log* file *counter* file
User defined parameters Ý	comm nmicro nblock hblock ntype ngroup	
HAPEM4 defined files Ý		*durhw.wrong_chad* *durhw.da* *durhw.nonzero*
INDEXPOP.f90		
User defined files Ý	*population* file (*e.g.,census.txt*) *statefip* file	*log* file *counter* file
User defined parameters Ý	region1 region2 ngroup	
HAPEM4 defined files Ý		*census.da* *census_direct.ind* *census.county_tract_pop_range* *census.state_county_pop_range*
COMMUTE.f90		

User defined files **Ý**	*commuting* file (e.g.,*comm.txt*) *population* file (*e.g.,census.txt*) *statefip* file	*log* file *counter* file *mistract* file
User defined parameters **Ý**	region1 region2	
HAPEM4 defined files **Ý**	*census_direct.ind* *census.county_tract_pop_range* *census.state_county_pop_range*	*comm.da*; *comm.ind* *comm.st_comm1_fip_ range*
AIRQUAL.f90		
User defined files **Ý**	*air quality* file (*e.g.,benzout.txt*) *population* file (*e.g.,census.txt*) *statefip* file	*log* file *counter* file *mistract* file
User defined parameters **Ý**	hblock nsource ngroup region1 region2	
HAPEM4 generated files **Ý**	*census.da* *census_direct.ind*	*benzout.air_da* *benzout.pop_air_da* *benzout.state_air_fip_range* *benzout.state_air1_fip_range* *benzout.state_air2_fip_range*
HAPEM.f90		
User defined files **Ý**	*factors* file (e.g., *factors.txt*) *air quality* file (*e.g.,benzout.txt*) *commuting* file (e.g.,*comm.txt*) *activity* file (e.g., *durhw.txt*)	*log* file *counter* file *mistract* file *afile* file (path only) *bfile* file (path only)

User defined parameters **Ý**	comm backg sarod nmicro hblock ntype ngroup nsource region1 region2	

HAPEM4 generated files **Ý**	*durhw.da*
	durhw.nonzero
	benzout.air_da
	benzout.pop_air_da
	benzout.state_air_fip_range
	benzout.state_air1_fip_range
	if commuting is included:
	  comm.da;
	  comm.ind
	  comm.st_comm1_fip_ range
	otherwise*:*
	   benzout.state_air2_fip_range	

The number of time blocks in the *activity* file is specified by the user in the *parameter* file of DURAV as ***nblock***. The number of microenvironments in both the *activity* file and the *factors* file (discussed below) must be the same and is specified in the *parameter* files of DURAV and HAPEM as ***nmicro***. The number of duration values in the *activity* file must equal twice the product of the values of the ***nmicro*** and ***nblock*** settings in the *parameter* file. The sum of the duration values for each individual profile should always equal 1,440 minutes (*i.e.*, there should be no unaccounted time); otherwise, the program will stop. Each duration must be specified as an integral (*i.e.*, no decimals) number (this number can be zero) of minutes in each microenvironment.

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Whether commuting will be included in the analysis is indicated by the value of ***comm***, specified in the *parameter* files of DURAV and HAPEM as either "yes" or "no". If no commuting is indicated, DURAV will aggregate the home and work durations for each time block.

The number of time blocks for the analysis is specified in the *parameter* files of DURAV, AIRQUAL, and HAPEM as ***hblock***. The number may be less than or equal to ***nblock***, however, it must be an integral factor of ***nblock***, so that the activity time blocks can be combined if necessary to match to match ***hblock***. For example, if ***nblock*** is 24 and ***hblock*** is set to 8, DURAV will combine the (24) one-hour activity time blocks into (8) three-hour activity time blocks.

Each record in the *activity* file also contains information about the individual from whose activities the data were derived, so that the records can be classified into demographic groups. The definitions of these groups are part of the DURAV source code, so that in order to change the demographic group definitions the source code must be modified and recompiled. Similarly, the definitions of day types, pertaining to season and day-of-week for categorizing activity patterns, are part of the DURAV source code. The number of demographic groups, ***ngroup***, is specified in the *parameter* files of DURAV, INDEXPOP, AIRQUAL, and HAPEM. The number of day types, ***ntype***, is specified on the *parameter* files of DURAV and HAPEM.

The current version of DURAV divides the activity data into 40 demographic groups, based on combinations of age (5 categories), race (4 categories), and gender. There are also 10 additional categories of age and gender combinations for data records of unknown race. Activity pattern data are also separated into 3 day types: summer weekdays, other weekdays, and weekends.

2.1.3   INDEXPOP and the Population File

The INDEXPOP program performs two main functions:

• It creates a direct access file of population data to be used in AIRQUAL

• It creates index files for the population data Census tracts, to facilitate file searching in COMMUTE and AIRQUAL

The main input file to INDEXPOP is the *population* file, which provides the number of people in each demographic group (defined in the DURAV source code) for each census tract in the study

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area under investigation. The data must be sorted according to state FIPS, county FIPS, and tract code. These data are typically obtained from the U.S. Census Bureau's census surveys. For example, the default *population* file contains US Census population counts for each of the demographic groups defined in the current version of the DURAV source code for each Census tract in the US.

2.1.4   COMMUTE and the Commuting File

The COMMUTE program performs two main functions.

•   It creates a file identifying for each Census tract (i.e., home tract) the associated set of work tracts (i.e., tracts in which the residents of the home tract work), and the fraction of home tract workers in each work tract

•   It creates index files to facilitate file searching in HAPEM

The *commuting* file is the main input file to the COMMUTE program. The default *commuting* file was derived from U.S. Census Bureau data identifying the place of work and place of residence for individuals in all fifty states and the District of Columbia. While there are approximately 500 million pairs of tracts nationwide within a reasonable commuting distance of each other, only about 5 million of these pairs have a non-zero flow of commuters. Only those pairs with non-zero flows are included in the *commuting* file.

An important issue pertaining to this commuting data is that workers do not always travel between their home and work locations on a daily basis. The larger the distance between home and work, the greater the likelihood that daily commuting does not occur. For example, places of residence in the lower 48 states appear with Alaskan places of work. These workers are almost surely not commuting on a daily basis between the continental U.S. and Alaska. To address this issue the commuting flows were examined as a function of distance. To examine how the decline in commuting flow is affected by distance, researchers plotted the natural log of the natural log of the total flow versus distance. This plot revealed that the ln(ln(total flow)) is nearly linear for distances ranging from 0 to about 100 km. For distances greater than 100 km, the graph exhibits a decreasingly negative slope with distance (*i.e.*, the curve "flattens out"). These findings suggest that people's "commuting behavior" is fairly consistent, on an aggregate basis, to a distance of approximately 100 km. Then, at greater distances, factors other than daily commuting may become increasingly important. Therefore, within the COMMUTE program a limit for the distance between home and work distance is specified, such that

commuting flows for greater distances are not processed. The distance limit is currently set at 120 km.

2.1.5   AIRQUAL and the Air Quality File

The AIRQUAL program performs two main functions.

•   It creates a direct access file of air quality data to be used in HAPEM.

•   It creates index files to facilitate file searching in HAPEM.

The *air quality* file contains the ambient air concentrations that are used by the AIRQUAL program. The AIRQUAL program is designed to read *air quality* files that are created by the ASPEN model. The ASPEN model calculates HAP concentration contributions from multiple emission source categories for multiple time blocks for every census tract in the US. AIRQUAL requires a separate *air quality* file for each pollutant being evaluated. Details about the format of the *air quality* file can be found in Chapter 3.

The number of emission source categories is specified in the *parameter* files of AIRQUAL and HAPEM as **nsource**, and must match the number in the *factors* file, discussed below. The user specifies the number of time blocks for the analysis in the *parameter* files of DURAV, AIRQUAL, and HAPEM as **hblock**.. As discussed above, this value must be an integral factor of nblock, the number of time blocks in the *activity* file, so that the activity time blocks can be combined if necessary to match to match **hblock**. Similarly, **hblock** may also be greater than or equal to the number of time blocks in the *air quality* file. But it must be an integral multiple of the number of air quality time blocks, so that the air quality values can be replicated if necessary to create **hblock** air quality values. For example, currently the air quality input file created by ASPEN has (8) three-hour time blocks per day. If **hblock** is set to 24 AIRQUAL will create 24 air quality time blocks with three replicates of each of the 8 air quality values.

2.1.6   HAPEM and the Microenvironmental Factors File

The HAPEM program performs four main functions.

•   For each demographic group in each Census tract, it randomly selects 30 of the 100 annual average activity patterns for each day type (created in DURAV).

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• For each activity pattern for a commuting demographic group, it randomly selects a work Census tract with probability weighting based on the fraction of residents that work in that tract..

• For each Census tract it estimates the concentration in each microenvironment based on microenviroment factors and outdoor concentrations.

• It combines activity pattern, commuting, and microenvironment concentration estimates to calculate 30 annual average exposure concentrations for each demographic group in each Census tract

The microenvironmental (ME) *factors* file provides the factors used to calculate an estimated microenvironmental concentration from an outdoor concentration. This version of HAPEM uses an updated ME factor methodology, and includes a data base for the air pollutants on EPA's urban HAPs list[1]. This updated methodology allows the user to specify values for three types of ME factors: penetration factors, proximity factors, and additive factors. These factors are combined with the outdoor concentration estimates according to the following algorithm.

$$\text{ME concentration} = PROX \times PEN \times \text{outdoor concentration} + ADD$$

The penetration factor, *PEN,* is an estimate of the ratio of the ME concentration contribution (from a given emission source category) to the concurrent outdoor concentration contribution in the immediate vicinity of the ME.

> The user should be aware that many variables affect the amount of a pollutant that infiltrates into an indoor location and that a single ME factor does not account for the myriad of possibilities.

The proximity factor, *PROX,* is an estimate of the ratio of the outdoor concentration in the immediate vicinity of the ME to the outdoor concentration represented by the air quality data. The air quality data from ASPEN represent a population-weighted average over the Census tract. For most situations the default *factors* file specifies a *PROX* value of 1.0, i.e., an outdoor concentration

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[1] The urban HAPs list was published in the Federal Register Notice describing EPA's Integrated Urban Air Toxics Strategy (64 FR 38706).

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contribution in the immediate vicinity of the Census tract equal to the Census tract average concentration contribution. However, when assessing exposure to motor vehicle emissions, for MEs near roadways (e.g., in-vehicle) the pollutant concentration contribution in the immediate vicinity of the ME is expected to be higher than the average pollutant concentration contribution over the Census tract, i.e., *PROX* is expected to be greater than 1.0, and this is reflected in the default *factors* file.

ADD is an additive factor that accounts for emission sources within or near to a microenvironment, i.e., indoor emission sources. Unlike the other two factors, the *ADD* factor is itself a concentration and therefore has units of mass/volume. The actual units used must be the same as those in the *air quality* file.

A fourth factor, *LAG*, is used to account for the possibility of very slow pollutant diffusion and penetration, so that the relevant air quality concentration value may be from the previous time block. A value of zero for *LAG* indicates no time lag, i.e., use the concurrent air quality value; otherwise, the previous time block value is used.

The *factors* file includes values for each of these factors for each ME/emission source category combination. As noted above, the number of MEs in the *factors* file must match the number in the *activity* file (i.e., **nmicro**). Similarly, the number of emission source categories (i.e., **nsource**) must match the number in the *air quality* file. The default *factors* file contains ME factors applicable to all the MEs included in the default *activity* file, for the four emission source categories (point, area, onroad mobile, and nonroad mobile) currently provided in the ASPEN *air quality* files. These pollutant-specific estimates were derived from reported measurement studies. However, because indoor emission sources were not addressed in the NATA application for which this version of HAPEM was developed, in the default *factors* file *ADD* is uniformly set equal to zero. Similarly, *LAG* is uniformly set to zero.

2.1.7 Statefip File

The *statefip* file cross-references the 2-digit state FIPS codes for each US state to its numerical ranking on the list. The default *statefip* file contains 53 codes: one for each US state, the District of Columbia, Puerto Rico, and the US Virgin Islands. Therefore, the numerical rankings range from 1 to 53, although the FIPS codes in the file range from 01 to 78, since several possible codes in the sequence are skipped (i.e., not assigned to a state, district, or territory).

The *statefip* file is used in conjunction with the parameters **region1** and **region2** specified in

the *parameter* files of INDEXPOP, COMMUTE, AIRQUAL, and HAPEM to specify the group of states to be included in the analysis, according to numerical ranking. For example, setting ***region1*** to 1 and ***region2*** to 53 results in assessment of all the states, districts, and territories in the default *statefip* file (assuming the input files contain all the necessary data). Alternatively, setting both ***region1*** and ***region2*** to 5 results in assessment of the fifth state only: California with FIPS code 06.

The region range need not be the same for each of the five HAPEM programs; the range for each program may be the same as or smaller than the range for the preceding program, where the order of the programs is as specified above. For example, INDEXPOP and COMMUTE could be run for region range 1 to 53, while AIRQUAL and HAPEM are run for a single state.

Note that the ***region1*** and ***region2*** parameters specify the states for which the program will look for data in the input files. The input files need not contain data for every tract within the specified states, however. For example, if the *air quality* file contains data for only a subset of tracts within a state, AIRQUAL and HAPEM will simply make estimates for those tracts, as long as the state or states are specified within the ***region1*** and ***region2*** range.

2.1.8   Background Concentration

In addition to estimating exposure concentration contributions for each emission source category for which data is provided in the *air quality* file, HAPEM also estimates the exposure concentration contribution from the background outdoor concentration.The background concentration is an estimate of the outdoor concentration that would occur in the absence of any anthropogenic emissions. It includes concentration contributions from natural sources, re-entrainment, or global transport. This background exposure contribution is added together with the emission source category contributions; the total exposure concentration is reported in the exposure output files. The background concentration is assumed uniform throughout the study area, and the single value is specified as ***backg*** in the *parameter* file of HAPEM. The units of measurement must be the same as those used in the *air quality* file.

2.1.9   Exposure Output Files

As currently configured HAPEM4 creates two exposure output files for each state/pollutant combination. The names of these files are constructed by the program based on the pollutant SAROAD code and the state FIPS code as follows:

XXXXX.YYd.dat
XXXXX.YY.a.dat

where   XXXXX   =   the 5-digit SAROAD pollutant code specified by the *sarod* parameter
and   YY   =   the 2-digit state FIPS code

The first file of these files contains exposure estimates for demographic groups defined according to age, gender, and race. These exposure estimates use activity data for individuals for which the race is known (about 80% of the CHAD data) and population data that is specific for age, gender, and race in each Census tract. The second file contains exposure estimates for demographic groups based on age and gender only. These exposure estimates use activity data for individuals whose race is unknown (about 20% of the CHAD data) and population data that is specific for age and gender in each Census tract, but combines values for all races.

These output files contain 30 records for each Census tract/demographic group combination. Each record identifies the Census tract, the demographic group, the number of people to which the exposure estimates apply (i.e., one-thirtieth of the population of the demographic group in the Census tract), and exposure concentration contribution estimates: one each for the *nsource* emission source categories, one for background, and a total of the contributions for all emission source categories and background.

2.2   CHANGING THE PARAMETER SETTINGS

The HAPEM4 was designed to be as easy to use as possible. With this in mind, the model's structure is such that, for routine applications, no changes need be made to the model's computer code, except to specify the name of the *parameter* file in the OPEN statement for unit 10. Otherwise, for most applications, the user need only supply the model with the appropriately formatted input files and parameter specifications declared in the *parameter* files.

However, there are several changes that a user can make to HAPEM4 to "tailor" the model to his or her needs. Changes or modifications to the model are most easily accomplished by altering the parameter settings. The following discussion describes those parameters that can be altered. For a more detailed explanation about how to change the parameter settings, refer to Chapter 6.

2.2.1   Changing the Number of Microenvironments

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In principle, HAPEM4 will work with any number of microenvironments. The number, specified as *nmicro* in the *parameter* files of DURAV and HAPEM, must match the number actually used in both the *activity* file and the *factors* file. Definitions of the microenvironments do not appear anywhere in HAPEM4 program code.

The HAPEM4 programs should be able to accommodate anywhere from one up to at least 100 microenvironments. However, large numbers of microenvironments could result in input-file line lengths beyond a system's limits (particularly in the case of the *activity* file) if other parameters (such as the number of time blocks) are also set to large values. Note that in the case of a single microenvironment (i.e., all of the individuals in each of the demographic groups spending 1,440 minutes per day in that microenvironment) the only differences in exposure to individuals or groups residing within a Census tract would be the result of commuting.

2.2.2   Changing the Number And/or Definitions of the Demographic Groups

The number of demographic groups, specified as *ngroup* in the *parameter* files of DURAV, INDEXPOP, AIRQUAL and HAPEM, must be consistent in two places:

- the group definitions in the source code for the DURAV program, and
- the number of columns in the *population* file.

The definitions of the groups appear only once explicitly (in the DURAV program). However, these definitions are paired with the columns in the *population* file by numerical order, so if the group definitions are changed then the columns in the *population* file must also be changed.

The 50 current demographic groups are defined by combinations of the following age, race, and gender categories.

Age:

- 0 - 4
- 5 - 11
- 12 - 17
- 18 - 64
- 65+

Race:

• White
• Black
• Hispanic
• Asian and Other
• Unknown

Gender:

• Male
• Female

The number of demographic groups is unlimited. However, the user is cautioned that for narrowly defined groups, there might not be enough activity pattern data to calculate a reliable group average. An extreme example of this is where no activity patterns fit a demographic group's definition, resulting in incorrect exposure calculations (*i.e.*, exposure concentrations equal to zero) for that group.

In addition, the final exposure output files are structured on the basis of the demographic group definitions. The results for the 10 groups with unknown race/ethnic group are written into output files separate from the results for the race-specific groups, since they provide alternative exposure estimates for the same populations. (See Section 4.2.) If the user wishes to change the demographic group definitions, consideration should also be given to the structure of the final exposure output files.

2.2.3   Changing the Number And/or Definitions of Day Types

Day types are used to guide the selection of the activity patterns. Demographic studies indicate that typical weekday (Monday-Friday) and weekend (Saturday-Sunday) activities differ significantly for most working people and school children. Furthermore, in certain respects, activities in summer (or warm weather) may differ from those in winter (or cold weather), especially for children or other non-workers. Currently, two variables, season and day of week, are used to determine three day types:

• weekdays in summer (June - August)
• other weekdays
• weekends.

In principle, year, month, day, season, temperature, rainfall, other meteorological variables, or even geographical variables could be used to assign day type. However, if there are too many day types, or if they are too narrowly defined, then there may not be enough activity pattern data fitting the day type definition to allow the determination of a reliable average. If additional variables are used to define day types, then the programmer is advised to check that there are an adequate number of activity pattern profiles for each new day type.

2.2.4   Changing the Number And/or Definitions of Time Blocks

The traditional method for running HAPEM has been to use one hour time increments (referred to as time blocks). The HAPEM4, however, was designed to allow more flexibility in the selection of time blocks. Time blocks can range between one minute (the finest resolution available for the activity data) to one day, so in principle, there can be any number from one to 1,440 time blocks. In most practical applications, the number of time blocks will be twenty-four or less. In order to accommodate the possible adjustment of time blocks from *nblock* to *hblock* as discussed above, the time blocks must each be of equal size.

2.2.5   Changing the Number of Annual Average Activity Patterns Created

As explained above, DURAV creates 100 annual average activity patterns for each demographic group/day type combination by averaging activity data from several randomly selected activity pattern records. The number of patterns created is set by the value of the variable *nsel*. This value is specified in the DECLARATIONS section of the source codes of both the DURAV and HAPEM programs. To change the number of activity patterns created, the user needs to change the value of *nsel* in both these programs before compiling.

2.2.6   Changing the Number of Annual Average Activity Patterns Sampled

As explained above, for each demographic group in each Census tract, HAPEM randomly selects for analysis 30 of the 100 annual average activity patterns for each day type (created in DURAV). The number of patterns selected is set by the value of the variable *amax*, which is specified in the DECLARATIONS section of the HAPEM source code. (Note that *amax* in the DURAV source code has a different function and value.) To change the number of activity patterns selected for analysis, the user needs to change the value of *amax* in HAPEM before compiling.

2.3   SETTING UP A HAPEM4 RUN

This section shows how to set-up and make a simple HAPEM4 run. Subsequent sections and chapters provide more detailed explanation about HAPEM4's input and output files and the model's programs. More advanced users are referred to Chapter 6 for information about how to modify HAPEM4's parameter settings.

The example shown in this section is for a hypothetical HAPEM4 analysis of benzene. Figure 2-3 presents a detailed picture of all of the inputs, outputs, and programs associated with HAPEM4.

The most important consideration for making a HAPEM4 run is ensuring that the input files are accurate and correctly formatted. This is the responsibility of the user. To run the model, the user must provide six data input files, the *parameter* file(s) (these files are used by the model to identify the name and location of the input and output files) and the five executable files that comprise the model. The programs can either be run consecutively by using a "batch" file, or they can be run independently.

Parameter file(s)

The *parameter* file for this example, presented above in Figure 2-2, can be used for running all five executables. The name of the *parameter* file must be specified in the OPEN statement for unit 10 in the source code of each of the five HAPEM4 programs before compiling.

Input/output files

As seen in Figure 2-2, the six input files (including full path names) are identified in the *parameter* file. The input files reside in a subdirectory named "c:/hapemin". The main exposure output files (*afile* and *bfile*) are sent to a subdirectory named "c:/hapemout", while the diagnostic output files (the *log* file, the *mistract* file, and the *counter* file) are sent to the subdirectory (unidentified) where the executable programs reside. When the full path name is identified for an input or output file, it is not required that it reside in the same subdirectory as the executables.
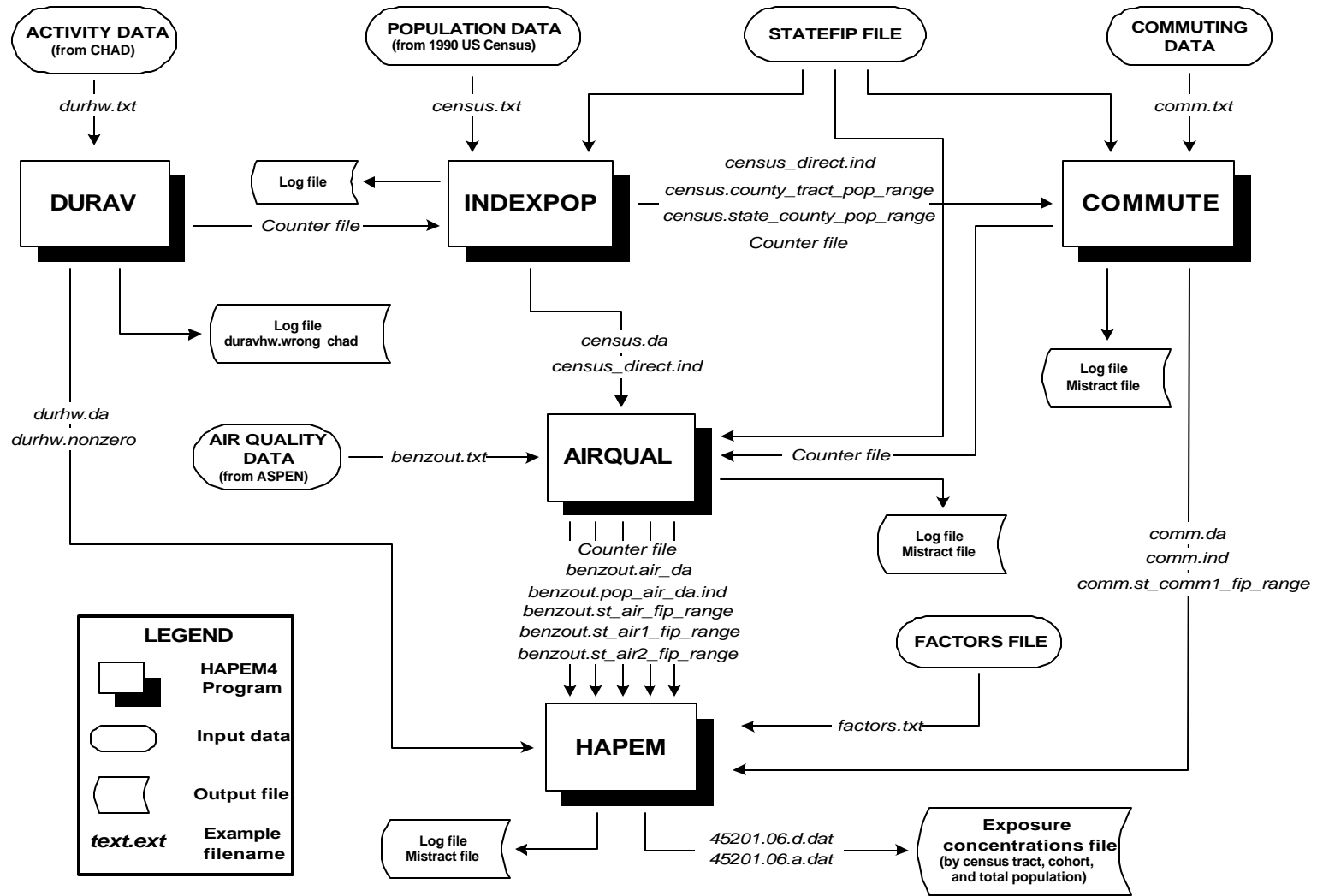
The names of the input and output files must be identified in the *parameter* file before the parameter settings.

Parameter settings

      The "PARAMETER SETTINGS" in the *parameter* file shows that **comm** = Yes (commuting is to be included in the analysis), the region to be modeled is 1 through 53 (all states, the District of Columbia, Puerto Rico, and the US Virgin Islands), and the pollutant SAROAD code is 45201 (benzene).

      The last group of information in the *parameter* file shows that there are thirty-seven microenvironments to be modeled (**nmicro**). This number of microenvironments must be consistent with the number of microenvironmental (ME) factors specified in the *factors* file (*i.e.*, *factors.txt*) and the number of duration values specified in the *activity* file (*i.e.*, *durhw.txt*). The number of time blocks per day in the *activity* file is 24 (**nblock**), but the number of time blocks per day for the analysis is 8 (**hblock**), which is an integral factor of the **nblock** value, as explained above. The number of emission source categories is four (**nsource**). The data in the *air quality* file (for this example the file is *benzout.txt*) must be consistent with **nsource**, and the number of time blocks must be an integral factor of **hblock**, as explained above. The number of demographic groups (**ngroup**) must be consistent with the demographic groups specified in the DURAV source code and in the *population* file (*i.e.*, *census.txt*).

Figure 2-3. HAPEM4 programs and input and output files

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2.3.1   Running HAPEM4 as a "Batch" Job

When running HAPEM4 by submitting batch jobs, each job should be allowed to finish before submitting the next job.

For this example a simple batch file was written to run the five HAPEM4 programs sequentially, with all five programs residing in the same directory as the batch file. The batch file is shown below:

Figure 2-4

```
durav.exe
indexpop.exe
commute.exe
airqual.exe
hapem.exe
```

Because the full path names of the *parameter* file(s) are specified as unit 10 in the source code of each program, and the *parameter* file(s) specify the names or paths of all the input and output files, as well as the parameter settings, the batch file simply specifies the order in which the HAPEM4 executable programs will be run.

2.3.2   Running HAPEM4 Programs Individually

Any of HAPEM4 programs can be run individually. The user must ensure that the required input files exist and are in the same location specified in the *parameter* file.

If a user is interested in running the DURAV program (this is typically the first program that is run when doing an exposure analysis), he or she would go to the subdirectory containing the executable program and type the following command on the DOS command line:

```
durav.exe
```

The other HAPEM4 programs are run similarly.

As indicated in Table 2-1 and Figure 2-3, INDEXPOP, COMMUTE, AIRQUAL and HAPEM all require input files that are generated from running other HAPEM4 programs. Therefore, if any of these programs is run alone, the user must ensure that the required HAPEM4 generated input files exist and are in the same subdirectory as the original input file from which their filenames were derived (see Table 2-1). For example, running AIRQUAL requires two files with filenames derived from the *population* file. For this example these files are *census.da* and *census_direct.ind*, with

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filenames derived from *census.txt*. Therefore, the *parameter* file for running AIRQUAL must specify the full path name of the *population* file, and the two intermediate files mu*s*t exist and reside in the subdirectory specified for *population* file.

3.   HAPEM4 INPUT FILES

The HAPEM4 programs use six user-supplied input data files, and one or more *parameter* files. All are in ASCII format. The function of each of the files and their relationship to the structure of HAPEM4 are discussed in Chapter 2. The reader is referred to that chapter for an overview of HAPEM4 input files. This chapter summarizes that information, and presents the format of each of the user-supplied input files.

The *parameter* files are the central input files for HAPEM4 simulations and customized *parameter* files should be prepared for every simulation or set of simulations. It is best to save the *parameter* file used for each simulation or set of simulations under a unique name, so that the files from earlier simulations are not overwritten. A consistent naming system should be developed to pair each *parameter* file with the output files generated by the simulation or set of simulations. This pairing serves as documentation for the model simulations, so the user can later determine which settings produced which results.

The *parameter* file name is the only file name directly coded into the HAPEM4 programs. The name of the *parameter* file is specified in the OPEN statement for unit 10 in the source code of each program. These statements should be modified to specify the correct *parameter* file name for each program as appropriate before compiling.

The remaining file names used by the HAPEM4 programs are input from the *parameter* file. Thus, the user must check that the *parameter* file refers to the correct file names before submitting a job. Which of the user-supplied files and HAPEM4-generated files are required for each of the five programs that comprise HAPEM4 is discussed in Chapter 2 and presented in Table 2-1.

As explained in Chapter 2, there are default files available for five of the six user-supplied input files. They are:

- the *activity* file;
- the *population* file (national scope);
- the *commuting* file (national scope);
- the *factors* file; and
- the *statefip* file (national scope).

The user may provide his or her own files as replacements for any or all of these files, using the file formats described in this chapter.

The sixth user-supplied file, the *air quality* file, must be provided by the user with the format described in this chapter.

3.1 Parameter FILE

The *parameter* file contain six types of information for use in HAPEM4 runs:

- Paths and file names for the input data files and all output data files except the final exposure output files;
- Path names for the final exposure output files;
- Identification of the set of states (optionally including the District of Columbia, Puerto Rico, and the US Virgin Islands) for the simulation
- Identification of the pollutant and its background concentration;
- Option for selecting commuting (YES or NO); and
- Six internal parameter settings.

All of this information is identified using keywords. The required *parameter* file information for running each of the five HAPEM4 programs is presented in Table 2-1 of Chapter 2 as user-defined files and user-defined parameters. The contents and format of each of the user defined files is described below. As explained in Chapter 2, any information in the *parameter* file in addition to that required by a program will be ignored by the program. Therefore, although a separate *parameter* file may be used for each program in the HAPEM set, it is possible to use the same parameter file for running more than one program by aggregating all the information needed for each program in the file. The format (including keywords) of a *parameter* file for running all five HAPEM4 programs, including COMMUTE is presented in Figure 2-2 in Chapter 2.

The HAPEM4 programs only scan lines containing an equals sign. The word or words to the left of the equals sign identify which variable is being set and thus should not be changed. The data to the right of the equals sign are the values or settings that the user selects for the run. The pathnames should precede the parameter settings in the file. The user can add additional lines (*e.g.,* comments) anywhere to the *parameter* file. It is safest if these lines do not contain an equals sign, which could cause them to be parsed accidentally by HAPEM4 programs. To ensure that all the necessary information is specified, it is safest to edit an existing *parameter* file, changing only the comments and the right hand sides of the equations.

3.1.1   Specifying the Location and Names of Input and Output Files

In editing the *parameter* file, the user should typically provide the full path names for input and output files (except the final exposure output files). The names can be up to 100 characters in length and should **not** use quotation marks to enclose the file

> Forward slashes (/) are used in path names on Unix systems; and backslashes (\\) are used in path names on PC systems.

names. If the full path names exceed 100 characters, the user may use abbreviated paths (location of the files relative to the *parameter* file), but must always update these paths if the *parameter* file is moved.

In addition to the input files discussed above, there are three diagnostic output files and two sets of final output files (i.e., two files for each state included in the simulation). The diagnostic output files are:

- the *log* file;
- the *counter* file; and
- the *mistract* file.

Full path names must be specified for these files.

As explained in Chapter 2, HAPEM4 creates two exposure output files for each state/pollutant combination. The names of these files are constructed by the program based on the pollutant SAROAD code, specified as the value of the *sarod* parameter, and the state FIPS code. Thus, the pathname, but not the filenames, for each of the two sets must be specified in the *parameter* file.

3.1.2   Identifying the Pollutant and Background Concentration

The user must also specify the pollutant SAROAD code and the background concentration, the value of the *backg* parameter, for running the HAPEM program. The pollutant SAROAD code has no effect on the exposure results but is used to construct the names of the final exposure output files.

The background concentration is an estimate of the outdoor concentration that would occur in the absence of any anthropogenic emissions. It includes concentration contributions from natural sources, re-entrainment, or global transport. In addition to estimating exposure concentration contributions for each emission source category for which data is provided in the *air quality* file, HAPEM also estimates the exposure concentration contribution from the background outdoor concentration. This background exposure contribution is also added together with the emission source category contributions to calculate the total exposure concentration. The background concentration is assumed uniform throughout the study area, i.e., a single value is specified as the *backg* parameter. The units of measurement must be the same as those used in the *air quality* file.

3.1.3 Selecting the Commuting Option

To include commuting in the HAPEM4 simulations the value of the ***comm*** parameter must be set to YES. The default mode for this option is not to include commuting in the simulations.

3.1.4 Setting the Internal Parameters

The six internal parameter settings (***nmicro***, ***nblock***, ***hblock,*** ***ntype***, ***ngroup***, and ***nsource***) are specified by the user in one or more of the *parameter* files and must be consistent with the structure of the other input data files. Each of these parameters are defined in the adjacent text box. Thus, if the user wishes to change the number of microenvironments, for example, the input files that specify microenvironments must also be altered in a consistent manner. More details about changing these parameters are presented in Chapter 6.

As explained in Chapter 2, the value of the ***hblock*** parameter, the number of time blocks per day for the analysis, must be selected to meet the following criteria.

Internal Parameters

nmicro	number of microenvironments in the *activity* and *factors* files
nblock	number of time blocks per day in the *activity* file
hblock	number of time blocks per day for the analysis
ntype	number of day types in the DURAV source code
ngroup	number of demographic groups in the DURAV source code and the *population* file
nsource	number of emission source categories in the *air quality* file

- The value of ***hblock*** must be an integral factor of ***nblock***, the number of time blocks per day in the *activity* file, so that the activity time blocks can be combined if necessary to match to match ***hblock.***

- The value of ***hblock*** must be an integral multiple of the number of time blocks per day in the *air quality* file, so that the air quality values can be replicated if necessary to create ***hblock*** air quality values.

3.2 ACTIVITY FILE

The *activity* file, the primary input to the DURAV program, contains information on the time spent in various microenvironments by individuals. This information is not presented as an activity sequence; rather it is presented in an *activity* file as the total time spent in each microenvironment during each block of time and at each location throughout the day.

3.2.1 Variables and Format of the Default File

The first line of the *activity* file is a text header that indicates the order of the variables in each record. The header in the default *activity* file, *durhw.txt*, is as follows.

Header of Default *activity* File (in "wrapped" view)

CHADID ZIP DAYTYPE STATE COUNTY GENDER RACE EMPLOYED YEAR MONTH DAY AGE COMMUTE
DURATION(MICRO,BLOCK,HW) (NMICRO=37 NBLOCK=24 HW=2 IN FORTRAN ORDER)

Although most of the header record of the *activity* file is not used by the HAPEM4 programs, it provides documentation to inform the user of the meaning of the data fields. The exception is the specification of the number of time blocks per day, *nblock*, which the DURAV program checks against the value of the **nblock** parameter specified in the *parameter* file for consistency. If inconsistent, an error message is sent to the *log* file and the program stops.

Each space-delimited record following the header record consists of one person-day (1,440 minutes) of activity data. The variables in the default *activity* file, extracted from CHAD, are defined as follows.

CHADID	9-character string identifying the data record; e.g., the corresponding person-day in the CHAD activity database. This information is used by the DURAV program only to identify faulty records in the diagnostic output files.
ZIP	5-character string identifying the zip code of respondent's residence. If a ZIP code is missing, it is reported as "00000 ". This information is not used by the DURAV program.
DAYTYPE	integer indicator of day type for classification, with values as follows:

DAYTYPE   integer indicator of day type for classification, with values as follows:

        1 = summer weekday
        2 = non-summer weekday
        3 = weekend

STATE   2-character string identifying the FIPS code of the state where the activities took place. This information is not used by the DURAV program.

COUNTY   3-character string identifying the FIPS code of the county where the activities took place. This information is not used by the DURAV program.

GENDER   1-character string, indicating gender, used to assign the respondent to a demographic group, with values as follows:

"1"	=	female
"2"	=	male
"9"	=	unknown

RACE   1-character string, indicating race/ethnic group, used to assign the respondent to a demographic group, with values as follows:

"1"	=	White (non-Hispanic)
"2"	=	Black (non-Hispanic)
"3"	=	Hispanic (any race)
"4"	=	Asian or Other (non-Hispanic)
"9"	=	unknown

EMPLOYED   1-character string, indicating employment status of respondent, with values as follows

"Y"	=	Yes
"N"	=	No
"X"	=	missing

This information is not used by the DURAV program.

YEAR, MONTH, DAY   numeric variables (four-digit year) that identify the date when the activities actually took place. This information is not used by the DURAV program.

AGE   integer indicator of the age group, used to assign the respondent to a demographic group with values as follows

1	=	0-4 years old
2	=	5-11 years old
3	=	12-17 years old
4	=	18-64 years old
5	=	65 years or older
9	=	unknown

COMMUTE   integer indicator of whether the respondent is a commuter, with values as follows:

0	=	no commuting
1	=	commuting

Following the commuting indicator is a series of duration values. The values specify the integral number of minutes (possibly zero) spent in each microenvironment/time block/location combination, where locations are the vicinity of either home and work. The default *activity* file, *durhw.txt*, with 37 microenvironments, 24 time blocks per day, and two locations has a total of 1776 duration values. These values are sequenced so that the 37 microenvironment durations for the first time block in the home location come first, followed by the 37 microenvironment durations for the second time block in the home location, and so on, until all the 888 values for the home location are specified These are followed by the 888 values for the work location. The following is an example of a record from *durhw.txt*.

Example Data Record from Default *activity* File (in "wrapped" view)

```
BAL97001A 21204 2  24 000 9 1 N 1997   1  21 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 30 0 0 0 0 0 0 0 0 0 0 0 0 30 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
45 0 0 0 0 0 0 0 0 0 0 0 0 0 15 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
60 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
```

The 37 microenvironments used in the default *activity* file were derived as combinations of location codes specified in the CHAD. They are as follows.

List of Microenvironments in the Default *activity* File

MICROENVIRONMENT #	MICROENVIRONMENT	
	SPECIFIC	GENERAL
1	Car	In vehicle
2	Bus	In vehicle
3	Truck	In vehicle
4	Other	In vehicle
5	Public garage	Indoors
6	Parking lot/garage	Outdoors
7	Near road	Outdoors
8	Motorcycle	Outdoors
9	Service station	Indoors
10	Service station	Outdoors
11	Residential garage	Indoors
12	Other repair shop	Indoors
13	Residence - no gas stove	Indoors
14	Residence - gas stove	Indoors
15	Residence - attached garage	Indoors
16	Residential - stove and garage	Indoors
17	Office	Indoors
18	Store	Indoors
19	Restaurant	Indoors
20	Manufacturing facility	Indoors
21	School	Indoors
22	Church	Indoors
23	Shopping mall	Indoors
24	Auditorium	Indoors
25	Health care facility	Indoors
26	Other public building	Indoors
27	Other location	Indoors
28	Not specified	Indoors
29	Construction site	Outdoors
30	Residential grounds	Outdoors

MICROENVIRONMENT #	MICROENVIRONMENT	
	SPECIFIC	GENERAL
31	School grounds	Outdoors
32	Sports arena	Outdoors
33	Park/golf course	Outdoors
34	Other location	Outdoors
35	Not specified	Outdoors
36	Train/subway	In vehicle
37	Airplane	In vehicle

3.2.2   Replacing or Modifying the Default File

If the user wishes to replace or modify the default *activity* file, he or she must ensure that the following two conditions are met.

• The number of duration values in each record must equal twice the product of the values of *nmicro* and *nblock* as specified in the *parameter* file.

• The sum of the duration values in each record must total 1,440 minutes (*i.e.*, no time is unaccounted); otherwise the DURAV program will stop.

In addition, the user must ensure that the *activity* file is consistent with several features of the DURAV source code. First, the record length of the *activity* file (unit 11) and two files derived from it (units 20 and 21) are specified in the DURAV program. Unit 21 is also used as input to the HAPEM program, where it's record length is again specified. If the user constructs a replacement activity file with a record length different from that of the default *activity* file, corresponding changes need to be made in both DURAV and HAPEM.

The variables used by the DURAV program for classifying activity records (i.e., DAYTYPE, GENDER, RACE, AGE, and COMMUTE), as well as the activity duration values, are identified by the program by their position in the data record. If the user constructs a replacement activity file with these variables positioned differently, corresponding changes need to be made in DURAV.

The definitions of the demographic groups (presented in Section 2.2.2) are part of the DURAV source code, so that in order to change the demographic group definitions the source code must be modified. Similarly, the definitions of day types for categorizing activity patterns, presented above, are part of the DURAV source code. The number of demographic groups and day types is unlimited. However, the user is cautioned that for narrowly defined groups and day types, there might not be

enough activity pattern data to calculate a reliable group average. An extreme example of this is where no activity patterns fit a demographic group's definition, resulting in incorrect exposure calculations (*i.e.*, exposure concentrations equal to zero) for that group.

Further, the structure of the final exposure output files was designed on the basis of the current definitions of the demographic groups. Every fifth demographic group represents the aggregate of all races and ethnic groups for a gender/age group combination. The results for these race-aggregate groups are written into output files separate from the results for the race-specific groups, since they provide alternative exposure estimates for the same populations. (See Section 4.4.) If the user wishes to change the demographic group definitions, consideration should also be given to the structure of the final exposure output files.

The number, definition, and order of microenvironments must be the same in both the *activity* file and the *factors* file (see Section 3.6). The number is specified in the *parameter* files as **nmicro**.

The *activity* file is read by the DURAV program, which creates several intermediate output files with the same path and root file name, but with different filename extensions. Thus, the user should NOT name an *activity* file with any of the following filename extensions: "*.da"*, "*.draft"*, "*.wrong_chad"*, and "*.nonzero"*.

As with other HAPEM4 input files, the user can add comments or other information after the last data record in the file. To prevent the program reading these comments as data, a blank line must be inserted after the last data record and before any comments.

3.3   POPULATION FILE

The *population* file, the primary input to the INDEXPOP program, provides the number of people in each demographic group residing in each census tract of the study area. The data must be sorted according to state FIPS, county FIPS, and tract code. The data is typically derived from the US Census data. The demographic group definitions are defined in the DURAV source code, and presented in Section 2.2.2.

3.3.1   Variables and Format of the Default File

The *population* file begins with two text header records, followed by one data record for each census tract. The first header record indicates the order of the variables in each of the data records. The first header record of the default *population* file is as follows.

First Header Record from the Default *population* File (in "wrapped" view)

```
   TRACT WM_00 BM_00 HM_00 OM_00 XM_00 WM_05 BM_05 HM_05 OM_05 XM_05 WM_12
BM_12 HM_12 OM_12 XM_12 WM_18 BM_18 HM_18 OM_18 XM_18 WM_65 BM_65 HM_65
OM_65 XM_65 WF_00 BF_00 HF_00 OF_00 XF_00 WF_05 BF_05 HF_05 OF_05 XF_05 WF_12
BF_12 HF_12 OF_12 XF_12 WF_18 BF_18 HF_18 OF_18 XF_18 WF_65 BF_65 HF_65 OF_65 XF_65
```

Although the header records of the *population* file are not used by the HAPEM4 programs, the first one provides documentation to inform the user of the meaning of the data fields. Each space-delimited data record following the header records consists of a census tract identifier and a population value for each of the indicated demographic groups in that tract. The definitions of the data fields in the default *population* file is as follows.

TRACT   11-character string uniquely identifying a US Census tract. The first two characters identify the state FIPS code, the next three characters the county FIPS code. The remaining 6 characters consist of the 4-digit tract code followed by its 2-digit extension. If there is no extension for the tract, "00" is used.

XY_ZZ   integer specifying the number of 1990 tract residents with race/ethnic group X, gender Y, and age group ZZ. The race/ethnic group definitions are:

W	=	White (non-Hispanic)
B	=	Black (non-Hispanic)
H	=	Hispanic
O	=	Asian or Other (non-Hispanic)
X	=	All races/ethnic groups combined.

The gender defintions are:

M	=	male
F	=	female

The age group definitions are:

00	=	0-4 years old
05	=	5-11 years old
12	=	12-17 years old
18	=	18-64 years old
65	=	65 years or older

An example data record from the default *population* file is presented below.

Example Data Record from the Default *population* File (in "wrapped" view)

```
01003010400        90        2        5        0       97      159       37       11        1
208       174       29        5        3      211      831       51        7       33      922
130         0        0        9      139      106        3        0        0      109      178
 27         5        3      213      143       15        4       12      174      832       35
  4        36      907      149       16       16        0      181
```

In this example, notice that every fifth population value is the sum of the preceding four values. This is because every fifth demographic group includes residents of all races and ethnic groups.

3.2.2   Replacing or Modifying the Default File

If the user wishes to replace or modify the default *population* file, he or she must ensure that the definitions and ordering of the demographic groups in the *population* file corresponds to the ordering in the output file from DURAV that is subsequently used in the HAPEM program.

In addition, the user must ensure that the record length is consistent with its specification in the INDEXPOP program (unit 14).

As noted elsewhere, the definitions of the demographic groups (presented in Section 2.2.2) are part of the DURAV source code, so that in order to change the demographic group definitions the source code must be modified.

The *population* file is read by the INDEXPOP program, which creates several intermediate output files with the same path and root file name, but with different filename extensions. Thus, the user should NOT name a *population* file with any of the following filename extensions: "*.da"*, *".county_tract_pop_range"*, and *".state_county_pop_range"*.

As with other HAPEM4 input files, the user can add comments or other information after the last data record in the file. To prevent the program reading these comments as data, a blank line must be inserted after the last data record and before any comments.

3.4   COMMUTING FLOW FILE

The *commuting* file, the main input file to the COMMUTE program, provides data on the commuting flows (*i.e.*, the number of commuters) between pairs of census tracts. The default *commuting* file was derived from U.S. Census Bureau data identifying the place of work and place of residence for individuals in all fifty states and the District of Columbia.

Although there are approximately 500 million pairs of tracts nationwide within a reasonable commuting distance of each other, only about 5 million of these pairs have a non-zero flow of commuters. Only those pairs with non-zero flows are included in the default *commuting* file.

The *commuting* file has no header records, only data records. Each space-delimited data record contains four variables, as follows.

Home tract ID (11-character string: state FIPS, county FIPS, and tract code)

Work tract ID (11-character string: state FIPS, county FIPS, and tract code)

Distance apart in kilometers (decimal number)

Number of workers in the commuting flow (integer)

The default *commuting* file is sorted by home tract ID, smallest to largest in numerical order. Several example data records from the default *commuting* file are presented below.

Extract from the Default *commuting* File

```
01001020100 01001020100     0.0    43
01001020100 01001020200     1.6     6
01001020100 01001020300     3.0    35
01001020100 01001020500     6.2   217
01001020100 01001020700     7.8   152
01001020100 01001020800     2.8    15
01001020100 01011952200    81.3     5
01001020100 01051031100    13.1    10
01001020100 01073012903   108.5     7
01001020100 01085981000    39.2     5
01001020100 01089002300   247.4     8
01001020100 01101000100    20.4    38
01001020100 01101000200    20.7    64
01001020100 01101000385    16.5    16
01001020100 01101000600    22.2    38
01001020100 01101000700    21.4    11
01001020100 01101001000    18.7    11
01001020100 01101001400    23.3     4
01001020100 01101001800    23.1    19
01001020100 01101002000    25.6     4
01001020100 01101002200    23.8     6
01001020100 01101002800    27.5     6
01001020100 01101002900    29.0    20
01001020100 01101003000    18.7    18
01001020100 01101003200    28.6     7
01001020100 01101003301    25.7     5
01001020100 01101005301    24.2     6
01001020100 01101005401    32.7    33
01001020100 01101005402    28.8    13
01001020100 01101005403    29.8     6
01001020100 01101005902    23.7     6
01001020100 01101006085    14.7    33
01001020100 22057021200   512.7     6
01001020100 51710004600  1055.9     4
```

The *commuting* file is read by the COMMUTE program, which creates several intermediate output files with the same path and root file name, but with different filename extensions. Thus, the user should NOT name a *commuting* file with any of the following filename extensions: "*.da"*, "*.ind"*, and "*.st_comm1_fip_range"*.

