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CDM 2.0 -- CLIMATOLOGICAL DISPERSION MODEL

User's Guide

by

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AFFILIATION

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FOREWORD

The Atmospheric Sciences Research Laboratory conducts a research program in the physical sciences to detect, define, and quantify the effects of air pollution on urban, regional, and global atmospheres and the subsequent impact on water quality and land use. This includes research and development programs designed to quantify the relationships between emissions of pollutants from all types of sources and air quality and atmospheric effects.

The Meteorology and Assessment Division conducts research programs in environmental meteorology to describe the roles and interrelationships of atmospheric processes and airborne pollutants in effective air and land resource management. Developed air quality simulation models are made available to dispersion model users in computer-readable form (magnetic tape media) from NTIS (see preface).

CDM-2.0 is an enhanced version of CDM. The following options have been added to the original CDM algorithm: 16 or 36 wind-direction sectors, initial dispersion, buoyancy-induced dispersion, stack downwash, and gradual plume rise. In addition, the user has a choice of seven dispersion parameter schemes. The output format has been modified to enhance readability. Concentration versus stability histograms have been added to an output option.

Limitations are imposed on the use of the program by the assumption that pollutants are nonreactive and that one wind vector and stability class are representative of the area being modeled. Despite these limitations, CDM-2.0 is a useful long-term (seasonal or annual) algorithm for estimating nonreactive pollutant concentrations from point and area sources in a rural or urban setting.

A. H. Ellison
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PREFACE

One area of research within the Meteorology and Assessment Division is development, evaluation, validation, and application of models for air quality simulation, photochemistry, and meteorology. The models must be able to describe air quality and atmospheric processes affecting the dispersion of airborne pollutants on scales ranging from local to global. Within the Division, the Environmental Operations Branch adapts and evaluates new and existing meteorological dispersion models and statistical technique models, tailors effective models for recurring user application, and makes these models available through EPA's User's Network for Applied Modeling of Air Pollution (UNAMAP) system.

CDM-2.0 estimates long-term nonreactive pollutant concentrations using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability.

Although attempts are made to thoroughly check computer programs with a wide variety of input data, errors are occasionally found. Revisions may be obtained as they are issued by completing and returning the form on the last page of this guide.

The first four sections of this document are directed to managers and project directors who wish to evaluate the applicability of the model to their needs. Sections 5, 6, and 10 are directed to engineers, meteorologists, and other scientists who are required to become familiar with the details of the model. Finally, Sections 7 through 10 are directed to persons responsible for implementing and executing the program.

Comments and suggestions regarding this publication should be directed to:

Chief, Environmental Operations Branch
Meteorology and Assessment Division (MD-80)
Environmental Protection Agency
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Technical questions regarding use of the model may be asked by calling (919) 541-4564. Users within the Federal Government may call FTS 629-4564. Copies of the user's guide are available from the National Technical Information Service (NTIS), Springfield, VA 22161.

The next release of UNAMAP (Version 6) will include the code for CDM-2.0. Inquiries regarding the purchase of UNAMAP should be addressed to Computer Products, NTIS, Springfield, VA 22161 (phone number: 703-487-4763).

ABSTRACT

CDM-2.0 (Climatological Dispersion Model - Version 2.0) determines long-term (seasonal or annual) quasi-stable pollutant concentrations in rural or urban settings using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability. The model is applicable to flat or gently rolling terrain. The Gaussian plume hypothesis forms the basis for the calculations; contributions are obtained assuming the narrow plume hypothesis, Calder (1971, 1977), and involve an upwind integration over the area sources. Computations can be made for up to 200 point sources and 2500 area sources at an unlimited number of receptor locations. The number of point and area sources can be easily modified within the code. CDM-2.0 is an enhanced version of CDM including the following options: 16 or 36 wind-direction sectors, initial plume dispersion, buoyancy-induced dispersion, stack-tip downwash, and gradual (transitional) plume rise. The user has a choice of seven dispersion parameter schemes. Also new in this release is a default option to set input parameters for regulatory use. Optional output includes point and area concentration roses and histograms of pollutant concentration by stability class.

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SYMBOLS AND ABBREVIATIONS

Dimensions are abbreviated as follows:
m = mass, l = length, t = time, K = temperature

a, b, c	= constants in dispersion parameter equations
A, B	= calibration constants (i.e., intercept and slope, respectively)
$\bar{C}_A$	= average concentration from area sources (m/l^3)
$\bar{C}_P$	= average concentration from point sources (m/l^3)
D_s	= stack inside diameter (l)
f	= stack-tip downwash correction factor
f_e	= fraction of the input area-source height that represents the physical height
F	= buoyancy flux parameter (l^4/t^3)
Fr	= Froude number
g	= acceleration due to gravity (l/t^2)
G_n	= emission rate of nth point source (m/t)
h	= physical stack height (l)
h'	= stack height adjusted for Briggs stack-tip downwash (l)
H	= effective stack height (l)
H_a	= input area source height (physical height plus assumed effluent rise with a 5 m/sec wind speed) (l)
k	= index identifying the wind-direction sector
k_n	= wind sector appropriate for nth point source
ℓ	= index identifying the wind-speed class
L	= mixing height (l)
m	= index identifying the stability category
n	= number of point sources
N	= number of wind-direction sectors
p	= wind-profile exponent

p_a = atmospheric pressure (m/lt^2)
P_m = stability class
$Q(\rho,\theta)$ = area source emission rate per unit area (m/tl^2)
$q_k(\rho)$ = $\int Q(\rho,\theta)d\theta$ (m/t)
s = stability parameter (t^{-2})
$S(\rho,z;U_\ell,P_m)$ = dispersion function
$T_{1/2}$ = pollutant half-life (t)
T_a = ambient air temperature (K)
T_s = stack gas exit temperature (K)
U = wind speed at stack height (l/t)
U_ℓ = representative wind speed (l/t)
V_s = stack gas exit velocity (l/t)
x_f = distance to final rise (l)
x^* = distance at which atmospheric turbulence begins to dominate entrainment (l)
X, Y = axes of the grid system; X-axis points east and Y-axis points north
z = height of receptor above ground level (l)
ΔH = plume rise (l)
$\partial\theta/\partial z$ = vertical potential temperature gradient of a layer of air (K/l)
θ = angle relative to polar coordinates centered on receptor (radians)
ρ = distance from receptor to source (l)
ρ_n = distance from receptor to nth point source (l)
σ_z = vertical dispersion parameter (l)
σ_{zb} = buoyancy-induced vertical dispersion (l)
σ_{ze} = effective vertical dispersion (l)
$\phi(k,\ell,m)$ = meteorological joint frequency function

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EXECUTIVE SUMMARY

CDM-2.0 (Climatological Dispersion Model - Version 2.0) determines long-term (seasonal or annual) pollutant concentrations in a rural or urban setting using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability. The algorithm is based on Gaussian plume assumptions and is thus subject to the limitations of nonreactive pollutants and a homogeneous wind field. Terrain in the modeling region is assumed to be level or gently rolling. Computations can be made for up to 200 point sources and 2500 area sources at an unlimited number of receptor locations.

CDM-2.0 is an enhanced version of CDM. The enhancements of CDM-2.0 give the user added flexibility to tailor technical features of the model to particular source-receptor configurations and locales. The joint-frequency function describing the meteorology can be specified using either a 16-point or a 36-point compass for the wind sectors. The initial dispersion for point sources can be computed as either a building effect (affecting dispersion from sources with stack heights below 50 m), as a buoyant plume rise effect (described by Pasquill, 1976), or both. Provision has been made to allow estimation of the effects of stack downwash on the plume rise using either of two algorithms -- Briggs (1974) or Bjorklund and Bowers (1982). The user has the option of choosing among seven schemes for characterizing vertical dispersion downwind of the source. Added to the dispersion algorithm used by CDM (Busse and Zimmerman, 1973) are the following schemes:

- Briggs-rural (Gifford, 1976),
- Briggs-urban (Gifford, 1976),
- Brookhaven National Laboratory (Singer and Smith, 1966),

- Klug (Vogt, 1977),
- St. Louis (Vogt, 1977), and
- PGSIG (Pasquill, 1961 and Gifford, 1960).

The former versions of CDM "slipped" the categories to account for urban effects on the dispersion. The inclusion of the various dispersion characterizations provides the user with both urban and rural dispersion schemes. Under user control is the specific curve to be applied to each of the stability categories of the input frequency function. The user specifies the initial dispersion for each stability category for use in the area source computations. The user specifies the power-law exponent and the central wind speed values to be employed for each stability category. Provision is made to model pollutant removal by physical or chemical processes by a half-life decay that is user specified. Plume rise for the point sources can be calculated following the methods of Briggs (1969, 1971, and 1975) or using the methods of Holland (1953). Provision has been made to allow estimation of the effects of wind speed variation on the area-source effective release height as described by Turner and Novak (1978). The output format has been modified to enhance readability; concentration versus stability histograms have been added as an output option. Also new in this release is a default option to set input parameters for regulatory use.

The source code has been designed so that future enhancements can be readily implemented. For instance, the number of sources considered by the model can be modified by a global change within the code. Also, other dispersion schemes can be added to subroutine SIGMAZ with little difficulty.

SECTION 1

INTRODUCTION

CDM-2.0 is an enhanced version of CDM (Version 80247) affording the user increased control of the technical features to be employed in each modeling analysis. The user now controls the specification of the wind profile power-law exponents, the central wind speed values, the dispersion curves, and the mixing heights to be associated with each stability category. These were formerly defined by DATA statements in CDM and beyond user control. The plume rise algorithm has been modified to handle rise during stable conditions and to consider momentum-dominated plumes. Stack downwash can be modeled using either of two schemes -- Briggs (1974) or Bjorklund and Bowers (1982). Initial dispersion can be modeled as (1) a building effect, affecting sources with stack heights below 50 m, (2) as a buoyant plume-rise effect, as described by Pasquill (1976), or (3) joint building and buoyant rise effects. The user has the option of choosing among seven schemes for characterizing vertical dispersion downwind of the source. The output format has been modified to enhance readability and the concentration versus stability histogram has been added as an output option.

CDM-2.0 is applicable to locations with level or gently rolling terrain. The Gaussian plume hypothesis is the basis for the model. Pasquill and Meade (1958) first modified the Gaussian plume equation to estimate long-term average concentrations from a particular source using a wind direction frequency distribution. Expanding on Pasquill and Meade's initial work, Martin and Tikvart (TRW Systems Group, 1969; Martin and Tikvart, 1968; and Martin, 1971) developed AQDM (Air Quality Display Model). In their methodology, the frequency of occurrence of various possible combinations of wind direction, wind speed, and atmospheric stability are used to obtain long-term average concentrations from a multiple source grid. Calder (1971, 1977) formulated a model called CDM (Climatological Dispersion Model) which eventually superseded AQDM. Although similiar to AQDM in many respects, CDM has several distinct features. AQDM treats area sources via a modified virtual point source technique. In CDM, contributions from area sources are calculated by assuming the narrow plume hypothesis (Calder, 1971, 1977) and involve an upwind integration over the area sources. Holland's plume rise equation (Holland, 1953) is used in AQDM, while in CDM the user has a choice between Briggs' plume rise (Briggs, 1971) or Holland's equation. A power-law profile is used in CDM to extrapolate surface wind speeds to the source height. AQDM and CDM were two of six air quality dispersion models used to calculate annual (1969) sulfur dioxide and total suspended particulate matter for the New York Air Quality Control Region (Turner et al., 1972). Model-predicted concentrations were compared statistically with the measured values. The results indicate that CDM performed better than AQDM (i.e., errors in the means and maxima were smaller for CDM).

This document is divided into three parts, each directed to a different reader: managers, dispersion meteorologists, and computer specialists. The first four sections are aimed at managers and project directors who wish to evaluate the applicability of the model to their needs. Sections 5, 6, and 10 are directed toward dispersion meteorologists or engineers who are required to become familiar with the details of the model. Finally, Sections 7 through 10 are directed toward persons responsible for implementing and executing the program. An example for model execution with the default option is given in Appendix A; detailed program flow diagrams and a listing of the FORTRAN source statements are given in Appendices B and C respectively.

SECTION 2

DATA-REQUIREMENTS CHECKLIST

CDM-2.0 requires data on user options, grid dimensions, sources, meteorology, receptors, and model calibration constants. The user must indicate whether the following options are to be employed for point source calculations:

- Initial dispersion and/or buoyancy-induced dispersion,
- Stack-tip downwash, and
- Gradual plume rise.

Also to be indicated is whether the stability array data is divided into 16 or 36 wind-direction sectors. Additionally, there is a choice of one of seven dispersion schemes. Output options include area and point source concentration roses and concentration versus stability histograms at selected receptors.

Information required for each source includes the following:

- Location (user units),
- Area-source side length (m)
- Average emission rate (g/sec) for both pollutants,
- Daytime and nighttime emission rate ratios,
- Source height (m),
- Stack diameter (m),
- Stack gas exit velocity (m/sec),
- Stack gas temperature (°F, °C, or K), and
- Decay half-life (hr).

Area-source side length is required for area sources; stack diameter, exit velocity, and exit temperature are pertinent to point sources only.

Meteorological data needed for the computations are:

- Joint frequency function of wind direction, wind speed, and stability category,
- Average wind speed (m/sec) representing each of six wind-speed categories,
- Mean atmospheric temperature (°C),
- Mixing heights (m) for each of six stability classes, and
- Wind-profile exponents for each stability class.

The user has the option of inputting a joint frequency function based on 16 or 36 wind-direction sectors. The first wind sector of the joint frequency function must be centered on the wind direction azimuth of 0°.

The location of each receptor must be indicated. If available, the observed concentration of each pollutant can be supplied. Also the user has the option of specifying the height above ground (m) of all the receptors.

Calibration constants based on previous CDM-2.0 runs and on observed data can be provided and used to obtain adjusted concentration values.

SECTION 3

FEATURES AND LIMITATIONS

As noted previously, CDM-2.0 is an upgraded version of program CDM which was released in 1973. CDM-2.0 is a long-term (seasonal or annual) algorithm for evaluating the effects of multiple point and area sources in the near-field (within 25 km). The modeling region should consist of relatively flat terrain. The model includes the following computation features in common with CDM:

- Can handle up to 200 point sources and 2500 area sources,
- Unlimited number of receptors can be considered, and
- Optional use of Holland's equation (1953) for limiting plume rise.

It should be noted that the number of sources can be modified by a global change within the code. Optional output features common to both CDM and CDM-2.0 are point and area concentration roses at a set of user-specified receptors. The user can reduce output volume by just listing concentration results and not echoing the input data.

Modeling features added to CDM-2.0 include:

- Optional initial dispersion, buoyancy-induced dispersion, stack-tip downwash, and gradual plume rise;
- Choice of joint frequency function based on 16 or 36 wind direction sectors;
- Choice of one of seven dispersion parameter schemes;
- Optional output of concentration versus stability histograms at user-specified receptors; and
- Default option to set input parameters for regulatory use.

The plume rise algorithm has been modified to handle rise during stable conditions and to consider momentum-dominated plumes.

Its limitations are as follows:

- Source emissions and meteorology should be uncorrelated,
- Variation in emission rate between adjacent area sources is assumed to be negligible,
- Terrain should be flat to gently rolling, and
- No consideration of chemical reactions or removal other than that which can be handled as a simple exponential decay.

It is assumed that one wind vector and one stability category are representative at any given time of the area being modeled.

Table 1 compares CDM-2.0 features to those of other long-term air quality models.

TABLE 1. A COMPARISON OF CDM-2.0 TO OTHER COMMONLY USED LONG-TERM AIR QUALITY MODELS.

X - used by model O - optional	CDM-2.0	MPTER	CRSTER	VALLEY	ISC	CDM
MODEL TYPE						
Gaussian	X	X	X	X	X	X
AVERAGING PERIOD						
Hour		O	X		O	
3-hour		O	X		O	
24-hour		O	X	O	O	
Annual	X	O	X	O	O	X
TYPE OF SOURCES						
Single stack	X	X	X	X	X	X
Multiple stacks	200	250	19[1]	50[2]	X[3]	200
Area sources	2500			50[2]	X[3]	2500
RECEPTORS						
Number of	X[4]	180	180	112	360	X[4]
Cartesian coordinates		X			X	X
Cartesian coordinates w/ elevations	X	X			X	
Polar coordinates		X	X		X	
Polar coordinates w/ elevations		X	X	X	X	
METEOROLOGICAL DATA						
RAMMET preprocessor		X	X		X	
STAR file[5]	X			X	X	X
User specified	X	O		X	O	X
POLLUTANT						
Non-reactive	X	X	X	X	X[6]	X
Half-life	O	O	O	O	O	O
PLUME RISE						
Stack-tip downwash	O	O	O		O	
Gradual plume rise	O	O	O	O	O	X
Buoyancy-induced dispersion	O	O	O	O		
TERRAIN ADJUSTMENTS		O	O	O	O	

(1) Collocated stacks.
(2) Total of 50 point and/or area sources.
(3) Number of sources depends upon several input parameters.
(4) Unlimited.
(5) Note the difference in STAR file for VALLEY, ISC, CDM.
(6) Gravitational settling and dry deposition considered.

SECTION 4

BASIS FOR CDM-2.0

This section presents a brief narrative highlighting important aspects of the modeling approach. A detailed technical description, including equations, is provided in Section 5.

GAUSSIAN PLUME ORIGINS

CDM-2.0 is based upon the Gaussian plume hypothesis. Gaussian plume methodology assumes that pollutant concentrations from a continuously emitted plume are proportional to the emission rate, and are diluted by the wind at the point of emission at a rate inversely proportional to the wind speed. It is also assumed that the pollutant concentrations in the vertical near the source are closely described by Gaussian or normal distributions. Calder (1971, 1977) showed that under the special circumstance when emissions and meteorology can be treated as statistically independent, i. e., uncorrelated, that the long-term average concentration values can be estimated using the average emission values and the joint frequency function of meteorological conditions. In the methodology, the joint frequency function is assumed to be piece-wise constant in 22.5° (10°) wind sectors of a 16-point (36-point) compass. We assume that in practice (and certainly when large grid areas are used to specify the area-source emissions), the variations in emission rates between adjacent area sources can be disregarded. Then under the narrow plume hypothesis, the equations for computing the long-term average concentration contributions from the point sources and the area sources do not involve the crosswind dispersion parameter, but only the vertical dispersion parameter. The area-source contributions are determined by an integration over the upwind area sources. For this integration, an area-source emission rate (over the wind-sector width) is determined at various distances upwind from each receptor.

PLUME RISE

The user can choose between two methods of estimating plume rise: Briggs' plume rise (1969, 1971, and 1975) and Holland's equation (1953). The Briggs formulation treats both buoyancy-dominated and momentum-dominated rise. In Holland's equation, the value of the product of the average wind speed and the height of plume rise is used. This option permits no variation of the product with distance from the stack and the magnitude of the plume rise is at the discretion of the user.

DISPERSION ALGORITHMS

As an option the user can choose one of seven schemes for characterizing vertical dispersion downwind of the source. These include the following:

- Briggs-rural (Gifford, 1976),
- Briggs-urban (Gifford, 1976),
- Brookhaven National Laboratory (Singer and Smith, 1966),
- Klug (Vogt, 1977),
- St. Louis (Vogt, 1977),
- PGCDM (Busse and Zimmerman, 1973), and
- PGSIG (Pasquill, 1961 and Gifford, 1960).

The above algorithms are functions of downwind distance and atmospheric stability. Dispersion curves and equations for each of the schemes are presented in the next section.

SECTION 5

TECHNICAL DESCRIPTION

This section expands on concepts mentioned briefly in Section 4. The mathematical formulation of the physical processes simulated by CDM-2.0 are presented here. Equations are shown in their final form (i.e., without derivations); however, references are provided for those readers interested in the details.

METEOROLOGICAL PARAMETERS

Joint Frequency Function

The joint frequency function (also known as STability ARray) is required as input for the model. This function gives the joint frequency of occurrence of a wind-direction sector, a wind-speed class, and a stability category index. The user has the option of providing a joint frequency function based on 16 wind-direction sectors (each sector is 22.5°) or 36 sectors (each sector is 10°). It is required that the first wind sector be centered on the wind direction azimuth of 0°. There are 576 entries in the joint frequency function table for 16 wind-direction sectors (i.e., 16 wind-direction sectors, 6 wind-speed classes, and 6 stability classes). If the user's joint frequency function is based on a 36 point wind rose, then there are 1296 entries in the table.

The relationship between the Pasquill stability classes and those used in CDM-2.0 is shown in Table 2.

TABLE 2. RELATIONSHIP BETWEEN PASQUILL STABILITY CLASSES AND THOSE USED IN CDM-2.0

Pasquill stability class	CDM-2.0 stability index
A	1
B	2
C	3
D, day	4
D, night	5
E	6
F	7

The seven classes result from neutral stability being separated into daytime and nighttime conditions. Although CDM-2.0 recognizes 7 distinct categories, the joint frequency function is assumed to be comprised of only 6 stability classes. The user indicates the dispersion curve associated with each of the stability categories of his joint frequency data via variables ICP and ICA. These and other input parameters are described in Section 8.

The user must supply the central wind speed values for a height of 10 m above ground level for each of the six speed categories; typically that is the harmonic average wind speed. Wind speed intervals assumed in the National Climatic Center (NCC) STAR summaries are shown in Table 3, along with appropriate central wind speeds.

TABLE 3. NCC STAR SPEED INTERVALS AND CENTRAL WIND SPEEDS

Wind speed class	NCC speed interval (knots)	Central wind speeds (m/sec)
1	0 to 3	1.50 *
2	4 to 6	2.46
3	7 to 10	4.47
4	11 to 16	6.93
5	17 to 21	9.61
6	> 21	12.52

* Light winds reported in the first wind speed class are rounded up to 1.50 m/sec. Operational wind instruments are designed for durability and also to withstand exposure to strong, gusty airflow. For these reasons, most wind sensors have a high starting speed, which can lead to the erroneous reporting of light winds as calms (Truppi, 1968).

Wind Profile

Wind speed generally increases with height above the surface, and this increase depends on both surface roughness and atmospheric stability. A power-law profile of the form

$$U(z) = U_{\ell}(z/10)^{p} \tag{1}$$

is used by CDM-2.0 to approximate this increase. The wind speed at a height z above the ground is $U(z)$; U_{ℓ} is the wind speed measured at the anemometer height (10 m above the ground); and p is a function of stability. The user supplies the wind-profile exponents, p, for each stability class. Suggested wind-profile exponents are shown in Table 4. For a more detailed discussion of wind profiles, the reader may refer to Irwin (1979).

TABLE 4. WIND PROFILE EXPONENTS FOR TWO SURFACE ROUGHNESSES

	Stability class					
	A	B	C	D	E	F
Urban p	0.15	0.15	0.20	0.25	0.30	0.30
Rural p	0.07	0.07	0.10	0.15	0.35	0.55

Mixing Height

The magnitude of the mixing height undergoes considerable diurnal, seasonal, and annual variation. It is impractical to account for all such variations in detail. Some recognition is given to changes in the magnitude of the mixing height by assigning an appropriate value to each stability category. The user must choose an appropriate relationship between mixing height and stability category. One possible parameterization is given in Table 5.

TABLE 5. MIXING HEIGHTS BASED ON STABILITY CATEGORY

Stability category	Mixing height, meters
A	$3\bar{L}/2$
B	$\bar{L}$
C	$\bar{L}$
D,day	$\bar{L}$
D,night	$(\bar{L} + L_{min})/2$
E - F	L_{min}

In Table 5, $\bar{L}$ is the climatological mean value of the mixing height as tabulated by Holzworth (1972) and L_{min} is the nocturnal mixing height.

CONCENTRATION FORMULAS

The average concentration due to area sources, $\bar{C}_A$, at a particular receptor is given by

$$\bar{C}_A = (N/2\pi) \int_0^{\infty} [\sum_{k=1}^{N} q_k(\rho) \sum_{\ell=1}^{6} \sum_{m=1}^{6} \phi(k,\ell,m)\ S(\rho,z;U_\ell,P_m)]\ d\rho, \quad (2)$$

where,

N = number of wind-direction sectors (i.e., 16 or 36),

k = index identifying wind-direction sector,

$q_k(\rho)$ = $\int Q(\rho,\theta)d\theta$ for the k sector,

$Q(\rho,\theta)$ = emission rate of the area source per unit area,

ρ = distance from the receptor to an infinitesimal area source,

θ = angle relative to polar coordinates centered on the receptor,

ℓ = index identifying the wind-speed class,

m = index identifying the stability category,

$\phi(k,\ell,m)$ = joint frequency function,

$S(\rho,z;U_\ell,P_m)$ = dispersion function defined in Eqs. 4 and 5,

z = height of receptor above ground level,

U_ℓ = representative wind speed,

P_m = stability category.

For point sources, the average concentration due to n point sources, $\bar{C}_P$, is given by

$$\bar{C}_P = (N/2\pi) \sum_{n=1}^{n} \sum_{\ell=1}^{6} \sum_{m=1}^{6} [\phi(k_n,\ell,m)\, G_n\, S(\rho_n,z;U_\ell,P_m)]/\rho_n , \quad (3)$$

where

k_n = wind sector appropriate to the nth point source,

G_n = emission rate of the nth point source,

ρ_n = distance from the receptor to the nth point source.

