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COMMUTER EXPOSURE MODEL

User's Guide

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ENVIRONMENTAL SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

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ABSTRACT

A topic of increasing concern to planning and regulatory agencies and to air quality modelers is the high air pollutant levels observed on roadways. Commuters, who drive during heavy demand periods and are exposed to perhaps the highest pollutant levels, are the group most affected. To investigate this problem, the U.S. EPA commissioned a study to develop a commuter exposure modeling methodology. The methodology has been designed to compute commuter exposure statistics through simulation of the traffic, vehicular emissions, and atmospheric dispersion of roadway-related air pollutants. A numerical computer-oriented code, based on the commuter exposure methodology, has been developed and implemented and is described in the User's Guide.

The commuter exposure modeling package consists of two programs that are to be run separately on the computer. The first program is an emissions preprocessor, which has been separated from the main model to facilitate updating of the model package when currently accepted methods for computing emissions factors are revised by EPA. The second program is the main portion of the commuter exposure model, which simulates traffic flow, computes the emissions rates resulting from the traffic (using the emission factors calculated by the preprocessor), simulates the dispersive effects of the atmosphere, and computes statistics describing commuter exposure.

The commuter exposure model is a tool that can be used to assess the pollutant levels to which commuters are exposed in various metropolitan areas. Since the model treats the spatial variation of exposure, regions

of the city in which commuters experience high exposures can be identified from model output. If a single commute pathway is of interest, that pathway can be examined in detail. The model facilitates study of exposure levels in relation to the percentage of the commuting population exposed. The length of time of exposure is also readily available for use in health effects studies. In addition to being useful for determining absolute exposure levels, the model can also assess the effects of implementing roadway improvements or transportation control measures.

The commuter exposure modeling package consists of two documents. This volume is the User's Guide. It describes program execution and provides the user with the information needed to run the program. The other volume provides a detailed description of the model methodology and code.

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SECTION 1

INTRODUCTION

Those concerned with air quality assessment are increasingly recognizing the inadequacy of fixed point monitoring data for characterizing the pollutant exposure of various population groups. The spatial variation of concentrations over short distances is recognized to be sufficiently great for some pollutants that concentration measurements made at fixed locations are not necessarily representative of the concentrations to which people, as moving receptors, are exposed. Since the objective of air quality regulation in general is to protect the health of people, the air quality assessment community has realized that simulation modeling should be directed toward modeling pollutant concentrations at the locations where people spend time, considering the amount of time spent at each location. Thus, it is being recognized that the quantity of real concern is not concentration, but rather exposure, which implies the interaction of concentration and a (human) receptor. The population group experienc ing the highest potential exposure to automobile-related pollutants is commuters. To assess commuter exposures, the U.S. Environmental Protection Agency commissioned a study (Simmon and Patterson, 1979) to develop methodologies for modeling commuter exposure using both computer and manual techniques. A numerical computer-oriented code, based on the commuter exposure methodology formulated in the referenced study, has been developed and implemented and is described in this User's Guide.

The commuter exposure model is a tool that can be used to assess the pollutant levels to which commuters are exposed in various metropolitan areas. The model can be used to look at annual average exposures when it is run in what is called the annual mode; when the user wants to examine specific or high risk worst-case commutes, the model can be run in the short-term mode. The model output provides the user with a substantive description of commuter exposure. Since the model treats the spatial variation of exposure, regions of the city in which commuters experience high exposures can be identified from model output. If a single commute pathway is of interest, that pathway can be examined in detail. The model facilitates study of exposure levels in relation to the percentage of the commuting population exposed. The length of time of exposure is also readily available for use in health effects studies. In addition to being useful for determining absolute exposure levels, the model can also assess the effects of implementing roadway improvements or transportation control measures.

The commuter exposure modeling package consists of two programs that are to be run separately on the computer. The first program is an emissions preprocessor, which has been separated from the main model to facilitate updating of the model package when currently accepted methods for computing emissions factors are revised by EPA. The second program is the main portion of the commuter exposure model, which simulates traffic flow, computes the emissions rates resulting from the traffic (using the emission factors calculated by the preprocessor), simulates the dispersive effects of the atmosphere, and computes statistics describing commuter exposure.

This User's Guide to the commuter exposure modeling package describes program execution and provides the user with the information needed to run the program. The other volume gives detailed descriptions of the model methodology and a listing (on microfiche) of the FORTRAN code. In this guide, the potential uses of the model are discussed and a brief overview of the modeling methodology is presented. A comprehensive section describing the details of the implementation of the model methodology on a computer and the associated computer requirements is included. The data necessary to run the model are fully described and numerous recommendations are made for preparing the input data. Model output is described and the uses and interpretation of the output are discussed along with the limitations of the model. Finally, a sample application is presented with a more detailed description in an Appendix.

SECTION 2

PROGRAM USAGE

The commuter exposure model is meant to be just what its name implies, a model that will calculate the exposure of commuters to air pollution and express this exposure in a variety of temporal and spatial formats. In no sense is it intended to function as an analytical simulation model for any of the three modules that it includes; i.e., traffic, emissions, and dispersion.

The commuter exposure model is a tool that can be used to assess the pollutant levels to which commuters are exposed. The model can generate data on annual average exposures or on exposures during specific commutes. Since the model treats the spatial variation of exposure, regions of an urban area in which commuters experience high exposures can be identified using the model. The model facilitates the study of exposure levels in relation to the percentage of the commuting population exposed to different levels. The length of time of exposure is also readily available for use in health effect studies.

In addition to determining absolute exposure levels, the model can also be used to assess the effects of implementing roadway improvements, transportation control measures, changes in vehicle mix or emission controls, or even the effects of topographical changes. The differences in commuter exposure under various planning alternatives can be found by running the model with and without the proposed changes and comparing the computed results.

Every attempt has been made to make the commuter exposure model usable by the technical person who is experienced in either dispersion

modeling or traffic modeling. However, instances may arise in which technical judgment must be applied by the user, and for these cases it is recommended that the user seek technical assistance from someone working in the relevant field. Examples include such things as the best way to treat traffic flow at a signalized intersection under the constrants of the model formulations, and whether to treat a particular roadway as a street canyon or not for dispersion modeling purposes.

In examining the output of the model, consideration must be given to the assumptions made in defining the parthway network from the data base. The more thorough and reliable the input data, the more reliable will be the results. Model output can be no better than the quality of the input data. If input parameters were estimated in a number of instances, note should be taken as to the potential effects of output values. As with any simulation model of this type, its best application is in examining relative differences rather than absolute values.

SECTION 3

BRIEF DESCRIPTION OF MODEL METHODOLOGY

3.1. Overview

The crux of the commuter exposure modeling problem is defining the modeling area, and the most critical aspect in defining the modeling area is choosing the appropriate commuter pathways. The commuter exposures that are calculated and the statistics that are derived all depend directly on the pathways that are defined.

For the problem to be manageable, a reasonable number of major commuting routes or pathways having the highest numbers of vehicle miles of travel (VMT) by commuters must be defined. While it is recognized that these pathways will not carry all commuters, they will include the commuters at risk of experiencing high exposures. The commuters "missed" will, on the average, be traveling shorter times and distances on less heavily traveled roads.

Commuting trips are not begun (for a morning commute) on the commute pathways as defined here, but rather, on local surface streets and "collectors." To handle the exposure during the approach to and departure from the pathway, minor pathways are used that are representative of the travel to and from the route. Likewise, at the end of a (morning) commute, ending routes are specified that are representative of travel from the major pathways to work locations. The process is reversed for the evening commute.

Traffic on roadways other than pathways is treated by allocating VMT on a grid square basis (see Ludwig, et al., 1977). This approximation is made because the major contribution to pollutant concentrations on a pathway is made by the vehicles traveling on the pathway itself. The gridded street network is divided into the primary network, which includes roadways for which traffic volumes are available, and the secondary network, which includes the remaining roadways. The VMT on the secondary network are assumed to be a function of the primary traffic and locale. The gridded traffic data are supplied by the user.

The model is designed to be used in a short-term mode simulating a single commute period, or in an annual mode that simulates an average commute over a year. A number of data are generated for each mode of operation.

3.2 Traffic Modeling

The traffic module of the commuter exposure model handles two separate traffic flow regimes: uninterrupted flow and interrupted flow. Travel on expressways is generally uninterrupted, although during a backup, the flow can become severely constrained to the point of becoming "stop and go." Interrupted flow describes travel on arterials with traffic signals at the intersections. (Intersections that have stop signs are not considered since they will not be present for the main traffic flow on an arterial, commuter pathway.) The following discussion details those elements that describe the traffic flow.

3 .2.1. Uninterrupted Flow

The characteristics of uninterrupted flow can be obtained from two parameters: Demand volume (V) and free-flow capacity (C) of the road segment. Volume data in some form are required. Data in the form of average daily traffic (ADT) or annual average daily traffic (AADT) are converted to hourly values through diurnal and seasonal distributions either by the user or by the model using national average distributions.

Travel speed is important for estimating vehicle pollutant emissions along the pathways and for calculating travel time, which is then used in the exposure and dose calculations. Speed may be input by the user, or if it is not, the model calculates speed on each pathway segment as a function of volume, capacity, and the type of roadway.

3.2.2. Freeway Backup

When demand exceeds capacity a traffic backup may occur. For the purposes of commuter exposure modeling a simple model was developed to estimate the size of a backup and the average delay that it would cause. It was assumed that the rate of growth of the backup equals the difference in demand minus capacity. The total number of vehicles affected is then

$$N = \frac{\hat{N}}{1-q/s} \tag{1}$$

where $\hat{N}$ is the total number affected while demand exceeds capacity and q and s are the demand and capacity in vehicles per unit time. The expression is evaluated after demand falls below capacity. The average delay (D) is calculated by

$$D = \frac{k\hat{N}^2}{vN} \quad , \qquad (2)$$

where k is the distance between vehicles, v is the travel speed, and k/v is the time headway.

3.2.3. Interrupted Flow

Interrupted flow pertains to traffic conditions when movement is routinely stopped, or interrupted, for a finite period of time. For the commuter exposure model, only two causes of interrupted flow need be considered: signalized intersections and toll booths, where traffic goes through mode changes from cruise to deceleration, idle, acceleration, and back to cruise. Emissions (and hence concentrations) and times of exposure are influenced by these mode changes.

Because of vehicle emission characteristics, the average route speed methodology used for freeways is used for arterials outside of the central business district (CBD).

A more thorough analysis is warranted to CBD pathway segments and toll booths. Calculations must be made of driving mode changes, the proportion of vehicles changing modes, and the length of time spent in the different modes. Basically, this requires a calculation of queue lengths and delay at intersections. The parameters required are demand volume, capacity, and the traffic signal parameters of cycle length and the length of the green phase. The user may choose to input the signal parameters or have the model calculate them. Queue length and delay data can then be sued to calculate modal emissions.

Once capacity, volume and the signal parameters are known, the proportion of vehicles that stop for a signal can be calculated from the length of the green pahse G, the signal cycle length Cy, the hourly demand volume V, and the capacity service volume per hour of green, Cs.

The number (n) of vehicles subject to queueing delay is

$$N = \frac{VCy}{3600}\left(\frac{1-G/Cy}{1-V/Cs}\right) \tag{3}$$

while the maximum length of the queue (Lq, m) is

$$Lq = 8N/M \tag{4}$$

where 8 is the distance (meters) occupied by each queued vehicle and M is the number of lanes in the approach. On the average, a stopped vehicle waits one-half the length of the red phase, so the average delay to those vehicles is

$$D = 0.5\ (Cy-G) \quad . \tag{5}$$

For toll booths, the methodology is different because <u>all</u> vehicles must stop and wait to be served. The average number of vehicles waiting to leave a toll booth is computed from classical queueing theory as

$$N = \frac{V}{C-V} \quad . \tag{6}$$

The queue length at a toll booth is given by Equation 4, while the average delay for vehicles at a toll booth is:

$$D = \frac{3600\ N}{C} \quad . \tag{7}$$

The traffic modeling methodology used in this model has been demonstrated for air pollution work in a number of studies (e.g., Patterson, 1975). While there are other more complicated methods of handling traffic flow modeling, the present approach has been found to be quite suitable for air quality simulation. The basic outputs of the traffic module--speed, volume, travle time, and modal behavior--are those required by the emissions and dispersion modules to calculate commuter exposure.

3.3. Emission Rate Computations

Emission rates for each pathway segment and grid square are computed using one of two types of emission treatments: a treatment based on the average route speed and one that considers the effects of driving mode changes on emissions. The first treatment is the EPA methodology (EPA, 1978) based on the Federal Test Procedure (FTP). The second treatment is the "Automobile Exhaust Emission Modal Analysis Model," EPA (1974), or modal model. Emissions modeling along pathways requires both treatments; FTP-based emissions estimates are suitable for nonpathway sources.

Emission rates (Q) for pathway segments that are freeways, expressways, or arterials outside the central business district (CBD) are found by multiplying an emission density, E, computed using the FTP methodology and chosen according to the average route speed on the segment, by the demand volume (V) on the segment. To compute the average emission rate over a segment having congested flow, it is convenient to break the emissions into two components: Those occurring during normal flow, E, and the excess over normal flow emissions that occur during congested flow, E'-E, where E' represents the emissions during congested flow. The component

of total emissions due to uncongested flow is given by Q, with E chosen according to the average route speed on the uncongested portion of the segment. The average emission rate over the pathway segment is the sum of the components due to uncongested (Q) and congested (Q') flow, as given by:

$$Qavg = Q + \frac{\hat{T}\ Lq\ Q'}{3600\ L} = \frac{EV + (E'-E)\hat{N}\ Lq/L}{(1609)(3600)} \tag{8}$$

where E' corresponds to an average route speed of 20 mi/h, L = segment length (m), and $\hat{T}$ is the duration (seconds) of the backup.

Travel on arterials within the CBD is characterized by interrupted flow and low speeds, and a modal emissions treatment should be used. This is available through an adaptation of EPA's modal model.

For the commuter exposure model, simulation of the effects of modal emissions is facilitated through the introduction of the concept of excess modal emissions. Excess modal emissions are those that occur over and above those that would have occurred had the vehicle not stopped. The total excess emissions, E_E(g/m/s), the sum of idle emissions and the acceleration and deceleration parts of the excess emission, E_{AD}, may be expressed as

$$E_E = \left(\frac{E_{AD}\ N}{Cy} + \frac{b_{10}\ DVP}{3600} \right) /Lq \tag{9}$$

where b_{10} = constant (g/s) and P = proportion of vehicles stopped for the signal. The cruise emissions that would have occurred had the vehicle

not stopped are found by integrating the modal model expression for the steady-speed emission rate over 1/2T. Once emissions are calculated with the modal treatment, they are averaged for each pathway segment.

3.4. Dispersion Modeling

3.4.1. Dispersion of Pathway Emissions

For the purpose of computing the dispersion of vehicular emissions on commute pathways, limited-access and nonlimited-access pathway segments are distinguished from segments located in a street canyon.

The dispersion of pollutants emitted by vehicles on both limited-access and nonlimited-access roadways is computed using a technique taken from the CALINE3 (Benson, 1979) dispersion model. In this formulation individual roadway links are divided into a series of elements that each contribute to the concentration at a receptor. As the distance between element and receptor increases, the size of the element increases as a function of wind/roadway angle to gain efficiency in computation. The concentrations resulting from the individual elements are summed to form a total concentration estimate at a receptor.

Each element is modeled as an "equivalent" finite line source that is centered at the midpoint of the element and positioned normal to the wind direction vector. The length of the equivalent line is a function of element size and wind/roadway angle. Emissions are assumed to disperse in a Gaussian distribution downwind of the element. To arrive at an equitable distribution of emissions, each element is divided into five sub-elements whose source strengths assume a step-function form.

The Gaussian crosswind finite line source equation is approximated in the formulation by the following equation:

$$X = \frac{1}{\sqrt{2\pi}\,U} * \sum_{i=1}^{n} \left\{ \frac{2}{SGZ_i} * \sum_{k=-CNT}^{CNT} \left[\exp\left(\frac{-(Z+2*k*L)^2}{2\ SGZ_i^{\,2}} \right) \right] \right. \tag{10}$$

$$\left. * \sum_{j=1}^{5} (WT_j * QE_j * PD_{ij}) \right\}$$

where n = total number of elements, CNT = number of multiple reflections required for convergence, U = wind speed, L - mixing height, SGZ_i = vertical dispersion function for ith element, QE_j = central sub-element lineal source strength for ith element, WT_j = source strength weighting factor for jth sub-element, and PD_{ij} = normal probability density function for jth sub-element of ith element. PD_{ij} is calculated by use of a fifth order polynomial approximation.

CALINE3 treats the region directly over the roadway as a mixing zone in which there are uniform emissions and turbulence. Initial vertical dispersion is formulated as a function of mixing zone residence time and roadway half-width and is used to account for the thermally and mechanically enhanced dispersion over and downwind of the roadway arising from the passage of the vehicles.

Dispersion on a roadway with tall buildings on both sides is greatly influenced by the presence of the buildings. The street-canyon dispersion treatment used in the commuter exposure model is based on the empirical street-canyon model developed by Johnson et al. and modified by Ludwig and Dabberdt. Their studies give evidence of a helical air circulation in street canyons, with concentrations differing on the windward and leeward sides of the street. The concentration arising from street-canyon emissions on the leeward side of buildings is given by:

$$X_\ell = \frac{KQ_\ell}{\left(U+0.5\right)\left[\left(x^2+z^2\right)^{1/2}+L_o\right]}.$$

where X = concentration on leeward side of street (g/m^3), Q = line source emission rate (g/m/sec), K = empirically derived nondimensional constant $\simeq 7$, U = wind speed (m/sec), x and z = horizontal and vertical distance of the receptor relative to the center of the traffic lane (m), and L_o = dimension representing vehicle width $\simeq 2$ m. The concentration on the windward side of the street is given by:

$$X_w = \frac{KQ_\ell\ (H-z)}{W(U+0.5)H}$$

where X_w = concentration on windward side of street (g/m^3), H = average building height (m), and W = street width (m).

In the commuter exposure model, the concentration on the roadway is assumed to be the average of the concentration on the windward and leeward sides of the street. Since the receptor is on the roadway, x and z are zero.

Substituting, and combining the above equations gives:

$$X = \frac{KQ_\ell}{2(U+0.5)}\left(\frac{1}{L_o} + \frac{1}{W}\right) \tag{11}$$

Segment pollutant concentrations are summed for each pathway and integrated over travel time to yield pathway exposures.

3.4.2. Dispersion of Nonpathway Source Emissions

It is expected that the portion of the total pathway integrated concentration (exposure) that results from nonpathway sources will be small in comparison to the portion resulting from traffic on the commuter pathways themselves. Therefore, a very simple emissions and dispersion treatment is used.

The line-source emissions on nonpathways have been aggregated into area-source emissions from grid squares. For each pathway segment a concentration is computed according to the so-called Hanna (1971) dispersion treatment, as discussed by Simmon and Patterson (1979). The basic assumption of the treatment is that the area source strength in a metropolitan area varies by less than a factor of 10 over distances of a few kilometers. That assumption permits the horizontal cross-wind dispersion component to be neglected in comparison with the vertical component and concentration can be approximated in the following manner:

$$X = \frac{CQ_o}{U}$$

where

$$C = \sqrt{\frac{2}{\pi}}\,\frac{D^{1-b}}{a(1-b)}$$

D = a parameter related to city size, and a and b are constants representative of various stability regimes. (See Simmon and Patterson, 1979)

Thus, for any point on a pathway, this equation can be used to compute the concentration from area sources. The commuter model computes these concentrations on a pathway-by-pathway basis. For a given pathway, the model takes the first segment and determines which grid squares contain the segment end points and midpoint. For each of these points, a concentration normalized by wind speed is calculated according to the relationship discussed above. The traffic module will have generated the times at which the average vehicle reaches the midpoint and the endpoint of the segment. The normalized integrated concentration over the segment (the exposure) is given by:

$$EU = \frac{1}{2}\left[X_1UT_1 + X_MU(T_1+T_2) + X_2UT_2 \right] .$$

where EU = normalized exposure, X_1U = normalized concentration at endpoint 1 of the segment, X_MU = normalized concentration at the segment midpoint, X_2U = normalized concentration at endpoint 2 of the segment, T_1 = travel time from endpoint 1 to midpoint, and T_2 = travel time from midpoint to endpoint 2. This normalized exposure applies to only one segment of a pathway. The model computes similar exposures for all segments of a pathway, and sums the results to yield the normalized pathway exposure resulting from non-pathway sources.

3.5 On-Roadway/In-Vehicle Concentration Relationship

The little information that exists about the relationship between the concentration on the roadway and the concentration within a vehicle indicates that concentrations of CO inside a vehicle are about equal to that on the outside. Therefore, the commuter exposure model assumes the concentration at the two locations are identical.

3.6 Generation of Commuter Exposure Statistics

Exposures are computed for each pathway according to the meteorological conditions of the mode of model operation chosen by the model user. If the short-term mode is chosen, one exposure is computed for each pathway, for the input meteorological conditions and traffic information. If the model is operating in the annual mode, morning and evening exposures are computed for each pathway for 480 sets of meteorological conditions (each combination of 6 wind speeds, 16 wind directions, and 5 atmospheric stability classes). These exposures are weighted according to the frequency of occurrence of each set of conditions and summed for each pathway. In addition to the exposures, the model stores the total travel time or times on each pathway and the average number of commuters using the pathway.

When the model is run in the short-term mode, the output includes a list of the exposure from pathway sources, exposure from non-pathway sources, total exposure, travel time, and average concentration on each pathway for the meteorological and traffic conditions that have been input to the model. Also output are the average and standard deviation of pathway exposure. When the model is in the annual mode it lists the annual average morning and evening pathway, non-pathway, and total exposure, travel times, and

average concentrations on each pathway as well as the annual average exposures over the modeled region. For either mode, the model produces data for two histograms. For the short-term mode the data pertain to a single commute; for the annual mode, the data are representative of annual variations. The histogram data include the percentage of the commuting poplulation treated by the model in each of several exposure classes, and the probability of experiencing the exposure levels in each of several classes (i.e., the percentage of time commuters are exposed to the levels of the exposure class). For the annual mode subsets of these statistics may be output at the user's discretion. For a more detailed discussion of how the statistics are computed, see Section 5.3.1. Finally, the model user has the option of attaching a plotting program to call for model output in graphical form.

SECTION 4

COMPUTER REQUIREMENTS

4.1 General

The numerical commuter exposure model code has been designed to be as modular as possible to facilitate understanding of the code; to reduce the possibility of coding error and ease debugging; and to increase the ease with which modifications to the code can be made in the future. Liberal use of comments ensures that program logic and technique are easily understood. The code was written in FORTRAN IV, and every attempt was made to make the program as machine-independent as possible. Thus, the code should be easily adaptable for use on various makes of computer.