As with other HAPEM4 input files, the user can add comments or other information after the last data record in the file. To prevent the program reading these comments as data, a blank line must be inserted after the last data record and before any comments.

3.5   AIR QUALITY FILE

The *air quality* file contains the ambient air concentrations that are used by the AIRQUAL program. AIRQUAL requires a separate *air quality* file for each pollutant being evaluated.

The *air quality* file must begin with at least one text header record, followed by one data record for each census tract to be evaluated. The required text header is used by the AIRQUAL program to determine the number of time blocks per day (of equal size) in the air quality data. This value should be indicated immediately following the last instance of the character string "block". For example, the sixth header record of the ASPEN-derived *air quality* files used for the recent NATA analysis, which indicates the order of the variables in each of the data records, is as follows.

Example Header Record from an *air quality* File (in "wrapped" view)

```
FIPS  Tract  Conc_block1  Conc_block2  Conc_block3  Conc_block4  Conc_block5  Conc_block6
Conc_block7  Conc_block8  Conc_block1  Conc_block2  Conc_block3  Conc_block4  Conc_block5
Conc_block6  Conc_block7  Conc_block8  Conc_block1  Conc_block2  Conc_block3  Conc_block4
Conc_block5  Conc_block6  Conc_block7  Conc_block8  Conc_block1  Conc_block2  Conc_block3
Conc_block4  Conc_block5  Conc_block6  Conc_block7  Conc_block8
```

For this example, AIRQUAL will interpret the number of time blocks per day as 8. As noted in elsewhere, the number of time blocks per day in the *air quality* file must be an integral factor of **hblock**, the number of time blocks per day for the analysis as specified in the *parameter* file; otherwise the program will stop. If the number of time blocks per day in the air quality file is less than **hblock**, AIRQUAL will replicate the values to create **hblock** concentration values.

The other information in this header record and all other header records is ignored by AIRQUAL.

After the required header information is found, AIRQUAL identifies data records by finding a numerical digit in the fourth data field. To avoid a mistaken identification, the user should insure that header records do NOT contain a numerical digit in the fourth data field.

The fields in the data records are defined as follows.

Fields 4-5   state FIPS code (2-character string)

Fields 6-8   county FIPS code (3-character string)

Fields 11-16   census tract ID (6-character string)

Fields 17 - end   space-delimited concentration contribution values for each emission source category/time block combination (decimal numbers, optionally in exponential format).

The number of concentration values in each data record must equal the product of the number of emissions sources (i.e., the value of *nsource* in the *parameter* file), and the number of time blocks per day, as indicated in the text header record discussed above. The values are ordered beginning with the first time block of the first emission source, followed by the second time block of the first emission source, and so on. An example of a data record from the ASPEN-derived *air quality* files used for the recent NATA analysis is presented below (*nsource* = 4).

Example Data Record from and *air quality* File (in "wrapped" view)

```
   01001   20100  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.123700E-01  0.142200E-01
0.114100E-01  0.670400E-02  0.724700E-02  0.192200E-01  0.139700E-01  0.123700E-01
0.846300E-02  0.881000E-02  0.296600E-01  0.190400E-01  0.232400E-01  0.705200E-01
0.350100E-01  0.182400E-01  0.204200E-05  0.201100E-04  0.290700E-02  0.244900E-02
```

The *air quality* file is read by the AIRQUAL program, which creates several intermediate output files with the same path and root file name, but with different filename extensions. Thus, the user should NOT name an *air quality* file with any of the following filename extensions: "*.da*", "*.air_da*", "*.pop_air_da*", "*.state_air_fip_range*", "*.state_air1_fip_range*", and "*.state_air2_fip_range*".

As with other HAPEM4 input files, the user can add comments or other information after the last data record in the file. To prevent the program reading these comments as data, a blank line must be inserted after the last data record and before any comments.

3.6   MICROENVIRONMENTAL FACTORS FILE

The microenvironmental (ME) *factors* file provides the factors used to calculate an estimated microenvironmental concentration from an outdoor concentration. The file contains 4 factors for each emission source category/microenvironment combination. These factors are used in the HAPEM algorithm, as follows.

$$ME(m,c,t) = ADD(m) + [PROX(m)][PEN(m)][AMB(c,t_{LAG(m)})] \qquad (3\text{-}1)$$

where:

ME(m,c,t):	concentration in microenvironment *m* located in census tract *c* at time *t*,
ADD(m):	additive factor for microenvironment *m* (defined below),
PROX(m):	proximity factor for microenvironment *m* (defined below),
PEN(m):	penetration factor for microenvironment *m* (defined below),
AMB(c,t):	ambient concentration for census tract *c* at time *t* from the *air quality* file, and
$t_{LAG(m)}$:	time *t* if *LAG(m) = 0*; time *t-1*, otherwise.

The penetration factor, *PEN,* is an estimate of the ratio of the ME concentration contribution (from a given emission source category) to the concurrent outdoor concentration contribution in the immediate vicinity of the ME. That is,

$$PEN \ = \ \frac{(\text{indoor or in - vehicle ME conc.})}{(\text{outdoor conc. in immediate vicinity of indoor or in - vehicle ME})} \quad (3\text{-}2)$$

The proximity factor, *PROX,* is an estimate of the ratio of the outdoor concentration in the immediate vicinity of the ME (or in the ME for outdoor Mes) to the outdoor concentration represented by the air quality data. That is,

$$PROX_i \ = \ \frac{(\text{outdoor conc. in immediate vicinity of indoor or in - vehicle ME})}{(\text{air quality file conc.})} \quad (3\text{-}3a)$$

$$PROX_o \ = \ \frac{(\text{outdoor ME conc.})}{(\text{air quality file conc.})} \quad (3\text{-}3b)$$

As explained elsewhere, the air quality data from ASPEN represent a population-weighted average over the Census tract. For most situations the default *factors* file specifies a *PROX* value of 1.0, i.e., an outdoor concentration contribution in the immediate vicinity of the Census tract equal to the Census tract average concentration contribution. However, when assessing exposure to motor vehicle emissions, for MEs near roadways (e.g., in-vehicle) the pollutant concentration contribution in the immediate vicinity of the ME is expected to be higher than the average pollutant concentration contribution over the Census tract, i.e., *PROX* is expected to be greater than 1.0, and this is reflected in the default *factors* file.

ADD is an additive factor that accounts for emission sources within or near to a microenvironment, i.e., indoor emission sources. Unlike the other two factors, the *ADD* factor is itself a concentration and therefore has units of mass/volume. The actual units used must be the same as those in the *air quality* file.

LAG, is used to account for the possibility of very slow pollutant diffusion and penetration, so that the relevant air quality concentration value may be from the previous time block. A value of zero for *LAG* indicates no time lag, i.e., use the concurrent air quality value; otherwise, the previous time block value is used.

The *factors* file has no header record, and contains one data record for each ME, with the same number, definition and order as the MEs in the *activity* file. Each space-delimited record contains values for each factor/emission source category combination. The record begins with the values for *PROX*, *PEN*, *LAG*, and *ADD* (in that order) for source category 1, followed by the factor values for source category 2, and so on. All values are decimal numbers. The number, definitions, and order of the emission source categories in the *factors* file must match those in the air quality file. The number of emission source categories is specified in the *parameter* file as **nsource**.

A separate default *factors* file is available for each pollutant on the EPA's urban HAPs list[1] The default *factors* files contain ME factors applicable to all the MEs included in the default *activity* file, for the four emission source categories (point, area, onroad mobile, and nonroad mobile) currently provided in the ASPEN *air quality* files. These pollutant-specific estimates were derived from reported measurement studies. However, because indoor emission sources were not addressed in the NATA application for which this version of HAPEM was developed, in the default *factors* file *ADD* is uniformly set equal to zero. Similarly, *LAG* was uniformly set to zero

An example default *factors* file is presented below.

---

[1] The urban HAPs list was published in the Federal Register Notice describing EPA's Integrated Urban Air Toxics Strategy (64 FR 38706).

As with other HAPEM4 input files, the user can add comments or other information after the last data record in the file. In this case a blank line need NOT be inserted after the last data record before the comments.

3.7   STATEFIP FILE

The *statefip* file cross-references the 2-digit state FIPS codes for each US state to its numerical ranking on the list. The default *statefip* file contains 53 codes: one for each US state, the District of Columbia, Puerto Rico, and the US Virgin Islands. It is presented below. The format of each record is as follows.

Fields 1-2   numerical rank (integer)
Fields 9-10   state FIPS code (2-character string)

As discussed in section 2.1.7, the *statefip* file is used in conjunction with the parameters *region1* and *region2* specified in the *parameter* files of INDEXPOP, COMMUTE, AIRQUAL, and HAPEM to specify the group of states to be included in the analysis, according to numerical ranking.

Example Default *factors* File

1	1	0	0	1	1	0	0	2.2	1	0	0	1	1	0	0
1	0.9	0	0	1	0.9	0	0	3.5	0.9	0	0	1	0.9	0	0
1	0.9	0	0	1	0.9	0	0	2.8	0.9	0	0	1	0.9	0	0
1	0.9	0	0	1	0.9	0	0	2.8	0.9	0	0	1	0.9	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	0.81	0	0	1	0.81	0	0	1	0.81	0	0	1	0.81	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.81	0	0	1	0.81	0	0	1	0.81	0	0	1	0.81	0	0
1	0.81	0	0	1	0.81	0	0	1	0.81	0	0	1	0.81	0	0
1	0.81	0	0	1	0.81	0	0	1	0.81	0	0	1	0.81	0	0
1	0.81	0	0	1	0.81	0	0	1	0.81	0	0	1	0.81	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	0.8	0	0	1	0.8	0	0	1	0.8	0	0	1	0.8	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	0.9	0	0	1	0.9	0	0	2.8	0.9	0	0	1	0.9	0	0
0	0.9	0	0	0	0.9	0	0	0	0.9	0	0	0	0.9	0	0

Default *statefip* File

```
1    01
2    02
3    04
4    05
5    06
6    08
7    09
8    10
9    11
10   12
11   13
12   15
13   16
14   17
15   18
16   19
17   20
18   21
19   22
20   23
21   24
22   25
23   26
24   27
25   28
26   29
27   30
28   31
29   32
30   33
31   34
32   35
33   36
34   37
35   38
36   39
37   40
38   41
39   42
40   44
41   45
42   46
43   47
44   48
45   49
46   50
47   51
48   53
49   54
50   55
51   56
52   72
53   78
```

4.   HAPEM4 OUTPUT FILES

The HAPEM4 creates three diagnostic output files and 2 sets of final exposure output files. The diagnostic files record information about the parameters of the simulations, as well as error messages. The names for these three files are specified by the user in the *parameter* files of each HAPEM4 program. The final exposure output files contain all of the exposure estimates from a HAPEM4 run. The path names for these files are specified by the user in the *parameter* file for the HAPEM program.

4.1   LOG FILE

The *log* file contains a record of a HAPEM4 analysis. Three of the HAPEM4 programs (INDEXPOP, COMMUTE, and HAPEM) will append records onto an existing *log* file, as specified its *parameter* file, without overwriting previous records. DURAV and AIRQUAL will overwrite any records on an existing *log* file. Therefore, if a single *log* file name is used to run all the HAPEM4 programs, a running record will be kept for DURAV, INDEXPOP, and COMMUTE, but a new record will be started by AIRQUAL and then added to by HAPEM. To maintain a complete *log* file record of a HAPEM4 simulation, two alternatives are:

•   If a single *parameter* file is for a complete simulation, so that the *log* file name is the same for all 5 programs, rename the *log* file created by the first 3 programs before AIRQUAL is run

•   Use a different *parameter* file for running AIRQUAL and HAPEM than for the other programs, with a different name specified for the *log* file.

If the HAPEM4 programs experience no fatal errors during a simulation, there are several items written to the *log* file by each of the programs. The first record written to the file by each program identifies the program and its start time. The time consists of three numbers; the first is the current time, the second is the size of the time increment equivalent to one second, and the third is the maximum value allowed for the current time before it is reset to zero. All three of these quantities are system dependent. An example record of this type is presented below.

Example *log* File Program and Start Time Record

```
Durav Start time=   34862630 1000 86399999
```

The last two records written to the log by each HAPEM4 program report the ending time and the total job time for the particular program. For the total job time record, the job time is converted into seconds. Note that the total job time will not be correct if the clock maximum is exceeded during the job. An example of these type of records is presented below.

Example *log* File Stop Time and Run Time Record

```
Durav End time =  34880980
Durav Job time =  18.3500004
```

If a error occurs that the HAPEM4 considers to be fatal, a diagnostic message will be written to the *log* file and the program stopped. For example, if DURAV finds that the number of time blocks per day specified in the *activity* file header does not match the value of **nblock** specified in the *parameter* file, it will write a message to the *log* file and stop. An example of this type of record is presented below.

Example *log* File Error Message Record

```
number of time blocks in activity file does not equal nblock
```

4.1.1 DURAV Output to the Log File

Apart from the text produced by all HAPEM4 programs, each program writes some specialized information to the *log* file. DURAV writes the name of the input *activity* file, and intermediate file used to randomly select activity patterns for each group. An example of these types of records is presented below.

Example *log* File Input and Intermediate File Records

```
Data read from file=c:\hapem4\durhw.txt
direct access in file=c:\hapem\durhw.draft
```

DURAV also records the number of records (person-days) extracted from the *activity* file, and the table of frequency counts for each combination of demographic group and day type (a matrix whose elements should sum to the total number of records extracted). If any elements of this matrix are zero then there are groups that have no activity patterns and thus are undefined. If the numbers are positive but small (*e.g.*, less than ten), then there is a chance that the exposure results might not be representative for the group. An example of a part of this type of matrix is presented below.

Example *log* File Matrix Records

```
Total number of person-days processed= 16613
Frequency table for person-days:
By demographic group (rows) & day type (cols)
 1421  1905  2816
   99   188   308
   72   194   300
  137   330   408
  108   236   434
  123   244   319
  948  1159  1213
   78   123   167
  127   209   273
          .
          .
          .
```

Before completing execution, DURAV writes the name of the output file (the averaged activity database) in the *log* file following the table of frequency counts. An example of this type of record is presented below.

Example *log* File Output File Record

```
 Data written to file=c:\hapem4\durhw.da
```

4.1.2   INDEXPOP Output to the Log File

In addition to the program name and the start, stop, and job time information provided to the *log* file by all the HAPEM4 programs, INDEXPOP writes 2 other records to the *log* file. The first confirms that all the input files were successfully opened, and the second records the total number of tract records in the *population* file. An example of these two records is presented below.

Example *log* File Records from INDEXPOP

```
Finished opening files
total number of tracts is 60803
```

4.1.3   COMMUTE Output to the Log File

The COMMUTE program write no information to the *log* file other than the program name and the start, stop, and job time.

4.1.4   AIRQUAL Output to the Log File

In addition to the program name and the start, stop, and job time information provided to the *log* file by all the HAPEM4 programs, AIRQUAL writes several other records to the *log* file. First, a summary of the *air quality* file, which is produced by counting the number of census tracts and distinct counties found in the file, is written. These tracts are then paired with the tracts found in the *population* file. The number of tracts found in the *air quality* file but not in the *census* file are recorded in the line containing the phrase "unpaired air tracts". This is followed by the list (if any) of unpaired tracts. Then, the number of tracts in the *population* file but not in the *air quality* file is reported, along with the number of matches and the number of repeated matches (two or more air tracts for one census tract). Next, similar statistics are given, for counties that have air quality data. Ideally, every tract in the *air quality* file should be paired with exactly one tract in the *population* file. An example of the log output produced by AIRQUAL is presented below.

Example *log* File Records from AIRQUAL

```
# air tracts = 60803
# counties on air file = 3111
There were  0  unpaired air tracts.
Overall, there were:
455  unpaired census tracts.
60803  census tracts with a matching air tract.
0  census tracts with 2 or more air tracts.
Within the counties on the air file, there were:
0  unpaired census tracts.
60803  census tracts with a matching air tract.
0  census tracts with 2 or more air tracts.
```

4.1.5   HAPEM Output to the Log File

In addition to the program name and the start, stop, and job time information provided to the *log* file by all the HAPEM4 programs, the HAPEM program writes two other records to the *log* file. HAPEM reports the time when dynamic array allocation is complete (i.e., HAPEM Allocation =) and the number of tracts used in the analysis (i.e., that had data in the *air quality*, *population*, and *commuting* files). An example of the log output produced by HAPEM is presented below.

Example *log* File Records from HAPEM

```
HAPEM Allocation = 35921930
There were  4046  tracts in the study area.
```

4.2   COUNTER FILE

A second diagnostic file created by HAPEM4 is the *counter* file. The *counter* file records the number of records in various data input and output files, which can also be a useful tool for keeping track of which files were used in the simulation, and for troubleshooting.

It is important to use same *counter* file for all the HAPEM4 programs in a simulation, because the programs use some of the information recorded by previous programs for dynamic memory allocation of arrays. If the expected records from previous programs are not in the *counter* file, an error will occur.

The HAPEM4 programs add records the *counter* file by appending to the end of the records generated by the previous programs, where programs are run in the expected order, as described in section 2.1. (Running COMMUTE is optional). For example, INDEXPOP reads the DURAV-generated records, and then begins its own recording. If INDEXPOP is run a second time, using the same counter file, the second run will overwrite the previous INDEXPOP-generated records.

The specific information recorded in the *counter* file is as follows.

DURAV:	record 1	- number of data records in the *activity* file (*durhw.txt*)
		- number of *activity* file data records with 1440 minute total
INDEXPOP	record 2	- number of data records (tracts) in the *population* file (*census.txt*)
		- number of counties in the *population* file (*census.txt*)
COMMUTE	record 3	- number of records in the population index file (*census_direct.ind*)
		- number of records in the *commuting* file (*comm.txt*)
	record 4	- number of records in the work tract file (*comm.da*)
		- number of records in the commuting index file *(comm.ind)*
AIRQUAL	record 5	- number of matching tracts in the *air quality* (e.g, *benzout.txt*) and population index (*census_direct.ind*) files
		- number of counties with matching tracts in the *air quality* (e.g, *benzout.txt*) and population index (*census_direct.ind*) files
		- number of data records (tracts) in the air quality file (e.g, *benzout.txt*)

The following relationships are expected among the numbers in the *counter* file.

- The number of records in the *population* file (*census.txt*), the population index file (*census_direct.ind*), and the commuting index file *(comm.ind)* should all be the same.

- The number of records in the work tract file (*comm.da*) may be larger or smaller than the number of records in the commuting file (*comm.txt*). It may be larger, because, if a tract in the *population* file has no matching home tract in the *commuting* file, COMMUTE creates a "commuting" flow, using the population tract as both the home and work tract. It may also be

smaller if the *population* file study area is smaller than the *commuting* file study area (all US states and the District of Columbia).

4.3 MISTRACT FILE

A third diagnostic file created by the COMMUTE, AIRQUAL, and HAPEM programs is the *mistract* file. If the same *mistract* file name is used for COMMUTE and AIRQUAL, The COMMUTE information will be overwritten by AIRQUAL. HAPEM will append records onto an existing *mistract* file. To maintain a complete record of this information for a HAPEM4 simulation, either different *mistract* file names should be used for COMMUTE and AIRQUAL (requiring different *parameter* files), or the *mistract* file should be re-named after the COMMUTE program is run.

Each of the three programs records a different set of information about the consistency of census tracts included in the input files.

- The COMMUTE *mistract* file records the state, county, and tract FIPS codes of each tract in the *population* file that is not matched by a home tract in the *commuting* file. These unmatched tracts are still processed by COMMUTE, as explained in the previous section, by creating a "commuting" flow, using the population tract as both the home and work tract.

- The AIRQUAL *mistract* file records the record number, state and county FIPS, and tract code of each tract in the *population* file that is not matched by a tract in the *air quality* file. Only tracts that are included in both the files are processed by HAPEM4, since both these pieces of information about a tract (population and air quality) are needed to make an exposure estimate.

- The HAPEM program records information on the *mistract* file only if commuting is included in the simulation. The HAPEM *mistract* file records the state, county, and tract FIPS codes of each home tract in the *commuting* file that is not matched by a tract in the air quality index files. These index files contain information on tracts that were included in both the *population* and *air quality* files. The unmatched home tracts are not processed further. The HAPEM *mistract* file also records each instance of a work tract that is not matched by a tract in the *air quality* file. For these cases, the work tract is assigned the air quality of the home tract.

4.4 FINAL EXPOSURE FILE

As explained in section 2.1.9, HAPEM4 creates two exposure output files for each state/pollutant combination. The names of these files are constructed by the program based on the pollutant SAROAD code and the state FIPS code as follows:

XXXXX.YY.d.dat

XXXXX.YY.a.dat

where XXXXX = the 5-digit SAROAD pollutant code specified by the **sarod** parameter
and YY = the 2-digit state FIPS code

   The "d"files contain exposure estimates for the 40 demographic groups defined according to age, gender, and race or ethnic group. These exposure estimates use activity data for individuals for which the race or ethnic group is known (about 80% of the CHAD data) and population data that is specific for age, gender, and race/ethnic group in each Census tract. The "a" files contain exposure estimates for the 10 demographic groups based on age and gender only. These exposure estimates use activity data for individuals whose race and ethnic group is unknown (about 20% of the CHAD data) and population data that is specific for age and gender in each Census tract, but combines values for all races and ethnic groups.

   The results for the race-aggregate groups are written into output files separate from the results for the race-specific groups, since they provide alternative exposure estimates for the same populations. That is, the "d" files contain an exposure assessment for the total study area population taking race and ethnic group into account, and the "a" files contain an alternative assessment for the total study area population without taking race and ethnic group into account. The user can choose to use the results in either the "d" files or the "a" files. Alternatively, the user can combine the results with weighted averaging, so that all the population activity data is utilized in making the exposure estimate.. For example, two separate estimates of the average population exposure concentration for a study area could be made -- one from the "d" files and one from the "a" files -- each as a population-weighted average of the exposure estimates. These two separate estimates could then be combined as a weighted average, e.g., with .8/.2 weighting to reflect the relative number of activity records used as the basis for each estimate. Similarly, a .8/.2 weighting could be used to combine separate estimates from the two sets of files for the number of individuals exposed to concentrations exceeding a particular threshold level.

4.4.1 File Format

   The final exposure output files each begin with a header record indicating:

- the total number of demographic groups for the analysis (i.e., the value of **ngroup** in the *parameter* file)
- the total number of replicates for each group/tract combination (i.e., the value of the parameter **amax** in the HAPEM source code, currently set at 30)
- the total number of source categories (i.e., the value of **nsource** in the *parameter* file)

An example header record is presented below.

Example Header Record for Final Exposure Output File

No. of Groups =	50 No. of Replicates =	30 No. of Source Categories =	4

The header record is then followed by *amax* (i.e., 30) data records for each group/tract combination, where the groups are allocated to the "d" and "a" files as explained above. The format of each data record, assuming *nsource* = 4, is as follows.

Fields 2-3	state FIPS code (2-character string)
Fields 5-7	county FIPS code (3-character string)
Fields 9-14	tract ID (6-character string)
Fields 16-17	demographic group indicator (integer from 1-50, ordered as in the *population* input file)
Fields 19-25	number of people to which the exposure estimates in the data record apply, equal to the population of the group/tract combination divided by the number of replicates (decimal number)
Fields 27-36	estimated exposure concentration contribution from emission source category 1 (decimal number in scientific notation, units of measurement as in the *air quality* file)
Fields 38-47	estimated exposure concentration contribution from emission source category 2
Fields 49-58	estimated exposure concentration contribution from emission source category 3
Fields 60-69	estimated exposure concentration contribution from emission source category 4
Fields 71-80	estimated exposure concentration contribution from background
Fields 82-91	estimated total exposure concentration, the sum of the preceding 5 values

An example set of replicate data records is presented below. Note that the background concentration contribution is zero for this example. The total population for demographic group 1 in this tract is 175, so that the number of people to which the exposure estimates in each record apply is 5.83 = 175/30.

Example Set of Replicate Data Records From a Final Exposure Output File

```
10 001 040100 1   5.83 0.8716E-02 0.2020E-01 0.1441E+00 0.2803E-01 0.0000E+00 0.2010E+00
10 001 040100 1   5.83 0.8669E-02 0.2023E-01 0.1438E+00 0.2808E-01 0.0000E+00 0.2008E+00
10 001 040100 1   5.83 0.8718E-02 0.2025E-01 0.1486E+00 0.2815E-01 0.0000E+00 0.2057E+00
10 001 040100 1   5.83 0.8660E-02 0.2015E-01 0.1441E+00 0.2800E-01 0.0000E+00 0.2009E+00
10 001 040100 1   5.83 0.8735E-02 0.2027E-01 0.1439E+00 0.2798E-01 0.0000E+00 0.2009E+00
10 001 040100 1   5.83 0.8741E-02 0.2008E-01 0.1424E+00 0.2801E-01 0.0000E+00 0.1992E+00
10 001 040100 1   5.83 0.8631E-02 0.2039E-01 0.1423E+00 0.2798E-01 0.0000E+00 0.1993E+00
10 001 040100 1   5.83 0.8721E-02 0.2020E-01 0.1450E+00 0.2809E-01 0.0000E+00 0.2020E+00
10 001 040100 1   5.83 0.8737E-02 0.2018E-01 0.1419E+00 0.2789E-01 0.0000E+00 0.1987E+00
10 001 040100 1   5.83 0.8703E-02 0.2025E-01 0.1458E+00 0.2802E-01 0.0000E+00 0.2027E+00
10 001 040100 1   5.83 0.8716E-02 0.2023E-01 0.1441E+00 0.2788E-01 0.0000E+00 0.2009E+00
10 001 040100 1   5.83 0.8657E-02 0.2019E-01 0.1438E+00 0.2786E-01 0.0000E+00 0.2005E+00
10 001 040100 1   5.83 0.8705E-02 0.2019E-01 0.1440E+00 0.2797E-01 0.0000E+00 0.2009E+00
10 001 040100 1   5.83 0.8675E-02 0.2027E-01 0.1461E+00 0.2812E-01 0.0000E+00 0.2032E+00
10 001 040100 1   5.83 0.8672E-02 0.2016E-01 0.1446E+00 0.2799E-01 0.0000E+00 0.2014E+00
10 001 040100 1   5.83 0.8727E-02 0.2007E-01 0.1438E+00 0.2799E-01 0.0000E+00 0.2006E+00
10 001 040100 1   5.83 0.8688E-02 0.2031E-01 0.1427E+00 0.2786E-01 0.0000E+00 0.1996E+00
10 001 040100 1   5.83 0.8612E-02 0.2008E-01 0.1447E+00 0.2791E-01 0.0000E+00 0.2013E+00
10 001 040100 1   5.83 0.8748E-02 0.2022E-01 0.1461E+00 0.2817E-01 0.0000E+00 0.2032E+00
10 001 040100 1   5.83 0.8730E-02 0.2037E-01 0.1472E+00 0.2816E-01 0.0000E+00 0.2045E+00
10 001 040100 1   5.83 0.8674E-02 0.2009E-01 0.1453E+00 0.2802E-01 0.0000E+00 0.2021E+00
10 001 040100 1   5.83 0.8690E-02 0.2022E-01 0.1434E+00 0.2804E-01 0.0000E+00 0.2004E+00
10 001 040100 1   5.83 0.8786E-02 0.2031E-01 0.1417E+00 0.2792E-01 0.0000E+00 0.1987E+00
10 001 040100 1   5.83 0.8675E-02 0.2021E-01 0.1458E+00 0.2809E-01 0.0000E+00 0.2028E+00
10 001 040100 1   5.83 0.8705E-02 0.2022E-01 0.1486E+00 0.2791E-01 0.0000E+00 0.2055E+00
10 001 040100 1   5.83 0.8666E-02 0.2023E-01 0.1436E+00 0.2801E-01 0.0000E+00 0.2005E+00
10 001 040100 1   5.83 0.8657E-02 0.2017E-01 0.1452E+00 0.2794E-01 0.0000E+00 0.2020E+00
10 001 040100 1   5.83 0.8738E-02 0.2032E-01 0.1435E+00 0.2818E-01 0.0000E+00 0.2007E+00
10 001 040100 1   5.83 0.8719E-02 0.2010E-01 0.1431E+00 0.2793E-01 0.0000E+00 0.1998E+00
10 001 040100 1   5.83 0.8702E-02 0.2011E-01 0.1433E+00 0.2816E-01 0.0000E+00 0.2003E+00
```

5. HAPEM4 PROGRAMS

This section presents detailed descriptions of the five programs that comprise the model: DURAV, INDEXPOP, COMMUTE, AIRQUAL, and HAPEM. The first four programs (DURAV, INDEXPOP, COMMUTE, and AIRQUAL) are essentially preprocessers that convert input data files into the form required for efficient exposure calculations. The final program (HAPEM) actually performs the exposure calculations and summarizes the results.

NOTE TO USERS

It is important to note that some understanding of Fortran programming is necessary to understand all the programming details discussed in this chapter. However, all of the general concepts related to the programs should be clear to all users.

5.1 PROGRAMMING GUIDELINES USED TO DEVELOP HAPEM4

The source code for each of the five HAPEM4 programs is written in Fortran 90 and designed so that it can be compiled and executed with little or no programming changes on various platforms (*e.g.,* UNIX, DOS, Windows).

The HAPEM4 programs incorporate a structured programming style as summarized by the following attributes:

• No "GO TO" statements or line numbers in any of the programs. Program flow is direct from the beginning to the end within each program, thus making the code easy to follow. The only looping is within "DO" blocks.

• Each line of code is short enough to avoid the need for continuation lines.

• Except for the *parameter* file, no filenames appear in source code of any of the HAPEM4 programs. Instead, this information is specified in the *parameter* file.

• Most parameter values are input from the *parameter* file so that the programs themselves only allocate space for and carry out as many calculations as are necessary.

• All arrays depending on variable parameters are dynamically allocated.

• To avoid limitations such as hard-coded numbers of variables on a "FORMAT" statement, many of the "FORMATS" are dynamically written during the run.

- All variables are declared (no implicit typing), with comments at the end of most declarations to assist in interpretation. Comment lines are inserted between the logical blocks of code for clarity. At the end of each program (after the "END PROGRAM" statement), additional comments are given to explain the structure and details of each program.

Each file is opened with an "OPEN" statement that specifies if the file is to be used for reading or writing, and also specifies the record length. Each "READ" and "WRITE" statement contains an ***IOSTAT*** variable, which is used by the program to determine how to respond to an error condition. All files that are opened are explicitly closed and all allocated arrays are deallocated at the end of each program. Generally, the "READ" statements use unformatted (list) input so that the data do not have to be in predetermined columns, but the "WRITE" statements are usually formatted for clarity.

5.1.1 Common structural elements

All of the HAPEM4 programs consist of a declarations section, a parameters section, a setup section, a primary section that processes the data, and a wrap-up section. In the declarations section, all variables are explicitly typed. Most lines include a trailing comment to indicate the general purpose of the variable(s). Arrays that are to be dynamically allocated are fixed in rank (number of dimensions), with a colon used to defer the size specification.

The second program section, referred to as the params section, reads the *parameter* file to determine the specific input file names and the parameter settings. This section is similar in all the HAPEM4 programs, except that only the names of files needed by each job are retained as variables. Each line of the *parameter* file is read in as a character string (maximum length of 120 characters) and inspected for an equals sign "=". If there is no equals sign then the line is ignored. This allows the programmer to add comments and other lines directly to the *parameter* file without altering its performance. Lines containing an equals sign are divided into two parts at the equals sign. The part to the left of the sign is scanned for keywords. All keywords are in lower case. If the string 'file' is found, then the line is assumed to specify one of the input or output files. For these lines, a second keyword is searched for. Possible keywords are presented below. Which filenames and paths are required by each HAPEM4 program are presented in Table 2.1 as user-defined files.

Keyword	Definition
activity	name of the *activity* file (input)
populat	name of the *population* file (input)
commut	name of the *commuting* file (input)
quality	name of the *air quality* file (input)
factors	name of the *factors* file (input)

statefip	name of the *statefip* file (input)
log	name of the *log* file (output)
counter	name of the *counter* file (output)
mistract	name of the *mistract* file(output)
afile	path of final exposure output files with demographic group defined by gender, age, and race/ethnic group (output)
bfile	path of final exposure output files with demographic group defined by gender and age (output)

The HAPEM4 user can use the above keywords in lines that do not contain an equals sign, or in comments containing an equals sign as long as the word "file" does not also appear left of the equals sign. The strings containing the directory and file names should not exceed 100 characters. If they do, then use an alias or a logical drive specification to identify most of the path, and thereby reduce the length to less than 100 characters. As described earlier in this guide, each of the input files requires a certain format for the data. It is the responsibility of the user to ensure that this format specification is met.

The setup section allocates and initializes the dynamic arrays that can be sized from the parameter settings specified in the *parameter* file. Other arrays that are dependent on the number of records in an input file are allocated elsewhere. The dynamic allocation serves three purposes, it saves space and time by only using as much space as is necessary, it allows for the parameters to be increased or decreased without recompiling the program, and it allows vector and array operations to be programmed more simply since they can be applied to the entire array rather than only to certain elements.

5.2 PROGRAM DESCRIPTIONS

As mentioned previously, HAPEM4 is composed of five programs: DURAV, INDEXPOP, COMMUTE, AIRQUAL ,and HAPEM. This section describes the purpose and structure of the processing section of each of these programs.

5.2.1 DURAV

As explained in section 2.1.2, the DURAV program performs two main functions.

- It categorizes population activity data extracted from CHAD into demographic groups and day types (season, day-of-week).

- It creates 100 annual average activity patterns for each demographic group/day type combination by random sampling to be used in HAPEM.

The 50 demographic groups are defined by combinations of the following age, race, and gender categories.

Age:

- 0 - 4
- 5 - 11
- 12 - 17
- 18 - 64
- 65+

Race:

- White
- Black
- Hispanic
- Asian and Other
- Unknown

Gender:

- Male
- Female

Two variables, season and day of week, are used to determine three day types:

- weekdays in summer (June - August)
- other weekdays
- weekends.

   DURAV constructs 100 annual average activity patterns for each demographic group/day type combination through a stochastic process as follows. All activity patterns in the CHAD database that correspond to that demographic group and day type combination are extracted. From that set a number of activity patterns, equal to the annual frequency of that day type, are randomly selected (with replacement) to represent the variation over a full year for an individual. Then all of the time blocks corresponding to the same time of day are averaged across the selected patterns to create a single annual average activity pattern. This procedure is repeated 100 times for each demographic group and

day type combination, resulting in 3 sets of 100 annual average activity patterns for each demographic group.

For example, there are generally 104 weekend days per year. Therefore, an annual average weekend activity pattern for any demographic group is constructed by selection (with replacement) of 104 weekend activity patterns for that group. To create the first time block of the annual average weekend activity pattern, the activity durations of the first time block in each of the 104 selected patterns are averaged together.

This selection procedure implicitly assumes that each activity pattern in the set is equally likely to occur. Moreover, because the available activity pattern data includes only a few days of sampling for any individual, it cannot be used to estimate the day to day correlation of an individual's activities over the course of a year. Therefore, such correlations are not considered in the selection process. For example, the selection for day 1 may specify a house with an attached garage, and for day 2 a house without an attached garage. As a result the averaged activity pattern is more representative of a population average pattern for the demographic group, than an average pattern for an individual. Thus, the distribution of exposure concentrations for the group estimated by HAPEM4 represents the uncertainty in the population average exposure concentration, rather than the variability of the individual exposure concentrations among members of the group.

5.2.1.1   DURAV Processing Operations

In addition to the operations discussed above, the params section of DURAV conducts the following operation.

• The values of **nblock**, the number of time blocks per day in the *activity* file, and **hblock**, the number of time blocks per day for the analysis, are checked for compatibility. As explained in section 2.1.2, **hblock** must be an integral factor of **nblock**, so that the activity time blocks can be combined if necessary to match to match **hblock**. If not, an error message is written to the *log* file and the program is stopped.

In addition to the operations discussed above, the setup section of DURAV conducts the following operation.

• The number of time blocks per day in the *activity* file is determined from the header record, as explained in section 3.2.1. This number is checked against the value of **nblock** specified in the *parameter* file. If the values are different, an error message is written to the *log* file and the program is stopped.

The main processing section of DURAV conducts several operations, as follows.

- The number of data records in the *activity* file is determined, so that memory can be allocated for various arrays used to hold the input data records and other data derived from them.

- Each activity record is checked to ensure that the total activity time is 1440 minutes. If not the record is recorded in an intermediate output file with filename extension "*.wrong_chad*" and dropped from further processing.

- The *nblock* time blocks in each activity record are aggregated, if necessary, to create *hblock* time blocks.

- The compressed activity records are checked to ensure the total activity time is still 1440 minutes. If not, an error message is written to the *log* file and the program is stopped.

- The compressed activity records are written into a direct access file with a file name extension of "*.draft*".

- Each compressed record is classified by day type (indicated as part of the activity record) and demographic group, as defined in the DURAV source code. If any records cannot be classified, and error message is written to the *log* file and the program is stopped. The serial record numbers of the compressed records for each category are recorded in the array "ntest".

- The total number of data records in the *activity* file, and the total number with activity durations of 1440 minutes are recorded in the *counter* file.

- The number of compressed records in each day type/demographic group category with and without commuting (i.e., time in work location) is determined. Day type/demographic group combinations with more than 10% commuting records are classified as "commuting" activity sets.

- The number of compressed activity records in each day type/demographic group combination and their commuting classifications are recorded in an intermediate file with filename extension "*.nonzero*".

- Compressed activity records for each day type/demographic group combination are randomly selected from the "*.draft*" file by use of the "ntest" array, and averaged as explained above to construct 100 annual average activity patterns for each. (Day type/demographic group combination with no records are skipped.) An attached subroutine, RANDOM, including an attached function, RAN1, is used to generate the random numbers used for selection.

- The total number of compressed activity records processed and their allocation among day types and demographic groups is written into the *log* file.

- The sets of 100 annual average activity patterns are written into a direct access file with filename extension "*.da*", and the filename is recorded in the *log* file.

5.2.2   INDEXPOP

As explained in section 2.1.3, the INDEXPOP program performs two main functions:

- It creates a direct access file of population data to be used in AIRQUAL

- It creates index files for the population data Census tracts, to facilitate file searching in COMMUTE and AIRQUAL

5.2.2.1   INDEXPOP Processing Operations

The specific operations performed in the main processing section of INDEXPOP are as follows.

- The number of data records in the *population* file is determined so that memory can be allocated for various arrays used to hold the input data records and other data derived from them.

- Each data record in the *population* file is read. The population array is recorded in a direct access file with the filename extension "*.da*". The state FIPS, county FIPS, tract code, and serial record number are recorded in a direct access file with the filename extension "*_direct.ind*".

- The total number of tract records in each county is determined.

- The total number of counties included in the *population* file that fall into each state is determined.

- A direct access index file is created with filename extension "*.county_tract_pop_range*". For each county in the *population* file, there is a record in this file indicating the serial record numbers of the first and last data record for tracts in that county in the "*.da*" and "*_direct.ind*" files.

- A direct access index file is created with filename extension "*.state_county_pop_range*". For each county there is a record in this file indicating the serial record numbers of the first and last data record for counties in that state in the "*.county_tract_pop_range*".

- The total number of records (tracts) and counties in the *population* file is added to the *counter* file.

5.2.3   COMMUTE

As explained in section 2.1.4, the COMMUTE program performs two main functions.

- It creates a file identifying for each Census tract (i.e., home tract) the associated set of work tracts (i.e., tracts in which the residents of the home tract work), and the fraction of home tract workers in each work tract

- It creates index files to facilitate file searching in HAPEM

5.2.3.1   COMMUTE Processing Operations

The specific operations performed in the main processing section of COMMUTE are as follows.

- The number of data records in the *commuting* file is determined so that memory can be allocated for various arrays used to hold the input data records and other data derived from them.

- The number of *commuting* file records with home tracts in each state is determined.

- For each state the serial record numbers of the first and last data record indicating a home tract in that state are determined.

- The number of records in the *population* file is read from the *counter* file, so that memory can be allocated for various arrays used to hold the input data records and other data derived from them.

- All the tract IDs are read from the "*_direct.ind*" file created by INDEXPOP, using the indices from the "*.state_county_pop_range*" and "*.county_tract_pop_range*" files created by INDEXPOP.

- For each tract in the "*_direct.ind*" file created by INDEXPOP, all matching home tracts in the *commuting* file are found. (There is one home tract record for every commuting flow originating in that tract). For each matched home tract, the number of commuting flows to work tracts within 120 km, and the magnitude of each flow is determined. Each work tract ID and the fraction of total commuting flow going to that tract from the home tract is recorded in a direct access file with filename extension "*.da*" (one record for each work tract).

- If no matching home tracts are found in the *commuting* file for a population tract, an entry is recorded in the *mistract* file, indicating the indices of the tract in the "*.state_county_pop_range*", "*.county_tract_pop_range*", and the "*_direct.ind*" files, as well as the tract ID.

- For population tracts with no matching commuting home tracts, a record is recorded in the "*.da*" file indicating the population tract as the work tract, with fractional commuting flow of 1.0, i.e., all work takes place in the home tract.

- For each population tract, a record is written into a direct access file with filename extension "*.ind*". The fields in the record are the population tract ID, the serial record numbers of the first and last work tract

record in the "*.da*" file, and a flag indicating whether the population tract was matched by a home tract in the *commuting* file (0=no; 1=yes).

- Two records are added to the *counter* file. The first indicates the number of records found in the "*_direct.ind*" file created by INDEXPOP, and the number of data records found in the *commuting* file. The second records the number of records in the "*.da*" file and the number in the "*.ind*" file.

- A direct access index file is created with filename extension "*.st_comm1_fip_range*". For each state there is a record in this file indicating the serial record numbers of the first and last data record for tracts in that state in the "*.ind*" file.

5.2.4   AIRQUAL

As explained in section 2.1.5, the AIRQUAL program performs two main functions.

- It creates a direct access file of air quality data to be used in HAPEM.

- It creates index files to facilitate file searching in HAPEM.

5.2.4.1   AIRQUAL Processing Operations

The specific operations performed in the main processing section of AIRQUAL are as follows.

- The number of data records in the *air quality* file is determined so that memory can be allocated for various arrays used to hold the input data records and other data derived from them.

- The number of time blocks in the *air quality* file is determined from the header record. It is checked for compatibility with the value of **hblock**, the number of time blocks for the analysis, as specified in the *parameter* file. As explained in section 2.1.5, **hblock** must be an integral multiple of the number of air quality time blocks, so that the air quality values can be replicated if necessary to create **hblock** air quality values. If this is not the case, an error message is written to the *log* file and the program is stopped.

- Each data record in the *air quality* file is read, and if necessary, the concentration values for each time block are replicated to create **hblock** values.

- All the unique county FIPS in the *air quality* file are counted and the values saved into an array.

- The number of records in the *population* file is read from the *counter* file

- An attempt is made to match each population tract specified in the "*_direct.ind*" file created by INDEXPOP with a tract in the *air quality* file. If a match is found, the population array from the "*.da*"

file created by INDEXPOP is recorded in a direct access file with the root name of the *population* file and the filename extension "*.pop_air_da*" (e.g., *census.pop_air_da)*. The tract ID (state FIPS, county FIPS, and tract code) and air quality data is recorded in a direct access file with the root name of the *air quality* file and the filename extension "*.air_da*", (e.g., *benzout.air_da*). If no match is found, the serial record number of the tract in the "*_direct.ind*" file created by INDEXPOP and the tract ID are recorded in the *mistract* file.

- For each state the number of tracts in the "*.air_da*" file is determined.

- For each county in the "*.air_da*" file the number of tracts is determined

- A direct access index file is created with filename extension "*.state_air_fip_range*". For each county there is a record in this file indicating the serial record numbers of the first and last data records in the "*.pop_air_da*" and "*.air_da*" files.

- A direct access index file is created with filename extension "*.state_air1_fip_range*". For each state there is a record in this file indicating the serial record numbers of the first and last data records in the "*.state_air_fip_range*" file.

- A direct access index file is created with filename extension "*.state_air2_fip_range*". For each state there is a record in this file indicating the serial record numbers of the first and last data records in the "*.pop_air_da*" and "*.air_da*" files.

- A record is added to the *counter* file indicating the number of data records (tracts) in the "*.pop_air_da*" and "*.air_da*" files, the number of records (counties) in the "*.state_air_fip_range*" file, and the number of data records in the *air quality* file.

5.2.5   HAPEM

As explained in section 2.1.6, the HAPEM program performs four main functions.

- For each demographic group in each Census tract, it randomly selects 30 of the 100 annual average activity patterns for each day type (created in DURAV).

- For each activity pattern for a commuting demographic group, it randomly selects a work Census tract with probability weighting based on the fraction of residents that work in that tract..

- For each Census tract it estimates the concentration in each microenvironment based on microenvironment factors and outdoor concentrations.

- It combines activity pattern, commuting, and microenvironment concentration estimates to calculate 30 annual average exposure concentrations for each demographic group in each Census tract

5.2.4.1   HAPEM Processing Operations

The specific operations performed in the main processing section of HAPEM are as follows.

- The microenvironment factors are read from the *factors* file and the values saved into arrays.

- The background exposure concentration contributions are calculated for each time block and microenvironment based on the uniform value of the **backg** parameter specified in the *parameter* file, and the microenvironment factors.

- For each day type/demographic group combination the number of records in the *activity* file and the commuting status of the set is read from the "*.nonzero*" file created in DURAV.

- For each day type/demographic group combination with a positive number of activity records, the 100 annual average activity pattern records are read from the "*.da*" file created in DURAV and the values saved into an array.

- If commuting is included in the simulation, for each day type/demographic group combination with non-commuting status (10% or less of *activity* file records with activity time at work location), any activity time at a work location in an annual average activity pattern is transferred to the home location.

- Each annual average activity pattern is checked to ensure a total activity time of 1440 minutes. If not, an error message is written to the *log* file and the program is stopped.

- Several values are read from the *counter* file to allocate memory for various arrays.

- Indices are read from the "*.state_air_fip_range*" and "*.state_air1_fip_range*" files created by AIRQUAL.

- Data is read from the "*.pop_air_da*" and "*.air_da*" files created by AIRQUAL.

- If commuting is included in the simulation, indices are read from the "*.st_comm1_fip_range*" and "*.ind*" files created by COMMUTE, and data from the "*.da*" file created by COMMUTE. Otherwise, indices are read from the "*.state_air2_fip_range*" file created by AIRQUAL.

- If commuting is included in the simulation for each tract in the "*.ind*" file created by COMMUTE an attempt is made to find a matching tract in the "*.state_air_fip_range*" file created by AIRQUAL. The air quality data from the "*.air_da*" file created by AIRQUAL for each matched tract is combined with

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the microenvironment factors to estimate the concentrations for each microenvironment/time block combination for that tract. If a match is not found, the commuting tract is recorded in the *mistract* file.

- If commuting is not included, every air quality record from the "*.air_da*" file created by AIRQUAL is processed.

- For each tract processed 30 of the 100 annual average activity patterns from the "*.da*" file created in DURAV are randomly selected (with replacement) for each day type/demographic group combination. (A different selection of 30 is made for each tract processed.) An attached subroutine RANDOM and an attached function RAN1 are used to generate the random numbers used in the selection.

- If commuting is included in the simulation, for each day type/demographic group combination with commuting status, a work tract is randomly selected for each selected activity pattern, using an attached subroutine, RANDOMR. The work tract is selected from the set of work tracts corresponding to that home tract, as specified in the "*.da*" file created by COMMUTE. The air quality data for that work tract is determined from the "*.air_da*" file created by AIRQUAL. If the work tract cannot be found in the "*.air_da*" file, the air quality data for the home tract is used. The air quality data is combined with the microenvironment factors to estimate the concentrations for each microenvironment/time block combination for that work tract.

- The microenvironment/time block time durations of the selected activity patterns are combined with the estimated microenvironment/time block concentrations for the home tract (and the work tracts if commuting is included) to estimate 30 annual average exposure concentrations for each day type/demographic group combination. A separate set of estimates is made for each emission source category. The algorithm for each day type/demographic group combination in the tract is as follows.

$$
ExpConc = \frac{\sum\limits_{TimeBlocks} \sum\limits_{Microenviroments} Conc_{t,m} \times Duration_{t,m}}{\sum\limits_{TimeBlocks} \sum\limits_{Microenvironment} Duration_{t,m}}
$$

where $Conc_{t,m}$ is the emission source category concentration during time block t in microenvironment m; and

   $Duration_{t,m}$ is the duration of activity during time block t in microenvironment m

- The exposure concentrations for each day type are combined with weighted averaging to create an overall annual average exposure concentration. The weights are the relative frequencies of the day types: 0.181 for summer weekday, 0.534 for non-summer weekdays, and 0.285 for weekends.