The dispersion function, $S(\rho,z,;U_\ell,P_m)$, is defined as

$$S(\rho,z;U_\ell,P_m) = 2/(\sqrt{2\pi}U_\ell\sigma_z)\Big[\exp\{-(1/2)[(z-H)/\sigma_z]^2\} + \exp\{-(1/2)[(z+H)/\sigma_z]^2\}\Big]\exp[-0.692\rho/(U_\ell T_{1/2})], \quad (4)$$

if σ_z < 0.8L and as

$$S(\rho,z;U_\ell,P_m) = (1/U_\ell L)\exp[-0.692\rho/(U_\ell T_{1/2})], \quad (5)$$

if σ_z > 0.8L. New terms in Eqs. 4 and 5 are defined as follows:

σ_z = vertical dispersion parameter, i.e., the standard deviation of the pollutant concentration in the vertical plane, H = effective stack height of source distribution, i.e., the average height of area source emissions in the kth wind direction sector at radial distance ρ from the receptor,

L = the mixing height,

$T_{1/2}$ = assumed half-life of pollutant (hr).

The possibility of pollutant removal by physical or chemical processes is included in the program by the decay expression, $\exp[-0.692\rho/(U_{\ell}T_{1/2})]$. The total concentration for the averaging period is the sum of concentrations of the point and area sources for that averaging period.

Computational procedures for area source contributions differ among the sector-average models in UNAMAP. For instance, Valley and ISCLT consider area sources as virtual point sources (Burt, 1977; Bowers et al., 1979). This computational method differs from the procedure used in CDM-2.0, which is discussed next.

Suppose that receptor R is located within the grid array as shown in Figure 1a. The first step in the program is to determine the distance from the receptor to the farthest corner of the grid array. This distance, ρ_M, is taken as the upper limit of the integral $q_k(\rho)$ in Eq. 2.

An angular integration, using the trapezoidal rule, is carried out numerically, as shown in the blow-up in Figure 1b. This integration determines $q_k(\rho)$ at various increments of ρ, as indicated in Table 6.

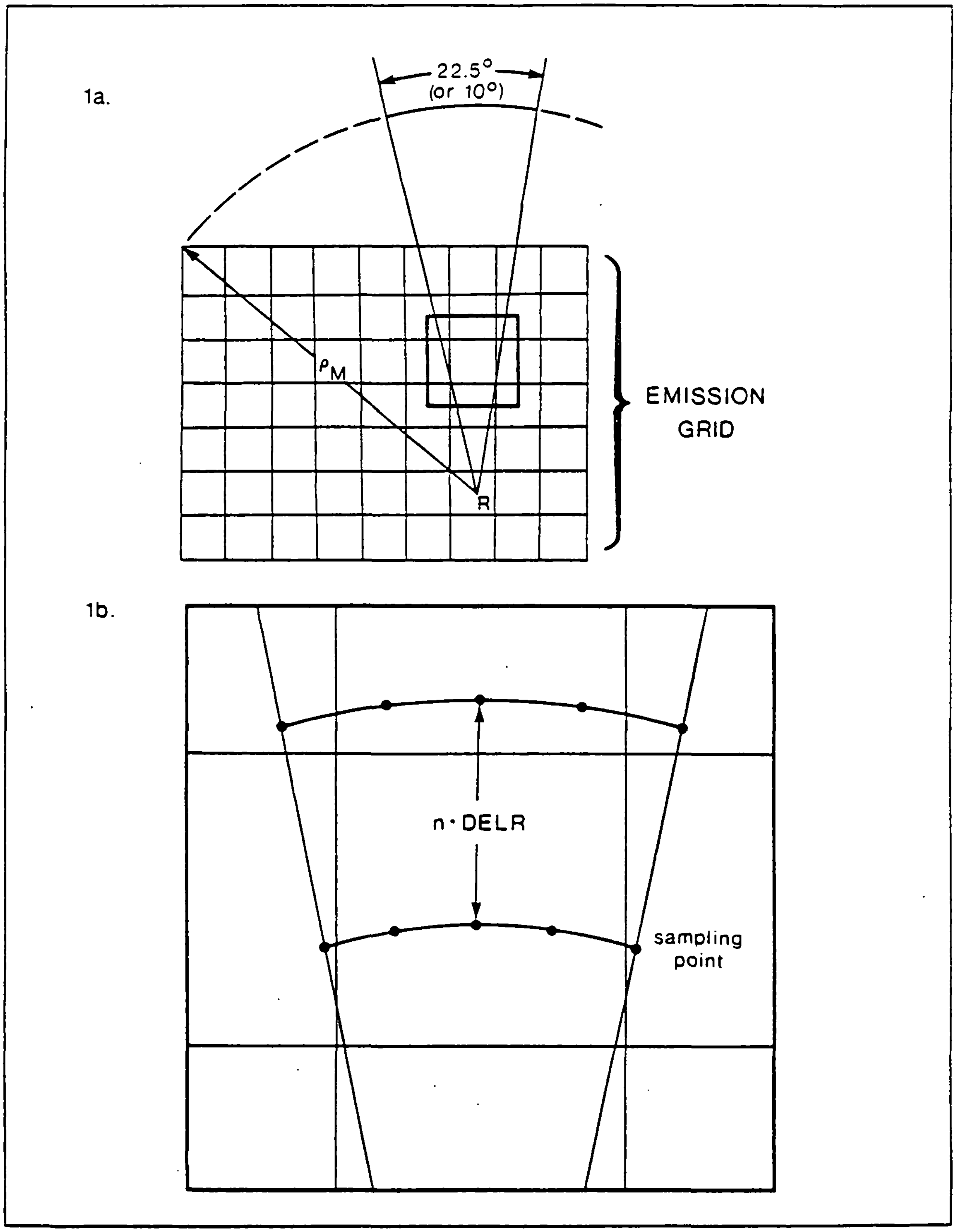


Figure 1. Illustration of sector integration (modified from Busse and Zimmerman, 1973).

TABLE 6. INCREMENTS OF INTEGRATION

Upwind range (m)	Increment *
$0 < \rho < 2500$	DELR
$2500 < \rho < 5000$	2•DELR
$5000 < \rho \leq \rho_M$	4•DELR

* The value of DELR is controlled by the user (see Section 8).

The integration over ρ (see Eq. 2) follows next and is also accomplished using the trapezoidal rule. As shown in Figure 1, the integration over ρ extends beyond the boundary of the grid system but no additional contribution to the concentration occurs since the source density is zero.

In the case where the receptor lies outside the emission grid array, the nearest distance, ρ_m, to the grid boundary as well as the maximum distance, ρ_M, is found. The lower limit to the integral over ρ is then ρ_m and the upper limit is ρ_M. Evaluating the integral from ρ_m instead of from zero results in reduced computer time.

STACK DOWNWASH

The user has the option of applying either of two stack-tip downwash algorithms: Briggs' (1974) or Bjorklund and Bowers' (1982).

Briggs Stack Downwash

The physical height is modified following Briggs (1974, p. 4). The modified physical stack height, h', is found from

$$h' = \begin{cases} h + 2[(V_s/U) - 1.5]D_s & \text{for } V_s < 1.5U, \\ h & \text{for } V_s \geq 1.5U, \end{cases} \qquad (6)$$

where h is the physical stack height (meters), V_s is stack gas velocity (m/sec), and D_s is inside stack-top diameter (meters). If the user chooses this downwash algorithm, then h' is used throughout the remainder of the plume height computation.

Bjorklund and Bowers Stack Downwash

The effects of stack-tip downwash can also be simulated by applying a correction factor to the estimated plume rise. According to Bjorklund and Bowers (1982) the stack-tip downwash correction factor, f, is defined by

$$f = \begin{Bmatrix} 1 & \text{for } U \le V_s/1.5 \\ (3V_s - 3U)/V_s & \text{for } V_s/1.5 < U < V_s \\ 0 & \text{for } U \ge V_s \end{Bmatrix} . \qquad (7)$$

This correction factor accounts for the effects of downwash in the lee of stacks during periods when the wind speed at the stack height is greater than or equal to 0.67 times the stack gas exit velocity. It is not used (i.e., f = 1) for stacks with Froude numbers less than 3.0. The Froude number, Fr, is the ratio of the inertial force to the force of gravity for a given fluid flow. Briggs (1969) defines the Froude number for stack gas releases as

$$Fr = V_s^2/\{g[(T_s - T_a)/T_a]D_s\}. \qquad (8)$$

PLUME RISE

The user has a choice between two methods of estimating plume rise: Briggs' algorithm (1969, 1971, and 1975) and Holland's equation (1953).

Briggs Plume Rise

Neutral-Unstable Momentum Rise--

Regardless of the atmospheric stability, neutral-unstable momentum rise is calculated. The plume rise is calculated from Briggs' (1969, p. 59) Eq. 5.2:

$$\Delta H = 3D_s V_s/U. \qquad (9)$$

Briggs (1969) suggests that this equation is most applicable when

V_s/U is greater than 4. Since momentum rise occurs quite close to the point of release, the distance to final rise is set equal to zero.

Neutral-Unstable Buoyancy Rise--

The value of the Briggs buoyancy flux parameter, F (m^4/s^3), is needed for computing the distance to final rise and the plume rise. The following equation is equivalent to Briggs' (1975, p. 63) Eq. 12:

$$F = (gV_s D_s^2 \Delta T)/(4T_s), \qquad (10)$$

where $\Delta T = T_s - T_a$, T_s is stack gas temperature (K), and T_a is ambient air temperature (K).

For situations where $T_s \geq T_a$, buoyancy is assumed to dominate. The distance to final rise x_f (in kilometers) is determined from the equivalent of Briggs' (1971, p. 1031) Eq. 7, and the distance to final rise is assumed to be 3.5x*, where x* is the distance at which atmospheric turbulence begins to dominate entrainment. For F less than 55,

$$x_f = 0.049F^{5/8}. \qquad (11)$$

For F equal to or greater than 55,

$$x_f = 0.119F^{2/5}. \qquad (12)$$

The plume rise, ΔH (in meters), is determined from the equivalent of the combination of Briggs' (1971, p. 1031) Eqs. 6 and 7. For F less than 55,

$$\Delta H = 21.425F^{3/4}/U. \qquad (13)$$

For F equal to or greater than 55,

$$\Delta H = 38.71F^{3/5}/U. \qquad (14)$$

If the neutral-unstable momentum rise (previously calculated from Eq. 9) is higher than the neutral-unstable buoyancy rise calculated here, momentum rise applies and the distance to final rise is set equal to zero.

Stability Parameter--

For stable situations, the stability parameter s is calculated from the equation (Briggs, 1971, p. 1031):

$$s = g(\partial \theta / \partial z)/T_a . \tag{15}$$

As an approximation, for stability class E (or 6), $\partial\theta/\partial z$ is taken as 0.02 K/m, and for stability class F (or 7), $\partial\theta/\partial z$ is taken as 0.035 K/m.

Stable Momentum Rise--

When the stack gas temperature is less than the ambient air temperature, it is assumed that the plume rise is dominated by momentum. The plume rise is calculated from Briggs' (1969, p. 59) Eq. 4.28:

$$\Delta H = 1.5[(V_s^2 D_s^2 T_a)/(4T_s U)]^{1/3} s^{-1/6} . \tag{16}$$

This is compared with the value for neutral-unstable momentum rise (Eq. 9) and the lower of the two values is used as the resulting plume height.

Stable Buoyancy Rise--

For situations where $T_s \geq T_a$, buoyancy is assumed to dominate. The distance to final rise (in kilometers) is determined by the equivalent of a combination of Briggs' (1975, p. 96) Eqs. 48 and 59:

$$x_f = 0.0020715Us^{-1/2} . \tag{17}$$

The plume rise is determined by the equivalent of Briggs' (1975, p. 96) Eq. 59:

$$\Delta H = 2.6[F/(U \cdot s)]^{1/3} . \tag{18}$$

The stable buoyancy rise for calm conditions (Briggs, 1975, pp. 81-82) is also evaluated:

$$\Delta H = 4F^{1/4} s^{-3/8} . \tag{19}$$

The lower of the two values obtained from Eqs. 18 and 19 is taken as the plume rise.

If the stable momentum rise is higher than the stable buoyancy rise calculated here, momentum rise applies and the distance to final rise is set equal to zero.

Gradual Plume Rise--

If the user exercises the gradual plume rise option and the distance upwind from receptor to source x (in kilometers) is less than the distance to final rise, the equivalent of Briggs' (1971, p. 1030) Eq. 2 is used to determine plume rise:

$$H = (160F^{1/3}h^{2/3})/U. \quad (20)$$

This height is used only for buoyancy-dominated conditions; should it exceed the final rise for the appropriate condition, the final rise is substituted instead.

Holland's Equation

Alternatively, plume rise can be estimated by Holland's equation (1953). The user supplies the product of the average wind speed and the height of plume rise ($U \cdot \Delta H$) via input variable SA (see Section 8). Holland's equation for $U \cdot \Delta H$ is as follows:

$$U \cdot \Delta H = D_s V_s \{1.5 + 0.00268p_a[(T_s - T_a)/T_s]D_s\}, \quad (21)$$

where p_a is the atmospheric pressure in millibars (the other variables are defined above). This equation frequently underestimates plume rise (Turner, 1970 and Johnson et al., 1976). Holland (1953) suggested that a value between 1.1 and 1.2 times the computed plume rise from Eq. 9 should be used for unstable conditions and a value between 0.8 and 0.9 times the computed plume rise should be used for stable conditions. This is accommodated in CDM-2.0 by adjusting the plume rise as,

$$\Delta H(final) = (SA/U)(1.4 - 0.1 \cdot ICP), \quad (22)$$

where SA is defined above and ICP is an array of values input by the user to define the dispersion curve to be associated with each stability category.

DISPERSION ALGORITHMS

As noted previously, the concentration formulas are independent of σ_y but dependent on σ_z, the vertical dispersion parameter. This results from the assumption in CDM-2.0 (and all other climatological dispersion models) that there are no variations of the wind direction frequency function within a wind-direction sector.

The user has the option of choosing among seven vertical dispersion parameter schemes; these are:

- Briggs-rural (Gifford, 1976),
- Briggs-urban (Gifford, 1976),
- Brookhaven National Laboratory (Singer and Smith, 1966),
- Klug (Vogt, 1977),
- St. Louis (Vogt, 1977),
- PGCDM (Busse and Zimmerman, 1973), and
- PGSIG (Pasquill, 1961 and Gifford, 1960).

The σ_z curves for each of the above dispersion algorithms are shown in Figure 2. The Pasquill stability categories have been used here for convenience. The BNL and St. Louis dispersion algorithms defined four curves and thus assumed different turbulence typing methods (Singer and Smith, 1966; Vogt, 1977). The PGCDM dispersion algorithm was included among the options since it is the scheme used by CDM, CDM-2.0's predecessor. The dispersion curves D1 and D2 in the PGSIG scheme represent adiabatic and subadiabatic neutral conditions, respectively. Lacking suitable temperature profile data for the lower 100 meters of the atmosphere, day and night may be substituted as criteria for adiabatic and subadiabatic lapse rates, respectively. Nighttime is typically defined as one hour prior to sunset to one hour after sunrise.

The dispersion curves shown in Figure 2 can be approximated by one of the following equations:

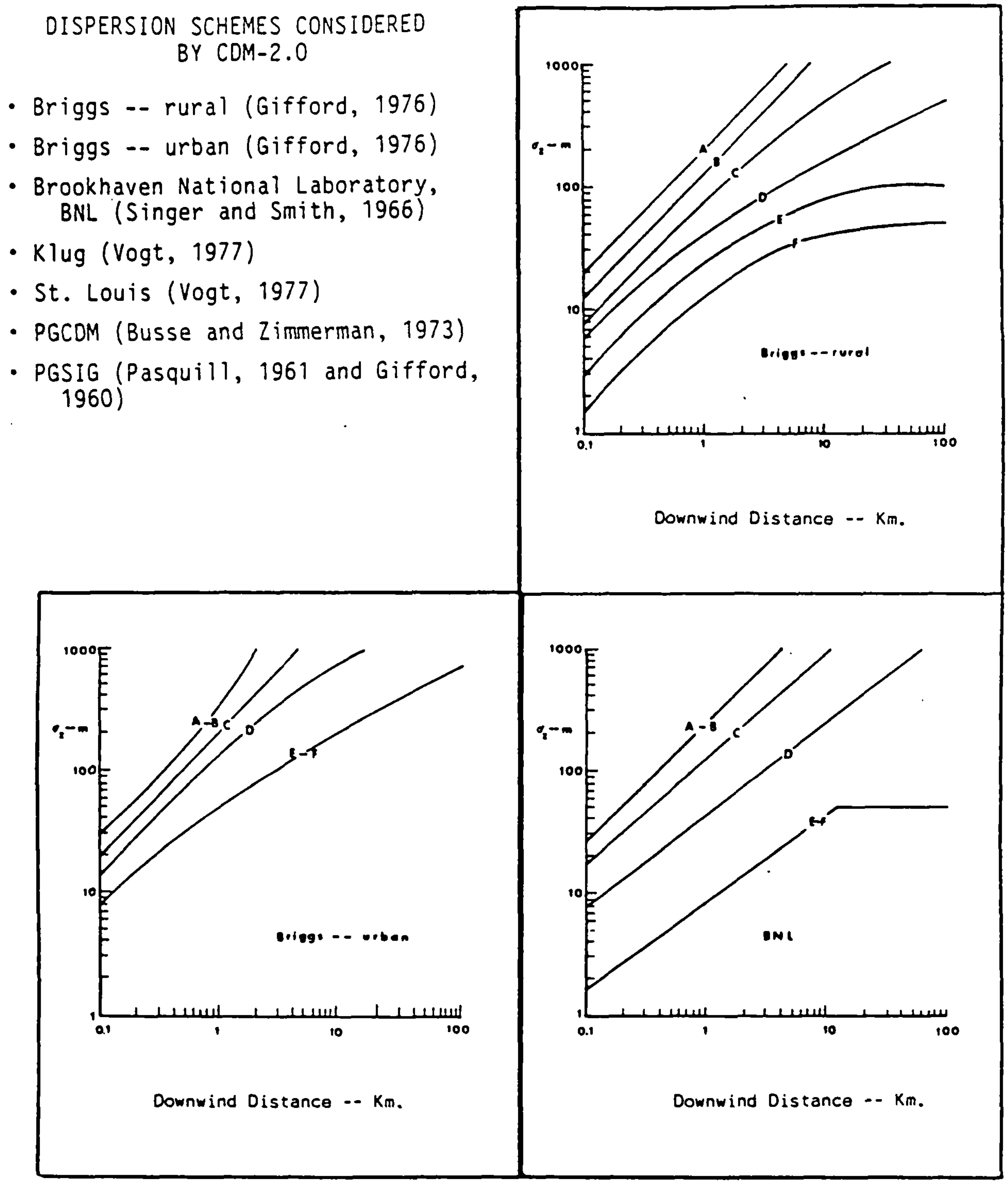


Figure 2. σ_z curves by stability class for the seven vertical dispersion schemes considered by CDM-2.0.

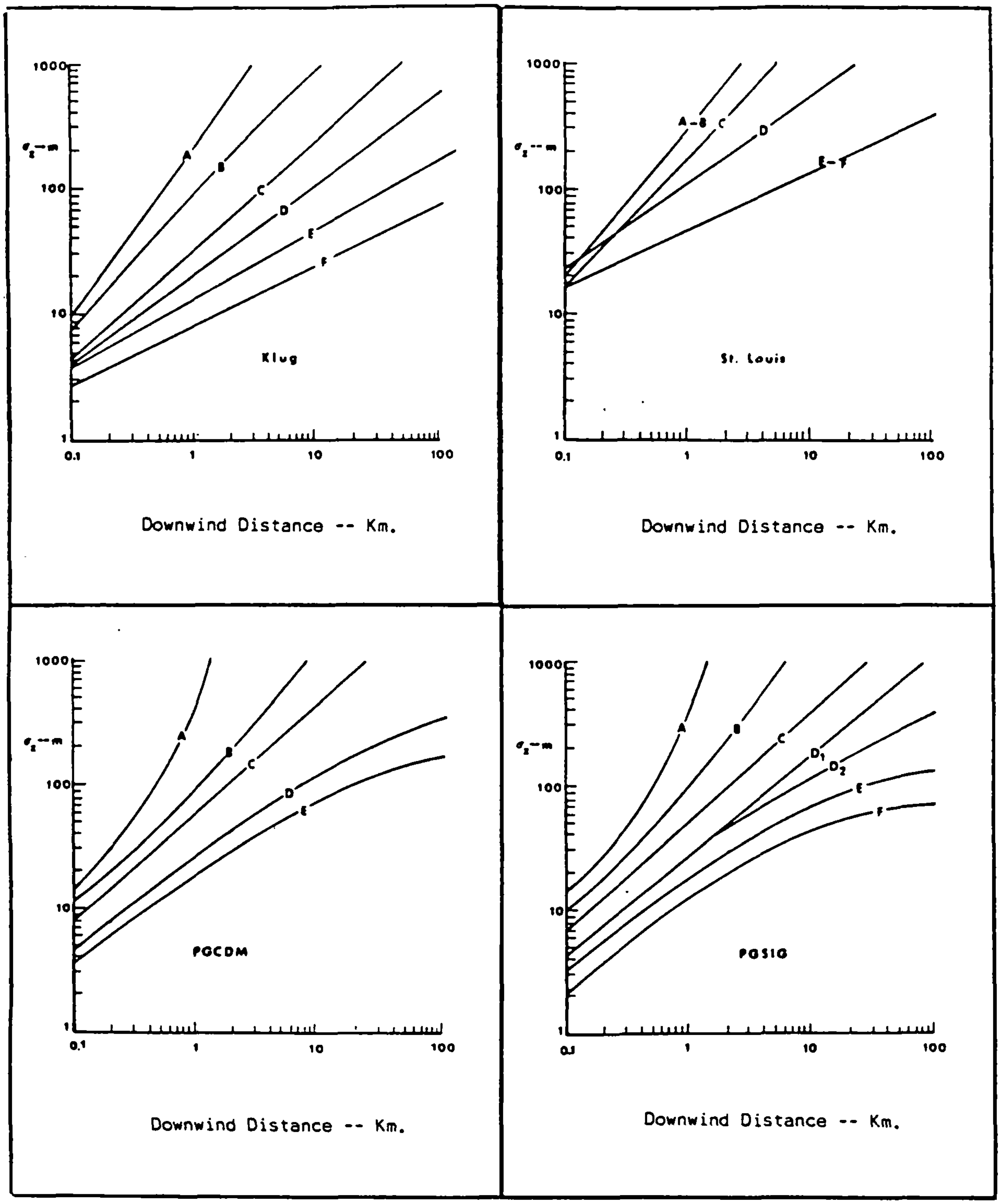


Figure 2. (continued)

$$\sigma_z = a\rho/(1 + b\rho)^c \quad \text{and} \tag{23}$$

$$\sigma_z = a\rho^b , \tag{24}$$

where a, b, and c are constants and ρ is the downwind distance. Eq. 23 is used to simulate the Briggs-rural and -urban schemes; the power-law formula shown in Eq. 24 represents the BNL, Klug, St. Louis, PGCDM, and PGSIG algorithms. Parameters a, b, and c are provided in Tables 7, 8, and 9.

CALIBRATION OF COMPUTED CONCENTRATION

If the calibration constants of the linear expression

$$C' = A + BC, \tag{25}$$

where

C' = calibrated concentration,
A, B = calibration constants, and
C = computed concentration,

are known, they may be entered into the program and used to obtain a calibrated concentration. The calibration constants are determined from regression analysis of observed air quality and the computed concentrations produced by the model. Thus, at least one initial run of the model must be made without the calibration feature. Once the model has been run to obtain computed concentrations, a regression procedure may be followed using computed versus observed concentrations. After finding the desired constants, calibrated concentrations can be obtained on subsequent operations of the model.

GRID SYSTEM AND AREA EMISSIONS

A rectangular grid array of uniform-sized squares is used to overlay the region of interest. The main purpose of this grid is to catalogue the emission inventory by area sources. There is some flexibility in the size of the grid squares in that the

TABLE 7. CONSTANTS FOR VERTICAL DISPERSION EQUATIONS USED BY FIVE DISPERSION SCHEMES

Dispersion algorithm	Eq	Const	Pasquill Stability Class A	B	C	D,day	D,night	E	F
Briggs-rural	23	a	0.2000	0.1200	0.0800	0.0600	0.0600	0.0300	0.0160
		b	0.0000	0.0000	0.0002	0.0015	0.0015	0.0003	0.0003
		c	1.0000	1.0000	0.5000	0.5000	0.5000	1.0000	1.0000
Briggs-urban	23	a	0.2400	0.2400	0.2000	0.1400	0.1400	0.0800	0.0800
		b	0.0010	0.0010	0.0000	0.0003	0.0003	0.0015	0.0015
		c	-0.5000	-0.5000	1.0000	0.5000	0.5000	0.5000	0.5000
BNL	24	a	0.4000	0.4000	0.3300	0.2200	0.2200	0.0600	0.0600
		b	0.9100	0.9100	0.8600	0.7800	0.7800	0.7100	0.7100
Klug	24	a	0.0170	0.0720	0.0760	0.1400	0.1400	0.2170	0.2620
		b	1.3800	1.0210	0.8790	0.7270	0.7270	0.6100	0.5000
St. Louis	24	a	0.0790	0.0790	0.1310	0.9100	0.9100	1.9300	1.9300
		b	1.2000	1.2000	1.0460	0.7020	0.7020	0.4650	0.4650

TABLE 8. CONSTANTS FOR THE VERTICAL DISPERSION PARAMETER EQUATION USED IN THE PGCDM SCHEME *

Stability class	Distance (m) 100 to 500 a	100 to 500 b	500 to 5000 a	500 to 5000 b	5000 to 50000 a	5000 to 50000 b
A	0.0383	1.2812	0.0002539	2.0886	0.2539E-3	2.0886
B	0.1393	0.9467	0.04936	1.1137	0.4936E-1	1.1137
C	0.1120	0.9100	0.1014	0.9260	0.1154	0.9109
D, day	0.0856	0.8650	0.2591	0.6869	0.7368	0.5642
D, night	0.0856	0.8650	0.2591	0.6869	0.7368	0.5642
E	0.0818	0.8155	0.2527	0.6341	1.2969	0.4421
F	0.0545	0.8124	0.2017	0.6020	1.5763	0.3606

* Constants are to be used in conjunction with Eq. 24.