In the past, techniques for estimating mobile source emissions have been subject to frequent change. A number of updates to the emissions modeling methodologies have been issued, and it is anticipated that other updates will be forthcoming as additional vechicle test data become available. The model has therefore been designed in two parts: an emissions preprocessor and the main model. Separation of the Federal Test Procedure (FTP) emissions modeling and the modal emissions modeling from the main commuter exposure model will allow modification of the emissions treatments of the commuter exposure model package, as emissions updates are issued, without change to the main model. Whenever changes, however minor, are made to a large computer program, the possibility of error is considerably greater than when modification is made to a small program. Thus, changing the emissions preprocessor is much simpler and less subject to error than changing the main model. Modification to the main model would

be required only if the mobile source emissions modeling methodologies underwent major methodological change.

The following sections detail the manner in which the commuter program is to be operated, discuss the structure of the computer program, and describe the major modules of the program.

4.2 Program Operation

4.2.1. Commuter Exposure Programs

The commuter exposure modeling package consists of two separate computer programs: the emission factor preprocessor, PREPRS, and the commuter exposure model, CEMAP. The preprocessor has its own set of input data, listed in Section 5.2, and would normally be run before the main portion of the model. The preprocessor creates disc files (on output device number 8) containing the tables of emission factors that will be read and used by the main model. Thus, the preprocessor run must have been executed before the main model job can be submitted. If the user decides to exercise the option of inputting pathway and gridded emissions to the model directly, rather than having the model package compute them, the emissions preprocessor would not be run, and flags would be set on input to the main model as a cue that emissions will be input directly.

Once the emissions preprocessor has been run successfully, the main model, CEMAP, should be executed. The input data for CEMAP are also listed in Section 5.2.

The input data in card image format is read from input device number 5, while the disc files created by PREPRS are read from device 8. The types of output data generated by the model are governed in part by the flags the

user has set on card type 8M of the input data (see Section 5.2). All model output is in printed or graphical form. A checklist of the steps the user must follow to use the commuter exposure modeling package is given in Table 1.

4.2.2. Core Storage Requirements

The preprocessing program, PREPRS, requires 110700 (octal) words (60 bits/word) of core storage, and the main model, CEMAP, requires 117700 (octal) words on a CDC 6400 when provisions for five pathways are included. These requirements may vary somewhat from one make of computer to another. Most arrays in the two programs are dimensioned for three pollutants to facilitate modification of the program if at some time in the future a user wanted to run more than one pollutant at a time. If the larger core storage requirements caused by having the arrays dimensioned as they are create a problem, the dimensions of some of the arrays could be reduced so that the pollutant index is one rather than three. Using the glossary of symbols and Tables 5 and 6 of the other volume of this package ("Description of Model Methodology and Code"), such reductions could be made. However, the user is cautioned that numerous DO loops exist in the program to increment pollutant index, and these loops are set to operate for CO only, from 2 to 2, i.e., DO 10 IP = 2,2. If the dimensions of arrays containing pollutant as an index are to be reduced, the loops must be changed to: DO xxx IP = 1,1.

4.2.3. Job Runstream

The emission factor preprocessor, PREPRS, has a simple runstream. Figure 1 shows sample runstreams for the preprocessor for CDC and UNIVAC

Table 1

CHECKLIST OF STEPS FOR APPLICATION OF THE COMMUTER EXPOSURE PACKAGE

1. Identify commute pathways.

2. Identify pathway segments.

3. Define coordinate system.

4. Define grid squares.

5. Determine segment endpoint and grid square corner coordinates.

6. Collect vehicle registration data.

7. Gather information on cold-starting/hot-starting vehicles and vehicle air conditioner usage.

8. Identify I/M program specifications.

9. Identify pathway segment street types, volumes, capacities, physical characteristics, and speeds or determine emission rates.

10. Identify intersection/freeway backup/toll booth specifications.

11. Determine acceleration/deceleration rates.

12. Determine diurnal traffic distributions.

13. Determine primary to secondary street VMT ratio by locale.

14. Determine number of commuters on each pathway.

15. Determine VMT on primary streets and locale of each grid square or grid square emission rate.

16. Compute morning and evening joint frequency distributions of wind speed, wind direction, and stability (annual mode).

17. Gather morning and evening average ambient air temperatures (annual mode).

18. Gather wind speed, wind direction, stability, and ambient air temperature of commute of interest (short-term mode).

19. Run PREPRS (unless pathway and grid square emissions are to be user-supplied).

20. Run CEMAP.

CDC Runstream	UNIVAC Runstream
PAW1,P30,T100,CM15000.	@RUN -
ACCOUNT (PBPAW,PSWORD)	@ASG,A FILE.
GET,PREPRS.	@ASG,A FILE8.
FTN, I=PREPRS, R=2.	@USE 8., FILE8.
MAP(FULL)	@XQT FILE.PREPRS
GET,TAPE5=PREIN.	.
DEFINE,TAPE8=PREOUT.	.
LGO.	.
	Input data cards
	.
	.
	.
	@FREE 8.
	@FIN

Figure 1 Sample CDC and UNIVAC Runstreams for Program PREPRS

CDC Runstream	UNIVAC Runstream
PAW2,P30,T100,CM15000.	@RUN -
ACCOUNT(PBPAW,PSWORD)	@ASG,A FILE.
GET,CEMAP.	@ASG,A FILE8.
FTN,I=CEMAP,R=2.	@USE 8., FILE8.
MAP(FULL)	@XQT FILE.CEMAP
GET,TAPE5=CEMIN.	.
GET,TAPE8=PREOUT.	.
LGO.	.
	Input data cards
	.
	.
	.
	@FREE 8.
	@FIN

Figure 2 Sample CDC and UNIVAC Runstreams for Program CEMAP

machines. The program PREPRS is contained in a disc file called PREPRS. The input data for the program, in card image format (card types 1P through 6P), are in file PREIN. They are read from device number 5. The output of the preprocessor is written on a disc file called PREOUT on device number 8.

The main model, CEMAP, also has a simple runstream. Sample CDC and UNIVAC runstreams for CEMAP are given in Figure 2. The program CEMAP is contained in a disc file called CEMAP. The input data cards (card types 1M through 9M) are on a file called CEMIN and are read from device number 5. The output of the preprocessor, file PREOUT, is read from device number 8.

4.3 Program Structure

4.3.1. Emission Factor Preprocessor

The emission factor preprocessor comprises a short main program, 5 subroutines that were written for the commuter exposure model, and 13 subroutines and BLOCK DATA that are from EPA's MOBILE1 (U.S. EPA, 1978) computer program for the computation of mobile source emission factors. All of the MOBILE1 program has been incorporated into PREPRS with the exception of subroutine OUTPUT. The subroutine now called OUTPUT was written for the preprocessor. Major changes were made to the MOBILE1 subroutines INPUT and the main program (now called subroutine MOBLE1). Very minor changes were made to subroutine EFCALX and ALUH. No other routines were modified.

To facilitate future updates of the commuter exposure model, the original MOBILE1 statements that were to be removed for this application

TABLE 2. SUBROUTINES OF THE COMMUTER EXPOSURE PACKAGE

Portion of Model Package and Subroutine Name	Short Description	Calling Subroutine	Function
Emissions preprocessor			
—	Main control program of the emissions preprocessor	—	Controls flow through emissions preprocessor program
INPT	Module that reads and edits input data	Main program of emissions preprocessor	Reads and edits all input data for the emissions preprocessor
FTP	FTP emissions module	Main program of emissions preprocessor	Computes emission factors (using MOBILE1) for non-CBD arterials, freeways, and expressways, and factors for grid squares
CORFAC	Module that computes correction factors	Main program of emissions preprocessor	Computes temperature, cold-starts, air conditioning, vehicle type distribution correction factors for modal emissions
MODMOD	Modal emissions module	Main program of emissions preprocessor	Computes tables of cruise and acceleration/deceleration emission factors
OUTPUT	Output module for emission factors	Main program of emissions preprocessor	Prints all emission factor tables and writes them on files
Main model			
—	Main control program of the main model	—	Controls flow through the main portion of the commuter exposure model package
INDATA	Module that reads and edits input data	Main program of main model	Reads and edits all input data for the main portion of the model
TRAF	Control module for traffic computations	Main program of main model	Controls traffic data computations. Returns volume, speed, driving mode, and travel time data for emission and exposure computations
FREE	Traffic computation module for freeways	TRAF	Computes volume, speed, and driving time data for emission and exposure computations for freeway segments
ART	Traffic computation module for arterials	TRAF	Computes volume, speed, and driving time data for emission and exposure computations for arterial segments
MODE	Traffic computation module for CBD locations	TRAF	Computes volume, speed, mode, and driving time data for emission and exposure computations for CBD segments

TABLE 2. (concluded)

Portion of Model Package and Subroutine Name	Short Description	Calling Subroutine	Function
Main model (continued)			
EMISS	Control module for emissions computations	Main program of main model	Computes emission rate on each pathway segment using results of traffic modules, and emissions preprocessor
NPATHE	Nonpathway source emissions module	Main program of main model	Computes emission rate in each grid square resulting from nonpathway sources
DISPRS	Control module for dispersion computations	Main program of main model	Controls computation of dispersion of pathway source emissions according to whether a pathway is or is not a street canyon and dispersion on non-pathway source emissions.
ROAD	Dispersion module for roadways that are not street canyons	DISPRS	Computes normalized concentrations on non-street-canyon pathway segments for various meteorological conditions during the morning and evening commutes or for the meteorological conditions specified for the short-term mode
STREET	Dispersion module for street canyon	DISPRS	Computes exposures on street-canyon pathway segments for either the annual or short-term mode of operation
NPATHD	Nonpathway source dispersion module	DISPRS	Computes normalized exposures on each pathway from non-pathway sources
SHORTY	Output module for short-term statistics	Main program of main model	Computes and prints model output for short-term mode of operation
STATIS	Annual statistical data generation module	Main program of main model	Computes annual average histogram data
ANNOUT	Output module for annual statistics	Main program of main model	Prints annual statistics for annual mode of operation
BLOCK DATA	Stores data	—	Stores data used in more than one subroutine
GRAF	Module through which graphical output may be created	Main program of main model	Contains appropriate common statements for user to attach code that will cause histogram data and other output to be plotted graphically

were made into comments. Thus, it will be clearer which statements were changed, deleted or added when a new version of MOBILE1 is to be similarly incorporated.

Table 2 lists the subroutines in the emissions preprocessor, except for subroutines that will be called from the modified MOBILE1 emissions program. The table gives the name of the subroutine, a short description, the name of the subroutine that calls it, and the function of the routine.

The main emission factor preprocessor program will first read the basic variables required for its operation. Next, it will call subroutine FTP, which in turn will call the MOBILE1 subroutines to compute an emission factor table for use by the main model in computing emissions on pathways that are freeways, expressways, or arterials outside the Central Business District (CBD), and emissions from nonpathway sources. The main program then calls subroutine CORFAC to compute factors that will correct modal emissions for temperature, cold-starts, air conditioner usage, and vehicle type distribution. CORFAC computes these factors using some of the MOBILE1 subroutines. Next, the main program of PREPRS calls subroutine MODMOD to compute modal emission factor tables for use by the main model in computing emissions on CBD arterials. Finally, subroutine OUTPUT is called to print the output of the preprocessor and write the emission factor table files. Figure 3 is a flow chart of the main program of the emissions preprocessor. It graphically illustrates the flow of control through the program that was described above.

4.3.2. Commuter Exposure Model

Table 2 lists all of the subroutines of the commuter exposure model. Figure 4 is a flow chart of the main control module of the main portion

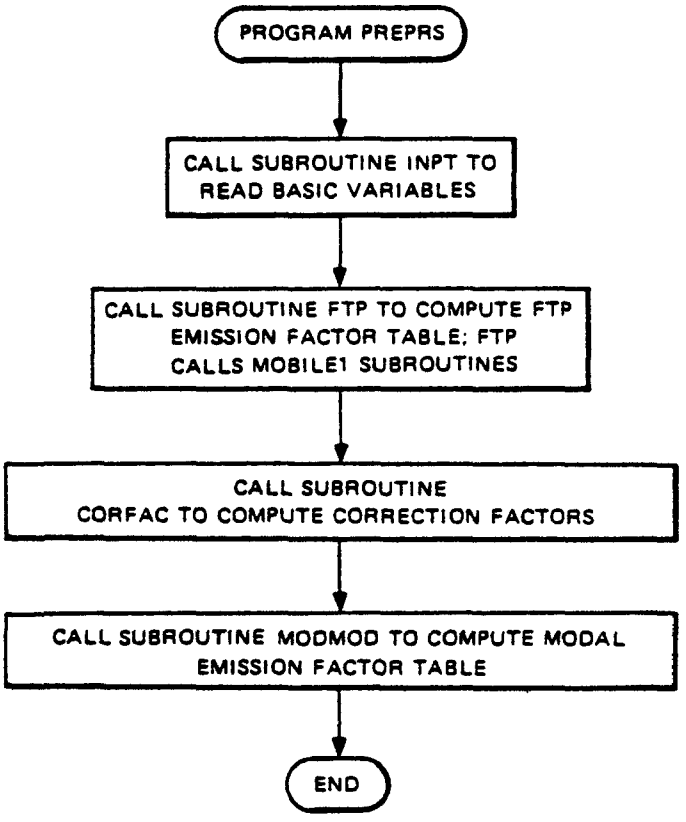


FIGURE 3 FLOWCHART OF EMISSIONS PREPROCESSOR – MAIN PROGRAM

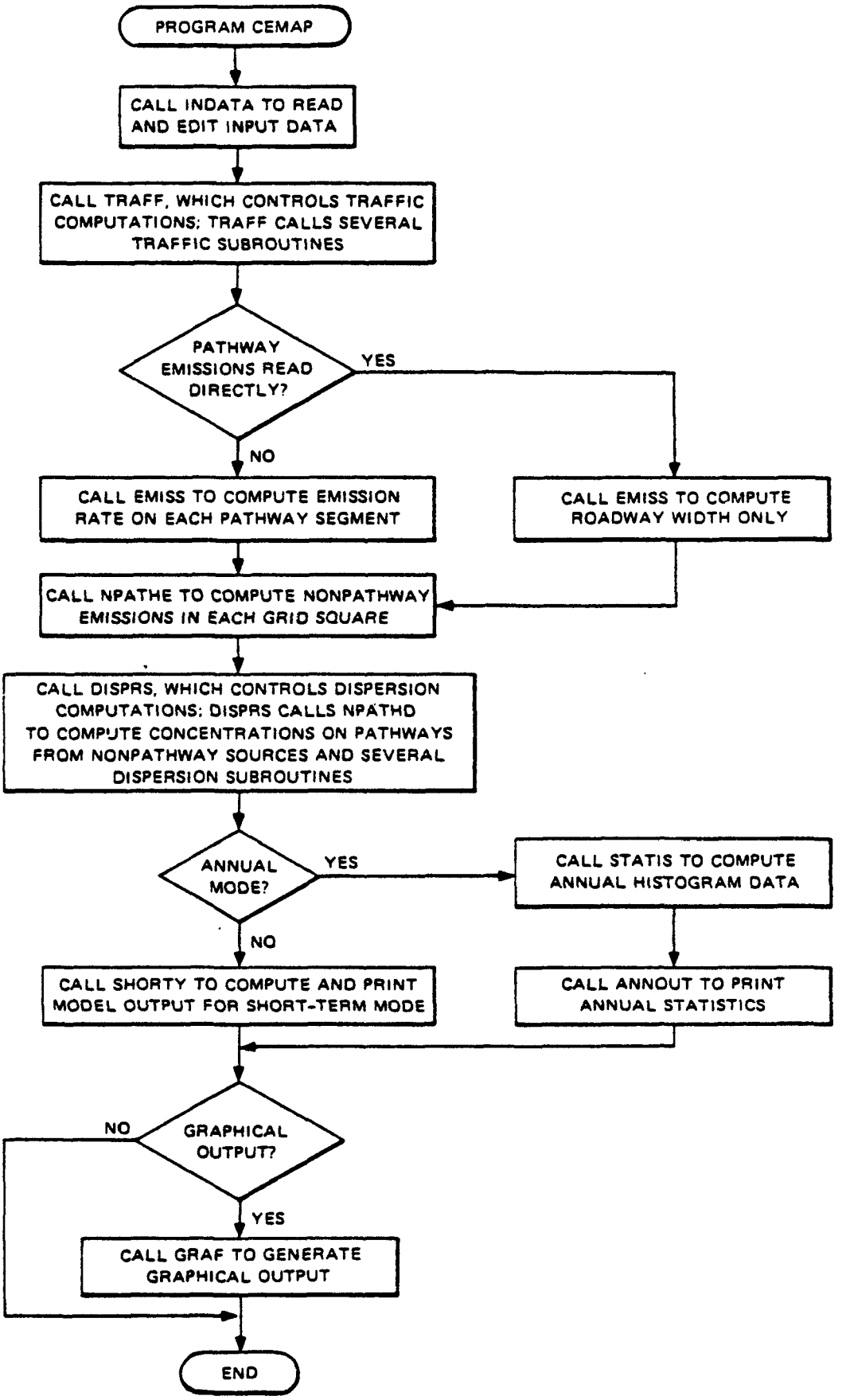


FIGURE 4 FLOWCHART OF MAIN CONTROL MODULE OF MAIN PORTION OF COMMUTER EXPOSURE MODEL

of the commuter exposure model. The figure shows how control passes through the program and indicates the order in which the main subroutines are called. The first subroutine called is INDATA, which reads and edits the input data.

The three main modules of the model that treat traffic, emissions, and dispersion, as well as the subroutines called by the main modules, are discussed in detail below. A description is also given of the modules that generate the commuter exposure statistics.

4.3.2.1. Traffic Subroutines

The control module for all pathway traffic computations is subroutine TRAFF. TRAFF identifies the pathway, the segment on the pathway, the direction of traffic flow on the segment, and the time of interest. At this point, TRAFF calls one of three other subroutines: FREE, ART, or MODE, depending on whether the segment is part of a freeway, an arterial, or a CBD street. TRAFF then continues its control function for additional hours, directions, segments, and pathways.

Subroutine FREE checks the form of the traffic data inputs for the segment and calls other subroutines based on the results. If ADT or AADT are input, rather than hourly traffic volume data, FREE converts to a volume for the time of interest. If the speed is not input, the subroutine checks whether capacity is input. If not, FREE computes the segment capacity, based on physical and traffic characteristics. A comparison of volume and capacity is made; if capacity is greater than volume, speed is calculated as a function of volume and capacity. If volume exceeds capacity, subroutine FREE handles the freeway backup. If speed were input

initially, FREE skips the capacity and speed calculations and computes driving time on the segment based on the supplied data.

Subroutine ART performs the same functions as FREE, but uses different algorithms that consider characteristics of arterial flow rather than those of freeways.

Subroutine MODE is called to handle CBD locations. However, MODE departs from the procedures of FREE and ART and checks whether the traffic signal parameters for the segment are available. If not, MODE calculates these parameters based on opposing critical approach volume and roadway physical data. MODE then calculates queue lengths, delay times, and driving times in the different modes on the segment.

4.3.2.2. Emission Subroutines

The emissions preprocessor generates tables of emission factors to be used in calculating the emission rate on each pathway segment and in each grid square. Computation of an emission rate or rates for each pathway segment is accomplished by subroutine EMISS. These emission rates are saved for each segment. If pathway emissions are read directly, EMISS is not called to compute roadway width and the remainder of the subroutine is bypassed.

The computation of an emission rate or rates for each grid square is made by subroutine NPATHE. Subroutine NPATHE is called by the main program whether grid square emission rates are to be computed by the model or read directly.

4.3.2.3 Dispersion Subroutines

Once the traffic and emissions modules have been run, the main control module of the main portion of the model will call subroutine DISPRS. This subroutine controls all dispersion computations made by the model.

For the annual mode of model operation, DISPRS begins with the first segment of the first pathway and checks as to whether the segment is or is not in a street canyon. If the segment is a street canyon, DISPRS calls subroutine STREET to make the appropriate dispersion computations for various meteorological conditions for the morning and evening emission rates. If the segment is not a street canyon, DISPRS calls subroutine ROAD to compute normalized concentrations corresponding to various meteorological conditions and morning and evening emissions. DIPRS continues to call the appropriate dispersion subroutines until all pathway segments have been treated.

If the model is in the short-term mode of operation, DISPRS also begins with the first segment of the first pathway and checks to see if it is a street canyon. If so, DISPRS calls subroutine STREET to compute the exposure for the input meteorological conditions. If the segment is not a street canyon, DISPRS calls subroutine ROAD to compute the concentration on the roadway for the input conditions. As for the annual mode, DISPRS continues to call the appropriate dispersion subroutines until all pathway segments have been treated.

Finally, for either mode of model operation, DISPRS calls subroutine NPATHD to make dispersion computations of emissions from nonpathway sources.

4.3.2.4 Generation of Commuter Exposure Statistics

Once the dispersion computations have been made, the model is ready to compute commuter exposure statistics in either the short-term or annual mode of model operation.

If the model is running in the short-term mode, the main control module calls subroutine SHORTY to compute and print the model output.

When the model is in the annual mode of operation, the main control module calls two subroutines. First, STATIS is called to compute the model output of annual statistics. If any of the optional outputs were requested with input data flags, STATIS also computes the optional outputs. Next, subroutine ANNOUT is called to print the annual statistics and any optional statistics that were requested.

Finally, if graphical output has been called for with a flag on model input, subroutine GRAF will be called to generate the graphical output. The software for subroutine GRAF needs to be supplied by the user (see 4.4.2.17).

4.4 Module Description

In the previous sections the overall structures of both the emission factor preprocessor and the main model were discussed. The flow of control through the subroutines was outlined and brief mention was made of the function of the routines. In this section the function of each individual subroutine is described in somewhat greater detail.

4.4.1. Emission Factor Preprocessor Subroutines

4.4.1.1. Main Program

The main program of the emission factor preprocessor controls the calling sequence of the preprocessor subroutines. It calls subroutines INPT, FTP, CORFAC, and MODMOD and uses common block PRE2.

4.4.1.2 Subroutine INPT

This routine reads and edits the input data needed by the emission factor preprocessor. It does not call any subroutines and uses common blocks PRE1, PRE2, PRE3, PRE4, PRE5, and REGCOM.

4.4.1.3 Subroutine FTP

Subroutine FTP calls the former MOBILE1 program several times to create tables of FTP emission factors. These tables of emission factors will be used by the main model to compute emission rates on non-CBD pathways and from non-pathway sources. FTP calls subroutines MOBLE1 and OUTPUT; it uses common blocks PRE1, PRE2, PRE4, and PRE6.