• A total annual average exposure concentration is calculated by adding the annual average values for each emission source category and from background.

• The results are written into the final exposure output files, 30 records for each demographic group in each tract. The format of the files is described in section 4.4.

6. REFERENCES

Glen, G., Y. Lakkadi, J.A. Tippett, and M. del Valle-Torres (Prepared by ManTech Environmental Technology, Inc.), 1997: Development of NERL/CHAD: The National Exposure Research Laboratory Consolidated Human Activity Database. EPA Contract No. 68-D5-0049.

Development of Microenvironmental Factors for the HAPEM4 in Support of the National Air Toxics Assessment (NATA)

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National Air Toxics Assessment (NATA)

External Review Draft Report

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BACKGROUND

The National Air Toxics Assessment (NATA) activities are a primary component of the Environmental Protection Agency's (EPA's) national air toxics program. The primary goal of the NATA activities are to set program priorities, characterize risks, and track progress toward meeting the overall national air toxics program goals, as well as specific risk-based goals, such as those of EPA's Integrated Urban Air Toxics Strategy (64 FR 38706). More specifically, our NATA activities include expanding air toxics monitoring, improving and periodically updating emissions inventories, periodically conducting national- and local-scale air quality, multi-media and exposure modeling, characterizing risks associated with air toxics exposures, and continuing research on health and environmental effects and exposures to both ambient and indoor sources.

As part of the NATA activities, EPA is currently conducting an initial screening-level assessment, which will demonstrate the approach to characterizing air toxics risks nationwide. This initial national-scale assessment (NSA), will help to characterize the potential health risks associated with inhalation exposures to thirty-three hazardous air pollutants (HAPs) identified as priority pollutants through EPA's Integrated Urban Air Toxics Strategy. It is important to note that, such a broad-scale assessment is limited in the scope of the risks that it can address quantitatively. Specifically, the assessment addresses risks associated with only inhalation exposure, and does not quantify exposures by ingestion or dermal contact, which may be important for some substances. The assessment is also limited by the uncertainties inherent in the various types of data and methods currently available. Despite these limitations, it represents an important first step in characterizing air toxics risks nationwide.

INTRODUCTION

To accomplish the inhalation exposure assessments under NATA, EPA chose the Hazardous Air Pollutant Exposure Model, Version 4 (HAPEM4). The HAPEM4 is a screening-level human inhalation exposure model designed to estimate exposures of population subgroups from concentrations of HAPs originating in the ambient (i.e., outdoor) environment. It was designed to predict the inhalation exposure for selected population groups and HAPs. Through a series of calculation routines, the model makes use of census data, information about human activity patterns, ambient air quality levels, climate data, and indoor/outdoor concentration relationships to estimate an expected range of inhalation exposure concentrations for subgroups of the population.

It is expected that for a majority of the thirty-three HAPs being examined in the initial NSA, the air medium, and hence, inhalation exposure, will be the dominant pathway in determining population risk. Furthermore, a lack of appropriate assessment tools and supporting data currently prohibits a national scale multimedia assessment. Due, in part, to these factors and limitations, the EPA chose the HAPEM4 as the tool to predict the inhalation exposure as part of the initial national-scale assessment. The HAPEM4 was a likely choice for the exposure modeling component of NATA based on its specific design features including its ability to process large amounts of input data thus enabling a national assessment at the census tract scale, its ability to predict exposure concentrations for both outdoor and indoor locations, its ability to calculate annual average exposures which reflect time-dependent patterns in ambient concentrations and activity patterns, and its ability to estimate exposures for workers at their

workplace and also during their commute. HAPEM4 is also desirable because of the probabilistic selection of the activity pattern data used by the model.

As part of the NATA activities, the HAPEM4 will be run to estimate inhalation exposure levels to selected HAPs, including those on the EPA's urban HAPs list[1], for all census tracts in the contiguous United States, Puerto Rico, and the U.S. Virgin Islands. Prior to running the HAPEM4, pollutant-specific microenvironmental (ME) factors need to be developed for each HAP/microenvironment combination. The list of HAPs and HAPEM4 microenvironments for which ME factors were sought can be found in Tables 1 and 2, respectively. This report provides details of the development of the HAPEM4 ME factors to be used in the NATA analyses.

Table 1. List of HAPs for Development of ME Factors[a]

1	acetaldehyde	13	1,2-dichloroethane (ethylene dichloride)	25	nickel compounds
2	acrolein	14	1,3-dichloropropene	26	7-PAH
3	acrylonitrile	15	ethylene dibromide (1,2-dibromoethane)	27	polychlorinated biphenyls
4	arsenic	16	ethylene oxide	28	propylene dichloride (1,2-dichloropropane)
5	benzene	17	formaldehyde	29	quinoline
6	beryllium compounds	18	hexachlorobenzene	30	styrene[b]
7	1,3-butadiene	19	hydrazine	31	2,3,7,8-TCDD
8	cadmium compounds	20	lead compounds - organic	32	1,1,2,2-tetrachloroethane
9	carbon tetrachloride	21	lead compounds - inorganic	33	tetrachloroethylene (perchloroethylene)
10	chloroform	22	manganese compounds	34	trichloroethylene
11	chromium compounds	23	mercury compounds	35	vinyl chloride
12	coke oven emissions	24	methylene chloride (dichloromethane)		

[a] In addition to this list, the following pollutants were also included for future development of ME factors: ethyl benzene, hexane, methyl-tertiary-butyl-ether (MTBE), propionaldehyde, toluene, and xylenes.
[b] Styrene is the only HAP in this table that is not on EPA's urban HAPs list.

[1]The urban HAPs list was published in the Federal Register Notice describing EPA's Integrated Urban Air Toxics Strategy (64 FR 38706).

Table 2. HAPEM4 Microenvironments

MICROENVIRONMENT #	MICROENVIRONMENT	
	SPECIFIC	GENERAL
1	Car	In vehicle
2	Bus	In vehicle
3	Truck	In vehicle
4	Other	In vehicle
5	Public garage	Indoors
6	Parking lot/garage	Outdoors
7	Near road	Outdoors
8	Motorcycle	Outdoors
9	Service station	Indoors
10	Service station	Outdoors
11	Residential garage	Indoors
12	Other repair shop	Indoors
13	Residence - no gas stove	Indoors
14	Residence - gas stove	Indoors
15	Residence - attached garage	Indoors
16	Residential - stove and garage	Indoors
17	Office	Indoors
18	Store	Indoors
19	Restaurant	Indoors
20	Manufacturing facility	Indoors
21	School	Indoors
22	Church	Indoors
23	Shopping mall	Indoors
24	Auditorium	Indoors
25	Health care facility	Indoors
26	Other public building	Indoors
27	Other location	Indoors
28	Not specified	Indoors
29	Construction site	Outdoors
30	Residential grounds	Outdoors
31	School grounds	Outdoors
32	Sports arena	Outdoors
33	Park/golf course	Outdoors
34	Other location	Outdoors
35	Not specified	Outdoors

MICROENVIRONMENT #	MICROENVIRONMENT	
	SPECIFIC	GENERAL
36	Train/subway	In vehicle
37	Airplane	In vehicle

METHODOLOGY

Defining the HAPEM4 ME Factors

It is important to point out prior to defining the ME factors that the goals of the initial NATA assessment are primarily concerned with HAP releases from inventoried sources (i.e., certain sources and source types whose emissions originate outdoors), so air quality estimates and ME factors in the HAPEM4 assessment will consider only exposures associated with emissions from these sources. Thus, the exposure predictions will not consider the effects of emissions of HAPs from indoor sources (e.g., internal combustion sources, off-gassing from wood products, consumer products, etc.). However, it is equally important to point out that indoor sources of HAPs could be important to total exposure levels and for determining specific HAP threshold levels.

The data used to calculate ME factors for use in the HAPEM4 came primarily from journal articles, agency reports, and scientific conference proceedings that report results from measurement studies that concurrently measured ambient pollutant concentrations with those in one or more of the various microenvironments shown in Table 2. The ratio of concurrent measurements of indoor pollutant concentrations to those collected outdoors in the immediate vicinity of the indoor microenvironment is typically referred to as an I/O ratio. For this report, this ratio, which is applicable to all HAPEM4 indoor and in-vehicle microenvironments, is referred to as the penetration factor, or *PEN*. Penetration factors are not applicable to outdoor microenvironments (all *PEN* factors for outdoor microenvironments have been set to 1.0 for this project).

In addition to the development of *PEN* factors for the HAPEM4 microenvironments, this work investigated the collection of measurement data for a new ME factor for the HAPEM4. This new factor, called the proximity factor (abbreviated *PROX*), relates a HAP's concentration measured or modeled at a specified location to that measured at an outdoor location that is either in close proximity to one of HAPEM4's indoor or in-vehicle microenvironments, or is itself one of HAPEM4's outdoor microenvironments. A third ME factor, called the multiplicative factor (abbreviated *MULT*), is the product of the *PEN* and *PROX* factors. The *PEN, PROX*, and *MULT* factors are defined mathematically in Equations 1, 2, and 3, respectively. Equation 2a applies to indoor or in-vehicle microenvironments, and Equation 2b applies to outdoor microenvironments.

$$PEN = \frac{(\text{indoor or in-vehicle ME conc.})}{(\text{outdoor conc. in immediate vicinity of indoor or in-vehicle ME})} \quad (1)$$

$$PROX_i = \frac{(\text{outdoor conc. in immediate vicinity of indoor or in-vehicle ME})}{(\text{measured or modeled ambient conc.})} \qquad (2a)$$

$$PROX_o = \frac{(\text{outdoor ME conc.})}{(\text{measured or modeled ambient conc.})} \qquad (2b)$$

$$MULT = PEN \times PROX_i = \frac{(\text{indoor or in-vehicle ME conc.})}{(\text{measured or modeled ambient conc.})} \qquad (3)$$

Calculating HAPEM4 ME Concentrations and Estimation of Proximity Factors

The HAPEM4 estimates concentrations within microenvironments through the relationship:

$$ME(m,c,t) = ADD(m) + [PROX(m)][PEN(m)][AMB(c,t)] \qquad (4)$$

where:

$ME(m,c,t)$:	concentration in microenvironment m located in census tract c at time t,
$ADD(m)$:	additive factor for microenvironment m,
$PROX(m)$:	proximity factor for microenvironment m,
$PEN(m)$:	penetration factor for microenvironment m, and
$AMB(c,t)$:	ambient concentration for census tract c at time t.

The additive factor (*ADD*) accounts for emission sources within or near to a microenvironment. The *ADD's* primary function is to account for emissions of a pollutant that originate indoors. Since this term is itself a concentration, the value of *ADD* can be set equal to zero, indicating no contribution from indoor sources. As stated previously, the initial NATA assessments are concerned with HAP releases from outdoor sources, therefore for these analyses, the *ADD* term has been set to zero. The *PEN* accounts for the relationship between the concentration in the microenvironment and the concentration in the outdoor air in the immediate vicinity of the microenvironment, when the microenvironment contains no sources. For example, the *PEN* factor for the indoors, residence microenvironment would represent the ratio of the indoor concentration to the concentration in the air surrounding the residence when sources are absent in the residence. The *PROX* accounts for the relationship between the outdoor concentration in the vicinity of the microenvironment and the concentration at the location represented by *AMB(c,t)*.

In some applications of the HAPEM4, the ambient concentration is determined by measurements made by a fixed-site monitor. If this fixed-site monitor is located at a greater distance from the predominant emission sources (e.g., roadways) than the microenvironment is, then the monitor would tend to record lower values than the outdoor concentration at the

microenvironment. In this case, the *PROX* factor should be greater than unity to compensate for the relatively low reading at the fixed-site monitor.

Estimating Ambient HAP Concentrations Using ASPEN

In the NATA application of HAPEM4, values for *AMB(c,t)* are provided by the ASPEN (Assessment System for Population Exposure Nationwide) dispersion model rather than by fixed-site monitors. The ASPEN first defines a receptor grid for each emission source which extends out 50 km from the source. This receptor grid, and hence the concentration estimates, varies according to emission source type (i.e., point sources, mobile sources, or area sources). Next, the model uses emissions and meteorological data specific to the census tract to estimate pollutant concentrations at each receptor point. The model then interpolates the receptor concentrations to the census tracts which fall within the 50 km study area. Finally, ASPEN weights the estimated pollutant concentrations by population to produce an average concentration value for each census tract.

The ASPEN uses the following designations for estimating concentrations within a census tract, depending on whether or not the tract contains the emission source under evaluation. These methods, related to census tracts defined as resident and non-resident tracts, are briefly summarized below.

• Resident Tract: The census tract containing a particular source is called the "resident" tract for that source. To avoid the effects of steep pollutant gradients within the resident tract, ASPEN determines an average concentration for the entire tract rather than the concentration at the tract's centroid[2]. The method varies with the type of emission source as follows:

  Point sources: For tracts with centroids close to a major point source, the ambient concentration is estimated by spatial averaging of the ambient concentrations estimated to fall within the bounds of the tracts, rather than by interpolation to the centroid. Because of the difficulty in characterizing the exact boundary locations of each tract, ASPEN uses a circle whose area equals that of the census tract to perform the spatial averaging.

  Mobile and area sources: In the resident tract, the mobile and area sources are treated as multiple "pseudo point sources" geographically dispersed throughout the census tract rather than as a single source. For resident tracts that have radii greater than 0.3 km, ambient concentrations are estimated on the basis of five pseudo point sources. The average concentration for the census tract is determined by spatially averaging the ambient concentrations associated with the receptors defined for the five pseudo sources which fall within the bounds of the tract. And, as in the case of point sources, the tract is assumed to be a circle with an area equal to that of the census tract for purposes of spatial averaging. One of the five pseudo sources is located at the

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[2] The centroid is the geographical center of a census tract.

center of this circle. The other four sources are located halfway between the center and the hypothetical circumference in each of the four principle compass directions. For resident tracts with radii <u>less than 0.3 km</u>, ambient concentrations are set equal to zero.

- <u>Non-Resident Tract</u>: The remaining tracts in the 50 km study zone are referred to as "non-resident" tracts. The ASPEN uses a log-log interpolation procedure to estimate the pollutant concentration at the population centroid of each non-resident tract. These estimates are population-weighted.

The ASPEN User's Guide (SAI, 1999) provides more detailed descriptions of these methods.

Ideally, the concentration values provided by ASPEN are unbiased estimates of the outdoor concentration at locations within the census tract where people are likely to reside and work. The values can be used without adjustment to represent outdoor (ambient) concentrations for microenvironments that do not tend to be in close proximity to the predominant sources of the pollutant. Consequently, the appropriate *PROX* factor for such microenvironments is unity.

However, the ASPEN model estimates ambient HAP concentrations by source category (i.e., major, area, "onroad" vehicles, and "nonroad" vehicles)[3], hence the estimates of outdoor concentrations are biased low for microenvironments that are usually located near predominant sources of a pollutant. The most prevalent example of this is for HAPs emitted by onroad motor vehicles that impact microenvironments in close proximity to roadways. For onroad mobile source pollutants such as benzene, these "close proximity" microenvironments include outdoor locations near roads (HAPEM4 microenvironment No. 7), vehicles (Nos. 1, 2, 3, 4, 8, and 36), service stations (No. 10), and parking facilities (No. 6). In these cases, the appropriate proximity factor should be greater than unity.

Table 3 lists the microenvironments whose *PROX* factors (from the literature) for acetaldehyde, acrolein, benzene, 1,3-butadiene, and formaldehyde for the onroad mobile source category are greater than unity. All other combinations of pollutants, microenvironments, and source categories have been assigned a default *PROX* factor equal to 1.0 (see Appendix C).

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[3] The definitions for major and area sources are in Title I of the Clean Air Act Amendments (CAAA) of 1990, while the "mobile source" terms are defined in Title II of the CAAA.

Table 3. Microenvironments that have *PROX* Factors Greater Than 1.0 for Acetaldehyde, Acrolein, Benzene, 1,3-Butadiene, and Formaldehyde For the "Onroad" Mobile-Source Category Only

MICROENVIRONMENT NO.	MICROENVIRONMENT	
	SPECIFIC	GENERAL
1	Car	In vehicle
2	Bus	In vehicle
3	Truck	In vehicle
4	Other	In vehicle
6	Parking lot/garage	Outdoors
7	Near road	Outdoors
8	Motorcycle	Outdoors
10	Service station	Outdoors
36	Train/subway	In vehicle

Literature Search

A broad literature search was conducted of all available sources containing measurement data for use in developing the *PEN* factors for HAPEM4. The search was accomplished with the aid of on-line library search engines that captured relevant literature from the United States and other countries. These library search engines included, but were not limited to, the National Technical Information Service (NTIS), Enviroline, Transportation Research Information Services (TRIS), Wilson Applied Science & Technology Abstracts, Energy Science and Technology, PASCAL, MEDLINE, TOXLINE, Occupational Safety and Health (NIOSHTIC®), and the Abstracts in New Technologies and Engineering (ANTE). The search was based on a large set of key words to ensure that it was comprehensive. The pollutants and microenvironments in Tables 1 and 2, respectively, were included as key words in the on-line search. Additional key words were used to focus the search on studies that had the potential for reporting results that had both indoor and outdoor measurements.

The search was conducted using the procedure described below.

Step 1

The on-line search was conducted using key words as described above. The search included all literature dating back to 1994. Literature published prior to 1994 was included in an earlier on-line search conducted by TRJ Environmental (see Step 5). Including years prior to 1994 in this search would have yielded more documents than could have been reviewed given the resources available for this project. The search initially yielded titles and key word descriptors for 5,424 documents encompassing all of the HAPs in Table 1 (including the six HAPs listed at the end of the table). All of the titles and key word descriptors were reviewed and ranked for the potential of containing data useful to the development of a ME factor. Three categories of

rankings were used: documents that had a high probability of containing relevant information, documents that had a moderate probability of containing relevant information, and documents that were unlikely to contain, or had a low probability of containing, relevant information.

Step 2

The next step was to retrieve the abstracts for each citation deemed to have either a high- or moderate probability of containing both indoor and outdoor measurements for the various HAPs. Of the original set of 5,424 titles obtained in Step 1, 251 abstracts were obtained because, based on the title review, they were thought to have the potential for providing the needed information for determining *PEN* factors, (i.e., high or moderate probability). The abstracts were obtained, reviewed, and ranked in a fashion similar to that in Step 1 to determine which articles or documents were most likely to provide the needed information for calculating *PEN* factors.

Step 3

The third step in the literature search was to obtain the complete paper or report for each abstract from Step 2 that was categorized as having either a high or moderate probability of containing relevant information for determining *PEN* factors. Of the 251 abstracts reviewed in Step 2, 100 were categorized with either a high or moderate potential for containing the necessary information for determining a *PEN* factor. The complete documents for these 100 references were obtained and reviewed for information needed to determine *PEN* factors.

Step 4

Because of the relative paucity of information obtained from the on-line literature search described in the three steps above, researchers obtained additional documents from studies that preceded those of the on-line search (i.e., pre-1994). These studies were thought to contain useful information on *PEN* factors and were identified during the review of papers and reports from the original on-line search. As a result of this step, researchers obtained and reviewed an additional 39 papers and reports for useful information on *PEN* factors.

Step 5

Concurrent with the activities described in Steps 1 through 4, researchers re-examined literature that had been obtained for an earlier review of scientific studies related to the measurement of *PEN* factors (refer to Fletcher et al. (1999) for a description of this work). This research included a total of 68 documents that were also collected and reviewed. Researchers were careful not to duplicate the documents collected in this step with those collected in Steps 1 through 3. Most of the documents collected in this step preceded the five-year period (i.e., 1994-1999) for which the studies in Steps 1 through 3 were collected.

Grouping HAPs and Microenvironments

Because of the paucity of published I/O measurement data for most of the 1,295 HAP/ME combinations (i.e., 35 HAPs × 37 microenvironments), it was decided to group similar HAPs together. Microenvironments were also grouped based on similarity to each other. The purpose

of this grouping was to allow assignment of ME factors to the groups, based on the best data available, so that more HAP/ME combinations could be covered (and to minimize the assignment of generic default values).

Microenvironmental Groups

Based on the characteristics of the 37 HAPEM4 microenvironments, each was assigned to one of five groups. Each group consists of microenvironments expected to have similar *PEN* factors, thus allowing ME factors developed for one microenvironment to be applied to other microenvironments in the same group. Table 4 shows the five ME groups used in this project, as well as the mapping between the original 37 HAPEM4 microenvironments and the five ME groups.

Table 4. Description of ME Groups

	HAPEM4 Microenvironments		Location[a]	Bldg. Type[b]	ME Group[c]
ME #	ME Designation	General ME Type			
1	Car	In vehicle	–	–	5
2	Bus	In vehicle	–	–	5
3	Truck	In vehicle	–	–	5
4	Other	In vehicle	–	–	5
5	Public garage	Indoors	–	O	2
6	Parking lot/garage	Outdoors	N	–	3
7	Near road	Outdoors	N	–	3
8	Motorcycle	Outdoors	N	–	3
9	Service station	Indoors	–	O	2
10	Service station	Outdoors	N	–	3
11	Residential garage	Indoors	–	R	1
12	Other repair shop	Indoors	–	O	2
13	Residence - no gas stove	Indoors	–	R	1
14	Residence - gas stove	Indoors	–	R	1
15	Residence - attached garage	Indoors	–	R	1
16	Residential - stove and garage	Indoors	–	R	1
17	Office	Indoors	–	O	2
18	Store	Indoors	–	O	2

	HAPEM4 Microenvironments		Location[a]	Bldg. Type[b]	ME Group[c]
ME #	ME Designation	General ME Type			
19	Restaurant	Indoors	–	O	2
20	Manufacturing facility	Indoors	–	O	2
21	School	Indoors	–	O	2
22	Church	Indoors	–	O	2
23	Shopping mall	Indoors	–	O	2
24	Auditorium	Indoors	–	O	2
25	Health care facility	Indoors	–	O	2
26	Other public building	Indoors	–	O	2
27	Other location	Indoors	–	O	2
28	Not specified	Indoors	–	O	2
29	Construction site	Outdoors	A	–	4
30	Residential grounds	Outdoors	A	–	4
31	School grounds	Outdoors	A	–	4
32	Sports arena	Outdoors	A	–	4
33	Park/golf course	Outdoors	A	–	4
34	Other location	Outdoors	A/N	–	3/4[d]
35	Not specified	Outdoors	A/N	–	3/4[d]
36	Train/subway	In vehicle	–	–	5
37	Airplane	In vehicle	–	–	5

[a] N = near road; A = away from road

[b] R = residence; O = other building

[c] 1 = indoors - residence; 2 = indoors - other building; 3 = outdoors, near road; 4 = outdoors, away from road; 5 = in vehicle

[d] Use average of factors determined for Groups 3 and 4.

The five ME groups were established based on the general ME type (indoor, outdoor, or in-vehicle), expected location relative to roadways (near road, away from road), and building type (residence, other). This five-group classification shown in Table 4 is similar to the ME categories used in previous versions of the HAPEM. The current groupings include information on location for outdoor microenvironments and building type for indoor microenvironments. *PROX* factors are likely to be influenced by ME location relative to roadway sources, while *PEN* factors are affected by the structural design and usage patterns of indoor microenvironments.

In general, researchers used the actual HAPEM4 ME designations to assign a microenvironment to one of the five groups. However, for certain microenvironments, researchers used CO concentration data from a personal exposure monitoring study in Denver to determine whether the microenvironment should be assigned to a "near road" or "away from road" group (USEPA, 1984). Researchers assigned two indoor microenvironments with broad descriptors ("other indoor location" and "indoors, not specified") to non-residence groups on the assumption that these microenvironments are not used to indicate residential locations.

Although these ME groups can be useful in situations where no data are available in the literature for a particular HAP/ME combination, there are limitations to this method of approximation. Different microenvironments, even those in the same group, have unique characteristics which may cause them to have different ME factors for some or all pollutants. However, the use of ME groups (essentially, extrapolating available data to closely related situations) is considered preferable to the use of more generic default assumptions.

<u>Pollutant Lifetime Groups</u>

For the purpose of estimating *PEN* factors for pollutants without I/O ratios available in the literature, researchers used the lifetime grouping method developed by TRJ Environmental (see Long and Johnson, 1999; included here in Appendix A). This method classifies HAPs into five groups based on expected atmospheric residence lifetime. The HAPs belonging to each group are expected to have similar decay or removal rates in typical microenvironments. However, in the case of certain HAPs, insufficient data were available to definitively assign them exclusively into either the short, medium, or long lifetime categories. Therefore, these HAPs [identified as lifetime Groups 2 (medium short lifetime category) and 4 (medium long lifetime category) in Table 5] were assigned to Group 3 (medium lifetime category) for this project. Furthermore, Groups 2 and 4 contain only three HAPs for which no literature data were available for most microenvironments. In the future, as additional data on atmospheric lifetimes of HAPs become available, it may be possible to further subdivide these categories into additional groupings having narrower time increments and then reassign the HAPs among the larger number of groups. Because the atmospheric lifetime of a pollutant should be a major factor in determining its I/O ratio for a given microenvironment (in the absence of indoor sources), pollutants in each lifetime group should exhibit similar *PEN* factors.

Researchers considered both atmospheric transformation reactions for gaseous HAPs and removal by deposition for particle-phase HAPs. Although the groups are not directly derived from structure or composition of each HAP, some broad associations can be made between structural class (e.g., aromatics, halogenated hydrocarbons) and lifetime group. Table 5 lists the lifetime group for each of the HAPs considered in this project, and the paper in Appendix A gives the lifetime classification for all 188 HAPs.

Table 5. HAP Groups for Use in HAPEM4

HAP #	Pollutant	Lifetime Group[b]	Source Distribution Group[c]	Predominant Ambient Sources
1	acetaldehyde	1	LN	motor vehicles (rxn product)
2	acrolein	1	LN	motor vehicles (rxn product)
3	acrylonitrile	4[d]	PS	chemical manufacturing facilities (vehicle exhaust)
4	arsenic compounds	5	PS	smelters; semiconductor manufacturing
5	benzene[a]	5	LN	motor vehicles; chemical manufacturing
6	beryllium compounds	5	PS	smelters; metal manufacturing
7	1,3-butadiene	1	LN	motor vehicles; chemical manufacturing
8	cadmium compounds	5	PS	smelters; power generation
9	carbon tetrachloride	5	PD	various manufacturing facilities; agricultural chemicals
10	chloroform	5	PD	dry cleaning
11	chromium compounds	5	PS	smelters; metal manufacturing facilities; power generation
12	coke oven emissions	--	PS	blast furnaces and steel mills
13	1,2-dichloroethane (ethylene dichloride)	5	PD	metal degreasing; chemical preparations
14	1,3-dichloropropene	1	AR	agricultural soil fumigation
15	ethylene dibromide (dibromoethane)	5	PS	chemical manufacturing
16	ethylene oxide	5	AR	agricultural fumigation
17	formaldehyde	3	LN	motor vehicles (rxn product)
18	hexachlorobenzene	5	AR	hydraulic cement; agricultural use as pesticide
19	hydrazine	1	PS	chemical manufacturing
20	lead compounds - organic	--	--	sources unknown (formerly motor vehicles; lead additives)
21	lead compounds - inorganic	5	PS	smelters; manufacturing facilities; power generation
22	manganese compounds	5	PS	various manufacturing
23	mercury compounds	5	PS	power generation; various manufacturing facilities

HAP #	Pollutant	Lifetime Group[b]	Source Distribution Group[c]	Predominant Ambient Sources
24	methylene chloride (dichloromethane)	5	PS	chemical and semiconductor manufacturing; laboratories
25	nickel compounds	5	PS	smelters; power generation; various manufacturing
26	7-PAH (2 categories: lower and upper bound)	2[d]	AR	residential burning (fireplaces, grills); diesel exhaust
27	polychlorinated biphenyls (aroclors)	5	PD	waste incineration and disposal; atmospheric redistribution
28	propylene dichloride (1,2-dichloropropane)	5	PD	dry cleaning; various manufacturing facilities
29	quinoline	3	PS	various manufacturing facilities
30	styrene	1	PS	polymer manufacturing facilities
31	2,3,7,8-TCDD (2 categories: lower and upper bound)	3	AR	residential burning; waste incineration; manufacturing; atmospheric redistribution
32	1,1,2,2-tetrachloroethane	5	PD	metal degreasing
33	tetrachloroethylene (perchloroethylene)	5	PD	dry cleaning; metal degreasing
34	trichloroethylene	5	PD	chemical manufacturing
35	vinyl chloride	2[d]	PS	chemical manufacturing

[a] Pollutants that have a long atmospheric lifetime and a line source distribution. These pollutants are expected to have ME factors similar to those developed for CO.

[b] Estimated atmospheric lifetimes. 1 = short (<1 day); 2 = medium short; 3 = medium (1-5 days); 4 = medium long; 5 = long (>5 days).

[c] Expected distribution of ambient sources. AR = area sources (e.g., residential fireplaces); LN = line sources (e.g., roadways); PD = point sources, densely distributed (e.g., dry cleaning establishments); PS = point sources, sparsely distributed (e.g., smelters, manufacturing facilities).

[d] Were placed in Group 3 for estimation of ME factors.

There are a number of limitations to the pollutant lifetime grouping method. One limitation is that the method does not explicitly consider the effect of multiple phases of a single pollutant on HAP lifetimes. This approach treats semi-volatile organics and other pollutants that may be present in both gas and particle phases as gaseous pollutants. Another limitation of the method is that it does not account for the production of HAPs through atmospheric transformations. Also, the method does not consider effects of HAP sorption by materials in indoor microenvironments.

RESULTS

The detailed results of the literature review are found in Appendix B. An electronic version of this information is available in the file called <u>App_B.wpd</u>. The first column, *Ref. No.*, has two integers separated by a hyphen. The first number always refers to the pollutant number as defined in Table 1, and the second number always refers to the microenvironment number, as defined in Table 2. The second column contains information retrieved from the literature source, including the pollutants addressed, the authors of the paper or report, the microenvironments investigated, and other information pertinent to this project. Data on ME factors, or concentration data that can be used to calculate ME factors, have been bolded. The third and last column, *Sources*, contains a code identifying the reviewer and assigning a tracking number to each reviewed document.

An Excel spreadsheet was developed that summarizes the results of the literature search described above. This file, named <u>All_Articles.xls</u> (provided in electronic format only), is intended to give a quick glance of the title of the paper or report, the authors, the pollutants considered, and a brief description of the results from each of the documents. In addition, there is a column entitled *Sources*; the codes in this column are matched to the codes in the *Sources* column of App_B.wpd. The documents in All_Articles.xls that do not have a code in the *Sources* column were from the earlier Fletcher et al. (1999) work described in Step 5 of the *Literature Search* subsection of the *Methodology*. The All_Articles.xls file contains four worksheets, one for each of the three researchers that reviewed the literature, and a fourth that combines all of the information from the previous three worksheets. Within each worksheet, the documents reviewed are divided between those that yielded information on ME factors (these are found at the top of each worksheet), and those reviewed papers or reports that did not provide information on ME factors. The two sections of each worksheet are divided by a bright yellow band.

Because this project is concerned with developing *PEN* factors for ambient pollutants that penetrate into indoor microenvironments, not all of the data reported in App_B.wpd are useful; that is, most of the I/O measurement studies of HAPs report indoor concentrations that are substantially greater than those measured outdoors. This is attributable to indoor sources of the HAPs being measured, which are not a primary concern of this project. Therefore, the I/O ratios are typically greater (often by a substantial amount) than unity. For this reason, the following guidelines were employed to calculate the *PEN* factors from studies that reported I/O measurement data:

> Case 1: If a study reports I/O measurement data whose median and/or mean is less than or equal to unity, then this value is used with preference given to the median. If more than one study reports mean and/or median I/O values less than or equal to unity, then the average of the values from these studies are used. Note, however, that median and mean values are not combined to form an average.

> Case 2: For situations not covered by Case 1, and where only the range of I/O values were reported, and the range extended below unity, the

PEN (I/O) factor was calculated by splitting the difference between the minimum value in the range and 1.0.

Case 3: For HAP/ME combinations where there was no indication of the I/O ratio being less than unity, 1.0 was used as a default value.

The results of the assignment of *PEN* and *PROX* factors are provided in Appendix C (also provided electronically in the file named App_C.wpd). Appendix C shows each pollutant (one pollutant per page), the HAPEM4 microenvironments and associated ME numbers, and the HAPEM4 ME (i.e., *PEN*, *PROX*, and *MULT*) factors defined above. In addition, there is a column for the additive, or *ADD*, values, i.e., concentrations that represent the contribution to a microenvironment from a source(s) within the microenvironment (e.g., benzene from smoking in a residence or in an automobile). Although identification of *ADD* factors was not within the scope of this project, they have been estimated for several HAP/ME combinations and can be included after the data are compiled. *PEN* factors for coke oven emissions (HAP #12) and MTBE could not be estimated since there was insufficient information to categorize them using the lifetime grouping methodology. The *Data Code* column in Appendix C indicates how the *PEN* and *PROX* factors were derived for each HAP/ME combination:

1 – indicates that measurement data for that particular combination were available and used,
2 – indicates that useful measurement data for the HAP/microenvironment pair were not available, and the *PEN* or *PROX* factor was obtained through the grouping scheme described in the *Methodology*,
3 – indicates that a default value of 1.0 was used. Note that for the *PEN* factors, the use of this default value only applies to those outdoor microenvironments that were in Groups 3 and 4 (see the *Grouping HAPs and Microenvironments* subsection of the *Methodology*).

Finally, the codes in the *Ref. Sources* column are directly matched to the *Sources* codes in Appendix B (as well as the App_B.wpd file) and the All_Articles.xls file.

DISCUSSION

The Use of a Linear Model for the Initial NATA Assessment

Equation 4 is acknowledgably an oversimplification of the physical processes that affect ME concentrations. In addition, Equation 4 does not include probabilistic components to account for the inherent variability of these processes. Ideally, ME concentrations would be estimated through the use of a probabilistic mass balance algorithm similar to those incorporated in recent versions of the probabilistic NAAQS[4] Exposure Model for Ozone (pNEM/O$_3$) (Johnson et al., 1996) and the probabilistic NAAQS Exposure Model for Carbon Monoxide (pNEM/CO) (Johnson et al., 2000). These exposure models provide short-term (i.e., less than 1 hour) estimates of ME concentrations which account for time-varying changes in outdoor (ambient)

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[4] National Ambient Air Quality Standards

concentration, air exchange rate, filtration, decay and other removal processes, and indoor emission rates. Values for the various parameters are selected from appropriate distributions that are specific to pollutant and microenvironment.

A mass-balance modeling algorithm was not implemented in HAPEM4 because (1) the refinement would have greatly increased computer program run times and (2) available data were judged inadequate for developing distributions for many of the algorithm parameters. In addition, the initial NATA assessment was focused on annual exposures which were assumed to be relatively insensitive to the short-term variations in ME concentrations provided by mass balance models. This assumption was based on the observation that the relationship between ME concentration and ambient concentration tends to become more linear as averaging time increases. For example, Dockery and Spengler (1981) analyzed a mass balance model applicable to particulate matter and found that the long-term relationship between indoor and outdoor concentration could be approximated by a simple linear function. The coefficients of this function were determined by performing linear regression analyses on empirical data.

The assumption of linearity has been used in other exposure models applied to HAPs. For example, the Benzene Exposure and Absorbed Dose Simulation (BEADS) model developed by MacIntosh et al. (1995) estimated the benzene concentration inside vehicles by the expression:

$$\text{benzene inside vehicle} = \alpha + (\beta)(\text{ambient benzene})$$

where the coefficients α and β were randomly selected from normal distributions. The means of these distributions were based on the results of a regression analysis performed by Chang et al. (1991) on empirical data collected during a field study in Raleigh, North Carolina.

To summarize, mass balance models are preferred when short-term exposure estimates are required and when analysts are able to identify appropriate data for estimating model parameters. Linear models such as Equation 4 are considered more appropriate for screening level analyses such as the initial NATA that attempts to estimate long-term (e.g., annual) exposures. This is because, compared to mass balance models, linear models typically require less data for parameter estimation and run faster.

SUMMARY

This project provides an up-to-date investigation into the availability of scientific studies that reported concurrent indoor and outdoor measurements of HAPs. We found that relatively few studies had concurrently measured indoor and outdoor concentrations of the HAPs listed in Table 1. Examination of the results of the literature review (Appendix B) revealed that much of the published measurement data were for aromatic hydrocarbons, particularly the BTEX compounds (i.e., benzene, toluene, ethylbenzene, and xylenes). Furthermore, the studies reported I/O values for only a few of the many microenvironments of interest to this work. These key microenvironments included automobiles (HAPEM4 microenvironment #1), residences (#13), and offices (#17). We found the I/O values reported in the literature to be highly variable, with most of the values being greater than unity, indicating a source(s) of the HAPs in the indoor microenvironment.

REFERENCES

Chang, C.C., H. Ozkaynak, J. D. Spengler, and L. Sheldon (1991) Driver exposure to volatile organic compounds, CO, ozone, and NO_2 under different driving conditions. *Environ. Sci. Technol.* **25,** 964-972.

Dockery, D.W. and J. D. Spengler (1981) Indoor-outdoor relationships of respirable sulfates and particles. *Atmos. Environ.* **15,** 335-343.

Fletcher, K., J. LaPointe, T. Long, and T. Johnson (1999) *Memo No. 1: Review of scientific literature relating to microenvironmental factors*. TRJ Environmental memorandum to EPA. EPA purchase order #8D-2091-NALX, April 5, 1999.

Johnson, T., J. Capel, M. McCoy, and J. Mozier (1996) *Estimation of Ozone Exposures Experienced by Outdoor Workers in Nine Urban Areas Using a Probabilistic Version of NEM*. Prepared under Contract No. 68-DO-30094 for the U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC.

Johnson, T., G. Mihlan, J. Lapointe, K. Fletcher, J. Capel, A. Rosenbaum, J. Cohen, and P. Stiefer (2000) *Estimation of Carbon Monoxide Exposures and Associated Carboxyhemoglobin Levels in Residents of Denver and Los Angeles Using pNEM/CO (Version 2.1)*. Prepared under Contract No. 68-D6-0064 for the U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC.

Long, T. and T. Johnson (1999) *Memo No. 2: Classification of hazardous air pollutants into groups likely to exhibit similar microenvironmental factors*. TRJ Environmental memorandum to EPA. EPA purchase order #8D-2091-NALX, April 6, 1999.

MacIntosh, D.L., J. Xue, H. Ozkaynak, J. D. Spengler, and P. B. Ryan (1995) A population-based exposure model for benzene. *J. of Exposure Anal. and Environ. Epidem.* **5,** 375-402.

SAI (Systems Applications International) (1999) *User's guide: Assessment System for Population Exposure Nationwide (ASPEN, Version 1.1) – Volumes I and II*. SYSAPP-98/25r2. Prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC.

USEPA (U.S. Environmental Protection Agency) (1984) *A study of personal exposure to carbon monoxide in Denver, Colorado*. EPA-600/54-84-014. Office of Research and Development, Research Triangle Park, NC.

APPENDIX A

LIFETIME GROUPING METHODOLOGY

(Memo to EPA from TRJ Environmental, Inc.)

(In files: TRJmemo2.wpd; TRJtable.wpd)

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MEMORANDUM

To: Ted Palma, USEPA

From: Tom Long and Ted Johnson
           TRJ Environmental, Inc.

Date: April 6, 1999

Project: EPA Purchase Order 8D-2091-NALX
           TRJ Project No. 324

Memo No. 2:   Classification of Hazardous Air Pollutants into Groups Likely to
                   Exhibit Similar Microenvironmental Factors

Under Purchase Order No. 8D-2091-NALX, TRJ Environmental, Inc. (TRJ) is assisting the U. S. Environmental Protection Agency (EPA) in developing microenvironmental factors suitable for use with the current version of the Hazardous Air Pollutant Exposure Model (HAPEM). In typical applications, HAPEM estimates the concentration in a particular microenvironment (C_{ME}) by the linear relationship

$$C_{ME} = ADD + (MULT)(C_{out})$$

in which C_{out} is the outdoor (ambient) pollutant concentration. The microenvironmental factors ADD and MULT are constants specific to the microenvironment and pollutant. Usually ADD represents the contribution of indoor sources, whereas MULT is the ratio of indoor to outdoor concentration expected when there are no indoor sources.

A recent memorandum prepared by Fletcher, LaPointe, Long, and Johnson (1999) summarizes the results of an in-depth review of relevant field research which may be useful in estimating microenvironmental factors. This memorandum presents the results of a supplementary effort in which Tom Long of TRJ evaluated the physical and chemical properties of each HAP and then attempted to assign the HAP to one of five groups. The HAPs belonging to each group are expected to exhibit similar decay or removal rates in typical microenvironments. As the indoor/outdoor (I/O) ratio in the absence of indoor sources (i.e., MULT) is typically a function of the decay/removal rate, these groupings should provide a means for making rough estimates of MULT when measured indoor/outdoor data are unavailable or ambiguous.

This memorandum summarizes the development of the grouping method, describes the method itself, and outlines some limitations of the method which indicate the need for further research and data collection. Tables attached to the report classify 179 of the 189 HAPs into five groups likely to have similar (microenvironmental) ME factors. For the remaining 10 HAPs, insufficient information was available to assign them to ME groups.

Overview of Project

TRJ initiated the work effort by performing a literature search to identify articles pertaining to the relationship between indoor/outdoor concentration (I/O) ratios and the kinetics of HAP removal from the atmosphere. Based on this literature review, a grouping method was developed which assigns HAPs to groups according to their estimated half-lives or lifetimes in the atmosphere.

Five groups were established, ranging from compounds with short lifetimes to those with long lifetimes. A table is included for each of the five groups which lists the phase, structural class, and type of removal mechanism for each HAP. Other information is also included when applicable, such as whether the HAP is likely to be present in more than one phase, or whether the HAP is either a product or a precursor in transformation reactions involving other HAPs.

This method has several limitations, primarily due to the limited amount of information available in the literature. Only broad groupings are possible, and ranking of compounds within a group cannot be accomplished at this point. Although HAPs likely to be present in multiple phases are identified, lifetimes are only computed for a single phase (usually the gas phase). In addition, reported lifetimes do not include production of HAPs from atmospheric transformation reactions. Sorption, which can be a removal mechanism over the short term and a source in the long term, is not included in the lifetime estimate.

Background Work and Literature Search

A literature search for this portion of the project identified several articles which were directly useful in developing the grouping method. These articles are briefly summarized below.

- Kelly et al. (1994) prepared a summary of all ambient concentrations and atmospheric lifetimes reported in the literature for the 189 HAPs identified in the 1990 Clean Air Act Amendments. "Lifetime" was defined as the time required for a one-unit logarithmic (base e) decrease in concentration, and the reported lifetimes were grouped into bins of <1 day, 1 – 5 days, and >5 days. Lifetime information was available for all but 11 of the 189 HAPs. The lifetimes given in this database formed the basis for the HAP grouping method.

- Atkinson (1986) prepared an extensive review of the kinetics of atmospheric reactions between hydroxyl radical and various organic compounds. The atmospheric lifetime of triethylamine, one of the HAPs without lifetime information given in Kelly et al. (1994), was estimated from this reference.

- Fogh et al. (1997) measured deposition rates for generated, radiolabeled 0.5 mm particles in residences by subtracting the air exchange rate from the total removal rate. The deposition rate was then related to the deposition velocity and particle diameter. This reference is useful in estimating lifetimes for particulate matter of known diameter.

- One article provided additional information on I/O ratios for HAPs which is useful for relating atmospheric lifetime to I/O ratio. Lewis & Zweidinger (1992) measured I/O ratios for several compounds, including benzene and lead.

In addition to the above articles, information gathered by Fletcher, LaPointe, Long, and Johnson (1999) during the literature review on I/O ratios was considered in grouping pollutants.

Description of Proposed Grouping Method

The proposed method for grouping HAPs with similar ME factors is based on the concept that a compound's atmospheric lifetime will determine its I/O ratio in the absence of indoor sources. If the removal rate of a particular compound in an indoor ME is low, over time the indoor concentration of the compound will build up until it is nearly equal to the outdoor concentration. If the removal rate is high, that is, if the atmospheric lifetime is short, the indoor concentration will remain low relative to the outdoor concentration. Therefore, compounds with similar atmospheric lifetimes should have similar I/O ratios.

This method groups together HAPs with similar atmospheric lifetimes. Sufficient information is available in the literature to classify the 189 HAP into five lifetime groups: those with short, medium-short, medium, medium-long, and long atmospheric lifetimes. As more lifetime data become available, it may be possible to further subdivide these groups or to rank the HAPs within the groups, but for the time being, no more than five groups can be identified.

Atmospheric lifetimes are generally those estimated by Kelly et al. (1994). For gaseous, reactive HAPs, several atmospheric transformation reactions were considered, including reaction with hydroxyl radical, ozone, liquid water, and light (photolysis). For particle-phase HAPs, dry and wet deposition were included as removal mechanisms. In some cases, lifetimes were directly available in the literature; for other HAPs, Kelly et al. (1994) used reported or estimated rate constants to calculate lifetimes. For triethylamine, TRJ Environmental estimated a rate constant and lifetime based on kinetic data from Atkinson (1986).

The groups created by this method are not directly related to structure or composition of the HAPs. Nevertheless, some structural classes appear to be associated with a particular lifetime range (e.g., aromatics tend to have short lifetimes). This may allow the remaining few HAPs without lifetime information to be assigned to a ME group on a preliminary basis.

With additional analysis, it may be possible to assign a range of I/O ratios (MULT values) to each of the five groupings based on the lifetime characterization. In general, the I/O ratios should decrease as lifetime decreases. The relationship between I/O ratio and structural class (e.g., halogenated aromatics) is discussed below.

HAP Lifetime Groups

The HAPs in each of the five lifetime groups are listed in Tables I - V. Table VI lists those HAPs without lifetime information, and Table VII summarizes the distribution of structural classes among the lifetime groups. Each table entry provides the name of a HAP, its CAS registry number, the predominant phase in which it is found in indoor air, its classification into one of ten structural groups, and the predominant mechanism for its removal from indoor air. A comments column is also included which provides information on existence of multiple phases, the likelihood of HAP formation in the atmosphere, metal densities, and other details.

Table VII indicates that broad associations can be made between some structural classes and lifetime groups. In particular, aromatics, hydrocarbons, nitrogenated organics, pesticides, and sulfates tend to be short-lived in the atmosphere, whereas halogenated aromatics, halogenated hydrocarbons, and inorganics tend to have long lifetimes. Oxygenated organics and phthalates have a range of lifetimes. These correlations may be useful in estimating the lifetime of a compound in the absence of other information, but they should be used with caution since not all compounds in each class follow the trend.

Method Limitations

Although a number of HAPs are likely to be present in more than one phase in the atmosphere, the proposed grouping method does not explicitly consider the effect of multiple phases on HAP lifetime. HAPs are considered to be in the gas phase unless the particle phase is clearly more important. This approach treats hydrophobic pesticides and other semi-volatile organic compounds, which may be associated with particles, as gaseous pollutants. HAPs likely to be in more than one phase are identified in the attached grouping tables.

Another limitation of this method is that it does not account for the production of HAPs through the transformation of other atmospheric contaminants, including other HAPs. Generation of HAPs in the atmosphere, such as formaldehyde, would tend to decrease their overall removal rate and extend their atmospheric lifetime. It is also relevant to consider which HAPs are likely to be precursors of other HAPs, so that information on concentration of precursors may be used to help determine expected concentrations of products.

The effect of HAP sorption to the contents of indoor MEs, such as carpeting and furniture, is also not considered in this grouping method. Over the short term, sorption could be a removal mechanism, decreasing the indoor concentration of a HAP. Conversely, if a large sorbed mass of a HAP is present in a ME, the sorbed fraction could act as an indoor source, increasing the HAP concentration. These competing effects make it difficult to determine the influence of sorption on indoor concentration and I/O ratio.

Recommendations for Further Work

Assigning a range of MULT values to each of the lifetime groups will improve the usefulness of this grouping method.   Analysis of I/O ratios available in the literature for compounds in each of the five lifetime classes should help determine the proper range for each group. As additional data become available on both atmospheric lifetimes and I/O ratios, this information will strengthen the quantitative relationship between the lifetime groups and MULT values.