TABLE 9. CONSTANTS FOR THE VERTICAL DISPERSION PARAMETER EQUATION USED IN THE PGSIG SCHEME *

Stability class	Distance (km)	Constants a	Constants b
A	< 0.1	122.80	0.9447
	0.1 - 0.15	158.08	1.0542
	0.15 - 0.2	170.22	1.0932
	0.2 - 0.25	179.52	1.1262
	0.25 - 0.3	217.41	1.2644
	0.3 - 0.4	258.89	1.4094
	0.4 - 0.5	346.75	1.7283
	> 0.5	453.85	2.1166
B	< 0.2	90.673	0.93198
	0.2 - 0.4	98.483	0.98332
	> 0.4	109.300	1.09710
C		61.141	0.91465
D, day		33.504	0.8098
D, night	< 0.3	34.459	0.86974
	0.3 - 1	32.093	0.81066
	1 - 3	32.093	0.64403
	3 - 10	33.504	0.60486
	10 - 30	36.650	0.56589
	> 30	44.053	0.51179
E	< 0.1	24.260	0.83660
	0.1 - 0.3	23.331	0.81956
	0.3 - 1	21.628	0.75660
	1 - 2	21.628	0.63077
	2 - 4	22.534	0.57154
	4 - 10	24.703	0.50527
	10 - 20	26.970	0.46713
	20 - 40	35.420	0.37615
	> 40	47.618	0.29592
F	< 0.2	15.209	0.81558
	0.2 - 0.7	14.457	0.78407
	0.7 - 1	13.953	0.68465
	1 - 2	13.953	0.63227
	2 - 3	14.823	0.54503
	3 - 7	16.187	0.46490
	7 - 15	17.836	0.41507
	15 - 30	22.651	0.32681
	30 - 60	27.074	0.27436
	> 60	34.219	0.21716

* Constants are to be used in conjunction with Eq. 24.

computer program accepts information on emissions from squares whose sides have lengths which are integer multiples of the length of the side of the basic square. Thus, if the basic square has a length s, emission information for a larger square whose side has a length, say 4s, is accepted by the model and distributed uniformly into 16 basic squares.

The origin of the overlay grid is located in the lower left-hand corner of the array with the X-axis pointing toward the east and the Y-axis pointing toward the north. With respect to the map coordinates of the region, the origin of the grid array is to be located at some suitably chosen point in the lower left-hand section of the region under consideration. The length of the side of a square is expressed in meters. However, the map coordinates can be expressed in any suitable units, say, thousands of feet or kilometers. The magnitude of the length of a square depends on how many squares are needed in the emission inventory of a region. For example, CDM-2.0 is dimensioned at present to handle 2500 area sources (and 200 point sources); thus, the grid square dimension must be chosen such that the limiting criteria of 2500 area sources is not exceeded. Computation can be performed for any number of receptor points.

OTHER CONSIDERATIONS

Initial Dispersion

The value of initial σ_z for point sources due to building effects is modeled as a function of the height above ground of the stack, h. Table 10 summarizes the relationship between initial σ_z and stack height.

TABLE 10. RELATIONSHIP BETWEEN INITIAL σ_z AND STACK HEIGHT

Stack height, h (m)	Initial σ_z (m)
$0 < h \leq 20$	30
$20 < h \leq 50$	$50 - h$
$50 < h$	0

For area sources, initial values of σ_z which account for building effects are user defined for each stability class.

Buoyancy-Induced Dispersion

For strongly buoyant plumes, entrainment as the plume ascends through the ambient air contributes to vertical spread. Pasquill (1976) suggests that this induced dispersion, σ_{zb}, can be approximated by the plume rise divided by 3.5. The effective dispersion can then be determined by adding variances:

$$\sigma_{ze} = (\sigma_{zb}^2 + \sigma_z^2)^{1/2} , \tag{26}$$

where σ_{ze} is the effective dispersion, and σ_z is the dispersion due to ambient turbulence levels.

Effluent Rise for Area Sources

CDM-2.0 can consider changes in effective height with wind speed for area sources. The input area source height, H_a, is assumed to be the average physical height of the area source plus the effluent rise with a wind speed of 5 m/sec. The user specifies the fraction, f_e, of the input height that represents the physical height, h. This fraction is the same for all area sources in the inventory. The relationship among H_a, f_e, and h is as follows:

$$h = f_e H_a . \tag{27}$$

If $f_e = 1$, there is no rise and the input height is the effective height for all wind speeds. For any wind speed, U, the rise is assumed to be inversely proportional to U and is determined by

$$\Delta H = (5/U)(H_a - h); \tag{28}$$

the effective height is then

$$H = h + \Delta H. \tag{29}$$

SECTION 6

EXAMPLE PROBLEM

In this section, a hypothetical problem is provided to illustrate the use of CDM-2.0 and the type of information it provides. Details concerning input and output for this example are discussed in Section 10.

Figure 3 shows the city limits of Test City along with the locations of sampling sites and major point sources of pollution. Minor point sources and area sources were cataloged and gridded. The emission grid is shown in Figure 3. The area and point source inventory is summarized in Table 11; all necessary source information is contained there.

TABLE 11. POLLUTION SOURCE INVENTORY FOR TEST CITY.

Location			Emission rate			Stack parameters		
X (km)	Y (km)	Width (km)	SO_2 (g/s)	Part (g/s)	Source height (m)	Dia (m)	Speed (m/s)	Temp (°C)
568.5	4403.4	--	1365.00	527.63	150	0.0	0.0	0
584.2	4391.6	--	1580.36	789.60	90	8.7	15.2	149
577.0	4401.1	--	221.76	34.13	30	0.7	17.8	515
574.1	4401.5	--	110.25	54.08	23	1.4	15.2	260
562.5	4402.5	5	1.37	1.68	0	--	--	--
567.5	4402.5	5	1.26	1.79	0	--	--	--
572.5	4402.5	5	5.25	3.99	10	--	--	--
577.5	4402.5	5	1.47	13.13	0	--	--	--
582.5	4402.5	5	1.20	1.58	0	--	--	--
562.5	4397.5	5	2.62	1.47	10	--	--	--
567.5	4392.5	10	32.66	21.11	15	--	--	--
577.5	4397.5	5	5.46	3.99	10	--	--	--

(continued)

TABLE 11. (continued)

Location			Emission rate			Stack parameters		
X (km)	Y (km)	Width (km)	SO_2 (g/s)	Part (g/s)	Source height (m)	Dia (m)	Speed (m/s)	Temp (°C)
582.5	4397.5	5	6.62	5.78	10	--	--	--
562.5	4392.5	5	2.63	1.16	10	--	--	--
577.5	4392.5	5	7.88	5.15	20	--	--	--
582.5	4392.5	5	5.25	3.68	10	--	--	--
562.5	4387.5	5	2.73	1.37	0	--	--	--
567.5	4387.5	5	2.42	1.89	10	--	--	--
572.5	4387.5	5	5.36	4.10	10	--	--	--
577.5	4387.5	5	5.57	3.89	10	--	--	--
582.5	4387.5	5	2.84	1.47	10	--	--	--

The meteorology for Test City and its environs is summarized in Figures 4 and 5. The wind rose indicates that north winds predominate, occurring almost 14% of the time. However, there is a secondary peak from the east-southeast. The stability distribution for Test City (Figure 5) shows the predominance of neutral conditions throughout the year.

Computed concentrations at the sampling sites shown in Figure 3 are listed in Table 12. Note that CDM-2.0 provides area and point source contributions. In this example, the point sources exhibit the greatest impact on the receptors.

Optional output from CDM-2.0 includes point and area concentration roses and histograms of concentration by stability class. Figure 6 illustrates the type of information available from CDM-2.0, except that CDM-2.0 provides the information in the form of tables. As mentioned earlier, neutral conditions dominate and this is confirmed in the concentration versus stability histograms. As noted from the concentration roses, north-northwest, north-northeast, northeast, and south-southeast winds account for over 70% of the total concentration (at this particular receptor), which corresponds to the directions of the four point sources.

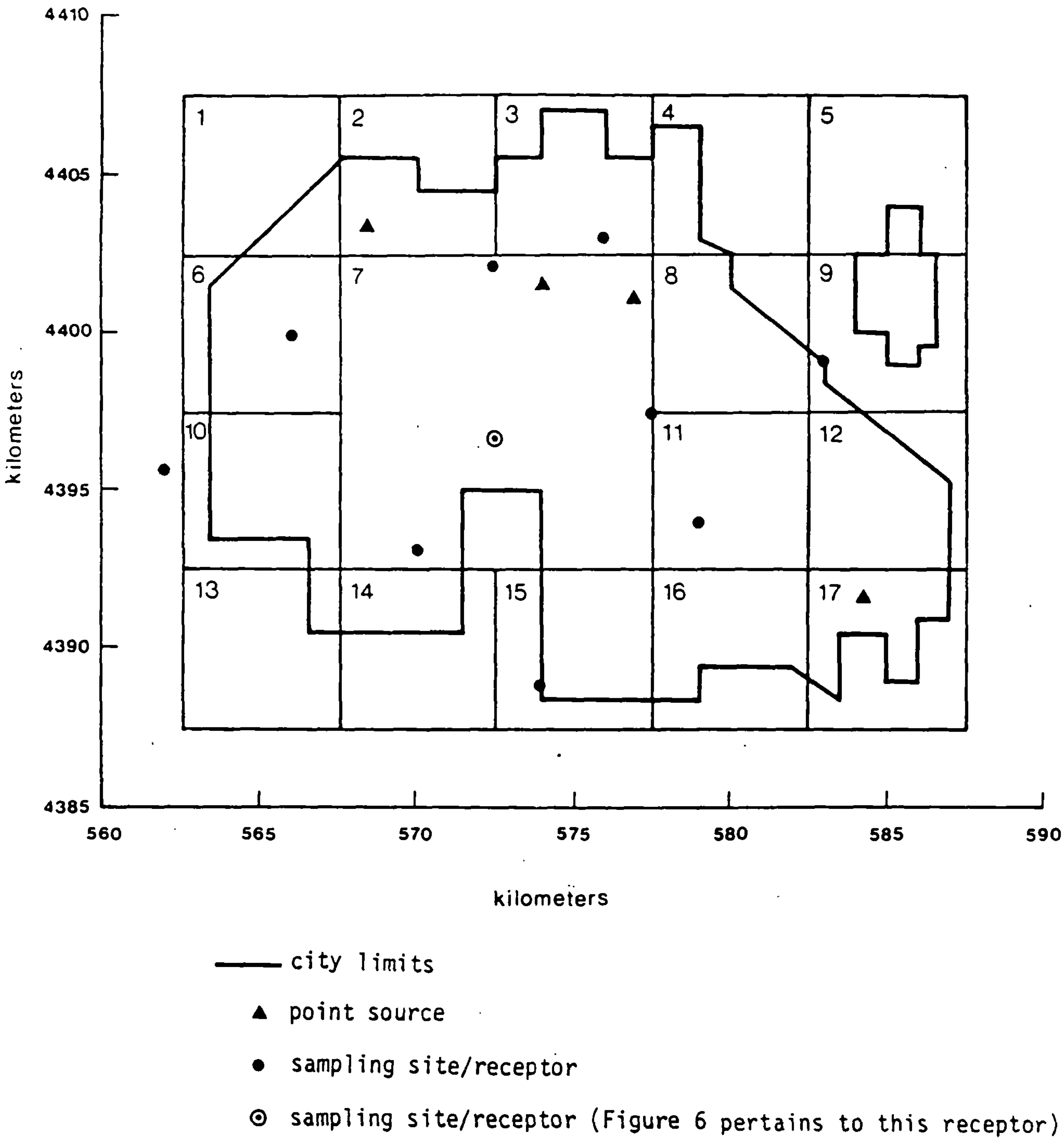


Figure 3. Test City base map (modified from Brubaker et al., 1977).

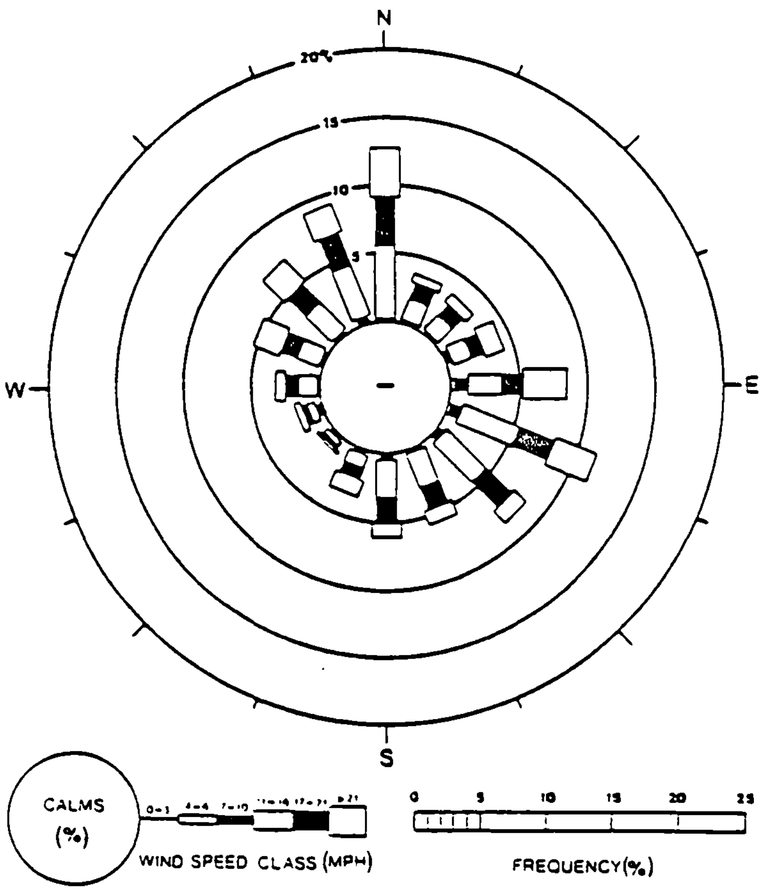


Figure 4. Wind rose for Test City.

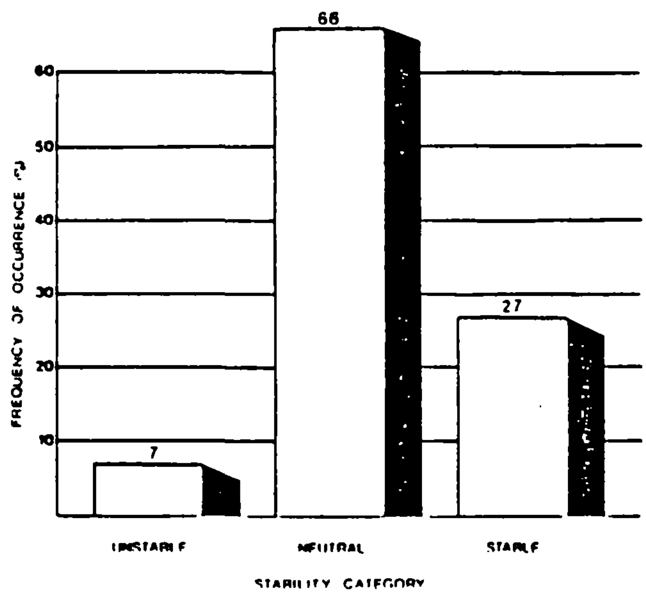


Figure 5. Stability distribution for Test City.

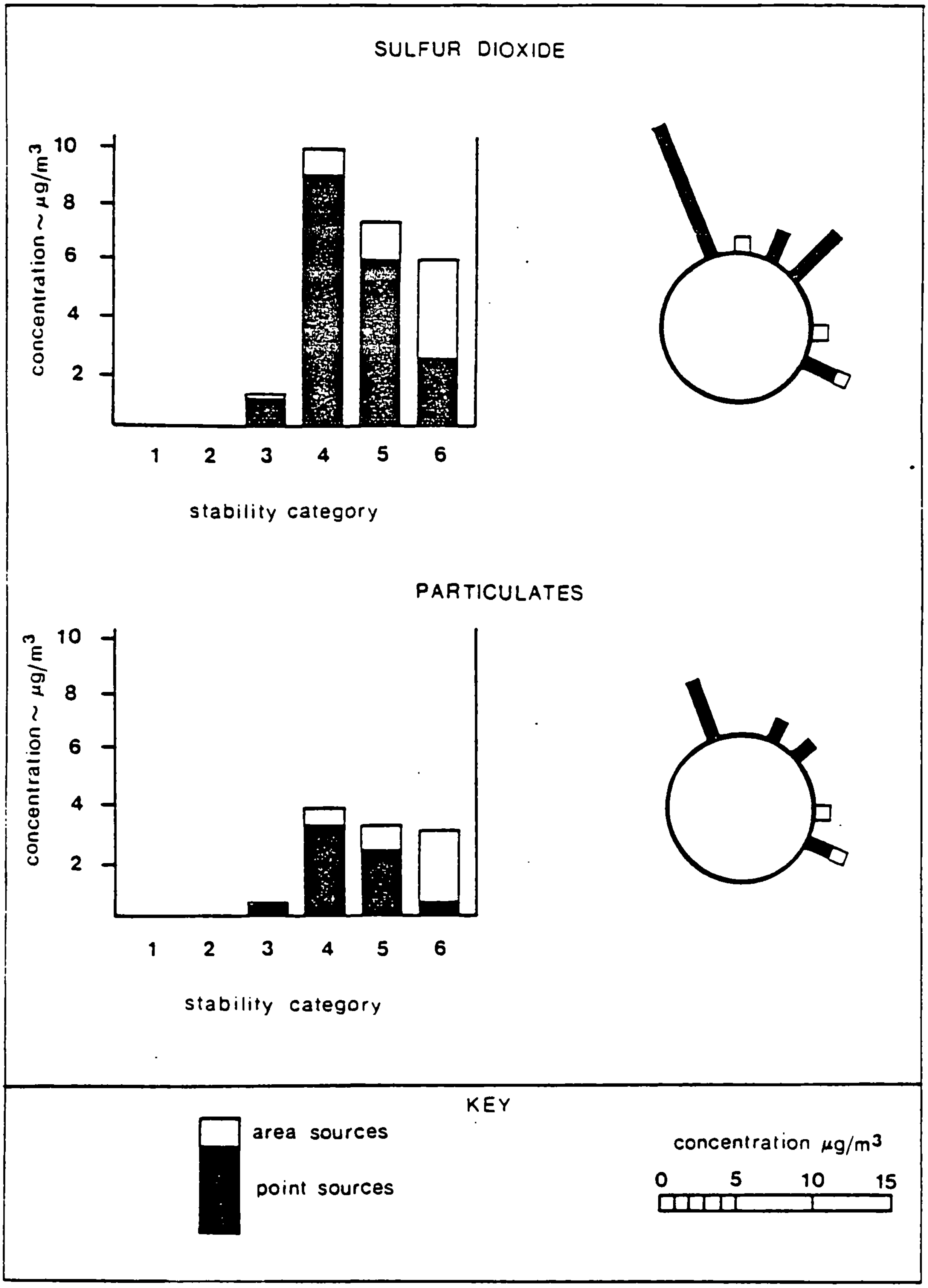


Figure 6. Concentration versus stability histograms and concentration roses for the receptor of Figure 3.

Both input stream and abridged output listing for this problem are provided in Section 10.

TABLE 12. COMPUTED CONCENTRATIONS AT SELECTED SITES IN TEST CITY.

Location		Concentrations ($\mu g/m^3$)					
		Area sources		Point sources		Total	
X (km)	Y (km)	SO_2	Part	SO_2	Part	SO_2	Part
570.0	4393.2	5.4	3.8	14.8	5.5	20.3	9.3
573.9	4388.9	4.6	3.4	9.5	3.6	14.1	7.0
572.4	4402.2	4.9	4.3	39.5	13.0	44.4	17.3
579.0	4394.0	5.4	4.3	15.3	4.4	20.7	8.7
583.0	4399.2	4.5	4.9	11.3	3.0	15.8	7.9
562.0	4395.7	2.7	1.9	6.2	2.2	8.9	4.0
566.1	4400.0	4.2	3.1	12.5	4.1	16.7	7.3
572.5	4396.7	6.0	4.3	17.5	6.3	23.5	10.6
577.5	4397.5	5.5	4.4	34.2	7.6	39.8	12.0
576.0	4403.0	4.4	4.8	27.8	6.2	32.3	11.0

SECTION 7

COMPUTER ASPECTS OF THE MODEL

This section discusses CDM-2.0 from a software design and programming perspective, and is intended to give the reader a general knowledge of the computational system, rather than a detailed description of each subroutine. The overall structure of the program, a brief description of each subroutine, and the general processing flow are given here. Also provided is the overall system flow, the input/output media, data flow, and alternative processing.

SYSTEM FLOW

An overview of the system will be beneficial to the reader. Figure 7 illustrates the input and output media as well as data flow for CDM-2.0. Input data requirements are contained in either one or two files depending on the user assignment of variable IRD (see Section 8). Output is in two forms: printed output and card image output, usually going to a disk file. Card-image records containing the calculated concentrations at each receptor are written for use in computer programs that analyze information produced by CDM-2.0. As discussed in Section 5, a regression program must be applied to obtain calibration constants. Additionally, the disk file output can be used with user-supplied plot routines to obtain isopleth plots of concentration.

In addition to the records containing the concentrations from area and point sources, further output may be produced if the NROSE option is used (see Section 8). If NROSE is specified as greater than zero, additional records are written. Concentration versus stability histograms and concentration roses for both pollutants and both source types are provided.

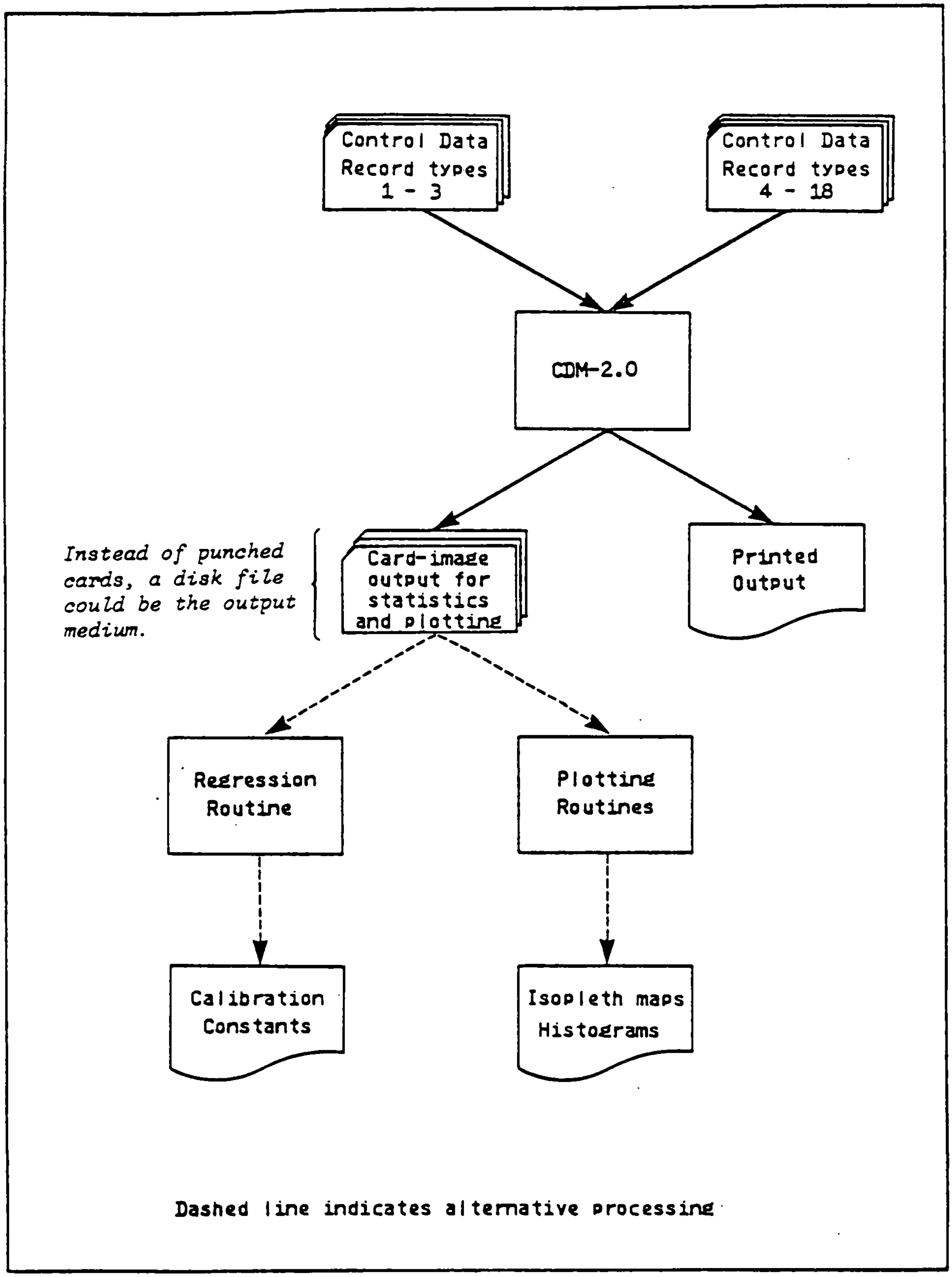


Figure 7. System flow for CDM-2.0.