4.4.1.4 Subroutine CORFAC

This subroutine computes the temperature/cold start correction factor ratios needed for model emission factor computations. It also computes the ratio of total emissions to LDV emissions and air conditioning correction factor for use in correction modal emissions. It calls subroutines INPUT, EFCALX, ALUH, and OUTPUT and uses common blocks MODEM, LNKCOM, RET1, PRE1, PRE2, PRE5, PRE6, and PRE7.

4.4.1.5 Subroutine MODMOD

This subroutine computes tables of modal excess and cruise emission factors for use by the main model. It calls subroutine OUTPUT and uses common blocks MYMCOM, MODEM, PRE2, PRE4, PRE6, and PRE7.

4.4.1.6 Subroutine OUTPUT

This subroutine replaces the output subroutine that was part of MOBILE1. It prints and writes files of the emission and correction factors computed by the preprocessor. OUTPUT does not call any other subroutines and uses common blocks FLGCOM, MTMCOM, MODEM, LNKCOM, IMCOM, REGCOM, PRE1, PRE2, PRE3, PRE5, PRE6, and PRE7.

4.4.1.7 Subroutine MOBLE1

Subroutine MOBLE1 was the main program of EPA's MOBILE1 code. It has been extensively modified and it controls FTP emission factor computations. It calls several subroutines from EPA's MOBILE1 program: INPUT, INITEX, LDVIMX, and EFCALX. It uses common blocks PRE1, PRE3, PRE6, PRE7, FLGCOM, REGCOM, LNKCOM, and ALTCOM.

4.4.1.8 Other Subroutines in PREPRS

The remaining subroutines were taken from EPA's MOBILE1 program. They are INPUT, EFCALX, BIGCFX, TRKOPC, SPFCLX, INITEX, TFCALX, EFALTX, BEFGEN, GETCUM, CCEVAX, LDVIMX, and ALUH. There is also a BLOCK DATA included. Subroutine INPUT has been extensively modified and subroutines EFCALX and ALUH have been slightly modified. No other subroutines were modified.

4.4.2 Commuter Exposure Model Subroutines

4.4.2.1 Main Program

The main program of the commuter exposure model controls the calling sequence of the major modules of the model. The main program calls basically four types of modules: those controlling traffic, emission rate, dispersion, and statistical computations. The subroutines called are

INDATA, TRAF, EMISS, NPATHE, DISPRS, STATIS, ANNOUT, SHORTY, and GRAF. The common blocks used in the main program are RUNTYP, OPTION, and DEFINE.

4.4.2.2 Subroutine INDATA

This subroutine reads all of the input data required by the model and performs some editing of the data. The routine reads both the card image data (types IM through 9M) called for in this guide and the disc files of emission factors created by the preprocessor. INDATA calls no other subroutines and uses common blocks IO, GENRL, RUNTYP, DEFINE, PACOOR, SECOND, GRID, META, METST, OPTION, EMSFAC, PAEMIS, TRAFEM, TRAFOT, SPREAD, TOLL, BAKUP, SIGNAL, INFO, and NOCOMM.

4.4.2.3 Subroutine TRAF

This subroutine controls the traffic module and provides the traffic-related data required by the emissions and dispersion modules. It selectively calls subroutines FREE, ART, and MODE and uses common blocks RUNTYPE, TRAFEM, DEFINE, GENRL, TRAFIN, TRAFOT, PACOOR, SPREAD, INFO, TIMES, SECOND, TOLL, BAKUP, and SIGNAL.

4.4.2.4 Subroutine FREE

Subroutine FREE calculates needed traffic parameters for free-flow movement on freeways. It also handles freeway backup and toll booths. FREE does not call any other subroutines and uses common blocks RUNTYP, TRAFEM, DEFINE, GENRL, TOLL, BAKUP, TRAFIN, TRAFOT, PACOOR, INFO, SPREAD, SECOND, and TIMES.

4.4.2.5 Subroutine ART

This subroutine handles the calculations required for traffic on arterials. It calls no other subroutines and uses common blocks RUNTYP,

TRAFEM, DEFINE, GENRL, TRAFIN, TRAFOT, PACOOR, SPREAD, INFO, SECOND, and TIMES.

4.4.2.6 Subroutine MODE

This subroutine treats the modal behavior of traffic at signalized intersections, and it computes signal parameters as required. It calls no other subroutines and uses common blocks RUNTYP, TRAFEM, DEFINE, GENRL, TRAFOT, TRAFIN, PACOOR, SIGNAL, INFO, SECOND, and TIMES.

4.4.2.7 Subroutine EMISS

This subroutine computes the emission rate on each path segment using the emission factors computed by the preprocessor. Emission factors computed with the MOBILE1 methodology are used for freeway and non-CBD segments, while modal emission factors are used on the CBD segments that are not freeways. EMISS does not call any other subroutines and uses common blocks RUNTYP, TRAFEM, DEFINE, PAEMIS, EMSFAC, TRAFOT, PACOOR, INFO, TRAFIN, and GENRL.

4.4.2.8 Subroutine NPATHE

Subroutine NPATHE computes the emission rates of sources that are not traveling on pathways, It computes emission rates for each grid square through which a pathway passes according to the amount of traffic flow on both non-pathway primary and secondary streets in the square. NPATHE does not call any other subroutines and uses common blocks GENRL, RUNTYP, DEFINE, GRID, SECOND, GREMIS, TIMES, and EMSFAC.

4.4.2.9 Subroutine DISPRS

This subroutine controls all of the dispersion computations. It calls the appropriate routine to compute dispersion of pathway emissions on each segment according to whether the segment is or is not located in a street canyon. DISPRS also calls the subroutine that computes the contribution to the concentration on the pathway that arises from non-pathway sources. It calls subroutines ROAD, STREET, and NPATHD and uses common blocks TRAFIN, LSTSEG, DEFINE, RUNTYP, TIMES, NOSTRT, STRT AND METST.

4.4.2.10 Subroutine ROAD

Subroutine ROAD uses the CALINE3 methodology to compute normalized concentrations on non-street canyon pathway segments. Much of the code in ROAD is an adaptation of the CALINE3 code. If the model is in the short-term mode, ROAD computes normalized concentration for the meteorological conditions input to the model. If the model is in the annual mode, ROAD computes normalized concentrations for a number of different combinations of meteorological conditions for both the morning and evening commutes. It calls no other subroutines and uses common block TRAFIN, GENRL, IO, PAEMIS, PACOOR, RUNTYP, METST, and META.

4.4.2.11 Subroutine STREET

This subroutine computes normalized exposures (annual mode) or exposure (short-term mode) on pathway segments that are located in street canyons. It uses an adaptation of the methodology for street canyons formulated for the APRAC series of models. STREET does not call any other subroutines and uses common blocks RUNTYP, METST, STRT, LSTSEG, DEFINE, and PAEMIS.

4.4.2.12 Subroutine NPATHD

This subroutine computes normalized exposures (annual mode) or exposure (short-term mode) on each pathway segment that arise from non-pathway sources. The routine determines which grid squares the segment passes through and uses those emission rates to compute exposure. NPATHD calls no other subroutines and uses common blocks RUNTYP, METST, GENRL, DEFINE, GRID, PACOOR, IO, NOPATH, LSTSEG, GREMIS, and TIMES.

4.4.2.13 Subroutine SHORTY

Subroutine SHORTY computes the statistical output of the model when the model is in the short-term mode. It also prints the output. If the model is in the annual mode, SHORTY is not called. SHORTY does not call any other subroutines; it uses common blocks IO, DEFINE, STRT, NOPATH, NOSTRT, LSTSEG, NOCOMM, SAVE, and TIMES.

4.4.2.14 Subroutine STATIS

This subroutine computes the commuter exposure statistics when the model is in the annual mode. It is not called when the model is in the short-term mode. It calls no other subroutines and uses common blocks DEFINE, META, OPTION, SAVE, STRT, NOPATH, NOSTRT, OPOUT, NOCOMM, PART, and TIMES.

4.4.2.15 Subroutine ANNOUT

This subroutine prints the model output statistics when the model is in the annual mode. It is not called if the model is in the short-term mode. ANNOUT does not call any other subroutines; it uses common blocks IO, DEFINE, OPTION, SAVE, OPOUT, PART, and TIMES.

4.4.2.16 BLOCK DATA

BLOCK DATA stores data that are used in more than one subroutine. It uses common blocks META and SPREAD.

4.4.2.17 Subroutine GRAF

This subroutine does not actually do any plotting. It contains the common statements that pass the appropriate variables to be plotted, but, when called, it simply prints a statement that the user must supply a plotting package. It does not call any other subroutines and, it uses common blocks RUNTYP, TIMES, IO, OPTION, OPOUT, SAVE, and PART.

SECTION 5

DATA SPECIFICATION

5.1 Input Data Requirements

5.1.1 General

In this section the input data requirements of the commuter exposure modeling package are presented. The types of data that are required for execution of the commuter exposure model are listed and described in Table 3. The table also contains information on the column number, data format, FORTRAN symbol, preferred units, data value limits, and typical values of each input parameter. For information concerning the definition of the modeling area and the pathway network, the user is referred to Section 5.2.

Since the commuter exposure model package consists of two parts that are run independently on the computer, two sets of input data are required: one for the emissions preprocessor and one for the main model. Card type numbers with input data for the emissions preprocessor will be followed by a P, e.g., 2P; card type numbers with input data for the main model will be followed by an M, e.g., 4M.

The data for the emissions preprocessor should be entered on six types of cards. Type 1P contains general information about the simulation to be run. The second card type is optional; it may specify the vehicle model year and type distributions specific to the city being modeled. Card type 3P contains information on the percentages of cold-

TABLE 3. INPUT DATA REQUIREMENTS FOR THE COMMUTER EXPOSURE MODEL PACKAGE

(a) Card 1P

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1-3			—		1P	Card type number
4-23	10A2	(MHEAD(I), I=1,10)	—	20 alpha-numeric characters	St. Louis	Heading (anything user wants printed at the beginning of the output)
24-29	3I2	IDATE	—	770101-951231	781215	Date (year, month, day)
31	I1	ILOC	—	1,2,3	1	City location; 1=<4000 ft, 2=California, 3=>4000 ft
33	I1	MODRUN	—	1,2	1	Model mode of operation; 1=annual, 2=short-term
35	I1	LPATH	—	1,2	1	Pathway emissions; 1=model-calculated, 2=user-supplied
37	I1	LNPATH	—	1,2	1	Nonpathway emissions; 1=model-calculated, 2=user-supplied
39	I1	IMFLAG	—	0,1	1	Inspection-maintenance program; 0=no I/M program, 1=include I/M program
41	I1	MYFLAG	—	0,2	2	LDV model year distribution; 0=default to national distribution, 2=user-supplied
43	I1	IVTFLG	—	0,2	2	Vehicle type distribution; 0=default to national distribution, 2=user-supplied

(b) Card 2P†

1-3			—		2P	Card type number
4-63	20F3.1	FMODYR(I), I=1,20	—	0. - 1.0	0.12 (national average)*	Fraction of LDV registered, of vehicle age i, i=1,20
64-78	5F3.1 F2.1	FVEHTY(J), J=1,6	—	0. - 1.0	0.76 (national average)*	Fraction of total VMT driven by vehicles of type j, j=1,6

†Omit card type if MYFLAG=IVTFLG=0

*Default Value

TABLE 3. (continued)

(c) Card 3P--annual mode

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1-3					3P	Card type number
4-6	I3	ICOLDN	—	0 - 100	20	†Percentage of non-catalyst-equipped LDV VMT accumulated in cold-start mode, evening commute, on CBD pathways
7-9	I3	ICOLDC	—	0 - 100	20	†Percentage of catalyst-equipped LDV VMT accumulated in cold-start mode, evening commute, on CBD pathways
10-12	I3	IHOTC	—	0 - 100	30	†Percentage of catalyst-equipped LDV VMT accumulated in hot-start mode, evening commute, on CBD pathways
13-15	I3	ITEMPA	°F	0 - 110	50	Annual average air temperature during morning commute
16-18	I3	ITEMPP	°F	0 - 110	60	Annual average air temperature during evening commute
19-21	I3	IACAM	—	0 - 100	10	Percent of vehicles equipped with air conditioning that has air conditioner running during morning commute
22-24	I3	IACPM	—	0 - 100	80	Percent of vehicles equipped with air conditioning that has air conditioner running during evening commute
25-28	F4.1	ACCEL	mi/hr/sec	>0	2.5	†Acceleration on CBD pathways
29-32	F4.1	DECEL	mi/hr/sec	<0	-2.5	†Deceleration on CBD pathways

†Omit if LPATH=2

TABLE 3. (continued)

(d) Card 3P—short-term mode

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1-3					3P	Card type number
4-6	I3	ICOLDN	—	0 - 100	20	†Percentage of non-catalyst equipped LDV VMT accumulated in cold-start mode on CBD pathways for commute of interest
7-9	I3	ICOLDC	—	0 - 100	20	†Percentage of catalyst-equipped LDV VMT accumulated in cold-start mode on CBD pathways for commute of interest
10-12	I3	IHOTC	—	0 - 100	30	†Percentage of catalyst-equipped LDV VMT accumulated in hot-start mode on CBD pathways for commute of interest.
13-15	I3	ITEMPS	°F	0 - 110	73	Average air temperature during commute of interest
16-18	I3	IACS	—	0 - 100	60	Percent of vehicles equipped with air conditioning that has air conditioner running during commute of interest
19-22	F4.1	ACCEL	mi/hr/sec	>0	2.5	†Acceleration on CBD pathways
23-26	F4.1	DECEL	mi/hr/sec	<0	-2.5	†Deceleration on CBD pathways

†Omit of LPATH=2

(e) Card 4P*—annual mode

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1-3					4P	Card type number
4-18	5I3	JCLDNA(L), L=1,5	—	0 - 100	20	Percentage of non-catalyst equipped LDV VMT accumulated in cold-start mode in locale type ℓ(ℓ=1,5), morning commute
19-33	5I3	JCLDCA(L), L-1,5	—	0 - 100	20	Percentage of catalyst-equipped LDV VMT accumulated in cold-start mode in locale type ℓ(ℓ=1,5), morning commute
34-48	5I3	JHDTA(L), L=1,5	—	0 - 100	10	Percentage of catalyst-equipped LDV VMT accumulated in hot-start mode in locale type ℓ(ℓ=1,5), morning commute

TABLE 3. (continued)

(f) Card 4P*—short-term mode

1-3					4P	Card type number
4-18	5I3	JCOLDN(L), L=1,5	—	0 - 100	20	Percentage of non-catalyst-equipped LDV VMT accumulated in cold-start mode in locale type ℓ(ℓ=1,5) for commute of interest
19-33	5I3	JCOLDC(L), L=1,5	—	0 - 100	20	Percentage of catalyst-equipped LDV VMT accumulated in cold-start mode in locale type ℓ(ℓ=1,5) for commute of interest
34-48	5I3	JHOT(L), L=1,5	—	0 - 100	10	Percentage of catalyst-equipped LDV VMT accumulated in hot-start mode in locale type ℓ(ℓ=1,5) for commute of interest

(g) Card 5P*†—annual mode

1-3					5P	Card type number
4-18	5I3	JCLDNP(L), L=1,5	—	0 - 100	20	Percentage of non-catalyst equipped LDV VMT accumulated in cold-start mode in locale type ℓ(ℓ=1,5), evening commute
19-33	5I3	JCLDCP(L), L=1,5	—	0 - 100	20	Percentage of catalyst equipped LDV VMT accumulated in cold-start mode in locale type ℓ(ℓ=1,5), evening commute
34-48	5I3	JHOTP(L), L=1,5	—	0 - 100	10	Percentage of catalyst-equipped LDV VMT accumulated in hot-start mode in locale type ℓ(ℓ=1,5), evening commute

*Omit card type if LNPATH=2

†For annual mode of operation; no card type 5P for short-term mode

(h) Card 6P*

Column	Format	Symbol	Units	Value Limts	Typical Value	Description
1-3					6P	Card type number
4-5	I2	IMYEAR	--	77-95	77	Year of I/M program implementation
6-7	I2	IMSTRG	--	10-50	20	Stringency level of I/M program
9	I1	IMMECH	--	0,1	0	Mechanic training flag; 0=no 1=yes
10-11	I2	IMBEG	--	58-95	60	Earliest model year included in I/M program
12-13	I2	IMEND	--	59-95	95	Latest model year included in I/M program

*Omit if IMFLAG=0

TABLE 3. (continued)

(i) Card 1M

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1-3			—		1M	Card type number
4-23	10A2	(MHEAD(I), I=1,10)	—	20 alpha-numeric characters	St. Louis Run 1	Heading (anything user wants printed at the beginning of the output)
24-29	3I2	(IDATE(I), I=1,3)	—	770101-951231	781215	Date (year, month, day)
31	I1	MODRUN	—	1,2	1	Model mode of operation; 1=annual, 2=short-term
33	I1	LPATH	—	1,2	1	Pathway emissions; 1=model-calculated, 2=user-supplied
35	I1	LNPATH	—	1,2	1	Nonpathway emissions; 1=model-calculated, 2=user-supplied
37	I1	NPRINT	—	1,2	1	Print input data; 1=yes 2=no

(j) Card 2M

1- 3			—		2M	Card type number
4- 5	I2	NPATHS	—	1 - 5	5	Number of pathways
6-15	5I2	NSEG(I), I=1, NPATHS	—	1 - 20	6	Number of segments in pathway i, i=1, NPATHS
16-18	I3	NGRID	—	1 - 500	400	Number of grid squares
19-28	F10.0	CONVRT	mi/map unit	>0	1.	Converts map units to miles

TABLE 3. (continued)

(k) Card 3M--annual mode (one card for each segment)

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1-3			--		3M	Card type number
4-5	I2	NPATH	--	1 - 5	5	Pathway number
6-7	I2	LINK	--	≤20	17	Segment or link number
8	I1	LINTOP(NPATH,LINK)	--	1,2	1	Segment topography; 1=non-street canyon 2=street canyon
9	I1	LINTYP(NPATH,LINK)	--	1,2,3	2	Segment type; 1=freeway,2=arterial, 3=surface street with intersection
10-15	F6.0	VOLHR(NPATH,LINK,1)	veh/hr or veh/day (if LPATH=1) or g/m-sec(if LPATH=2)	≥0.	3600. or 0.0248	Demand volume (if LPATH=1) or emission rate (if LPATH =2) in inbound direction, morning commute
16-21	F6.0	VOLHR(NPATH,LINK,2)	veh/hr or veh/day (if LPATH=1) or g/m-sec (if LPATH=2)	≥0.	1200. or 0.0082	Demand volume (if LPATH=1) or emission rate (if LPATH =2) in outbound direction, morning commute.
22-27	F6.0	VOLHR(NPATH,LINK,3)	veh/hr or veh/day (if LPATH=1) or g/m-sec (if LPATH=2)	≥0.	1200. or 0.0082	Demand volume (if LPATH=1) or emission rate (if LPATH =2) in inbound direction, evening commute
28-33	F6.0	VOLHR(NPATH,LINK,4)	veh/hr or veh/day (if LPATH=1) or g/m-sec (if LPATH=2)	≥0.	3600. or 0.0248	Demand volume (if LPATH=1) or emission rate (if LPATH =2) in outbound direction, evening commute
34-35	I2	IVFORM(NPATH,LINK)	--	-1 or +1	-1	Volume data format; +1=per lane, -1=entire link
36-37	I2	IVSPRD(NPATH,LINK)	--	-1,0,+1	+1	*Volume data format; -1=ADT, 0=hourly data, +1=AADT
38-42	I5	LINCAP(NPATH,LINK)	veh/hr	≥0	1800	*Lane capacity of segment
43	I1	NLANE(NPATH,LINK,1)	--	1 - 6	2	Number of lanes on segment, inbound direction
44	I1	NLANE(NPATH,LINK,2)	--	1 - 6	2	Number of lanes on segment, outbound direction
45-46	I2	LANWID(NPATH,LINK)	ft	9 - 14	12	Lane width
47-48	I2	LINSPD(NPATH,LINK,1)	mi/hr	5-60	30	Speed on segment, inbound direction, morning commute
49-50	I2	LINSPD(NPATH,LINK,2)	mi/hr	5-60	45	Speed on segment, outbound direction, morning commute
51-52	I2	LINSPD(NPATH,LINK,3)	mi/hr	5-60	45	Speed on segment, inbound direction, evening commute
53-54	I2	LINSPD(NPATH,LINK,4)	mi/hr	5-60	30	Speed on segment, outbound direction, evening commute
55-60	F6.0	X1(NPATH,LINK)	map units	>0	1550.	x-coordinate of first end-point of segment
61-66	F6.0	Y1(NPATH,LINK)	map units	>0	1430.	y-coordinate of first end-point of segment

*Omit of LPATH=2

TABLE 3. (continued)

(k) Card 3M—annual mode (one card for each segment)

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
67-72	F6.0	X2(NPATH,LINK)	map units	>0	1550.	x-coordinate of second endpoint of segment
73-78	F6.0	Y2(NPATH,LINK)	map units	>0	1690.	y-coordinate of second endpoint of segment
79	I1	INTYPE(NPATH,LINK)	—	0,1,2,3	0	*Intersection type; 0=no intersection; 1=toll booth, 2=signalized, 3=freeway backup
80	I1	INTDAT(NPATH,LINK)	—	1,2	2	†*Intersection data; 1=user-supplied 2=model-calculated

*Omit if LPATH=2

†Include only if INTYPE=2

TABLE 3. (continued)

(1) Card 3M--short-term mode (one card for each segment)