Inclusion of other removal (and source) mechanisms in the method is another area for future work. Precursor/product relationships among HAPs can be investigated further to help determine which HAPs are likely to show a significant effect on I/O ratio due to transformation reactions. HAPs involved in sorptive interactions which may act either to reduce or increase indoor concentration can also be identified. Some information is available on particle density, but the relationship between density and particle deposition rate may be useful for refining the grouping method.

Additional work on grouping HAPs may allow further subdivision of the current five groups and ranking of pollutants within the groups, improving the utility of the method for estimating ME factors for HAPs without I/O concentration data.

References

Atkinson, R. (1986). *Chemical Reviews*, **86**, 69-201.

Daisey, J. M; Hodgson, A. T.; Fisk, W. J.; Mendell, M. J.; Brinke, J. (1994). *Atmospheric Environment*, **28**:22, 3557-3562.

Fletcher, K.; LaPointe, J.; Long, T.; Johnson, T. (1998). "Memo No. 1: Review of Literature Relating to Microenvironmental Factors." Memorandum prepared by TRJ Environmental, Inc., under EPA Purchase Order No. 8D-2091-NALX, Office of Air Quality and Pollutant Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

Fogh, C. L.; Byrne, M. A.; Roed, J.; Goddard, A. J. H. (1997). *Atmospheric Environment*, **31**:15, 2193-2203.

Kelly, T. J.; Mukund, R.; Spicer, C. W.; Pollack, A. J. (1994). *Environmental Science and Technology*, **28**:8, 378A-387A.

Lewis, C. W.; Zweidinger, R. B. (1992). *Atmospheric Environment*, **26A**:12, 2179-2184.

Table I. HAPs with short atmospheric lifetimes (< 1 day).

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
acetaldehyde	75-07-0	gas	Oxy Org	reaction	
acetamide	60-35-5	gas	Nitro Org	reaction	
2-acetylaminofluorene	53-96-3	gas	Nitro Org	reaction	also particle phase
acrolein	107-02-8	gas	Oxy Org	reaction	
acrylic acid	79-10-7	gas	Oxy Org	reaction	
allyl chloride	107-05-1	gas	Hal Hydro	reaction	
4-aminobiphenyl	92-67-1	gas	Nitro Org	reaction	also particle phase
aniline	62-53-3	gas	Nitro Org	reaction	
o-anisidine	90-04-0	gas	Nitro Org	reaction	
benzidine	92-87-5	gas	Nitro Org	reaction	also particle phase
bis(2-ethylhexyl) phthalate	117-81-7	gas	Phthal	reaction	also particle phase
1,3-butadiene	106-99-0	gas	Hydro	reaction	
calcium cyanamide	156-62-7	particle	Inorg	reaction	
captan	133-06-2	gas	Pestic	reaction	also particle phase
carbaryl	63-25-2	gas	Pestic	reaction	also particle phase
catechol	120-80-9	gas	Arom	reaction	
chlordane	57-74-9	gas	Pestic	reaction	also particle phase
chlorine	7782-50-5	gas	Inorg	photolysis	
chlorobenzilate	510-15-6	gas	Pestic	reaction	also particle phase
chloroprene	126-99-8	gas	Hal Hydro	reaction	
cresols/cresylic acid	1319-77-3	gas	Arom	reaction	
o-cresol	95-48-7	gas	Arom	reaction	
m-cresol	108-39-4	gas	Arom	reaction	
p-cresol	106-44-5	gas	Arom	reaction	
cumene	98-82-8	gas	Arom	reaction	
2,4-D, salts and esters	94-75-7	gas	Pestic	reaction	also particle phase
DDE	3547-04-4	gas	Pestic	photolysis	also particle phase
diazomethane	334-88-3	gas	Nitro Org	rxn with ozone	

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
dibenzofurans	132-64-9	gas	Oxy Org	reaction	also particle phase
dibutylphthalate	84-74-2	gas	Phthal	reaction	also particle phase
3,3'-dichlorobenzidene	91-94-1	gas	Nitro Org	photolysis	also particle phase
1,3-dichloropropene	542-75-6	gas	Hal Hydro	reaction	
dichlorvos	62-73-7	gas	Pestic	reaction	
diethanolamine	111-42-2	gas	Nitro Org	reaction	
n,n-diethyl aniline	121-69-7	gas	Nitro Org	reaction	
diethyl sulfate	64-67-5	gas	Sulfat	rxn with liquid water	
3,3'-dimethoxybenzi-dine	119-90-4	gas	Nitro Org	reaction	also particle phase
dimethyl aminoazobenzene	60-11-7	gas	Nitro Org	reaction	also particle phase
3,3'-dimethyl benzidine	119-93-7	gas	Nitro Org	reaction	also particle phase
dimethyl carbamoyl chloride	79-44-7	gas	Nitro Org	reaction	
1,1-dimethyl hydrazine	57-14-7	gas	Nitro Org	reaction	
dimethyl sulfate	77-78-1	gas	Sulfat	rxn with liquid water	
1,2-diphenylhydrazine	122-66-7	gas	Nitro Org	reaction	
ethyl benzene	100-41-4	gas	Arom	reaction	
ethyl carbamate (urethane)	51-79-6	gas	Nitro Org	reaction	
heptachlor	76-44-8	gas	Pestic	reaction	
hexachlorocyclopenta-diene	77-47-4	gas	Hal Hydro	reaction	
hexane	110-54-3	gas	Hydro	reaction	
hydrazine	302-01-2	gas	Nitro Org	reaction	
isophorone	78-59-1	gas	Oxy Org	reaction	
lindane (all isomers)	58-89-9	gas	Pestic	reaction	also particle phase
maleic anhydride	108-31-6	gas	Oxy Org	reaction	also particle phase
methoxychlor	72-43-5	gas	Pestic	reaction	also particle phase
methyl ethyl ketone (2-butanone)	78-93-3	gas	Oxy Org	photolysis	

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
methyl hydrazine	60-34-4	gas	Nitro Org	reaction	
methyl isocyanate	624-83-9	gas	Nitro Org	reaction	
4,4'-methylene bis(2-chloroaniline)	101-14-4	gas	Nitro Org	reaction	also particle phase
methylene diphenyl diisocyanate (MDI)	101-68-8	gas	Nitro Org	reaction	
4,4-methylenedianiline	101-77-9	gas	Nitro Org	reaction	also particle phase
napthalene	91-20-3	gas	Arom	reaction	
2-nitropropane	79-46-9	gas	Nitro Org	reaction	
N-nitroso-*N*-methylurea	684-93-5	gas	Nitro Org	reaction	
N-nitrosodimethyl-amine***	62-75-9	gas	Nitro Org	photolysis	
N-nitrosomorpholine	59-89-2	gas	Nitro Org	reaction	
parathion	56-38-2	gas	Pestic	reaction	also particle phase
phenol	108-95-2	gas	Oxy Org	reaction	
p-phenylenediamine	106-50-3	gas	Nitro Org	reaction	
phosphine	7803-51-2	gas	Inorg	reaction	
phosphorus	7723-14-0	particle	Inorg	rxn with oxygen	
propoxur (Baygon)	114-26-1	gas	Pestic	reaction	also particle phase
1,2-propylenimine (2-methyl-aziridine)	75-55-8	gas	Nitro Org	reaction	
styrene	100-42-5	gas	Arom	reaction	
2,4-toluene diamine	95-80-7	gas	Nitro Org	reaction	also particle phase
2,4-tolune diisocyanate	584-84-9	gas	Nitro Org	reaction	
o-toluidine	95-53-4	gas	Nitro Org	reaction	
triethylamine	121-44-8	gas	Nitro Org	reaction	
trifluralin	1582-09-8	gas	Pestic	reaction	also particle phase
vinyl acetate	108-05-4	gas	Oxy Org	reaction	
vinylidene chloride (1,1-dichloroethylene)	75-35-4	gas	Hal Hydro	reaction	
xylenes (isomers and mixture)	1330-20-7	gas	Arom	reaction	

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
o-xylenes	95-47-6	gas	Arom	reaction	
m-xylenes	108-38-3	gas	Arom	reaction	
glycol ethers	0	gas	Oxy Org	reaction	

[a] Structural class abbreviations: Arom = aromatic; Hal Arom = halogenated aromatic; Hal Hydro = halogenated hydrocarbon; Hydro = hydrocarbon; Inorg = inorganic; Nitro Org = nitrogenated organic; Oxy Org = oxygenated organic; Pestic = pesticide; Phthal = phthalate; Sulfat = sulfate
[b] Reaction is with hydroxyl radical unless indicated otherwise

Table II. HAPs with short to medium atmospheric lifetimes (< 1 day to 1-5 days).

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
bis(chloromethyl)ether	542-88-1	gas	Oxy Org	rxn with liquid water	
chloromethyl methyl ether	107-30-2	gas	Oxy Org	rxn with liquid water	
ethylene imine (aziridine)	151-56-4	gas	Nitro Org	reaction	
methyl methacrylate	80-62-6	gas	Oxy Org	reaction	
vinyl bromide	593-60-2	gas	Hal Hydro	reaction	
vinyl chloride	75-01-4	gas	Hal Hydro	reaction	
p-xylenes	106-42-3	gas	Arom	reaction	
polycyclic organic matter	0	gas	Arom	reaction	also particle phase

[a] Structural class abbreviations: Arom = aromatic; Hal Arom = halogenated aromatic; Hal Hydro = halogenated hydrocarbon; Hydro = hydrocarbon; Inorg = inorganic; Nitro Org = nitrogenated organic; Oxy Org = oxygenated organic; Pestic = pesticide; Phthal = phthalate; Sulfat = sulfate
[b] Reaction is with hydroxyl radical unless indicated otherwise

Table III. HAPs with medium atmospheric lifetimes (1-5 days).

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
acetophenone	98-86-2	gas	Oxy Org	reaction	
dichloroethyl ether	111-44-4	gas	Oxy Org	reaction	
dimethyl phthalate	131-11-3	gas	Phthal	reaction	
2,4-dinitrotoluene	121-14-2	gas	Nitro Org	photolysis	
1,4-dioxane (1,4-diethyleneoxide)	123-91-1	gas	Oxy Org	reaction	
1,2-epoxybutane	106-88-7	gas	Oxy Org	reaction	
ethyl acrylate	140-88-5	gas	Oxy Org	rxn with ozone	
ethylene glycol	107-21-1	gas	Oxy Org	reaction	
ethylidene dichloride (1,1-dichloroethane)	75-34-3	gas	Hal Hydro	reaction	
formaldehyde	50-00-0	gas	Oxy Org	photolysis	formed in atmospheric reactions
hydrochloric acid	7647-01-0	gas	Inorg	deposition	
hydrogen fluoride (hydrofluoric acid)	7664-39-3	gas	Inorg	deposition	
hydroquinone	123-31-9	gas	Oxy Org	reaction	also particle phase
methanol	67-56-1	gas	Oxy Org	reaction	
methyl isobutyl ketone (hexanone)	108-10-1	gas	Oxy Org	reaction	
methyl *tert*-butyl ether	1634-04-4	gas	Oxy Org	reaction	
phosgene	75-44-5	gas	Oxy Org	rxn with liquid water	
1,3-propane sulfone	1120-71-4	gas	Oxy Org	reaction	
propionaldehyde	123-38-6	gas	Oxy Org	reaction	
quinoline	91-22-5	gas	Nitro Org	reaction	
styrene oxide	96-09-3	gas	Oxy Org	reaction	
2,3,7,8-tetrachloro-dibenzo-*p*-dioxin	1746-01-6	gas	Hal Arom	reaction	also particle phase
toluene	108-88-3	gas	Arom	reaction	
2,2,4-trimethylpentane	540-84-1	gas	Hydro	reaction	

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
radionuclides	0	particle	Inorg	radioactive decay	radon in gas phase

[a] Structural class abbreviations: Arom = aromatic; Hal Arom = halogenated aromatic; Hal Hydro = halogenated hydrocarbon; Hydro = hydrocarbon; Inorg = inorganic; Nitro Org = nitrogenated organic; Oxy Org = oxygenated organic; Pestic = pesticide; Phthal = phthalate; Sulfat = sulfate

[b] Reaction is with hydroxyl radical unless indicated otherwise

Table IV. HAPs with medium to long atmospheric lifetimes (1-5 days to > 5 days).

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
acrylonitrile	107-13-1	gas	Nitro Org	reaction	
benzyl chloride	100-44-7	gas	Hal Arom	reaction	
carbon disulfide	75-15-0	gas	Inorg	reaction	
4-nitrobiphenyl	92-93-3	gas	Nitro Org	reaction	also particle phase
4-nitrophenol	100-02-7	gas	Nitro Org	reaction	also particle phase

[a] Structural class abbreviations: Arom = aromatic; Hal Arom = halogenated aromatic; Hal Hydro = halogenated hydrocarbon; Hydro = hydrocarbon; Inorg = inorganic; Nitro Org = nitrogenated organic; Oxy Org = oxygenated organic; Pestic = pesticide; Phthal = phthalate; Sulfat = sulfate

[b] Reaction is with hydroxyl radical unless indicated otherwise

Table V. HAPs with long atmospheric lifetimes (> 5 days).

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
acetonitrile	75-05-8	gas	Nitro Org	reaction	
asbestos	1332-21-4	particle	Inorg	deposition	
benzene	71-43-2	gas	Arom	reaction	
benzotrichloride	98-07-7	gas	Hal Arom	reaction	
carbon tetrachloride	56-23-5	gas	Hal Hydro	photolysis	
carbonyl sulfide	463-58-1	gas	Oxy Org	reaction	
chloroacetic acid	79-11-8	gas	Oxy Org	reaction	
2-chloroacetophenone	532-27-4	gas	Oxy Org	reaction	
chlorobenzene	108-90-7	gas	Hal Arom	reaction	
chloroform	67-66-3	gas	Hal Hydro	reaction	
1,2-dibromo-3-chloro-propane	96-12-8	gas	Hal Hydro	reaction	
1,4-dichlorobenzene(*p*)	106-46-7	gas	Hal Arom	reaction	
4,6-dinitro-*o*-cresol, and salts	534-52-1	gas	Nitro Org	reaction	also particle phase
2,4-dinitrophenol	51-28-5	gas	Nitro Org	reaction	also particle phase
epichlorohydrin (1-chloro-2,3-epoxy-propane)	106-89-8	gas	Oxy Org	reaction	
ethyl chloride (chloroethane)	75-00-3	gas	Hal Hydro	reaction	
ethylene dibromide (dibromoethane)	106-93-4	gas	Hal Hydro	reaction	
ethylene dichloride (1,2-dichloroethane)	107-06-2	gas	Hal Hydro	reaction	
ethylene oxide	75-21-8	gas	Oxy Org	reaction	
hexachlorobenzene	118-74-1	gas	Hal Arom	reaction	
hexachlorobutadiene	87-68-3	gas	Hal Hydro	reaction	
hexachloroethane	67-72-1	gas	Hal Hydro	reaction	
methyl bromide (bromomethane)	74-83-9	gas	Hal Hydro	reaction	
methyl chloride (chloromethane)	74-87-3	gas	Hal Hydro	reaction	

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
methyl chloroform (1,1,1-trichloroethane)	71-55-6	gas	Hal Hydro	reaction	
methyl iodide (iodomethane)	74-88-4	gas	Hal Hydro	reaction	
methylene chloride (dichloromethane)	75-09-2	gas	Hal Hydro	reaction	
nitrobenzene	98-95-3	gas	Nitro Org	reaction	
pentachloronitro-benzene	82-68-8	gas	Nitro Org	reaction	
pentachlorophenol	87-86-5	gas	Oxy Org	reaction	also particle phase
phthalic anhydride	85-44-9	gas	Phthal	reaction	
polychlorinated biphenyls (Aroclors)	1336-36-3	gas	Hal Arom	reaction	also particle phase
beta-propiolactone	57-57-8	gas	Oxy Org	reaction	
propylene dichloride (1,2-dichloropropane)	78-87-5	gas	Hal Hydro	reaction	
propylene oxide	75-56-9	gas	Oxy Org	reaction	
quinone	106-51-4	gas	Oxy Org	reaction	
1,1,2,2,-tetrachloro-ethane	79-34-5	gas	Hal Hydro	reaction	
tetrachloroethylene (perchloroethylene)	127-18-4	gas	Hal Hydro	reaction	
toxaphene (chlorinated camphene)	8001-35-2	gas	Pestic	deposition	also particle phase
1,2,4-trichlorobenzene	120-82-1	gas	Hal Arom	reaction	
1,1,2-trichloroethane	79-00-5	gas	Hal Hydro	reaction	
trichloroethylene	79-01-6	gas	Hal Hydro	reaction	
2,4,5-trichlorophenol	95-95-4	gas	Oxy Org	reaction	
2,4,6-trichlorophenol	88-06-2	gas	Oxy Org	reaction	
antimony cpds	0	particle	Inorg	deposition	metal density 6.7 g/cm^3
arsenic cpds (incl. Arsine)	0	particle	Inorg	deposition	arsine in gas phase; metal density 4.7 g/cm^3
beryllium cpds	0	particle	Inorg	deposition	metal density 1.8 g/cm^3

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HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
cadmium cpds	0	particle	Inorg	deposition	metal density 8.6 g/cm^3
chromium cpds	0	particle	Inorg	deposition	metal density 7.1 g/cm^3
cobalt cpds	0	particle	Inorg	deposition	metal density 8.9 g/cm^3
cyanide cpds	0	particle	Inorg	deposition	cyanic acid in gas phase
lead cpds	0	particle	Inorg	deposition	metal density 11.3 g/cm^3
manganese cpds	0	particle	Inorg	deposition	metal density 7.5 g/cm^3
mercury cpds	0	gas	Inorg	rxn with aqueous ozone	metal density 13.5 g/cm^3
fine mineral fibers	0	particle	Inorg	deposition	
nickel cpds	0	particle	Inorg	deposition	metal density 8.9 g/cm^3
selenium cpds	0	particle	Inorg	deposition	metal density 4.8 g/cm^3

[a] Structural class abbreviations: Arom = aromatic; Hal Arom = halogenated aromatic; Hal Hydro = halogenated hydrocarbon; Hydro = hydrocarbon; Inorg = inorganic; Nitro Org = nitrogenated organic; Oxy Org = oxygenated organic; Pestic = pesticide; Phthal = phthalate; Sulfat = sulfate
[b] Reaction is with hydroxyl radical unless indicated otherwise

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Table VI. HAPs without atmospheric lifetime information.

HAP Name	CAS No.	Predominant Phase	Structural Class [a]	Main Removal Mechanism [b]	Comments
acrylamide	79-06-1	gas	Nitro Org		
bromoform	75-25-2	gas	Hal Hydro		
caprolactam	105-60-2	gas	Oxy Org		
chloramben	133-90-4	gas	Pestic		also particle phase
dimethyl formamide	68-12-2	gas	Nitro Org		
ethylene thiourea	96-45-7	gas	Nitro Org		also particle phase
hexamethylene-1,6-diisocyanate	822-06-0	gas	Nitro Org		
hexamethyl-phosphoramide	680-31-9	gas	Nitro Org		
titanium tetrachloride	7550-45-0	gas	Inorg		
coke oven emissions	0	gas	Arom		

[a] Structural class abbreviations: Arom = aromatic; Hal Arom = halogenated aromatic; Hal Hydro = halogenated hydrocarbon; Hydro = hydrocarbon; Inorg = inorganic; Nitro Org = nitrogenated organic; Oxy Org = oxygenated organic; Pestic = pesticide; Phthal = phthalate; Sulfat = sulfate
[b] Reaction is with hydroxyl radical unless indicated otherwise

Table VII. Distribution of structural classes among lifetime groups.

Structural Group	Lifetime Classes						Total
	Short	Short-Med	Med	Med-Long	Long	Other	
Aromatic	12	2	2		1	1	18
Halogenated aromatic			1	1	6		8
Hydrocarbon	2		1				3
Halogenated Hydrocarbon	5	2	1		18	1	27
Oxygenated Organic	10	3	15		11	1	40
Nitrogenated Organic	33	1	2	3	5	5	49
Pesticide	13				1	1	15
Phthalate	2		1		1		4
Sulfate	2						2
Inorganic	4		3	1	14	1	23
Total	83	8	26	5	57	10	189

APPENDIX B

RESULTS OF THE LITERATURE REVIEW

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Ref. No.	Supporting Information	Sources
1-1	**Acetaldehyde** Source #TL17 measured acetaldehyde concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed. The I/O average ratio calculated by TRJ researchers was **1.4**, indicating the presence of sources near the vehicle. Therefore, the difference between the average in-vehicle and ambient concentrations can be used to estimate a lower bound for the ADD factor. This difference was 1.8 ppb (3.2 μg/m^3). **ADD = 3.2 μg/m^3** (Quality Code = 2)	TL17
1-1	**Acetaldehyde** Author: South Coast Air Quality Management District ▸ Report gives results of concurrent **in-vehicle** and ambient (fixed site) monitoring study. ▸ Table 3-3 (p. 37) presents a comparison of in-vehicle and background mean concentrations. ◦ Since measurements were reported only for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the MULT factor. From Table 3-3: **MULT = 1.4**	MZ 37 (subset of this data reported in MZ 33)
1-13	**Acetaldehyde** Author: Gonzalez-Flesca, N. Has indoor & outdoor measurements for each of the ten residences measured. Indoor samples taken in bedroom of residences. Outdoor measurements taken at various locations. In addition, a fixed, central-site monitor was used and may provide input to a proximately factor. **From Tables 1 & 2:** **PEN PROX MULT ADD** **12.2 0.71 8.7**	MZ 3
1-13	**Acetaldehyde** Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ Table 1 has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ Table 2 (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **I/O ratio (mean) = 6.0** **I/O ratio (median) = 3.6**	MZ 27

Ref. No.	Supporting Information	Sources
1-13	<u>Acetaldehyde</u> Source #<u>TL02</u> measured simultaneous indoor and outdoor acetaldehyde concentrations for 10 residences in Roanoke, VA during the period November 1988 - February 1989. The authors reported the data as results from a source model (Table II), from which original measured concentrations can be back-calculated. The presence of indoor sources was not independently determined. The residences were heated by either gas or electricity, with no information provided regarding cooking or garage status. Therefore, the information was assigned to ME # 13. TRJ researchers calculated concurrent I/O ratios from the original concentration data and averaged the ratios. In the absence of indoor sources, this method should yield an estimate of the PEN factor. However, the average I/O ratio was calculated to be **5.7**, indicating that significant indoor sources were present. The authors estimated the indoor source contribution for each of the residences by subtracting the measured outdoor concentration from the measured indoor concentration. The average indoor source contribution was 7.6 $\mu g/m^3$. This represents a lower bound on the ADD factor. **ADD = 7.6 $\mu g/m^3$** (Quality Code = 1)	TL02
1-13	<u>Acetaldehyde</u> Author: Barguil, S., Le Moullec, Y., Person, A., Laurent, A-M, and Festy, B. ▸ Study which reports concurrent indoor and outdoor measurements taken in **residences** (5 detached houses and 4 apartments). ∘ The paper reports the average I/O measurements (Fig 2. — bar chart) of samples taken over the entire length of the study (Sept. 1987 – Aug. 1988). **I/O ratios (average of 75 samples):** **PEN = 2.0**	MZ 36
1-17	<u>Acetaldehyde</u> Author: Brickus, L.; Cardoso, J.; de Aquino Neto, F. Reports concurrent measurements of aldehyde and VOC concentrations on four different floors of an **office building** for several different days. I/O ratios provided – see tables 1, 2, & 3. **Mean PEN (building wide) = 1.3** (Range: 0.1 – 2.2)	MZ 10

1-34	<u>Acetaldehyde</u>
	Author: Gonzalez-Flesca, N.
	Has indoor & outdoor measurements for each of the ten residences measured. Indoor samples taken in bedroom of residences. Outdoor measurements taken at various locations. In addition, a fixed, central-site monitor was used and may provide input to a proximately factor.
	From Table 1:
	      PROX
	      0.71 (note: this is the same value as shown for PROX above)
		MZ 3

Ref. No.	Supporting Information	Sources
3-13	**Acrylonitrile** Source #<u>TL03</u> measured simultaneous indoor and outdoor acrylonitrile concentrations for 44 residences in Toronto in the winter and spring of 1996. The authors reported average indoor and outdoor concentrations (Table 1), from which the I/O average ratio can be computed. Stove/garage sources in the residences were not identified. Therefore, the information was assigned to ME # 13. The I/O average ratio calculated by TRJ researchers was **5.3**, indicating the presence of significant indoor sources. Therefore, the difference between the average indoor and outdoor concentrations can be used to estimate a lower bound for the ADD factor. This difference was $0.11 \ \mu g/m^3$. **ADD = 0.11 μg/m^3** (Quality Code = 2)	TL03
5-1	**Benzene** Author: Leung, PL.; Harrison, RM. In-vehicle, immediately outside the vehicle (out-vehicle), and roadside SIMULTANEOUS sampling on six different roads. Roadside (static/fixed-site) sampling sites at different distances from road and measured at different heights Ambient air concentrations – continuous measurements at a background location – measured data each hour throughout the year. Ambient data presented as mean over the sampling period (p. 194) Table 2: DAILY means and standard deviations of concentrations in-vehicle, out-vehicle, roadside, and ambient. **Table 4: I/O ratios for benzene on six different roads** Comparison of in-vehicle vs. out-vehicle concentrations during rush hours and non-rush hours – Tables 6&7. Comparison of in-vehicle vs. out-vehicle concentrations for different types of cars – Tables 8&9. **PEN = 1.17** **MULT = 12.17** **PROX = 10.52**	RA 32
5-1	**Benzene** Author: Liu, C.S., Shikiya, D., Kahn, M.I., and Juarros, J. ▸ Paper reports results of concurrent **in-vehicle** and <u>ambient</u> (fixed site) monitoring study. ▸ <u>Figure 1</u> (p. 250) summarizes the data with a bar graph. ∘ Since measurements were reported for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Fig. 1</u>: **MULT = 2.5**	MZ 33 (Results also reported in MZ 37)

Ref. No.	Supporting Information	Sources
5-1	**Benzene** Source #<u>TL01</u> computed ME factors using regression analysis of data collected by RTI in Los Angeles. In September and October 1997, researchers collected benzene concentration measurements during a series of "commutes". RTI data included simultaneous measurements inside the vehicle, outside the vehicle, along the roadways, and at the nearest ambient monitoring stations. ADD and MULT factors were available directly from the regression of in-vehicle concentration against ambient monitor concentration (Eq 20). The PROX factor was available from regression of outside-vehicle concentration against ambient monitor concentration (Eq 22). The PEN factor can then be calculated from the formula PEN = (MULT) / (PROX). The ME factors from Source #TL01 are: **ADD = 11 μg/m^3** ; PROX = 0.90 ; **PEN = 1.11**; MULT = 1.00 (Quality Code = 1). Source #<u>TL04</u> simultaneously measured benzene concentrations inside the vehicle (passenger sedan), outside the vehicle, and at a nearby fixed-site monitor in Raleigh, NC during the summer of 1988. The authors calculated in-vehicle / vehicle exterior ratios for each concurrent measurement pair (Table V), which can be used to estimate the PEN factor (**PEN = 1.08**; Quality Code = 1). The authors also reported median in vehicle, vehicle exterior, and fixed-site concentrations (Table II), which can be used to calculate average ratios of in-vehicle / fixed-site (I/F) and vehicle exterior / fixed-site (E/F) concentrations. TRJ researchers calculated the I/F ratio to be 6.7 and the E/F ratio to be 6.9, indicating significant sources near the vehicle (as expected). Therefore, the concentration information can be used to estimate the ADD factor from the difference between the in-vehicle and fixed-site concentration (**ADD = 9.1 μg/m^3** ; Quality Code = 2). Source #<u>TL05</u> measured concurrent in-vehicle (passenger cars) and ambient benzene concentrations during city driving in Sydney, Australia (date not given). The authors report average concentrations (Table 1), from which an in-vehicle / ambient ratio can be calculated. TRJ researchers calculated this ratio to be 11, indicating significant sources near the vehicle. Therefore, the concentration information was used to estimate the ADD ME factor, as with Source #TL04 above (**ADD = 64 μg/m^3** ; Quality Code = 2). Source #<u>TL06</u> measured concurrent in-vehicle (passenger car) and vehicle exterior benzene concentrations during suburban commuting in New Jersey during the period from January 1991 to July 1992. The authors report the average concentrations in graphical form (Figure 4), allowing calculation of the in-vehicle / vehicle exterior average ratio (PEN factor). TRJ researchers scaled the concentrations from the graph and computed the PEN factor as follows: in-vehicle conc. = 13.0; vehicle exterior conc. = 13.4 (**PEN = 0.97**; Quality Code = 2).	TL01, TL04, TL05, TL06
5-1	**Benzene** Author: Shahnaz Alimokhtari Vayghani and Clifford Weisel Data presented for paired measurements of in-car and "at the pump" concentrations *during refueling* (Table 1). **I/O* ratio (median) = 2.3** * I=in-cabin, O=at the pump.	MZ 13

Ref. No.	Supporting Information	Sources
5-1	<u>Benzene</u> Author: Jo, W.K.; Park, K.H. In-vehicle and ambient concentrations of VOCs measured prior to and during idling presented GRAPHICALLY. - p. 220. Fig. 1. See RA21(data presented in table format), MZ12. Bar graphs of concentrations measured in-car and ambient are presented for both idling and driving conditions. Mean ambient roadway air samples and invehicle concentrations with standard deviation for 115 commutes in Korean urban route for two types of cars (old model=Elantra; new model =Sonata II). NEW MODEL: Mean indoor conc reported: 49ug/m^3 Mean outdoor conc reported: 24.9ug/m^3 **PEN= I/O = 49/24.9 = 1.97** OLD MODEL: Mean indoor conc reported: 49.1ug/m^3 Mean outdoor conc reported: 25.8ug/m^3 **PEN= I/O = 49.1/25.8 = 1.9**	RA 19 RA21 MZ 12

5-1	<u>Benzene</u>
	Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M.
	▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by **<u>car</u>**, <u>subway</u>, <u>bicycling (other)</u>, and <u>walking</u>. -- See <u>Table I</u>, (p. 1596).
	  ∘ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient.* ***Therefore, only calculation of a MULT factor is possible.***
	▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597).
	  ∘ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.*
	▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples.
	  ∘ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time.
	▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.
	
	MULT (median) = 1.8
		MZ 34

5-1	<u>Benzene</u> Author: Weisel, C.P., Nicholas, N.J., and Lioy, P.J. ▸ Numerous HAPs/VOCs were measured in automobile interiors. Ambient outdoor HAPs measured at the start of a commute and at the end of a commute for benzene and xylenes. ∘ <u>Table 7</u> – provides mean automobile cabin and suburban outdoor concentrations for benzene and xylenes from this study. ▸ <u>No</u> measurements from the exterior of the vehicle were reported. Therefore, only calculation of a MULT factor is feasible. ▸ This study also summarizes indoor and outdoor measurements from other studies (TEAM and SCAQMD). The average values reported do not appear to be concurrent. <u>From Table 7</u>: **MULT (mean value) = 12.0**	MZ 16

Ref. No.	Supporting Information	Sources
5-1	<u>Benzene</u> Author: Wan-Kuen Jo and Kun-Ho Park Table 1has data on concentrations for **in-auto**, in-bus, and ambient air. Also, just below this table, the authors provide ratios for in-auto/in-bus/fixed-site. Finally, a possible proximity factor is suggested (also just below <u>Table 1</u>). No measurements for outside the vehicle were reported. **PEN PROX MULT** [Ratio calculated using <u>median</u> measurement values] **N/A N/A 9.4**	MZ 14
5-1	<u>Benzene</u> Source #<u>TL17</u> measured benzene concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed. The I/O average ratio calculated by TRJ researchers was **2.5**, indicating the presence of in-vehicle sources. Therefore, the difference between the average in-vehicle and ambient concentrations can be used to estimate a lower bound for the ADD factor. This difference was 8 ppb (25 μg/m^3). **ADD = 25 μg/m^3** (Quality Code = 2)	TL17
5-1	<u>Benzene</u> Author: Jo, W.K.; Park, K.H. In-vehicle and ambient concentrations of VOCs measured prior to and during idling presented GRAPHICALLY. - p. 220. Fig. 1 See RA21, MZ12. Bar graphs of concentrations measured in-car and ambient are presented for both idling and driving conditions.	RA 19 MZ 12
5-1	<u>Benzene</u> Author: Duffy, B.L., Nelson, P.F. Average in-vehicle concentrations (ppb) in catalyst equipped vs. non catalyst equipped cars and ambient air concentrations – Table 1. I/O ratios – Table 2 (p.3880). POST-1986 CARS **MULT = 11 (morning commute)** **I/O ratio = PEN =22.1/2 = 11.05 (morning peak-hour)** **PROX = MULT/PEN = 11/11.05 = 0.99 (morning)** **MULT= 3 (midday)** **I/O ratio = PEN =____(midday)** PRE-1986 CARS **MULT = 27 (morning commute)** **I/O ratio = PEN = 48.1/1.8 = 26.7 (morning peak-hour)** **PROX = MULT/PEN =27/26.7 = 1.01** **MULT = 18 (midday)** **I/O ratio = PEN =____(midday)**	RA 7

B-6

Ref. No.	Supporting Information	Sources
5-1	<u>Benzene</u> Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for **in-vehicle (ME #1)**, car exterior, fixed-site, and sidewalk (i.e., <u>near road) (ME #7)</u>. Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. From Table II *(Median values)*: **<u>PROX</u> <u>PEN</u> <u>MULT</u>** **PEN Range** (from Table V)**: 0.75 – 2.49** **6.9 0.96 6.7**	MZ 28
5-2	<u>Benzene</u> Source #<u>TL19</u> measured benzene concentrations in buses and along the roadway (10 meters from the road) during commutes in the city of Taegu, Korea during the winter of 1996-97. The authors present mean concentrations for approximately 50 samples (Table 2), from which an I/O average ratio can be calculated. The I/O ratio calculated by TRJ researchers was **2.9**, indicating the presence of benzene sources. Since the buses used diesel fuel, the roadway is likely to be a larger benzene source than the bus microenvironment. This situation, with the source occurring between the ambient monitor and the microenvironment, provides information relevant to the PROX factor rather than the PEN factor. In this case, the two factors cannot be distinguished since no measurements were made directly at the bus exterior. Therefore, the I/O ratio can be used to estimate the MULT factor for this microenvironment. MULT = 2.9 (Quality Code = 2)	TL19
5-2	<u>Benzene</u> Author: Wan-Kuen Jo and Kun-Ho Park Table 1 has data on concentrations for in-auto, **in-bus**, and ambient air. Also, just below this table, the authors provide ratios for in-auto/in-bus/fixed-site. Finally, a possible proximity factor is suggested (also just below <u>Table 1</u>). Assumed that in-bus and roadway concentrations were the same. **<u>PEN</u> <u>PROX</u> <u>MULT</u>** [All ratios calculated using <u>median</u> measurement values.] **1.0 3.5 3.5**	MZ 14
5-2	<u>Benzene</u> Author: Duffy, B.L., Nelson, P.F. Average in-vehicle concentrations (ppb) in catalyst equipped vs. non catalyst equipped cars and ambient air concentrations – Table 1. I/O ratios – Table 2 (p.3880). **I/O ratio = PEN = 9.4/10.3 = 0.91; 7.2/7.9 = 0.91 (morning peak-hour)** **I/O ratio = PEN = 4.5/5.7 = 0.79 (midday)** **I/O ratio = PEN = 6/9.1 = 0.66 (evening peak-hour)**	RA 7

Ref. No.	Supporting Information	Sources
5-2	<u>Benzene</u> Source #<u>TL05</u> measured concurrent in-vehicle (bus) and ambient benzene concentrations during city driving in Sydney, Australia (date not given). The authors report individual concentration pairs (Table 5), from which in-vehicle / vehicle exterior ratios can be calculated. The average of these ratios is an estimate of the PEN factor. **PEN = 0.84**; (Quality Code = 1)	TL05

5-4	<u>Benzene</u>
	Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M.
	▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, **bicycling (other)**, and walking. -- See <u>Table I</u>, (p. 1596).
	  ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient. **Therefore, only calculation of a MULT factor is possible.***
	▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597).
	  ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.*
	▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples.
	  ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time.
	▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.
	
	MULT (median) = 0.9
		MZ 34

5-5	<u>Benzene</u> Author: Schwar, M.; Booker, J.; Tait, L. Comparison of concentrations **in the car park** vs. **at the exit of the car park**. Max. concentrations averaged over specified time periods. Table 7. WEEKDAYS (11 GARAGES) Mean of averaged 1-hr inside car park conc: 0.25mg/m^3 Mean of averaged 1-hr exit of car park conc: 0.16mg/m^3 **PEN= I/O = 0.25/0.16 = 1.6** WEEKENDS (5 GARAGES) Mean of averaged 1-hr inside car park conc: 0.24mg/m^3 Mean of averaged 1-hr exit of car park conc: 0.34mg/m^3 **PEN= I/O = 0.24/.34 = 0.71**	RA 24
5-5	<u>Benzene</u> Source #<u>TL05</u> measured concurrent benzene concentrations in a covered parking garage and at an ambient monitoring site in Sydney, Australia (date not given). The authors report average concentrations, allowing calculation of the I/O average ratio. TRJ researchers calculated this ratio to be **41**, indicating significant sources in the parking garage. Therefore, the concentration information was used to estimate the ADD factor by subtracting the ambient concentration from the parking garage concentration. **ADD = 38 μg/m^3** ; (Quality Code = 2)	TL05

Ref. No.	Supporting Information	Sources
5-7	<u>Benzene</u> Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for <u>in-vehicle (ME #1)</u>, car exterior, fixed-site, and sidewalk (i.e., **near road) (ME #7)**. Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. <u>From Table II</u>: **PROX** **4.4** *Median value*	MZ 28
5-7	<u>Benzene</u> Source #<u>TL01</u> computed ME factors using regression analysis of data collected by RTI in Los Angeles. In September and October 1997, researchers collected benzene concentration measurements during a series of "commutes". RTI data included simultaneous measurements along the roadway and at the nearest ambient monitoring stations. ADD and MULT factors were available directly from the regression of roadside concentration against ambient monitor concentration (Eq 25). The ME factors from Source #TL01 are: **ADD = 3 μg/m^3** ; **MULT = 1.40** (Quality Code = 1). Source #<u>TL04</u> simultaneously measured benzene concentrations along the roadway and at a nearby fixed-site monitor in Raleigh, NC during the summer of 1988. The authors reported median sidewalk and fixed-site concentrations (Table II), which can be used to calculate a ratio of average sidewalk / fixed-site concentrations. TRJ researchers calculated this ratio to be **4.4**, indicating significant sources near the roadway (as expected). Therefore, the concentration information can be used to estimate the ADD factor from the difference between the sidewalk and fixed-site concentration (**ADD = 5.5 μg/m^3** ; Quality Code = 2).	TL01, TL04
5-11	<u>Benzene</u> Source #<u>TL18</u> measured simultaneous garage and outdoor benzene concentrations at three New Jersey residences with attached garages during December 1987. The authors report mean concentrations for each residence (Table 3), from which I/O average ratios can be computed. For all three residences, the I/O ratio was greater than 1 (**I/O ratio = 2.1, 6.5, and 15**, respectively). This indicates the presence of significant sources within the garages. Therefore, the difference between the mean garage and outdoor concentrations can be used to estimate a lower bound for the ADD factor. These differences were 5.2 μg/m^3, 26.2 μg/m^3, and 93.4 μg/m^3 respectively. Taking the arithmetic mean of these values, ADD can be estimated to be 42 μg/m^3 (geometric mean = 23 μg/m^3). **ADD = 42 μg/m^3** (Quality Code = 2)	TL18

Ref. No.	Supporting Information	Sources

5-13	<u>Benzene</u>
	Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., et al.
	▸ Summary of TEAM study in NJ (Fall, 1981).
	▸ Samples collected for:
	    personal air - two consecutive 12-hr samples taken from appr. 350 people,
	    outdoor air - two consecutive 12-hr samples taken from appr. 90 people, also drinking
	      water and breath.
	<u>Table 9</u> reports a summary of median, max. concs., and ratios (from both the median and max. conc. data) for 85 matched overnight personal air and overnight outdoor air samples. (It is our conclusion that this data provides the best concurrent I/O ratios for **residences** from this study.)
	
	PEN = 1.9 (median value)
		MZ 22

5-13	<u>Benzene</u>
	Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M.
	▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596).
	  ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate.*
	▸ In addition, VOC concs. were also measured in subjects' **residences** and in <u>offices</u> -- See <u>Table III</u>, (p. 1597).
	  ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.*
	▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples.
	  ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time.
	▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.
		MZ 34

5-13	<u>Benzene</u> Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. NOTE: See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **I/O =PEN = 1.86 (spring); 2.46 (summer)**	RA 29
5-13	<u>benzene</u> Author: Barguil, S., Le Moullec, Y., Person, A., Laurent, A-M, and Festy, B. ▸ Study which reports concurrent indoor and outdoor measurements taken in **residences** (5 detached houses and 4 apartments). ◦ The paper reports the average I/O measurements (Fig 2. - bar chart) of samples taken over the entire length of the study (Sept. 1987 - Aug. 1988). **I/O ratios (average of 75 samples):** **PEN = 2.75**	MZ 36

Ref. No.	Supporting Information	Sources
5-13	<u>Benzene</u> Author: Bouhamra, W.S. Table 2 (p.199) -- Indoor VOCs concentrations. Table 3 (p.200) -- Ambient air VOCs concentrations. Min, max., mean, median, std. deviation provided. Table 4 (p.202) -- I/O ratios. Sampled during Dec 94-Jan 95. CONCURRENT MEASUREMENTS. **I/O ratio provided: 1.04=PEN** Ambient air conc. provided: 1805ug/m^3 (mean),1916ug/m^3(median), 537ug/m^3(min), 3263ug/m^3(max),742ug/m^3(std. dev) Indoor air conc provided: 1882ug/m^3 (mean), 1774ug/m^3(median), 626ug/m^3(min), 3788ug/m^3(max), 1009ug/m^3(std. dev) **MULT = (indoor conc)/(ambient conc) = 1774/1916 = 0.93 (from median conc)** Since PEN>1 ==> calculate ADD: Indoor conc (median) = 1774ug/m^3; PEN = I/O = 1.04; Outdoor conc (calculated) = 1774/1.04 = 1705ug/m^3 **69ug/m^3<ADD<1774 ug/m^3** **PROX (calculated from medians) 1705/1916 =0.37**	RA 14
5-13	<u>Benzene</u> Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., Sparacino, C., et al. ▸ Results of the TEAM study that report measurements of personal and outdoor air sampling; in addition, breath and drinking water samples were measured. ◦ The personal and outdoor air measurements were 12-hr integrated samples. These roughly correspond to daytime (6am-6pm) and nighttime (6pm-6am). Unfortunately, the personal and outdoor results for NJ (Table 2) are combined into 24-hr averages. ▸ Fig. 2 (p. 297) has a bar graph of the nighttime (6pm-6am) personal (might be used as a surrogate for indoor residence) and outdoor concentrations. NOTE: these are geometric means with more than four times the number of personal (347) compared to outdoor samples (84). ◦ *Also, all I/O ratios are greater than 1.5.* ▸ Table 3 also has 24-hr averaged results of personal air and outdoor air sampling for Greensboro, NC and Devils Lake, ND.	MZ 30
5-13	<u>Benzene</u> Author: Wallace, L. (EPA/600/6-87/002a) "Blue book" ▸ Bound volume of results from the TEAM studies. Indoor ME is **residence**. ▸ <u>Table 29</u> (pp. 61-62) provide indoor/outdoor comparisons (and ratios) for <u>matched</u> samples. ◦ These concentrations are median values for the 12-hr nighttime samples collected for two seasons (Jan. 1984 and May 1984) in LA, and during June 1984 in Contra Costa. ▸ <u>Table 46</u> (p. 97) provides median concentrations for indoor air in New Jersey (three different sampling periods) and California (also three different sampling periods). ▸ <u>Table 47</u> (p. 98) provides median concentrations for outdoor air in New Jersey (the same three sampling periods for NJ in Table 46) and California (the same three sampling periods for CA in Table 46). ◦ However, the number of outdoor measurements are always less than the number of indoor measurements. <u>From Table 29</u>: **<u>LA(1/84)</u> <u>LA(5/84)</u> <u>Contra(6/84)</u> <u>Avg.</u>** **PEN** (medians)**: 1.1 1.7 2.3 1.7**	MZ 38

Ref. No.	Supporting Information	Sources
5-13	<u>Benzene</u> Author: Gonzalez-Flesca, N. Has indoor & outdoor measurements for each of the ten residences measured. Indoor samples taken in bedroom of residences. Outdoor measurements taken at various locations. In addition, a fixed, central-site monitor was used and may provide input to a proximately factor. **From Tables 1 & 2:** **PEN PROX MULT ADD** **2.6 0.76 2.0**	MZ 3
5-13	<u>Benzene</u> Author: Crump, D.R. Indoor & outdoor measurements of HAPs over 2 years with data reported for a summer season only and a winter season only. Measurements are for four newly constructed unoccupied test houses. Although the methods state that measurements were taken in the living room, kitchen, bedrooms, and bathroom; only the average for the whole house was reported. The mean, max, and minimum data provided for each house and for each contaminant measured in each house for two consecutive years. **House T1 / PEN* / Mean** 		Yr. 1	Yr. 2	Summer	Winter	(S and W only)
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benzene	4.5	0.8	1.0	1.0	1.0 | **House T2 / PEN* / Mean** |	Yr. 1	Yr. 2	Summer	Winter	(S and W only)
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benzene	0.9	1.0	0.75	1.0	0.9 | **House M3 / PEN* / Mean** |	Yr. 1	Yr. 2	Summer	Winter	(S and W only)
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benzene	1.3	1.4	1.0	1.25	1.1 | **House M4 / PEN* / Mean** |	Yr. 1	Yr. 2	Summer	Winter	(S and W only)
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benzene	1.3	0.8	1.25	1.0	1.1	 *Mean values **Overall Mean: benzene 1.0** **(all houses, S and W only)**	MZ 2
5-13	<u>Benzene</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided – Tables 3,4&5 **I/O ratio provided from median conc = PEN = 1.1**	RA 35

Ref. No.	Supporting Information	Sources
5-13	**Benzene** Author: Gilli, G Concurrent indoor and outdoors (apartment),ambient fixed-site, and personal samples collected. I/O ratios reported (Table 3) I/O Ratios for Benzene: **3.78 (day), 2.68 (night)** Mean indoor, outdoor, and personal concentrations reported (Table 4) **Dec. 1991 mean *I/O ratio* provided:** **3.78 (day) = PEN (day);** **2.68 (night) = PEN (night)** Winter 1991mean *ambient conc* provided = 9.84 ppb Dec. 1991 mean indoor conc provided (day) = 16.25 ppb Dec. 1991 mean indoor conc provided (night) = 18.38 ppb **MULT(day) = (indoor conc)/(ambient conc) = 16.25/9.84 = 1.65** **MULT(night) = (indoor conc)/(ambient conc) = 18.38/9.84 = 1.87** Winter 1991mean *ambient conc* provided = 9.84 ppb Dec. 1991 mean outdoor conc provided (day) = 16.45 ppb Dec. 1991 mean outdoor conc provided (night) = 18.73 ppb **PROX (day) = (outdoor conc)/(ambient conc) = 16.45/9.84 = 1.67** **PROX (night) = (outdoor conc)/(ambient conc) = 18.73/9.84 = 1.9**	RA 16 MZ 8
5-13	**Benzene** Author: Lebret, E., van de Wiel, H.J., Bos, H.P., Noij, D., and Boleij, J.S.M. ▸ Table 2 (p. 326) reports median and maximum HAP concentrations in **residences** (a total of approx. 300) of three different age groups; the median and maximum outdoor concs.; and the overall median I/O ratio for all homes. ∘ These concentrations were weekly averages. **Median, overall I/O ratios:** **benzene = 2**	MZ 26
5-13	**Benzene** Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ Table 1 has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ Table 2 (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **I/O ratio (mean) = 3.8** **I/O ratio (median) = 1.7**	MZ 27
5-13	**Benzene** Author: Schneider, P.; Lorinci, G.; Gebefugi, IL.; Heinrich, J.; Kettrup, A. Simultaneous I/O sampling in residences (p.284) Concentration profiles provided by height at which sampling took place. Table 5: median I/O ratios supplied for bedroom, living room, kitchen. Table 6: median I/O ratios (for bedroom, living room, kitchen) presented by apartment age group (old vs. new) **I/O =PEN = 1.7 (kitchen); 1.5 (living room); 1.3 (bedroom)** **Mean I/O = 1.5**	RA 30