The input/output (I/O) units used by CDM-2.0 are summarized in Table 13.

TABLE 13. INPUT/OUTPUT UNITS USED BY CDM-2.0

FORTRAN unit	I/O unit	Mode	Contents
5	Disk	input	Program control and input data (record types 1-3)
IRD*	Disk	input	Program control and input data (record types 4-18)
IWR*	Printer or disk	output	Output listing
IPU*	Disk or magnetic tape	output	Concentration data

* See Section 8.

STRUCTURE OF CDM-2.0

CDM-2.0 consists of a main routine and nine subroutines as shown in Figure 8. Program control data, meteorological data, and source information are read by subroutine CLINT. The main routine reads receptor data until an end-of-file is encountered and then execution is terminated. With the exception of one warning message generated by CALQ, all output is performed by the main routine or by subroutine CLINT. Brief descriptions of the main program and subroutines follow.

CDM-2.0 -- The main program first calls subroutine CLINT to read all the input data except the receptor information which is subsequently read by the main program. It directs the concentration calculations by calling subroutines CALQ, AREA, and POINT. It is also responsible for printing and writing concentration results to a file.

CLINT -- This subroutine is called by the main routine to read program control data, meteorological data, and source information. It also echoes input according to user specification. It calls subroutine VIRTX.

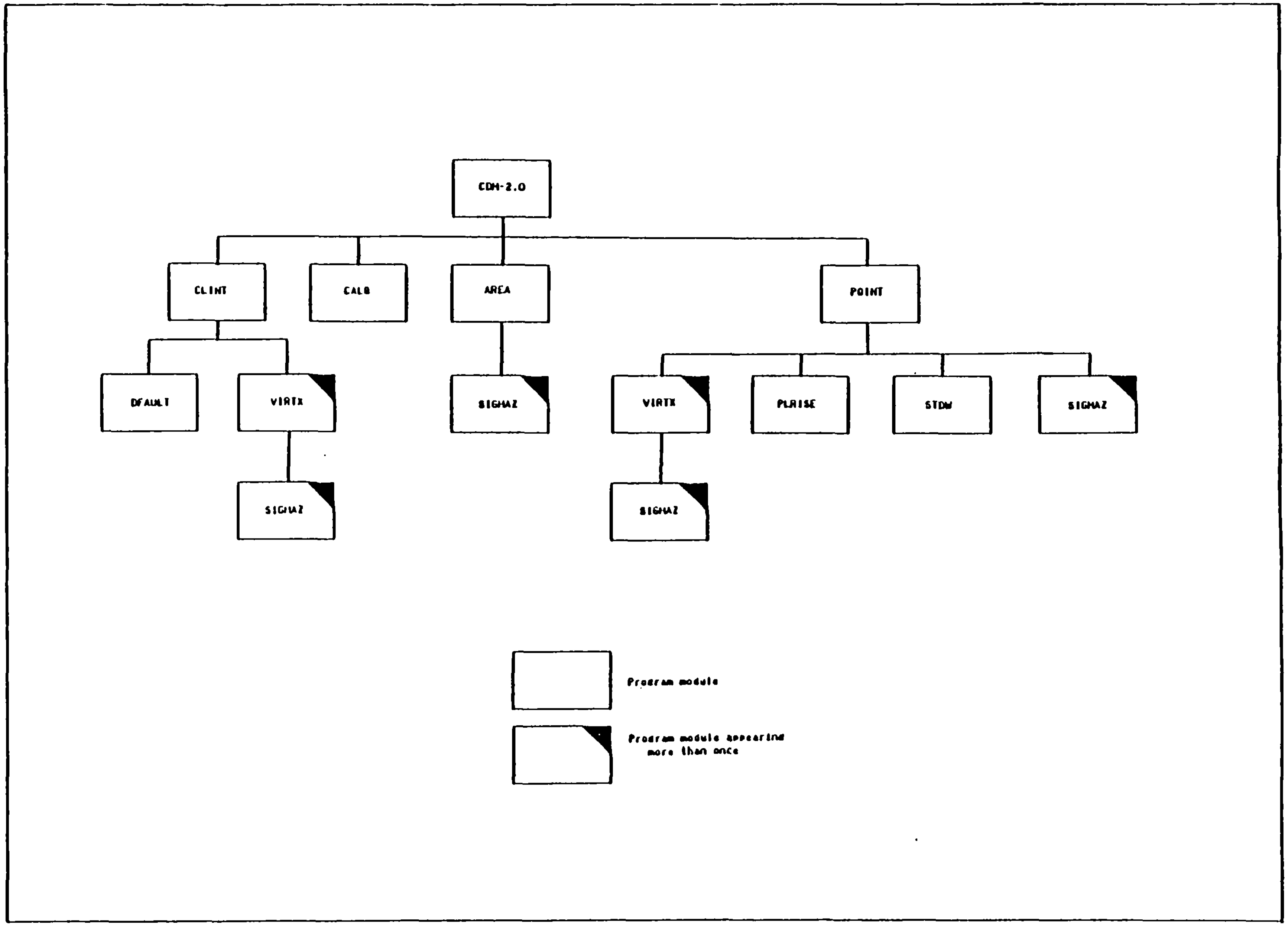


Figure 8. CDM-2.0 program structure.

CALQ -- Called by the main program, subroutine CALQ computes the area source vector for each direction sector. The area source vector contains emission rates for two pollutants and release heights at various upwind distances.

AREA -- This subroutine is called by the main routine to calculate concentrations due to area sources. It calls subroutine SIGMAZ.

POINT -- Subroutine POINT is called by the main routine to calculate concentrations due to point sources. It calls subroutines VIRTX, STDW, and SIGMAZ.

DFAULT -- This second level subroutine sets some of the user-defined options; see Appendix A for further discussion. It is called by subroutine CLINT if the user turns on the default option.

PLRISE -- Called by subroutine POINT, this module calculates plume rise according to the methods of Briggs (1969, 1971, and 1975).

VIRTX -- This second level subroutine is called by CLINT and POINT; it computes the virtual distance applicable to the user-specified initial dispersion. VIRTX calls SIGMAZ to estimate vertical dispersion.

STDW -- This subroutine is called by POINT to estimate stack downwash.

SIGMAZ -- This subroutine is called by AREA, POINT, and VIRTX to calculate the vertical dispersion parameter. The user can choose among seven different schemes.

Figure 9 is an abbreviated flow diagram of CDM-2.0 showing its major loops and relationships among the subroutines and the main routine. A set of program flow charts is provided in Appendix B.

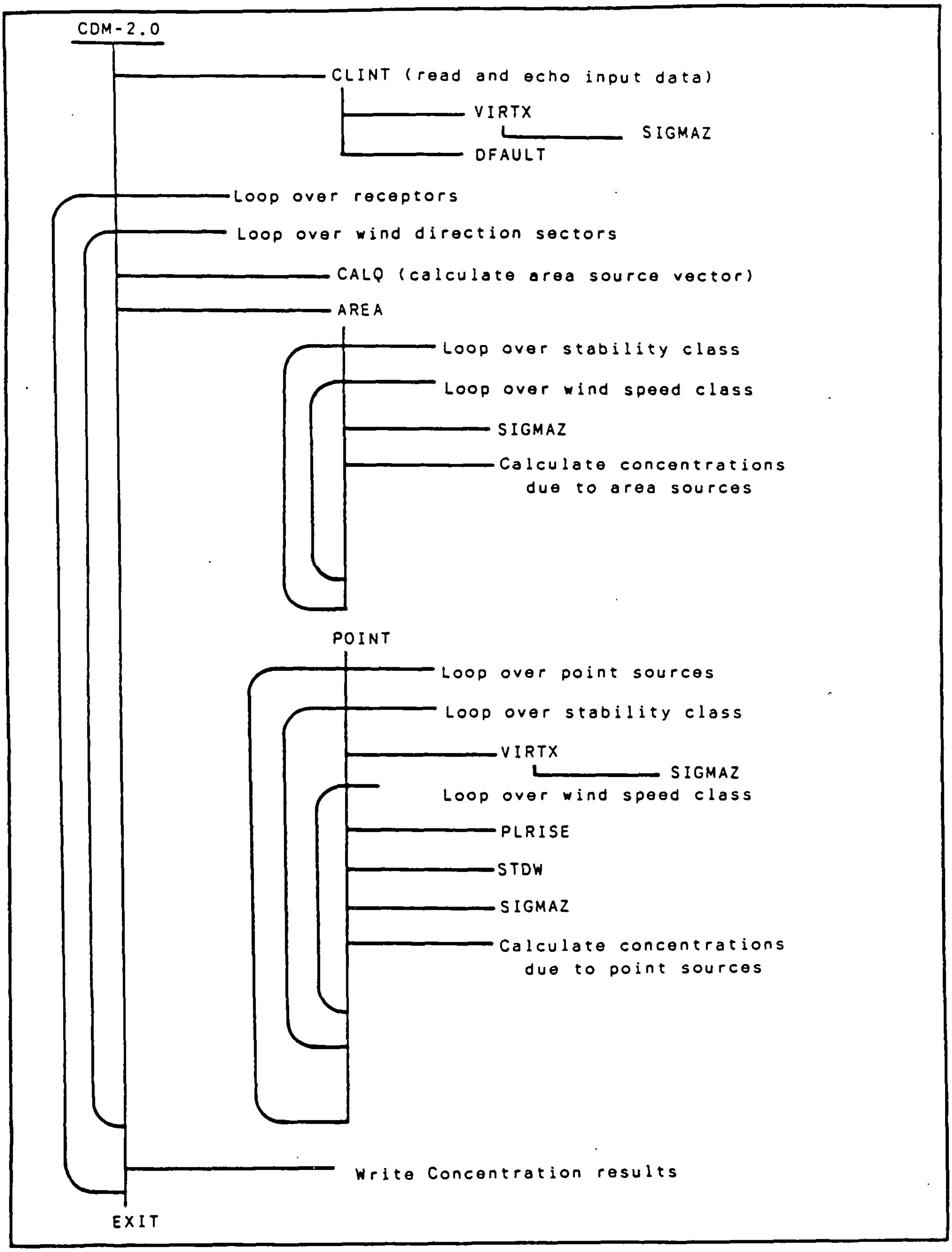


Figure 9. CDM-2.0 flow diagram.

NON-STANDARD FEATURES

The PARAMETER statement, which is used in the main program, is not an ANSI FORTRAN statement, and hence may not be available in the user's FORTRAN compiler. As PARAMETER allows constants to be referenced by symbolic names, it facilitates the updating of programs in which the only changes between compilations are in the values of certain constants. In CDM-2.0, the PARAMETER statement initializes the following variables:

NPTS - number of point sources,
NQLIM - number of upwind integration steps allowed,
NASE - number of east-west area-source grid squares,
NASN - number of north-south area-source grid squares,

which in turn are used to dimension several arrays. If the user's compiler does not support the PARAMETER statement, the variables NPTS, NQLIM, NASE, and NASN must be hardcoded. The best way to do this is to perform global changes using a text editor.

SECTION 8

INPUT DATA PREPARATION

RECORD INPUT SEQUENCE

There are 18 record types read by CDM-2.0. Six of these are free format input, eight are fixed format, three are of user-specified format, and one is a blank record. While the free format is easy to use, care should be taken to ensure that every. variable is given a value in the correct order. Also each variable should be separated by a comma and should conform to the variable name type (integer or real). Table 14 lists the record types and input associated with each record. A brief description of each input variable is given in Table 15 with the appropriate units. Under the "Format" column of Table 15, FF represents free format and US indicates user-specified format.

TABLE 14. SUMMARY OF RECORD TYPES FOR INPUT DATA.

Record type	Description	Format type	Input unit	Calling subroutine
1	HEADNG - run title	Fixed	5	CLINT
2	NSO2,PNAME	Fixed	5	CLINT
3	AROS,PROS,IRUN,NLIST,IRD, IWR,IPU,CA,CB	Fixed	5	CLINT
4	N1636,NP50,NPDH,NSTDW,NGRAD, FAC,RCEPTZ,KELVIN,NDEF	Free	IRD	CLINT
5	KLOW,ICA	Free	IRD	CLINT
6	KHIGH,ICP	Free	IRD	CLINT
7	DELR,RAT,CV,XG,YG,TOA,TXX	Fixed	IRD	CLINT
8	DINT,YD,YN,SZA,GB	Fixed	IRD	CLINT
9	UE	Free	IRD	CLINT
10	U	Free	IRD	CLINT
11	H	Free	IRD	CLINT
12	FMETEO	Fixed	IRD	CLINT
13	F	FMETEO	IRD	CLINT
14	FSOURC	Fixed	IRD	CLINT
15	X,Y,TX,S1,S2,SH,D,VS,T,SA	FSOURC	IRD	CLINT
16	Blank Sentinel Card (End of source input)	--	IRD	CLINT
17	FRECPT	Fixed	IRD	MAIN
18	RX,RY,KPX(9),KPX(10),NROSE	FRECPT	IRD	MAIN

TABLE 15. RECORD INPUT SEQUENCE FOR CDM-2.0

Record type, Variable	Column	Format	Variable description (units)
Record type 1			
HEADNG	1-80	20A4	80-character description or title of model run
Record type 2			
NSO2	1- 1	I1	Pollutant number for SO_2 = 0, SO_2 not considered = 1, pollutant 1 is SO_2 = 2, pollutant 2 is SO_2
PNAME	5-12	2A4	Names of two pollutants to be modeled (e.g., SO_2, TSP)
Record type 3			
AROS	1- 8	2A4	Alphanumeric area rose output identification
PROS	9-16	2A4	Alphanumeric point rose output identification
IRUN	17-21	I5	User-defined run identification
NLIST	22-26	I5	Control for printed output > 0, echo set-up information, meteorology, and list concentration results = 0, echo set-up information, meteorology, source, and list concentration results < 0, list concentration results only
IRD	27-31	I5	FORTRAN logical unit number - read
IWR	32-36	I5	FORTRAN logical unit number - print
IPU	37-41	I5	FORTRAN logical unit number - punch
CA	42-59	2F9.0	Intercepts of calibration for both pollutants ($\mu g/m^3$)
CB	60-77	2F9.0	Slopes of calibration for both pollutants

(continued)

TABLE 15 (continued)

Record type, Variable	Column	Format	Variable description (units)
Record type 4			
N1636	---	FF	Number of wind directions used in the meteorological joint frequency function (16 or 36)
NP50	---	FF	Initial dispersion option ≤ 0, no action taken on point sources with release heights below 50 m > 0, initially dispersed as described in Section 5
NPDH	---	FF	Buoyancy-induced dispersion option ≤ 0, no action taken ≥ 0, include buoyancy-induced dispersion effects (Pasquill, 1976) in point source dispersion
NSTDW	---	FF	Stack downwash option < 0, Bjorklund, Bowers (1982) stack downwash used = 0, no action taken > 0, Briggs (1974) stack downwash considered
NGRAD	---	FF	Gradual plume rise option = 0, no action taken > 0, gradual plume rise used
FAC	---	FF	Effluent rise for area sources See Section 5 for description.
RCEPTZ	---	FF	Height above ground of all receptors (meters)
KELVIN	---	FF	Units flag for stack gas temperature < 0, °F = 0, °C > 0, K
NDEF	---	FF	Default option = 0, no action taken > 0, implement default option (see Appendix A)

(continued)

TABLE 15 (continued)

Record type, Variable	Column	Format	Variable description (units)
Record type 5			
KLOW	---	FF	Dispersion parameter scheme for area sources
ICA	---	FF	Array of six values defining dispersion curves (as defined by KLOW) to be used for the six stability categories summarized in the joint frequency function
Record type 6			
KHIGH	---	FF	Dispersion parameter scheme for point sources
ICP	---	FF	Array of six values defining dispersion curves (as defined by KHIGH) to be used for the six stability categories summarized in the joint frequency function
Record type 7			
DELR	1- 6	F6.0	Radial increment (meters)
RAT	7-12	F6.0	Length of basic emission grid square (user units)
CV	13-18	F6.0	Conversion factor (m/user units) CV·RAT = emission grid interval in meters
XG	19-24	F6.0	East-west map coordinate of the southwest corner of the emission grid array (user units)
YG	25-30	F6.0	North-south map coordinate of the southwest corner of the emission grid array (user units)
TOA	31-36	F6.0	Mean atmospheric temperature (°C)
TXX	37-42	F6.0	Width of the basic emission grid square (meters)
Record type 8			
DINT	1- 6	F6.0	Number of intervals used to integrate over a 22.5° or 10° sector. Maximum value is 20; minimum is 2.

(continued)

TABLE 15 (continued)

Record type, Variable	Column	Format	Variable description (units)
YD	7-12	F6.0	Ratio of the daytime emission rate to the average 24-hour emission rate
YN	13-18	F6.0	Ratio of the nighttime emission rate to the average 24-hour emission rate
SZA	19-54	6F6.0	Initial σ_z for area sources (meters)
GB	55-66	2F6.0	Decay half-life for the two pollutants (hours)
Record type 9			
UE	---	FF	Array of six values defining wind profile exponents to be associated with the six stability categories summarized in the joint frequency function
Record type 10			
U	---	FF	Array of six values defining wind speeds at 10 m to be associated with the six wind speed categories summarized in the joint frequency function (m/sec)
Record type 11			
HL	---	FF	Array of six values defining mixing heights to be associated with the six stability categories summarized in the joint frequency function (meters)
Record type 12			
FMETEO	1-64	16A4	Format statement, including beginning and ending parenthesis, for the meteorological joint frequency function. User note: CDM format was (7X,6F7.0)

(continued)

TABLE 15 (continued)

Record type, Variable	Column	Format	Variable description (units)
Record type 13*			
F(i,j,k)	---	US	Meteorological joint frequency function; i = index for stability class j = index for wind speed class k = index for wind direction
Record type 14			
FSOURC	1-64	16A4	Format statement, including beginning and ending parenthesis, for the source inventory. User note: CDM format was (F6.0,2F7.0,2F8.0,F7.0, F5.0,2F7.0,F5.0)
Record type 15†			
X	---	US	East-west coordinate of source (user units)
Y	---	US	North-south coordinate of source (user units)
TX	---	US	Width of area source (meters). Leave blank for point sources.
S1	---	US	Emission rate of pollutant 1 (g/sec)
S2	---	US	Emission rate of pollutant 2 (g/sec)
SH	---	US	Source height (meters)
D	---	US	Stack diameter (meters). Leave blank for area sources.
VS	---	US	Exit velocity (m/sec). Leave blank for area sources.
T	---	US	Stack gas temperature. Leave blank for area sources. User selected units (see record type 4).

(continued)

TABLE 15 (continued)

Record type, Variable	Column	Format	Variable description (units)
SA	---	US	Plume rise option ≤ 0, Briggs plume rise > 0, Holland's equation. Enter product of plume rise and wind speed (m^2/sec)
Record type 16			
--	---	--	This is a blank record which follows the source data. It is used to test for the end of the source data and must not be left out.
Record type 17			
FRECPT	1-64	16A4	Format statement, including beginning and ending paren-thesis, for the receptors. User note: CDM format was (2F8.0,14X,I4,3X,I4,I5)
Record type 18]			
RX	---	US	East-west coordinate of the receptor (user units)
RY	---	US	North-south coordinate of the receptor (user units)
KPX9	---	US	Observed concentration of pollutant 1 at the receptor, if known (μg/m^3)
KPX10	---	US	Observed concentration of pollutant 2 at the receptor, if known (μg/m^3)
NROSE	---	US	Option for pollutant concen-tration roses > 0, print concentration roses ≤ 0, no concentration roses

FF = free format; US = user-specified format

* If N1636 = 16 there are 96 records of this type; if N1636 = 36 there are 216 records of this type.

† There are as many of this record type as there are sources.

] There are as many of this record type as there are receptors.

INTRICACIES OF THE DATA

Most of the input data are straightforward and typical of the kind of information required for Gaussian models. However, there are some input variables which require additional explanation to ensure proper value assignment.

Record Type 2

CDM-2.0 calculates concentrations for two pollutants in a single execution. Therefore, the user is asked to input two pollutant names, two sets of calibration constants, and two emission rates, one for each of the two pollutants modeled. In this record, the user is asked to provide two names for the pollutants. These two names, which are each four characters in length, are subsequently used in the output as labels. It is important that the order used in this record for array variable PNAME is followed for array variables CA and CB in record type 3 and variables S1 and S2 in record type 15.

Variable NSO2 informs the program which of the pollutants if any is SO_2. Within the program, SO_2 requires special processing depending on the options exercised. If NSO2 = 0, then the program assumes that SO_2 will not be run. If NSO2 = 1, then pollutant 1 is assumed to be SO_2; if NSO2 = 2, then pollutant 2 is assumed to be SO_2.

Record Type 3

AROS and PROS are alphanumeric arrays to identify the output record for the area and point concentration roses. In defining these two arrays it is important to keep in mind that area and point concentration roses are provided for both pollutants. AROS and PROS might be input as follows:

AROS(1) = A P1	PROS(1) = P P1
AROS(2) = A P2	PROS(2) = P P2

The first two characters refer to the source type (i.e., A for area and P for point) and the last two characters refer to pollutant (i.e., P1 for pollutant 1 and P2 for pollutant 2).

If the calibration feature of CDM-2.0 is not used, the value of the intercept (CA) and slope (CB) should be specified as 0 and 1, respectively. This results in the calibrated concentration identical to the computed value. Note that CA and CB are two entry arrays for the two pollutants being modeled.

Record Type 4

For point sources, CDM-2.0 allows user selection of both initial dispersion due to building effects and buoyancy-induced dispersion. The user should verify that simultaneous selection of these options is appropriate for the particular modeling situation.

Variable NDEF is the default option switch. This feature is designed as a convenience to the user with the aim of avoiding inadvertent errors in setting the options. By exercising the default option, several features are automatically set thus overriding other user-input selections. Specifics of the default option are summarized in Appendix A.

Record Types 5 and 6

The user-specified dispersion parameter scheme for area and point sources is indicated through variables KLOW and KHIGH, respectively. Table 16 lists the dispersion algorithm and its corresponding value of KLOW or KHIGH.

TABLE 16. VALUES OF KLOW OR KHIGH AND THEIR CORRESPONDING DISPERSION PARAMETER SCHEMES

KLOW or KHIGH	Dispersion parameter scheme
1	Briggs-rural (Gifford, 1976)
2	Briggs-urban (Gifford, 1976)
3	BNL (Singer and Smith, 1966)
4	Klug (Vogt, 1977)
5	St. Louis (Vogt, 1977)
6	PGCDM (Busse and Zimmerman, 1973)
7	PGSIG (Pasquill, 1961 and Gifford, 1960)

Although CDM-2.0 recognizes seven distinct stability categories, the meteorological joint frequency function is assumed to be comprised of only six classes. The specification of the values for arrays ICA and ICP is, in part, a function of the manner in which the joint frequency function is formulated, and these arrays are a function of the dispersion parameter scheme selected. In the original CDM, the PGCDM dispersion parameter scheme was employed. The urban effects were modeled by "slipping" the curves, i.e. using a curve other than that which would ordinarily be used in a rural situation. With the enhancements incorporated in CDM-2.0, one can select either to accommodate urban effects as was done in CDM or, one can select either the Briggs-urban or the St. Louis schemes. An example should clarify their use.

Assume we have specified KLOW and KHIGH to be 7 (PGSIG scheme). Suppose NCC's Day-Night STAR program is used to generate the joint frequency function; this summary includes the following stability categories: A, B, C, D-day, D-night, and nighttime stable (i.e., a combination of Pasquill classes E and F). Array variables ICP and ICA would be defined as 1, 2, 3, 4, 5, and 6 for modeling a rural situation. If one wanted to account for urban effects by "slipping" the categories, as was done by CDM, then ICP would be 1, 2, 3, 5, 5, 5, and ICA would be 1, 1, 2, 3, 5, 5. However, if the joint frequency function is formulated using categories A, B, C, D, E, and F, then ICP and ICA are input as: 1, 2, 3, 5, 6, and 7 for a rural situation. Mixing height is not affected by array variables ICP and ICA since it is linked to the six stability categories summarized in the joint frequency function.

Record Type 7

A potential error in the area source integration algorithm is radial skipover (Brubaker et al., 1977); radial skipover is illustrated in Figure 10a. In this instance, the area source size is smaller than the sampling interval, n DELR, where n = 1, 2, or 4 (see Section 5). It is easy to see that radial skipover can be minimized by keeping DELR small. However, not only is CPU time increased with decreasing DELR but also CDM-2.0 is limited presently to 100 radial arcs. Thus the use of smaller DELR may result in the termination of the radial integration due to array size restrictions before the far edge of the emission grid is reached with the corresponding omission of a significant part of the total area source contribution. Figure 11 gives the maximum range attainable as a function of DELR; it should be used in defining an appropriate DELR for the user's modeling range.

The easiest way to explain the emission grid is by a practical example. Suppose that an emission inventory exists with the smallest emission square 5000 feet on a side and all coordinates are given in terms of feet. In this instance, the basic emission grid square is 5000 feet on a side and thus RAT is 5000. CV is 0.3048 (i.e., 1 ft = 0.3048 m); TXX is 1524 (i.e., 5000 ft = 1524 m); and XG, YG, are in feet. Also, all source and receptor coordinates are expressed in feet (map coordinates).