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1-2			—		3M	Card type number
4-5	I2	NPATH	—	1 - 5	5	Pathway number
6-7	I2	LINK	—	≤20	17	Segment or link number
8	I1	LINTOP(NPATH,LINK)	—	1,2	1	Segment topography; 1=non-street canyon, 2=street canyon
9	I1	LINTYP(NPATH,LINK)	—	1,2,3	2	Segment type: 1=freeway,2=arterial, 3=surface street with intersection
10-15	F6.0	VOLHR(NPATH,LINK,1)	veh/hr or veh/day (if LPATH=1) or g/m-sec (if LPATH=2)	≥0.	3600. or 0.0248	Demand volume (if LPATH=1) or emission rate (if LPATH =2), inbound direction
16-21	F6.0	VOLHR(NPATH,LINK,2)	veh/hr or veh/day (if LPATH=1) or g/m-sec (if LPATH=2)	≥0.	1200. or 0.0082	Demand volume (if LPATH=1) or emission rate (if LPATH =2), outbound direction
23	I1	IBOUND	—	1 or 2	1	Direction of commute; 1=inbound, 2=outbound
34-35	I2	IVFORM(NPATH,LINK)	—	-1 or +1	-1	Volume data format; +1=per lane, -1=entire link
36-37	I2	IVSPRD(NPATH,LINK)	—	-1,0,+1	+1	*Volume data format; -1=ADT, 0=hourly data, +1=AADT
38-42	I5	LINCAP(NPATH,LINK)	veh/hr	≥0	1800	*Lane capacity of segment
43	I1	NLANE(NPATH,LINK,1)	—	1 - 6	2	Number of lanes on segment, inbound direction
44	I1	NLANE(NPATH,LINK,2)	—	1 - 6	2	Number of lanes on segment, outbound direction
45-46	I2	LANWID(NPATH,LINK)	ft	9 - 14	12	Lane width
47-48	I2	LINSPD(NPATH,LINK,1)	mi/hr	5-60	30	Speed on segment, inbound direction
49-50	I2	LINSPD(NPATH,LINK,2)	mi/hr	5-60	45	Speed on segment, outbound direction
55-60	F6.0	X1(NPATH,LINK)	map units	>0	1550.	x-coordinate of first end-point of segment
61-66	F6.0	Y1(NPATH,LINK)	map units	>0	1430.	y-coordinate of first end-point of segment
67-72	F6.0	X2(NPATH,LINK)	map units	>0	1550.	x-coordinate of second end-point of segment
73-78	F6.0	Y2(NPATH,LINK)	map units	>0	1690.	y-coordinate of second end-point of segment
79	I1	INTYPE(NPATH,LINK)	—	0,1,2,3	0	*Intersection data; 0=no intersection; 1=toll booth, 2=signalized, 3=freeway backup
80	I1	INTDAT(NPATH,LINK)	—	1,2	2	†*Intersection data; 1=user-supplied, 2=model-calculated

*Omit if LPATH=2

†Include only if INTYPE=2

(m) Card 4M*--short-term mode (one card for each segment having INTYPE≠0)

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1-3			--		4M	Card type number
4-5	I2	NPATH	—	1-25	5	Pathway number
6-7	I2	LINK	—	≤50	17	Segment or link number
8-11	F4.0	ADV(NPATH,LINK,1)	veh/hr	≥0.	600. per lane	†Demand volume on segment approach if inbound commute
12-15	F4.0	ADV(NPATH,LINK,2)	veh/hr	≥0.	1200. per lane	†Demand volume on opposing controlling approach if inbound commute
16-19	F4.0	ADV(NPATH,LINK,3)	veh/hr	≥0.	600. per lane	†Demand volume on segment approach if outbound commute
20-23	F4.0	ADV(NPATH,LINK,4)	veh/hr	≥0.	1200. per lane	†Demand volume on opposing controlling approach if outbound commute
24-27	F4.0	ACAP(NPATH,LINK,1)	veh/hr of green	≥0.	1200. per lane	†Capacity of segment controlling approach if inbound commute
28-31	F4.0	ACAP(NPATH,LINK,2)	veh/hr of green	≥0.	1800. per lane	†Capacity of cross street controlling approach if inbound commute
32-35	F4.0	ACAP(NPATH,LINK,3)	veh/hr of green	≥0.	1200. per lane	†Capacity of segment approach if outbound commute
36-39	F4.0	ACAP(NPATH,LINK,4)	veh/hr of green	≥0.	1800. per lane	†Capacity of cross street controlling approach if outbound commute
40-42	F3.0	CYCL(NPATH,LINK,1)	sec	≥sum of all phases	90.	δCycle length(if inbound commute)
43-45	F3.0	CYCL(NPATH,LINK,2)	sec	≥sum of all phases	90.	δCycle length(if outbound commute)
46-48	F3.0	GPH(NPATH,LINK,1)	sec	≥0.	15.	δPhase green time(if inbound commute)
49-51	F3.0	GPH(NPATH,LINK,2)	sec	≥0.	45.	δPhase green time(if outbound commute)
52-55	F4.0	VOLBAK(NPATH,LINK,1)	veh/hr	≥0.	2300. per lane	**Demand volume during backup, if inbound commute
56-59	F4.0	VOLBAK(NPATH,LINK,2)	veh/hr	≥0.	2300. per lane	**Demand volume during backup, if outbound commute
60-63	F4.0	CAPBAK(NPATH,LINK,1)	veh/hr	≥0.	2000. per lane	**Capacity(if inbound commute)
64-67	F4.0	CAPBAK(NPATH,LINK,2)	veh/hr	≥0.	2000. per lane	**Capacity(if outbound commute)
68-69	F2.0	BAKTIM(NPATH,LINK,1)	min	≥0.	15.	**Averaging time for backup (if inbound commute)
70-71	F2.0	BAKTIM(NPATH,LINK,2)	min	≥0.	15.	**Averaging time for backup (if outbound commute)
72-73	F2.0	TOLLS(NPATH,LINK,1)	--	≥0.	3	††Number of toll booths, inbound direction(if inbound commute)
74-75	F2.0	TOLLS(NPATH,LINK,2)	—	≥0.	3	††Number of toll booths, outbound direction(if outbound commute)

*Omit if LPATH=2

†Enter only if INTYPE=2

δEnter only if INTYPE=2 and INTDAT=1

**Enter only if INTYPE=3

††Enter only if INTYPE=1

Note: Data must be entered in the position(inbound or outbound) appropriate to the direction of travel of the short-term commute being modeled.

TABLE 3. (continued)

(n) Card 5M--annual mode

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1-3					5M	Card type number
4-78	15I5	(NCOMM(I,1), I=1,NPATHS)	people/commute	>0	20000	Number of commuters on pathway i, morning commute
		(NCOMM(I,2), I=1,NPATHS)	people/commute	>0	20000	Number of commuters on pathway i, evening commute

(o) Card 5M--short-term mode

1-3					5M	Card type number
4-78	15I5	(NCOMM(I,1), I=1,NPATHS)	people/commute	>0	20000	Number of commuters on pathway i, commute of interest

Table 3(Continued)

(p) Card 6M--annual model

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1-3			—		6M	Card type number
4-6	I3	IAMPC	—	0 - 100	30	Percentage of average daily VMT on primary and secondary streets during an average hour of the morning commute
7-9	I3	IPMPC	—	0 - 100	32	Percentage of average daily VMT on primary and secondary street during an average hour of the evening commute
10-34	5F5.0	RATSEC(K), K=1,5	—	≥0.	0.4	*Ratio of secondary to primary VMT for locale type k, k=1,5

*Omit if LNPATH=2

(q) Card 6M--short-term mode

1-3			—		6M	Card type number
4-6	I3	IPCWH	—	0 - 100	16	Percentage of daily VMT on primary and secondary streets during worst hour of commute
7-31	5F5.0	RATSEC(K), K=1,5	—	≥0.	0.4	*Ratio of secondary to primary VMT for locale type k, k=1,5

*Omit if LNPATH=2

(r) Card 7M

1-3			—		7M	Card type number
4-6	I3	LGRID	—	1 - 500	23	Grid square number
7-16	F10.0	XG(LGRID)	map units	≥0.	1525.	x-coordinate of SW corner of grid square
17-26	F10.0	YG(LGRID)	map units	≥0.	1310.	y-coordinate of SW corner of grid square
27-36	F10.0	GSIZE(LGRID)	map units	≥0.	20.	one side of length of grid square
37-46	F10.0	GVMT(LGRID)	veh-mi/day	≥0.	—	*Daily VMT on primary streets in grid square
48	I1	GLOC(LGRID)	—	1,2,3,4,5	1	*Grid square locale type; 1=CBD, 2=commercial/suburban, 3=residential, 4=industrial, 5=rural/other
49-58	E10.3	GEMIS(LGRID)	$g/m^2/day$	≥0.	4500.	†Grid square average daily emission rate from primary network

*Omit if LNPATH=2

†Omit if LNPATH=1

Table 3 (Concluded)

(s) Card 8M—annual mode

Column	Format	Symbol	Units	Value Limits	Typical Value	Description
1- 3			—		8M	Card type number
4-63	6F10.0	(((FREQA(K,L,M), K=1,6),L=1,16), M=1,6)	—	0. - 1.0	0.002	Joint frequency of occurrence of stability k, wind direction ℓ, wind speed m; k=1,6; ℓ=1,16; m=1,6 for morning commute period
		(((FREQP(K,L,M), K=1,6),L=1,16), M=1,6)	—	0. - 1.0	0.002	Joint frequency of occurrence of stability k, wind direction ℓ, wind speed m; k=1,6; ℓ=1,16; m=1,6 for evening commute period

(t) Card 8M—short-term mode

1- 3			—		8M	Card type number
4-13	F10.0	WS	m sec^{-1}	≥1.0	2.4	Wind speed during worst hour of commute
14-16	I3	IWD	degrees	0 - 360	120	Wind direction during worst hour of commute
18	I1	ISTAB	—	1 - 5	4	Stability during worst hour of commute

(u) Card 9M (optional output)—annual mode*

1- 3			—		9M	Card type number
4-13	5I2	(NOPT1(M), M=1,5)	—	1 to no. of pathways	1, 8, 17	Up to 5 pathway numbers for which percentage of commuters in each of several exposure classes will be printed
14-23	5I2	(NOPT2(M), M=1,5)	—	1 to no. of pathways	2, 10, 21	Up to 5 pathway numbers for which probability of experiencing exposure levels in each of several exposure classes will be printed
24-25	I2	NOPT3	—	1 to no. of pathways	10	Pathway number for which exposures for the meteorological conditions given below will be printed
26-55	10I3	(NMET(N), N=1,10)	—	1 - 576	62, 208, 342, 461	Up to 10 numbers of sets of meteorological conditions for which exposure on pathway above will be printed
57	I1	IGRAF	—	0, 1	1	Flag for graphics package; 0=no graphical output, 1=call graphical package

*For annual mode of operation; no card type 9M for short-term mode.

starting and hot-starting vehicles on CBD pathways as well as ambient air temperature, acceleration and deceleration rates, and information on vehicle air conditioner usage. Card types 4P and 5P contain information for non-pathway sources on percentages of cold- and hot-starting vehicles. Card type 6P, included only if an inspection/maintenance program is in effect, specifies the details of the I/M program. Of course, if both pathway and nonpathway emissions are to be read directly, the emissions preprocessor need not be run and its input data need not be prepared.

The data for the main model should be entered on nine types of cards. Type 1M contains general information about the computer simulation to be run, such as a heading, the date, and various run flags. The second card type tells the model the number of pathways, the number of segments in each pathway, the number of grid squares that will be treated in the simulation, and so forth. The next two card types contain traffic information about each commute pathway segment. One card type 3M is input for each segment of each pathway, and one card type 4M is input for each segment that has an intersection, a toll booth, or a freeway backup. Card type 4M is omitted if pathway emissions are input directly. Card type 6M records information concerning the vehicle miles traveled on the network and is required for emissions computations. Information on nonpathway sources in input on card type 7M (one card for each grid square); meteorological data appear on card type 8. Card type 9 contains several output flags that cause additional output of the specific types requested to be printed.

Card types 3P, 4P, 3M, 4M, 5M, 6M and 8M are shown with two formats in Table 3: The user selects the format appropriate to the specified mode of model operation (annual or short-term).

5.1.2 Emission Factor Preprocessor (PREPRS) Input Data

Card Type 1P--General data relating to the operation of the emissions preprocessor are input on card type 1P. The first input is an alphanumeric heading, up to 20 characters long, that may say anything the user would like to have printed at the beginning of the preprocessor's output. The date is entered next on this card type, and then seven flags are set. The first flag indicates if the city being modeled is at a low or high altitude or in California. The second flag indicates whether the model is to be run in the annual or short-term mode. The next two flags indicate whether pathway and nonpathway emissions are to be model-calculated or user-supplied. The next flag specifies whether an inspection/maintenance program is in effect, and the last two flags determine whether the LDV model year registration distribution and the vehicle type distribution are to be supplied by the user or the national average distributions are to be supplied by the model as default parameters.

Card Type 2P--If the distributions of model year and vehicle type needed to compute mobile source emissions are to be user-supplied, they are entered on card type 2P. Otherwise, this card type is omitted. The fraction of the annual travel by each of 20 model years, beginning with the calendar year being modeled and followed by the 19 previous model years, is entered on this card. These fractions must sum to 1.0. Finally, the fraction of the annual travel driven by light-duty vehicles, 2 classes of light-duty trucks, heavy-duty gasoline-powered trucks, heavy-duty diesel trucks, and motorcycles will be input. These fractions must also sum to 1.0. Either or both of the distributions may be included, depending on how the flags on card type 1M were set.

Card Type 3P--The type of data to be entered on card type 3P depends on the mode of operation of the model. A description of the data required for both the annual and short-term modes of operation is given in Table 3.

For the annual mode, the model requires the entry of the annual average percentages of cold-starting LDV that are not catalyst-equipped, that are catalyst-equipped, and that are hot-starting and catalyst-equipped on CBD pathways for the evening commute. Commuting vehicles usually begin the evening commute in the CBD; therefore, the percentage should refer to the CBD pathways. If pathway emissions are to be read directly (LPATH=2) these percentages may be omitted. The next data inputs on card type 3P are the annual average ambient air temperatures for the morning and evening commute periods, followed by the percentage of vehicles equipped with air conditioners that have the air conditioning operating during the morning and evening commutes. The last two entries on card type 3P are the average acceleration and average deceleration on CBD pathways.

For the short-term mode of operation, the input data on card type 3P are similar to those for the annual mode, but the data are for only one commute. The percentages of cold-starting and hot-starting vehicles on pathways refer to the commute time of interest. These percentages should apply to the area in which most of the commute vehicles begin their trips. (The percentages may be omitted if pathway emissions are to be read directly (LPATH=2)). The temperature entered on card type 3P should be an average temperature for the commute being analyzed. Percentage of vehicles equipped with air conditioning that have their units in operation should also apply to the single commute being modeled. Finally, average acceleration and deceleration on CBD pathways is entered.

Card Type 4P--The data to be input on card type 4P also depend on the chosen operating mode for the model. If non-pathway (gridded) emissions are to be input directly (LNPATH=2), omit card type 4P.

For both modes of model operation, the percentages of cold-starting and hot-starting vehicles on the primary street network (nonpathways) are input by locale type. For the annual mode, the percentages refer to the morning commute; for the short-term mode, the percentages refer to the commute of interest.

The five locale types are:

(1) Central business district

(2) Commercial/suburban

(3) Residential

(4) Industrial

(5) Rural and miscellaneous.

Card Type 5P--This card type is input only for the annual mode. If nonpathway (gridded) emissions are to be input directly (LNPATH=2), it should be omitted. Card type 5P contains the same information as card type 4P (see previous paragraphs), but the percentages pertain to the evening commute.

Card Type 6P--This card thpe is included only when a vehicle inspection/maintenance (I/M) program is in effect in the region to be modeled (IMFLAG=1). The first input is the year the I/M program is to be implemented. The next two entries are the stringency level of the program and a flag indicating whether there is to be mechanic training. The last two entries on the card are the earliest and latest model years included in the I/M program.

5.1.3 Commuter Exposure Model (CEMAP) Input Data

Card Type 1M--The data to be entered on card type 1M are general in nature. First is an alphanumeric heading, which may be up to 20 characters long. The heading may say anything the user would like to have printed at the beginning of model output. Next, the date is input, followed by four flags, specifying the desired mode of operation for the model (annual or short-term, MODRUN), whether pathway emissions are to be entered directly or calculated by the model (LPATH), and whether nonpathway emissions are to be entered directly or calculated by the model (LNPATH). The last entry is a flag to indicate whether the input data should be printed along with the model ouput (NPRINT).

Card Type 2M--The first input on card type 2M is the number of pathways to be modeled: This parameter may be no larger than 5. Next, the number of segments that define each pathway is entered (no larger than 20), followed by the total number of grid squares through which pathways pass (up to 500). Finally, a conversion factor is input to convert to miles any consistent units that were used to define the segment endpoint coordinates.

Card Type 3M--Card type 3M has a slightly different format and input data for the two modes of model operation. Table 3 lists the data required for each mode.

One card type 3M must be input for each segment of each pathway. The program is currently dimensioned to accept up to five pathways. (See Volume II for instruction on how to change these dimensions.) Note that pathways must be numbered sequentially. See Section 5.2.1.1.3 regarding the required pathway and segment numbering convention. Cards

of type 3M must be ordered such that data for all segments of the first pathway are given, in numerical order by segment number, before information on the next pathway is given. Then all segments of the second pathway are input in numerical order, and so forth. Neither pathway nor segment number may be skipped.

For the annual mode, the first data listed on card type 3M are the pathway and segment numbers and two flags defining segment type. Next, if hourly volumes are known, the demand volumes in the inbound and outbound directions for an average hour of both the morning and evening commutes are entered and the demand volume flags which follow are set to the appropriate values. If volume data are in the form of ADT or AADT, a single volume may be input but it must be input four times. The model adjusts these volumes by time of day and direction of travel. The flags are set to the appropriate values. If pathway emissions are to be input directly, four emission rates, for the inbound and outbound directions of the morning and evening commutes, should be input in lieu of the volumes. If emissions are input, then speeds must also be input. Other inputs on card type 3M include number of lanes for each direction, lane capacity, lane width, and the endpoint coordinates of the segment. Note that segment length must be greater than or equal to segment width plus 6 m. Capacity may be entered directly, if known, or a default input of Ø will cause values internal to the model to be used. Similarly, speeds (morning and evening commutes, inbound and outbound) may be entered if known, but a zero value will cause speed to be calculated from the capacity restraint relationships. If pathway emissions are input directly (LPATH=2) with zero speeds, the model assigns speeds according to the type of link.

The endpoint coordinates of the segment may be in any convenient, consistent units and then converted to miles by the conversion factor specified by the user on card type 2M. However, the endpoint numbering convention described in Section 5.2.1.1.3 must be followed.

At the end of card type 3M are two flags concerning data on intersections. The first describes the existence and type of intersection (including interrupted flow on expressways); the second is a flag that denotes whether or not the user is supplying the intersection data; this flag must be entered only for segments for which the previous flag was given a value of 2.

Several of the parameters listed in Table 3 need not be input if pathway emissions are read directly; these parameters are indicated as such in the table. For the short-term mode, all of the data are entered as described above with the exception of the demand volume/emission rate and speed entries and a direction of commute flag. For the short-term mode, if the inbound and outbound hourly volumes for the specified hour of the commute being modeled are known, they are input in columns 10-15 and 16-21 and the appropriate flags are set. If the volume data are ADT or AADT, follow the instructions given above for the annual mode. (If the volumes are AADT they are further adjusted for season.) If pathway emissions are to be input directly, the inbound and outbound direction emission rates for the specified hour of the commute being modeled should be input in lieu of the volumes. Speeds for the inbound and outbound directions are input in columns 47-48 and 49-50. These may be zero, to invoke capacity restraint speed computation, unless LPATH=2, in which case speeds must be entered, otherwise the model will assign a speed. For the short-

term mode, one additional item of data is required on card type 3M. A flag (IBOUND) must be included that indicates whether the commute being modeled is in the morning or evening.

Card Type 4M--Card type 4M includes data that characterize the interrupted flow conditions simulated by the commuter exposure model: signalized intersections, toll booths, and freeway backups.

One card type 4M must be input for each segment having INTYPE different from zero on card type 3M. The input data requirements very depending on the type of interrupted flow, and the data are grouped for signalized intersections, freeway backups, and toll booths. Only the data for the particular type of interrupted flow being simulated need be entered for each segment. Special attention should be paid to the fact that volume and capacity data entered on card type 4M must be per lane.

Following the pathway and segment identification, the first data grouping is for signalized intersections. The demand volume and capacity for the controlling, opposing intersection approaches are entered in the following order: segment AM, opposing critical approach AM, segment PM, opposing critical approach PM. Note that capacities must be greater than or equal to one or division by zero may result. Also note that these data are included whether the signal data are included or not. When the model is used in the short-term mode, the data should be entered in the position (inbound or outbound) appropriate to the direction of travel of the commute being modeled. For example, if the commute being modeled is an inbound morning commute, the capacity of the segment approach should be entered in columns 24-27, the capacity of the cross-street approach should be entered in columns 28-31, and columns 32-39 may be left blank.

Signal data on cycle length and green phase length are entered next, if known. The model will calculate appropriate values from the volume and capacity data if INTDAT is not equal to one on card type 3M. Only the length of the green phase for the segment is needed.

The next data grouping is for freeway backups. The algorithms used are similar to those for signalized intersections and so are the data. The demand volume and roadway capacity are entered, on a per lane basis, and the time duration of the backup is also entered. Again, in the short-term mode only the relevant inbound or outbound data need to be entered.

he final data grouping is for toll booths. The number of toll booths for AM (inbound) and PM (outbound) periods are entered for annual mode operation. Only one need be entered for the short-term mode.

Card Type 5M--As with several other card types, the data included on each type 5M differ for the annual and short-term modes.

For the annual mode, the number of commuters traveling the full length of each pathway during the morning commute are input; although the model is currently dimensioned for 5 pathways, the number could be increased. In that case, the number of commuters traveling the full pathway would be input 15 pathways to a card. This could take more than one card, depending on the number of pathways. Beginning with a new card, the same information should be input for the evening commute. This will take another card (or more if the program has been redimensioned for more pathways) which should follow the cards for the morning commute. Number of commuters is found by multiplying the number of commute vehicles on the pathway by the average vehicle occupancy.

For the short-term mode, the number of commuters traveling on the pathway are input only for the commute of interest, (up to 15 pathways to a card).

Card Type 6M--Card type 6M has a different format and input data for the two modes of model operation. Table 3 lists the data required for each mode.

For the annual mode of operation, the first input parameter is the percentage of the average daily VMT on primary and secondary streets that occurs during the average hour of the morning commute, followed by the percentage that occurs during the average hour of the evening commute. Lastly, the ratio of the VMT on secondary streets to the VMT on primary streets that is typical for each locale type is input. (These ratios may be omitted if nonpathway emissions are to be read directly (LNPATH=2).)

For the short-term mode of operation, the percentage of the average daily VMT on primary and secondary streets during the specified hour of the commute of interest should be entered. Often, this will be the hour with the heaviest travel (and hence highest exposures). If the user is not analyzing a "worst-case" commute, but rather an average--but specific--commute, this percentage should apply to the average hour of the specific commute. The ratio of the VMT on secondary streets to the VMT on primary streets during the commute being analyzed that is typical for each locale type is input last. If nonpathway emissions are to be read directly (LNPATH=2), these ratios may be omitted.

Card Type 7M--Data describing the grid squares is entered on card type 7M: One card should be input for each grid square through which a pathway passes; the maximum number of grid squares allowed is 500. The first data item to appear on card type 7M is the number of the grid square, followed by the coordinates of the southwest corner of the grid square and the length of one side of the grid square. The next entry is different

when the model computes nonpathway source emissions and when emissions are input directly. If the model is to compute nonpathway source emissions (LNPATH=1), the next input is the average daily VMT on primary streets in the grid square, followed by the locale type associated with the the grid square. If emissions are input directly (LNPATH=2), the above two inputs are omitted, and the average daily emission rate for the square should be entered. The grid squares must be numbered sequentially and input in numerical order (although the numbering system may be determined by the user). The units of the grid square coordinates must be consistent with the units of the pathway segment coordinates.