Ref. No.	Supporting Information	Sources
5-13	<u>Benzene</u> Author: Brown, V. and Crump, D. ▸ Measurement study at **residences** using passive samplers. ∘ Samplers were exposed for 1-month periods. ∘ Far more indoor measurements (173) were taken than outdoor measurements (13). ∘ Matched samples <u>not</u> reported. ▸ <u>Table 1</u> (p. 386) reports the min, max, median, and mean for inside 173 homes; and also reports the mean for outdoors for 13 homes. Indoors* Outdoors* <u>median</u> <u>mean</u> <u>min</u> <u>max</u> <u>mean</u> <u>**mean I/O**</u> benzene 7 8 2 32 5 **1.6** * All values in μg/m^3. ▸ <u>Fig. 1</u> (p. 391) shows the mean concentrations of benzene and toluene by month for both indoors and outdoors. ∘ Not specified how many indoor (or outdoor) measurements were included in each monthly mean reported in Fig. 1's graphs. **Estimated ratios (I/O)** (from Fig. 1)**:** <u>**min**</u> <u>**max**</u> **benzene** **1.4** **2.0**	MZ 35
5-13	<u>Benzene</u> Author: Gilli, G Concurrent indoor (apartment), outdoor fixed-site, and personal samples collected. I/O ratios reported (Table 3) I/O Ratios for Benzene: **3.78 (day), 2.68 (night)** Mean indoor, outdoor, and personal concentrations reported (Table 4)	MZ 8 RA 16
5-13	<u>Benzene</u> Author: Wallace, L. ▸ Summarizes (i.e., summary statistics: including mean, GM, and percentiles) indoor and outdoor benzene concs. for residences in the TEAM studies (Tables 2&3, p. 1131). ▸ Summaries are for LA (winter and summer), Valdez (winter and summer), and Woodland, CA (summer and winter). ∘ The LA and Valdez data are for day and night (i.e., 12-hr samples), while the Woodland data are 24-hr samples). ∘ Of the 11 indoor/outdoor combinations reported from the three cities, only 3 had the number of samples equal for both the indoor and outdoor measurements (these are circled on Tables 2 & 3). ▸ In addition, this paper summarizes mean indoor/outdoor values measured from other studies (see p. 1130). ∘ NOTE: Not possible to determine if these mean values were from concurrent measurements w/o obtaining reports on these studies. • Ref (28) — mean I/O = **1.36** } 48-hr averages measured at 161 homes in CA. • Ref (29) — mean I/O = **0.92** (summer) � Average from seventeen volunteers. — mean I/O = **1.35** (winter) ▸ Finally, mean benzene concs. were reported from other studies (see Table 4, p. 1132). ∘ All of the I/O ratios in Table 4 are > 1.0 (range: 1.4 to 4.0). <u>This study</u>: <u>**PEN**</u> **1987, summer, daytime =** **1.6** **1990, summer, daytime =** **2.7** **1991, winter, daytime =** **1.7**	MZ 23

Ref. No.	Supporting Information	Sources
5-13	<u>Benzene</u> Author: Drahonovska, H. Indoor & outdoor measurements of 140 residences (both kitchen and bedroom measurements) taken for listed HAPs. Energy use for heating is broken down by electric, gas, and coal sources. Average I/O ratios provided (Table 5) for benzene. **I/O=1.6 for house heated** **I/O=1.4 for non-heated house**	MZ 4
5-13	<u>Benzene</u> Author: Gilli, G., Scursatone, E., and Bono, R. ▸ Indoor and outdoor simultaneous measurements taken for a **residence** (apartment). 　◦ Samples were collected by 10 non-smoking university students who each collected samples for 10 consecutive days [2 integrated samples per day: 1) 8:00 - 20:00 (12-hrs), and 2) 0:00 - 8:00 (8-hrs)] in December 1991. ▸ <u>Table 3</u> (p. 53) shows the mean I/O ratios for both day (i.e., 8:00 - 20:00) and night (ie, 0:00 - 8:00). Data is the average form all students. ▸ <u>Table 4</u> (p. 54) shows indoor and outdoor pollutant concentrations for both day and night. NOTE: It is not clear how this data relates to the ratios reported in Table 3. It might be data for only a single student. **<u>Average I/O data for all students (Table 3)</u>:** **benzene (day) = 3.78** **benzene (night) = 2.68**	MZ 25

Ref. No.	Supporting Information	Sources
5-13	<u>Benzene</u> Source #<u>TL02</u> measured simultaneous indoor and outdoor benzene concentrations for 6 residences in Roanoke, VA during the period November 1988 - February 1989. The authors reported the data as results from a source model (Table II), from which original measured concentrations can be back-calculated. The presence of indoor sources was not independently determined. The residences were heated by either gas or electricity, with no information provided regarding cooking or garage status. Therefore, the information was assigned to ME # 13. TRJ researchers calculated concurrent I/O ratios from the original concentration data and averaged the ratios to estimate the PEN factor for the residences (**PEN = 1.06**; Quality Code = 1). Source #<u>TL03</u> measured simultaneous indoor and outdoor benzene concentrations for 44 residences in Toronto in the winter and spring of 1996. The authors reported average indoor and outdoor concentrations (Table 1), from which the I/O average ratio can be computed. Stove/garage sources in the residences were not identified. Therefore, the information was assigned to ME # 13. The I/O average ratio calculated by TRJ researchers was **2.3**, indicating the presence of significant indoor sources. Therefore, the difference between the average indoor and outdoor concentrations can be used to estimate a lower bound for the ADD factor (**ADD = 2.3 μg/m^3**; Quality Code = 2). Source #<u>TL07</u> reported the indoor/outdoor benzene concentration ratio measured in June, 1990 for residences in Woodland, CA (Table 2-5). No information was given on stove/garage sources in the residences. The geometric mean ratio was **2.1**, indicating the presence of indoor sources. Therefore, the difference between the median indoor and outdoor concentrations can be used to estimate a lower bound for the ADD factor (**ADD = 1.1 μg/m^3**; Quality Code = 2). Source #<u>TL13</u> reported simultaneous indoor and outdoor benzene concentrations for three residences in two Taiwanese cities. The authors did not provide information on the cooking or heating status in the residences. TRJ researchers calculated the I/O ratios of the mean concentrations for the three residences (0.94, 0.94, 0.88). The average of these three I/O ratios can be used as an estimate of the PEN factor for these residences (**PEN = 0.92**; Quality Code = 2).	TL02, TL03, TL07, TL13

B-16

Ref. No.	Supporting Information	Sources
5-15	<u>Benzene</u> Source #<u>TL18</u> measured simultaneous indoor and outdoor benzene concentrations at three New Jersey residences with attached garages during December 1987. The authors report mean concentrations (Table 3) and the range of simultaneous I/O ratios (Table 4) for each residence. For two of the residences, the minimum I/O ratio was greater than 1 (I/O ratio range 1.5 - 6.7 and 1.5 - 9.3, respectively). This indicates the presence of significant indoor sources. Therefore, the difference between the mean indoor and outdoor concentrations can be used to estimate a lower bound for the ADD factor. This difference was 11.2 $\mu g/m^3$ for one residence and 25.4 $\mu g/m^3$ for the other. Using the average of these values, ADD can be estimated to be 18 $\mu g/m^3$. For the third residence, the I/O ratio ranged from 0.9 - 2.0, indicating occasional indoor sources. Assuming the minimum I/O ratio may have been due to temporal concentration variations which were observed for all residences, a reasonable estimate for the PEN factor is 1.0. **ADD = 18 $\mu g/m^3$** (Quality Code = 2); **PEN = 1.0** (Quality Code = 1)	TL18
5-17	<u>Benzene</u> Author: Daisey, J.M., Hodgson, A.T., Fisk, W.J., et al. ‣ Indoor/outdoor measurements for 12 **office buildings**. ‣ <u>Table 2</u> (p. 3559) reports the range of I/O ratios measured for eleven of the twelve office buildings. <u>From Table 2</u>: **PEN (range): 0.25-4.2**	MZ 39
5-17	<u>Benzene</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ‣ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate.* ‣ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in **offices** -- See <u>Table III</u>, (p. 1597). ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ‣ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ‣ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.	MZ 34
5-17	<u>Benzene</u> Source #<u>TL10</u> measured simultaneous indoor and outdoor benzene concentrations for 12 office buildings in the San Francisco Bay Area during the period June - September 1990. The authors calculated the I/O ratio for each building, but they reported only the range of I/O ratios for all buildings (Range = 0.25 - 4.2, Table 2). The lower end of the range can be considered an estimate of the PEN factor since indoor sources are likely to be minimal. The upper portion of the range likely indicates the presence of indoor sources. **PEN = 0.25** (Quality Code = 1)	TL10

Ref. No.	Supporting Information	Sources
5-17	<u>Benzene</u> Author: Brickus, L.; Cardoso, J.; de Aquino Neto, F. Reports concurrent measurements of aldehyde and VOC concentrations on four different floors of an office building for several different days. I/O ratios provided – see tables 1, 2, & 3. **Mean PEN (building wide; ie., four floors) = 3.1** (Range: 1.6 – 4.8)	MZ 10
5-17	<u>Benzene</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 1.6**	RA 35
5-19	<u>Benzene</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 0.9**	RA 35
5-21 5-31	<u>Benzene</u> Author: Underwood, M.C. Concurrent indoor & outdoor samples reported for two different schools (one test school and one control school). <u>Table 1</u> provides monitoring data, both AM and PM, for two different sampling dates. <u>Figure 2</u> contains a graphical representation of I/O ratios from Table 1. In addition, concurrent fixed-site monitoring data for local air district provided. Will enable calculation of both penetration and proximity factors. **From Table 1:**	MZ 1

From Table 1:

	PEN	PROX	MULT
Test sch., Rm. B3, 8/11/92:	**1.4**	**0.60**	**0.83**
Test sch., Rm. B4, 8/11/92:	**1.1**	**0.60**	**0.67**
Test sch., Rm. B3, 11/9/92:	**6.6**	**0.56**	**3.67**
Test sch., Rm. B4, 11/9/92:	**6.0**	**0.56**	**3.33**
Control school, 8/11/92:	**0.4**	**0.87**	**0.37**
Control school, 11/9/92:	**<u>3.75</u>**	**<u>0.44</u>**	**<u>1.67</u>**
MEDIAN:	**3.5**	**0.66**	**2.02**

From Table 2:

	PEN	PROX	MULT
Test sch., Rm. B3, cond. (b):	**1.2**	**0.56**	**0.67**
Test sch., Rm. B4, cond. (b):	**1.2**	**0.56**	**0.67**
Control school, cond. (b):	**>2.0**	**<0.2**	**<u>0.44</u>**
MEDIAN:			**0.56**

Ref. No.	Supporting Information	Sources
5-26	<u>Benzene</u> Author: Fantuzzi, G.; Aggazzotti, G.; Righi, E.; Cavazzutti, L.; Predieri, G. Table 2 (p.53) – INDOOR and OUTDOOR concentrations provided for university libraries in Italian city (inner city and suburb locations) – median, min. and max. NOT SURE IF CONCURRENT MEASUREMENTS. INNER CITY Indoor median conc = $11 ug/m^3$ Outdoor median ambient conc = $11 ug/m^3$ **MULT = (indoor conc)/(ambient conc) = 11/11 = 1** SUBURBS Indoor median conc = $8.9 ug/m^3$ Outdoor median ambient conc = $4.4 ug/m^3$ **MULT = (indoor conc)/(ambient conc) = 8.9/4.4 = 2.02**	RA 23
5-30	<u>Benzene</u> Author: Gilli, G Concurrent indoor (apartment), outdoor fixed-site, and personal samples collected. I/O ratios reported (Table 3) I/O Ratios for Benzene: 3.78 (day), 2.68 (night) Mean indoor, outdoor, and personal concentrations reported (Table 4)	MZ 8 RA 16
5-30	<u>Benzene</u> Author: Crump, D.R. Indoor & outdoor measurements of HAPs over 2 years with data reported for a summer season only and a winter season only. Measurements are for four newly constructed unoccupied test houses. Although the methods state that measurements were taken in the living room, kitchen, bedrooms, and bathroom; only the average for the whole house was reported. The mean, max, and minimum data provided for each house and for each contaminant measured in each house for two consecutive years	MZ 2

5-34	<u>Benzene</u>
	Author: Gonzalez-Flesca, N.
	Has indoor & outdoor measurements for each of the ten residences measured. Indoor samples taken in bedroom of residences. Outdoor measurements taken at various locations. In addition, a fixed, central-site monitor was used and may provide input to a proximately factor.
	From Table 1:
	    PROX
	    0.76 (note: this is the same value as shown for PROX above)
		MZ 3

Ref. No.	Supporting Information	Sources
5-36	<u>Benzene</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, **<u>subway</u>**, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient.* ***Therefore, only calculation of a MULT factor is possible.*** ▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs. **MULT (median) = 0.7**	MZ 34
6-27	<u>Beryllium</u> Author: Durec, F., Durecova, A., et al. ▸ Paper reports results of concurrent indoor and outdoor sampling. However, the type of indoor location was not specified -- ICF surmised that this was a government laboratory and thus labeled it as ***indoor, other location*** **(ME #27)**. ◦ <u>Fig. 2</u> is a line plot of the outdoor/indoor ratio of the air concs. of Be. This graph is difficult to read, but the text states that the average outdoor and indoor Be concs. are 2.5 mBq/m^3 and 1.7 mBq/m^3, resp. Therefore, the average I/O ratio = **0.68**.	MZ 24
7-1	<u>1,3-butadiene</u> Source #<u>TL04</u> measured concurrent in-vehicle and vehicle exterior 1,3-butadiene concentrations in Raleigh, NC during the summer of 1988. The authors calculated the in-vehicle / vehicle exterior ratios for each concurrent measurement pair (Table V). The median ratio can be used to estimate the PEN factor. Source #<u>TL05</u> measured concurrent in-vehicle (passenger cars) and ambient 1,3-butadiene concentrations during city driving in Sydney, Australia (date not given). The authors report average concentrations (Table 1), from which an in-vehicle / ambient ratio can be calculated. Measurable concentrations were found inside the vehicle, but not at the ambient monitor site, indicating significant sources near the vehicle. Therefore, TRJ researchers estimated the ADD ME factor by subtracting the ambient detection limit from the in-vehicle concentration information. **ADD = 12 μg/m³** ; (Quality Code = 2) **PEN = 1.21**; (Quality Code = 1)	TL04, TL05

Ref. No.	Supporting Information	Sources
7-1	<u>1,3-butadiene</u> Author: Duffy, B.L., Nelson, P.F. Average in-vehicle concentrations (ppb) in catalyst equipped vs. non catalyst equipped cars and ambient air concentrations – Table 1. I/O ratios – Table 2 (p.3880). POST-1986 CARS **MULT** = 55 (morning commute) **MULT**= 1 (midday) PRE-1986 CARS **MULT** = 115 (morning commute) **MULT** = 1 (midday)	RA 7
7-1	<u>1,3-Butadiene</u> Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ‣ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for **in-vehicle (ME #1)**, car exterior, fixed-site, and sidewalk (i.e., <u>near road) (ME #7)</u>. Measurements are simultaneous. ‣ Table II (p. 966) — Concs. for each of the above locations. ‣ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ‣ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ‣ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. <u>From Table II</u> (Median values): **PROX PEN MULT** **PEN Range** (from Table V)**: 0.44 – 14.33** **2.2 1.1 2.4**	MZ 28
7-2	<u>1,3-butadiene</u> Author: Duffy, B.L., Nelson, P.F. Average in-vehicle concentrations (ppb) in catalyst equipped vs. non catalyst equipped cars and ambient air concentrations – Table 1. I/O ratios – Table 2 (p.3880). **I/O ratio = PEN = 2.6/2.8 = 0.93; 2.1/2 = 1.05 (morning peak-hour)** **I/O ratio = PEN = 1.2/1.4 = 0.86 (midday)** **I/O ratio = PEN = 1.8/2.3 = 0.78 (evening peak-hour)**	RA 7
7-2	<u>1,3-butadiene</u> Source #<u>TL05</u> measured concurrent in-vehicle (bus) and ambient 1,3-butadiene concentrations during city driving in Sydney, Australia (date not given). The authors report individual concentration pairs (Table 5), from which in-vehicle / vehicle exterior ratios can be calculated. The average of these ratios is an estimate of the PEN factor. **PEN = 0.91**; (Quality Code = 1)	TL05

Ref. No.	Supporting Information	Sources
7-7	<u>1,3-butadiene</u> Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for <u>in-vehicle (ME #1)</u>, car exterior, fixed-site, and sidewalk (i.e., <u>near road) (ME #7)</u>. Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. <u>From Table II</u>: **PROX** **1.0** *Median values*	MZ 28
7-13	<u>1,3-Butadiene</u> Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **I/O =PEN = 3.25 (spring); nothing provide for summer**	RA 29
8-1	<u>Cadmium</u> Author: South Coast Air Quality Management District ▸ Report gives results of concurrent **in-vehicle** and <u>ambient</u> (fixed site) monitoring study. ▸ <u>Table 3-3</u> (p. 37) presents a comparison of in-vehicle and background mean concentrations. ◦ Since measurements were reported only for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Table 3-3</u>: **MULT = 0.3**	MZ 37 (subset of this data reported in MZ 33)
8-1	<u>Cadmium</u> Source #<u>TL17</u> measured cadmium concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed (I/O = 0.33). This ratio can be used as an estimate of the MULT factor. **MULT = 0.33** (Quality Code = 2)	TL17
9-1	<u>Carbon tetrachloride</u> Author: South Coast Air Quality Management District ▸ Report gives results of concurrent **in-vehicle** and <u>ambient</u> (fixed site) monitoring study. ▸ <u>Table 3-3</u> (p. 37) presents a comparison of in-vehicle and background mean concentrations. ◦ Since measurements were reported only for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Table 3-3</u>: **MULT = 1.0**	MZ 37 (subset of this data reported in MZ 33)

Ref. No.	Supporting Information	Sources
9-1	Carbon tetrachloride Source #TL17 measured carbon tetrachloride concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed (I/O = 1.0). This ratio can be used as an estimate of the MULT factor. **MULT = 1.0** (Quality Code = 2)	TL17

9-13	Carbon tetrachloride
	Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., Sparacino, C., et al.
	▸ Results of the TEAM study that report measurements of personal and outdoor air sampling; in addition, breath and drinking water samples were measured.
	  ◦ The personal and outdoor air measurements were 12-hr integrated samples. These roughly correspond to daytime (6am-6pm) and nighttime (6pm-6am). Unfortunately, the personal and outdoor results for NJ (Table 2) are combined into 24-hr averages.
	▸ Fig. 2 (p. 297) has a bar graph of the nighttime (6pm-6am) personal (might be used as a surrogate for indoor residence) and outdoor concentrations. NOTE: these are geometric means with more than four times the number of personal (347) compared to outdoor samples (84).
	  ◦ *Also, all I/O ratios are greater than 1.5.*
	▸ Table 3 also has 24-hr averaged results of personal air and outdoor air sampling for Greensboro, NC and Devils Lake, ND.
		MZ 30

9-13	Carbon tetrachloride. Author: Bouhamra, W.S. Table 2 (p.199) -- Indoor VOCs concentrations. Table 3 (p.200) -- Ambient air VOCs concentrations. Min, max., mean, median, std. deviation provided. Table 4 (p.202) -- I/O ratios. Sampled during Dec 94-Jan 95. CONCURRENT MEASUREMENTS. **This compound had non detect results and thus I/O ratio was not provided.**	RA 14
9-13	Carbon tetrachloride Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ Table 1 has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ Table 2 (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **I/O ratio (mean) = 1.3** **I/O ratio (median) = 1.4**	MZ 27

Ref. No.	Supporting Information	Sources
9-13	Carbon tetrachloride Author: Wallace, L. (EPA/600/6-87/002a) "Blue book" ▸ Bound volume of results from the TEAM studies. Indoor ME is **residence**. ▸ <u>Table 29</u> (pp. 61-62) provide indoor/outdoor comparisons (and ratios) for <u>matched</u> samples. ○ These concentrations are median values for the 12-hr nighttime samples collected for two seasons (Jan. 1984 and May 1984) in LA, and during June 1984 in Contra Costa. ▸ <u>Table 46</u> (p. 97) provides median concentrations for indoor air in New Jersey (three different sampling periods) and California (also three different sampling periods). ▸ <u>Table 47</u> (p. 98) provides median concentrations for outdoor air in New Jersey (the same three sampling periods for NJ in Table 46) and California (the same three sampling periods for CA in Table 46). ○ However, the number of outdoor measurements are always less than the number of indoor measurements. <u>From Table 29</u>: **LA(1/84)** **LA(5/84)** **Contra(6/84)** **Avg.** **PEN** (medians)**:** **1.0** **1.1** **2.2** **1.4**	MZ 38
9-13	Carbon tetrachloride Source #<u>TL07</u> reported the indoor/outdoor carbon tetrachloride concentration ratio measured in June, 1990 for residences in Woodland, CA (Table 2-5). No information was given on stove/garage sources in the residences. The geometric mean ratio was 1.0, although all of the indoor and outdoor measurements were near the method quantifiable limit. This ratio provides an estimate of the PEN factor (PEN = 1.0). **PEN = 1.0**; (Quality Code = 2)	TL07

9-13	Carbon tetrachloride
	Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., et al.
	Summary of TEAM study in NJ (Fall, 1981).
	Samples collected for: *personal air* - two consecutive 12-hr samples taken from appr. 350 people,
	               outdoor air - two consecutive 12-hr samples taken from appr. 90 people,
	               also drinking water and breath.
	<u>Table 9</u> reports a summary of median, max. concs., and ratios (from both the median and max. conc. data) for 85 matched overnight personal air and overnight outdoor air samples. (It is our conclusion that this data provides the best concurrent I/O ratios for **residences** from this study.)
	
	PEN = 1.7 (median value)
		MZ 22

10-1	Chloroform Author: South Coast Air Quality Management District ▸ Report gives results of concurrent **in-vehicle** and <u>ambient</u> (fixed site) monitoring study. ▸ <u>Table 3-3</u> (p. 37) presents a comparison of in-vehicle and background mean concentrations. ○ Since measurements were reported only for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Table 3-3</u>: **MULT = 0.75**	MZ 37 (subset of this data reported in MZ 33)

Ref. No.	Supporting Information	Sources
10-1	**Chloroform** Source #<u>TL17</u> measured chloroform concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed (I/O = 0.75). This ratio can be used as an estimate of the MULT factor. **MULT = 0.75** (Quality Code = 2)	TL17
10-13	**Chloroform** Author: Wallace, L. (EPA/600/6-87/002a) "Blue book" ▸ Bound volume of results from the TEAM studies. Indoor ME is **residence**. ▸ <u>Table 29</u> (pp. 61-62) provide indoor/outdoor comparisons (and ratios) for <u>matched</u> samples. ◦ These concentrations are median values for the 12-hr nighttime samples collected for two seasons (Jan. 1984 and May 1984) in LA, and during June 1984 in Contra Costa. ▸ <u>Table 46</u> (p. 97) provides median concentrations for indoor air in New Jersey (three different sampling periods) and California (also three different sampling periods). ▸ <u>Table 47</u> (p. 98) provides median concentrations for outdoor air in New Jersey (the same three sampling periods for NJ in Table 46) and California (the same three sampling periods for CA in Table 46). ◦ However, the number of outdoor measurements are always less than the number of indoor measurements. <u>From Table 29</u>: <table><tr><td></td><td>**LA(1/84)**</td><td>**LA(5/84)**</td><td>**Contra(6/84)**</td><td>**Avg.**</td></tr><tr><td>**PEN** (medians)**:**</td><td>2.5</td><td>25.0</td><td>0.7</td><td>9.4</td></tr></table>	MZ 38
10-13	**Chloroform** Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., et al. Summary of TEAM study in NJ (Fall, 1981). Samples collected for: *personal air* - two consecutive 12-hr samples taken from appr. 350 people, *outdoor air* - two consecutive 12-hr samples taken from appr. 90 people, also drinking water and breath. <u>Table 9</u> reports a summary of median, max. concs., and ratios (from both the median and max. conc. data) for 85 <u>matched</u> overnight personal air and overnight outdoor air samples. (It is our conclusion that this data provides the best available I/O ratios for **residences** from this study.) **PEN = 3.9** (median value)	MZ 22
10-13	**Chloroform** Source #<u>TL03</u> measured simultaneous indoor and outdoor chloroform concentrations for 44 residences in Toronto in the winter and spring of 1996. The authors reported average indoor and outdoor concentrations (Table 1), from which the I/O average ratio can be computed. Stove/garage sources in the residences were not identified. Therefore, the information was assigned to ME # 13. The I/O average ratio calculated by TRJ researchers was **4.2**, indicating the presence of significant indoor sources. Therefore, the difference between the average indoor and outdoor concentrations can be used to estimate a lower bound for the ADD factor. This difference was 0.67 $\mu g/m^3$. **ADD = 0.67 μg/m³** (Quality Code = 2)	TL03

Ref. No.	Supporting Information	Sources
10-13	<u>Chloroform</u> Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., Sparacino, C., et al. ▸ Results of the TEAM study that report measurements of personal and outdoor air sampling; in addition, breath and drinking water samples were measured. ∘ The personal and outdoor air measurements were 12-hr integrated samples. These roughly correspond to daytime (6am-6pm) and nighttime (6pm-6am). Unfortunately, the personal and outdoor results for NJ (Table 2) are combined into 24-hr averages. ▸ Fig. 2 (p. 297) has a bar graph of the nighttime (6pm-6am) personal (might be used as a surrogate for indoor residence) and outdoor concentrations. NOTE: these are geometric means with more than four times the number of personal (347) compared to outdoor samples (84). ∘ *Also, all I/O ratios are greater than 1.5.* ▸ Table 3 also has 24-hr averaged results of personal air and outdoor air sampling for Greensboro, NC and Devils Lake, ND.	MZ 30
10-13	<u>Chloroform</u> Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ <u>Table 1</u> has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ <u>Table 2</u> (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **I/O ratio (mean) = M** **I/O ratio (median) = > 2**	MZ 27
10-17	<u>Chloroform</u> Author: Brickus, L.; Cardoso, J.; de Aquino Neto, F. Reports concurrent measurements of aldehyde and VOC concentrations on four different floors of an **office building** for several different days. I/O ratios provided – see tables 1,2, & 3. **Mean PEN (building wide; ie., two floors) = 3.3** (Range: 2.4 – 4.1)	MZ 10
11-1	<u>Chromium</u> Author: Liu, C.S., Shikiya, D., Kahn, M.I., and Juarros, J. ▸ Paper reports results of concurrent **<u>in-vehicle</u>** and <u>ambient</u> (fixed site) monitoring study. ▸ <u>Figure 1</u> (p. 250) summarizes the data with a bar graph. ∘ Since measurements were reported for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Fig. 1</u>: **MULT = 0.6**	MZ 33 (Results also reported in MZ 37)
11-1	<u>Chromium</u> Source #<u>TL17</u> measured chromium concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed (I/O = 0.52). This ratio can be used as an estimate of the MULT factor. **MULT = 0.52** (Quality Code = 2)	TL17

Ref. No.	Supporting Information	Sources
11-13	<u>Chromium</u> Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **Chromium: no I/O ratio provided.**	RA 29
11-13	<u>Chromium</u> Source #<u>TL09</u> measured simultaneous indoor and outdoor hexavalent chromium concentrations for approximately 30 - 50 residences in Hamilton, Ontario during the summer of 1993. The authors reported average indoor and outdoor concentrations from which the I/O average ratio can be computed. Stove/garage sources in the residences were not identified. Therefore, the information was assigned to ME # 13. The I/O average ratio calculated by TRJ researchers was 0.35. This value can be used as an estimate of the PEN factor for these residences. **PEN = 0.35** (Quality Code = 2)	TL09
11-20	<u>Chromium</u> Source #<u>TL11</u> measured simultaneous indoor and outdoor hexavalent and total chromium concentrations at 21 industrial sites in Hudson County, New Jersey during 1989 and 1990. The sites were chosen because they are known to have soils containing chromite ore processing residue, which was used as a fill material in the area for several decades. The authors reported average indoor and outdoor concentrations from which the I/O average ratio can be computed. The I/O average ratios calculated by TRJ researchers were 0.31 for hexavalent chromium and 0.62 for total chromium. These values can be used as an estimate of the PEN factors for these facilities. However, it should be noted that these factors were developed for facilities known to have chromium contamination. **PEN = 0.31 for hexavalent Cr** (Quality Code = 2); **PEN = 0.62 for total Cr** (Quality Code = 2)	TL11
13-1	<u>Ethylene dichloride</u> (1,2-dichloroethane) Author: Liu, C.S., Shikiya, D., Kahn, M.I., and Juarros, J. ▸ Paper reports results of concurrent **in-vehicle** and <u>ambient</u> (fixed site) monitoring study. ▸ <u>Figure 1</u> (p. 250) summarizes the data with a bar graph. ◦ Since measurements were reported for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Fig. 1</u>: **MULT = 3.0**	MZ 33 (Results also reported in MZ 37)

Ref. No.	Supporting Information	Sources
13-1	<u>Ethylene dichloride</u> Source #<u>TL17</u> measured 1,2-dichloroethane concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed. The I/O average ratio calculated by TRJ researchers was **3.3**, indicating the presence of sources near the vehicle. However, the mean in-vehicle concentration was less than the standard deviation. This result should be interpreted with caution, particularly since 1,2-dichloroethane is not a typical automotive pollutant. The difference between the average in-vehicle and ambient concentrations can be used to estimate a lower bound for the ADD factor. This difference was 0.023 ppb (0.093 μg/m^3). **ADD = 0.093 μg/m^3** (Quality Code = 2)	TL17
13-13	<u>Ethylene dichloride</u> (1,2-dichloroethane) Author: Wallace, L. (EPA/600/6-87/002a) "Blue book" ▸ Bound volume of results from the TEAM studies. Indoor ME is **residence**. ▸ <u>Table 29</u> (pp. 61-62) provide indoor/outdoor comparisons (and ratios) for <u>matched</u> samples. ∘ These concentrations are median values for the 12-hr nighttime samples collected for two seasons (Jan. 1984 and May 1984) in LA, and during June 1984 in Contra Costa. ▸ <u>Table 46</u> (p. 97) provides median concentrations for indoor air in New Jersey (three different sampling periods) and California (also three different sampling periods). ▸ <u>Table 47</u> (p. 98) provides median concentrations for outdoor air in New Jersey (the same three sampling periods for NJ in Table 46) and California (the same three sampling periods for CA in Table 46). ∘ However, the number of outdoor measurements are always less than the number of indoor measurements. <u>From Table 29</u>: <u>LA(1/84)</u> <u>LA(5/84)</u> <u>Contra(6/84)</u> <u>Avg.</u> **PEN** (medians)**:** **1.0** **1.1** **4.7** **2.3**	MZ 38
13-13	<u>1,2 Dichloroethane (ethylene dichloride)</u> Author: Bouhamra, W.S. Table 2 (p.199) -- Indoor VOCs concentrations. Table 3 (p.200) -- Ambient air VOCs concentrations. Min, max., mean, median, std. deviation provided. Table 4 (p.202) -- I/O ratios. Sampled during Dec 94-Jan 95. CONCURRENT MEASUREMENTS. **This compound had non detect results and thus I/O ratio was not provided.**	RA 14

Ref. No.	Supporting Information	Sources
14-13	1,3-dichloropropene Source #TL03 measured simultaneous indoor and outdoor 1,3-dichloropropene concentrations for 44 residences in Toronto in the winter and spring of 1996. The authors reported average indoor and outdoor concentrations (Table 1), from which the I/O average ratio can be computed. Stove/garage sources in the residences were not identified. Therefore, the information was assigned to ME # 13. The I/O average ratio calculated by TRJ researchers was 0.81. This value can be used as an estimate of the PEN factor for these residences. **PEN = 0.81** (Quality Code = 2)	TL03
15-1	Ethylene dibromide Author: Liu, C.S., Shikiya, D., Kahn, M.I., and Juarros, J. ‣ Paper reports results of concurrent **in-vehicle** and ambient (fixed site) monitoring study. ‣ Figure 1 (p. 250) summarizes the data with a bar graph. ◦ Since measurements were reported for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the MULT factor. From Fig. 1: **MULT = 0.86**	MZ 33 (Results also reported in MZ 37)
15-1	Ethylene dibromide Source #TL17 measured ethylene dibromide concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed (I/O = 0.88). This ratio can be used as an estimate of the MULT factor. **MULT = 0.88** (Quality Code = 2)	TL17
17-1	Formaldehyde Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ‣ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by **car**, subway, bicycling (other), and walking. -- See Table I, (p. 1596). ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient. **Therefore, only calculation of a MULT factor is possible.*** ‣ In addition, VOC concs. were also measured in subjects' residences and in offices -- See Table III, (p. 1597). ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ‣ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ‣ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs. **MULT (median) = 0.9**	MZ 34

Ref. No.	Supporting Information	Sources
17-1	<u>Formaldehyde</u> Source #<u>TL17</u> measured formaldehyde concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed. The I/O average ratio calculated by TRJ researchers was **1.8**, indicating the presence of in-vehicle sources. Therefore, the difference between the average in-vehicle and ambient concentrations can be used to estimate a lower bound for the ADD factor. This difference was 5.7 ppb (7 μg/m^3). **ADD = 7 μg/m^3** (Quality Code = 2)	TL17
17-1	<u>Formaldehyde</u> Author: Liu, C.S., Shikiya, D., Kahn, M.I., and Juarros, J. ▸ Paper reports results of concurrent **in-vehicle** and <u>ambient</u> (fixed site) monitoring study. ▸ <u>Figure 1</u> (p. 250) summarizes the data with a bar graph. ◦ Since measurements were reported for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Fig. 1</u>: **MULT = 1.8**	MZ 33 (Results also reported in MZ 37)
17-4	<u>Formaldehyde</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, **bicycling (other)**, and walking. -- See <u>Table I</u>, (p. 1596). ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient. **Therefore, only calculation of a MULT factor is possible.*** ▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs. **MULT (median) = 0.9**	MZ 34
17-13	<u>Formaldehyde</u> Author: Peters, J.M. Concurrent indoor and outdoor monitoring in residences – Table 3-20a (p. 3-92), Table 3-20b (p. 3-93). This study primarily looked at O$_3$ and PM. <u>From Table 3-20b</u>: **PEN (median) = 3.75** (range: 0.01 – 40.0)	MZ 15

Ref. No.	Supporting Information	Sources
17-13	**Formaldehyde** Author: Drahonovska, H. Indoor & outdoor measurements of 140 residences (both kitchen and bedroom measurements) taken for listed HAPs. Energy use for heating is broken down by electric, gas, and coal sources. Average I/O ratios provided (Table 5) for formaldehyde. **I/O=4.8 for house heated** **I/O=3.2 for non-heated house**	MZ 4
17-13	**Formaldehyde** Author: Gonzalez-Flesca, N. Has indoor & outdoor measurements for each of the ten residences measured. Indoor samples taken in bedroom of residences. Outdoor measurements taken at various locations. In addition, a fixed, central-site monitor was used and may provide input to a proximately factor. **From Tables 1 & 2:** **PEN PROX MULT ADD** **8.9 0.72 6.4**	MZ 3
17-13	**Formaldehyde** Author: Crump, D.R. Indoor & outdoor measurements of HAPs over 2 years with data reported for a summer season only and a winter season only. Measurements are for four newly constructed unoccupied test houses. Although the methods state that measurements were taken in the living room, kitchen, bedrooms, and bathroom; only the average for the whole house was reported. The mean, max, and minimum data provided for each house and for each contaminant measured in each house for two consecutive years. **House T1 — PEN*** **Yr. 1 Yr. 2 Summer Winter Mean (S and W only)** formaldehyde 19.7 21.0 21.0 18.5 19.8 **House T2 — PEN*** **Yr. 1 Yr. 2 Summer Winter Mean (S and W only)** formaldehyde 17.0 18.5 17.3 14.0 16.2 **House M3 — PEN*** **Yr. 1 Yr. 2 Summer Winter Mean (S and W only)** formaldehyde 13.7 20.0 17.7 15.0 16.4 **House M4 — PEN*** **Yr. 1 Yr. 2 Summer Winter Mean (S and W only)** formaldehyde 14.3 22.5 19.7 17.5 18.6 *Mean values **HCHO** **Overall Mean:** *17.8* **(all houses, S and W only)**	MZ 2

Ref. No.	Supporting Information	Sources
17-13	<u>Formaldehyde</u> Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ <u>Table 1</u> has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ <u>Table 2</u> (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **I/O ratio (mean) = 5.3** **I/O ratio (median) = 3.2**	MZ 27
17-13	<u>Formaldehyde</u> Author: Barguil, S., Le Moullec, Y., Person, A., Laurent, A-M, and Festy, B. ▸ Study which reports concurrent indoor and outdoor measurements taken in **residences** (5 detached houses and 4 apartments). ∘ The paper reports the average I/O measurements (Fig 2. - bar chart) of samples taken over the entire length of the study (Sept. 1987 - Aug. 1988). **I/O ratios (average of 75 samples):** **PEN = 1.8**	MZ 36
17-13	<u>Formaldehyde</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ∘ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate.* ▸ In addition, VOC concs. were also measured in subjects' **residences** and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ∘ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ∘ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.	MZ 34

Ref. No.	Supporting Information	Sources
17-13	<u>Formaldehyde</u> Source #<u>TL02</u> measured simultaneous indoor and outdoor formaldehyde concentrations for 10 residences in Roanoke, VA during the period November 1988 - February 1989. The authors reported the data as results from a source model (Table II), from which original measured concentrations can be back-calculated. The presence of indoor sources was not independently determined. The residences were heated by either gas or electricity, with no information provided regarding cooking or garage status. Therefore, the information was assigned to ME # 13. TRJ researchers calculated concurrent I/O ratios from the original concentration data and averaged the ratios. In the absence of indoor sources, this method should yield an estimate of the PEN factor. However, the average I/O ratio was calculated to be **7.6**, indicating that significant indoor sources were present. The authors estimated the indoor source contribution for each of the residences by subtracting the measured outdoor concentration from the measured indoor concentration. The average indoor source contribution was **13.8 μg/m^3**. This represents a lower bound on the ADD factor. Source #<u>TL14</u> measured simultaneous week-long indoor and neighborhood ambient formaldehyde concentrations at approximately 40 residences near Houston, TX during the period June-October 1981. The ratio of mean concentrations was near **7**, indicating that significant indoor sources were present. Source #<u>TL15</u> measured simultaneous week-long indoor and neighborhood ambient formaldehyde concentrations at approximately 80 residences near Houston, TX during the summer of 1980. The ratio of mean concentrations was near **7**, indicating that significant indoor sources were present. **ADD = 13.8 μg/m^3** (Quality Code = 1)	TL02, TL14, TL15
17-17	<u>Formaldehyde</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ‣ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate.* ‣ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in **offices** -- See <u>Table III</u>, (p. 1597). ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ‣ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ‣ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.	MZ 34

Ref. No.	Supporting Information	Sources
17-17	<u>Formaldehyde</u> Author: Brickus, L.; Cardoso, J.; de Aquino Neto, F. Reports concurrent measurements of aldehyde and VOC concentrations on four different floors of an **office building** for several different days. I/O ratios provided – see tables 1, 2, & 3. **Mean PEN (building wide) = 2.6** (Range: 1.1 – 4.7)	MZ 10
17-26	<u>Formaldehyde</u> Author: Fantuzzi, G.; Aggazzotti, G.; Righi, E.; Cavazzutti, L.; Predieri, G. Table 2 (p.53) – INDOOR and OUTDOOR ambient concentrations provided for university libraries in Italian city (inner city and suburb locations) – median, min. and max. NOT SURE IF CONCURRENT MEASUREMENTS. INNER CITY Indoor median conc = $22.9 ug/m^3$ Outdoor median ambient conc = $22 ug/m^3$ **MULT = (indoor conc)/(ambient conc) = 22.9/22 = 1.04** SUBURBS Indoor median conc = $10.5 ug/m^3$ Outdoor median ambient conc = $9.2 ug/m^3$ **MULT = (indoor conc)/(ambient conc) =10.5/9.2 = 1.14**	RA 23
17-30	<u>Formaldehyde</u> Author: Crump, D.R. Indoor & outdoor measurements of HAPs over 2 years with data reported for a summer season only and a winter season only. Measurements are for four newly constructed unoccupied test houses. Although the methods state that measurements were taken in the living room, kitchen, bedrooms, and bathroom; only the average for the whole house was reported. The mean, max, and minimum data provided for each house and for each contaminant measured in each house for two consecutive years	MZ 2
17-34	<u>Formaldehyde</u> Author: Gonzalez-Flesca, N. Has indoor & outdoor measurements for each of the ten residences measured. Indoor samples taken in bedroom of residences. Outdoor measurements taken at various locations. In addition, a fixed, central-site monitor was used and may provide input to a proximately factor. **From Table 1:** 　　　**PROX** 　　　**0.72** (note: this is the same value as shown for PROX above)	MZ 3

Ref. No.	Supporting Information	Sources
17-36	**Formaldehyde** Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ‣ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, **subway**, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient.* ***Therefore, only calculation of a MULT factor is possible.*** ‣ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ‣ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ‣ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs. **MULT (median) = 0.8**	MZ 34
18-13	**Hexachlorobenzene** Source #<u>TL03</u> measured simultaneous indoor and outdoor hexachlorobenzene concentrations for 44 residences in Toronto in the winter and spring of 1996. The authors reported average indoor and outdoor concentrations (Table 1), from which the I/O average ratio can be computed. Stove/garage sources in the residences were not identified. Therefore, the information was assigned to ME # 13. The I/O average ratio calculated by TRJ researchers was 0.82. This value can be used as an estimate of the PEN factor for these residences. **PEN = 0.82** (Quality Code = 2)	TL03
20/21-1	<u>Lead</u> Source #<u>TL17</u> measured lead concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed (I/O = 1.05). This ratio can be used as an estimate of the MULT factor. **MULT = 1.05** (Quality Code = 2)	TL17
20/21-1	<u>Lead</u> Author: Liu, C.S., Shikiya, D., Kahn, M.I., and Juarros, J. ‣ Paper reports results of concurrent **in-vehicle** and <u>ambient</u> (fixed site) monitoring study. ‣ <u>Figure 1</u> (p. 250) summarizes the data with a bar graph. ◦ Since measurements were reported for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Fig. 1</u>: **MULT = 1.0**	MZ 33 (Results also reported in MZ 37)
20/21-7	<u>Lead</u> Source #<u>TL16</u> computed the MULT factor for outdoor locations near roadways based on outdoor/ambient mean concentrations from two data sets (**MULT =1.5**; Quality Code = 2).	TL16

B-35

Ref. No.	Supporting Information	Sources
20/21-13	<u>Lead</u> Source #<u>TL12</u> measured simultaneous indoor and outdoor lead concentrations at two apartment buildings in New York City prior to July 1978. The author calculated the I/O ratio for each pair of measurements and reported the mean I/O ratio for each building (Site A = 0.82; Site D = 0.87). Statistical analyses performed by the author showed that the ratios were not significantly different. The average of these two values can be used as an estimate of the PEN factor for these apartment buildings (**PEN = 0.85**; Quality Code = 1). Source #<u>TL16</u> computed the MULT factor for residences based on indoor/outdoor mean concentrations from several data sets (**MULT = 0.70**; Quality Code = 2).	TL12, TL16
20/21-13	<u>Lead</u> Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **I/O = PEN = 0.96 (spring); none supplied for summer**	RA 29
20/21-17	<u>Lead</u> Source #<u>TL08</u> measured simultaneous indoor and outdoor lead concentrations at a university office in Bradford, England during July 1990. Lead concentrations were measured using active samplers mounted on either side of an open window. The authors calculated the ratio of the mean indoor and outdoor concentrations (Table 1) to be 0.86. This value can be used as an estimate of the PEN factor for this office. However, the reported value may be an upper bound on the PEN factor since high air exchange rates would be expected through the open window. **PEN = 0.86** (Quality Code = 2)	TL08
20/21-26	<u>Lead</u> Source #<u>TL12</u> measured simultaneous indoor and outdoor lead concentrations at a museum in New York City prior to July 1978. The author calculated the I/O ratio for each pair of measurements and reported the mean I/O ratio (0.63).This value can be used as an estimate of the PEN factor for this public building. **PEN = 0.63** (Quality Code = 1)	TL12
20/21-27	<u>Lead</u> Source #<u>TL16</u> computed the MULT factor for other indoor locations based on indoor/outdoor mean concentrations from several data sets (**MULT = 0.55**; Quality Code = 2).	TL16
22-13	<u>Manganese</u> Author: Wallace, L. and Slonecker, T. Paper reports PTEAM results of concurrent indoor and outdoor sampling of a residence for both $PM_{2.5}$ Mn and PM_{10} Mn for both daytime and nighttime (one sampling day) (See Table 4, pg.64). Arithmetic means provided with percentiles. **Median values for Mn PM10 and PM2.5:** **PEN (day) PEN (night)** **PM10: 0.66 0.55** **PM2.5: 0.73 0.75**	MZ 6

Ref. No.	Supporting Information	Sources
22-13	<u>Manganese</u> Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **I/O =PEN = 1.53 (spring); 0.97 (summer)**	RA 29
22-13	<u>Manganese</u> (Also, PM2.5 and PM10) Author: Pellizzari, E.D., Clayton, C.A., Rodes, C.E., Mason, R.E., et al. ‣ Results of an exposure study to fine and PM10 Mn. ‣ <u>Table 9 (p. 732)</u> summarizes Mn concs. in PM for matched 3-day monitoring periods. ∘ The reporting of indoor, outdoor, and two fixed-site locations enables calculation of a <u>penetration factor</u>, and two <u>proximity factors</u> (also resulting in two <u>MULT factors</u>). **PEN = 0.46** **PEN = 0.46 (same as before)** **PROX (fixed site 2) = 6.23** **PROX (roof site) = 0.81** **MULT (fixed site 2) = 2.77** **MULT (roof site) = 0.35**	MZ 7
22-30	<u>Manganese</u> (Also, PM2.5 and PM10) Author: Pellizzari, E.D., Clayton, C.A., Rodes, C.E., Mason, R.E., et al. ‣ Results of an exposure study to fine and PM10 Mn. ‣ <u>Table 9 (p. 732)</u> summarizes Mn concs. in PM for matched 3-day monitoring periods. ∘ The reporting of indoor, outdoor, and two fixed-site locations enables calculation of a <u>penetration factor</u>, and two <u>proximity factors</u> (also resulting in two <u>MULT factors</u>). **PEN = 0.46** **PEN = 0.46 (same as before)** **PROX (fixed site 2) = 6.23** **PROX (roof site) = 0.81** **MULT (fixed site 2) = 2.77** **MULT (roof site) = 0.35**	MZ 7
24-17	<u>Methylene chloride</u> Source #<u>TL10</u> measured simultaneous indoor and outdoor methylene chloride concentrations for 12 office buildings in the San Francisco Bay Area during the period June - September 1990. The authors calculated the I/O ratio for each building, but they reported only the range of I/O ratios for all buildings (Range = 1.0 - 45, Table 2). The lower end of the range can be considered an estimate of the PEN factor since indoor sources are likely to be minimal. The upper portion of the range likely indicates the presence of indoor sources. **PEN = 1.0** (Quality Code = 1)	TL10
24-17	<u>Methylene chloride</u> (dichloromethane) Author: Daisey, J.M., Hodgson, A.T., Fisk, W.J., et al. ‣ Indoor/outdoor measurements for 12 **office buildings**. ‣ <u>Table 2</u> (p. 3559) reports the range of I/O ratios measured for eleven of the twelve office buildings. <u>From Table 2</u>: **PEN (range): 1.0–45.0**	MZ 39

Ref. No.	Supporting Information	Sources
25-1	<u>Nickel</u> Author: South Coast Air Quality Management District ‣ Report gives results of concurrent **in-vehicle** and <u>ambient</u> (fixed site) monitoring study. ‣ <u>Table 3-3</u> (p. 37) presents a comparison of in-vehicle and background mean concentrations. ◦ Since measurements were reported only for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Table 3-3</u>: **MULT = 0.5**	MZ 37 (subset of this data reported in MZ 33)
25-1	<u>Nickel</u> Source #<u>TL17</u> measured nickel concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed (I/O = 0.47). This ratio can be used as an estimate of the MULT factor. **MULT = 0.47** (Quality Code = 2)	TL17
26-13	<u>PAHs</u> Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **Use B(a)P as indicator species for PAHs** **I/O =PEN = 1.1 (spring); nothing provided for summer**	RA 29
26-13	<u>PAH [B(a)P]</u> Author: Ando, M., Katagiri, K., Tamura, K., Yamamoto, S. Study reports indoor and outdoor concentrations of B(a)P in residences in both Tokyo and Beijing. Although the authors never specifically call the I/O samples concurrent, the presumption is that they are for each city (Fig. 8 & 10, resp.). They also report the I/O concentrations (Fig. 12) for residences using 3 different fuel types (coal, coal gas, and NG). **PEN** **0.7** (median and mean of two values calculated from regression lines)	MZ 17
26-17	<u>PAHs [B(a)P, B(k)F, and B(ghi)P]</u> Author: Ando, M., Tamura, K., and Katagiri, K. Concurrent indoor and outdoor measurements for PAHs (see Fig. 6a-c, p. 300) presented in scatter plots with regression lines. [NOTE: Indoor ME never specified in paper -- using picture provided and judgement, it was decided that the ME is an **office**.] <u>From Fig. 6a (B(a)P)</u>: **PEN = 1.2** (estimated from regression line on scatter plot)	MZ 21