Record Type 8

Another source of error in the area source integration is angular skipover. As shown in Figure 10b, the area source is skipped over by the sampling points. Obviously, the potential for angular skipover is reduced if the area source inventory is

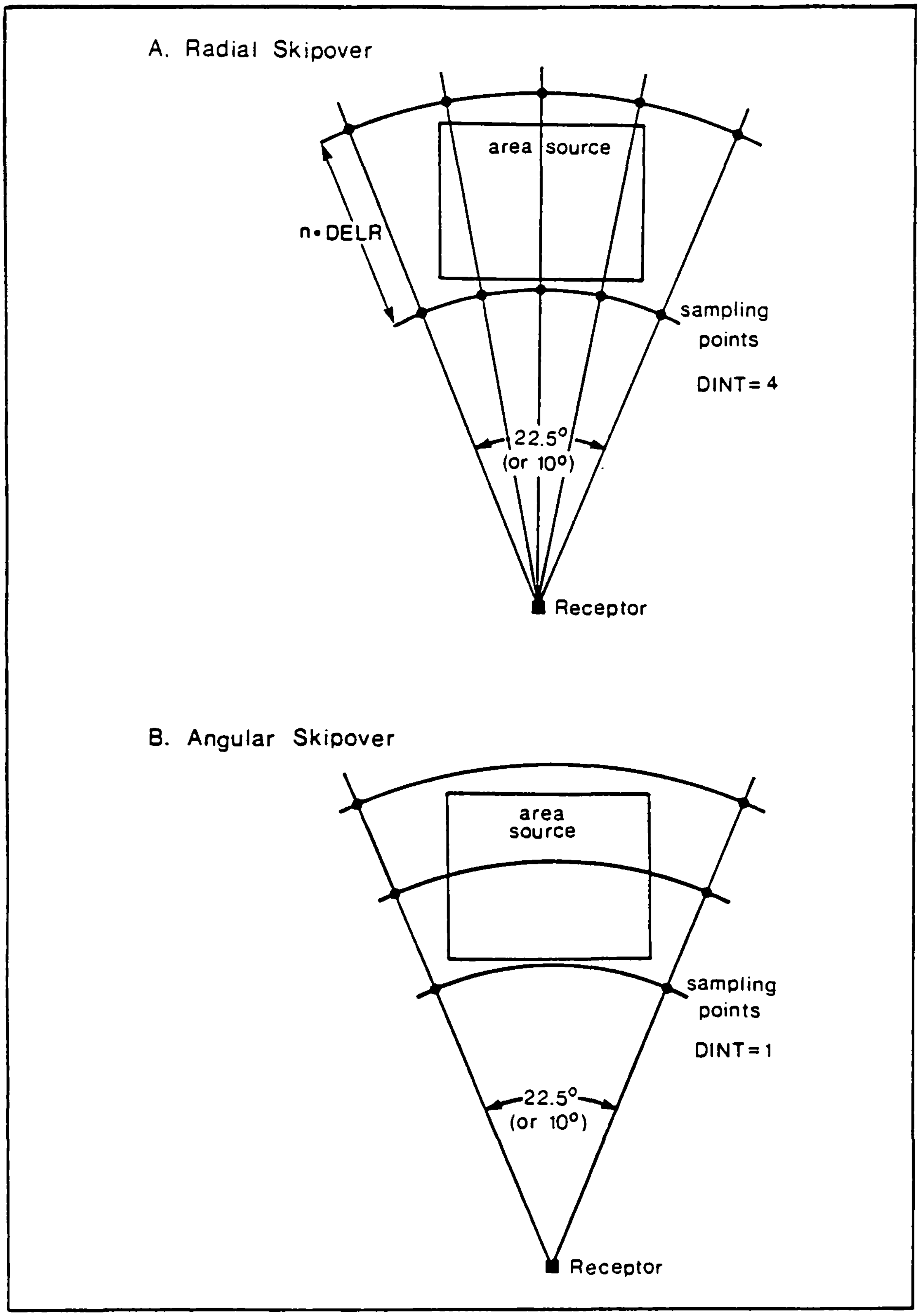


Figure 10. Radial and angular skipover (modified from Brubaker et al., 1977).

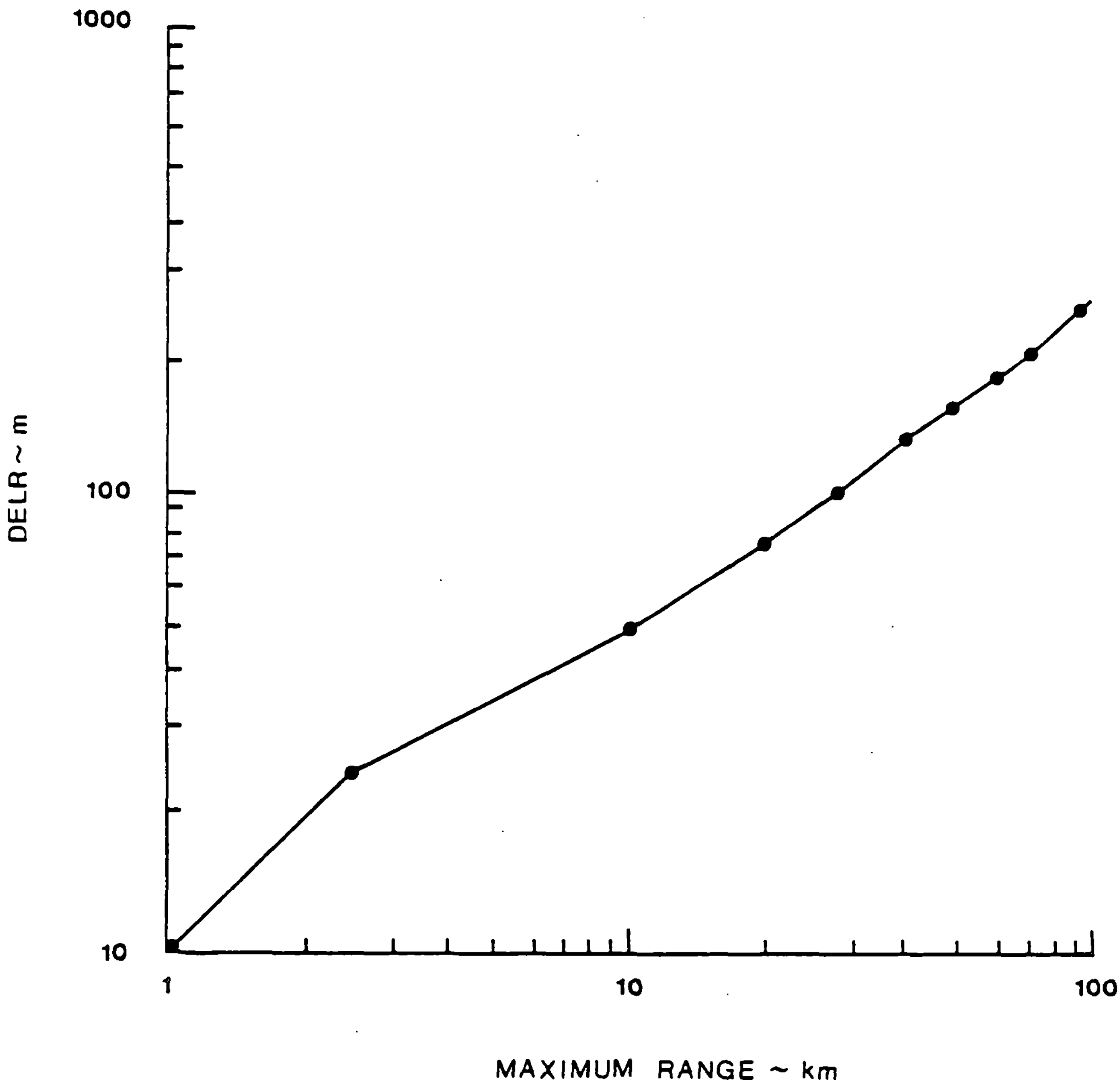


Figure 11. DELR as a function of maximum range of area source integration (modified from Brubaker et al., 1977).

described using large (say 5 km or larger) grid squares. For a detailed inventory employing area-source squares with side lengths of 1 km, Brubaker et al. (1977) suggests using DINT = 10 with a wind direction sector of 22.5° to reduce the likelihood of angular skipover. DINT = 4 is probably sufficient with a 10° wind-direction sector (i.e., N1636 = 36).

Record Type 11

HL is an array variable containing six values which define mixing heights (in meters) associated with the six stability categories summarized in the joint frequency function. The user must decide on an appropriate relationship between mixing height and stability category. One possible scheme is shown in Table 5.

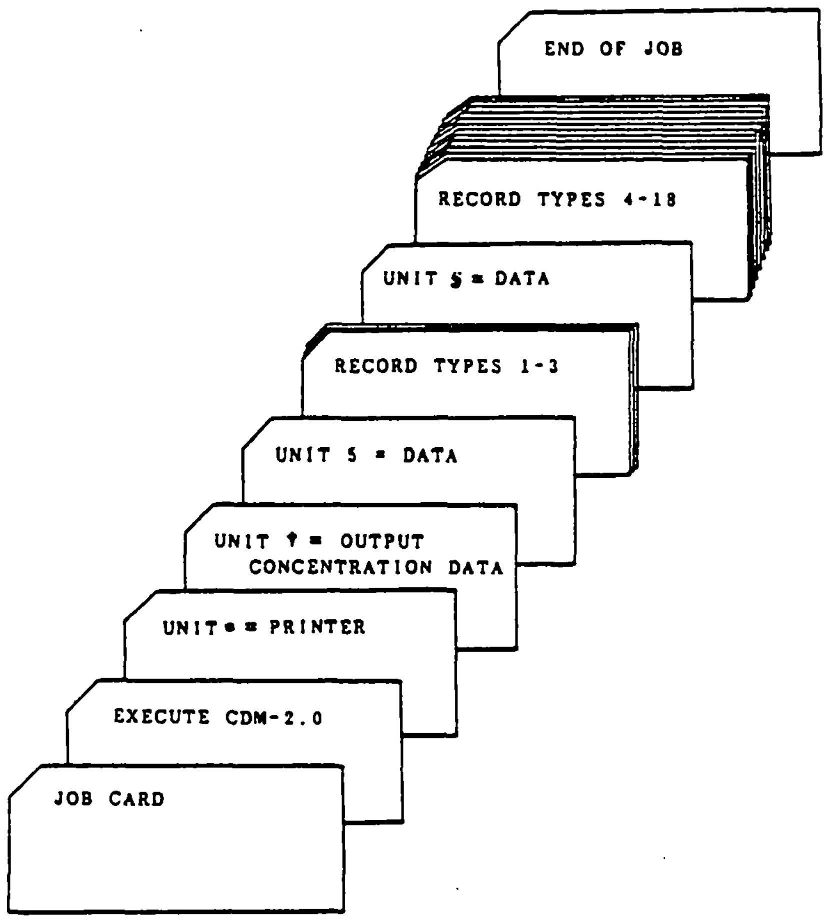
Dispersion from sources with effective release heights above the mixing height is not assumed to reach the receptors. If the mixing height is set to zero for a particular stability, then no contributions from any of the sources would occur (during that particular stability). If the user believes that unlimited mixing is the appropriate condition for a particular stability, then the mixing height (for that stability category) should be specified as a very large value (say 9999. m).

SECTION 9

EXECUTION OF THE MODEL AND SAMPLE TEST

EXECUTION

CDM-2.0 produces an error-free compile on IBM MVS and UNIVAC EXEC 8 computers with comparable execution results. A sample job stream is presented below.



• Unit number provided by user via input variable, IWR.
† Unit number provided by user via input variable, IPU.
§ Unit number provided by user via input variable, IRD.

Figure 12. Sample job stream for CDM-2.0.

A job stream for a UNIVAC EXEC 8 system might have the following form:

```
@RUN,R/R JOB-ID,ETC
@ASG,A MODELS*LOAD.
@ASG,A CONC.
@USE 8,CONC.
@XQT MODELS*LOAD.CDM2
(input records shown in Table 17)
@FIN
```

The following is a sample job stream for a typical IBM system under OS or MVS.

```
//JOBID     JOB  (PROJ,ACCT,OTHER),CLASS=A,TIME=1
//XCDM2     EXEC PGM=CDM2,TIME=(,10)
//STEPLIB   DD   DSN=USER.MODELS.LOAD,DISP=SHR
//FT08F001  DD   DSN=USER.CONC.DATA,DISP=SHR
//FT06F001  DD   SYSOUT=A
//FT05F001  DD   *
(input records shown in Table 17)
/*
//
```

Sample test data for model verification are given in Table 17; Figures 13 and 14 provide the output for the sample test. Users may verify the proper execution of the program by comparing their results with those given in the figures.

TABLE 17. INPUT DATA FOR THE SAMPLE TEST

Record	Record type
SAMPLE TEST OF CDM-2.0	1
1 SO2PART	2
A P1A P2P P1P P299999 0 5 6 8 0.0 0.0 1.0 1.0	3
16,1,0,0,0,1.,0.,0,0	4
6,1,1,2,3,4,4	5
6,1,2,3,4,4,4	6
250. 5. 1000. 5. 5. 1.25 5000.	7
4. 1. 1. 30. 30. 30. 30. 30. 30. 3.999999	8
.10,.15,.20,.25,.25,.30	9
1.5,2.45872,4.4704,6.92912,9.61136,12.51712	10
1200.,800.,800.,800.,475.,150.	11
(7X,6F7.0)	12
48 blank card images	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
0.062500.000000.000000.000000.000000.00000	13
32 blank card images	13
(F6.0,F7.0,F7.0,F8.0,F8.0,F7.0,F5.0,F7.0,F7.0,F5.0)	14
5.0 5.0 10000. 4000. 4000. 20.	15
5.0 15.0 5000. 1000. 1000. 20.	15
10.0 15.0 5000. 1000. 1000. 20.	15
15.0 15.0 5000. 1000. 1000. 20.	15
15.0 10.0 5000. 1000. 1000. 20.	15
15.0 5.0 5000. 1000. 1000. 20.	15
12.5 12.5 0. 1000. 1000. 20. 1.0 5.0 20.0 0.0	15
1 blank card image to indicate end of source records	16
(F8.2,F8.2,I4,I4,I5)	17
5.0 5.0 0 0 0	18
5.0 10.0 0 0 0	18
5.0 15.0 0 0 0	18
5.0 20.0 0 0 0	18
10.0 5.0 0 0 0	18
10.0 10.0 0 0 0	18
10.0 15.0 0 0 0	18
10.0 20.0 0 0 0	18
15.0 5.0 0 0 0	18
15.0 10.0 0 0 0	18
15.0 15.0 0 0 0	18
15.0 20.0 0 0 0	18
20.0 5.0 0 0 0	18
20.0 10.0 0 0 0	18
20.0 15.0 0 0 0	18
20.0 20.0 0 0 1	18

```
                    CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                              CODE VERSION 85293
                                  RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION


TECHNICAL OPTIONS:

    NUMBER OF WIND DIRECTIONS USED IN METEOROLOGICAL JOINT
      FREQUENCY FUNCTION (N1636) ..............................   16
    DISPERSION PARAMETER SCHEME FOR AREA SOURCES (KLOW) .......    2              BRIGGS-URBAN, GIFFORD (1976)
    DISPERSION PARAMETER SCHEME FOR POINT SOURCES (KHIGH) .....    2              BRIGGS-URBAN, GIFFORD (1976)
    EFFLUENT RISE FOR AREA SOURCES (FAC) ......................    1.000000E+00
    HEIGHT ABOVE GROUND OF ALL RECEPTORS (RCEPTZ) .............    0.000000E+00 M
    CALIBRATION CONSTANTS --  SO2
        INTERCEPT OF CALIBRATION ..............................    0.000000E+00 MICROGRAMS/CU. METER
        SLOPE OF CALIBRATION ..................................    1.000000E+00 DIMENSIONLESS
    CALIBRATION CONSTANTS -- PART
        INTERCEPT OF CALIBRATION ..............................    0.000000E+00 MICROGRAMS/CU. METER
        SLOPE OF CALIBRATION ..................................    1.000000E+00 DIMENSIONLESS
        INITIAL DISPERSION OPTION (NPSO) ......................    0
        BUOYANCY INDUCED DISPERSION OPTION (NPDH) .............    1
        STACK DOWNWASH OPTION (NSTDW) .........................    1
        GRADUAL PLUME RISE OPTION (NGRAD) .....................    0
        DEFAULT OPTION (NDEF) .................................    1


PRINT OPTIONS:

    CONTROL FOR PRINTED OUTPUT ................................    0
    FORTRAN LOGICAL UNIT NUMBER (READ) ........................    5
    FORTRAN LOGICAL UNIT NUMBER (PRINTER) .....................    6
    FORTRAN LOGICAL UNIT NUMBER (PUNCH) .......................    8


OPERATING PARAMETERS:

    X-MINIMUM OF AREA EMISSION INVENTORY MAP GRID (XG) ........    5.000000E+00 USER UNITS
    Y-MINIMUM OF AREA EMISSION INVENTORY MAP GRID (YG) ........    5.000000E+00 USER UNITS
    WIDTH OF A BASIC EMISSION GRID SQUARE (RAT) ...............    5.000000E+00 USER UNITS
    GRID CONVERSION FACTOR (CV) ...............................    1.000000E+03 M/USER UNITS
    WIDTH OF A BASIC EMISSION GRID SQUARE (TXX) ...............    5.000000E+03 M
    NUMBER OF SUBSECTORS CONSIDERED FOR EACH SECTOR (DINT) ....    4.000000E+00 DIMENSIONLESS
    ANGULAR WIDTH OF A SUBSECTOR (THETA) ......................    5.625000E+00 DEG
    INITIAL RADIAL INCREMENT (DELR) ...........................    2.500000E+03 M


MISCELLANEOUS METEOROLOGICAL DATA:

    AMBIENT AIR TEMPERATURE (TOA) .............................    2.744100E+02 K
    MIXING HEIGHTS BY STABILITY CLASS (HL):
       STABILITY CLASS:       1 ...............................    1.200000E+03 M
                              2 ...............................    8.000000E+02 M
                              3 ...............................    8.000000E+02 M
                              4 ...............................    8.000000E+02 M
                              5 ...............................    4.750000E+02 M
                              6 ...............................    1.500000E+02 M
```

Figure 13. Printed output for the sample test.

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85293
RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

MISCELLANEOUS METEOROLOGICAL DATA (CONTINUED):

CENTRAL WIND SPEED OF THE SIX WIND SPEED CLASSES (U):

WIND SPEED CLASS:		
1	....	1.500000E+00 M/SEC
2	....	2.458720E+00 M/SEC
3	....	4.470400E+00 M/SEC
4	....	6.929120E+00 M/SEC
5	....	9.611360E+00 M/SEC
6	....	1.251712E+01 M/SEC

EXPONENTIAL OF THE VERTICAL WIND PROFILE (UE):

STABILITY CLASS:		
1	....	1.000000E-01 DIMENSIONLESS
2	....	1.500000E-01 DIMENSIONLESS
3	....	2.000000E-01 DIMENSIONLESS
4	....	2.500000E-01 DIMENSIONLESS
5	....	2.500000E-01 DIMENSIONLESS
6	....	3.000000E-01 DIMENSIONLESS

SOURCE DATA:

POLLUTANTS TO BE MODELED .... SO2 & PART
DECAY HALF-LIFE FOR SO2 (GB(1)) .... 4.000000E+00 HR
DECAY HALF-LIFE FOR PART (GB(2)) .... 9.999990E+05 HR
DAYTIME EMISSION WEIGHT FACTOR (YD) .... 1.000000E+00 DIMENSIONLESS
NIGHTTIME EMISSION WEIGHT FACTOR (YN) .... 1.000000E+00 DIMENSIONLESS
INITIAL SIGMA-Z FOR AREA SOURCES (SZA):

STABILITY CLASS:		
1	....	3.000000E+01 M
2	....	3.000000E+01 M
3	....	3.000000E+01 M
4	....	3.000000E+01 M
5	....	3.000000E+01 M
6	....	3.000000E+01 M

DISPERSION CURVE USED FOR EACH STABILITY CLASS

STABILITY CLASS	POINT SOURCES	AREA SOURCES
1	A	A
2	B	B
3	C	C
4	D1	D1
5	D2	D2
6	E	E

Figure 13. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85293
RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

METEOROLOGICAL JOINT FREQUENCY FUNCTION

STABILITY CLASS 1 — WIND SPEED CLASS

WIND DIRECTION	SECTOR	1	2	3	4	5	6
N	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNE	2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NE	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ENE	4	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	5	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ESE	6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE	7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	8	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
S	9	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSW	10	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SW	11	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WSW	12	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
W	13	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WNW	14	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NW	15	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNW	16	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

COMPUTED MEAN SPEED = 0.00 M/SEC

STABILITY CLASS 2 — WIND SPEED CLASS

WIND DIRECTION	SECTOR	1	2	3	4	5	6
N	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNE	2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NE	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ENE	4	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	5	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ESE	6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE	7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	8	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
S	9	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSW	10	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SW	11	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WSW	12	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
W	13	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WNW	14	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NW	15	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNW	16	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

COMPUTED MEAN SPEED = 0.00 M/SEC

Figure 13. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85293
RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

METEOROLOGICAL JOINT FREQUENCY FUNCTION

STABILITY CLASS 3

WIND DIRECTION	SECTOR	WIND SPEED CLASS 1	2	3	4	5	6
N	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNE	2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NE	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ENE	4	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	5	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ESE	6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE	7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	8	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
S	9	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSW	10	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SW	11	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WSW	12	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
W	13	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WNW	14	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NW	15	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNW	16	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

COMPUTED MEAN SPEED = 0.00 M/SEC

STABILITY CLASS 4

WIND DIRECTION	SECTOR	WIND SPEED CLASS 1	2	3	4	5	6
N	1	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
NNE	2	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
NE	3	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
ENE	4	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
E	5	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
ESE	6	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
SE	7	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	8	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
S	9	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
SSW	10	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
SW	11	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
WSW	12	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
W	13	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
WNW	14	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
NW	15	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000
NNW	16	0.062500	0.000000	0.000000	0.000000	0.000000	0.000000

COMPUTED MEAN SPEED = 1.50 M/SEC

Figure 13. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85293
RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

METEOROLOGICAL JOINT FREQUENCY FUNCTION

STABILITY CLASS 5

		WIND SPEED CLASS					
WIND DIRECTION	SECTOR	1	2	3	4	5	6
N	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNE	2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NE	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ENE	4	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	5	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ESE	6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE	7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	8	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
S	9	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSW	10	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SW	11	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WSW	12	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
W	13	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WNW	14	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NW	15	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNW	16	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

COMPUTED MEAN SPEED = 0.00 M/SEC

STABILITY CLASS 6

		WIND SPEED CLASS					
WIND DIRECTION	SECTOR	1	2	3	4	5	6
N	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNE	2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NE	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ENE	4	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	5	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ESE	6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE	7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	8	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
S	9	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSW	10	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SW	11	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WSW	12	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
W	13	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WNW	14	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NW	15	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNW	16	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

COMPUTED MEAN SPEED = 0.00 M/SEC

Figure 13. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85293
RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

AREA AND POINT SOURCE INVENTORY

X MAP COORDINATE	Y MAP COORDINATE	WIDTH OF GRID SQUARE (M)	----EMISSION RATE---- SO2 (G/SEC)	PART (G/SEC)	SOURCE HEIGHT (M)	STACK DIAM (M)	STACK EXIT SPEED (M/SEC)	STACK GAS TEMP (DEG C)	OPTIONAL PLUME RISE COEFFICIENT (M**2/SEC)
5.00	5.00	10000.	4000.00	4000.00	20.00	0.00	0.00	0.0	0.00
5.00	15.00	5000.	1000.00	1000.00	20.00	0.00	0.00	0.0	0.00
10.00	15.00	5000.	1000.00	1000.00	20.00	0.00	0.00	0.0	0.00
15.00	15.00	5000.	1000.00	1000.00	20.00	0.00	0.00	0.0	0.00
15.00	10.00	5000.	1000.00	1000.00	20.00	0.00	0.00	0.0	0.00
15.00	5.00	5000.	1000.00	1000.00	20.00	0.00	0.00	0.0	0.00
12.50	12.50	0.	1000.00	1000.00	20.00	1.00	5.00	20.0	0.00

6 AREA SOURCES. 1 POINT SOURCES.

Figure 13. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85293
RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

CONCENTRATIONS (MICROGRAMS/CU. METER)

		AREA SOURCES		POINT SOURCES		-----TOTAL-----		--CALIBRATED--		---OBSERVED---	
X COORD	Y COORD	SO2	PART	SO2	PART	SO2	PART	SO2	PART	SO2	PART
5.00	5.00	235.9	264.5	7.9	10.5	243.8	275.0	243.8	275.0	0	0
5.00	10.00	342.7	374.1	12.1	15.0	354.8	389.1	354.8	389.1	0	0
5.00	15.00	342.7	374.1	12.1	15.0	354.8	389.1	354.8	389.1	0	0
5.00	20.00	235.9	264.5	7.9	10.5	243.8	275.0	243.8	275.0	0	0
10.00	5.00	342.7	374.1	12.1	15.0	354.8	389.1	354.8	389.1	0	0
10.00	10.00	542.7	580.3	52.9	58.2	595.6	638.5	595.6	638.5	0	0
10.00	15.00	542.7	580.3	52.9	58.2	595.6	638.5	595.6	638.5	0	0
10.00	20.00	342.7	374.1	12.1	15.0	354.8	389.1	354.8	389.1	0	0
15.00	5.00	342.7	374.1	12.1	15.0	354.8	389.1	354.8	389.1	0	0
15.00	10.00	542.7	580.3	52.9	58.2	595.6	638.5	595.6	638.5	0	0
15.00	15.00	542.7	580.3	52.9	58.2	595.6	638.5	595.6	638.5	0	0
15.00	20.00	342.7	374.1	12.1	15.0	354.8	389.1	354.8	389.1	0	0
20.00	5.00	235.9	264.5	7.9	10.5	243.8	275.0	243.8	275.0	0	0
20.00	10.00	342.7	374.1	12.1	15.0	354.8	389.1	354.8	389.1	0	0
20.00	15.00	342.7	374.1	12.1	15.0	354.8	389.1	354.8	389.1	0	0

Figure 13. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85293
RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

CONCENTRATIONS (MICROGRAMS/CU. METER)

X COORD	Y COORD	AREA SOURCES SO2	AREA SOURCES PART	POINT SOURCES SO2	POINT SOURCES PART	TOTAL SO2	TOTAL PART	CALIBRATED SO2	CALIBRATED PART	OBSERVED SO2	OBSERVED PART
20.00	20.00	235.9	264.5	7.9	10.5	243.8	275.0	243.8	275.0	0	0

** AVERAGE CONCENTRATIONS BY STABILITY **

POLLUTANT	TYPE OF SOURCE	STABILITY CATEGORY 1	2	3	4	5	6
1 (SO2)	AREA	0.0	0.0	0.0	235.9	0.0	0.0
1 (SO2)	POINT	0.0	0.0	0.0	7.9	0.0	0.0
2 (PART)	AREA	0.0	0.0	0.0	264.5	0.0	0.0
2 (PART)	POINT	0.0	0.0	0.0	10.5	0.0	0.0

** AREA ROSES (MICROGRAMS/CU. METER) **

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	4	4	4	4	4	4	4	4	29	45	48	45	29	4	4	4
2	4	4	4	4	4	4	4	4	32	51	57	51	32	4	4	4

** POINT ROSES (MICROGRAMS/CU. METER) **

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0

****

Figure 13. (continued).