Card Type 8M--The meteorological data are entered into the model on card type 8M. As with some of the other card types, different formats and data will be used for the two different modes of model operation.

For the annual mode, the meteorological data are in the form of joint frequency distributions of wind direction, wind speed, and atmospheric stability. A distribution consists of the fractions of time that each combination of wind direction, speed, and stability occurs. For the purposes of the commuter exposure model, "time" in the previous sentence is defined as the morning commute period (usually 6-9 am) or the evening commute period (usually 4-7 pm) for the area being modeled; the hours which comprise a commute period may vary with area. Two distributions must be input to the model, one describing the morning commute period and the other for the evening commute.

The meteorological parameters are categorized into 16 wind direction classes, 6 wind speed classes, and 6 stability classes. The value intervals for the classes are given in Table 4. Note that the model will

TABLE 4. DEFINITION OF VALUE INTERVALS OF METEOROLOGICAL PARAMETERS

Wind Direction		Wind Speed		Stability	
Class	Interval (degrees)	Class	Interval (knots)	Class	Definition
1	11.25 - 33.75	1	0-3	1	Very Unstable
2	33.75 - 56.25	2	4-6	2	Moderately Unstable
3	56.25 - 78.75	3	7-10	3	Slightly Unstable
4	78.75 - 101.25	4	11-16	4	Neutral
5	101.25 - 123.75	5	17-21	5	Slightly Stable
6	123.75 - 146.25	6	>21	6	Stable
7	146.25 - 168.75				
8	168.75 - 191.25				
9	191.25 - 213.75				
10	213.75 - 236.25				
11	236.25 - 258.75				
12	258.75 - 281.25				
13	281.25 - 303.75				
14	303.75 - 326.25				
15	326.25 - 348.75				
16	348.75 - 11.25				

combine stability classes 4 and 5, day and night neutral, into one class called 4, and class 6, stable, will be called class 5. The morning distribution should be input first in the following order: For stability class 1, 16 cards (one for each wind direction class), 6 values per card (for each wind speed class); then stability class 2, 16 cards, and so forth -- 96 cards for each frequency distribution. The evening distribution, ordered as described above, should follow the morning distribution.

For the short-term mode, values for wind speed, wind direction, and stability should be entered for the hour of the commute of interest. Stability class is defined as shown in Table 4 except class 4 is neutral, class 5 is stable, and there is no class 6.

Card Type 9M--Card type 9M is a data card used to cause optional output to be generated by the model; it is included only when running in the annual mode. If only some of the options available are to be used, zeroes should be entered for all remaining inputs on the card. If no options are called for, the card may be blank, but it still must be included.

The first set of input values on card type 9M consists of the numbers of those pathways for which the user wants the percentage of commuters on each of the pathways in each of several exposure classes to be printed. The output can be obtained for up to five pathways. Pathway numbers must be input in increasing numerical order.

The next set of input values contains the numbers of those pathways for which the user wants the probability of the commuters on each of the pathways experiencing exposure levels in each of several exposure classes

to be printed. As many as five pathway numbers can be input. Pathway numbers must be input in increasing numerical order.

The next values to be entered on card type 9M allow the user to observe the variation of exposure on a specific pathway with meteorological conditions. First, the number of the pathway of interest is entered. Next, the number associated with a particular combination of wind direction class, wind speed class, and atmospheric stability class is entered. The model allows up to 10 sets of meteorological conditions to be input. The number associated with each combination of meteorological conditions is taken from Table 5. The definitions of the value intervals for the wind direction, wind speed, and stability referred to in Table 5 appear in Table 4. Remember, the model will combine day and night neutral stability, so there is really no difference in choosing either of the two classes. Table 4 has been left showing six stability classes so it will correspond to the format of the frequency distributions.

The last parameter to be entered on card type 9M is a flag calling for graphical output. Remember that the user must furnish the plotting routine, either as a part of subroutine GRAF or as a separate routine, called from GRAF. (See Section 5.3.1.)

5.2 Preparation of Input Data

5.2.1 Definition of the Modeling Approach

The crux of the commuter exposure modeling problem is defining the modeling area. The modeling area should coincide with the Standard Metropolitan Statistical Area (SMSA) or the Air Quality Control Region (AQCR) bounding the urban core. Such a practical choice has been made because those areas usually encompass the region that influences and is impacted

TABLE 5. NUMBERS ASSOCIATED WITH COMBINATIONS OF METEOROLOGICAL PARAMETERS

Stability and Wind Speed Classes	Wind Direction Class															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Stability 1																
Wind Speed 1	1	7	13	19	25	31	37	43	49	55	61	67	73	79	85	91
Wind Speed 2	2	8	14	20	26	32	38	44	50	56	62	68	74	80	86	92
Wind Speed 3	3	9	15	21	27	33	39	45	51	57	63	69	75	81	87	93
Wind Speed 4	4	10	16	22	28	34	40	46	52	58	64	70	76	82	88	94
Wind Speed 5	5	11	17	23	29	35	41	47	53	59	65	71	77	83	89	95
Wind Speed 6	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96
Stability 2																
Wind Speed 1	97	103	109	115	121	127	133	139	145	151	157	163	169	175	181	187
Wind Speed 2	98	104	110	116	122	128	134	140	146	152	158	164	170	176	182	188
Wind Speed 3	99	105	111	117	123	129	135	141	147	153	159	165	171	177	183	189
Wind Speed 4	100	106	112	118	124	130	136	142	148	154	160	166	172	178	184	190
Wind Speed 5	101	107	113	119	125	131	137	143	149	155	161	167	173	179	185	191
Wind Speed 6	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192
Stability 3																
Wind Speed 1	193	199	205	211	217	223	229	235	241	247	253	259	265	271	277	283
Wind Speed 2	194	200	206	212	218	224	230	236	242	248	254	260	266	272	278	284
Wind Speed 3	195	201	207	213	219	225	231	237	243	249	255	261	267	273	279	285
Wind Speed 4	196	202	208	214	220	226	232	238	244	250	256	262	268	274	280	286
Wind Speed 5	197	203	209	215	221	227	233	239	245	251	257	263	269	275	281	287
Wind Speed 6	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288
Stability 4																
Wind Speed 1	289	295	301	307	313	319	325	331	337	343	349	355	361	367	373	379
Wind Speed 2	290	296	302	308	314	320	326	332	338	344	350	356	362	368	374	380
Wind Speed 3	291	297	303	309	315	321	327	333	339	345	351	357	363	369	375	381
Wind Speed 4	292	298	304	310	316	322	328	334	340	346	352	358	364	370	376	382
Wind Speed 5	293	299	305	311	317	323	329	335	341	347	353	359	365	371	377	383
Wind Speed 6	294	300	306	312	318	324	330	336	342	348	354	360	366	372	378	384
Stability 5																
Wind Speed 1	385	391	397	403	409	415	421	427	433	439	445	451	457	463	469	475
Wind Speed 2	386	392	398	404	410	416	422	428	434	440	446	452	458	464	470	476
Wind Speed 3	387	393	399	405	411	417	423	429	435	441	447	453	459	465	471	477
Wind Speed 4	388	394	400	406	412	418	424	430	436	442	448	454	460	466	472	478
Wind Speed 5	389	395	401	407	413	419	425	431	437	443	449	455	461	467	473	479
Wind Speed 6	390	396	402	408	414	420	426	432	438	444	450	456	462	468	474	480
Stability 6																
Wind Speed 1	481	487	493	499	505	511	517	523	529	535	541	547	553	559	565	571
Wind Speed 2	482	488	494	500	506	512	518	524	530	536	542	548	554	560	566	572
Wind Speed 3	483	489	495	501	507	513	519	525	531	537	543	549	555	561	567	573
Wind Speed 4	484	490	496	502	508	514	520	526	532	538	544	550	556	562	568	574
Wind Speed 5	485	491	497	503	509	515	521	527	533	539	545	551	557	563	569	575
Wind Speed 6	486	492	498	504	510	516	522	528	534	540	546	552	558	564	570	576

by the urban core, and because a wealth of requisite data is routinely available for them. Generally, the SMSA and AQCR boundaries are the same.

This section describes a methodology for defining the modeling area in terms of the two important types of emission sources in a commuter exposure model: (1) line sources, or commuter pathways; and (2) non-pathway sources (the "background source effects") from the remaining roadway network.

5.2.1.1 Commuter Pathways

The most critical aspect in defining the modeling area is choosing the appropriate commuter pathways. The commuter exposures that are calculated and the statistics that are derived all depend directly on the pathways that are defined.

Fortunately, the major commuting pathways, or "commuting corridors," are well-defined and recognizable if one is familiar with the modeling area. Often, just the physical size of the roadway, or, more properly, its capacity, will identify it as a commute route. The commuting pathways are also corridors of development, fostered largely by the access to the urban core that the route provides.

From a methodological standpoint, however, it is suggested that the user of the commuter exposure model seek advice in defining the major commuting routes. The local transportation department, the metropolitan transportation planning authority, or the coucil of governments should be able to provide this assistance. The remainder of this discussion provides the criteria that should be presented to the transportation expert to help him help the model user in defining the commuting pathways.

5.2.1.1.1 Origin-Destination Zones

A key part of the transportation planning process is the estimation of trends of demand for transportation services. Estimates of demand are based on a knowledge of existing demand, and on known and planned land-use and demographic characteristics of the planning region. Tools that help quantify this demand are the origin-destination survey and the additional data that can be generated from the survey results.

Typically, the region is divided into subareas, or zones. They are of variable size, depending on population density and other demographic characteristics, and on the roadway network. The zones are smaller and denser in the urban core than in outlying areas. For example, the transportation planning region for Pittsburgh encompasses about 9000 square miles and contains approximately 900 zones. However, about 100 of them are in the downtown, "Golden Triangle," are of the city.

In simplest for, the origin-destination data will supply the daily trips between zones. Thus, they may be broken down by trip purpose, by trip purpose pairs indicating the direction of flow (home-work, work-home), and by time of day. For the commuter exposure model, trips to and from work are the main ones of concern in defining the commuting routes. Fortunately, work trips have the most tractable statistics. They are likely to vary the least from one weekday to the next and they occur during fairly well-defined time periods. They are relatively insensitive to weather and travel conditions. Additionally, even if the trip is identified only as a work trip, it can be assumed to be from home to work in the morning and from work to home in the evening. The origin-destination data are usually presented as a matrix, with an accompanying map indicating the zones. The matrix elements are the numbers of trips between origins and destinations.

The purpose of origin-destination data for commuter exposure modeling is to define the commute pathways. Accepted accuracy for the data is ± 20 percent, so they should not be used to generate traffic volumes. Their utility lies in showing the spatial flow of home-work and work-home trips. Once the spatial flow is known, the key roadways can be determined, and traffic volumes can be taken from volume flow maps.

Given fairly comprehensive origin-destination data, it would be tempting to try to model all commuters. All of the work-related trips are identified, and one could seemingly define routes for them and model the exposures. But the futility of doing so becomes readily apparent when the Pittsburgh example is considered: the total number of possible origin-destination pairs is 900^2, or 810,000. Even as few as 100 zones would yield 10,000 combinations. While not every combination will produce a work-related trip, the percentage is large enough to render such an approach impractical.

5.2.1.1.2 Definition of Commute Pathways

For commuter exposure modeling to be a manageable problem, a reasonable number of major commuting routes or pathways must be defined even though a plethora of origin-destination data is available. The number of pathways will be a function of the size of the modeling area; the program is presently dimensioned for five pathways. (If more than five pathways are defined, the user is referred to Volume II of the guide for instructions on how to increase the dimensions of the program.) Those routes will generally have the highest number of vehicle miles traveled (VMT) by commuters. Again, it is recommended that the advice of a transportation planner or traffic engineer familiar with the area be sought when the routes are defined.

It is recognized that the commute pathways defined in such a manner will not carry all commuters. However, the method described here should include a great majority of the commuters who are at risk of experiencing high exposures on the order of the air quality standards. Most of the extensive commuting will be done along the defined pathways, both in time and distance, and the pathways will by definition carry high volumes of traffic. Although their total number may be close to that on the pathways, the commuters "missed" will, on the average, be traveling shorter times and distances on less heavily traveled roads. They are not considered to be at risk to high pollutant exposures during their commute.

5.2.1.1.3 Characteristics of Commute Pathway Segments

In general, commute pathways will include different types of roadways. Two types of roadways that are prime candidates to be commute pathways are expressways and arterials. A pathway may be composed of both. The Highway Capacity Manual[1] (HCM) defines an expressway as "a divided arterial highway for through traffic with full or partial control of access and generally with grade separations at major intersections." (A freeway is defined as an expressway "with full control of access.") The term arterial is intended to have the meaning that the HCM applies to a major street or highway: "an arterial highway with intersections at grade and direct access to abutting property, and on which geometric design and traffic control measures are used to expedite the safe movement of through traffic." In addition, commuting trips usually begin and end on local surface streets, and these too will be part of the pathway.

To describe a commute pathway for the purposes of the commuter exposure model, the pathway should be numbered sequentially and then divided into segments or links. No pathway numbers may be skipped. The following are criteria for defining different pathway segments:

- Change of the roadway type, e.g., freeway to arterial or arterial to surface street.
- Abrupt change in roadway direction or traffic flow direction.
- Presence of a major intersection.
- Abrupt change in vehicle volume.
- Beginning and ending parts of pathway.

For a given commute pathway, several segments will be defined, and each segment will be described with the input data listed in Section 5.1.3 for card type 3M. In addition, card type 4M must be included for all segments on which there are intersections, freeway backups, or toll booths.

A note should be made regarding the definition of the beginning and ending segments of the pathway. In general, commuting trips begin on local surface streets and "collectors." Often, they will not even begin in the same zone that they are in when they enter the pathway. To handle the exposure during the approach to and departure from the pathway, minor pathways should be used that are representative of the travel to and from the route. If such a pathway cannot be found, one should be "invented," with a location, volume, and characteristics typical of the kind of route on which commuters in the region of the pathway endpoint would travel. Here again, the local transportation authority can give guidance on the definition of such a segment.

For both the annual and short-term modes of model operation, the commute pathway segments should be defined in the following way. A segment is a section of roadway on which there is travel in both directions. The first segment of the pathway is the beginning of the pathway for the morning commute. The segments must be numbered sequentially, from one to no more than 20, for each pathway. The model distinguishes one segment from another by both pathway and segment number, so for each pathway, segment numbering should begin with one. No segment numbers may be skipped.

Note that the convention specified above regarding segment numbering applies to the short-term mode of operation even if the commute being analyzed is the evening commute; that is, the segment numbered as one is the first inbound segment of the morning commute.

There is also a convention that must be adhered to regarding the numbering of the segment endpoints. The first end of the segment, whose coordinates are (X1, Y1), is the beginning end of the segment in the direction of the morning commute, and (X2, Y2) is the other end of the segment. Again, this convention applies to both modes of model operation, even if the commute being analyzed in the short-term mode is the evening commute.

5.2.1.2 Non-Pathway Sources

5.2.1.2.1 Definition of Grid System

Non commute pathway pollutant emissions are treated on a grid square basis. The user should overlay the study area with a grid system, and in general the grid squares should have dimensions in the neighborhood of 2 km by 2 km. For convenience, the model allows input of grid squares

of different sizes. However, if this option is used, care must be taken that grid squares do not overlap and that all points on each segment fall with a grid square.

The coordinate system used to define the grid must be consistent with the system used to define commuter pathway coordinates. Grid squares are defined by their lower left corner coordinates.

The grid square coordinates, and the other grid square descriptors described in Section 5.1.3, need be input to the model for only those squares through which commuter pathways pass. Figure 5 illustrates a typical commuter pathway network, overlaid by a uniform grid system. The shaded grid squares are those for which input data are required. They contribute appreciably more to the concentrations experienced on the pathway than do other squares.

5.2.1.2.2 Apportionment of Vehicle Miles Traveled on the Primary Network

The primary street network is defined as those roadways carrying a major amount ofthe total vehicle miles traveled (VMT) on the entire roadway network of a metropolitan area. In general, the primary network can be considered to be those streets for which average daily traffic (ADT) values are available. For the commuter exposure model, the primary network should not include roadways that are commuter pathways.

Because the major part of the concentration on a commuter pathway is expected to result from vehicles traveling on the pathway itself, the part of the concentration resulting from the other non-pathway roadways in the vicinity can be approximated. The approximation used in the

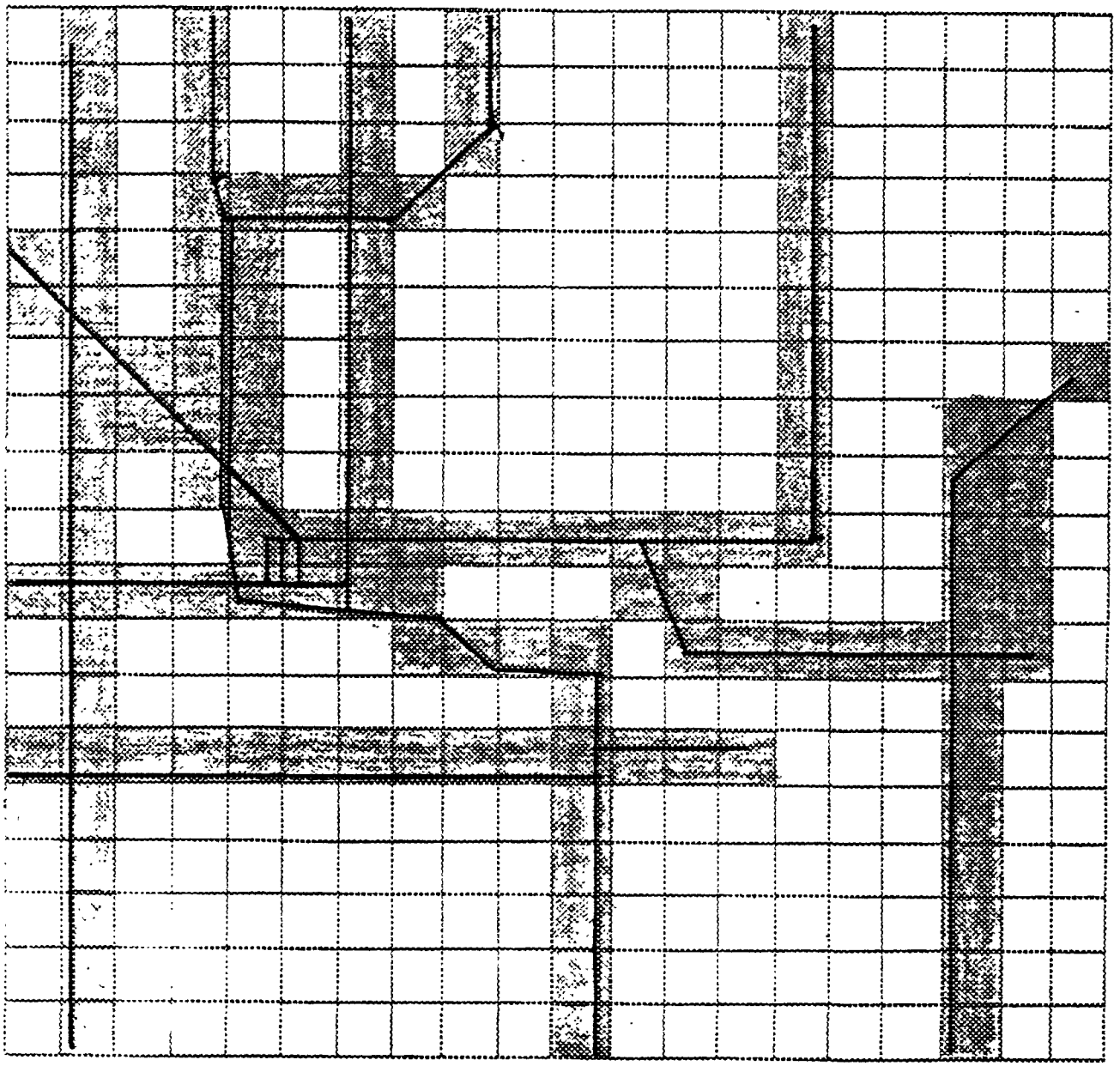


FIGURE 5 SAMPLE COMMUTER PATHWAY NETWORK WITH GRID OVERLAY

Data must be input for shaded squares.

model consists of an aggregation of primary network emissions into grid squares, with the assumption of a uniform emission rate across the square. This approach saves the user considerable effort that would be required if each raodway in the primary network, and its associated characteristics, were used as model input.

Therefore, once the grid system is defined, the user must apportion the total VMT of primary network streets among the grid squares and input that information for the appropriate squares. The recommended approach for the apportionment is the following. A volume flow map showing the ADT on the major roadways in the study area should be overlaid with the grid system. The length of the portion of each roadway that lies in the grid square should be multiplied by the number of vehicles traveling on that roadway each day, yielding the VMT on the portion of the roadway that lies in the grid square. This procedure should be followed for each portion of roadway in the grid square; the total VMT in the grid square will be the sum of the individual roadway VMTs. The measurement of roadway lengths and volumes need not be exact, because the primary network emissions and dispersion treatments involve a number of approximations.

The VMT for each grid square through which a commuter pathway passes must be input to the model; it is used to generate an emission rate for the square. Care should be taken so that the VMT on commuter pathways is not included in the VMT of a grid square.

In general, the results of the foregoing procedure is used to compute emissions from the primary network. However, the model allows the user to input an average daily emission rate for each grid square, in lieu

of VMT. This option would be used when gridded emissions for the study area are readily available from another source or when the user has access to the projections generated by the Federal Highway Administration's (FHWA) battery of computer programs. In the latter case, the user may opt to run the APRAC-3 emissions module, which takes the FHWA historical traffic files as input (deleting, of course, the commuter pathways), to produce a gridded emission inventory. The values from this inventory may be used as input to the commuter exposure model. For further details on the APRAC-3 emissions module, see Simmon, et al. (1981). If emission rates are input directly, note that they should be daily rates, as the model will automatically reduce the daily rates to hourly rates for the morning and evening or short-term commutes.

5.2.1.2.3 Apportionment of Secondary Newwork VMT

The secondary traffic network consists of all streets not in the primary network or commuter pathways. The approach used for assigning secondary traffic to grid squares assumes that the ratio of secondary traffic to primary traffic varies by locale (or by land use). For instance, virtually all of the streets in the Central Business District (CBD) are likely to be important enough to be included in the primary traffic network. Similarly, very little traffic in rural areas is likely to be found off the major roadways. In residential and industrial areas, a large fraction of the total traffic may use secondary streets. The user estimates the ratio of secondary to primary traffic for each locale type. The locale type of each grid square or group of grid squares for which data are required also will be input. The model will allot secondary network VMT on the grid squares in proportion to the product of the VMT

on the primary network in that square and the ratio of the secondary to primary traffic associated with the locale type of the square. A list of locale types appears in Table 6.