Ref. No.	Supporting Information	Sources
26-20	PAHs [acenaphtene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(ah)anthracene, benzo(ghi)perylene, indeno(123-cd)pyrene] Author: Branisteanu, R.; Aiking, H. Sampling inside coal-fired power plant (six different locations) and sampling /urban measurements in 5 different locations covering the whole town area (p. 534). Table 1 and Table 2 – indoor and outdoor concentrations of PAHs provided. NOT SURE IF CONCURRENT MEASUREMENTS. **Used B(a)P as indicator species for PAHs**. Range of B(a)P conc indoors: 0.057 - 0.4 ng/m^3 Mean indoors conc (calc from 6 locations in plant) = 0.12 ng/m^3 Range of B(a)P conc in ambient outdoors: 80 - 1250 ng/m^3 Mean ambient conc (calc from 5 locations in city) = 716 ng/m^3 **MULT = (mean indoor conc)/(mean ambient conc) = 0.12/716 = 1.7E-4**	RA 22
26-20	(see Tables 2&3 of article for list of individual PAHs) PAHs Author: Petry, T.; Schmid, P.; Schlatter, C. Air sampling at 5 different workplaces. Environmental/ambient monitoring done in March & July, 1992 at sampling site in town center – stationary fixed-site monitoring. Table 2 (p.642) provides geometric mean concentrations of PAHs at different locations.	RA 15
27-13	PCB Author: Currado, G.M. and Harrad, S. Concurrent indoor and outdoor (ambient monitoring) samples taken for PCB conogeners Sum PCB concentrations reported for two office buildings and two different residences (presented in Figure 1, p. 3046). **ΣPCB:** **PEN** **PROX** **MULT** **House 1:** **1.86** **7.0** **13.0** **House 2:** **1.83** **3.0** **5.5**	MZ 9
27-17	PCB Author: Currado, G.M. and Harrad, S. Concurrent indoor and outdoor (ambient monitoring) samples taken for PCB conogeners Sum PCB concentrations reported for two office buildings and two different residences (presented in Figure 1, p. 3046). **ΣPCB:** **PEN** **PROX** **MULT** **Office 1:** **180.** **0.5** **90.0** **Office 2:** **8.0** **1.0** **8.0**	MZ 9
27-30	PCB Author: Currado, G.M. and Harrad, S. Concurrent indoor and outdoor (ambient monitoring) samples taken for PCB conogeners Sum PCB concentrations reported for two office buildings and two different residences (presented in Figure 1, p. 3046). **ΣPCB:** **PROX** **House 1:** **7.0** **House 2:** **3.0**	MZ 9

Ref. No.	Supporting Information	Sources
30-13	<u>Styrene</u> Author: Drahonovska, H. Indoor & outdoor measurements of 140 residences (both kitchen and bedroom measurements) taken for listed HAPs. Energy use for heating is broken down by electric, gas, and coal sources. **<u>Average I/O ratios provided (Table 4) for styrene:</u>** **I/O = 0.2–0.9 for bedroom and kitchen, respectively.**	MZ 4
30-13	<u>Styrene</u> Source #<u>TL03</u> measured simultaneous indoor and outdoor styrene concentrations for 44 residences in Toronto in the winter and spring of 1996. The authors reported average indoor and outdoor concentrations (Table 1), from which the I/O average ratio can be computed. Stove/garage sources in the residences were not identified. Therefore, the information was assigned to ME # 13. The I/O average ratio calculated by TRJ researchers was **43**, indicating the presence of significant indoor sources. Therefore, the difference between the average indoor and outdoor concentrations can be used to estimate a lower bound for the ADD factor (**ADD = 0.13 μg/m^3**; Quality Code = 2). Source #<u>TL07</u> reported the indoor/outdoor styrene concentration ratio measured in June, 1990 for residences in Woodland, CA (Table 2-5). No information was given on stove/garage sources in the residences. The geometric mean ratio was **8.5**, indicating the presence of significant indoor sources. Therefore, the difference between the median indoor and outdoor concentrations can be used to estimate a lower bound for the ADD factor (**ADD = 0.77 μg/m^3**; Quality Code = 2).	TL03, TL07
30-13	<u>Styrene</u> Author: Wallace, L. (EPA/600/6-87/002a) "Blue book" ▸ Bound volume of results from the TEAM studies. Indoor ME is **residence**. ▸ <u>Table 29</u> (pp. 61-62) provide indoor/outdoor comparisons (and ratios) for <u>matched</u> samples. ◦ These concentrations are median values for the 12-hr nighttime samples collected for two seasons (Jan. 1984 and May 1984) in LA, and during June 1984 in Contra Costa. ▸ <u>Table 46</u> (p. 97) provides median concentrations for indoor air in New Jersey (three different sampling periods) and California (also three different sampling periods). ▸ <u>Table 47</u> (p. 98) provides median concentrations for outdoor air in New Jersey (the same three sampling periods for NJ in Table 46) and California (the same three sampling periods for CA in Table 46). ◦ However, the number of outdoor measurements are always less than the number of indoor measurements. <u>From Table 29</u>: <table><tr><td></td><td>**LA(1/84)**</td><td>**LA(5/84)**</td><td>**Contra(6/84)**</td><td>**Avg.**</td></tr><tr><td>**PEN** (medians)**:**</td><td>**0.9**</td><td>**1.0**</td><td>**1.5**</td><td>**1.1**</td></tr></table>	MZ 38
30-13	<u>Styrene</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 1.1**	RA 35

Ref. No.	Supporting Information	Sources
30-13	<u>Styrene</u> Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **I/O =PEN = 0.88 (spring); 2.00 (summer)**	RA 29
30-13	<u>Styrene</u> Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., Sparacino, C., et al. ▸ Results of the TEAM study that report measurements of personal and outdoor air sampling; in addition, breath and drinking water samples were measured. ∘ The personal and outdoor air measurements were 12-hr integrated samples. These roughly correspond to daytime (6am-6pm) and nighttime (6pm-6am). Unfortunately, the personal and outdoor results for NJ (Table 2) are combined into 24-hr averages. ▸ Fig. 2 (p. 297) has a bar graph of the nighttime (6pm-6am) personal (might be used as a surrogate for indoor residence) and outdoor concentrations. NOTE: these are geometric means with more than four times the number of personal (347) compared to outdoor samples (84). ∘ *Also, all I/O ratios are greater than 1.5.* ▸ Table 3 also has 24-hr averaged results of personal air and outdoor air sampling for Greensboro, NC and Devils Lake, ND.	MZ 30
30-13	<u>Styrene</u> Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., et al. Summary of TEAM study in NJ (Fall, 1981). Samples collected for: *personal air* - two consecutive 12-hr samples taken from appr. 350 people, *outdoor air* - two consecutive 12-hr samples taken from appr. 90 people, also drinking water and breath. <u>Table 9</u> reports a summary of median, max. concs., and ratios (from both the median and max. conc. data) for 85 matched overnight personal air and overnight outdoor air samples. (It is our conclusion that this data provides the best concurrent I/O ratios for **residences** from this study.) **PEN = 2.7** (median value)	MZ 22
30-13	<u>Styrene.</u> Author: Bouhamra, W.S. Table 2 (p.199) -- Indoor VOCs concentrations. Table 3 (p.200) -- Ambient air VOCs concentrations. Min, max., mean, median, std. deviation provided. Table 4 (p.202) -- I/O ratios. Sampled during Dec 94-Jan 95. CONCURRENT MEASUREMENTS. **I/O ratio provided: 1.08 =PEN** Ambient air conc. provided: 747ug/m^3 (mean), 403ug/m^3(median) Indoor air conc provided: 805ug/m^3 (mean), 532ug/m^3(median) **MULT = (indoor conc)/(ambient conc) = 532/403 = 1.32 (from median conc)** Since PEN>1 ==> calculate ADD: Indoor conc (median) = 532ug/m^3; PEN = I/O = 1.08; Outdoor conc (calculated) = 532/1.08 = 492ug/m^3 **___ug/m^3<ADD<___ ug/m^3** **PROX (calculated from medians) =(outdoor conc)/(ambient conc) =492/403 = 1.22**	RA 14

Ref. No.	Supporting Information	Sources
30-17	<u>Styrene</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 1.3**	RA 35
30-17	<u>Styrene</u> Source #<u>TL10</u> measured simultaneous indoor and outdoor styrene concentrations for 12 office buildings in the San Francisco Bay Area during the period June - September 1990. The authors calculated the I/O ratio for each building, but they reported only the range of I/O ratios for all buildings (Range = 0.69 - 13, Table 2). The lower end of the range can be considered an estimate of the PEN factor since indoor sources are likely to be minimal. The upper portion of the range likely indicates the presence of indoor sources. **PEN = 0.69** (Quality Code = 1)	TL10 (same as MZ 39)
30-17	<u>Styrene</u> Author: Shields, H.C., Fleischer, D.M., and Weschler, C.J. ▸ Indoor and outdoor concentration s for 3-types of **offices** (Telecommunications (n=50); data centers (n=9); and administrative offices (n=11)). Geometric means are provided for each office type (see Table 3). ▸ <u>I/O ratios</u> by HAP and office type are provided for each office type using geometric means (see Table 4). **<u>I/O's for Styrene</u> :** Telco: **2.0** (2.7) *Values are GM (GSD)* Data Ctrs: **3.5** (1.7) Admin. Offices: **2.1** (1.7)	MZ 11
30-17	<u>Styrene</u> Author: Daisey, J.M., Hodgson, A.T., Fisk, W.J., et al. ▸ Indoor/outdoor measurements for 12 **office buildings**. ▸ <u>Table 2</u> (p. 3559) reports the range of I/O ratios measured for eleven of the twelve office buildings. <u>From Table 2</u>: **PEN (range): 0.69–13.0**	MZ 39 (same as TL 10)
30-19	<u>Styrene</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 1.2**	RA 35

Ref. No.	Supporting Information	Sources

30-27	<u>Styrene</u>
	Author: Shields, H.C. and Weschler, C.J.
	▸ Paper reports matched indoor/outdoor measurements at a telephone switching center (might be classified as an office (ME #17) or **other indoor location (ME #27)**.
	  ◦ <u>Table II</u> - Indoor (2 locations) & outdoor concs. during the March 87 and May 87 sampling.
	  ◦ <u>Table III</u> - Indoor (2 locations) & outdoor concs. during the Dec. 87 and Feb. 88 sampling.
	  ◦ <u>Table IV</u> - Indoor (2 locations) & outdoor concs. during the April 88 sampling.
	▸ NO outdoor measurements for styrene were reported.
		MZ 29

32-13	<u>1,1,2,2 Tetrachloroethane.</u> Author: Bouhamra, W.S. Table 2 (p.199) -- Indoor VOCs concentrations. Table 3 (p.200) -- Ambient air VOCs concentrations. Min, max., mean, median, std. deviation provided. Table 4 (p.202) -- I/O ratios. Sampled during Dec 94-Jan 95. CONCURRENT MEASUREMENTS. **I/O ratio provided: 2.62=PEN** Ambient air conc. provided: $1188ug/m^3$ (mean), $0ug/m^3$(median), $0ug/m^3$(min), $17604ug/m^3$(max), $4111ug/m^3$(std. dev) Indoor air conc provided: $3458ug/m^3$ (mean), $965ug/m^3$(median), $0ug/m^3$(min), $26521ug/m^3$(max), $6193ug/m^3$(std. dev) **MULT = (indoor conc)/(ambient conc) = 3458/1188 = 2.91 (from mean conc)** Since PEN>1 ==> calculate ADD: Indoor conc (mean) = $3458ug/m^3$; PEN = I/O = 2.62; Outdoor conc (calculated) = 3458/2.62 = $1319ug/m^3$ **$?ug/m^3$ <ADD< $?ug/m^3$** **PROX (calculated from means) =1319/1188 =1.11**	RA 14
32-17	<u>1,1,2,2-tetrachloroethane</u> Author: Daisey, J.M., Hodgson, A.T., Fisk, W.J., et al. ▸ Indoor/outdoor measurements for 12 **office buildings**. ▸ <u>Table 2</u> (p. 3559) reports the range of I/O ratios measured for eleven of the twelve office buildings. <u>From Table 2</u>: **PEN (range): 0.73–2.8**	MZ 39
32-17	<u>1,1,2,2-tetrachloroethane</u> Source #<u>TL10</u> measured simultaneous indoor and outdoor tetrachloroethane concentrations for 12 office buildings in the San Francisco Bay Area during the period June - September 1990. The authors calculated the I/O ratio for each building, but they reported only the range of I/O ratios for all buildings (Range = 0.73 - 2.8, Table 2). The lower end of the range can be considered an estimate of the PEN factor since indoor sources are likely to be minimal. The upper portion of the range likely indicates the presence of indoor sources. **PEN = 0.73** (Quality Code = 1)	TL10

Ref. No.	Supporting Information	Sources
33-1	Tetrachloroethylene (perchloroethylene) Author: South Coast Air Quality Management District ▸ Report gives results of concurrent **in-vehicle** and ambient (fixed site) monitoring study. ▸ Table 3-3 (p. 37) presents a comparison of in-vehicle and background mean concentrations. ◦ Since measurements were reported only for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the MULT factor. From Table 3-3: **MULT = 0.96**	MZ 37 (subset of this data reported in MZ 33)
33-1	Tetrachloroethylene (perchloroethylene) Source #TL17 measured tetrachloroethylene concentrations in commuting vehicles and at ambient monitoring sites in the Los Angeles area during the summer and winter of 1987. Measurements were made during the same time period, but were not necessarily concurrent. The authors reported mean in-vehicle and ambient concentrations (Table 3-3), from which an I/O ratio can be computed (I/O = 0.96). This ratio can be used as an estimate of the MULT factor. **MULT = 0.96** (Quality Code = 2)	TL17
33-13	Tetrachloroethylene Author: Begerow, J., et al. Time integrated data, first three sampling periods provide concurrent indoor/outdoor measurements for residences (see Table 2, p. 402; and in bar chart form, Figs. 3 & 4). Geometric mean, geometric standard deviation and range are reported. **Geom. Mean PEN values:** **Essen** **Borken** **winter:** 1.7 1.3 **spring:** 3.0 2.8 **summer:** 3.6 2.6	MZ 5
33-13	Tetrochloroethylene [Also, Total VHH (see explanation below)] Author: Gilli, G., Bono, R., and Scursatone, E. ▸ Paper reports results of concurrent indoor and outdoor air sampling in **residences** (apartments) in Turin. ◦ Measured concentrations are 6-hr integrated samples. ▸ Table 6 (p. 105) gives the median and ranges of the I/O ratios during both wintertime and summertime sampling. ◦ Unfortunately, only I/O ratios are reported for tetrachloroethylene singularly. The I/O ratios for the other HAPs are grouped together and reported as Total Volatile Halogenated Hydrocarbons (VHH). These include: chloroform, carbon tetrachloride, and trichloroethylene. **I/O Ratios:** **Wintertime** **Summertime** **Median** **Range** **Median** **Range** **Tetrachloroethylene** 2.15 0.59 - 30.91 1.38 1.03 - 4.22 **Total VHH** 2.69 1.85 - 29.45 1.33 0.79 - 2.75	MZ 31

Ref. No.	Supporting Information	Sources
33-13	Tetrachloroethene / tetrachloroethylene Author: Bouhamra, W.S. Table 2 (p.199) -- Indoor VOCs concentrations. Table 3 (p.200) -- Ambient air VOCs concentrations. Min, max., mean, median, std. deviation provided. Table 4 (p.202) -- I/O ratios. Sampled during Dec 94-Jan 95. CONCURRENT MEASUREMENTS. **I/O ratio provided: 2.96 =PEN** Ambient air conc. provided: 245ug/m^3 (mean), 241ug/m^3(median) Indoor air conc provided: 727ug/m^3 (mean), 472ug/m^3(median) **MULT = (indoor conc)/(ambient conc) = 472/241 = 1.96 (from median conc)** Since PEN>1 ==> calculate ADD: Indoor conc (median) = 472ug/m^3; PEN = I/O = 2.96; Outdoor conc (calculated) = 472/2.96 = 159ug/m^3 **___ug/m^3<ADD<___ ug/m^3** **PROX (calculated from medians) =(outdoor conc)/(ambient conc) =159/241 = 0.66**	RA 14
33-13	Tetrachloroethylene / tetrachloroethene Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **I/O =PEN = 1.17 (spring); none supplied for summer**	RA 29
33-13	Tetrachloroethylene (perchloroethylene) Source #TL03 measured simultaneous indoor and outdoor tetrachloroethylene concentrations for 44 residences in Toronto in the winter and spring of 1996. The authors reported average indoor and outdoor concentrations (Table 1), from which the I/O average ratio can be computed. Stove/garage sources in the residences were not identified. Therefore, the information was assigned to ME # 13. The I/O average ratio calculated by TRJ researchers was **2.3**, indicating the presence of significant indoor sources. Therefore, the difference between the average indoor and outdoor concentrations can be used to estimate a lower bound for the ADD factor (**ADD = 0.91 μg/m^3**; Quality Code = 2). Source #TL07 reported the indoor/outdoor tetrachloroethylene concentration ratio measured in June, 1990 for residences in Woodland, CA (Table 2-5). No information was given on stove/garage sources in the residences. The geometric mean ratio was **1.9**, indicating the presence of indoor sources. The ADD factor cannot be reliably estimated from this study since the median outdoor concentration was not quantifiable.	TL03, TL07

Ref. No.	Supporting Information	Sources

33-13	<u>Tetrachlorethylene</u>
	Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., Sparacino, C., et al.
	▸ Results of the TEAM study that report measurements of personal and outdoor air sampling; in addition, breath and drinking water samples were measured.
	  ○ The personal and outdoor air measurements were 12-hr integrated samples. These roughly correspond to daytime (6am-6pm) and nighttime (6pm-6am). Unfortunately, the personal and outdoor results for NJ (Table 2) are combined into 24-hr averages.
	▸ Fig. 2 (p. 297) has a bar graph of the nighttime (6pm-6am) personal (might be used as a surrogate for indoor residence) and outdoor concentrations. NOTE: these are geometric means with more than four times the number of personal (347) compared to outdoor samples (84).
	  ○ *Also, all I/O ratios are greater than 1.5.*
	▸ Table 3 also has 24-hr averaged results of personal air and outdoor air sampling for Greensboro, NC and Devils Lake, ND.
		MZ 30

33-13	<u>Tetrachloroethylene</u> Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ <u>Table 1</u> has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ <u>Table 2</u> (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **I/O ratio (mean) = 2.2** **I/O ratio (median) = 1.8**	MZ 27
33-13	<u>Tetrachloroethylene</u> Author: Drahonovska, H. Indoor & outdoor measurements of 140 residences (both kitchen and bedroom measurements) taken for listed HAPs. Energy use for heating is broken down by electric, gas, and coal sources. Unfortunately, <u>no</u> outdoor measurements were reported.	MZ 4
33-13	<u>Tetrachloroethylene (perchloroethylene)</u> Author: Chao, C.Y.H., Tung, T.C.W., Niu, J.L., Pang, S.W., Lee, R.Y.M. ▸ Indoor values reported for bedrooms of 3 different residences. Indoor samples were all 7-day integrated samples. ▸ Two 24-h ambient (outdoor) measurements were taken for each residence, but these samples did <u>not</u> coincide with the indoor sampling. See Tables 2-4.	MZ 19
33-13	<u>Tetrachloroethylene</u> Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., et al. Summary of TEAM study in NJ (Fall, 1981). Samples collected for: *personal air* - two consecutive 12-hr samples taken from appr. 350 people, *outdoor air* - two consecutive 12-hr samples taken from appr. 90 people, also drinking water and breath. <u>Table 9</u> reports a summary of median, max. concs., and ratios (from both the median and max. conc. data) for 85 matched overnight personal air and overnight outdoor air samples. (It is our conclusion that this data provides the best concurrent I/O ratios for **residences** from this study.) **PEN = 2.2** (median value)	MZ 22

Ref. No.	Supporting Information	Sources
33-13	Tetrachloroethylene Author: Wallace, L. (EPA/600/6-87/002a) "Blue book" ▸ Bound volume of results from the TEAM studies. Indoor ME is **residence**. ▸ Table 29 (pp. 61-62) provide indoor/outdoor comparisons (and ratios) for matched samples. 　○ These concentrations are median values for the 12-hr nighttime samples collected for two seasons (Jan. 1984 and May 1984) in LA, and during June 1984 in Contra Costa. ▸ Table 46 (p. 97) provides median concentrations for indoor air in New Jersey (three different sampling periods) and California (also three different sampling periods). ▸ Table 47 (p. 98) provides median concentrations for outdoor air in New Jersey (the same three sampling periods for NJ in Table 46) and California (the same three sampling periods for CA in Table 46). 　○ However, the number of outdoor measurements are always less than the number of indoor measurements. From Table 29: 　　　　　　　　**LA(1/84)**　**LA(5/84)**　**Contra(6/84)**　　**Avg.** **PEN** (medians)**:　1.2**　　　　**1.3**　　　　**8.4**　　　　　　**3.6**	MZ 38
33-17	Tetrachloroethylene Author: Shields, H.C., Fleischer, D.M., and Weschler, C.J. ▸ Indoor and outdoor concentration s for 3-types of **offices** (Telecommunications (n=50); data centers (n=9); and administrative offices (n=11)). Geometric means are provided for each office type (see Table 3). ▸ I/O ratios by HAP and office type are provided for each office type using geometric means (see Table 4). **I/O's for Tetrachloroethylene :** Telco:　**2.1** (4.6)　　　　　　　*Values are GM (GSD)* Data Ctrs:　**2.7** (2.1) Admin. Offices:　**3.5** (3.7)	MZ 11
33-20	tetrachloroethylene (perchloroethylene)/tetrachlroethene Table 1: Indoor and outdoor air concentrations. NOT SURE IF CONCURRENT MEASUREMENTS. Indoors conc = 2.8 ppb (one sample measurement) Outdoors conc = 1.8 ppb (one sample measurement) **I/O ratio = PEN = 2.8/1.8 = 1.56**	RA 37

Ref. No.	Supporting Information	Sources
33-21 33-31	Tetrachloroethylene (PCE) Author: Underwood, M.C. Concurrent indoor & outdoor samples reported for two different <u>schools</u> (one test school and one control school). <u>Table 1</u> provides monitoring data, both AM and PM, for two different sampling dates. <u>Figure 2</u> contains a graphical representation of I/O ratios from Table 1. In addition, concurrent fixed-site monitoring data for local air district provided. *Should enable calculation of both penetration and proximity factors.* **From Table 1:** **PEN PROX MULT** **Test sch., Rm. B3, 8/11/92:** **1.1 0.11 0.12** **Test sch., Rm. B4, 8/11/92:** **1.9 0.11 0.21** **Test sch., Rm. B3, 11/9/92:** **6.0 0.04 0.26** **Test sch., Rm. B4, 11/9/92:** **6.3 0.04 0.27** **Control school, 8/11/92:** **0.3 0.86 0.24** **Control school, 11/9/92:** **<u>0.5</u> <u>0.63</u> <u>0.29</u>** **MEDIAN: 3.3 0.45 0.21** **From Table 2:** **PEN PROX MULT** **Test sch., Rm. B3, cond. (b):** **1.0 0.2 0.20** **Test sch., Rm. B4, cond. (b):** **0.8 0.2 0.15** **Control school, cond. (b):** **<u>0.8</u> <u>0.13</u> <u>0.11</u>** **MEDIAN: 0.9 0.17 0.16**	MZ 1
33-27	Perchloroethylene (Tetrachloroethylene) Author: Shields, H.C. and Weschler, C.J. ▸ Paper reports matched indoor/outdoor measurements at a telephone switching center (might be classified as an office (ME #17) or other **indoor location (ME #27)**. ○ <u>Table II</u> - Indoor (2 locations) & outdoor concs. during the March 87 and May 87 sampling. ○ <u>Table III</u> - Indoor (2 locations) & outdoor concs. during the Dec. 87 and Feb. 88 sampling. ○ <u>Table IV</u> - Indoor (2 locations) & outdoor concs. during the April 88 sampling. ○ <u>Table VI</u> - Indoor (3 locations) & outdoor concs. during the Nov. 88 sampling. Samples collected during: **PEN** 03/87 & 05/87: **4.4** Range: 0.7 – 8.5 12/87 & 02/88: **2.2** Range: 1.4 – 3.0 <u>11/88:</u> **<u>1.6</u>** Range: 1.5 – 1.7 Overall avg.: **2.7**	MZ 29
33-27	Tetrachloroethylene Author: Hisham, M. and Grosjean, D. ▸ Paper presents results of concurrent indoor and outdoor sampling in nine different museums in the LA area. ○ Hourly samples were collected over the course of 1-2 weeks at each museum. Hourly samples were collected around the clock. ▸ Table I (p. 859) shows the maximum and range of pollutant concs. for both indoors and outdoors at each museum. ▸ Table II (p. 861) shows the average I/O ratios calculated from all paired measurements for each museum. **Average I/O ratio range (all museums but one) (see Table II) = 0.33 to 1.58** **Average I/O ratio for above museums (not incl. Olivas or Southwest) = 0.91**	MZ 32

Ref. No.	Supporting Information	Sources
33-30	<u>Tetrachloroethylene</u> Author: Begerow, J. Time integrated data, first three sampling periods provide concurrent indoor/outdoor measurements for residences (see Table 2, pg.402; and in bar chart form, Figs. 3&4). Geometric mean, geometric standard deviation and range are provided.	MZ 5
34-13	<u>Trichloroethylene (TCE)</u> Author: Wallace, L. (EPA/600/6-87/002a) "Blue book" ▸ Bound volume of results from the TEAM studies. Indoor ME is **residence**. ▸ <u>Table 29</u> (pp. 61-62) provide indoor/outdoor comparisons (and ratios) for <u>matched</u> samples. ◦ These concentrations are median values for the 12-hr nighttime samples collected for two seasons (Jan. 1984 and May 1984) in LA, and during June 1984 in Contra Costa. ▸ <u>Table 46</u> (p. 97) provides median concentrations for indoor air in New Jersey (three different sampling periods) and California (also three different sampling periods). ▸ <u>Table 47</u> (p. 98) provides median concentrations for outdoor air in New Jersey (the same three sampling periods for NJ in Table 46) and California (the same three sampling periods for CA in Table 46). ◦ However, the number of outdoor measurements are always less than the number of indoor measurements. <u>From Table 29</u>: **LA(1/84)** **LA(5/84)** **Contra(6/84)** **Avg.** **PEN** (medians)**:** **1.8** **4.8** **3.2** **3.3**	MZ 38
34-13	<u>Trichloroethylene / trichloroethene</u> Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **I/O =PEN = 1.35 (spring); none supplied for summer**	RA 29
34-13	<u>Trichloroethylene</u> Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., Sparacino, C., et al. ▸ Results of the TEAM study that report measurements of personal and outdoor air sampling; in addition, breath and drinking water samples were measured. ◦ The personal and outdoor air measurements were 12-hr integrated samples. These roughly correspond to daytime (6am-6pm) and nighttime (6pm-6am). Unfortunately, the personal and outdoor results for NJ (Table 2) are combined into 24-hr averages. ▸ Fig. 2 (p. 297) has a bar graph of the nighttime (6pm-6am) personal (might be used as a surrogate for indoor residence) and outdoor concentrations. NOTE: these are geometric means with more than four times the number of personal (347) compared to outdoor samples (84). ◦ *Also, all I/O ratios are greater than 1.5.* ▸ Table 3 also has 24-hr averaged results of personal air and outdoor air sampling for Greensboro, NC and Devils Lake, ND.	MZ 30
34-13	<u>Trichloroethylene</u> Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ <u>Table 1</u> has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ <u>Table 2</u> (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **I/O ratio (mean) = 3.4** **I/O ratio (median) = 1.8**	MZ 27

Ref. No.	Supporting Information	Sources
34-13	Trichloroethylene (TCE) Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., et al. Summary of TEAM study in NJ (Fall, 1981). Samples collected for: *personal air* - two consecutive 12-hr samples taken from appr. 350 people, *outdoor air* - two consecutive 12-hr samples taken from appr. 90 people, also drinking water and breath. Table 9 reports a summary of median, max. concs., and ratios (from both the median and max. conc. data) for 85 matched overnight personal air and overnight outdoor air samples. (It is our conclusion that this data provides the best concurrent I/O ratios for **residences** from this study.) **PEN = 1.5** (median value)	MZ 22

34-21
34-31
	Trichloroethylene (TCE)
	Author: Underwood, M.C.
	Concurrent indoor & outdoor samples reported for two different schools (one test school and one control school). Table 1. provides monitoring data, both AM and PM, for two different sampling dates. Figure 2. contains a graphical representation of I/O ratios from Table 1.
	In addition, concurrent fixed-site monitoring data for local air district provided. Will enable calculation of both penetration and proximity factors.
	From Table 1:
	
	                      PEN **PROX** **MULT**
	Test sch., Rm. B3, 8/11/92: **>4.1** **NA** **NA=Not available**
	Test sch., Rm. B4, 8/11/92: **>33.9** **NA** **NA**
	Test sch., Rm. B3, 11/9/92: **>5.6** **NA** **NA**
	Test sch., Rm. B4, 11/9/92: **>29.5** **NA** **NA**
	
	From Table 2:
	
	                      PEN **PROX** **MULT**
	Test sch., Rm. B4, cond. (b): **>1.25** **NA** **NA**
	
	MEDIAN (incl. Table 1): **17.6**
		MZ 1

TBDL-1	Ethylbenzene Author: Jo, W.K.; Park, K.H. In-vehicle and ambient concentrations of VOCs measured prior to and during idling presented GRAPHICALLY. - p. 220. Fig. 1 See RA21, MZ12. Bar graphs of concentrations measured in-car and ambient are presented for both idling and driving conditions.	RA 19 MZ 12

Ref. No.	Supporting Information	Sources
TBDL-1	Ethylbenzene Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by **car**, subway, bicycling (other), and walking. -- See Table I, (p. 1596). ∘ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient. **Therefore, only calculation of a MULT factor is possible.*** ▸ In addition, VOC concs. were also measured in subjects' residences and in offices -- See Table III, (p. 1597). ∘ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ∘ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs. **MULT (median) = 2.0**	MZ 34
TBDL-1	Ethylbenzene Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for **in-vehicle (ME #1)**, car exterior, fixed-site, and sidewalk (i.e., near road) (ME #7). Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. From Table II (median values): **PROX PEN MULT** **PEN Range** (from Table V)**: 0.70 – 1.63** **7.0 0.8 5.9**	MZ 28
TBDL-1	Ethylbenzene Author: Jo, W.K.; Park, K.H. In-vehicle and ambient concentrations of VOCs measured prior to and during idling presented GRAPHICALLY. - p. 220. Fig. 1 See RA21 (data presented in table format), MZ12. Bar graphs of concentrations measured in-car and ambient are presented for both idling and driving conditions. Mean ambient roadway air samples and invehicle concentrations with standard deviation for 115 commutes in Korean urban route for two types of cars (old model=Elantra; new model =Sonata II). NEW MODEL: Mean indoor conc reported: 9.4ug/m^3 Mean outdoor conc reported: 9.0ug/m^3 **PEN= I/O = 9.4/9 = 1.04** OLD MODEL: Mean indoor conc reported: 13.8ug/m^3 Mean outdoor conc reported: 14.1ug/m^3 **PEN= I/O = 13.8/14.1 = 0.98**	RA 19 RA21 MZ 12

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Ref. No.	Supporting Information	Sources

TBDL-4	Ethylbenzene
	Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M.
	▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by car, subway, **bicycling (other)**, and walking. -- See Table I, (p. 1596).
	  ∘ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient. **Therefore, only calculation of a MULT factor is possible.***
	▸ In addition, VOC concs. were also measured in subjects' residences and in offices -- See Table III, (p. 1597).
	  ∘ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.*
	▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples.
	  ∘ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time.
	▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.
	
	MULT (median) = 1.1
		MZ 34

TBDL-5	Ethylbenzene Author: Schwar, M.; Booker, J.; Tait, L. Comparison of concentrations **in the car park** vs. **at the exit of the car park**. Max. concentrations averaged over specified time periods. Table 7. WEEKDAYS (11 GARAGES) Mean of averaged 1-hr inside car park conc: 0.18mg/m^3 Mean of averaged 1-hr exit of car park conc: 0.2mg/m^3 **PEN= I/O = 0.18/0.2 = 0.9** WEEKENDS (5 GARAGES) Mean of averaged 1-hr inside car park conc: 0.2mg/m^3 Mean of averaged 1-hr exit of car park conc: 0.3mg/m^3 **PEN= I/O = 0.2/0.3 = 0.67**	RA 24
TBDL-7	Ethylbenzene Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for in-vehicle (ME #1), car exterior, fixed-site, and sidewalk (i.e., **near road) (ME #7)**. Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. From Table II: **PROX** **4.0** *Median value*	MZ 28

Ref. No.	Supporting Information	Sources
TBDL-13	Ethylbenzene Author: Schneider, P.; Lorinci, G.; Gebefugi, IL.; Heinrich, J.; Kettrup, A. Simultaneous I/O sampling (p.284) Concentration profiles provided by height at which sampling took place. Table 5: median I/O ratios supplied for bedroom, living room, kitchen. Table 6: median I/O ratios (for bedroom, living room, kitchen) presented by apartment age group (old vs. new) **I/O =PEN = 3.5 (kitchen); 3.2 (living room); 2.0 (bedroom)** **Mean I/O = 2.9**	RA 30
TBDL-13	Ethylbenzene. Author: Bouhamra, W.S. Table 2 (p.199) -- Indoor VOCs concentrations. Table 3 (p.200) -- Ambient air VOCs concentrations. Min, max., mean, median, std. deviation provided. Table 4 (p.202) -- I/O ratios. Sampled during Dec 94-Jan 95. CONCURRENT MEASUREMENTS. **I/O ratio provided: 1.05=PEN** Ambient air conc. provided: 267 ug/m^3 (mean), 234 ug/m^3(median), 0 ug/m^3(min), 966 ug/m^3(max), 301 ug/m^3(std. dev) Indoor air conc provided: 280 ug/m^3 (mean), 286 ug/m^3(median), 0 ug/m^3(min), 674 ug/m^3(max), 240 ug/m^3(std. dev) **MULT = (indoor conc)/(ambient conc) = 286/234 =1.22 (from median conc)** Since PEN>1 ==> calculate ADD: Indoor conc (median) = 286 ug/m^3; PEN = I/O = 1.05; Outdoor conc (calculated) = 286/1.05 = 272.38 ug/m^3 **13.63ug/m^3<ADD<286 ug/m^3** **PROX (calculated from medians) = 272.38/234 = 1.16**	RA 14
TBDL-13	Ethylbenzene Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 1.0**	RA 35
TBDL-13	Ethylbenzene Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **I/O =PEN = 1.44 (spring); 3.50 (summer)**	RA 29

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Ref. No.	Supporting Information	Sources
TBDL-13	<u>Ethylbenzene</u> Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., et al. Summary of TEAM study in NJ (Fall, 1981). Samples collected for: *personal air* - two consecutive 12-hr samples taken from appr. 350 people, *outdoor air* - two consecutive 12-hr samples taken from appr. 90 people, also drinking water and breath. <u>Table 9</u> reports a summary of median, max. concs., and ratios (from both the median and max. conc. data) for 85 matched overnight personal air and overnight outdoor air samples. (It is our conclusion that this data provides the best concurrent I/O ratios for **residences** from this study.) **PEN = 1.9** (median value)	MZ 22
TBDL-13	<u>Ethylbenzene</u> Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ <u>Table 1</u> has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ <u>Table 2</u> (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **I/O ratio (mean) = 6.8** **I/O ratio (median) = > 2**	MZ 27
TBDL-13	<u>Ethylbenzene</u> Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., Sparacino, C., et al. ▸ Results of the TEAM study that report measurements of personal and outdoor air sampling; in addition, breath and drinking water samples were measured. ○ The personal and outdoor air measurements were 12-hr integrated samples. These roughly correspond to daytime (6am-6pm) and nighttime (6pm-6am). Unfortunately, the personal and outdoor results for NJ (Table 2) are combined into 24-hr averages. ▸ Fig. 2 (p. 297) has a bar graph of the nighttime (6pm-6am) personal (might be used as a surrogate for indoor residence) and outdoor concentrations. NOTE: these are geometric means with more than four times the number of personal (347) compared to outdoor samples (84). ○ *Also, all I/O ratios are greater than 1.5.* ▸ Table 3 also has 24-hr averaged results of personal air and outdoor air sampling for Greensboro, NC and Devils Lake, ND.	MZ 30
TBDL-13	<u>Ethylbenzene</u> Author: Lebret, E., van de Wiel, H.J., Bos, H.P., Noij, D., and Boleij, J.S.M. ▸ <u>Table 2</u> (p. 326) reports median and maximum HAP concentrations in **residences** (a total of approx. 300) of three different age groups; the median and maximum outdoor concs.; and the overall median I/O ratio for all homes. ○ These concentrations were weekly averages. **<u>Median, overall I/O ratios:</u>** **ethylbenzene = 5**	MZ 26

Ref. No.	Supporting Information	Sources
TBDL-13	**Ethylbenzene** Author: Wallace, L. (EPA/600/6-87/002a) "Blue book" ▸ Bound volume of results from the TEAM studies. Indoor ME is **residence**. ▸ <u>Table 29</u> (pp. 61-62) provide indoor/outdoor comparisons (and ratios) for <u>matched</u> samples. ∘ These concentrations are median values for the 12-hr nighttime samples collected for two seasons (Jan. 1984 and May 1984) in LA, and during June 1984 in Contra Costa. ▸ <u>Table 46</u> (p. 97) provides median concentrations for indoor air in New Jersey (three different sampling periods) and California (also three different sampling periods). ▸ <u>Table 47</u> (p. 98) provides median concentrations for outdoor air in New Jersey (the same three sampling periods for NJ in Table 46) and California (the same three sampling periods for CA in Table 46). ∘ However, the number of outdoor measurements are always less than the number of indoor measurements. <u>From Table 29</u>: **LA(1/84) LA(5/84) Contra(6/84) Avg.** **PEN** (medians)**: 0.9 1.1 2.8 1.6**	MZ 38
TBDL-13	**Ethylbenzene** Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ∘ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate.* ▸ In addition, VOC concs. were also measured in subjects' **residences** and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ∘ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ∘ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.	MZ 34
TBDL-17	**Ethylbenzene** Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 1.7**	RA 35
TBDL-17	**Ethylbenzene** Author: Brickus, L.; Cardoso, J.; de Aquino Neto, F. Reports concurrent measurements of aldehyde and VOC concentrations on four different floors of an **office building** for several different days. I/O ratios provided – see tables 1, 2, & 3. **Mean PEN (building wide; ie., four floors) = 2.5** (Range: 1.8 – 3.0)	MZ 10

Ref. No.	Supporting Information	Sources
TBDL-17	<u>Ethylbenzene</u> Author: Shields, H.C. Indoor and outdoor concentration s for 3-types of offices (Telecommunications (n=50); data centers (n=9); and administrative offices (n=11), geometric means are provided for each office type See Table 3 I/O ratios by HAP and office type are provided for each office type using geometric means, (see Table 4) **I/O's for Ethylbenzene are** Telco: **1.6**; Data Cntrs.: **2.7**; Admin. Office: **1.9**	30–13
TBDL-17	<u>Ethylbenzene</u> Author: Daisey, J.M., Hodgson, A.T., Fisk, W.J., et al. ▸ Indoor/outdoor measurements for 12 **office buildings**. ▸ <u>Table 2</u> (p. 3559) reports the range of I/O ratios measured for eleven of the twelve office buildings. <u>From Table 2</u>: **PEN (range): 0.48–2.5**	MZ 39
TBDL-17	<u>Ethylbenzene</u> Author: Shields, H.C., Fleischer, D.M., and Weschler, C.J. ▸ Indoor and outdoor concentration s for 3-types of **offices** (Telecommunications (n=50); data centers (n=9); and administrative offices (n=11)). Geometric means are provided for each office type (see Table 3). ▸ <u>I/O ratios</u> by HAP and office type are provided for each office type using geometric means (see Table 4). **<u>I/O's for Ethylbenzene :</u>** Telco: **1.6** (2.3) *Values are GM (GSD)* Data Ctrs: **2.7** (1.6) Admin. Offices: **1.9** (1.8)	MZ 11

TBDL-17	<u>Ethylbenzene</u>
	Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M.
	▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596).
	  ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate.*
	▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in **offices** -- See <u>Table III</u>, (p. 1597).
	  ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.*
	▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples.
	  ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time.
	▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.
		MZ 34

TBDL-19	<u>Ethylbenzene</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 1.5**	RA 35

Ref. No.	Supporting Information	Sources
TBDL-27	**Ethylbenzene** Author: Shields, H.C. and Weschler, C.J. ▸ Paper reports matched indoor/outdoor measurements at a telephone switching center (might be classified as an office (ME #17) or **other indoor location (ME #27)**. 　◦ <u>Table II</u> - Indoor (2 locations) & outdoor concs. during the March 87 and May 87 sampling. 　◦ <u>Table III</u> - Indoor (2 locations) & outdoor concs. during the Dec. 87 and Feb. 88 sampling. 　◦ <u>Table IV</u> - Indoor (2 locations) & outdoor concs. during the April 88 sampling. 　◦ <u>Table V</u> - Indoor (3 locations) & outdoor concs. during the May 88 and July 88 sampling. 　◦ <u>Table VI</u> - Indoor (3 locations) & outdoor concs. during the Nov. 88 sampling. Samples collected during: 　　　　　　**PEN** 03/87 & 05/87:　**1.6**　　Range: 1.2 – 2.0 12/87 & 02/88:　**2.1**　　Range: 1.9 – 2.6 04/88:　　　　**1.5**　　Range: 1.5 – 1.5 05/88 & 07/88:　**4.9**　　Range: 4.6 – 5.3 <u>11/88:</u>　　　　**2.2**　　Range: 2.0 – 2.3 Overall avg.:　**2.5**	MZ 29
TBDL-36	**Ethylbenzene** Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, **subway**, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). 　◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient. **Therefore, only calculation of a MULT factor is possible.*** ▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See Table III, (p. 1597). 　◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. 　◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs. **MULT (median) = 1.0**	MZ 34
TBDL-1	**Hexane** Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for **in-vehicle (ME #1)**, car exterior, fixed-site, and sidewalk (i.e., <u>near road) (ME #7)</u>. Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. <u>From Table II</u> *(Median values)*: **PROX　PEN　MULT**　　　　　　**PEN Range: 0.85 – 1.3** **5.3　　1.1　　5.8**	MZ 28

Ref. No.	Supporting Information	Sources
TBDL-7	<u>Hexane</u> Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for <u>in-vehicle (ME #1)</u>, car exterior, fixed-site, and sidewalk (i.e., **near road) (ME #7)**. Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. <u>From Table II</u>: **PROX** **4.2**　　*Median value*	MZ 28
TBDL-13	<u>n-Hexane</u> Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ <u>Table 1</u> has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ <u>Table 2</u> (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **I/O ratio (mean) = 8.7** **I/O ratio (median) = 1.8**	MZ 27
TBDL-13	<u>n-Hexane</u> Author: Lebret, E., van de Wiel, H.J., Bos, H.P., Noij, D., and Boleij, J.S.M. ▸ <u>Table 2</u> (p. 326) reports median and maximum HAP concentrations in **residences** (a total of approx. 300) of three different age groups; the median and maximum outdoor concs.; and the overall median I/O ratio for all homes. 　◦ These concentrations were weekly averages. **Median, overall I/O ratios:** **n-hexane = 2**	MZ 26
TBDL-17	<u>Hexane</u> Author: Brickus, L.; Cardoso, J.; de Aquino Neto, F. Reports concurrent measurements of aldehyde and VOC concentrations on four different floors of an **office building** for several different days. I/O ratios provided – see tables 1, 2, & 3. **Mean PEN (building wide; ie., four floors) = 4.8** (Range: 1.5 – 11.7)	MZ 10
TBDL-1	<u>MTBE</u> Author: Lioy, Weisel, Jo, Pellizzari, Raymer Two microenvironmental combinations of MTBE were reported, including: concurrent **in-cabin** and **outside** during refueling (Fig. 2 – bar chart), and concurrent **in-cabin** and **roadway (hood of car)** (Fig. 3– scatter plot).	MZ 20

Ref. No.	Supporting Information	Sources
TBDL-1	<u>MTBE</u> Author: Wan-Kuen Jo and Kun-Ho Park Table 1 has data on concentrations for **in-auto**, in-bus, and ambient air. Also, just below this table, the authors provide ratios for in-auto/in-bus/fixed-site. Finally, a possible proximity factor is suggested (also just below <u>Table 1</u>). No measurements for outside the vehicle were reported. **<u>PEN</u> <u>PROX</u> <u>MULT</u>** [Ratio calculated using median measurement values] **N/A N/A 13.9**	MZ 14
TBDL-1	<u>MTBE</u> Author: Shahnaz Alimokhtari Vayghani and Clifford Weisel Data presented for paired measurements of in-car and "at the pump" concentrations *during refueling* (Table 1). **I/O* ratio (median) = 4.3** * I=in-cabin, O=at the pump.	MZ 13
TBDL-2	<u>MTBE</u> Author: Wan-Kuen Jo and Kun-Ho Park Table 1 has data on concentrations for in-auto, **in-bus**, and ambient air. Also, just below this table, the authors provide ratios for in-auto/in-bus/fixed-site. Finally, a possible proximity factor is suggested (also just below <u>Table 1</u>). Assumed that in-bus and roadway concentrations were the same. **<u>PEN</u> <u>PROX</u> <u>MULT</u>** [All ratios calculated using <u>median</u> measurement values.] **1.0 4.4 4.4**	MZ 14
TBDL-1	<u>Toluene</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ‣ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>**car**</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ○ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient. **Therefore, only calculation of a MULT factor is possible.*** ‣ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ○ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ‣ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ○ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ‣ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs. **MULT (median) = 1.5**	MZ 34

Ref. No.	Supporting Information	Sources
TBDL-1	<u>Toluene</u> Author: South Coast Air Quality Management District ▸ Report gives results of concurrent **in-vehicle** and <u>ambient</u> (fixed site) monitoring study. ▸ <u>Table 3-3</u> (p. 37) presents a comparison of in-vehicle and background mean concentrations. ◦ Since measurements were reported only for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Table 3-3</u>: **MULT = 2.5**	MZ 37 (subset of this data reported in MZ 33)
TBDL-1	<u>Toluene</u> Author: Shahnaz Alimokhtari Vayghani and Clifford Weisel Data presented for paired measurements of in-car and "at the pump" concentrations *during refueling* (Table 1). **I/O* ratio (median) = 2.8** * I=in-cabin, O=at the pump.	MZ 13
TBDL-1	<u>Toluene</u> Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for **car (ME #1)**, car exterior, fixed-site, and sidewalk (i.e., <u>near road) (ME #7)</u>. Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. <u>From Table II</u> *(Median values)*: **PROX PEN MULT** **PEN Range** (from Table V)**: 0.73 – 1.66** **7.1 0.88 6.2**	MZ 28
TBDL-1	<u>Toluene</u> Author: Leung, PL.; Harrison, RM. In-vehicle, immediately outside the vehicle (out-vehicle), and roadside SIMULTANEOUS sampling on six different roads. Roadside (static/fixed-site) sampling sites at different distances from road and measured at different heights Ambient air concentrations – continuous measurements at a background location – measured data each hour throughout the year. Ambient data presented as mean over the sampling period (p. 194) Table 3: DAILY means and standard deviations of concentrations in-vehicle, out-vehicle, roadside, and ambient. **Table 5: Mean I/O ratios/PEN, PROX, MULT for Toluene on six different roads** Comparison of in-vehicle vs. out-vehicle concentrations during rush hours and non-rush hours – tables 6&7. Comparison of in-vehicle vs. out-vehicle concentrations for different types of cars – tables 8&9. **PEN = 1.11** **MULT = 20.94** **PROX = 17.73**	RA 32

Ref. No.	Supporting Information	Sources
TBDL-1	Toluene Author: Jo, W.K.; Park, K.H. In-vehicle and ambient concentrations of VOCs measured prior to and during idling presented GRAPHICALLY. - p. 220. Fig. 1 See RA21 (data presented in table format), MZ12. Bar graphs of concentrations measured in-car and ambient are presented for both idling and driving conditions. Mean ambient roadway air samples and invehicle concentrations with standard deviation for 115 commutes in Korean urban route for two types of cars (old model=Elantra; new model =Sonata II). NEW MODEL: Mean indoor conc reported: 100ug/m^3 Mean outdoor conc reported: 81.1ug/m^3 **PEN= I/O = 100/81.1 = 1.23** OLD MODEL: Mean indoor conc reported: 129ug/m^3 Mean outdoor conc reported: 105ug/m^3 **PEN= I/O = 129/105 = 1.23**	RA 19 RA21 MZ 12
TBDL-1	Toluene Author: Jo, W.K.; Park, K.H. In-vehicle and ambient concentrations of VOCs measured prior to and during idling presented GRAPHICALLY. - p. 220. Fig. 1 See RA21, MZ12. Bar graphs of concentrations measured in-car and ambient are presented for both idling and driving conditions.	RA 19 MZ 12

TBDL-4	Toluene
	Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M.
	▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, **bicycling (other)**, and walking. -- See <u>Table I</u>, (p. 1596).
	  ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient. **Therefore, only calculation of a MULT factor is possible.***
	▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597).
	  ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.*
	▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples.
	  ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time.
	▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.
	