5.00	5.0099999I	236	264	8	10	244	275	244	275	0	0
5.00	10.0099999I	343	374	12	15	355	389	355	389	0	0
5.00	15.0099999I	343	374	12	15	355	389	355	389	0	0
5.00	20.0099999I	236	264	8	10	244	275	244	275	0	0
10.00	5.0099999I	343	374	12	15	355	389	355	389	0	0
10.00	10.0099999I	543	580	53	58	596	638	596	638	0	0
10.00	15.0099999I	543	580	53	58	596	638	244	275	0	0
10.00	20.0099999I	343	374	12	15	355	389	355	389	0	0
15.00	5.0099999I	343	374	12	15	355	389	355	389	0	0
15.00	10.0099999I	543	580	53	58	596	638	596	638	0	0
15.00	15.0099999I	543	580	53	58	596	638	596	638	0	0
15.00	20.0099999I	343	374	12	15	355	389	355	389	0	0
20.00	5.0099999I	236	264	8	10	244	275	244	275	0	0
20.00	10.0099999I	343	374	12	15	355	389	355	389	0	0
20.00	15.0099999I	344	374	12	15	355	389	355	389	0	0

A P1	0.0	0.0	0.0	235.9	0.0	0.0	2000	2000
P P1	0.0	0.0	0.0	7.9	0.0	0.0	2000	2000
A P2	0.0	0.0	0.0	264.5	0.0	0.0	2000	2000
P P2	0.0	0.0	0.2	10.5	0.0	0.0	2000	2000

A P1	4	4	4	4	4	4	4	4	2000	2000
A P1	29	45	48	45	29	4	4	4	2000	2000
A P2	4	4	4	4	4	4	4	4	2000	2000
A P2	32	51	57	51	32	4	4	4	2000	2000
P P1	0	0	0	0	0	0	0	0	2000	2000
P P1	0	0	8	0	0	0	0	0	2000	2000
P P2	0	0	0	0	0	0	0	0	2000	2000
P P2	0	0	11	0	0	0	0	0	2000	2000

Figure 14. Card image output for the sample test.

ERROR MESSAGES AND REMEDIAL ACTION

CDM-2.0 can generate nine error messages and two warning messages. An error message results in program termination while a warning message allows execution to continue. Table 18 lists each message, along with its description and suggested corrective action.

TABLE 18. CDM-2.0 ERROR/WARNING MESSAGES AND CORRECTIVE ACTION

MESSAGE (1):	*** VALID VALUES FOR NSO2 ARE 0, 1, OR 2. *** USER INPUT NSO2 = nnnn *** EXECUTION TERMINATED.
DESCRIPTION:	NSO_2 must be set to 0, 1, or 2. Any other value will result in program termination.
ACTION:	Modify input stream so that NSO_2 is equal to 0, 1, or 2 and resubmit the job.
MESSAGE (1):	*** VALID VALUES FOR N1636 ARE 16 OR 36. *** USER INPUT N1636 = nnnn *** EXECUTION TERMINATED.
DESCRIPTION:	The meteorological joint frequency function can only consist of 16 or 36 wind-direction sectors. The user tried to input a value different from 16 or 36.
ACTION:	Modify the input stream so that N1636 is equal to 16 or 36 and make sure that the number of wind direction sectors in the joint frequency function agrees with the value given by N1636.
MESSAGE (1):	*** VALID VALUES FOR FAC RANGE FROM 0 TO 1. *** USER INPUT FAC = xxx.xx *** EXECUTION TERMINATED.
DESCRIPTION:	FAC must be between 0 and 1, inclusive. The user tried to input a value outside that range.

(continued)

TABLE 18 (continued)

ACTION:	Modify input stream so that FAC is between 0 and 1, inclusive.
MESSAGE (1):	*** VALID VALUES OF KLOW RANGE FROM 1 TO 7. *** USER TRIED TO INPUT KLOW = nnnn *** EXECUTION TERMINATED.
DESCRIPTION:	KLOW must be between 1 and 7, inclusive. The user tried to input a value outside that range.
ACTION:	Modify input stream so that KLOW is between 1 and 7, inclusive.
MESSAGE (1):	*** VALID VALUES FOR ICA RANGE FROM 1 TO 7. *** USER TRIED TO INPUT ICA(i) = nnnn *** EXECUTION TERMINATED.
DESCRIPTION:	Values in the array ICA must be between 1 and 7, inclusive. The user tried to input a value outside that range.
ACTION:	Modify input stream so that <u>all</u> the values in the array ICA are between 1 and 7, inclusive.
MESSAGE (1):	*** VALID VALUES FOR KHIGH RANGE FROM 1 TO 7. *** USER INPUT KHIGH = nnnn *** EXECUTION TERMINATED.
DESCRIPTION:	KHIGH must be between 1 and 7, inclusive. The user tried to input a value outside that range.
ACTION:	Modify input stream so that KHIGH is between 1 and 7, inclusive.
MESSAGE (1):	*** VALID VALUES FOR ICP RANGE FROM 1 TO 7. *** USER INPUT ICP(i) = nnnn *** EXECUTION TERMINATED.

(continued)

TABLE 18 (continued)

DESCRIPTION:	Values in the array ICP must be between 1 and 7, inclusive. The user tried to input a value outside that range.
ACTION:	Modify input stream so that <u>all</u> the values in the array ICP are between 1 and 7, inclusive.
MESSAGE (1):	*** THE PRODUCT OF RAT AND CV MUST EQUAL TXX. *** THE VALUES PROVIDED BY THE USER DO NOT CONFORM TO THIS RELATIONSHIP. *** EXECUTION TERMINATED.
DESCRIPTION:	The quantities RAT, CV, and TXX are related by the following equation: TXX = RAT·CV. However the user-supplied quantities do not relate in the prescribed manner.
ACTION:	Modify input stream so that the quantities meet the above-mentioned relationship.
MESSAGE (1):	*** VALID VALUES FOR DINT RANGE FROM 2 TO 20. *** USER INPUT DINT = xxx.x *** EXECUTION TERMINATED.
DESCRIPTION:	DINT must be between 2 and 20, inclusive. The user tried to input a value outside that range.
ACTION:	Modify input stream so that DINT is between 2 and 20, inclusive.
MESSAGE (2):	NOTE: AREA SOURCE WITH X COORD xxxxxxx.xx AND Y COORD yyyyyyy.yy VIOLATES AREA SOURCE ARRAY LIMITS. AREA SOURCES MUST LIE ENTIRELY WITHIN A xxxxxxxx.xx BY xxxxxxxx.xx METER SQUARE WITH SOUTHWEST CORNER AT THE USER-DEFINED ORIGIN (XG,YG). THIS SOURCE WILL NOT BE INCLUDED IN THIS CALCULATION.

(continued)

DESCRIPTION:	The area source emission grid may not be larger than 50 grid squares in either the x or the y direction, this limit being determined by the dimensions of various arrays defined within the computer program. This limit, together with the user-specified size of a basic grid square (TXX), imposes a limit to the total size of the emission grid. A test is made to see that each area source falls within the boundaries of the grid. It was determined the area source mentioned in the warning message lies partially or wholly outside the grid boundaries. As indicated in the message, the calculation proceeds but the area source in violation is omitted from the inventory.
ACTION:	Adjust the location of the origin (XG,YG) or the size of the basic emission grid square (TXX) such that <u>all</u> area sources are within the boundaries of the grid. Alternatively, the dimensions could be appropriately increased to accommodate the area source inventory.
MESSAGE (2):	WARNING: MORE THAN 100 ARCS ARE REQUIRED FOR CALCULATION OF AREA CONTRIBUTION. AREA SOURCES BEYOND xxx.x KM ARE NOT INCLUDED IN THIS CALCULATION.
DESCRIPTION:	As discussed in Section 5, the area source algorithm evaluates the average emission rate on a series of arcs centered on the receptor of interest. No more than 100 arcs are used, this limit, together with the user-supplied radial integration step, DELR, imposes an upper limit to the distance to which the area source calculations

(continued)

TABLE 18 (continued)

	are taken. If there are area sources beyond this range, they are not included in the calculations.
ACTION:	Guidance on choosing DELR to avoid this problem is provided in Figure 11. The integration step, DELR, should be modified such that all area sources are included in the calculation. Alternatively, the user could increase the number of integration steps allowed.

(1) Error message -- execution terminated.

(2) Warning message -- execution continues.

SECTION 10

INTERPRETATION OF OUTPUT

The input stream and output listing of the example problem in Section 6 are presented here. The reader is referred to the earlier section for the physical description of the problem. Intricacies of the input data are discussed here and the output listing is annotated for ease of interpretation.

Table 19 lists the input data for the example problem. Note that the PGCDM dispersion scheme (KLOW = KHIGH = 6) was chosen for this example. Arrays ICP and ICA were so defined to simulate the more unstable conditions of the urban atmosphere. As shown in Figure 15, RAT (the basic emission grid square in user units) is 5 km; thus TXX = 5000 m and CV = 1000. The coordinates of the southwest corner of the emission grid (XG, YG) is also given in Figure 15. As indicated in Table 19, receptors are combined into two groups: those in which NROSE $\leq$ 0 and those in which NROSE > 0. Output volume is reduced in this manner.

The printed output of CDM-2.0 consists of four parts: set-up information, meteorology, source inventory, and concentration results. The set-up information, meteorology, and source inventory are optionally provided (see variable NLIST of record type 5 in Table 15). Abridged output from the example problem is given in Figure 16; output in card image form is shown in Table 20. The format of the card image output is given in Table 21 for ease of interpretation.

TABLE 19. INPUT DATA FOR THE EXAMPLE PROBLEM.

Record	Record type
AQDM TEST CITY	1
1 SO2PART	2
A P1A P2P P1P P2 100 0 5 6 8 0.0 0.0 1.0 1.0	3
16,1,0,0,0,1.,0.,0,0	4
8,1,1,2,3,4,4	5
6,1,2,3,4,4,4	6
100. 5. 1000. 562.54387.5 15. 5000.	7
10. 1. 1. 30. 30. 30. 30. 30. 30.999999999999	8
0.1,0.15,0.2,0.25,0.25,0.3	9
1.5,2.45872,4.4704,6.92912,9.61136,12.51712	10
1500.,1000.,1000.,1000.,550.,100.	11
(9X,6F9.0)	12
16 blank card images	13
.000500 .000500 .0 .0 .0 .0	13
.0 .0 .0 .0 .0 .0	13
.0 .000500 .0 .0 .0 .0	13
.000500 .0 .0 .0 .0 .0	13
.000900 .000500 .000500 .0 .0 .0	13
.000900 .0 .0 .0 .0 .0	13
.000900 .000500 .0 .0 .0 .0	13
.0 .0 .0 .0 .0 .0	13
.0 .0 .0 .0 .0 .0	13
.0 .0 .0 .0 .0 .0	13
.0 .0 .0 .0 .0 .0	13
.000900 .0 .0 .0 .0 .0	13
.0 .000500 .0 .0 .0 .0	13
.000500 .0 .0 .0 .0 .0	13
.0 .0 .0 .0 .0 .0	13
.0 .0 .0 .0 .0 .0	13
.000500 .0 .003200 .0 .0 .0	13
.0 .000500 .000900 .0 .0 .0	13
.0 .0 .000900 .0 .0 .0	13
.000900 .000900 .004600 .0 .0 .0	13
.001800 .002800 .004100 .000500 .0 .0	13
.0 .003700 .004600 .0 .0 .0	13
.001400 .003200 .002800 .0 .0 .0	13
.0 .002800 .000900 .0 .0 .0	13
.0 .000900 .000900 .0 .0 .0	13
.0 .001800 .000900 .0 .0 .0	13
.0 .001800 .000900 .0 .0 .0	13
.000500 .001400 .000900 .0 .0 .0	13
.0 .001400 .000900 .0 .0 .0	13
.000500 .000500 .000900 .0 .0 .0	13
.0 .000900 .000500 .0 .0 .0	13
.0 .001400 .001400 .0 .0 .0	13
.0 .001080 .031560 .022980 .002220 .0	13
.0 .000540 .008040 .009420 .001680 .0	13
.0 .000540 .006360 .008880 .000300 .0	13
.0 .002220 .006360 .006360 .000300 .0	13
.0 .003360 .008880 .008280 .003300 .000840	13
.0 .001680 .006060 .030420 .006660 .000840	13
.0 .000840 .013020 .024600 .003060 .000300	13
.0 .001080 .010500 .014640 .001680 .0	13
.0 .000300 .008880 .018000 .001380 .0	13
.0 .000840 .005280 .005280 .0 .0	13
.0 .001080 .001080 .0 .0 .0	13
.0 .000540 .005280 .000300 .0 .0	13
.0 .002460 .007740 .004140 .0 .0	13
.0 .002220 .009420 .006660 .001080 .0	13
.0 .001380 .014640 .009660 .001680 .0	13
.0 .001680 .018000 .019620 .001380 .0	13
.0 .000720 .021040 .019320 .001480 .0	13
.0 .000360 .005360 .006280 .001120 .0	13

(continued)

TABLE 19. (continued)

Record										Record type
.0	.000360	.004240	.005920	.000200	.0					13
.0	.001480	.004240	.004240	.000200	.0					13
.0	.002240	.005920	.005520	.002200	.000560					13
.0	.001120	.004040	.020280	.004440	.000560					13
.0	.000560	.008680	.016400	.002040	.000200					13
.0	.000720	.007000	.009760	.001120	.0					13
.0	.000200	.005920	.012000	.000920	.0					13
.0	.000560	.003520	.003520	.0	.0					13
.0	.000720	.000720	.0	.0	.0					13
.0	.000360	.003520	.000200	.0	.0					13
.0	.001640	.005160	.002760	.0	.0					13
.0	.001480	.006280	.004440	.000720	.0					13
.0	.000920	.009780	.006440	.001120	.0					13
.0	.001120	.012000	.013080	.000920	.0					13
.005100	.012400	.021200	.0	.0	.0					13
.000500	.002800	.004600	.0	.0	.0					13
.000900	.005100	.002800	.0	.0	.0					13
.003200	.007800	.004100	.0	.0	.0					13
.010600	.016100	.005500	.0	.0	.0					13
.005500	.016100	.012400	.0	.0	.0					13
.001400	.006900	.004600	.0	.0	.0					13
.000900	.005100	.005100	.0	.0	.0					13
.002800	.004600	.002300	.0	.0	.0					13
.005100	.006500	.0	.0	.0	.0					13
.000900	.003700	.0	.0	.0	.0					13
.001800	.003700	.0	.0	.0	.0					13
.001800	.006500	.000500	.0	.0	.0					13
.005500	.012000	.003700	.0	.0	.0					13
.008800	.011100	.003700	.0	.0	.0					13
.003200	.011500	.006900	.0	.0	.0					13
(F6.0,2F7.0,2F8.0,F7.0,F5.0,2F7.0,F5.0)										14
568.5	4403.4		1365.00	527.63	150.				.0001	15
584.2	4391.6		1580.38	789.6	90.	8.7	15.2	149.		15
577.0	4401.1		221.78	34.13	30.	.7	17.8	515.		15
574.1	4401.5		110.25	54.08	23.	1.4	15.2	280.		15
562.5	4402.5	5000.	1.37	1.68						15
567.5	4402.5	5000.	1.28	1.79						15
572.5	4402.5	5000.	5.25	3.99	10.					15
577.5	4402.5	5000.	1.47	13.13						15
582.5	4402.5	5000.	1.2	1.58						15
562.5	4397.5	5000.	2.62	1.47	10.					15
567.5	4392.5	10000.	32.66	21.11	15.					15
577.5	4397.5	5000.	5.46	3.99	10.					15
582.5	4397.5	5000.	6.62	5.78	10.					15
562.5	4392.5	5000.	2.63	1.16	10.					15
577.5	4392.5	5000.	7.88	5.15	20.					15
582.5	4392.5	5000.	5.25	3.68	10.					15
562.5	4387.5	5000.	2.73	1.37						15
567.5	4387.5	5000.	2.42	1.89	10.					15
572.5	4387.5	5000.	5.36	4.10	10.					15
577.5	4387.5	5000.	5.57	3.89	10.					15
582.5	4387.5	5000.	2.84	1.47	10.					15
1 blank card image to indicate end of source records										16
(2F8.2,14X,I4,3X,I4,I5)										17
570.0	4393.2	12	8							18
573.9	4388.9	14	11							18
572.4	4402.2	50	25							18
579.0	4394.0	20	8							18
583.0	4399.2	16	7							18
562.0	4395.7	10	6	1						18
566.1	4400.0	18	10	1						18
572.5	4396.7		9	1						18
577.5	4397.5			1						18
576.0	4403.0			1						19

To reduce length of output listing, receptors should be combined into two groups - those in which NROSE ≤ 0 and those in which NROSE > 0.

NROSE ≤ 0 (records 573.9 through 579.0, type 18)

NROSE > 0 (records 562.0 through 572.5, type 18)

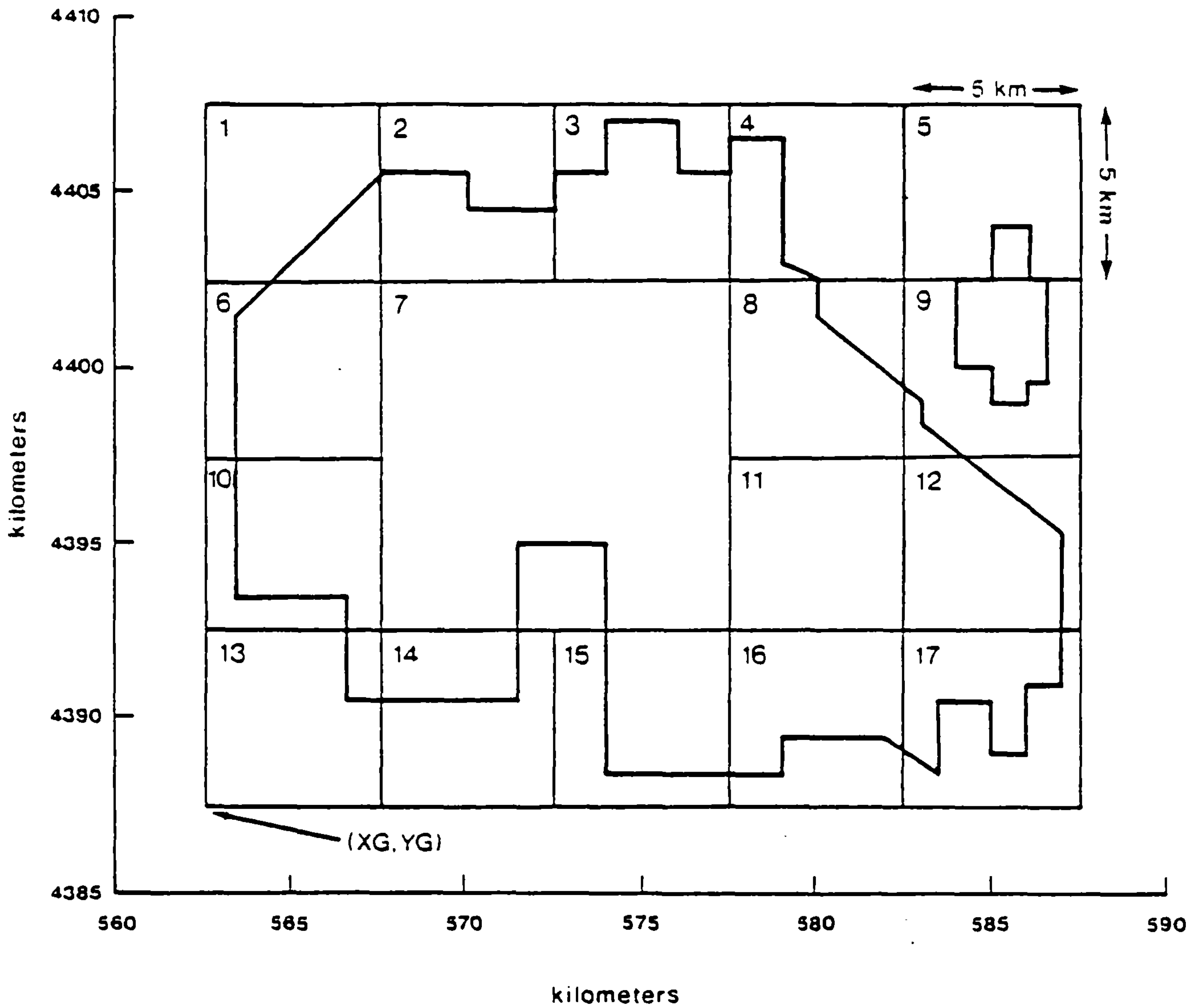


Figure 15. Annotated Test City map (modified from Brubaker et al., 1977).

```
                         CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                  CODE VERSION 85267
                                       RUN   100

AQDM TEST CITY

TECHNICAL OPTIONS:

   NUMBER OF WIND DIRECTIONS USED IN METEOROLOGICAL JOINT
     FREQUENCY FUNCTION (N1636) ..............................   16
   DISPERSION PARAMETER SCHEME FOR AREA SOURCES (KLOW) .......    6          POCDM, BUSSE & ZIMMERMAN (1973)
   DISPERSION PARAMETER SCHEME FOR POINT SOURCES (KHIGH) .....    6          POCDM, BUSSE & ZIMMERMAN (1973)
   EFFLUENT RISE FOR AREA SOURCES (PAC) ......................   1.000000E+00
   HEIGHT ABOVE GROUND OF ALL RECEPTORS (RCEPTZ) .............   0.000000E+00 M
   CALIBRATION CONSTANTS --  SO2
       INTERCEPT OF CALIBRATION ..............................   0.000000E+00 MICROGRAMS/CU. METER
       SLOPE OF CALIBRATION ..................................   1.000000E+00 DIMENSIONLESS
   CALIBRATION CONSTANTS -- PART
       INTERCEPT OF CALIBRATION ..............................   0.000000E+00 MICROGRAMS/CU. METER
       SLOPE OF CALIBRATION ..................................   1.000000E+00 DIMENSIONLESS
       INITIAL DISPERSION OPTION (NPSO) ......................   1
       BUOYANCY INDUCED DISPERSION OPTION (NPDH) .............   0
       STACK DOWNWASH OPTION (NSTDW) .........................   0
       GRADUAL PLUME RISE OPTION (NGRAD) .....................   0
       DEFAULT OPTION (NDEF) .................................   0

PRINT OPTIONS:

   CONTROL FOR PRINTED OUTPUT ................................   0
   FORTRAN LOGICAL UNIT NUMBER (READ) ........................   5
   FORTRAN LOGICAL UNIT NUMBER (PRINTER) .....................   6
   FORTRAN LOGICAL UNIT NUMBER (PUNCH) .......................   8

OPERATING PARAMETERS:

   X-MINIMUM OF AREA EMISSION INVENTORY MAP GRID (XG) ........   5.625000E+02 USER UNITS
   Y-MINIMUM OF AREA EMISSION INVENTORY MAP GRID (YG) ........   4.387500E+03 USER UNITS
   WIDTH OF A BASIC EMISSION GRID SQUARE (RAT) ...............   5.000000E+00 USER UNITS
   GRID CONVERSION FACTOR (CV) ...............................   1.000000E+03 M/USER UNITS
   WIDTH OF A BASIC EMISSION GRID SQUARE (TXX) ...............   5.000000E+03 M
   NUMBER OF SUBSECTORS CONSIDERED FOR EACH SECTOR (DINT) ....   1.000000E+01 DIMENSIONLESS
   ANGULAR WIDTH OF A SUBSECTOR (THETA) ......................   2.250000E+00 DEG
   INITIAL RADIAL INCREMENT (DELR) ...........................   1.000000E+02 M

MISCELLANEOUS METEOROLOGICAL DATA:

   AMBIENT AIR TEMPERATURE (TOA) .............................   2.881600E+02 K
   MIXING HEIGHTS BY STABILITY CLASS (HL):
      STABILITY CLASS:      1 ................................   1.600000E+03 M
                            2 ................................   1.000000E+03 M
                            3 ................................   1.000000E+03 M
                            4 ................................   1.000000E+03 M
                            5 ................................   5.500000E+02 M
                            6 ................................   1.000000E+02 M
```

SET-UP INFORMATION

Run title (AQDM TEST CITY)

Status of initial dispersion, buoyancy-induced dispersion, and stack downwash options.