Table 6

LOCALE TYPES

1. Central business district
2. Commercial areas in the core of the city, or suburban centers
3. Residential areas
4. Industrial areas
5. Rural and miscellaneous

If gridded emissions are input directly, as discussed in the previous section, secondary network emissions should be included in that inventory.

5.2.2 Data Sources

5.2.2.1 Emission Factor Preprocessor Data

Card Type 1P--All of the input data on card type 1P are determined by the user, depending on the place, time, and type of application being considered.

Card Type 2P--Card type 2P contains the distributions of LDV registrations by model year and the total VMT by vehicle type. These data are sometimes available from the state Department of Motor Vehicles, the state or county Department of Transportation, or the local Transit District or planning agency. Private firms offer data of this type, for a number of cities, for sale. If no other information is available, the national

average distributions are stored in the model and are available as default parameters.

Card Type 3P--Data describing the percentages of cold- and hot-starting vehicles and vehicle air-conditioner usage are in general, difficult to find. The transportation agencies listed for type 2P data are places the user is advised to contact. Guidance for determining such percentages is given in the EPA publication (Midurski et al., 1977) and the user is also referred to this document. The temperatures required on card type 3P are available from the National Weather Service or the National Climatic Center.

Card Types 4P and 5P--Sources of percentages of cold- and hot-starting vehicles are discussed under card type 3P.

Card Type 6P--This card type contains data describing an inspection/maintenance program. Such data should be available from the state or local transportation planning agency.

5.2.2.2 Commuter Exposure Model Data

Card Type 1M--The data contained on card type 1M are determined by the user, according to the application intended.

Card Type 2M--This card type describes the number of pathways, segments, and grid squares in the modeling area and includes a map unit conversion factor. These data will be determined by the user after defining the commute pathways and grid system.

Card Type 3M--This card describes the basic traffic and roadway data. The data on this card should generally be available from the local transportation planning agency. Volume or emission rate must always be input, as must the flags describing the data format, the type of roadway, and

the existence of a backup or an intersection. If emission rates are input directly, then speed must also be input so that exposure time may be calculated; if volumes are input rather than emission rates, speed may be input or the model will calculate it if it is omitted. Note that card type 3M calls for four volumes, or emission rates and speeds, per segment in the annual mode and only two when the model is exercised in the short-term mode.

Card Type 4M--This card type continues the traffic inputs for freeway backups, toll booths, and modal flow calculations. The traffic signal data may be input directly or calculated by the model. If they are calculated by the model, then the volumes and capacities for the opposing approaches must be input. The data for toll booths and freeway backups must always be included when these cases arise.

Card Type 5M--The data on this card, the number of commuters on each pathway, should be available from the local planning agency or council of governments. Alternatively, it may be estimated from traffic volumes and vehicle occupancy rates.

Card Type 6M--All of the information contained on card type 6M should be available from the state or county Department of Transportation or the local Transit District or planning agency. The percentages of average daily VMT on primary and secondary streets during an average hour of the morning and/or evening commutes may have to be derived by the user from the hourly volume measurements that are available for various roadways. An average diurnal distribution may be available, from which the percentages could be easily computed. The secondary street network to primary street network VMT ratios may have to be determined by an "educated guess" of the local traffic personnel.

Card Type 7M--This card type contains grid square information. The user determines the coordinates of the grid squares and their daily VMT on primary streets using the method described in detail in Section 5.2.1.2.2. The volumes on the primary street network can be obtained from the state, county, or local transportation and planning agencies. The locale type of the grid squares can be derived from land-use maps available from the local planning agency. Gridded emission rates are sometimes available for metropolitan areas; see the discussion of this in Section 5.2.1.2.2.

Card Type 8M--Card type 8M contains meteorological data. The source of such data is generally the National Climatic Center (NCC). Historical records of hourly surface observations for many cities are available from the NCC. In addition, NCC has a computer program, called STAR, which processes hourly observations to produce climatological joint frequency distributions of the type required by the model in the annual mode of operation. The user should inquire as to whether NCC could generate such distributions for the morning and evening commute period. The distributions could be generated by the user from hourly surface observations.

Card Type 9M--This card contains a number of flags calling for various optional model outputs. The user sets these flags according to what output is to be generated.

5.2.3 Additional Recommendations

This section contains recommendations for generating various data necessary to the model that may be difficult to obtain. In some instances the information given here will help clarify how a model input parameter is determined using other available information. The following discussions center on traffic parameters.

Additional notes regarding choice of the terminating (or originating) pathway segment may be helpful to the model user. When the commute paths enter the CBD, and the queueing calculations are applied, single routes must be chosen for each commute path, terminating at a reasonable location. This can be a central point in the CBD, or there can be a separate terminus for each path, such as locations of relatively high employment density within the urban core. For paths not going to the CBD, the end points should be clear because they had to have been identified already in order to support a commute path not involving the CBD.

Demand volume may be obtained from volume flow maps or tabulated volume data available from the local transportation agency. Ideally, hourly data should be available, but often only the average daily traffic (ADT) or annual average daily traffic (AADT) can be obtained. In the latter cases, factors must be applied to arrive at estimated hourly volumes during commuting periods. Those factors should be obtained from the local transportation agency so that they are representative of the area. If they are unavailable, national average values should be used. Default values are contained in the model in BLOCK DATA. As an example, Table 7 shows the percentage of weekday AADT by hour, land use type, and direction of travel on freeways in the San Francisco Bay Area. Table 8 supplies the same data for nonfreeway streets.

Table 7

EXAMPLES OF WEEKDAY DIURNAL TRAFFIC CYCLES ON FREEWAYS IN THE SAN FRANCISCO BAY AREA

Hour Ending (local time)	CBD*		Commercial		Residential		Industrial		Rural	
	NB†	SB	NB	SB	NB	SB	NB	SB	EB	WB
00	.017	.014	.013	.012	.007	.017	.009	.012	.022	.011
01	.010	.007	.004	.006	.003	.005	.006	.006	.011	.006
02	.006	.004	.004	.004	.002	.003	.004	.004	.007	.005
03	.004	.004	.002	.001	.001	.001	.003	.003	.005	.004
04	.004	.006	.003	.001	.000	.001	.005	.004	.005	.007
05	.007	.016	.005	.005	.009	.001	.011	.008	.007	.023
06	.022	.062	.033	.026	.077	.009	.055	.047	.019	.110
07	.057	.097	.127	.079	.175	.041	.094	.069	.053	.117
08	.055	.075	.130	.086	.131	.049	.072	.053	.045	.083
09	.044	.052	.066	.049	.056	.034	.059	.052	.045	.061
010	.044	.051	.048	.039	.045	.032	.032	.055	.045	.054
011	.050	.054	.043	.040	.041	.034	.058	.056	.047	.049
012	.057	.049	.047	.043	.039	.035	.054	.052	.043	.045
013	.053	.056	.042	.046	.042	.035	.058	.061	.050	.046
014	.059	.063	.045	.052	.041	.043	.059	.063	.053	.050
015	.078	.067	.051	.071	.057	.070	.070	.073	.070	.050
016	.110	.072	.070	.091	.059	.163	.083	.088	.099	.065
017	.099	.064	.073	.103	.059	.181	.068	.097	.101	.058
018	.060	.047	.055	.074	.045	.101	.051	.067	.095	.042
019	.045	.039	.042	.048	.048	.051	.039	.041	.045	.037
020	.033	.027	.031	.035	.032	.028	.033	.029	.036	.021
021	.035	.027	.026	.033	.021	.024	.034	.026	.039	.019
022	.028	.026	.020	.029	.023	.025	.023	.018	.033	.021
023	.024	.022	.017	.025	.013	.017	.018	.019	.025	.017
Total	1.001	1.001	.998	.998	1.001	1.000	.998	1.003	1.000	1.001

*These data are from Seattle; others are San Francisco Bay Area Locales.

†Directions:
NB = Northbound
SB = Southbound
EB = Eastbound
WB = Westbound

Table 8

EXAMPLES OF WEEKDAY DIURNAL TRAFFIC CYCLES ON NONFREEWAY STREETS IN THE SAN FRANCISCO BAY AREA

Hour Ending (local time)	CBD*		Commercial		Residential		Industrial		Rural	
	NB+	SB	EB	WB	NB	SB	EB	WB	EB	WB
00	.013	.015	.008	.014	.006	.021	.015	.010	.007	.016
01	.006	.008	.004	.007	.003	.010	.007	.004	.002	.009
02	.003	.006	.003	.005	.002	.005	.005	.004	.002	.005
03	.004	.004	.002	.003	.002	.003	.004	.002	.001	.002
04	.002	.004	.002	.002	.003	.002	.002	.005	.012	.004
05	.003	.007	.007	.002	.015	.003	.004	.018	.012	.003
06	.017	.027	.036	.010	.078	.009	.024	.066	.056	.017
07	.035	.061	.101	.031	.149	.033	.086	.103	.161	.054
08	.036	.052	.081	.041	.077	.036	.057	.079	.091	.046
09	.039	.040	.051	.038	.059	.034	.049	.001	.058	.037
010	.048	.050	.052	.046	.052	.040	.051	.057	.058	.051
011	.067	.059	.057	.055	.051	.053	.053	.057	.055	.052
012	.104	.078	.064	.068	.052	.057	.057	.056	.045	.048
013	.068	.081	.066	.060	.049	.064	.064	.056	.052	.051
014	.070	.070	.061	.064	.058	.067	.067	.061	.062	.057
015	.071	.066	.065	.073	.071	.074	.074	.062	.066	.073
016	.095	.077	.068	.097	.056	.099	.099	.079	.064	.127
017	.081	.072	.052	.121	.052	.079	.079	.065	.059	.125
018	.057	.049	.052	.081	.055	.052	.052	.054	.054	.063
019	.048	.043	.052	.058	.043	.036	.036	.031	.032	.035
020	.046	.047	.045	.035	.021	.032	.032	.019	.017	.030
021	.039	.036	.028	.038	.017	.039	.039	.018	.012	.040
022	.028	.026	.025	.031	.017	.027	.027	.016	.019	.031
023	.020	.021	.018	.019	.011	.019	.019	.016	.015	.022
Total	1.000	0.999	1.000	0.999	0.999	1.002	1.002	0.999	1.001	0.998

*These data are from Seattle, others are San Franciosco Bay Area Locales.

+Directions:
NB = Northbound
SB = Southbound
EB = Eastbound
WB = Westbound

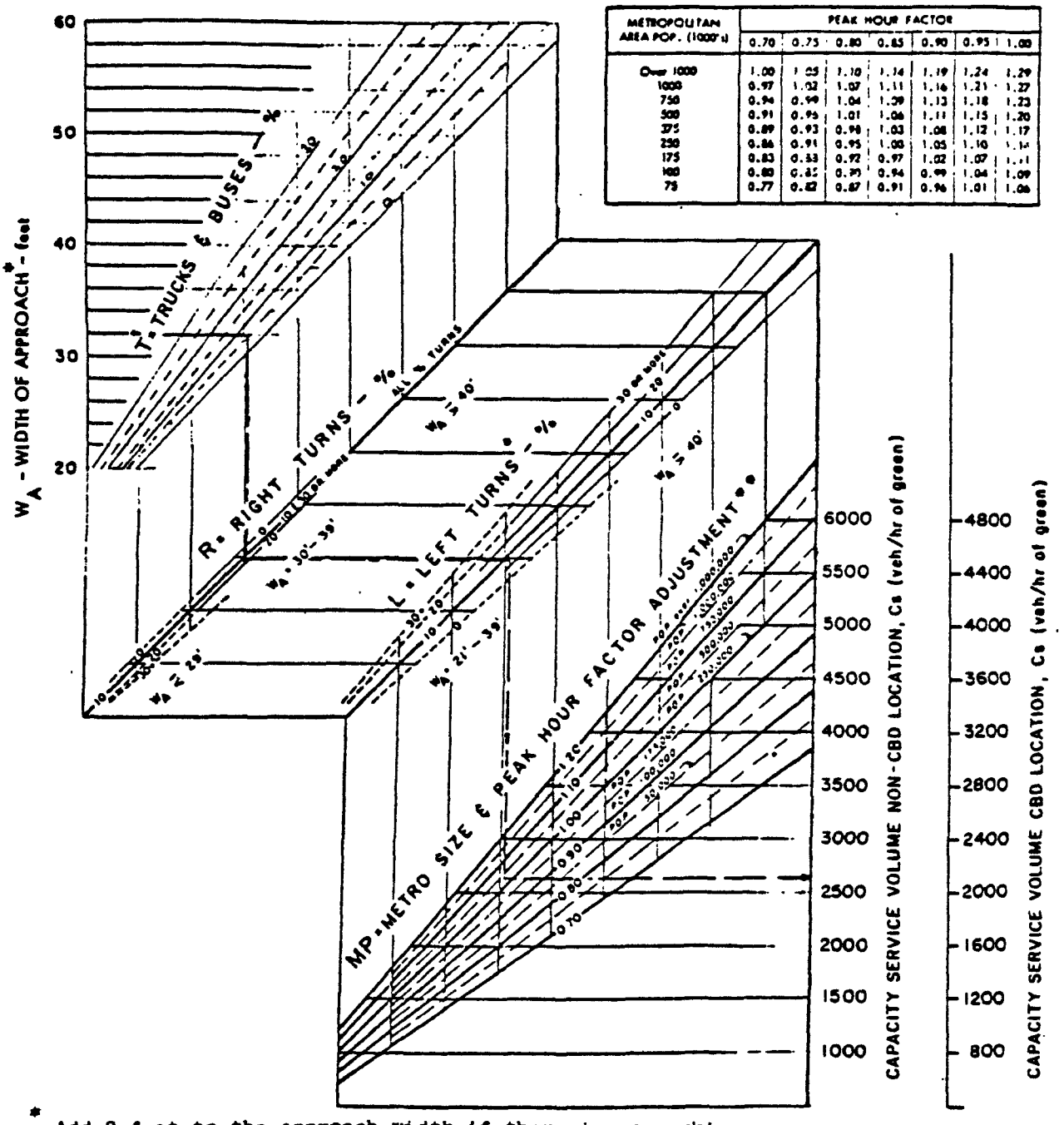
The capacity service volume in vehicles per hour of green is determined using the nomograph, Figure 6. The user must know the percentage of trucks and buses, left turners, right turners, the location within the metropolitan area, the size of the metropolitan area, and whether or not the intersection is located in the CBD. The nomograph provides a solution for a two-way urban street with parking. The solution for that type of intersection is the most conservative estimate of capacity in the Highway Capacity Manual. If a street has no parking within 250 feet of the intersection, eight feet can be added to the curb-to-center line width (Wa) and a conservative solution will still result from use of the nomograph.

Average route speed is another input parameter. The local transportation agency should be able to offer advice on average route speed estimates for interrupted flow portions of pathways. As a default, the CURVE I in Figure 7 has been fitted to an equation and included in the model. The curves rely on volume-to-capacity ratios as input, and they estimate an average speed for coordinated and uncoordinated traffic signals. As a comparison with Figure 7, which is based on national data, Figure 8 shows site-specific curves specifically for the Washington, D.C. metropolitan area (see Metropolitan Washington Council of Government). If a transportation agency cannot supply average speed data, they may be able to provide curves similar to those in Figure 8, but based on data from the local region.

Usually the signal cycle time is the sum of the green phase times and amber times for all phases. When overlapping phases occur, the cycle time is the sum of the left turn and through phases plus amber time,

TABLE 8 MP = METROPOLITAN SIZE AND PEAK HOUR FACTOR ADJUSTMENT

METROPOLITAN AREA POP. (1000's)	PEAK HOUR FACTOR						
	0.70	0.75	0.80	0.85	0.90	0.95	1.00
Over 1000	1.00	1.05	1.10	1.14	1.19	1.24	1.29
1000	0.97	1.02	1.07	1.11	1.16	1.21	1.27
750	0.94	0.99	1.04	1.09	1.13	1.18	1.23
500	0.91	0.95	1.01	1.06	1.11	1.15	1.20
375	0.89	0.93	0.98	1.03	1.08	1.12	1.17
250	0.86	0.91	0.95	1.00	1.05	1.10	1.14
175	0.83	0.88	0.92	0.97	1.02	1.07	1.11
100	0.80	0.85	0.89	0.94	0.99	1.04	1.09
75	0.77	0.82	0.87	0.91	0.96	1.01	1.06



* Add 8 feet to the approach width if there is no parking.

** When the peak hour factor is known, use table above to determine MP; when peak hour factor is not known use population directly.

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FIGURE 6 SERVICE VOLUME OF A SIGNALIZED INTERSECTION APPROACH

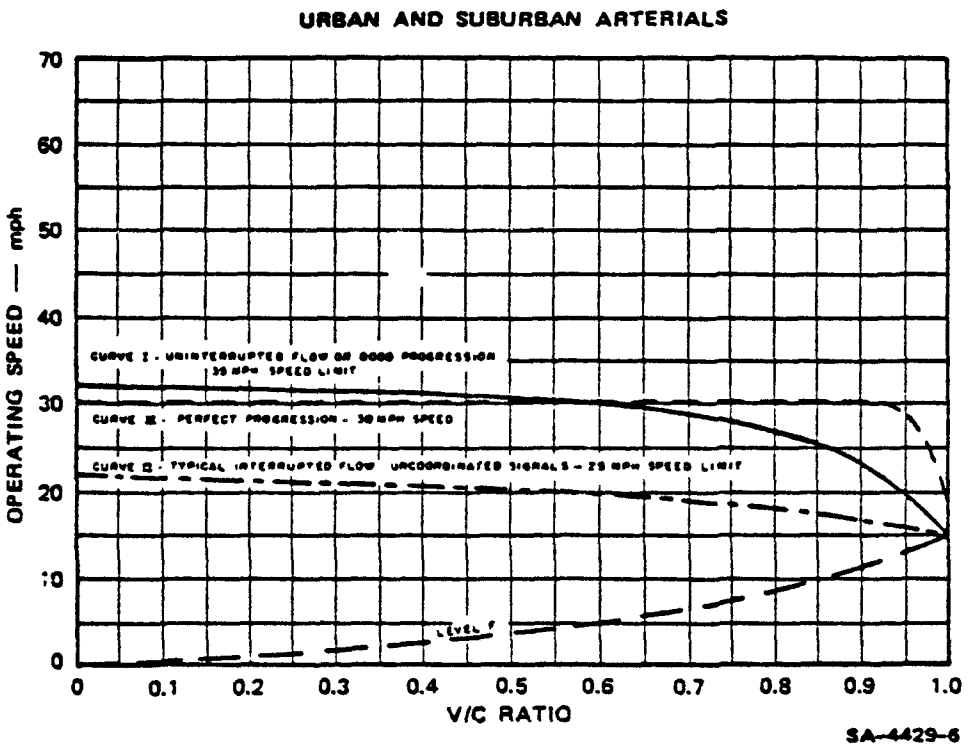

FIGURE 7 TYPICAL RELATIONSHIPS BETWEEN V/C RATIO AND AVERAGE OVERALL TRAVEL SPEED, IN ONE DIRECTION OF TRAVEL, ON URBAN AND SUBURBAN ARTERIAL STREETS

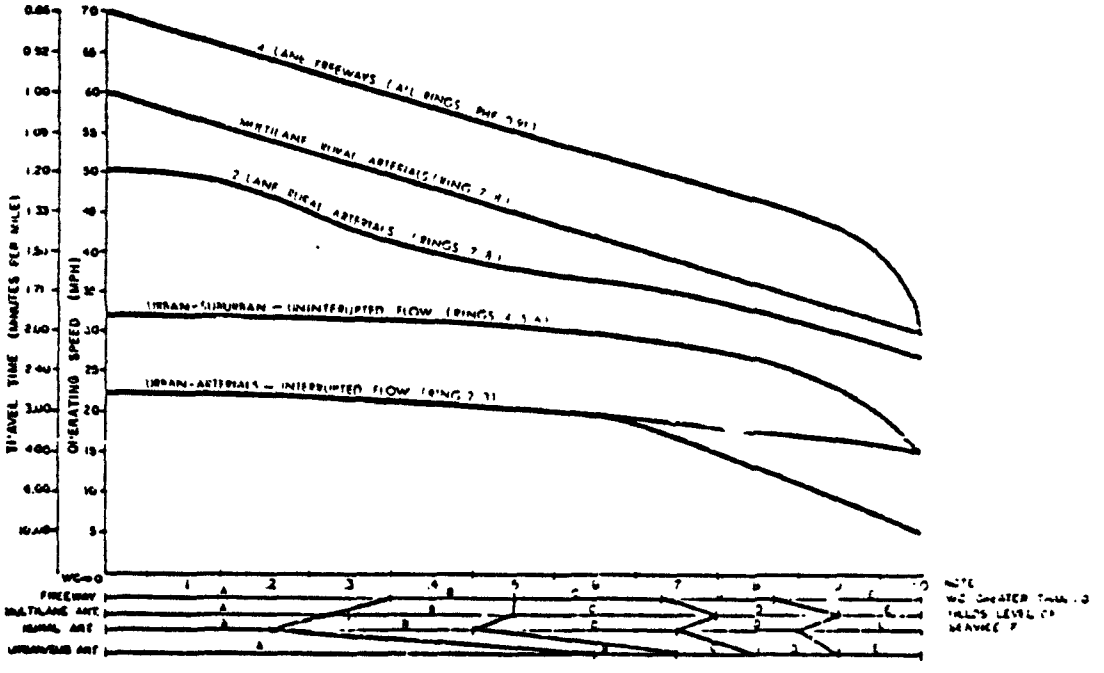

FIGURE 8 OPERATING SPEED RELATED TO LEVEL OF SERVICE, ROUTE TYPE VOLUME/CAPACITY RATIO AND RING

when there is no simultaneous green indicator. The capacity of an approach is the sum of the capacities for each through or turning movement on the approach.

5.3 Model Output

5.3.1. Description of Output

The commuter exposure model output differs for the two modes of model operation. The commuter exposure statistics calculated and printed in each mode of operation are discussed in the following sections. A summary of the output for each mode is given in Table 9.

5.3.1.1 Short-term Statistics--When the model is run in the short-term mode, commuter exposures are output in several forms. One is a list of the pathway, non-pathway, and total exposures, travel time, and average concentration on each pathway, as well as the area source concentration on the last segment of each pathway for the input worst-case meteorological and traffic conditions. Next is the average exposure for all pathways and the standard deviation of exposure over all pathways. Finally, data are generated that can be used to construct two histograms. To compute the histogram data, the model divides the range of exposures found on all pathways into several classes. For each class two paramters are listed: the percentage of the commuting population treated by the model that experience exposure levels in the class; and the probability of experiencing the exposure levels in the class (i.e., the percentage of time commuters are exposed to the levels of the exposure class).