	MULT (median) = 0.7
		MZ 34

Ref. No.	Supporting Information	Sources
TBDL-5	<u>Toluene</u> Author: Schwar, M.; Booker, J.; Tait, L. Comparison of concentrations **in the car park** vs. **at the exit of the car park**. Max. concentrations averaged over specified time periods. Table 7. WEEKDAYS (11 GARAGES) Mean of averaged 1-hr inside car park conc: 0.76mg/m^3 Mean of averaged 1-hr exit of car park conc: 1.09mg/m^3 **PEN= I/O = 0.76/1.09 = 0.7** WEEKENDS (5 GARAGES) Mean of averaged 1-hr inside car park conc: 1.4mg/m^3 Mean of averaged 1-hr exit of car park conc: 1.6mg/m^3 **PEN= I/O = 1.4/1.6 = 0.88**	RA 24
TBDL-7	<u>Toluene</u> Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for <u>car (ME #1)</u>, car exterior, fixed-site, and sidewalk (i.e., **<u>near road) (ME #7)</u>). Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. <u>From Table II</u>: **PROX** **4.1** *Median values*	MZ 28
TBDL-13	<u>Toluene</u> Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ <u>Table 1</u> has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ <u>Table 2</u> (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **I/O ratio (mean) = 6.1** **I/O ratio (median) = 2.6**	MZ 27

Ref. No.	Supporting Information	Sources
TBDL-13	**Toluene** Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate.* ▸ In addition, VOC concs. were also measured in subjects' **residences** and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.	MZ 34
TBDL-13	**Toluene** Author: Crump, D.R. Indoor & outdoor measurements of HAPs over 2 years with data reported for a summer season only and a winter season only. Measurements are for four newly constructed unoccupied test houses. Although the methods state that measurements were taken in the living room, kitchen, bedrooms, and bathroom; only the average for the whole house was reported. The mean, max, and minimum data provided for each house and for each contaminant measured in each house for two consecutive years. **House T1** PEN* Mean **Yr. 1 Yr. 2 Summer Winter (S and W only)** **toluene 2.1 1.0 1.0 1.0 1.0** **House T2** PEN* Mean **Yr. 1 Yr. 2 Summer Winter (S and W only)** **toluene 1.3 1.0 1.0 1.0 1.0** **House M3** PEN* Mean **Yr. 1 Yr. 2 Summer Winter (S and W only)** **toluene 1.1 6.0 0.67 1.0 0.8** **House M4** PEN* Mean **Yr. 1 Yr. 2 Summer Winter (S and W only)** **toluene 1.3 1.2 1.5 1.2 1.35** *Mean values **toluene** **Overall Mean:** *1.0* **(all houses, S and W only)**	MZ 2
TBDL-13	<u>Toluene</u> Author: Drahonovska, H. Indoor & outdoor measurements of 140 residences (both kitchen and bedroom measurements) taken for listed HAPs. Energy use for heating is broken down by electric, gas, and coal sources. Average I/O ratios provided (Table 5) for toluene. **I/O=7.8 for house heated** **I/O=3.2 for non-heated house**	MZ 4

Ref. No.	Supporting Information	Sources
TBDL-13	<u>Toluene</u> Author: Gilli, G., Scursatone, E., and Bono, R. ▸ Indoor and outdoor simultaneous measurements taken for a **residence** (apartment). ∘ Samples were collected by 10 non-smoking university students who each collected samples for 10 consecutive days [2 integrated samples per day: 1) 8:00 - 20:00 (12-hrs), and 2) 0:00 - 8:00 (8-hrs)] in December 1991. ▸ <u>Table 3</u> (p. 53) shows the mean I/O ratios for both day (i.e., 8:00 - 20:00) and night (ie, 0:00 - 8:00). Data is the average form all students. ▸ <u>Table 4</u> (p. 54) shows indoor and outdoor pollutant concentrations for both day and night. NOTE: It is not clear how this data relates to the ratios reported in Table 3. It might be data for only a single student. **<u>Average I/O data for all students (Table 3)</u>:** **toluene (day) = 1.11** **toluene (night) = 2.86**	MZ 25
TBDL-13	<u>Toluene</u> Author: Lebret, E., van de Wiel, H.J., Bos, H.P., Noij, D., and Boleij, J.S.M. ▸ <u>Table 2</u> (p. 326) reports median and maximum HAP concentrations in **residences** (a total of approx. 300) of three different age groups; the median and maximum outdoor concs.; and the overall median I/O ratio for all homes. ∘ These concentrations were weekly averages. **<u>Median, overall I/O ratios</u>:** **toluene = 8**	MZ 26
TBDL-13	<u>Toluene</u> Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **I/O =PEN = 1.42 (spring); 4.72 (summer)**	RA 29
TBDL-13	<u>Toluene</u> Author: Barguil, S., Le Moullec, Y., Person, A., Laurent, A-M, and Festy, B. ▸ Study which reports concurrent indoor and outdoor measurements taken in **residences** (5 detached houses and 4 apartments). ∘ The paper reports the average I/O measurements (Fig 2. - bar chart) of samples taken over the entire length of the study (Sept. 1987 - Aug. 1988). **<u>I/O ratios (average of 75 samples)</u>:** **PEN = 3.6**	MZ 36

Ref. No.	Supporting Information	Sources

TBDL-13	<u>Toluene</u>
	Author: Brown, V. and Crump, D.
	▸ Measurement study at **residences** using passive samplers.
	◦ Samplers were exposed for 1-month periods.
	◦ Far more indoor measurements (173) were taken than outdoor measurements (13).
	◦ Matched samples <u>not</u> reported.
	▸ <u>Table 1</u> (p. 386) reports the min, max, median, and mean for inside 173 homes; and also reports the mean for outdoors for 13 homes.
	
	                              Indoors* Outdoors*
	            <u>median</u> <u>mean</u> <u>min</u> <u>max</u> <u>mean</u> **<u>mean I/O</u>**
	toluene 25 40 8 1004 12 **3.3**
	* All values in $\mu g/m^3$.
	
	▸ <u>Fig. 1</u> (p. 391) shows the mean concentrations of benzene and toluene by month for both indoors and outdoors.
	◦ Not specified how many indoor (or outdoor) measurements were included in each monthly mean reported in Fig. 1's graphs.
	<u>Estimated ratios (I/O)</u> (from Fig. 1)**:**
	             <u>min</u> **<u>max</u>**
	toluene **3.2** **5.5**
		MZ 35

TBDL-13	<u>Toluene</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 1.1**	RA 35
TBDL-13	<u>Toluene</u> Author: Schneider, P.; Lorinci, G.; Gebefugi, IL.; Heinrich, J.; Kettrup, A. Simultaneous I/O sampling (p.284) Concentration profiles provided by height at which sampling took place. Table 5: median I/O ratios supplied for bedroom, living room, kitchen. Table 6: median I/O ratios (for bedroom, living room, kitchen) presented by apartment age group (old vs. new) **I/O =PEN = 6.1 (kitchen); 7.5 (living room); 2.6 (bedroom)** **Mean I/O = 5.4**	RA 30
TBDL-17	<u>Toluene</u> Author: Daisey, J.M., Hodgson, A.T., Fisk, W.J., et al. ▸ Indoor/outdoor measurements for 12 **office buildings**. ▸ <u>Table 2</u> (p. 3559) reports the range of I/O ratios measured for eleven of the twelve office buildings. <u>From Table 2</u>: **PEN (range): 0.63–5.2**	MZ 39

Ref. No.	Supporting Information	Sources
TBDL-17	<u>Toluene</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 2.4**	RA 35
TBDL-17	<u>Toluene</u> Author: Shields, H.C., Fleischer, D.M., and Weschler, C.J. ▸ Indoor and outdoor concentration s for 3-types of **offices** (Telecommunications (n=50); data centers (n=9); and administrative offices (n=11)). Geometric means are provided for each office type (see Table 3). ▸ <u>I/O ratios</u> by HAP and office type are provided for each office type using geometric means (see Table 4). **<u>I/O's for Toluene</u> :** Telco: **1.8** (2.6) *Values are GM (GSD)* Data Ctrs: **4.9** (2.5) Admin. Offices: **2.2** (2.0)	MZ 11
TBDL-17	<u>Toluene</u> Author: Brickus, L.; Cardoso, J.; de Aquino Neto, F. Reports concurrent measurements of aldehyde and VOC concentrations on four different floors of an **office building** for several different days. I/O ratios provided – see tables 1, 2, & 3. **Mean PEN (building wide; ie., four floors) = 7.1** (Range: 2.2 – 11.5)	MZ 10
TBDL-17	<u>Toluene</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ○ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate.* ▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in **offices** -- See <u>Table III</u>, (p. 1597). ○ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ○ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.	MZ 34
TBDL-19	<u>Toluene</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **I/O ratio provided from median conc = PEN = 1.4**	RA 35

Ref. No.	Supporting Information	Sources
TBDL-26	<u>Toluene</u> Author: Fantuzzi, G.; Aggazzotti, G.; Righi, E.; Cavazzutti, L.; Predieri, G. Table 2 (p.53) – INDOOR and OUTDOOR concentrations provided for university libraries in Italian city (inner city and suburb locations) – median, min. and max. NOT SURE IF CONCURRENT MEASUREMENTS. INNER CITY Indoor median conc = 22ug/m^3 Outdoor median ambient conc = 32.5ug/m^3 **MULT = (indoor conc)/(ambient conc) = 22/32.5 = 0.68** SUBURBS Indoor median conc = 24.5ug/m^3 Outdoor median ambient conc = 16ug/m^3 **MULT = (indoor conc)/(ambient conc) = 24.5/16 = 1.53**	RA 23
TBDL-27	<u>Toluene</u> Author: Shields, H.C. and Weschler, C.J. ‣ Paper reports matched indoor/outdoor measurements at a telephone switching center (might be classified as an office (ME #17) or **other indoor location (ME #27)**. ∘ <u>Table II</u> - Indoor (2 locations) & outdoor concs. during the March 87 and May 87 sampling. ∘ <u>Table III</u> - Indoor (2 locations) & outdoor concs. during the Dec. 87 and Feb. 88 sampling. ∘ <u>Table IV</u> - Indoor (2 locations) & outdoor concs. during the April 88 sampling. ∘ <u>Table V</u> - Indoor (3 locations) & outdoor concs. during the May 88 and July 88 sampling. ∘ <u>Table VI</u> - Indoor (3 locations) & outdoor concs. during the Nov. 88 sampling. Samples collected during: **PEN** 03/87 & 05/87: **1.4** Range: 1.1 – 1.6 12/87 & 02/88: **5.0** Range: 1.2 – 13.4 04/88: **1.5** Range: 1.5 – 1.5 05/88 & 07/88: **3.1** Range: 2.3 – 5.0 <u>11/88:</u> **<u>1.8</u>** Range: 1.6 – 2.0 Overall avg.: **2.6**	MZ 29
TBDL-36	<u>Toluene</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ‣ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by car, **subway**, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ∘ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient.* ***Therefore, only calculation of a MULT factor is possible.*** ‣ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ∘ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ‣ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ∘ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ‣ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs. **MULT (median) = 1.1**	MZ 34

Ref. No.	Supporting Information	Sources
TBDL-1	<u>o-, m-, p-Xylenes</u> Author: Jo, W.K.; Park, K.H. In-vehicle and ambient concentrations of VOCs measured prior to and during idling presented GRAPHICALLY. - p. 220. Fig. 1 See RA21 (data presented in table format), MZ12. Bar graphs of concentrations measured in-car and ambient are presented for both idling and driving conditions. Mean ambient roadway air samples and invehicle concentrations with standard deviation for 115 commutes in Korean urban route for two types of cars (old model=Elantra; new model =Sonata II). NEW MODEL: Mean indoor conc reported: 6.7 (p-), 14.1 (m-), 8.6 (o-)ug/m^3 Mean outdoor conc reported: 7.3 (p-), 14 (m-), 10.3 (o-)ug/m^3 **PEN= I/O = 0.9(p-), 1.0(m-), 0.8(o-) ==>choose 0.9** OLD MODEL: Mean indoor conc reported: 13.3 (p-), 26.3 (m-), 17.4 (o-)ug/m^3 Mean outdoor conc reported: 14.5 (p-), 27.9 (m-), 20.8 (o-)ug/m^3 **PEN= I/O = 0.9(p-), 0.9(m-), 0.8(o-) ==>choose 0.9**	RA 19 RA21 MZ 12

TBDL-1	<u>Xylenes</u>
	Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M.
	▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by **<u>car</u>**, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596).
	  ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient. **Therefore, only calculation of a MULT factor is possible.***
	▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597).
	  ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.*
	▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples.
	  ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time.
	▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.
	
	MULT (median) = 1.7 (avg. of MULT for m,p- = 1.6, and o-xylene = 1.8)
		MZ 34

Ref. No.	Supporting Information	Sources
TBDL-1	<u>Xylenes</u> Author: Weisel, C.P., Nicholas, N.J., and Lioy, P.J. ▸ Numerous HAPs/VOCs were measured in automobile interiors. Ambient outdoor HAPs measured at the start of a commute and at the end of a commute for benzene and xylenes. ◦ <u>Table 7</u> – provides mean automobile cabin and suburban outdoor concentrations for benzene and xylenes from this study. ▸ <u>No</u> measurements from the exterior of the vehicle were reported. Therefore, only calculation of a MULT factor is feasible. ▸ This study also summarizes indoor and outdoor measurements from other studies (TEAM and SCAQMD). The average values reported do not appear to be concurrent. <u>From Table 7</u>: **MULT (mean value), (m&p) = 12.0** **MULT (mean value), (o) = 14.8**	MZ 16
TBDL-1	<u>Xylenes</u> Author: South Coast Air Quality Management District ▸ Report gives results of concurrent **in-vehicle** and <u>ambient</u> (fixed site) monitoring study. ▸ <u>Table 3-3</u> (p. 37) presents a comparison of in-vehicle and background mean concentrations. ◦ Since measurements were reported only for in-vehicle and fixed site monitors -- the only ME factor that can be estimated from this work is the <u>MULT</u> factor. <u>From Table 3-3</u>: **MULT = 2.2**	MZ 37 (subset of this data reported in MZ 33)
TBDL-1	<u>Xylenes</u> Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for **car (ME #1)**, car exterior, fixed-site, and sidewalk (i.e., <u>near road) (ME #7)</u>. Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. <u>From Table II</u> (median values): **PROX PEN MULT** **PEN Range** (from Table V)**: 0.66/0.64* – 1.60/1.55*** **7.6/6.9* 0.88** 6.7/6.1** * First value is for m,p-xylene, second value is for o-xylene. ** Same PEN factor for m,p-xylene and o-xylene.	MZ 28

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Ref. No.	Supporting Information	Sources
TBDL-4	<u>Xylenes</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, **bicycling (other)**, and <u>walking</u>. -- See <u>Table I</u>, (p. 1596). ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient. **Therefore, only calculation of a MULT factor is possible.*** ▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs. **MULT (median) = 0.9** (avg. of MULT for m,p- = 0.8, and o-xylene = 0.9)	MZ 34
TBDL-5	<u>o-, m-, p-Xylenes</u> Author: Schwar, M.; Booker, J.; Tait, L. Comparison of concentrations **in the car park** vs. **at the exit of the car park**. Max. concentrations averaged over specified time periods. Table 7. WEEKDAYS (11 GARAGES) Mean of averaged 1-hr inside car park conc: $1.34 mg/m^3$ Mean of averaged 1-hr exit of car park conc: $0.22 mg/m^3$ **PEN= I/O =1.34/0.22 = 6.09** WEEKENDS (5 GARAGES) Mean of averaged 1-hr inside car park conc: $0.3 mg/m^3$ Mean of averaged 1-hr exit of car park conc: $0.34 mg/m^3$ **PEN= I/O =0.3/0.34 = 0.88**	RA 24
TBDL-7	<u>Xylenes</u> Author: Chan, C-C, Ozkaynak, H., Spengler, J.D., and Sheldon, L. ▸ Paper reports measurement results and parameters (i.e., min, 25%, median, 75%, max., mean, and SD) for <u>car (ME #1)</u>, car exterior, fixed-site, and sidewalk (i.e., **near road) (ME #7)**. Measurements are simultaneous. ▸ Table II (p. 966) — Concs. for each of the above locations. ▸ Table III (p. 968) — Median concs. measured inside vehicles and at a fixed site for three different driving routes (urban, interstate, and rural). ▸ Table V (p. 970) — I/O ratios for in-vehicle/car exterior. ▸ Fig. 1 (p. 969) — Ratios of median concs. between in-vehicle and fixed site. <u>From Table II</u>: **PROX** **4.3/4.0** *Median values* * First value is for m,p-xylene, second value is for o-xylene.	MZ 28

Ref. No.	Supporting Information	Sources
TBDL-13	o-, m-, p-Xylenes Author: Schneider, P.; Lorinci, G.; Gebefugi, IL.; Heinrich, J.; Kettrup, A. Simultaneous I/O sampling (p.284) Concentration profiles provided by height at which sampling took place. Table 5: median I/O ratios supplied for bedroom, living room, kitchen. Table 6: median I/O ratios (for bedroom, living room, kitchen) presented by apartment age group (old vs. new) **m-, p-xylenes: I/O =PEN = 2.8 (kitchen); 2.4 (living room); 1.7 (bedroom)** **o-xylenes: I/O =PEN = 2.3 (kitchen); 2.2 (living room); 1.5 (bedroom)** **Mean I/O = 2.15**	RA 30
TBDL-13	o-, m-, p-Xylenes Author: Mukherjee, S.; Ellenson, WD.; Lewis, RG.; Stevens, RK. See RA11 Median concentrations of indoor and outdoor provided for spring and summer. Median I/O ratios by season supplied – tables 2, 8 and 9. **m-, p-Xylene: I/O =PEN = 1.42 (spring); 3.72 (summer)** **o-Xylene: I/O =PEN = 1.38 (spring); 3.92 (summer)** **Mean I/O for spring: 1.4** **Mean I/O for summer: 3.82**	RA 29
TBDL-13	Xylenes Author: De Bortoli, M., Knoppel, H., Pecchio, E., Peil, A., et al. ▸ Simultaneous indoor and outdoor measurements taken in **residences** (5 apartments and 9 single family homes) and one office building. NOTE, however, that the data were not reported separately for the office, nor were the data separated according to the type of residence (i.e., apartment or house). ▸ Table 1 has the minima, maxima, and means of the indoor and outdoor concentrations. ▸ Table 2 (p. 347) has the minima, maxima, means, and medians of the I/O ratios. **1,3-xylene & 1,4-xylene:** **1,2-xylene:** **I/O ratio (mean) = 7.8** **I/O ratio (mean) = 8.0** **I/O ratio (median) = 2.3** **I/O ratio (median) = 3.0**	MZ 27

TBDL-13	Xylenes
	Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., Sparacino, C., et al.
	▸ Results of the TEAM study that report measurements of personal and outdoor air sampling; in addition, breath and drinking water samples were measured.
	  ◦ The personal and outdoor air measurements were 12-hr integrated samples. These roughly correspond to daytime (6am-6pm) and nighttime (6pm-6am). Unfortunately, the personal and outdoor results for NJ (Table 2) are combined into 24-hr averages.
	▸ Fig. 2 (p. 297) has a bar graph of the nighttime (6pm-6am) personal (might be used as a surrogate for indoor residence) and outdoor concentrations. NOTE: these are geometric means with more than four times the number of personal (347) compared to outdoor samples (84).
	  ◦ *Also, all I/O ratios are greater than 1.5.*
	▸ Table 3 also has 24-hr averaged results of personal air and outdoor air sampling for Greensboro, NC and Devils Lake, ND.
		MZ 30

Ref. No.	Supporting Information	Sources
TBDL-13	**Xylenes** Author: Crump, D.R. Indoor & outdoor measurements of HAPs over 2 years with data reported for a summer season only and a winter season only. Measurements are for four newly constructed unoccupied test houses. Although the methods state that measurements were taken in the living room, kitchen, bedrooms, and bathroom; only the average for the whole house was reported. The mean, max, and minimum data provided for each house and for each contaminant measured in each house for two consecutive years.	MZ 2

House T1

	PEN*				Mean
	Yr. 1	**Yr. 2**	**Summer**	**Winter**	**(S and W only)**
xylenes	**11.6**	**6.3**	**10.5**	**3.2**	**6.9**

House T2

	PEN*				Mean
	Yr. 1	**Yr. 2**	**Summer**	**Winter**	**(S and W only)**
xylenes	**9.1**	**5.3**	**9.0**	**3.0**	**6.0**

House M3

	PEN*				Mean
	Yr. 1	**Yr. 2**	**Summer**	**Winter**	**(S and W only)**
xylenes	**4.3**	**5.0**	**4.8**	**1.6**	**3.2**

House M4

	PEN*				Mean
	Yr. 1	**Yr. 2**	**Summer**	**Winter**	**(S and W only)**
xylenes	**4.7**	**11.3**	**6.25**	**5.2**	**5.7**

*Mean values

	xylenes
Overall Mean:	*5.4*
(all houses, S and W only)	

Ref. No.	Supporting Information	Sources
TBDL-13	**Xylenes** Author: Wallace, L. (EPA/600/6-87/002a) "Blue book" ▸ Bound volume of results from the TEAM studies. Indoor ME is **residence**. ▸ Table 29 (pp. 61-62) provide indoor/outdoor comparisons (and ratios) for matched samples. ◦ These concentrations are median values for the 12-hr nighttime samples collected for two seasons (Jan. 1984 and May 1984) in LA, and during June 1984 in Contra Costa. ▸ Table 46 (p. 97) provides median concentrations for indoor air in New Jersey (three different sampling periods) and California (also three different sampling periods). ▸ Table 47 (p. 98) provides median concentrations for outdoor air in New Jersey (the same three sampling periods for NJ in Table 46) and California (the same three sampling periods for CA in Table 46). ◦ However, the number of outdoor measurements are always less than the number of indoor measurements. From Table 29:	MZ 38

PEN (medians):	LA(1/84)	LA(5/84)	Contra(6/84)	Avg.
m,p xylene:	**0.9**	**1.1**	**4.3**	**2.1**
o-xylene	**1.0**	**1.2**	**4.7**	**2.3**

Ref. No.	Supporting Information	Sources
TBDL-13	**Xylenes** Author: Drahonovska, H. Indoor & outdoor measurements of 140 residences (both kitchen and bedroom measurements) taken for listed HAPs. Energy use for heating is broken down by electric, gas, and coal sources. Average I/O ratios provided (Table 5) for xylenes. **I/O=4.2 for house heated** **I/O=3.2 for non-heated house**	MZ 4

Ref. No.	Supporting Information	Sources
TBDL-13	<u>Xylenes</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596). ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate.* ▸ In addition, VOC concs. were also measured in subjects' **residences** and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.	MZ 34
TBDL-13	<u>Xylenes</u> Author: Lebret, E., van de Wiel, H.J., Bos, H.P., Noij, D., and Boleij, J.S.M. ▸ <u>Table 2</u> (p. 326) reports median and maximum HAP concentrations in **residences** (a total of approx. 300) of three different age groups; the median and maximum outdoor concs.; and the overall median I/O ratio for all homes. ◦ These concentrations were weekly averages. **Median, overall I/O ratios:** **xylenes = 3**	MZ 26
TBDL-13	<u>o-,m-,p-Xylenes</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **m-, p-xylenes: I/O ratio provided from median conc = PEN = 1.1** **o-xylenes: I/O ratio provided from median conc = PEN = 1.3** **Mean I/O = 1.2**	RA 35
TBDL-13	<u>Xylenes</u> (based on p-Xylene results) Author: Bouhamra, W.S. Table 2 (p.199) -- Indoor VOCs concentrations. Table 3 (p.200) -- Ambient air VOCs concentrations. Min, max., mean, median, std. deviation provided. Table 4 (p.202) -- I/O ratios. Sampled during Dec 94-Jan 95. CONCURRENT MEASUREMENTS. **I/O ratio provided: 1.06=PEN** Ambient air conc. provided: 1152 ug/m^3 (mean), 1071 ug/m^3(median) Indoor air conc provided: 1222 ug/m^3 (mean), 998 ug/m^3(median) **MULT = (indoor conc)/(ambient conc) = 998/1071 = 0.93 (from median conc)** Since PEN>1 ==> calculate ADD: Indoor conc (median) = 998 ug/m^3; PEN = I/O = 1.06; Outdoor conc (calculated) = 998/1.06 = 941 ug/m^3 **____ug/m^3<ADD<___ ug/m^3** **PROX (calc from medians) = (outdoor conc)/(ambient conc) = 941/1071 = 0.88**	RA 14

Ref. No.	Supporting Information	Sources
TBDL-13	<u>Xylenes</u> Author: Barguil, S., Le Moullec, Y., Person, A., Laurent, A-M, and Festy, B. ▸ Study which reports concurrent indoor and outdoor measurements taken in **residences** (5 detached houses and 4 apartments). ∘ The paper reports the average I/O measurements (Fig 2. - bar chart) of samples taken over the entire length of the study (Sept. 1987 - Aug. 1988). **I/O ratios (average of 75 samples):** **PEN = 2.4**	MZ 36
TBDL-13	<u>m-xylene; p-xylene; o-xylene</u> Author: Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., et al. Summary of TEAM study in NJ (Fall, 1981). Samples collected for: *personal air* - two consecutive 12-hr samples taken from appr. 350 people, *outdoor air* - two consecutive 12-hr samples taken from appr. 90 people, also drinking water and breath. <u>Table 9</u> reports a summary of median, max. concs., and ratios (from both the median and max. conc. data) for 85 matched overnight personal air and overnight outdoor air samples. (It is our conclusion that this data provides the best concurrent I/O ratios for **residences** from this study.) **PEN = 1.7** (median value) — o-xylene **PEN = 1.6** (median value) — m,p-xylene	MZ 22
TBDL-13	<u>Xylenes</u> Author: Gilli, G., Scursatone, E., and Bono, R. ▸ Indoor and outdoor simultaneous measurements taken for a <u>residence</u> (apartment). ∘ Samples were collected by 10 non-smoking university students who each collected samples for 10 consecutive days [2 integrated samples per day: 1) 8:00 - 20:00 (12-hrs), and 2) 0:00 - 8:00 (8-hrs)] in December 1991. ▸ <u>Table 3</u> (p. 53) shows the mean I/O ratios for both day (i.e., 8:00 - 20:00) and night (ie, 0:00 - 8:00). Data is the average form all students. ▸ <u>Table 4</u> (p. 54) shows indoor and outdoor pollutant concentrations for both day and night. NOTE: It is not clear how this data relates to the ratios reproted in Table 3. It might be data for only a single student. **Average I/O data for all students (Table 3):** **xylene (day) = 1.02** **xylene (night) = 2.58**	MZ 25

TBDL-17	<u>Xylenes</u>
	Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M.
	▸ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by <u>car</u>, <u>subway</u>, <u>bicycling (other)</u>, and walking. -- See <u>Table I</u>, (p. 1596).
	  ∘ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate.*
	▸ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in **offices** -- See <u>Table III</u>, (p. 1597).
	  ∘ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.*
	▸ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples.
	  ∘ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time.
	▸ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs.
		MZ 34

Ref. No.	Supporting Information	Sources
TBDL-17	<u>Xylenes</u> Author: Brickus, L.; Cardoso, J.; de Aquino Neto, F. Reports concurrent measurements of aldehyde and VOC concentrations on four different floors of an **office building** for several different days. I/O ratios provided – see tables 1, 2, & 3. **Mean PEN (building wide; ie., four floors) = 3.5** (Range: 2.0 – 6.6)	MZ 10
TBDL-17	<u>Xylenes</u> Author: Shields, H.C., Fleischer, D.M., and Weschler, C.J. ‣ Indoor and outdoor concentration s for 3-types of **offices** (Telecommunications (n=50); data centers (n=9); and administrative offices (n=11)). Geometric means are provided for each office type (see Table 3). ‣ <u>I/O ratios</u> by HAP and office type are provided for each office type using geometric means (see Table 4). **I/O's for xylene :** *Values are GM (GSD)* <table><tr><td></td><td><u>Telco</u></td><td><u>Data Cnt.</u></td><td><u>Admin. office</u></td></tr><tr><td>**xylene (m&p)**</td><td>**1.6**(2.6)</td><td>**2.7**(1.7)</td><td>**1.5**(1.9)</td></tr><tr><td>**xylene (o)**</td><td>**2.0**(2.7)</td><td>**3.5**(1.7)</td><td>**2.1**(1.7)</td></tr></table>	MZ 11
TBDL-17	<u>o-,m-,p-Xylenes</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **m-, p-xylenes: I/O ratio provided from median conc = PEN = 1.7** **o-xylenes: I/O ratio provided from median conc = PEN = 1.7** **Mean I/O = 1.7**	RA 35
TBDL-17	<u>Xylenes</u> Author: Daisey, J.M., Hodgson, A.T., Fisk, W.J., et al. ‣ Indoor/outdoor measurements for 12 **office buildings**. ‣ <u>Table 2</u> (p. 3559) reports the range of I/O ratios measured for eleven of the twelve office buildings. <u>From Table 2:</u> **PEN (range), m,p-xylene: 0.47 – 3.7** **PEN (range), o-xylene: 0.51 – 3.3**	MZ 39
TBDL-19	<u>o-,m-,p-Xylenes</u> Author: Baek, S.O.; Kim, Y.S.; Perry, R.; Spencer, R.D.; Green, M.A.; Biggs, P. SIMULTANEOUS indoor/outdoor sampling at six residences, six offices, six restaurants in two cities in Korea. Median, mean, standard deviation, range of concentrations, median I/O ratios provided for each mE – Tables 3,4&5. **m-, p-xylenes: I/O ratio provided from median conc = PEN = 1.4** **o-xylenes: I/O ratio provided from median conc = PEN = 1.4** **Mean I/O = 1.4**	RA 35

Ref. No.	Supporting Information	Sources
TBDL-26	<u>Xylenes</u> Author: Fantuzzi, G.; Aggazzotti, G.; Righi, E.; Cavazzutti, L.; Predieri, G. Table 2 (p.53) – INDOOR and OUTDOOR concentrations provided for university libraries in Italian city (inner city and suburb locations) – median, min. and max. NOT SURE IF CONCURRENT MEASUREMENTS. INNER CITY Indoor median conc = 38ug/m^3 Outdoor median ambient conc = 59ug/m^3 **MULT = (indoor conc)/(ambient conc) = 38/59 = 0.64** SUBURBS Indoor median conc = 25.5ug/m^3 Outdoor median ambient conc = 24ug/m^3 **MULT = (indoor conc)/(ambient conc) = 25.5/24 = 1.06**	RA 23
TBDL-27	<u>Xylenes</u> Author: Shields, H.C. and Weschler, C.J. ‣ Paper reports matched indoor/outdoor measurements at a telephone switching center (might be classified as an office (ME #17) or other **indoor location (ME #27)**. ◦ <u>Table II</u> - Indoor (2 locations) & outdoor concs. during the March 87 and May 87 sampling. ◦ <u>Table III</u> - Indoor (2 locations) & outdoor concs. during the Dec. 87 and Feb. 88 sampling. ◦ <u>Table IV</u> - Indoor (2 locations) & outdoor concs. during the April 88 sampling. ◦ <u>Table V</u> - Indoor (3 locations) & outdoor concs. during the May 88 and July 88 sampling. ◦ <u>Table VI</u> - Indoor (3 locations) & outdoor concs. during the Nov. 88 sampling. Samples collected during: **PEN** 03/87 & 05/87: **1.7** Range: 1.0 – 2.1 12/87 & 02/88: **2.0** Range: 1.5 – 2.7 04/88: **1.4** Range: 1.3 – 1.4 05/88 & 07/88: **7.9** Range: 3.7 – 17.9 <u>11/88:</u> **2.2** Range: 1.9 – 2.5 Overall avg.: **3.0**	MZ 29
TBDL-36	<u>Xylenes</u> Author: Chan, C-C., Spengler, J.D., Ozkaynak, H., and Lefkopoulou, M. ‣ Results of sampling field study where measurements of VOC concs. were taken while subjects commuted by car, **subway**, bicycling (other), and walking. -- See <u>Table I</u>, (p. 1596). ◦ *NOTE: No ambient monitoring data were reported so values taken for those subjects while walking would have to be used as a surrogate for ambient.* ***Therefore, only calculation of a MULT factor is possible.*** ‣ In addition, VOC concs. were also measured in subjects' <u>residences</u> and in <u>offices</u> -- See <u>Table III</u>, (p. 1597). ◦ *Measurements taken on a sidewalk next to a busy street are used as a surrogate for ambient monitoring.* ‣ Note that while the these samples may have overlapped, it is not specified which sets of measurements (if any) were paired samples. ◦ Nor is it specified where the sidewalk (i.e., the surrogate for ambient, outdoors) concentrations were taken in relation to the other MEs, or with respect to time. ‣ Tables I and III provide median, mean, and max. concs. for the different VOCs and various MEs. **MULT (median) = 0.9** (m,p-xylene = 0.9, and o-xylene = 0.9)	MZ 34

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Ref. No.	Supporting Information	Sources
To be assigned	320 VOCs, with 261 VOCs measured in the outdoor air and 66 measured indoors. Author: Shah, J., Singh, H. Distribution of multiple VOCs in indoor and outdoor air – NATIONAL VOC DATABASE. Outdoor data measured in urban, rural, suburban, remote, or near source. Indoor data measured in residential and workplace/commercial locations. UNABLE TO DETERMINE WHETHER CONCURRENT MEASUREMENTS WITHOUT ACCESS TO THE DATABASE.	MZ 18

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APPENDIX C

ME FACTOR RESULTS

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Microenvironmental Factors by Pollutant, Microenvironment, and Source Category for Specified HAPs

Pollutant: <u>Acetaldehyde</u> (#1) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a] Onroad [b]	PROX [Data Code] [a] Major, area, and nonroad [c]	PEN [Data Code] [a]	MULT = PROX × PEN Onroad [d]	MULT = PROX × PEN Major, area, and nonroad [d]	Reference Sources
Car - In vehicle / 1		3.5 [2]	1.0 [3]	0.90 [2]	3.15	0.9	
Bus - In vehicle / 2		3.5 [2]	1.0 [3]	0.90 [2]	3.15	0.9	
Truck - In vehicle / 3		3.5 [2]	1.0 [3]	0.90 [2]	3.15	0.9	
Other - In vehicle / 4		3.5 [2]	1.0 [3]	0.90 [2]	3.15	0.9	
Public garage - Indoors / 5		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Parking lot/garage - Outdoors / 6		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Near road - Outdoors / 7		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Motorcycle - Outdoors / 8		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Service station - Indoors / 9		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Service station - Outdoors / 10		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Residential garage - Indoors / 11		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Other repair shop - Indoors / 12		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Residence (no CO source) - Indoors/13		1.0 [3]	1.0 [3]	0.75 [1]	0.75	0.75	MZ 27
Residence (gas stove) - Indoors / 14		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Residence (attached garage) - Indoors/15		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Residence (stove and garage)- Indoors/16		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Office - Indoors / 17		1.0 [3]	1.0 [3]	0.55 [1]	0.55	0.55	MZ 10
Store - Indoors / 18		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Restaurant - Indoors / 19		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Manufacturing facility - Indoors / 20		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
School - Indoors / 21		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Church- Indoors / 22		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Shopping mall - Indoors / 23		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Auditorium - Indoors / 24		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Health care facility - Indoors / 25		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Other public building - Indoors / 26		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Other location - Indoors / 27		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Not specified - Indoors / 28		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Train/subway - In vehicle / 36		3.5 [2]	1.0 [3]	0.90 [2]	3.15	0.9	
Airplane - In vehicle / 37		0.0 [3]	0.0 [3]	0.90 [2]	0	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] Onroad vehicle source category (see text).
[c] Major, area, and nonroad-mobile source categories (see text).
[d] The MULT factor is the product of the PROX factor and the PEN factor for the onroad vehicle source category and for the major, area, and nonroad-mobile source categories for this pollutant.

<u>Formula</u>: Microenvironmental concentration, µg/m³ = ADD + (PROX)(PEN)(monitor concentration, µg/m³).
<u>Abbreviations</u>: ADD = additive factor; PROX = proximity factor; PEN = penetration factor; MULT = PROX × PEN.

Pollutant: <u>Acrolein</u> (#2) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a]		PEN [Data Code] [a]	MULT = PROX × PEN		Reference Sources
		Onroad [b]	Major, area, and nonroad [c]		Onroad [d]	Major, area, and nonroad [d]	
Car - In vehicle / 1		3.5 [2]	1.0 [3]	0.90 [2]	3.15	0.9	
Bus - In vehicle / 2		3.5 [2]	1.0 [3]	0.90 [2]	3.15	0.9	
Truck - In vehicle / 3		3.5 [2]	1.0 [3]	0.90 [2]	3.15	0.9	
Other - In vehicle / 4		3.5 [2]	1.0 [3]	0.90 [2]	3.15	0.9	
Public garage - Indoors /5		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Parking lot/garage - Outdoors / 6		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Near road - Outdoors / 7		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Motorcycle - Outdoors / 8		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Service station - Indoors / 9		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Service station - Outdoors / 10		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Residential garage - Indoors / 11		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Other repair shop - Indoors / 12		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Residence (no CO source) - Indoors/13		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Residence (gas stove) - Indoors / 14		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Residence (attached garage) - Indoors/15		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Residence (stove and garage)- Indoors/16		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Office - Indoors / 17		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Store - Indoors / 18		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Restaurant - Indoors / 19		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Manufacturing facility - Indoors / 20		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
School - Indoors / 21		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Church- Indoors / 22		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Shopping mall - Indoors / 23		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Auditorium - Indoors / 24		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Health care facility - Indoors / 25		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Other public building - Indoors / 26		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Other location - Indoors / 27		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Not specified - Indoors / 28		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Train/subway - In vehicle / 36		3.5 [2]	1.0 [3]	0.90 [2]	3.15	0.9	
Airplane - In vehicle / 37		0.0 [3]	0.0 [3]	0.90 [2]	0	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.

[b] Onroad vehicle source category (see text).

[c] Major, area, and nonroad-mobile source categories (see text).

[d] The MULT factor is the product of the PROX factor and the PEN factor for the onroad vehicle source category and for the major, area, and nonroad-mobile source categories for this pollutant.

<u>Formula</u>: Microenvironmental concentration, $\mu g/m^3$ = ADD + (PROX)(PEN)(monitor concentration, $\mu g/m^3$).

<u>Abbreviations</u>: ADD = additive factor; PROX = proximity factor; PEN = penetration factor; MULT = PROX × PEN.

Pollutant: <u>Acrylonitrile</u> (#3) HAPEM ME / Number	ADD (μg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors /5		1.0 [3]	0.81 [2]	0.81	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.81 [2]	0.81	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.72 [2]	0.72	
Other repair shop - Indoors / 12		1.0 [3]	0.81 [2]	0.81	
Residence (no CO source) - Indoors/13		1.0 [3]	0.72 [2]	0.72	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.72 [2]	0.72	
Residence (attached garage) - Indoors/15		1.0 [3]	0.72 [2]	0.72	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.72 [2]	0.72	
Office - Indoors / 17		1.0 [3]	0.81 [2]	0.81	
Store - Indoors / 18		1.0 [3]	0.81 [2]	0.81	
Restaurant - Indoors / 19		1.0 [3]	0.81 [2]	0.81	
Manufacturing facility - Indoors / 20		1.0 [3]	0.81 [2]	0.81	
School - Indoors / 21		1.0 [3]	0.81 [2]	0.81	
Church- Indoors / 22		1.0 [3]	0.81 [2]	0.81	
Shopping mall - Indoors / 23		1.0 [3]	0.81 [2]	0.81	
Auditorium - Indoors / 24		1.0 [3]	0.81 [2]	0.81	
Health care facility - Indoors / 25		1.0 [3]	0.81 [2]	0.81	
Other public building - Indoors / 26		1.0 [3]	0.81 [2]	0.81	
Other location - Indoors / 27		1.0 [3]	0.81 [2]	0.81	
Not specified - Indoors / 28		1.0 [3]	0.81 [2]	0.81	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

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Pollutant: <u>Arsenic compnds</u> (#4) HAPEM ME / Number	ADD (μg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors /5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: <u>Benzene</u> (#5) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a]		PEN [Data Code] [a]	MULT = PROX × PEN		Reference Sources
		Onroad [b]	Major, area, and nonroad [c]		Onroad [d]	Major, area, and nonroad [d]	
Car - In vehicle / 1		6.9 [1]	1.0 [3]	0.96 [1]	6.6	0.96	MZ 28
Bus - In vehicle / 2		3.5 [1]	1.0 [3]	0.79 [1]	2.8	0.79	MZ 14[e], RA 7[f]
Truck - In vehicle / 3		5.2 [2]	1.0 [3]	0.88 [2]	4.6	0.88	
Other - In vehicle / 4		5.2 [2]	1.0 [3]	0.88 [2]	4.6	0.88	
Public garage - Indoors /5		1.0 [3]	1.0 [3]	0.86 [1]	0.9	0.86	RA 24
Parking lot/garage - Outdoors / 6		4.4 [2]	1.0 [3]	1.0 [3]	4.4	1	
Near road - Outdoors / 7		4.4 [1]	1.0 [3]	1.0 [3]	4.4	1	MZ 28
Motorcycle - Outdoors / 8		4.4 [2]	1.0 [3]	1.0 [3]	4.4	1	
Service station - Indoors / 9		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
Service station - Outdoors / 10		4.4 [2]	1.0 [3]	1.0 [3]	4.4	1	
Residential garage - Indoors / 11		1.0 [3]	1.0 [3]	0.77 [2]	0.8	0.77	
Other repair shop - Indoors / 12		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	1.0 [3]	0.88 [1]	0.9	0.88	MZ 2
Residence (gas stove) - Indoors / 14		1.0 [3]	1.0 [3]	0.77 [2]	0.8	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	1.0 [3]	1.0 [1]	1.0	1	TL 18
Residence (stove and garage)- Indoors/16		1.0 [3]	1.0 [3]	0.77 [2]	0.8	0.77	
Office - Indoors / 17		1.0 [3]	1.0 [3]	0.63 [1]	0.6	0.63	MZ 39
Store - Indoors / 18		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
Restaurant - Indoors / 19		1.0 [3]	1.0 [3]	0.9 [1]	0.9	0.9	RA 35
Manufacturing facility - Indoors / 20		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
School - Indoors / 21		1.0 [3]	1.0 [3]	0.7 [1]	0.7	0.7	MZ 1
Church- Indoors / 22		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
Shopping mall - Indoors / 23		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
Auditorium - Indoors / 24		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
Health care facility - Indoors / 25		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
Other public building - Indoors / 26		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
Other location - Indoors / 27		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
Not specified - Indoors / 28		1.0 [3]	1.0 [3]	0.78 [2]	0.8	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1.0 [3]	1.0	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1.0 [3]	1.0	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1.0 [3]	1.0	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1.0 [3]	1.0	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1.0 [3]	1.0	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1.0 [3]	1.0	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1.0 [3]	1.0	1	
Train/subway - In vehicle / 36		5.2 [2]	1.0 [3]	0.88 [2]	4.6	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.0 [3]	0.88 [2]	0.0	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.

[b] Onroad vehicle source category (see text).

[c] Major, area, and nonroad-mobile source categories (see text).

[d] The MULT factor is the product of the PROX factor and the PEN factor for the onroad vehicle source category and for the major, area, and nonroad-mobile source categories for this pollutant.

[e] Reference used to derive PROX factor

[f] Reference used to derive PEN factor

<u>Formula</u>: Microenvironmental concentration, µg/m³ = ADD + (PROX)(PEN)(monitor concentration, µg/m³).

<u>Abbreviations</u>: ADD = additive factor; PROX = proximity factor; PEN = penetration factor; MULT = PROX × PEN.

Pollutant: Beryllium cmpds (#6) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors /5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.7[c] [1]	0.7	MZ 24
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.
[c] Indoor location is a laboratory

C-6

Pollutant: 1,3-butadiene (#7) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a]		PEN [Data Code] [a]	MULT = PROX × PEN		Reference Sources
		Onroad [b]	Major, area, and nonroad [c]		Onroad [d]	Major, area, and nonroad [d]	
Car - In vehicle / 1		2.2 [1]	1.0 [3]	1.0 [1]	2.2	1	MZ 28
Bus - In vehicle / 2		3.5 [2]	1.0 [3]	0.9 [1]	3.15	0.9	RA 7
Truck - In vehicle / 3		2.8 [2]	1.0 [3]	0.90 [2]	2.52	0.9	
Other - In vehicle / 4		2.8 [2]	1.0 [3]	0.90 [2]	2.52	0.9	
Public garage - Indoors / 5		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Parking lot/garage - Outdoors / 6		1.0 [2]	1.0 [3]	1.0 [3]	1	1	
Near road - Outdoors / 7		1.0 [1]	1.0 [3]	1.0 [3]	1	1	MZ 28
Motorcycle - Outdoors / 8		1.0 [2]	1.0 [3]	1.0 [3]	1	1	
Service station - Indoors / 9		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Service station - Outdoors / 10		1.0 [2]	1.0 [3]	1.0 [3]	1	1	
Residential garage - Indoors / 11		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Other repair shop - Indoors / 12		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Residence (no CO source) - Indoors/13		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Residence (gas stove) - Indoors / 14		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Residence (attached garage) - Indoors/15		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Residence (stove and garage)- Indoors/16		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Office - Indoors / 17		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Store - Indoors / 18		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Restaurant - Indoors / 19		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Manufacturing facility - Indoors / 20		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
School - Indoors / 21		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Church- Indoors / 22		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Shopping mall - Indoors / 23		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Auditorium - Indoors / 24		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Health care facility - Indoors / 25		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Other public building - Indoors / 26		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Other location - Indoors / 27		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Not specified - Indoors / 28		1.0 [3]	1.0 [3]	0.80 [2]	0.8	0.8	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Train/subway - In vehicle / 36		2.8 [2]	1.0 [3]	0.90 [2]	2.52	0.9	
Airplane - In vehicle / 37		0.0 [3]	0.0 [3]	0.90 [2]	0	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.

[b] Onroad vehicle source category (see text).

[c] Major, area, and nonroad-mobile source categories (see text).

[d] The MULT factor is the product of the PROX factor and the PEN factor for the onroad vehicle source category and for the major, area, and nonroad-mobile source categories for this pollutant.

Formula: Microenvironmental concentration, µg/m³ = ADD + (PROX)(PEN)(monitor concentration, µg/m³).

Abbreviations: ADD = additive factor; PROX = proximity factor; PEN = penetration factor; MULT = PROX × PEN.