NLIST (CONTROL FOR PRINTED OUTPUT)

Since NLIST = 0, set-up information is echoed for verification. When NLIST < 0, this page and following page are not printed.

Figure 16. Printed output for the example problem.

```
                              CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                        CODE VERSION 85267
                                           RUN    100

AQDM TEST CITY
```
← *Run title included on every page of listing*

```
MISCELLANEOUS METEOROLOGICAL DATA (CONTINUED):

   CENTRAL WIND SPEED OF THE SIX WIND SPEED CLASSES (U):
      WIND SPEED CLASS:  1 ................................   1.500000E+00 M/SEC
                         2 ................................   2.458720E+00 M/SEC
                         3 ................................   4.470400E+00 M/SEC
                         4 ................................   6.929120E+00 M/SEC
                         5 ................................   9.611360E+00 M/SEC
                         6 ................................   1.251712E+01 M/SEC

   EXPONENTIAL OF THE VERTICAL WIND PROFILE (UE):
      STABILITY CLASS:   1 ................................   1.000000E-01 DIMENSIONLESS
                         2 ................................   1.500000E-01 DIMENSIONLESS
                         3 ................................   2.000000E-01 DIMENSIONLESS
                         4 ................................   2.500000E-01 DIMENSIONLESS
                         5 ................................   2.500000E-01 DIMENSIONLESS
                         6 ................................   3.000000E-01 DIMENSIONLESS


SOURCE DATA:

   POLLUTANTS TO BE MODELED ...............................    SO2 & PART
   DECAY HALF-LIFE FOR SO2 (QB(1)) ........................   9.999990E+06 HR
   DECAY HALF-LIFE FOR PART (QB(2)) .......................   9.999990E+06 HR
   DAYTIME EMISSION WEIGHT FACTOR (YD) ....................   1.000000E+00 DIMENSIONLESS
   NIGHTTIME EMISSION WEIGHT FACTOR (YN) ..................   1.000000E+00 DIMENSIONLESS
   INITIAL SIGMA-Z FOR AREA SOURCES (SZA):
      STABILITY CLASS:   1 ................................   3.000000E+01 M
                         2 ................................   3.000000E+01 M
                         3 ................................   3.000000E+01 M
                         4 ................................   3.000000E+01 M
                         5 ................................   3.000000E+01 M
                         6 ................................   3.000000E+01 M

DISPERSION CURVE USED FOR EACH STABILTY CLASS
   STABILITY        POINT          AREA
     CLASS         SOURCES        SOURCES
       1              A              A
       2              B              A
       3              C              B
       4              D1             C
       5              D1             D1
       6              D1             D1
```

Figure 16. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 86287
RUN 100

METEOROLOGY

AQDM TEST CITY

When NLIST < 0, the meteorological joint frequency function is not printed.

METEOROLOGICAL JOINT FREQUENCY FUNCTION

Output is abridged. The meteorological joint frequency function is missing for stability classes 2, 3, 4, and 5.

STABILITY CLASS 1

WIND DIRECTION	SECTOR	WIND SPEED CLASS 1	2	3	4	5	6
N	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNE	2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NE	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ENE	4	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	5	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ESE	6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE	7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	8	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
S	9	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSW	10	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SW	11	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WSW	12	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
W	13	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WNW	14	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NW	15	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNW	16	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

COMPUTED MEAN SPEED = 0.00 M/SEC

STABILITY CLASS 6

WIND DIRECTION	SECTOR	WIND SPEED CLASS 1	2	3	4	5	6
N	1	0.005100	0.012400	0.021200	0.000000	0.000000	0.000000
NNE	2	0.000500	0.002800	0.004600	0.000000	0.000000	0.000000
NE	3	0.000900	0.005100	0.002800	0.000000	0.000000	0.000000
ENE	4	0.003200	0.007800	0.004100	0.000000	0.000000	0.000000
E	5	0.010600	0.016100	0.005500	0.000000	0.000000	0.000000
ESE	6	0.005500	0.016100	0.012400	0.000000	0.000000	0.000000
SE	7	0.001400	0.006900	0.004600	0.000000	0.000000	0.000000
SSE	8	0.000900	0.005100	0.005100	0.000000	0.000000	0.000000
S	9	0.002800	0.004600	0.002300	0.000000	0.000000	0.000000
SSW	10	0.005100	0.008500	0.000000	0.000000	0.000000	0.000000
SW	11	0.000900	0.003700	0.000000	0.000000	0.000000	0.000000
WSW	12	0.001800	0.003700	0.000000	0.000000	0.000000	0.000000
W	13	0.001800	0.006500	0.000500	0.000000	0.000000	0.000000
WNW	14	0.005500	0.012000	0.003700	0.000000	0.000000	0.000000
NW	15	0.008800	0.011100	0.003700	0.000000	0.000000	0.000000
NNW	16	0.003200	0.011600	0.008900	0.000000	0.000000	0.000000

Average wind speed for stability class 6. ——→ COMPUTED MEAN SPEED = 2.83 M/SEC

Figure 16. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85287
RUN 100

AQDM TEST CITY

AREA AND POINT SOURCE INVENTORY

X MAP COORDINATE	Y MAP COORDINATE	WIDTH OF GRID SQUARE (M)	----EMISSION RATE---- SO2 (G/SEC)	PART (G/SEC)	SOURCE HEIGHT (M)	STACK DIAM (M)	STACK EXIT SPEED (M/SEC)	STACK GAS TEMP (DEG C)	OPTIONAL PLUME RISE COEFFICIENT (M**2/SEC)
568.50	4403.40	0.	1365.00	527.83	150.00	0.00	0.00	0.0	0.00
584.20	4391.60	0.	1580.36	789.60	90.00	8.70	15.20	149.0	0.00
577.00	4401.10	0.	221.78	34.13	30.00	0.70	17.80	515.0	0.00
574.10	4401.50	0.	110.25	64.08	23.00	1.40	15.20	260.0	0.00
562.50	4402.50	5000.	1.37	1.68	0.00	0.00	0.00	0.0	0.00
567.50	4402.50	5000.	1.28	1.79	0.00	0.00	0.00	0.0	0.00
572.50	4402.50	5000.	6.25	3.99	10.00	0.00	0.00	0.0	0.00
577.50	4402.50	5000.	1.47	13.13	0.00	0.00	0.00	0.0	0.00
582.50	4402.50	5000.	1.20	1.58	0.00	0.00	0.00	0.0	0.00
562.50	4397.50	5000.	2.62	1.47	10.00	0.00	0.00	0.0	0.00
567.50	4392.50	10000.	32.66	21.11	15.00	0.00	0.00	0.0	0.00
577.50	4397.50	5000.	5.48	3.09	10.00	0.00	0.00	0.0	0.00
582.50	4397.50	5000.	6.62	5.78	10.00	0.00	0.00	0.0	0.00
562.50	4392.50	5000.	2.63	1.16	10.00	0.00	0.00	0.0	0.00
577.50	4392.50	5000.	7.88	5.15	20.00	0.00	0.00	0.0	0.00
582.50	4392.50	5000.	5.25	3.68	10.00	0.00	0.00	0.0	0.00
562.50	4387.50	5000.	2.73	1.37	0.00	0.00	0.00	0.0	0.00
567.50	4387.50	5000.	2.42	1.89	10.00	0.00	0.00	0.0	0.00
572.50	4387.50	5000.	5.38	4.10	10.00	0.00	0.00	0.0	0.00
577.50	4387.50	5000.	5.57	3.89	10.00	0.00	0.08	0.0	0.00
582.50	4387.50	5000.	2.84	1.47	10.00	0.00	0.00	0.0	0.00

17 AREA SOURCES. 4 POINT SOURCES.

Total number of area and point sources

Since NLIST = 0, the source inventory is echoed for verification. When NLIST ≠ 0, this information is not printed.

Figure 16. (continued).

Receptors in which NROSE = 0.

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85267
RUN 100

AQDM TEST CITY

CONCENTRATIONS (MICROGRAMS/CU. METER)

X COORD	Y COORD	AREA SOURCES SO2	AREA SOURCES PART	POINT SOURCES SO2	POINT SOURCES PART	TOTAL SO2	TOTAL PART	CALIBRATED SO2	CALIBRATED PART	OBSERVED SO2	OBSERVED PART
570.00	4393.20	5.4	3.8	14.8	5.5	20.3	9.3	20.3	9.3	12	8
573.90	4388.90	4.6	3.4	9.5	3.6	14.1	7.0	14.1	7.0	14	11
572.40	4402.20	4.9	4.3	39.5	13.0	44.4	17.3	44.4	17.3	50	26
579.00	4394.00	5.4	4.3	15.3	4.4	20.7	8.7	20.7	8.7	20	8
583.00	4399.20	4.5	4.9	11.3	3.0	15.8	7.9	15.8	7.9	18	7

CDM-2.0 provides separate point and area source contributions.

"Total" and "calibrated" concentrations are identical since slope and intercept input as 1 and 0, respectively.

<u>*Note*</u> *In order to reduce length of output listing, receptors should be combined into two groups on input: those in which NROSE ≤ 0 and those in which NROSE > 0.*

Figure 16. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85287
RUN 100

CONCENTRATION RESULTS (continued)

AQDM TEST CITY

CONCENTRATIONS (MICROGRAMS/CU. METER)

X COORD	Y COORD	AREA SOURCES SO2	AREA SOURCES PART	POINT SOURCES SO2	POINT SOURCES PART	TOTAL SO2	TOTAL PART	CALIBRATED SO2	CALIBRATED PART	OBSERVED SO2	OBSERVED PART
562.00	4395.70	2.7	1.8	6.2	2.2	8.9	4.0	8.9	4.0	10	6

•• AVERAGE CONCENTRATIONS BY STABILITY ••

POLLUTANT	TYPE OF SOURCE	STABILITY CATEGORY 1	2	3	4	5	6
1 (SO2)	AREA	0.0	0.0	0.1	0.2	0.4	2.0
1 (SO2)	POINT	0.0	0.1	0.4	2.7	1.8	1.2
2 (PART)	AREA	0.0	0.0	0.0	0.1	0.3	1.4
2 (PART)	POINT	0.0	0.0	0.2	1.0	0.7	0.2

NROSE > 0 for this receptor, thus concentration versus stability histogram and concentration roses provided.

•• AREA ROSES (MICROGRAMS/CU. METER) ••

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

•• POINT ROSES (MICROGRAMS/CU. METER) ••

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0	0	3	2	1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0

••

Figure 16. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85267
RUN 100

CONCENTRATION RESULTS (continued)

AQDM TEST CITY

CONCENTRATIONS (MICROGRAMS/CU. METER)

		AREA SOURCES		POINT SOURCES		-----TOTAL-----		--CALIBRATED--		---OBSERVED---	
X COORD	Y COORD	SO2	PART	SO2	PART	SO2	PART	SO2	PART	SO2	PART
566.10	4400.00	4.2	3.1	12.5	4.1	16.7	7.2	16.7	7.2	18	10

•• AVERAGE CONCENTRATIONS BY STABILITY ••

	TYPE OF	-------------STABILITY CATEGORY-------------					
POLLUTANT	SOURCE	1	2	3	4	5	6
1 (SO2)	AREA	0.0	0.0	0.1	0.5	0.8	2.7
1 (SO2)	POINT	0.0	0.2	1.0	4.8	3.2	3.2
2 (PART)	AREA	0.0	0.0	0.1	0.3	0.6	2.1
2 (PART)	POINT	0.0	0.1	0.4	1.8	1.2	0.6

••• AREA ROSES (MICROGRAMS/CU. METER) •••

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0

••• POINT ROSES (MICROGRAMS/CU. METER) •••

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0	0	4	0	7	2	0	0	0	0	0	0	0	0	0	0
2	0	0	2	0	2	1	0	0	0	0	0	0	0	0	0	0

••

Figure 16. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85267
RUN 100

CONCENTRATION RESULTS (continued)

AQCM TEST CITY

CONCENTRATIONS (MICROGRAMS/CU. METER)

X COORD	Y COORD	AREA SOURCES SO2	AREA SOURCES PART	POINT SOURCES SO2	POINT SOURCES PART	TOTAL SO2	TOTAL PART	CALIBRATED SO2	CALIBRATED PART	OBSERVED SO2	OBSERVED PART
572.50	4396.70	6.0	4.3	17.5	6.3	23.5	10.6	23.5	10.6	0	9

AVERAGE CONCENTRATIONS BY STABILITY

POLLUTANT	TYPE OF SOURCE	STABILITY CATEGORY 1	2	3	4	5	6
1 (SO2)	AREA	0.0	0.0	0.2	0.9	1.3	3.6
1 (SO2)	POINT	0.0	0.0	0.9	8.6	5.7	2.2
2 (PART)	AREA	0.0	0.0	0.1	0.6	0.9	2.6
2 (PART)	POINT	0.0	0.0	0.4	3.2	2.2	0.5

AREA ROSES (MICROGRAMS/CU. METER)

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0
2	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0

POINT ROSES (MICROGRAMS/CU. METER)

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0	2	4	0	0	2	0	0	0	0	0	0	0	0	0	9
2	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	4

Figure 16. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85267
RUN 100

CONCENTRATION RESULTS (continued)

AQDM TEST CITY

CONCENTRATIONS (MICROGRAMS/CU. METER)

X COORD	Y COORD	AREA SOURCES SO2	AREA SOURCES PART	POINT SOURCES SO2	POINT SOURCES PART	TOTAL SO2	TOTAL PART	CALIBRATED SO2	CALIBRATED PART	OBSERVED SO2	OBSERVED PART
577.50	4397.50	5.5	4.4	34.2	7.6	39.8	12.0	39.8	12.0	0	0

AVERAGE CONCENTRATIONS BY STABILITY

POLLUTANT	TYPE OF SOURCE	STABILITY CATEGORY 1	2	3	4	5	6
1 (SO2)	AREA	0.0	0.0	0.1	0.8	1.2	3.3
1 (SO2)	POINT	0.0	0.3	1.1	14.7	9.8	8.3
2 (PART)	AREA	0.0	0.0	0.1	0.6	1.0	2.7
2 (PART)	POINT	0.0	0.1	0.4	3.5	2.3	1.4

AREA ROSES (MICROGRAMS/CU. METER)

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	1	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

POINT ROSES (MICROGRAMS/CU. METER)

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	26	0	0	0	0	0	2	0	0	0	0	0	0	4	3	0
2	4	0	0	0	0	0	1	0	0	0	0	0	0	2	1	0

Figure 16. (continued).

CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
CODE VERSION 85267
RUN 100

CONCENTRATION RESULTS (continued)

AQDM TEST CITY

CONCENTRATIONS (MICROGRAMS/CU. METER)

X COORD	Y COORD	AREA SOURCES SO2	AREA SOURCES PART	POINT SOURCES SO2	POINT SOURCES PART	TOTAL SO2	TOTAL PART	CALIBRATED SO2	CALIBRATED PART	OBSERVED SO2	OBSERVED PART
576.00	4403.00	4.4	4.8	27.8	6.2	32.3	11.0	32.3	11.0	0	0

AVERAGE CONCENTRATIONS BY STABILITY

POLLUTANT	TYPE OF SOURCE	STABILITY CATEGORY 1	2	3	4	5	6
1 (SO2)	AREA	0.0	0.0	0.1	0.7	1.0	2.6
1 (SO2)	POINT	0.0	0.1	2.4	12.6	8.4	4.3
2 (PART)	AREA	0.0	0.0	0.1	0.7	1.0	3.0
2 (PART)	POINT	0.0	0.0	0.7	2.9	1.9	0.7

AREA ROSES (MICROGRAMS/CU. METER)

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0

POINT ROSES (MICROGRAMS/CU. METER)

POLLUTANT	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	0	0	0	0	0	0	2	21	0	0	1	0	4	0	0	0
2	0	0	0	0	0	0	1	3	0	0	0	0	2	0	0	0

Figure 16. (continued).

TABLE 20. CARD IMAGE OUTPUT FOR THE EXAMPLE PROBLEM.

Card image output														Record type
	570.00	4393.20	1001	5	4	15	5	20	9	20	9	12	8	1
	573.90	4388.90	1001	5	3	10	4	14	7	14	7	14	11	1
	572.40	4402.20	1001	5	4	39	13	44	17	44	17	50	26	1
	579.00	4394.00	1001	5	4	15	4	21	9	21	9	20	8	1
	583.00	4399.20	1001	5	5	11	3	16	8	16	8	16	7	1
	562.00	4395.70	1001	3	2	6	2	9	4	9	4	10	6	1
A P1	0.0	0.0	0.1	0.2	0.4	2.0	56200	439570						2
P P1	0.0	0.1	0.4	2.7	1.8	1.2	56200	439570						3
A P2	0.0	0.0	0.0	0.1	0.3	1.4	56200	439570						4
P P2	0.0	0.0	0.2	1.0	0.7	0.2	56200	439570						5
A P1	0	0	0	0	1	1	0	0	56200	439570				6
A P1	0	0	0	0	0	0	0	0	56200	439570				6
A P2	0	0	0	0	1	0	0	0	56200	439570				7
A P2	0	0	0	0	0	0	0	0	56200	439570				7
P P1	0	0	3	2	1	0	0	0	56200	439570				8
P P1	0	0	0	0	0	0	0	0	56200	439570				8
P P2	0	0	1	1	1	0	0	0	56200	439570				9
P P2	0	0	0	0	0	0	0	0	56200	439570				9
⋮			⋮					⋮						
	576.00	4403.00	1001	4	5	28	6	32	11	32	11	0	0	1
A P1	0.0	0.0	0.1	0.7	1.0	2.6	57600	440300						2
P P1	0.0	0.1	2.4	12.6	8.4	4.3	57600	440300						3
A P2	0.0	0.0	0.1	0.7	1.0	3.0	57600	440300						4
P P2	0.0	0.0	0.7	2.9	1.9	0.7	57600	440300						5
A P1	0	0	0	0	0	1	0	0	57600	440300				6
A P1	0	0	0	0	0	0	0	0	57600	440300				6
A P2	0	0	0	1	1	1	0	0	57600	440300				7
A P2	0	0	0	0	0	0	0	0	57600	440300				7
P P1	0	0	0	0	0	0	2	21	57600	440300				8
P P1	0	0	1	0	4	0	0	0	57600	440300				8
P P2	0	0	0	0	0	0	1	3	57600	440300				9
P P2	0	0	0	0	2	0	0	0	57600	440300				9

TABLE 21. FORMAT OF CARD IMAGE OUTPUT.

Record type, Variable	Column	Format	Variable description (units)
Record type 1			
RX	1-10	F10.2	X map coordinate of receptor (user units)
RY	11-20	F10.2	Y map coordinate of receptor (user units)
IRUN	21-25	I5	Run identification number
--	26	--	Card identifier
KPX(1)	27-30	I4	Concentration contribution from area sources for the first pollutant ($\mu g/m^3$)
KPX(2)	31-34	I4	Concentration contribution from area sources for the second pollutant ($\mu g/m^3$)
KPX(3)	35-38	I4	Concentration contribution from point sources for the first pollutant ($\mu g/m^3$)
KPX(4)	39-42	I4	Concentration contribution from point sources for the second pollutant ($\mu g/m^3$)
KPX(5)	43-45	I4	Total concentration for the first pollutant ($\mu g/m^3$)
KPX(6)	46-50	I4	Total concentration for the second pollutant ($\mu g/m^3$)
KPX(7)	51-54	I4	Calibrated total concentration for the first pollutant ($\mu g/m^3$)
KPX(8)	55-58	I4	Calibrated total concentration for the second pollutant ($\mu g/m^3$)
KPX(9)	59-62	I4	Observed concentration for the first pollutant ($\mu g/m^3$)
KPX(10)	63-66	I4	Observed concentration for the second pollutant ($\mu g/m^3$)

(continued)

TABLE 21 (continued)

Record type, Variable	Column	Format	Variable description (units)
Record type 2*			
AROS	1- 4	A4	Identifier indicating area source contribution for the first pollutant
APAR	5-46	6F7.1	Area source contribution by stability class for the first pollutant ($\mu g/m^3$)
KPX(37)	47-54	I8	X map coordinate of receptor multiplied by 100 to remove decimals (user units)
KPX(38)	55-62	I8	Y map coordinate of receptor multiplied by 100 to remove decimals (user units)
Record type 3*			
PROS	1- 4	A4	Identifier indicating point source contribution for the first pollutant
PPAR	5-46	6F7.1	Point source contribution by stability class for the first pollutant ($\mu g/m^3$)
KPX(37)	47-54	I8	X map coordinate of receptor multiplied by 100 to remove decimals (user units)
KPX(38)	55-62	I8	Y map coordinate of receptor multiplied by 100 to remove decimals (user units)
Record type 4*			
--	---	--	Same as record type 2 for the second pollutant
Record type 5*			
--	---	--	Same as record type 3 for the second pollutant

(continued)

TABLE 21 (continued)

Record type, Variable	Column	Format	Variable description (units)
Record type 6*†			
AROS	1- 4	A4	Identifier indicating area source contribution for the first pollutant
KPX	5-44	8I5	Area source contribution by wind direction starting at north and rotating clockwise ($\mu g/m^3$)
RX	45-52	I8	X map coordinate of receptor multiplied by 100 to remove decimals (user units)
RY	53-60	I8	Y map coordinate of receptor multiplied by 100 to remove decimals (user units)
Record type 7*†			
--	---	--	Same as record type 6 for the second pollutant
Record type 8*†			
PROS	1- 4	A4	Identifier indicating point source contribution for the first pollutant
KPX	5-44	8I5	Point source contribution by wind direction starting at north and rotating clockwise ($\mu g/m^3$)
RX	45-52	I8	X map coordinate of receptor multiplied by 100 to remove decimals (user units)
RY	53-60	I8	Y map coordinate of receptor multiplied by 100 to remove decimals (user units)
Record type 9*†			
--	---	--	Same as record type 8 for the second pollutant

* Records written only if NROSE > 0.

† If N1636 = 16 there are two records of this type; if N1636 = 36 there are four records of this type.

REFERENCES

Bjorklund, J. R. and J. F. Bowers. 1982. User's Instructions for the SHORTZ and LONGZ Computer Programs, Vols. I and II. EPA-903/9-82-004A and B (NTIS Accession Numbers PB83-146 092 and PB83-146 100). U. S. Environmental Protection Agency, Middle Atlantic Region III, Philadelphia, PA.

Bowers, J. F., J. R. Bjorklund, and C. S. Cheney. 1979. Industrial Source Complex (ISC) Dispersion Model User's Guide. EPA-450/4-79-030, U. S. Environmental Protection Agency, Research Triangle Park, NC 27711. 360 pp.

Briggs, G. A. 1969. Plume Rise, USAEC Critical Review Series. TID-25075, National Technical Information Service, U. S. Department of Commerce, Springfield, VA 22161. 81 pp.

Briggs, G. A. 1971. Some Recent Analyses of Plume Rise Observation. In: Proceedings of the Second International Clean Air Congress, H. M. Englund and W. T. Berry (eds.), Academic Press, New York. pp. 1029-1032.

Briggs, G. A. 1974. Diffusion Estimation for Small Emissions. In: ERL, ARL USAEC Report ATDL-106. U. S. Atomic Energy Commission, Oak Ridge, TN. 59 pp.

Briggs, G. A. 1975. Plume rise predictions. In: Lectures on Air Pollution and Environmental Impact Analysis, D. A. Haugen (ed.), Amer. Meteor. Soc., Boston, MA. pp. 59-111.

Brubaker, K. L., P. Brown, and R. R. Cirillo. 1977. Addendum to User's Guide for Climatological Dispersion Model. EPA-450/3-77-015, U. S. Environmental Protection Agency, Research Triangle Park, NC 27711. 134 pp.

Burt, E. W. 1977. Valley Model User's Guide. EPA-450/2-77-018, U. S. Environmental Protection Agency, Research Triangle Park, NC 27711. 112 pp.

Busse, A. D. and J. R. Zimmerman. 1973. User's Guide for the Climatological Dispersion Model. EPA-R4-73-024, U. S. Environmental Protection Agency, Research Triangle Park, NC 27711. 132 pp.

Calder, K. L. 1971. A Climatological Model for Multiple Source Urban Air Pollution. In: Proceedings of the Second Meeting of the Expert Panel on Air Pollution Modeling. NATO, Committee on the Challenges of Modern Society (CCMS). Paris, France, July 26-27. 33 pp.

Calder, K. L. 1977. Multiple-source plume models of urban air pollution - their general structure. Atmos. Environ. 11: 403-414.

Gifford, F. A., Jr. 1960. Atmospheric dispersion calculations using the generalized Gaussian plume model. Nucl. Saf. 2: 56-59.

Gifford, F. A., Jr. 1976. Turbulent diffusion typing schemes -- A review. Nucl. Saf. 17: 68-86.

Hanna, S. R., G. A. Briggs, and R. P. Hosker, Jr. 1982. Handbook on Atmospheric Diffusion. DOE/TIC-11223, National Technical Information Service, U. S. Department of Commerce, Springfield, VA 22161. 102 pp.

Holland, J. Z. 1953. A Meteorological Survey of the Oak Ridge Area. Atomic Energy Comm., Report ORO-99, Washington, DC. 584 pp.

Holzworth, G. C. 1972. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. Office of Air Programs Publication No. AP-101. U. S. Environmental Protection Agency, Research Triangle Park, NC. 118 pp.