The histogram data are produced by: assigning a range of exposure values to be included in each exposure class; determining which class the

TABLE 9. COMMUTER EXPOSURE MODEL OUTPUT

Short-Term Mode	Annual Mode
List of pathway, non-pathway, and total exposures, travel time, and average concentration on each pathway and area source concentration on last segment of each pathway	Annual average pathway exposure
Average and standard deviation of exposures on pathways in modeled region	Annual average morning and evening pathway, non-pathway, and total exposures, travel times, and concentrations on each pathway
Percentage of commuters in each of several exposure classes	Percentage of commuters in each of several exposure classes (for all pathways)
Probability of experiencing exposure levels in each of several exposure classes	Probability of experiencing exposure levels in each of several exposure classes (for all pathways)
	OPTION--Percentage of commuters in each of several exposure classes (on up to 5 single pathways)
	OPTION--Probability of experiencing exposure levels in each of several exposure classes (on up to 5 single pathways)
	OPTION--Pathway exposure associated with up to 10 different sets of meteorological conditions

total exposure value on each pathway lies and assigning the pathway's commuters and travel time multiplied by commuters (commute-seconds) to that class; and then tabulating the number of commuters and the commuter-weighted travel times in each class. Dividing the number of commuters associated with each class by the total number of commuters on the pathway network yields the percentage of commuters exposed to each range of exposure values. Dividing the commute-seconds associated with each class by the total commute-seconds on the pathway network gives the probability of occurrence of the exposure levels in each class. These calculations are made in subroutine SHORTY, which also prints the output.

To further clarify how the histogram data are computed, consider the following simple example. Assume two pathways are modeled. The first pathway has an exposure of 8.5 gsec/m^3, a 350 second travel time, and carries 8000 commuters. The second pathway has an exposure of 7 gsec/m^3, a 250 second travel time and carries 9000 commuters. The exposure class intervals are from 0-0.9 gsec/m^3, 0.9-1.8, and so forth, with the last interval being 8.1-9.0. For the first pathway, the model will determine that its exposure lies in interval 10, and it will store its 8000 commuters in a bin for that interval and its 2.8×10^6 commute-seconds (8000 commuers times 350 seconds) in another bin for that interval. For the second pathway, the model will determine that its exposure lies in interval 8 (6.3-7.2), and it will store its 9000 commuters in the interval 8 "commuters" bin and its 2.25×10^6 commute-seconds (9000 x 250) in the interval 8 "commute-second" bin. The model then adds the numbers in the 10 "commuters" bins to find the total cummters (in the example this is 8000+9000=17,000) and adds the numbers in the 10 "commute-second" bins to find the total commute

seconds ($2.8 \times 10^6 + 2.25 \times 10^6 = 5.05 \times 10^6$). Finally, the total number of commuters in each bin is divided by the total number of commuters in all bins and the results are multiplied by 100 to give the percentage of commuters exposed to the range of exposure values represented by each interval. In the example 47 percent (100 times 8000/17000) of commuters modeled experience exposures between 8.1 and 9.0 gsec/m^3, and 53 percent (100 times 9000/1700) experience exposures between 6.3 and 7.2 gsec/m^3. A similar procedure is followed for commute-seconds. In the example there is a 55 percent probability (199 times $2.8 \times 10^6/5.05 \times 10^6$) of experiencing exposures between 8.1 and 9.0 gsec/m^3 and a 45 percent probability (100 times $2.25 \times 10^6/5.05 \times 10^6$) of experiencing exposures between 6.3 and 7.2 gsec/m^3.

5.3.1.2 Annual Statistics--Several forms of annual statistics are produced by the model when it is in the annual mode. (Subsets of those statistics may be output at the user's discretion.) The model first prints the annual average morning and evening pathway, non-pathway, and total exposures, travel times, and concentrations on each pathway. Next, the model prints the annual average exposure over the modeled region. Two kinds of annual histogram data are then generated: the percentage of commuters exposed to various classes (ranges) of exposure; and the probability of experiencing various classes of exposure (i.e., the percentage of time commuters are exposed to those classes).

The model produces both of these types of statistics by the process described below. The model begins with the first pathway. As stated previously, several semi-normalized exposures are computed for each pathway: 480 normalized exposures arising from non-street-canyon pathway sources (for 16 wind directions, five stabilities, 3 wind speeds, and morning and evening emission rates); two normalized exposures resulting from street-canyon sources (for morning and evening emission rates); and ten normalized exposures resulting from nonpathway sources(for five stabilities, and morning and evening emission rates). The model takes the first of the 480 cases (one combination of wind direction, stability, wind speed, and morning or evening emissions) and divides the exposure by one of six wind speed values. Next, the normalized street-canyon exposure for the corresponding time (morning and evening) is divided by the same wind speed plus 0.5. Finally, the normalized non-pathway source exposure for the corresponding time and stability is divided by the wind speed, and all three exposure values are summed. The model deter-

mines the appropriate exposure class for this total exposure value and multiplies the pathway travel time by the number of commuters on the pathway. It then weights the following parameters by the frequency of occurrence of the case's wind speed, wind direction, and stability for the emission time period (morning or evening): the number of commuters on the pathway; the pathway commute-seconds; and the pathway exposure. The first two weighted numbers are stored for the exposure class; the third number is stored for use in computing the annual average pathway exposure. The model then cycles to the next wind speed and repeats the procedure, then to the next case (of the 480) for each wind speed, and so forth. For each pathway, the weighted number of commuters is summed for each exposure class, as are the weighted commute-seconds, and the weighted exposures are summed. Finally, the percentage of commuters in each exposure class is found by dividing the number in the class by the total commuters; the percentages of commute-seconds (probabilities) are similarly found. The annual average pathway exposure is the weighted exposure sum.

If the user desires one or more subsets of the preceding information, he may request it with model input. For example, if pathway "X" is of particular interest, the user can input a flag and the pathway number to produce either or both types of histogram data for pathway "X" only.

One other type of output is available when the model is in the annual mode. If information about the variation with meteorology of exposure on a particular pathway is desired, the user inputs a flag, the pathway number, and the meteorological conditions of interest, and the model lists the morning and evening exposures on the pathway for each combination of

of meteorological parameters. If the meteorological conditions input by the user do not occur (according to the frequency distribution), the model will print a value of -99. for exposure.

5.3.1.3 Graphical Output--Histograms provide a convenient means to depict the statistics generated by the model, especially since such plots can be generated on a line printer. Due to incompatibilities between makes of computers and between line printers, the code that generates such plots has not been included in the commuter exposure model. However, all of the variables needed to plot histograms are included in COMMON statements in a subroutine called GRAF. Definitions of the symbols used as well as instructions on how to plot the histograms are also included in subroutine GRAF as COMMENT statements. An input flag, IGRAF, on card type 9M will cause GRAF to be called. Currently, it only prints a message. The user is referred to subroutine GRAF and to the Glossary of Symbols in the other volume of this package for aid in adding the histogram-plotting capability to the model.

5.3.2 Uses and Interpretation of Output

The commuter exposure model can be used to analyze a number of air quality problems as they relate to commuters. Regulatory agencies are now showing increased interest in assessment of the daily or long-term exposure to air pollutants of certain critical population groups. The emphasis in air quality assessment is shifting away from the use of single-point monitoring to define air quality and toward the analysis of the pollutant exposure to which people, as moving receptors, are subject.

The population group subject to some of the highest exposure risk

is commuters. Not only are the pollutant levels on the roadways over which commuters drive high, but this group comprises a very large segment of the population. The commuter exposure model is a tool that can be used to assess the pollutant levels to which commuters are exposed in various metropolitan areas. The model can be used to look at annual average exposures when it is run in the annual mode; when the user wants to examine specific commutes, the model can be run in the short-term mode. A single commute under worst-case traffic and meteorological conditions, or an average single commute on an average single commute on an average day, can be analyzed.

In either mode, the model output provides the user with a substantive description of commuter exposure. Since the model treats the spatial variation of exposure, regions of the city in which commuters experience high exposures can be identified from model output. If a single commute pathway is of interest, that pathway can be examined in detail.

The model facilitates study of exposure levels in relation to the percentage of the commuting population exposed. The length of time of exposure is also readily available for use in health effects studies.

In addition to being useful for determining absolute exposure levels, the model can also assess the effects of implementing roadway improvements or transportation control measures. The difference in commuter exposure resulting from the various planning alternatives can be found by running the model both without and with the proposed changes and then comparing the computed results.

When interpreting the output of the commuter exposure model, the user should bear in mind the assumptions made in defining the pathway network

from the data base. The more thorough and complete the definition of the network, the more reliable will be the results. The output of the model can be no better than the data that was input: If, in a number of instances, the user was required to estimate values for input parameters, note should be taken as to the potential effects of such estimation on the output.

Another matter of importance regarding the interpretation of the statistics generated by the model concerns the number of commuters treated by the model. As discussed in our modeling methodologies report (Simmon and Patterson, 1978) the commute pathways do not account for all of the commuting in the modeled region. The number and complexity of the commuting routes in most metropolitan areas render a computer simulation of the complete commuting picture nearly impossible. Given this initial limitation for all cities, the model can nevertheless consider a larger percentage of the total commuter population in some cities than in other cities. The percentage of commuters treated by the model is dependent not only on the size of the modeling area and the numbers of actual commuting routes in the area, but also on the user's choice of routes and the number of routes defined. For most cities, sufficient data are available to enable the user to determine the total number of commuters in the area and thus the percentage of the total commuters traveling on the defined commute pathways. In interpreting model-produced statistics, the user should remember that the statistics apply only to this percentage of the commuters. In addition, the user knows that commuters traveling on the pathways have, by definition, relatively long commutes, and hence risk high exposure. By the same token, the commuters "skipped" by the suggested method for pathway definition are those commuters with short home-to-work

trips or having non-centralized places of employment. Thus, the commuter exposure statistics developed by the model are biased toward high exposure levels.

5.3.3 Model Limitations

Because of the complex nature of the commuter exposure assessment problem, a model will of necessity have some limitations. The limitations of the model detailed in this report are:

- Not all commuters treated
- Semiobjective method of commute pathway selection
- No seasonal or weekly traffic distribution
- Constant acceleration and deceleration rates
- Assumes annual average ambient air temperature
- All morning commute vehicles assumed hot-running
- Cold-start and hot-start percentages fixed for each locale type for morning and evening commutes
- Gaussian dispersion treatments cannot treat fumigation or stagnation
- Nonpathway dispersion treatment does not allow variation of grid square emission rates
- No provision for effects of precipitation
- On-roadway and in-vehicle concentrations assumed equal.

In most instances, the commuter exposure model uses state-of-the-art technology to simulate the traffic, vehicle emissions, and pollutant dispersion affecting commuters in an urban area. The areas in which improvements to state-of-the-art techniques are needed are well known and have been widely discussed. For example, the use of a Gaussian distribution

to represent the variation in pollutant concentration usually assumes a steady-state condition for periods of up to one hour in duration. Of course, wind direction and speed and many other descriptive parameters can vary considerably during such a time period. Thus, the assumption of a steady-state is not always valid and (ideally) should be replaced by a treatment that can accommodate high-frequency variations in basic descriptive parameters. Limitations of this sort are well known, and as the state-of-the-art progresses, they will be eliminated.

The model limitations discussed here relate to those assumptions in the methodology that, while not ideal, are necessary to produce a practical, useful model of a reasonable size and moderate running costs. To keep the modeling problem tractable, certain assumptions were necessary, but care was taken that such assumptions would have a relatively minor effect on the model output.

First, and most important, the model does not treat all commuters, especially those with short commutes and commutes on less popular routes. While ideally all commuters would be treated, the number of origin destination zone pairs in a major metropolitan area needed to define all commute routes is far greater than can be reasonably handled. Another potential model limitation is the semiobjective method by which commute routes are defined. A background familiarity with the area to be modeled and experience in traffic modeling will undoubtedly make possible better choices of commute routes. However, the suggestion that the local transportation agency be contacted for help in selecting the commuting routes somewhat mitigates this limitation.

To keep the calculation of annual average exposures within reason-

able computational bounds, no peaks (other than diurnal) are allowed in the traffic distribution. If the volume input to the model is annual average daily traffic (AADT), the lack of peaking characteristics is not a problem. However, if average daily traffic (ADT) is input, the lack of weekly and seasonal peaks could affect the annual average exposures. This effect can be alleviated by adjusting ADT to AADT using seasonal factors when computing annual average exposures. Another model assumption is that the acceleration and deceleration rates have a constant value, although the effects of this are expected to be minor. Single, constant rates may be chosen that reflect the average emissions from a distribution of rates.

Three assumptions are made relating to the computation of emission rates. The assumptions are necessary to keep the number of model computations and the computer storage required at realistic levels. First, an annual average ambient air temperature is used when the model is in the annual mode. Next, in the morning, all vehicles on the commute routes are assumed to be in a "warmed-up" mode of operation. (The vehicles reached this state while traveling to the beginning of the commute route.) Finally, when computing pollutant concentrations resulting from nonpathway sources, fixed cold-start and hot-start percentages are assumed for the morning and evening commutes for each locale type.

Four potential model limitations are related to the simulation of atmospheric dispersion. The use of the Gaussian dispersion formulations presented precludes treatment of fumigation or stagnation conditions. The Hanna-Gifford dispersion treatment used to compute concentrations resulting from nonpathway sources assumes that the emission rate in grid squares

adjacent to the receptor square is the same as the emission rate in the receptor grid square. Another factor which has been ignored in the commuter exposure modeling methodology is the effect of precipitation. Undoubtedly, some scavenging or rainout would occur. Finally, on-roadway and in-vehicle concentrations have been assumed to be equal. The state of the windows, air conditioner, heater, and so forth in the vehicle would affect this relationship.

SECTION 6

SAMPLE APPLICATION

6.1 Overview

This section contains listings showing the results of PREPRS and CEMAP applied to two commute pathways in St. Louis, Missouri. This sample application is intended only as a simple example using real world data rather than a comprehensive model application.

The listings in this section are divided into four parts. The first is a listing of the input file used to run PREPRS; the second is the output printed by PREPRS using the preceding input data. The third listing is the input file used to run CEMAP in the sample application. Finally, the listing generated by CEMAP, giving the model results, is included.

6.2 Data Sources

Several state and local agencies supplied the data necessary to run the commuter exposure model for the St. Louis sample application. The data and the agencies are identified below.

Traffic data for the sample application for St. Louis were obtained from two sources: the East-West Gateway Coordinating Council and the Transportation and Traffic Division for the City of St. Louis.

The East-West Gateway Coordinating Council is the comprehensive planning organization for the St. Louis region. They were able to supply maps of the major road transportation network for the region, and they assisted in outlining the major commute pathways. Traffic volume maps

showing ADT values were also obtained from this source, as were diurnal distribution data, origin/destination data, land use information, and vehicle miles traveled (VMT) figures.

The Transportation and Traffic Division was the source for intersection signal data for the CBD, as well as specific traffic count data collected at various locations throughout the city.

The differences in the types of data obtained from these two agencies should be noted, since the differences correspond to the basic functions of each. The East-West Gateway Coordinating Council, as the comprehensive planning organization, is responsible for large-scale planning and hence develops and uses correspondingly large-scale network data. They are knowledgeable about transportation patterns in the region. The Transportation and Traffic Division, on the other hand, must be concerned with basic traffic movement and control, and hence is responsible for the design, operation, and maintenance of the specific physical controls on traffic movement.

Meteorological data for several sites in the St. Louis area were obtained from GCA Corporation. Meteorological data for the airport observation site were obtained from the National Weather Service station in St. Charles, Missouri.

The Division of Air Pollution Control, City of St. Louis, supplied measured CO concentration data for five monitoring sites for the period of interest.

6.3 Input Data Formulation

The data gathered from the agencies discussed in Section 2 were reduced by various means to a form compatible with the commuter exposure model.

Reduction of the input data for the emissions preprocessor was relatively straightforward. Model year and vehicle type distributions had been obtained directly and were input to the model. Cold-start/hot-start percentages were derived using the EPA guideline (Midurski and Castaline, 1977) for the determination of such percentages. The average ambient air temperature used in the model was an average of the measured values at five sites for the commute hour selected.

The intention of the sample application was to use actual data in the model as a check to see that exposure levels of a magnitude that might be expected were indeed predicted by the model. No attempt was made to conduct a comprehensive modeling exercise, as such a model application could be a small project unto itself. Rather, the intent was to choose a small number of pathways to model as a check and as an example.

Thus, two commute pathways were selected to be modeled. One of the pathways contains one of the major commute freeways into the central business district (CBD). It was divided into twenty segments. The other pathway terminates in a secondary employment center, Clayton, and the pathway consists primarily of arterial streets. It is represented by four segments.

The segments on each pathway were determined by the existence of major interchanges, changes in traffic volume, or changes in roadway direction. Segments were numbered from the commute origin to its desti-

nation. The coordinates of segment endpoints were derived from maps and were measured in miles from an arbitrary grid origin. Traffic volumes were taken from a network map showing bi-directional average daily traffic (ADT) volumes. The model adapted the ADT to peak hour volumes internally using the diurnal distribution data. Capacities were obtained from model default values; speeds were computed by the model from capacity-restraint relationships. Traffic signal data were taken directly from data supplied by the local agency.

The number of commuters on the pathways were determined using average daily traffic volumes, diurnal traffic distributions, length of the commute, average vehicle occupancy rates, and overall guidance from origin/destination data.

Diurnal traffic distributions were available and were used directly to determine the percentage of average daily VMT that occurs on primary and secondary streets during the commute hour that was modeled (0800-0900). The ratios of secondary to primary street VMT by locale type were determined subjectively using network-wide averages and volume flow diagrams.

Grid square information was found by overlaying a grid system on the volume flow map and manually tabulating the VMT in each grid square. The length of each portion of a primary street passing through a grid square was multiplied by the volume on that portion of the street. Such products were summed to give the total VMT for each grid square. Locale type was determined through a familiarity with the St. Louis area.

The meteorological data input to the model were derived from the data listed in Table 1. The stations 1 through 5 are located in the City of St. Louis and the near county. The airport station is somewhat more

removed from the pathways that were modeled. The average wind speed, wind direction, and temperature values used in the model were derived giving more weight to data from observing sites near the pathways than to the airport data. Neutral stability, class 4, was determined from sky cover, wind speed, and time of day.

Table 10

METEOROLOGICAL DATA FOR ST. LOUIS SAMPLE APPLICATION DAY
13 MAY 1977, HOUR 0900

Station	Wind Direction (Degrees)	Wind Speed (MPH)	Temperature (Degrees F)	CO (PPM)	Opaque Sky Cover (Tenths)	Stability
1	180	1.7	72.8	13.6		
2	195	3.8	67.9	2.5		
3	212	3.1	74.3	5.5		
4	--	--	--	0(?)		
5	--	--	70.9	6.1		
airport	300	4 knots	72		0	
average used in model	200	1.3 m/s	72			4

6.4 Discussion of Results of Sample Application

A listing of the input data for both parts of the model and the results of the sample application are included on the following pages. The output of the emissions preprocessor is typical of emission factors for carbon monoxide.

Exposures computed by CEMAP are within the range of values that would be expected. Total exposure and the average pathway concentration on pathway 1 are greater than the corresponding numbers for pathway 2. This is reasonable, since pathway 1 consists primarly of a major commute freeway, while pathway 2 is representative of a less heavily traveled, shorter commute route.

Pathway 1 terminates in the St. Louis CBD. The model computed a background concentration of 12.6 mg/m^3 (11 ppm) in that area. Of the measured CO concentrations listed in Table 1, only one monitor is located near either of the pathways modeled. That one is Station 1, which is located in the CBD. The CO concentration measured at that location during the commute being modeled was 13.6 ppm. Thus, it appears that the commuter exposure model performed well in predicting the CBD background concentration.

The average concentration on pathway 1 was predicted at 15.6 mg/m^3 (13.7 ppm) and on pathway 2 at 9.28 mg/m^3 (8.1 ppm). These values are higher than the background levels that normally occur outside of the CBD but are in keeping with the increased levels expected on the roadway itself, rather than nearby.

The model output includes warnings that the traffic volumes have exceeded the listed capacity of some segments. These warnings are included so that the user will know that the program has encountered instances where adjustments in the volume were necessary for the program to continue calculations and that the inputs should be checked for accuracy.

In addition to providing the histogram information about commuter exposures, the model output also includes a breakdown of some of the in-

formation used to generate the statistics. For example, the last page of the output that follows gives a breakdown of the commuter exposures arising from pathway and nonpathway sources, the travel time calculated for the pathway and the average concentration along the pathway. The last column also shows the concentration found for the last pathway segment, arising from nonpathway sources. This latter information is printed only to provide a check to see if reasonable concentrations are being generated near the path ending.