C-7

Pollutant: Cadmium compounds (#8) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: Carbon tetrachloride (#9) HAPEM ME / Number	ADD (μg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.55 [1]	0.55	MZ 27
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-9

Pollutant: <u>Chloroform</u> (#10) HAPEM ME / Number	ADD ($\mu g/m^3$)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.85 [1]	0.85	MZ 38
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-10

Pollutant: Chromium compounds (#11) HAPEM ME / Number	ADD (μg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.35 [1]	0.35	TL 9
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.31 (Cr^{6+}); 0.62 Tot (Cr) [1]	0.31	TL 11
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-11

Pollutant: <u>Coke oven emissions</u> (#12) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]			
Bus - In vehicle / 2		1.0 [3]			
Truck - In vehicle / 3		1.0 [3]			
Other - In vehicle / 4		1.0 [3]			
Public garage - Indoors / 5		1.0 [3]			
Parking lot/garage - Outdoors / 6		1.0 [3]			
Near road - Outdoors / 7		1.0 [3]			
Motorcycle - Outdoors / 8		1.0 [3]			
Service station - Indoors / 9		1.0 [3]			
Service station - Outdoors / 10		1.0 [3]			
Residential garage - Indoors / 11		1.0 [3]			
Other repair shop - Indoors / 12		1.0 [3]			
Residence (no CO source) - Indoors/13		1.0 [3]			
Residence (gas stove) - Indoors / 14		1.0 [3]			
Residence (attached garage) - Indoors/15		1.0 [3]			
Residence (stove and garage)- Indoors/16		1.0 [3]			
Office - Indoors / 17		1.0 [3]			
Store - Indoors / 18		1.0 [3]			
Restaurant - Indoors / 19		1.0 [3]			
Manufacturing facility - Indoors / 20		1.0 [3]			
School - Indoors / 21		1.0 [3]			
Church- Indoors / 22		1.0 [3]			
Shopping mall - Indoors / 23		1.0 [3]			
Auditorium - Indoors / 24		1.0 [3]			
Health care facility - Indoors / 25		1.0 [3]			
Other public building - Indoors / 26		1.0 [3]			
Other location - Indoors / 27		1.0 [3]			
Not specified - Indoors / 28		1.0 [3]			
Construction site - Outdoors / 29		1.0 [3]			
Residential grounds - Outdoors / 30		1.0 [3]			
School grounds - Outdoors / 31		1.0 [3]			
Sports arena - Outdoors / 32		1.0 [3]			
Park/golf course - Outdoors / 33		1.0 [3]			
Other location - Outdoors / 34		1.0 [3]			
Not specified - Outdoors / 35		1.0 [3]			
Train/subway - In vehicle / 36		1.0 [3]			
Airplane - In vehicle / 37		0.0 [3]			

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-12

Pollutant: 1,2-dichloroethane (ethylene dichloride) (#13) HAPEM ME / Number	ADD (μg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	1.0 [1]	1	MZ 38
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-13

Pollutant: 1,3-dichloropropene (#14) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.90 [2]	0.9	
Bus - In vehicle / 2		1.0 [3]	0.90 [2]	0.9	
Truck - In vehicle / 3		1.0 [3]	0.90 [2]	0.9	
Other - In vehicle / 4		1.0 [3]	0.90 [2]	0.9	
Public garage - Indoors / 5		1.0 [3]	0.80 [2]	0.8	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.80 [2]	0.8	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.81 [2]	0.81	
Other repair shop - Indoors / 12		1.0 [3]	0.80 [2]	0.8	
Residence (no CO source) - Indoors/13		1.0 [3]	0.81 [1]	0.81	TL 3
Residence (gas stove) - Indoors / 14		1.0 [3]	0.81 [2]	0.81	
Residence (attached garage) - Indoors/15		1.0 [3]	0.81 [2]	0.81	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.81 [2]	0.81	
Office - Indoors / 17		1.0 [3]	0.80 [2]	0.8	
Store - Indoors / 18		1.0 [3]	0.80 [2]	0.8	
Restaurant - Indoors / 19		1.0 [3]	0.80 [2]	0.8	
Manufacturing facility - Indoors / 20		1.0 [3]	0.80 [2]	0.8	
School - Indoors / 21		1.0 [3]	0.80 [2]	0.8	
Church- Indoors / 22		1.0 [3]	0.80 [2]	0.8	
Shopping mall - Indoors / 23		1.0 [3]	0.80 [2]	0.8	
Auditorium - Indoors / 24		1.0 [3]	0.80 [2]	0.8	
Health care facility - Indoors / 25		1.0 [3]	0.80 [2]	0.8	
Other public building - Indoors / 26		1.0 [3]	0.80 [2]	0.8	
Other location - Indoors / 27		1.0 [3]	0.80 [2]	0.8	
Not specified - Indoors / 28		1.0 [3]	0.80 [2]	0.8	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.90 [2]	0.9	
Airplane - In vehicle / 37		0.0 [3]	0.90 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-14

Pollutant: **Ethylene dibromide (dibromoethane) (#15)** HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-15

Pollutant: Ethylene oxide (#16) HAPEM ME / Number	ADD (μg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: <u>Formaldehyde (#17)</u> HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a]		PEN [Data Code] [a]	MULT = PROX × PEN		Reference Sources
		Onroad [b]	Major, area, and nonroad [c]		Onroad [d]	Major, area, and nonroad [d]	
Car - In vehicle/1		3.5 [2]	1.0 [3]	0.88 [2]	3.08	0.88	
Bus - In vehicle/2		3.5 [2]	1.0 [3]	0.88 [2]	3.08	0.88	
Truck - In vehicle/3		3.5 [2]	1.0 [3]	0.88 [2]	3.08	0.88	
Other - In vehicle/4		3.5 [2]	1.0 [3]	0.88 [2]	3.08	0.88	
Public garage - Indoors/5		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Parking lot/garage - Outdoors/ 6		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Near road - Outdoors/7		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Motorcycle - Outdoors/ 8		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Service station - Indoors/9		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Service station - Outdoors/10		2.7 [2]	1.0 [3]	1.0 [3]	2.7	1	
Residential garage - Indoors/11		1.0 [3]	1.0 [3]	0.72 [2]	0.72	0.72	
Other repair shop - Indoors/12		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Residence (no CO source) - Indoors/13		1.0 [3]	1.0 [3]	0.5 [1]	0.5	0.5	MZ 15
Residence (gas stove) - Indoors/14		1.0 [3]	1.0 [3]	0.72 [2]	0.72	0.72	
Residence (attached garage) - Indoors/15		1.0 [3]	1.0 [3]	0.72 [2]	0.72	0.72	
Residence (stove and garage)- Indoors/16		1.0 [3]	1.0 [3]	0.72 [2]	0.72	0.72	
Office - Indoors / 17		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Store - Indoors / 18		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Restaurant - Indoors / 19		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Manufacturing facility - Indoors / 20		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
School - Indoors / 21		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Church- Indoors/22		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Shopping mall - Indoors/23		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Auditorium - Indoors / 24		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Health care facility - Indoors/25		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Other public building - Indoors/26		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Other location - Indoors/27		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Not specified - Indoors/28		1.0 [3]	1.0 [3]	0.81 [2]	0.81	0.81	
Construction site - Outdoors/29		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Residential grounds - Outdoors/30		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
School grounds - Outdoors/31		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Sports arena - Outdoors/32		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Park/golf course - Outdoors/33		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Other location - Outdoors/34		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Not specified - Outdoors/35		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
Train/subway - In vehicle/36		3.5 [2]	1.0 [3]	0.88 [2]	3.08	0.88	
Airplane - In vehicle/37		0.0 [3]	0.0 [3]	0.88 [2]	0	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.

[b] Onroad vehicle source category (see text).

[c] Major, area, and nonroad-mobile source categories (see text).

[d] The MULT factor is the product of the PROX factor and the PEN factor for the onroad vehicle source category and for the major, area, and nonroad-mobile source categories for this pollutant.

<u>Formula</u>: Microenvironmental concentration, µg/m³ = ADD + (PROX)(PEN)(monitor concentration, µg/m³).

<u>Abbreviations</u>: ADD = additive factor; PROX = proximity factor; PEN = penetration factor; MULT = PROX × PEN.

Pollutant: <u>Hexachlorobenzene</u> (#18) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.82 [1]	0.82	TL 3
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: Hydrazine (#19) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.90 [2]	0.9	
Bus - In vehicle / 2		1.0 [3]	0.90 [2]	0.9	
Truck - In vehicle / 3		1.0 [3]	0.90 [2]	0.9	
Other - In vehicle / 4		1.0 [3]	0.90 [2]	0.9	
Public garage - Indoors / 5		1.0 [3]	0.80 [2]	0.8	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.80 [2]	0.8	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.81 [2]	0.81	
Other repair shop - Indoors / 12		1.0 [3]	0.80 [2]	0.8	
Residence (no CO source) - Indoors/13		1.0 [3]	0.81 [2]	0.81	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.81 [2]	0.81	
Residence (attached garage) - Indoors/15		1.0 [3]	0.81 [2]	0.81	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.81 [2]	0.81	
Office - Indoors / 17		1.0 [3]	0.80 [2]	0.8	
Store - Indoors / 18		1.0 [3]	0.80 [2]	0.8	
Restaurant - Indoors / 19		1.0 [3]	0.80 [2]	0.8	
Manufacturing facility - Indoors / 20		1.0 [3]	0.80 [2]	0.8	
School - Indoors / 21		1.0 [3]	0.80 [2]	0.8	
Church- Indoors / 22		1.0 [3]	0.80 [2]	0.8	
Shopping mall - Indoors / 23		1.0 [3]	0.80 [2]	0.8	
Auditorium - Indoors / 24		1.0 [3]	0.80 [2]	0.8	
Health care facility - Indoors / 25		1.0 [3]	0.80 [2]	0.8	
Other public building - Indoors / 26		1.0 [3]	0.80 [2]	0.8	
Other location - Indoors / 27		1.0 [3]	0.80 [2]	0.8	
Not specified - Indoors / 28		1.0 [3]	0.80 [2]	0.8	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.90 [2]	0.9	
Airplane - In vehicle / 37		0.0 [3]	0.90 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: Lead compounds - organic (#20) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: Lead compounds - inorganic (#21) HAPEM ME / Number	ADD (μg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.91[c] [1]	0.91	RA 29, TL12
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.86 [1]	0.86	TL 8
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.63 [1]	0.63	TL 12
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.
[c] Average of values from RA 29 and TL12.

C-21

Pollutant: **Manganese cmpds (#22)** HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.61 [1]	0.61	MZ 6, MZ 7
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: <u>Mercury compounds</u> (#23) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-23

Pollutant: **Methylene chloride** **(dichloromethane) (#24)** HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	1.0 [1]	1	MZ 39, TL 10
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: <u>Nickel compounds</u> (#25) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: **7-PAH : (Lower and upper bound) (#26)** **HAPEM ME / Number**	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.81 [2]	0.81	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.81 [2]	0.81	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.72 [2]	0.72	
Other repair shop - Indoors / 12		1.0 [3]	0.81 [2]	0.81	
Residence (no CO source) - Indoors/13		1.0 [3]	0.7 [1]	0.7	MZ 17
Residence (gas stove) - Indoors / 14		1.0 [3]	0.72 [2]	0.72	
Residence (attached garage) - Indoors/15		1.0 [3]	0.72 [2]	0.72	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.72 [2]	0.72	
Office - Indoors / 17		1.0 [3]	0.81 [2]	0.81	
Store - Indoors / 18		1.0 [3]	0.81 [2]	0.81	
Restaurant - Indoors / 19		1.0 [3]	0.81 [2]	0.81	
Manufacturing facility - Indoors / 20		1.0 [3]	0.81 [2]	0.81	
School - Indoors / 21		1.0 [3]	0.81 [2]	0.81	
Church- Indoors / 22		1.0 [3]	0.81 [2]	0.81	
Shopping mall - Indoors / 23		1.0 [3]	0.81 [2]	0.81	
Auditorium - Indoors / 24		1.0 [3]	0.81 [2]	0.81	
Health care facility - Indoors / 25		1.0 [3]	0.81 [2]	0.81	
Other public building - Indoors / 26		1.0 [3]	0.81 [2]	0.81	
Other location - Indoors / 27		1.0 [3]	0.81 [2]	0.81	
Not specified - Indoors / 28		1.0 [3]	0.81 [2]	0.81	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: Polychlorinated biphenyls (#27) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: **Propylene dichloride (1,2-dichloropropane) (#28)** HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

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Pollutant: Quinoline (#29) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.81 [2]	0.81	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.81 [2]	0.81	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.72 [2]	0.72	
Other repair shop - Indoors / 12		1.0 [3]	0.81 [2]	0.81	
Residence (no CO source) - Indoors/13		1.0 [3]	0.72 [2]	0.72	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.72 [2]	0.72	
Residence (attached garage) - Indoors/15		1.0 [3]	0.72 [2]	0.72	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.72 [2]	0.72	
Office - Indoors / 17		1.0 [3]	0.81 [2]	0.81	
Store - Indoors / 18		1.0 [3]	0.81 [2]	0.81	
Restaurant - Indoors / 19		1.0 [3]	0.81 [2]	0.81	
Manufacturing facility - Indoors / 20		1.0 [3]	0.81 [2]	0.81	
School - Indoors / 21		1.0 [3]	0.81 [2]	0.81	
Church- Indoors / 22		1.0 [3]	0.81 [2]	0.81	
Shopping mall - Indoors / 23		1.0 [3]	0.81 [2]	0.81	
Auditorium - Indoors / 24		1.0 [3]	0.81 [2]	0.81	
Health care facility - Indoors / 25		1.0 [3]	0.81 [2]	0.81	
Other public building - Indoors / 26		1.0 [3]	0.81 [2]	0.81	
Other location - Indoors / 27		1.0 [3]	0.81 [2]	0.81	
Not specified - Indoors / 28		1.0 [3]	0.81 [2]	0.81	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: <u>Styrene</u> (#30) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.90 [2]	0.9	
Bus - In vehicle / 2		1.0 [3]	0.90 [2]	0.9	
Truck - In vehicle / 3		1.0 [3]	0.90 [2]	0.9	
Other - In vehicle / 4		1.0 [3]	0.90 [2]	0.9	
Public garage - Indoors / 5		1.0 [3]	0.80 [2]	0.8	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.80 [2]	0.8	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.81 [2]	0.81	
Other repair shop - Indoors / 12		1.0 [3]	0.80 [2]	0.8	
Residence (no CO source) - Indoors/13		1.0 [3]	0.95 [1]	0.95	MZ 38
Residence (gas stove) - Indoors / 14		1.0 [3]	0.81 [2]	0.81	
Residence (attached garage) - Indoors/15		1.0 [3]	0.81 [2]	0.81	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.81 [2]	0.81	
Office - Indoors / 17		1.0 [3]	0.85 [1]	0.85	MZ 39
Store - Indoors / 18		1.0 [3]	0.80 [2]	0.8	
Restaurant - Indoors / 19		1.0 [3]	0.80 [2]	0.8	
Manufacturing facility - Indoors / 20		1.0 [3]	0.80 [2]	0.8	
School - Indoors / 21		1.0 [3]	0.80 [2]	0.8	
Church- Indoors / 22		1.0 [3]	0.80 [2]	0.8	
Shopping mall - Indoors / 23		1.0 [3]	0.80 [2]	0.8	
Auditorium - Indoors / 24		1.0 [3]	0.80 [2]	0.8	
Health care facility - Indoors / 25		1.0 [3]	0.80 [2]	0.8	
Other public building - Indoors / 26		1.0 [3]	0.80 [2]	0.8	
Other location - Indoors / 27		1.0 [3]	0.80 [2]	0.8	
Not specified - Indoors / 28		1.0 [3]	0.80 [2]	0.8	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.90 [2]	0.9	
Airplane - In vehicle / 37		0.0 [3]	0.90 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: 2,3,7,8-TCDD: (Lower and upper bound) (#31) HAPEM ME / Number	ADD (μg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.81 [2]	0.81	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.81 [2]	0.81	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.72 [2]	0.72	
Other repair shop - Indoors / 12		1.0 [3]	0.81 [2]	0.81	
Residence (no CO source) - Indoors/13		1.0 [3]	0.72 [2]	0.72	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.72 [2]	0.72	
Residence (attached garage) - Indoors/15		1.0 [3]	0.72 [2]	0.72	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.72 [2]	0.72	
Office - Indoors / 17		1.0 [3]	0.81 [2]	0.81	
Store - Indoors / 18		1.0 [3]	0.81 [2]	0.81	
Restaurant - Indoors / 19		1.0 [3]	0.81 [2]	0.81	
Manufacturing facility - Indoors / 20		1.0 [3]	0.81 [2]	0.81	
School - Indoors / 21		1.0 [3]	0.81 [2]	0.81	
Church- Indoors / 22		1.0 [3]	0.81 [2]	0.81	
Shopping mall - Indoors / 23		1.0 [3]	0.81 [2]	0.81	
Auditorium - Indoors / 24		1.0 [3]	0.81 [2]	0.81	
Health care facility - Indoors / 25		1.0 [3]	0.81 [2]	0.81	
Other public building - Indoors / 26		1.0 [3]	0.81 [2]	0.81	
Other location - Indoors / 27		1.0 [3]	0.81 [2]	0.81	
Not specified - Indoors / 28		1.0 [3]	0.81 [2]	0.81	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

Pollutant: **1,1,2,2-tetrachloroethane** (#32) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.77 [2]	0.77	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.87 [1]	0.87	MZ 39
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

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Pollutant: Tetrachloroethylene (perchloroethylene) (#33) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.65 [1]	0.65	MZ 27
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.65 [1]	0.65	MZ 1
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.9[c] [1]	0.9	MZ 32
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.
[c] Museum

C-33

Pollutant: <u>Trichloroethylene</u> (#34) HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.78 [2]	0.78	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.78 [2]	0.78	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.77 [2]	0.77	
Other repair shop - Indoors / 12		1.0 [3]	0.78 [2]	0.78	
Residence (no CO source) - Indoors/13		1.0 [3]	0.9 [1]	0.9	MZ 27
Residence (gas stove) - Indoors / 14		1.0 [3]	0.77 [2]	0.77	
Residence (attached garage) - Indoors/15		1.0 [3]	0.77 [2]	0.77	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.77 [2]	0.77	
Office - Indoors / 17		1.0 [3]	0.78 [2]	0.78	
Store - Indoors / 18		1.0 [3]	0.78 [2]	0.78	
Restaurant - Indoors / 19		1.0 [3]	0.78 [2]	0.78	
Manufacturing facility - Indoors / 20		1.0 [3]	0.78 [2]	0.78	
School - Indoors / 21		1.0 [3]	0.78 [2]	0.78	
Church- Indoors / 22		1.0 [3]	0.78 [2]	0.78	
Shopping mall - Indoors / 23		1.0 [3]	0.78 [2]	0.78	
Auditorium - Indoors / 24		1.0 [3]	0.78 [2]	0.78	
Health care facility - Indoors / 25		1.0 [3]	0.78 [2]	0.78	
Other public building - Indoors / 26		1.0 [3]	0.78 [2]	0.78	
Other location - Indoors / 27		1.0 [3]	0.78 [2]	0.78	
Not specified - Indoors / 28		1.0 [3]	0.78 [2]	0.78	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-34

Pollutant: <u>Vinyl chloride</u> (#35) HAPEM ME / Number	ADD (μg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [2]	0.88	
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.81 [2]	0.81	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.81 [2]	0.81	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.72 [2]	0.72	
Other repair shop - Indoors / 12		1.0 [3]	0.81 [2]	0.81	
Residence (no CO source) - Indoors/13		1.0 [3]	0.72 [2]	0.72	
Residence (gas stove) - Indoors / 14		1.0 [3]	0.72 [2]	0.72	
Residence (attached garage) - Indoors/15		1.0 [3]	0.72 [2]	0.72	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.72 [2]	0.72	
Office - Indoors / 17		1.0 [3]	0.81 [2]	0.81	
Store - Indoors / 18		1.0 [3]	0.81 [2]	0.81	
Restaurant - Indoors / 19		1.0 [3]	0.81 [2]	0.81	
Manufacturing facility - Indoors / 20		1.0 [3]	0.81 [2]	0.81	
School - Indoors / 21		1.0 [3]	0.81 [2]	0.81	
Church- Indoors / 22		1.0 [3]	0.81 [2]	0.81	
Shopping mall - Indoors / 23		1.0 [3]	0.81 [2]	0.81	
Auditorium - Indoors / 24		1.0 [3]	0.81 [2]	0.81	
Health care facility - Indoors / 25		1.0 [3]	0.81 [2]	0.81	
Other public building - Indoors / 26		1.0 [3]	0.81 [2]	0.81	
Other location - Indoors / 27		1.0 [3]	0.81 [2]	0.81	
Not specified - Indoors / 28		1.0 [3]	0.81 [2]	0.81	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-35

Pollutant: Ethylbenzene HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.8 [1]	0.8	MZ 28
Bus - In vehicle / 2		1.0 [3]	0.90 [2]	0.9	
Truck - In vehicle / 3		1.0 [3]	0.90 [2]	0.9	
Other - In vehicle / 4		1.0 [3]	0.90 [2]	0.9	
Public garage - Indoors / 5		1.0 [3]	0.79 [1]	0.79	RA 24
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.80 [2]	0.8	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.81 [2]	0.81	
Other repair shop - Indoors / 12		1.0 [3]	0.80 [2]	0.8	
Residence (no CO source) - Indoors/13		1.0 [3]	0.85 [1]	0.85	MZ 27
Residence (gas stove) - Indoors / 14		1.0 [3]	0.81 [2]	0.81	
Residence (attached garage) - Indoors/15		1.0 [3]	0.81 [2]	0.81	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.81 [2]	0.81	
Office - Indoors / 17		1.0 [3]	0.74 [1]	0.74	MZ 39
Store - Indoors / 18		1.0 [3]	0.80 [2]	0.8	
Restaurant - Indoors / 19		1.0 [3]	0.80 [2]	0.8	
Manufacturing facility - Indoors / 20		1.0 [3]	0.80 [2]	0.8	
School - Indoors / 21		1.0 [3]	0.80 [2]	0.8	
Church- Indoors / 22		1.0 [3]	0.80 [2]	0.8	
Shopping mall - Indoors / 23		1.0 [3]	0.80 [2]	0.8	
Auditorium - Indoors / 24		1.0 [3]	0.80 [2]	0.8	
Health care facility - Indoors / 25		1.0 [3]	0.80 [2]	0.8	
Other public building - Indoors / 26		1.0 [3]	0.80 [2]	0.8	
Other location - Indoors / 27		1.0 [3]	0.80 [2]	0.8	
Not specified - Indoors / 28		1.0 [3]	0.80 [2]	0.8	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.90 [2]	0.9	
Airplane - In vehicle / 37		0.0 [3]	0.90 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-36

Pollutant: Hexane HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.93 [1]	0.93	MZ 28
Bus - In vehicle / 2		1.0 [3]	0.90 [2]	0.9	
Truck - In vehicle / 3		1.0 [3]	0.90 [2]	0.9	
Other - In vehicle / 4		1.0 [3]	0.90 [2]	0.9	
Public garage - Indoors / 5		1.0 [3]	0.80 [2]	0.8	
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.80 [2]	0.8	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.81 [2]	0.81	
Other repair shop - Indoors / 12		1.0 [3]	0.80 [2]	0.8	
Residence (no CO source) - Indoors/13		1.0 [3]	0.65 [1]	0.65	MZ 27
Residence (gas stove) - Indoors / 14		1.0 [3]	0.81 [2]	0.81	
Residence (attached garage) - Indoors/15		1.0 [3]	0.81 [2]	0.81	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.81 [2]	0.81	
Office - Indoors / 17		1.0 [3]	0.80 [2]	0.8	
Store - Indoors / 18		1.0 [3]	0.80 [2]	0.8	
Restaurant - Indoors / 19		1.0 [3]	0.80 [2]	0.8	
Manufacturing facility - Indoors / 20		1.0 [3]	0.80 [2]	0.8	
School - Indoors / 21		1.0 [3]	0.80 [2]	0.8	
Church- Indoors / 22		1.0 [3]	0.80 [2]	0.8	
Shopping mall - Indoors / 23		1.0 [3]	0.80 [2]	0.8	
Auditorium - Indoors / 24		1.0 [3]	0.80 [2]	0.8	
Health care facility - Indoors / 25		1.0 [3]	0.80 [2]	0.8	
Other public building - Indoors / 26		1.0 [3]	0.80 [2]	0.8	
Other location - Indoors / 27		1.0 [3]	0.80 [2]	0.8	
Not specified - Indoors / 28		1.0 [3]	0.80 [2]	0.8	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.90 [2]	0.9	
Airplane - In vehicle / 37		0.0 [3]	0.90 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-37

Pollutant: **MTBE** HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]		0	
Bus - In vehicle / 2		1.0 [3]	1.0 [1]	1	MZ 14
Truck - In vehicle / 3		1.0 [3]		0	
Other - In vehicle / 4		1.0 [3]		0	
Public garage - Indoors / 5		1.0 [3]		0	
Parking lot/garage - Outdoors / 6		1.0 [3]		0	
Near road - Outdoors / 7		1.0 [3]		0	
Motorcycle - Outdoors / 8		1.0 [3]		0	
Service station - Indoors / 9		1.0 [3]		0	
Service station - Outdoors / 10		1.0 [3]		0	
Residential garage - Indoors / 11		1.0 [3]		0	
Other repair shop - Indoors / 12		1.0 [3]		0	
Residence (no CO source) - Indoors/13		1.0 [3]		0	
Residence (gas stove) - Indoors / 14		1.0 [3]		0	
Residence (attached garage) - Indoors/15		1.0 [3]		0	
Residence (stove and garage)- Indoors/16		1.0 [3]		0	
Office - Indoors / 17		1.0 [3]		0	
Store - Indoors / 18		1.0 [3]		0	
Restaurant - Indoors / 19		1.0 [3]		0	
Manufacturing facility - Indoors / 20		1.0 [3]		0	
School - Indoors / 21		1.0 [3]		0	
Church- Indoors / 22		1.0 [3]		0	
Shopping mall - Indoors / 23		1.0 [3]		0	
Auditorium - Indoors / 24		1.0 [3]		0	
Health care facility - Indoors / 25		1.0 [3]		0	
Other public building - Indoors / 26		1.0 [3]		0	
Other location - Indoors / 27		1.0 [3]		0	
Not specified - Indoors / 28		1.0 [3]		0	
Construction site - Outdoors / 29		1.0 [3]		0	
Residential grounds - Outdoors / 30		1.0 [3]		0	
School grounds - Outdoors / 31		1.0 [3]		0	
Sports arena - Outdoors / 32		1.0 [3]		0	
Park/golf course - Outdoors / 33		1.0 [3]		0	
Other location - Outdoors / 34		1.0 [3]		0	
Not specified - Outdoors / 35		1.0 [3]		0	
Train/subway - In vehicle / 36		1.0 [3]		0	
Airplane - In vehicle / 37		0.0 [3]		0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-38

Pollutant: <u>Toluene</u> HAPEM ME / Number	ADD (µg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [1]	0.88	MZ 28
Bus - In vehicle / 2		1.0 [3]	0.88 [2]	0.88	
Truck - In vehicle / 3		1.0 [3]	0.88 [2]	0.88	
Other - In vehicle / 4		1.0 [3]	0.88 [2]	0.88	
Public garage - Indoors / 5		1.0 [3]	0.80 [1]	0.8	RA 24
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.81 [2]	0.81	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.72 [2]	0.72	
Other repair shop - Indoors / 12		1.0 [3]	0.81 [2]	0.81	
Residence (no CO source) - Indoors/13		1.0 [3]	0.95 [1]	0.95	MZ 27
Residence (gas stove) - Indoors / 14		1.0 [3]	0.72 [2]	0.72	
Residence (attached garage) - Indoors/15		1.0 [3]	0.72 [2]	0.72	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.72 [2]	0.72	
Office - Indoors / 17		1.0 [3]	0.82 [1]	0.82	MZ 39
Store - Indoors / 18		1.0 [3]	0.81 [2]	0.81	
Restaurant - Indoors / 19		1.0 [3]	0.81 [2]	0.81	
Manufacturing facility - Indoors / 20		1.0 [3]	0.81 [2]	0.81	
School - Indoors / 21		1.0 [3]	0.81 [2]	0.81	
Church- Indoors / 22		1.0 [3]	0.81 [2]	0.81	
Shopping mall - Indoors / 23		1.0 [3]	0.81 [2]	0.81	
Auditorium - Indoors / 24		1.0 [3]	0.81 [2]	0.81	
Health care facility - Indoors / 25		1.0 [3]	0.81 [2]	0.81	
Other public building - Indoors / 26		1.0 [3]	0.81 [2]	0.81	
Other location - Indoors / 27		1.0 [3]	0.81 [2]	0.81	
Not specified - Indoors / 28		1.0 [3]	0.81 [2]	0.81	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.88 [2]	0.88	
Airplane - In vehicle / 37		0.0 [3]	0.88 [2]	0	

[a] <u>Data Code</u>: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.

C-39

Pollutant: Xylenes HAPEM ME / Number	ADD (μg/m³)	PROX [Data Code] [a, b]	PEN [Data Code] [a]	MULT	Reference Sources
Car - In vehicle / 1		1.0 [3]	0.88 [1]	0.88	MZ 28
Bus - In vehicle / 2		1.0 [3]	0.90 [2]	0.9	
Truck - In vehicle / 3		1.0 [3]	0.90 [2]	0.9	
Other - In vehicle / 4		1.0 [3]	0.90 [2]	0.9	
Public garage - Indoors / 5		1.0 [3]	0.94 [1]	0.94	RA 24
Parking lot/garage - Outdoors / 6		1.0 [3]	1.0 [3]	1	
Near road - Outdoors / 7		1.0 [3]	1.0 [3]	1	
Motorcycle - Outdoors / 8		1.0 [3]	1.0 [3]	1	
Service station - Indoors / 9		1.0 [3]	0.80 [2]	0.8	
Service station - Outdoors / 10		1.0 [3]	1.0 [3]	1	
Residential garage - Indoors / 11		1.0 [3]	0.81 [2]	0.81	
Other repair shop - Indoors / 12		1.0 [3]	0.80 [2]	0.8	
Residence (no CO source) - Indoors/13		1.0 [3]	0.85 [1]	0.85	MZ 27
Residence (gas stove) - Indoors / 14		1.0 [3]	0.81 [2]	0.81	
Residence (attached garage) - Indoors/15		1.0 [3]	0.81 [2]	0.81	
Residence (stove and garage)- Indoors/16		1.0 [3]	0.81 [2]	0.81	
Office - Indoors / 17		1.0 [3]	0.74 [1]	0.74	MZ 39
Store - Indoors / 18		1.0 [3]	0.80 [2]	0.8	
Restaurant - Indoors / 19		1.0 [3]	0.80 [2]	0.8	
Manufacturing facility - Indoors / 20		1.0 [3]	0.80 [2]	0.8	
School - Indoors / 21		1.0 [3]	0.80 [2]	0.8	
Church- Indoors / 22		1.0 [3]	0.80 [2]	0.8	
Shopping mall - Indoors / 23		1.0 [3]	0.80 [2]	0.8	
Auditorium - Indoors / 24		1.0 [3]	0.80 [2]	0.8	
Health care facility - Indoors / 25		1.0 [3]	0.80 [2]	0.8	
Other public building - Indoors / 26		1.0 [3]	0.80 [2]	0.8	
Other location - Indoors / 27		1.0 [3]	1.0[c] [1]	1	MZ 29
Not specified - Indoors / 28		1.0 [3]	0.80 [2]	0.8	
Construction site - Outdoors / 29		1.0 [3]	1.0 [3]	1	
Residential grounds - Outdoors / 30		1.0 [3]	1.0 [3]	1	
School grounds - Outdoors / 31		1.0 [3]	1.0 [3]	1	
Sports arena - Outdoors / 32		1.0 [3]	1.0 [3]	1	
Park/golf course - Outdoors / 33		1.0 [3]	1.0 [3]	1	
Other location - Outdoors / 34		1.0 [3]	1.0 [3]	1	
Not specified - Outdoors / 35		1.0 [3]	1.0 [3]	1	
Train/subway - In vehicle / 36		1.0 [3]	0.90 [2]	0.9	
Airplane - In vehicle / 37		0.0 [3]	0.90 [2]	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] The PROX factor is assumed to be the same for each source category for this pollutant.
[c] Telephone switching center

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ADDENDUM

Determination of Microenvironmental Factors for Diesel PM

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INTRODUCTION

ICF Consulting (ICF) and TRJ Environmental, Inc. (TRJ) prepared a report titled ADevelopment of Microenvironmental Factors for the HAPEM4 in Support of the National Air Toxics Assessment (NATA)@ for the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency (USEPA). That report describes the procedures ICF and TRJ used to estimate pollutant-specific microenvironmental (ME) factors for 35 hazardous air pollutants (HAPs) in 37 microenvironments. USEPA will use these ME factors to run Version 4 of the Hazardous Air Pollution Exposure Model (HAPEM4) and estimate inhalation exposures as part of the NATA assessment activities.

To broaden the scope of these exposure assessments, USEPA requested that ICF and TRJ develop ME factors for one additional pollutant: particulate matter associated with diesel engine emissions (diesel PM). Diesel PM ME factors developed as part of this effort are presented in Table 1 of this addendum. This addendum also provides a list of references in Tables 2 and 3, as well as a brief description of the procedures ICF and TRJ used to develop ME factors for diesel PM. Additional details on the definition and development of HAPEM4 ME factors are contained in the main report.

METHODOLOGY

Defining the HAPEM4 ME Factors

The initial NATA assessment is concerned with estimating the influence of outdoor sources on inhalation exposure. HAPEM4 is a computer-based exposure model that estimates the contribution of outdoor HAP concentrations to air concentrations in indoor, outdoor, and vehicle microenvironments using three ME factors: *PEN*, the penetration factor; *PROX*, the proximity factor; and *MULT*, the multiplicative factor.

For indoor and in-vehicle microenvironments, *PEN* is defined as the ratio of the microenvironmental concentration to the outdoor concentration in the immediate vicinity of the microenvironment. This ratio is often reported in the literature as the I/O (indoor/outdoor) ratio in the absence of indoor sources. Since *PEN* factors are not applicable to outdoor microenvironments, all outdoor *PEN* factors have been set to 1.0 for this project.

The *PROX* factor relates the HAP concentration at a specific location (e.g., at a fixed-site monitor or at the centroid of a census tract) to the outdoor concentration in the immediate vicinity of the microenvironment, or to the concentration in the microenvironment itself for outdoor microenvironments. *PROX* is defined as the ratio of the outdoor concentration in the

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immediate vicinity of the microenvironment (or outdoor microenvironmental concentration) to the measured or modeled ambient concentration.

The *MULT* factor is the product of the *PEN* and *PROX* factors, or the overall ratio of the microenvironmental concentration to the measured or modeled ambient concentration. A fourth ME factor, the additive (*ADD*) factor, is used by HAPEM4 to account for the contribution of sources within the microenvironment, such as indoor sources. For this initial NATA assessment emphasizing outdoor sources, all *ADD* factors have ben set to zero.

Calculating HAPEM4 ME Concentrations and Estimation of Proximity Factors

The HAPEM4 uses these ME factors to estimate concentrations within microenvironments with the equation

$$ME(m,c,t) = ADD(m) + [PROX(m)][PEN(m)][AMB(c,t)] \qquad (1)$$

where:

ME(m,c,t):	concentration in microenvironment *m* located in census tract *c* at time *t*,
ADD(m):	additive factor for microenvironment *m*,
PEN(m):	penetration factor for microenvironment *m*,
PROX(m):	proximity factor for microenvironment *m*, and
AMB(c,t):	ambient concentration for census tract *c* at time *t*.

In the NATA application of HAPEM4, the ambient concentration values used in Equation (1) are obtained from a dispersion model which computes the ambient concentration at the centroid, or population center, of each census tract based on information on emission sources in the surrounding area. This method provides an average concentration estimate applicable to the entire census tract. However, this estimate would tend to be biased low for microenvironments usually located near predominant sources of a pollutant. For diesel PM, which is emitted by onroad motor vehicles, this low bias would be observed in microenvironments near roadways. These near-road microenvironments include outdoor locations near roads (HAPEM4 microenvironment No. 7), in-vehicle microenvironments (Nos. 1, 2, 3, 4, 8, and 36), service stations (No. 10), and parking facilities (No. 6).

The effect of the low bias in the computed ambient concentration is to yield *PROX* factors greater than 1.0 for diesel PM in these microenvironments. In other words, the outdoor concentration in the immediate vicinity of the microenvironment is expected to be higher than the ambient concentration measured at a remote fixed-site monitor or computed by the dispersion model. *PROX* factors for all other microenvironments have been assigned a default value of 1.0.

Literature Search

ICF and TRJ conducted a broad literature search similar to that described in the main report to identify references useful for developing diesel PM ME factors. Researchers performed an online search using key words relating to diesel PM. The initial large list of titles and key

word descriptors was reviewed and ranked according to the potential for containing valuable data for ME factor estimation. Abstracts were retrieved for citations with a high probability of containing both indoor and outdoor measurements for the various microenvironments. Researchers reviewed these abstracts and obtained the complete paper or report for the 12 citations identified as most likely to provide relevant information.

In addition to the online search, researchers used several other sources to identify relevant articles. Several extended abstracts from the American Waste Management Association=s PM2000 Conference in January, 2000 contained useful information on I/O ratios for particles of various sizes, particle size distribution of diesel PM, and other data which could be combined to estimate diesel PM ME factors. Researchers also contacted air quality experts for suggestions on relevant literature, yielding several articles. Some documents relating to diesel PM were retrieved from existing ICF and TRJ files. Finally, researchers retrieved relevant citations from the reference lists of articles found by other methods.

Despite this broad literature review, relatively few articles were found to contain actual measurement data on diesel PM I/O ratios in the absence of microenvironmental sources; that is, data which would be directly applicable to estimation of *PEN* factors. Therefore, researchers combined general particulate matter data in certain microenvironments with information on characteristics of diesel PM to arrive at diesel PM ME factors. Researchers found sufficient information to estimate ME factors for key microenvironments, allowing development of factors for the remaining microenvironments using the grouping scheme described below.

Grouping Microenvironments

Since published diesel PM I/O measurement data were not available for most of the 37 HAPEM4 microenvironments, analysts decided to use the microenvironmental grouping scheme described in the main report to estimate ME factors for those microenvironments. In this grouping scheme, the microenvironments were organized into five groups. Each group consists of microenvironments expected to have similar *PEN* factors, thus enabling ME factors developed for one microenvironment to be applied to other microenvironments in the same group. Table 4 in the main report shows the ME grouping assignments. The five ME groups were established based on the general ME type (indoor, outdoor, or in-vehicle), expected location relative to roadways (near road, away from road), and building type (residence, other). For specific microenvironments without useful data in the literature, researchers calculated the average of ME factors developed for other microenvironments in the same group and used the result as the ME factor estimate. This is indicated in the ME factor table, Table 1, by a Data Code of 2.

RESULTS

Table 1 presents the diesel PM ME factors developed in this effort. An estimated value is provided for each ME factor in each microenvironment, except for *ADD* factors, which represent indoor sources and were therefore not included in this project. Because onroad mobile sources are significant for diesel PM, analysts developed separate estimates of the *PROX* and *MULT* factors to be used for the onroad source category and the nonroad, major, and area source

categories. A Data Code in brackets follows each factor estimate, indicating how the ME factor value was derived. These Data Codes are defined below:

Data Code [1]: indicates that measurement data for that microenvironment were available and used.

Data Code [2]: indicates that useful measurement data were not available, and that the ME factor was obtained through the grouping scheme described above in the Methodology section.

Data Code [3]: indicates that a default value of 1.0 was used.

The most commonly studied microenvironment was residence - indoors (ME #13). For this microenvironment, multiple references containing high-quality data were available. Analysts used the average of factors determined from these references as the *PEN* factor estimate for ME #13.

The last column in Table 1 lists the references used to develop factors for each microenvironment. If no reference code is provided, then researchers did not find any useful documents for that particular microenvironment. Table 2 provides specific information on the reference documents reviewed for this addendum, including both those with and without sufficient data to estimate ME factors. Table 2 lists the title, author, citation, pollutants addressed, and a brief description of the pertinent results for each document. It also includes a Sources column with codes matched to the Reference Sources codes in Table 1. An alphabetized version of the reference list is provided in Table 3.

SUMMARY

This addendum extends the scope of the main report by developing *PEN*, *PROX*, and *MULT* ME factors for one additional pollutant, diesel PM. Researchers identified relatively few studies with measurement data directly applicable to estimating diesel PM ME factors, and these studies tended to focus on the residential microenvironment. Analysts combined information from various studies on the characteristics of diesel PM, apportionment of PM to diesel sources, and general PM measurement data to develop ME factors in those microenvironments with sufficient data. These ME factors were then propagated to other related microenvironments using a grouping scheme, enabling analysts to develop factors for all applicable microenvironments. The use of default values was restricted to those microenvironments for which ME factors are not applicable. Default values for the *PEN* factor were used only for outdoor microenvironments, where the *PEN* factor is not relevant. Since diesel PM *PROX* factors greater than 1.0 are only expected in near-road microenvironments for the onroad mobile source category, researchers assigned default values for the *PROX* factor to all other microenvironments. As additional measurement information becomes available, these ME factor values can be refined and updated to provide improved estimates of the influence of outdoor sources on indoor diesel PM concentrations.

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Table 1. Diesel PM Microenvironmental Factors by Microenvironment

HAPEM Microenvironment	ADD (Fg/m^3)	PROX [Data Code] [a] Onroad [b]	PROX Major, area, and nonroad [c]	PEN [Data Code] [a]	MULT = PROX H PEN Onroad [d]	MULT Major, area, and nonroad [d]	Reference Sources
1. Car - In vehicle		1.76 [1]	1.0 [3]	0.63 [1]	1.1088	0.63	TL33
2. Bus - In vehicle		1.76 [2]	1.0 [3]	0.63 [2]	1.1088	0.63	
3. Truck - In vehicle		1.76 [2]	1.0 [3]	0.63 [2]	1.1088	0.63	
4. Other - In vehicle		1.76 [2]	1.0 [3]	0.63 [2]	1.1088	0.63	
5. Public garage - Indoors		1.0 [3]	1.0 [3]	0.75 [2]	0.75	0.75	
6. Parking lot/garage - Outdoors		1.45 [2]	1.0 [3]	1.0 [3]	1.45	1	
7. Near road - Outdoors		1.45 [1]	1.0 [3]	1.0 [3]	1.45	1	TL33
8. Motorcycle - Outdoors		1.45 [2]	1.0 [3]	1.0 [3]	1.45	1	
9. Service station - Indoors		1.0 [3]	1.0 [3]	0.75 [2]	0.75	0.75	
10. Service station - Outdoors		1.45 [2]	1.0 [3]	1.0 [3]	1.45	1	
11. Residential garage - Indoors		1.0 [3]	1.0 [3]	0.65 [2]	0.65	0.65	
12. Other repair shop - Indoors		1.0 [3]	1.0 [3]	0.75 [2]	0.75	0.75	
13. Residence (no CO source) - Indoors		1.0 [3]	1.0 [3]	0.74 [1]	0.74	0.74	TL23, TL27, TL29, TL30, TL32, TL34, TL35, TL39
14. Residence (gas stove) - Indoors		1.0 [3]	1.0 [3]	0.56 [1]	0.56	0.56	TL39
15. Residence (attached garage) - Indoors		1.0 [3]	1.0 [3]	0.65 [2]	0.65	0.65	
16. Residence (stove and garage) - Indoors		1.0 [3]	1.0 [3]	0.65 [2]	0.65	0.65	
17. Office - Indoors		1.0 [3]	1.0 [3]	0.54 [1]	0.54	0.54	TL27
18. Store - Indoors		1.0 [3]	1.0 [3]	0.76 [1]	0.76	0.76	TL27
19. Restaurant - Indoors		1.0 [3]	1.0 [3]	0.75 [2]	0.75	0.75	
20. Manufacturing facility - Indoors		1.0 [3]	1.0 [3]	0.75 [2]	0.75	0.75	
21. School - Indoors		1.0 [3]	1.0 [3]	0.69 [1]	0.69	0.69	TL27
22. Church - Indoors		1.0 [3]	1.0 [3]	0.76 [1]	0.76	0.76	TL27
23. Shopping mall - Indoors		1.0 [3]	1.0 [3]	0.76 [1]	0.76	0.76	TL27
24. Auditorium - Indoors		1.0 [3]	1.0 [3]	0.75 [2]	0.75	0.75	
25. Health care facility - Indoors		1.0 [3]	1.0 [3]	0.76 [1]	0.76	0.76	TL27
26. Other public building - Indoors		1.0 [3]	1.0 [3]	0.75 [2]	0.75	0.75	
27. Other location - Indoors		1.0 [3]	1.0 [3]	0.75 [2]	0.75	0.75	
28. Not specified - Indoors		1.0 [3]	1.0 [3]	0.95 [1]	0.95	0.95	TL22
29. Construction site - Outdoors		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
30. Residential grounds - Outdoors		1.0 [3]	1.0 [3]	1.0 [3]	1	1	

HAPEM Microenvironment	ADD (μg/m^3)	PROX [Data Code] [a]		PEN [Data Code] [a]	MULT = PROX H PEN		Reference Sources
		Onroad [b]	Major, area, and nonroad [c]		Onroad [d]	Major, area, and nonroad [d]	
31. School grounds - Outdoors		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
32. Sports arena - Outdoors		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
33. Park/golf course - Outdoors		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
34. Other location - Outdoors		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
35. Not specified - Outdoors		1.0 [3]	1.0 [3]	1.0 [3]	1	1	
36. Train/subway - In vehicle		1.76 [2]	1.0 [3]	0.63 [2]	1.1088	0.63	
37. Airplane - In vehicle		0.0 [3]	0.0 [3]	0.90 [2]	0	0	

[a] Data Code: 1 = value obtained from literature; 2 = value obtained using grouping scheme; 3 = default value.
[b] Onroad vehicle source category (see text).
[c] Major, area, and nonroad-mobile source categories (see main report text).
[d] The MULT factor is the product of the PROX factor and the PEN factor for the onroad vehicle source category and for the major, area, and nonroad-mobile source categories for this pollutant.

Formula: Microenvironmental concentration, μg/m^3 = ADD + (PROX)(PEN)(monitor concentration, μg/m^3).

Abbreviations: ADD = additive factor; PROX = proximity factor; PEN = penetration factor; MULT = PROX H PEN.

Page 2 Limitations for HAPEM4 Charts

EPA strongly cautions that these modeling results should not be used to draw conclusions about local exposure concentrations or risk. The results are most meaningful when viewed at the state or national level; for smaller areas, the modeling becomes less certain. In addition, these results represent conditions in 1996 rather than current conditions and only include exposures from outdoor sources of air toxics.

C   The exposure estimates presented above represent midrange estimates of population exposures. Due to a number of factors, some individuals may have substantially higher or lower exposures. It is important to note that the model, as applied on the national scale, is not designed to quantify these extreme values of individual exposures.

C   Note that for certain chemicals, exposure pathways other than inhalation as well as indoor sources of air toxics may contribute substantially to total exposures of concern. This assessment does not address these other routes of exposure (i.e., ingestion or dermal) or inhalation exposure resulting from indoor sources.

C   The emissions used in this assessment do not reflect potentially significant emission reductions that have taken effect since 1996, including those from: 1) mobile source regulations which are being phased in over time; 2) many of the air toxics regulations EPA has issued for major industrial sources; 3) State or industry initiatives; and 4) any facility closures.

C   Simplified modeling assumptions may introduce significant uncertainties into each component of the assessment. See the full discussion of these limitations.

C   Because of these uncertainties, EPA will not use the results of this assessment to determine source-specific contributions or to set regulatory requirements. However, EPA expects to use these results to inform decisions about the priorities of the air toxics program as well as to guide the collection of additional data that could lead to regulatory decisions.

C   EPA provides cancer risk estimates for carcinogens at various exposure levels (e.g., 100 in a million) to assist readers in placing the exposure levels in context. The interpretation of a risk level of 100 in a million is that an individual continually exposed to a pollutant at this level over the course of a lifetime sustains a 100 in a million chance of contracting cancer as a result of that exposure. All risk estimates are considered conservative, but not worst-case. True risk would probably be less, but could be greater.

C   EPA also provides hazard quotient (HQ) values for non-carcinogens at various exposure levels (e.g., HQ=1.0) to assist readers in placing the exposure levels in context. The HQ is the ratio of a given exposure level to the reference concentration (RfC), which in turn is an estimate of the continuous lifetime inhalation exposure which the EPA believes is likely to be without appreciable risk of deleterious non-cancer effect. Thus, if HQ=1.0, the predicted exposure concentration is equivalent to the RfC level for that pollutant. While exposures below the RfC are believed safe, exposures above the RfC are not necessarily harmful. Nevertheless,as exposure increases above the RfC, the risk for adverse effects also increases.

C   It is important to realize that these risk and HQ levels are not regulatory levels – they are provided to help in judging the relative importance of these different pollutants with regard to their potential to create adverse health effects . The determination of what risk or HQ levels are acceptable or unacceptable depends on additional factors and more refined information, and is not addressed in this assessment.

C   Health effects information is available at: www.epa.gov/ttn/uatw/hapindex.html