PREPRS INPUT FOR SAMPLE RUN
(see Table 3)

```
                                   Column Numbers
1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
1P   ST LOUIS TEST       770513 1 2 1 1 C 2 2
2P  .02.09.10.10.09.06.08.09.08.06.05.05.04.03.02.02.01.010. 0. .80.13.02.04.010.
3P   15 15  0 72  02.5 -2.5
4F   15 15 15 15 15 15 15 15 15 15  0  C  0  0  0
```

PREPRS OUTPUT FOR SAMPLE RUN

```
ST LOUIS TEST


CAL. YEAR    1977          VEH. TYPE   LDV  LDT1  LDT2   HDG   HDD   MC
REGION    49 STATE                    .800/ .130/ .020/ .040/ .010/0.000

LDV MODEL
YEAR MIX  0.000/0.000/ .005/ .005/ .010/ .011/ .017/ .024/ .032/ .032
             .044/ .066/ .082/ .080/ .065/ .106/ .126/ .135/ .130/ .031


COMPOSITE EMISSION FACTORS (GRAMS/MILE) FOR NON-CBD PATHWAY VMT


TEMPERATURE    72 (F)
AIR CONDITIONING     0 PC
100 PC WARM OPERATION

                  CARBON MONOXIDE
SPEED (MPH)       EMISSION FACTOR

     10           1.196E+02
     15           8.074E+01
     20           6.212E+01
     25           5.052E+01
     30           4.214E+01
     35           3.606E+01
     40           3.208E+01
     45           2.996E+01
     50           2.912E+01
     55           2.828E+01
     60           2.558E+01
```

PREPRS OUTPUT FOR SAMPLE RUN
(continued)

COMPOSITE EMISSION FACTORS (GRAMS/MILE) FOR GRIDDED VMT

TEMPERATURE 72 (F)
AIR CONDITIONING 0 PC
SPEED 19.5 MPH

LOCALE TYPE	CARBON MONOXIDE START MODE (PC) COLD CATALYST	COLD NON-CAT.	HOT CATALYST	EMISSION FACTOR
1	15	15	0	7.264E+01
2	15	15	0	7.264E+01
3	15	15	0	7.264E+01
4	15	15	0	7.264E+01
5	15	15	0	7.264E+01

TEMPERATURE/COLD STARTS CORRECTION FACTORS FOR CBD PATHWAY MODAL EMISSION FACTORS

TEMPERATURE 72 (F)
AIR CONDITIONING 0 PC
COLD STARTS 15 PC (NON-CATALYST) 15 PC (CATALYST)
HOT STARTS 0 PC (CATALYST)

CARBON MONOXIDE

VEHICLE AGE (YEARS)	SPEED (MPH) 5	10	15	20	25	30
1	1.323	1.321	1.290	1.275	1.286	1.315
2	1.310	1.309	1.279	1.264	1.274	1.303
3	1.287	1.286	1.257	1.243	1.253	1.280
4	1.117	1.152	1.173	1.193	1.217	1.245
5	1.115	1.150	1.171	1.191	1.214	1.242
6	1.124	1.150	1.170	1.186	1.200	1.214
7	1.118	1.145	1.168	1.191	1.215	1.240
8	1.101	1.134	1.165	1.194	1.219	1.243
9	1.099	1.132	1.164	1.193	1.218	1.239
10	1.149	1.159	1.168	1.176	1.183	1.188
11	1.122	1.122	1.122	1.122	1.122	1.122
12	1.121	1.121	1.121	1.121	1.121	1.121
13	1.121	1.121	1.121	1.121	1.121	1.121
14	1.121	1.121	1.121	1.121	1.121	1.121
15	1.121	1.121	1.121	1.121	1.121	1.121
16	1.121	1.121	1.121	1.121	1.121	1.121
17	1.121	1.121	1.121	1.121	1.121	1.121
18	1.121	1.121	1.121	1.121	1.121	1.121
19	1.120	1.120	1.120	1.120	1.120	1.120
20	1.120	1.120	1.120	1.120	1.120	1.120

PREPRS OUTPUT FOR SAMPLE RUN
(continued)

RATIO OF FTP COMPOSITE TO LDV EMISSION FACTORS FOR CORRECTING MODAL CBD PATHWAY EMISSIONS

TEMPERATURE 72 (F)
AIR CONDITIONING 0 PC
COLD STARTS 15 PC (NON-CATALYST) 15 PC (CATALYST)
HOT STARTS 0 PC (CATALYST)

SPEED (MPH)	CARBON MONOXIDE RATIO
5	1.076
10	1.121
15	1.129
20	1.121
25	1.113
30	1.111

AIR CONDITIONING CORRECTION FACTORS FOR CBD PATHWAY MODAL EMISSION FACTORS

AIR CONDITIONING 0 PC

VEHICLE AGE (YEARS)	CARBON MONOXIDE CORRECTION FACTOR
1	1.000
2	1.000
3	1.000
4	1.000
5	1.000
6	1.000
7	1.000
8	1.000
9	1.000
10	1.000
11	1.000
12	1.000
13	1.000
14	1.000
15	1.000
16	1.000
17	1.000
18	1.000
19	1.000
20	1.000

PREPRS OUTPUT FOR SAMPLE RUN
(concluded)

COMPOSITE CRUISE (GRAMS/SEC) AND EXCESS (GRAMS) EMISSION FACTORS FOR CBD PATHWAY VMT

TEMPERATURE 72 (F)
AIR CONDITIONING 0 PC
COLD STARTS 15 PC (NON-CATALYST) 15 PC (CATALYST)
HOT STARTS 0 PC (CATALYST)

	CARBON MONOXIDE	
SPEED (MPH)	CRUISE EMISSION FACTOR	EXCESS EMISSION FACTOR
5	5.754E-01	1.092E+00
10	5.445E-01	2.945E+00
15	5.077E-01	4.886E+00
20	4.780E-01	6.949E+00
25	4.630E-01	9.267E+00
30	4.652E-01	1.199E+01

IDLE EMISSION FACTOR (GRAMS/SEC) FOR CBD PATHWAYS

POLLUTANT	EMISSION FACTOR
CARBON MONOXIDE	2.902E+01

CEMAP INPUT FOR SAMPLE RUN
(see Table 3)

```
                                   Column Numbers
1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
1*   ST LOUIS TEST       770513 2 1 1 1
2*   220 4        201.
3*   1 11120340.20340. 1            -1-1     02212555       5.33  3.67  5.67  3.670
3*   1 21132185.32185. 1            -1-1     02212 0 0      5.67  3.67  7.00  3.670
3*   1 31133700.33700. 1            -1-1     02212 0 0      7.00  3.67  8.88  3.460
3*   1 41134815.34815. 1            -1-1     02212 0 0      8.88  3.46  9.38  3.460
3*   1 51138745.38745. 1            -1-1     02212 0 0      9.38  3.46 10.00  3.500
3*   1 61141560.41560. 1            -1-1     02212 0 0     10.00  3.50 10.58  3.210
3*   1 71141560.41560. 1            -1-1     02212 0 0     10.58  3.21 11.79  3.040
3*   1 81142935.42935. 1            -1-1     02212 0 0     11.79  3.04 12.67  3.040
3*   1 91144415.44415. 1            -1-1     03312 0 0     12.67  3.04 13.29  3.000
3*   1101152660.52660. 1            -1-1     03312 0 0     13.29  3.00 14.63  3.000
3*   1111145510.45510. 1            -1-1     03312 0 0     14.63  3.00 15.17  3.290
3*   1121146075.46075. 1            -1-1     03312 0 0     15.17  3.29 15.92  3.210
3*   1131142880.42880. 1            -1-1     03312 0 0     15.92  3.21 17.08  3.170
3*   1141140985.40985. 1            -1-1     03312 0 0     17.08  3.17 18.75  3.250
3*   1151128185.28185. 1            -1-1     04412 0 0     18.75  3.25 19.92  2.920
3*   1161129075.29075. 1            -1-1     04412 0 0     19.92  2.92 20.46  2.630
3*   11713  300.  300. 1            -1-0     02212 0 0     20.46  2.63 20.42  2.3321
3*   11813  444.  444. 1            -1-0     02212 0 0     20.42  2.33 20.58  2.2921
3*   11913 2020. 2020. 1            -1-0     02212 0 0     20.58  2.29 20.67  2.7421
3*   12012  529.  529. 1            -1-0     02212 0 0     20.67  2.74 20.75  2.920
3*   2 112 9260. 9260. 1            -1-1     02212 0 0     13.63  7.88 13.63  6.790
3*   2 212 9260. 9260. 1            -1-1     02212 0 0     13.63  6.79 13.46  5.960
3*   2 312 8485. 8485. 1            -1-1     02212 0 0     13.46  5.96 13.29  4.460
3*   2 412 4809. 4809. 1            -1-1     02212 0 0     13.29  4.46 13.21  4.460
4*   117150.150.150.150.150015001500150075.64.48.35.
4*   118222.222.222.222.150015001500150010053.72.35.
4*   119101010101010101015001500150015001001007 2.52.
5*   5100 1450
```

CEMAP INPUT FOR SAMPLE RUN
(concluded)

```
                                Column Numbers
1    5    10   15   20   25   30   35   40   45   50
6M   90.     .50  .20  .15  .05
7M   1        5.0        3.01.0                7031 5
7M   2        6.0        3.01.0               76000 5
7M   3        7.0        3.01.0               25430 3
7M   4        8.0        3.01.0               15527 3
7M   5        9.0        3.01.0               54268 3
7M   6       10.0        2.81.0               15184 3
7M   7       11.0        2.51.0                2696 3
7M   8       12.0        2.51.0               52638 2
7M   9       13.0        2.51.0               40480 2
7M  10       14.0        2.51.0               45670 2
7M  11       15.0        2.51.0               42930 2
7M  12       16.0        2.51.0               70258 4
7M  13       17.0        2.51.0               87286 4
7M  14       18.0        2.51.0               94579 4
7M  15       19.0        2.51.0               84775 1
7M  16       20.0       2.251.0              103511 1
7M  17       13.3        7.01.0               15441 3
7M  18       13.3        6.01.0               46083 3
7M  19       13.0        5.01.0               13905 3
7M  20       13.0        4.01.0               74783 2
8M 1.3        200 4
```

CEMAP INPUT FOR SAMPLE RUN
(concluded)

```
                                Column Numbers
1    5    10    15    20    25    30    35    40    45    50
6W   90.   .50  .20  .15  .05
7W   1      5.0        3.01.0                    7031 5
7W   2      6.0        3.01.0                   76000 5
7W   3      7.0        3.01.0                   25430 3
7W   4      8.0        3.01.0                   15527 3
7W   5      9.0        3.01.0                   54268 3
7W   6     10.0        2.81.0                   15184 3
7W   7     11.0        2.51.0                    2696 3
7W   8     12.0        2.51.0                   52638 2
7W   9     13.0        2.51.0                   40480 2
7W  10     14.0        2.51.0                   45670 2
7W  11     15.0        2.51.0                   42930 2
7W  12     16.0        2.51.0                   70258 4
7W  13     17.0        2.51.0                   87286 4
7W  14     18.0        2.51.0                   94579 4
7W  15     19.0        2.51.0                   84775 1
7W  16     20.0       2.251.0                  103511 1
7W  17     13.3        7.01.0                   15441 3
7W  18     13.3        6.01.0                   46083 3
7W  19     13.0        5.01.0                   13905 3
7W  20     13.0        4.01.0                   74783 2
8W 1.3      200 4
```

CEMAP INPUT FOR SAMPLE RUN
(concluded)

```
                    Column Numbers
1    5    10    15    20    25    30    35    40    45    50
6M   90.     .50  .20  .15  .05
7M   1        5.0        3.01.0                    7031  5
7M   2        6.0        3.01.0                   76000  5
7M   3        7.0        3.01.0                   25430  3
7M   4        8.0        3.01.0                   15527  3
7M   5        9.0        3.01.0                   54268  3
7M   6       10.0        2.81.0                   15184  3
7M   7       11.0        2.51.0                    2696  3
7M   8       12.0        2.51.0                   52638  2
7M   9       13.0        2.51.0                   40480  2
7M  10       14.0        2.51.0                   45670  2
7M  11       15.0        2.51.0                   42930  2
7M  12       16.0        2.51.0                   70258  4
7M  13       17.0        2.51.0                   87286  4
7M  14       18.0        2.51.0                   94579  4
7M  15       19.0        2.51.0                   84775  1
7M  16       20.0       2.251.0                  103511  1
7M  17       13.3        7.01.0                   15441  3
7M  18       13.3        6.01.0                   46083  3
7M  19       13.0        5.01.0                   13905  3
7M  20       13.0        4.01.0                   74783  2
8M 1.3        200 4
```

Column Numbers

```
1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
1M   ST LOUIS TEST       770513 2 1 1 1
2M   220 4        201.
3M   1 11120340.20340. 1            -1-1     022125555        5.33  3.67  5.67  3.670
3M   1 21132185.32185. 1            -1-1     02212 0 0        5.67  3.67  7.00  3.670
3M   1 31133700.33700. 1            -1-1     02212 0 0        7.00  3.67  8.88  3.460
3M   1 41134815.34815. 1            -1-1     02212 0 0        8.88  3.46  9.38  3.460
3M   1 51138745.38745. 1            -1-1     02212 0 0        9.38  3.46 10.00  3.500
3M   1 61141560.41560. 1            -1-1     02212 0 0       10.00  3.50 10.58  3.210
3M   1 71141560.41560. 1            -1-1     02212 0 0       10.58  3.21 11.79  3.040
3M   1 81142935.42935. 1            -1-1     02212 0 0       11.79  3.04 12.67  3.040
3M   1 91144415.44415. 1            -1-1     03312 0 0       12.67  3.04 13.29  3.000
3M   1101152660.52660. 1            -1-1     03312 0 0       13.29  3.00 14.63  3.000
3M   1111145510.45510. 1            -1-1     03312 0 0       14.63  3.00 15.17  3.290
3M   1121146075.46075. 1            -1-1     03312 0 0       15.17  3.29 15.92  3.210
3M   1131142880.42880. 1            -1-1     03312 0 0       15.92  3.21 17.08  3.170
3M   1141140985.40985. 1            -1-1     03312 0 0       17.08  3.17 18.75  3.250
3M   1151128185.28185. 1            -1-1     04412 0 0       18.75  3.25 19.92  2.920
3M   1161129075.29075. 1            -1-1     04412 0 0       19.92  2.92 20.46  2.630
3M   11713  300.  300. 1            -1-0     02212 0 0       20.46  2.63 20.42  2.3321
3M   11813  444.  444. 1            -1-0     02212 0 0       20.42  2.33 20.58  2.2921
3M   11913 2020. 2020. 1            -1-0     02212 0 0       20.58  2.29 20.67  2.7421
3M   12012  529.  529. 1            -1-0     02212 0 0       20.67  2.74 20.75  2.920
3M   2 112 9260. 9260. 1            -1-1     02212 0 0       13.63  7.88 13.63  6.790
3M   2 212 9260. 9260. 1            -1-1     02212 0 0       13.63  6.79 13.46  5.960
3M   2 312 8485. 8485. 1            -1-1     02212 0 0       13.46  5.96 13.29  4.460
3M   2 412 4809. 4809. 1            -1-1     02212 0 0       13.29  4.46 13.21  4.460
4M   117150.150.150.150.150015001500150079.64.48.35.
4M   118222.222.222.222.150015001500150010053.72.35.
4M   119101010101010101015001500150015001001007 2.52.
5M   5100 1450
```

ST LOUIS TEST

DATE IS 77 513
FLAG FOR MODE OF MODEL OPERATION IS 2
PATHWAY EMISSIONS FLAG IS 1
NON-PATHWAY EMISSIONS FLAG IS 1
NO. OF PATHWAYS 2
NO. OF GRID SQUARES IS 20
MAP CONVERSION FACTOR IS .100E+01 MI/MAP UNIT

FOR SHORT-TERM MODE TRAFFIC DATA FOR MODELED COMMUTE IS LISTED IN AM POSITION

BASIC TRAFFIC INFORMATION

			VOLUMES				DATA		LANES				SPEED				COORDINATES				INTERSECT	
PATH	LINK	TYPE	IN/AM	OUT/AM	IN/PM	OUT/PM	FORM	SPRD	IN	OUT	WIDTH	CAPCY	IN	OUT	IN	OUT	X1	Y1	X2	Y2	TYPE	DATA
1	1	1	20340.	20340.	0.	0.	-1	-1	2	2	12	0	55	55	0	0	5.330	3.670	5.670	3.670	0	-0
1	2	1	32185.	32185.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	5.670	3.670	7.000	3.670	0	-0
1	3	1	33700.	33700.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	7.000	3.670	8.880	3.460	0	-0
1	4	1	34815.	34815.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	8.880	3.460	9.380	3.460	0	-0
1	5	1	38745.	38745.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	9.380	3.460	10.000	3.500	0	-0
1	6	1	41560.	41560.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	10.000	3.500	10.580	3.210	0	-0
1	7	1	41560.	41560.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	10.580	3.210	11.790	3.040	0	-0
1	8	1	42935.	42935.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	11.790	3.040	12.670	3.040	0	-0
1	9	1	44415.	44415.	0.	0.	-1	-1	3	3	12	0	0	0	0	0	12.670	3.040	13.290	3.000	0	-0
1	10	1	52660.	52660.	0.	0.	-1	-1	3	3	12	0	0	0	0	0	13.290	3.000	14.630	3.000	0	-0
1	11	1	45510.	45510.	0.	0.	-1	-1	3	3	12	0	0	0	0	0	14.630	3.000	15.170	3.290	0	-0
1	12	1	46075.	46075.	0.	0.	-1	-1	3	3	12	0	0	0	0	0	15.170	3.290	15.920	3.210	0	-0
1	13	1	4[illegible]90.	42880.	0.	0.	-1	-1	3	3	12	0	0	0	0	0	15.920	3.210	17.080	3.170	0	-0
1	14	1	4[illegible]35.	40985.	0.	0.	-1	-1	3	3	12	0	0	0	0	0	17.080	3.170	18.750	3.250	0	-0
1	15	1	28185.	28185.	0.	0.	-1	-1	4	4	12	0	0	0	0	0	18.750	3.250	19.920	2.920	0	-0
1	16	1	29075.	29075.	0.	0.	-1	-1	4	4	12	0	0	0	0	0	19.920	2.920	20.460	2.630	0	-0
1	17	3	300.	300.	0.	0.	-1	-0	2	2	12	0	0	0	0	0	20.460	2.630	20.420	2.330	2	1
1	18	3	444.	444.	0.	0.	-1	-0	2	2	12	0	0	0	0	0	20.420	2.330	20.580	2.290	2	1
1	19	3	2020.	2020.	0.	0.	-1	-0	2	2	12	0	0	0	0	0	20.580	2.290	20.670	2.740	2	1
1	20	2	529.	529.	0.	0.	-1	-0	2	2	12	0	0	0	0	0	20.670	2.740	20.750	2.920	0	-0
2	1	2	9260.	9260.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	13.630	7.880	13.630	6.790	0	-0
2	2	2	9260.	9260.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	13.630	6.790	13.460	5.960	0	-0
2	3	2	8485.	8485.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	13.460	5.960	13.290	4.460	0	-0
2	4	2	4809.	4809.	0.	0.	-1	-1	2	2	12	0	0	0	0	0	13.290	4.460	13.210	4.460	0	-0

INTERSECTION INFORMATION

		SIGNALIZED INTERSECTIONS												FREEWAY BACKUPS						
		CAPACITIES				VOLUMES				CYCLE		GREEN		VOLUMES		CAPACITIES		TIMES		TOLLS
PATH	LINK	IN/AM	OPPOSE	OUT/PM	OPPOSE	IN/AM	OPPOSE	OUT/PM	OPPOSE	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN OUT
1	17	1500.	1500.	1500.	1500.	150.	150.	150.	150.	79.	64.	48.	35.							
1	18	1500.	1500.	1500.	1500.	222.	222.	222.	222.	100.	53.	72.	35.							
1	19	1500.	1500.	1500.	1500.	1010.	1010.	1010.	1010.	100.	100.	72.	52.							

9 PC OF NON-PATHWAY ADT DURING WORST COMMUTE HOUR

LOCALE TYPE	RATIO OF SECONDARY TO PRIMARY VMT
1	0.000
2	.500
3	.200
4	.150
5	.050

GRID SQUARE INFORMATION

GRID	XG	YG	GSIZE	GVMT	IGLOC	GEMIS
1	5.000	3.000	1.000	.703E+04	5	
2	6.000	3.000	1.000	.760E+05	5	
3	7.000	3.000	1.000	.254E+05	3	
4	8.000	3.000	1.000	.155E+05	3	
5	9.000	3.000	1.000	.543E+05	3	
6	10.000	2.800	1.000	.152E+05	3	
7	11.000	2.500	1.000	.270E+04	3	
8	12.000	2.500	1.000	.526E+05	2	
9	13.000	2.500	1.000	.405E+05	2	
10	14.000	2.500	1.000	.457E+05	2	
11	15.000	2.500	1.000	.429E+05	2	
12	16.000	2.500	1.000	.703E+05	4	
13	17.000	2.500	1.000	.873E+05	4	
14	18.000	2.500	1.000	.946E+05	4	
15	19.000	2.500	1.000	.848E+05	1	
16	20.000	2.250	1.000	.104E+06	1	
17	13.300	7.000	1.000	.154E+05	3	
18	13.300	6.000	1.000	.461E+05	3	
19	13.000	5.000	1.000	.139E+05	3	
20	13.000	4.000	1.000	.748E+05	2	

```
 WIND SPEED IS   1.3 MPS
 WIND DIRECTION IS 200 DEGREES
 STABILITY IS CLASS  4
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   2.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   2.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   3.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   3.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   4.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   4.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   5.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   5.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   6.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   6.
```

```
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   7.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   7.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   8.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   8.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   9.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK   9.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  10.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  10.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  11.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  11.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  12.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  12.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  13.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  13.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  14.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  14.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  15.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  15.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  16.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
WARNING. ****************
 VOLUME IS GREATERTHAN CAPACITY ON PATHWAY .  1. LINK  16.
 VOLUME IS BEING SET EQUAL TO CAPACITY FOR THIS RUN.  CHECK INPUTS..
```

COMMUTER EXPOSURE STATISTICS

PATHWAY	EXPOSURE FROM PATHWAY SOURCES (GRAM SEC/CU. M)	EXPOSURE FROM NON-PATHWAY SOURCES (GRAM SEC/CU. M)	TOTAL EXPOSURE (GRAM SEC/CU. M)	TOTAL TRAVEL TIME (SEC)	AV. CONCENTRATION (GRAMS/CU. M)	LAST AREA SOURCE CONCENTRATION (GRAMS/CU. M)
1	.180E+02	.193E+02	.374E+02	2394.33	.156E-01	.126E-01
2	.190E+01	.203E+01	.393E+01	423.22	.928E-02	.136E-01

AVERAGE EXPOSURE FOR ALL PATHWAYS (GRAM SEC/CU. M) .206E+02
STANDARD DEVIATION OF PATHWAY EXPOSURE (GRAM SEC/CU. M) .167E+02

CLASS	VALUE LIMITS (GRAM SEC/CU. M)	PERCENT COMMUTERS IN CLASS	PROBABILITY OF EXPERIENCING EXPOSURE CLASS
1	0. - .400E+01	22.	.048
2	.400E+01 - .800E+01	0.	0.000
3	.800E+01 - .120E+02	0.	0.000
4	.120E+02 - .160E+02	0.	0.000
5	.160E+02 - .200E+02	0.	0.000
6	.200E+02 - .240E+02	0.	0.000
7	.240E+02 - .280E+02	0.	0.000
8	.280E+02 - .320E+02	0.	0.000
9	.320E+02 - .360E+02	0.	0.000
10	.360E+02 - .400E+02	76.	.952

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TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE COMMUTER EXPOSURE MODEL User's Guide		5. REPORT DATE
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) P. B. Simmon and R. M. Patterson		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS SRI International Menlo Park, CA 94025		10. PROGRAM ELEMENT NO. CDTA1D/04-0500 (FY-82)
		11. CONTRACT/GRANT NO. 68-02-2981
12. SPONSORING AGENCY NAME AND ADDRESS Environmental Sciences Research Laboratory--RTP,NC Office of Research and Development U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711		13. TYPE OF REPORT AND PERIOD COVERED Final 10/78 - 4/81
		14. SPONSORING AGENCY CODE EPA/600/09
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

The commuter exposure modeling package consists of two documents. This volume is the User's Guide. It describes program execution and provides the user with the information needed to run the program. The other volume provides a detailed description of the model methodology and code. In this guide, the potential uses of the model are discussed and a brief overview of the modeling methodology is presented. A comprehensive section describing the details of the implementation of the model methodology on a computer and the associated computer requirements is included.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 139
	20. SECURITY CLASS *(This page)*	22. PRICE

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