Irwin, J. S. 1979. A theoretical variation of the wind profile law exponent as a function of surface roughness and stability. Atmos. Environ. 13: 191-194.

Johnson, W. B., R. C. Sklarew, and D. B. Turner. 1976. Urban Air Quality Simulation Modeling. In: Air Pollution, Part I -- Air Pollutants, Their Transformation and Transport, A. C. Stern (ed.), Academic Press, New York and London. pp. 503-562.

Martin, D. O. and J. A. Tikvart. 1968. A General Atmospheric Diffusion Model for Estimating the Effects of Air Quality of One or More Sources. APCA Paper 68-148, presented at 61st Annual APCA Meeting, St. Paul, Minnesota, June 1968.

Martin, D. O. 1971. An urban diffusion model for estimating long term average values of air quality. J. Air Poll. Contr. Assoc. 21: 16-19.

Pasquill, F. and P. J. Meade. 1958. A study of the average distribution of pollution around Staythorpe. Int. J. Air Poll. 1: 60-70.

Pasquill, F. 1961. The estimation of the dispersion of windborne material. Meteorol. Mag. 90: 33-49.

Pasquill, F. 1976. Atmospheric Dispersion Parameters in Gaussian Plume Modeling. Part II. Possible Requirements for Change in the Turner Workbook Values. EPA-600/4-76-030b, U. S. Environmental Protection Agency, Research Triangle Park, NC 27711. 44 pp.

Singer, I. A. and M. E. Smith. 1966. Atmospheric dispersion at Brookhaven National Laboratory. Int. J. Air Water Pollut. 10: 125-135.

Truppi, L. E. 1968. Bias introduced by anemometer starting speeds in climatological wind rose summaries. Mon. Wea. Rev. 96: 325-327.

Turner, D. B. 1970. Workbook of Atmospheric Dispersion Estimates. Office of Air Programs Publication No. AP-26 (NTIS-PB-191-482). U. S. Environmental Protection Agency, Research Triangle Park, NC 27711. 84 pp.

Turner, D. B., J. R. Zimmerman, and A. D. Busse. 1972. An evaluation of some climatological dispersion models. Presented at 3rd Meeting of the NATO/CCMS Panel on Modeling.

Turner, D. B. and J. H. Novak. 1978. User's Guide for RAM. Vol. I. Algorithm Description and Use. EPA-600/8-78-016a, U. S. Environmental Protection Agency, Research Triangle Park, NC. 60 pp.

TRW Systems Group. 1969. Air Quality Display Model. NTIS-PB-189-194, National Technical Information Service, U. S. Department of Commerce, Springfield, VA 22161.

Vogt, K. J. 1977. Empirical investigation of the diffusion of waste air plumes in the atmosphere. Nuclear Technology 34: 43-57.

APPENDIX A

DEFAULT OPTION

The default option is provided as a convenience to the user to help avoid inadvertent errors in setting the appropriate options. Exercising the default option (i.e., NDEF = 1) overrides other user-input selections and results in the following.

(1) Stack downwash according to Briggs (1974) is used.

(2) Briggs' plume rise (1969, 1971, and 1975) is used.

(3) Buoyancy-induced dispersion is exercised. For distances less than the distance to final rise, the gradual plume rise is used to determine the buoyancy-induced dispersion only.

(4) Final plume rise is used.

(5) To calculate vertical dispersion, the Briggs-urban scheme is selected.

(6) The joint frequency function is assumed to be comprised of the following six classes: A, B, C, D-day, D-night, and nighttime stable.

(7) Initial σ_z values for area sources are 30 meters for all stability classes.

(8) Wind profile exponents are set to .15, .15, .20, .25, .25, and .30 for stabilities A, B, C, D-day, D-night, and stable cases respectively.

(9) Calibration intercepts and slopes are set to 0 and 1, respectively.

(10) A pollutant half-life of 4 hours for SO_2 is assumed and a half-life near infinity is assumed for all other pollutants.

Default values for all the affected variables are provided in Table A-1. For all other input variables not shown in Table A-1, CDM-2.0 assumes the values provided by the user.

TABLE A-1. VARIABLES AFFECTED BY THE DEFAULT OPTION

Record type	Variable	Default values
3	CA	0.0, 0.0
	CB	1.0, 1.0
4	NP50	-1
	NPDH	1
	NSTDW	1
5	KLOW	2
	ICA	1, 2, 3, 4, 5, 6
6	KHIGH	2
	ICP	1, 2, 3, 4, 5, 6
8	SZA	30., 30., 30., 30., 30., 30.
	GB	4.0 (for SO_2), 999999. (for all others)
9	UE	.15, .15, .20, .25, .25, .30
10	SA	-1

APPENDIX B

DETAILED FLOW DIAGRAMS

Detailed flow diagrams for the main program and the four primary subroutines (i.e., CLINT, CALQ, AREA, and POINT) follow.

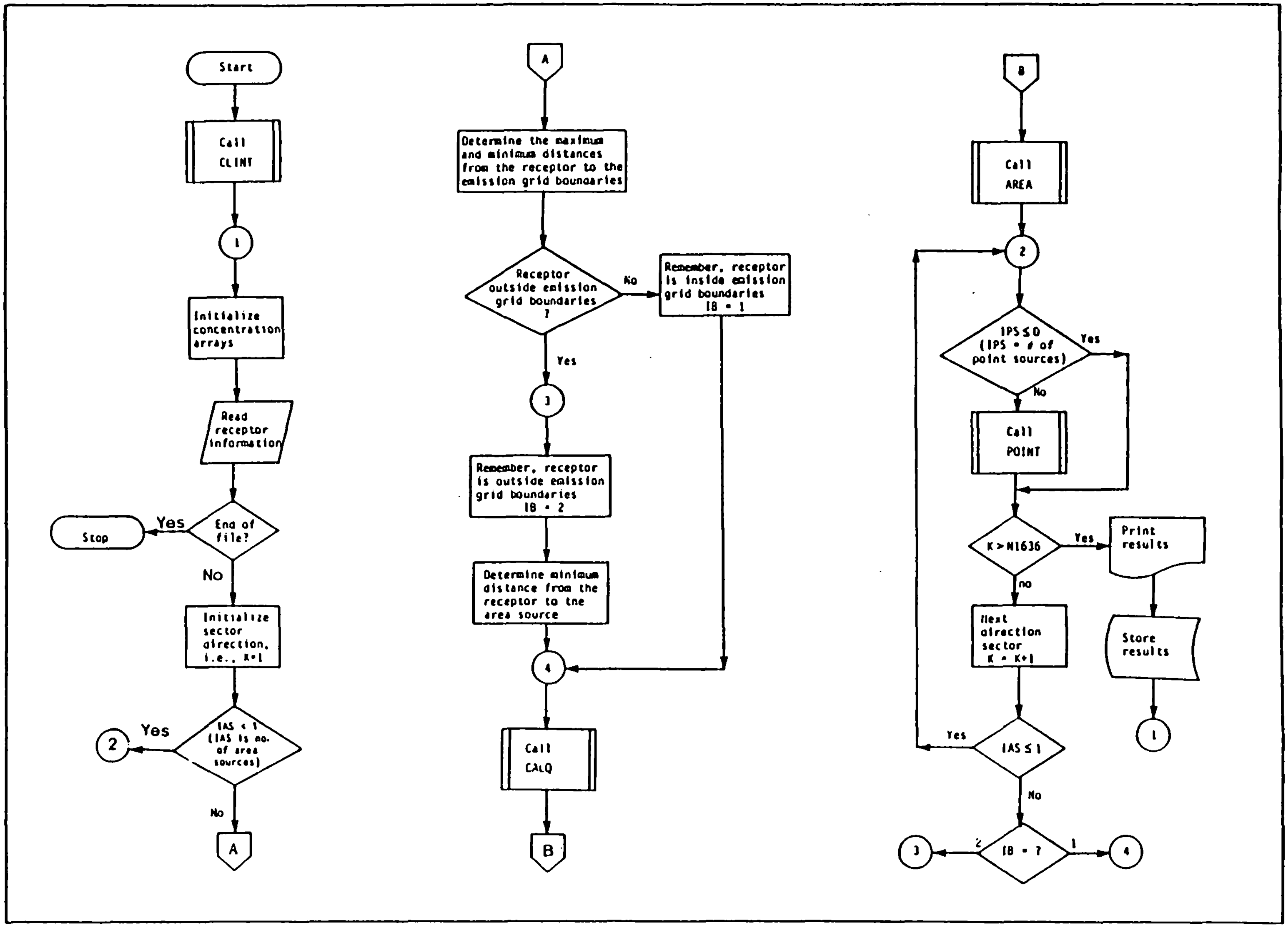


Figure B-1. Flow diagram for the main routine.

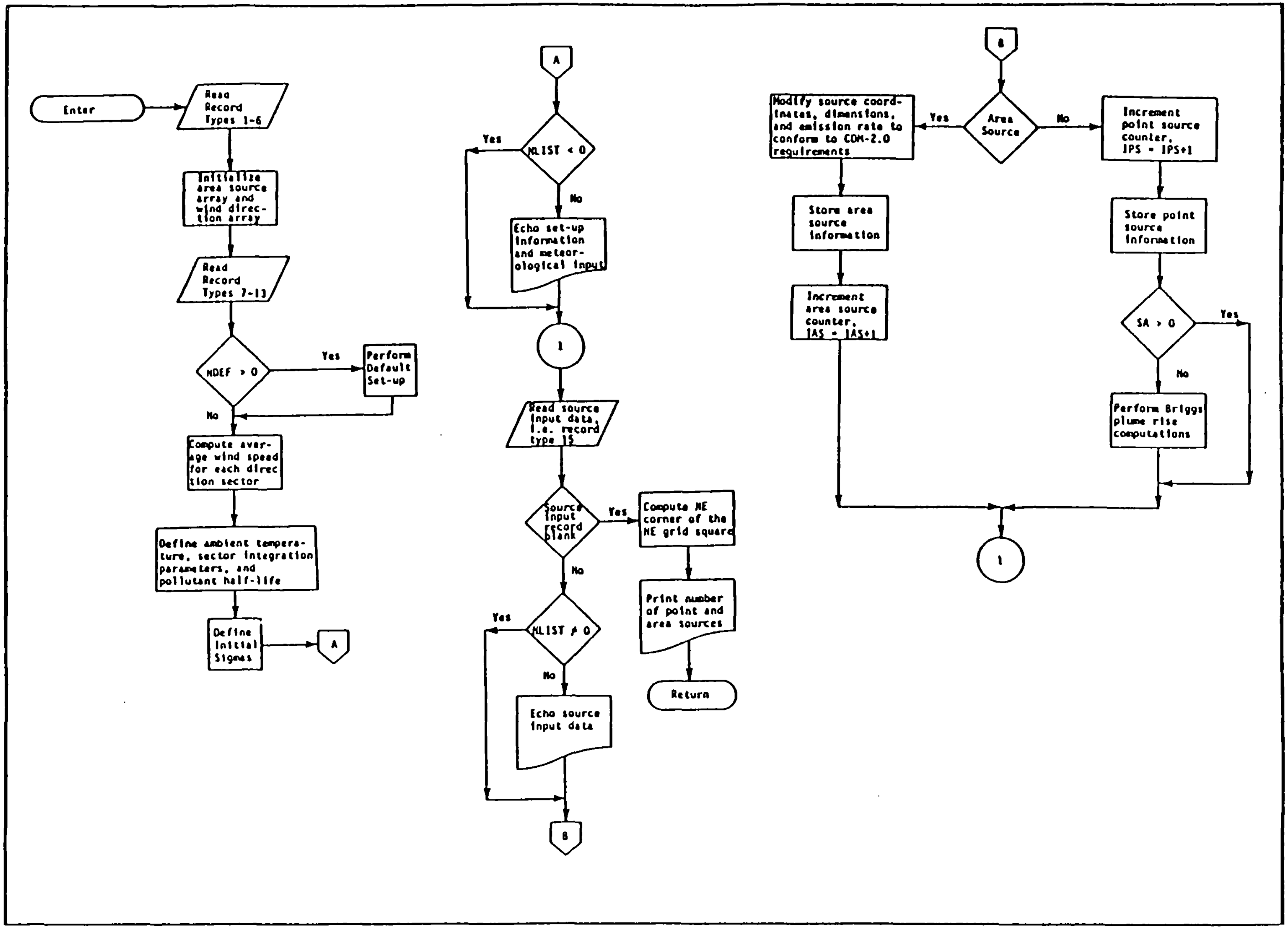


Figure B-2. Flow diagram for subroutine CLINT.

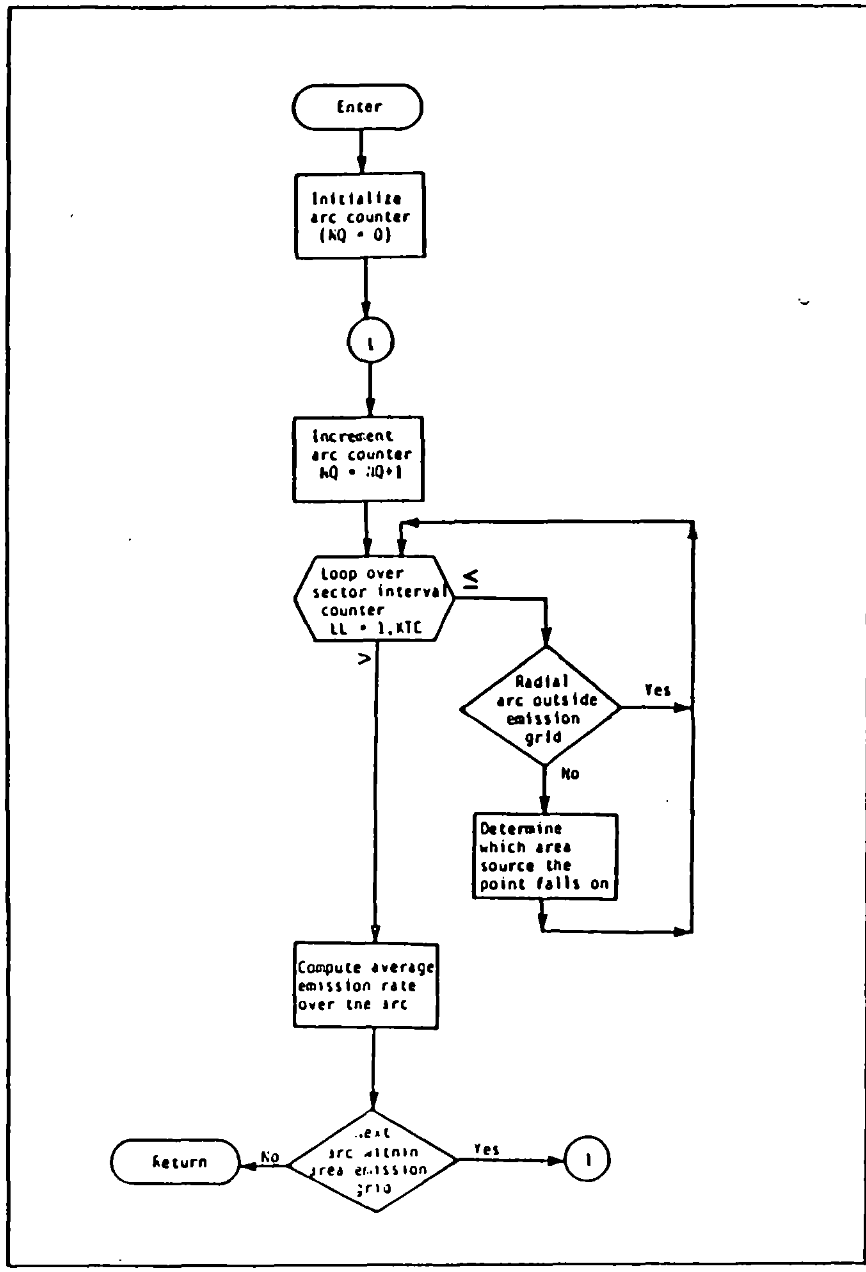


Figure B-3. Flow diagram for subroutine CALQ.

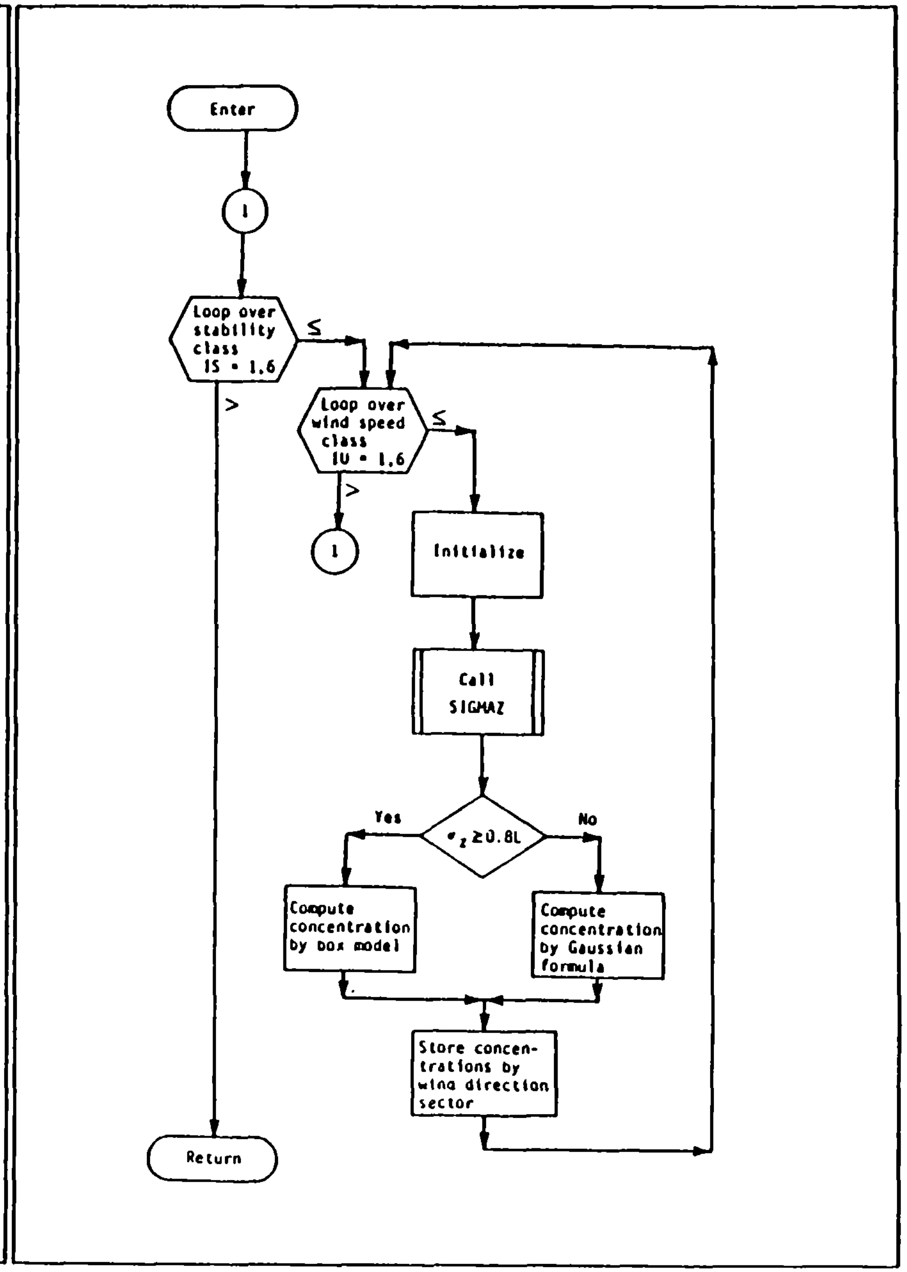


Figure B-4. Flow diagram for subroutine AREA.

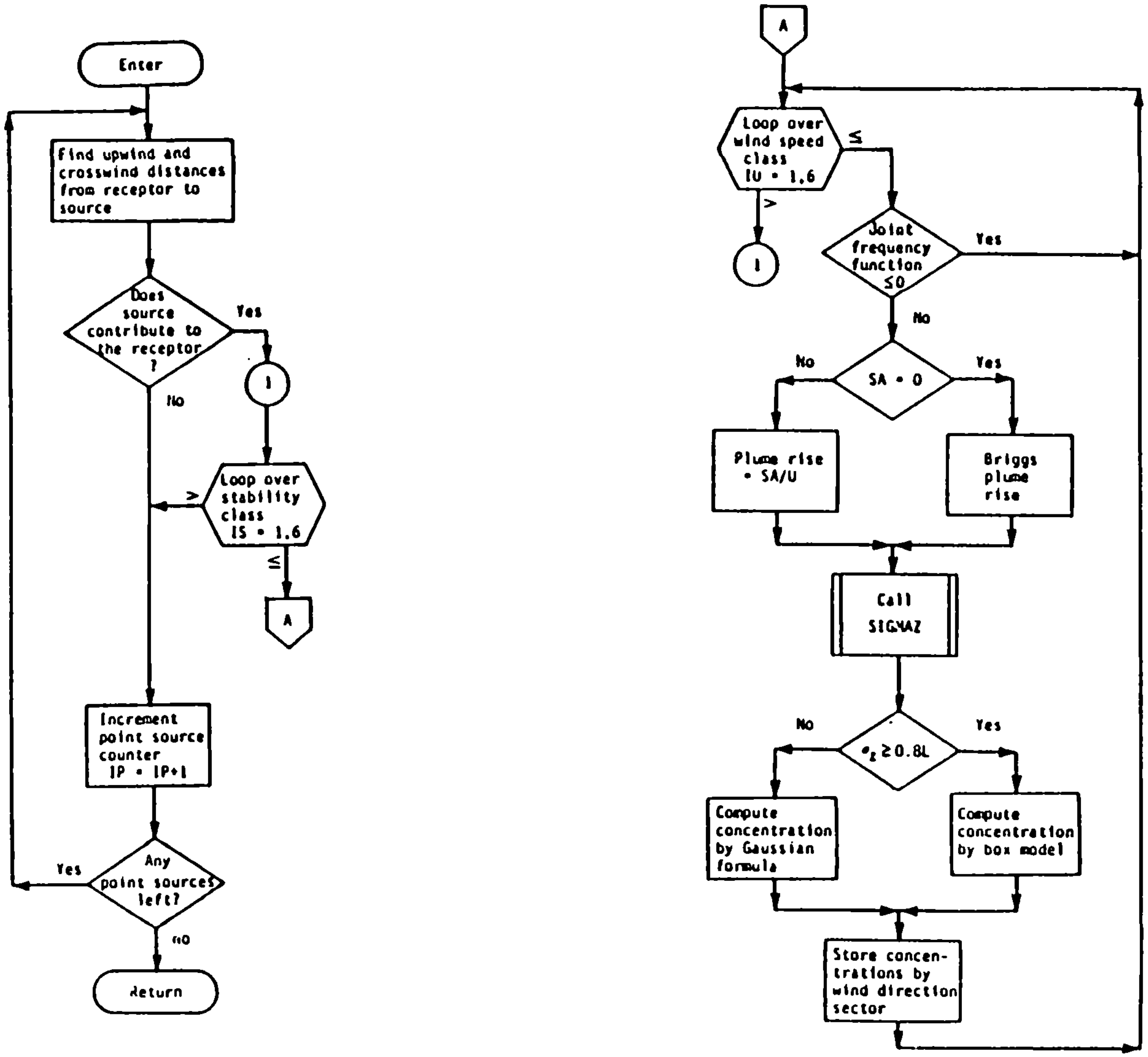


Figure B-5. Flow diagram for subroutine POINT.

APPENDIX C

LISTING OF FORTRAN SOURCE CODE

The source code listing of CDM-2.0 follows. The program consists of a main module and nine subroutines.

```
C        CDM-2.0 CLIMATOLOGICAL DISPERSION MODEL VERSION 2.0 (BATCH)
C                  CDM-2.0    (VERSION 85293)
C
C
C
C
C
C * * *  PROGRAM ABSTRACT
C
C        CDM-2.0 DETERMINES LONG-TERM (SEASONAL OR ANNUAL) QUASI-
C        STABLE POLLUTANT CONCENTRATIONS IN A RURAL OR URBAN SETTING
C        USING AVERAGE EMISSION RATES FROM POINT AND AREA SOURCES AND
C        A JOINT FREQUENCY DISTRIBUTION OF WIND DIRECTION, WIND SPEED,
C        AND STABILITY.  THE GAUSSIAN PLUME HYPOTHESIS FORMS THE BASIS
C        FOR THE CALCULATIONS.  CONTRIBUTIONS ARE CALCULATED ASSUMING
C        THE NARROW PLUME HYPOTHESIS, CALDER (1971, 1977), AND INVOLVE
C        AN UPWIND INTEGRATION OVER THE AREA SOURCES.  COMPUTATIONS
C        CAN BE MADE FOR UP TO 200 POINT SOURCES AND 2500 AREA SOURCES
C        AT AN UNLIMITED NUMBER OF RECEPTOR LOCATIONS.  THE NUMBER OF
C        POINT AND AREA SOURCES CAN BE EASILY MODIFIED WITHIN THE CODE
C        CDM-2.0 IS AN ENHANCED VERSION OF CDM INCLUDING THE FOLLOWING
C        OPTIONS:  16 OR 36 WIND DIRECTION SECOTRS, INITIAL PLUME
C        DISPERSION, BUOYANCY-INDUCED DISPERSION, STACK DOWNWASH, AND
C        GRADUAL PLUME RISE.  THE USER HAS A CHOICE OF SEVEN DISPERSIO
C        PARAMETER SCHEMES.  OPTIONAL OUTPUT INCLUDES POINT AND AREA
C        CONCENTRATION ROSES AND HISTOGRAMS OF POLLUTANT CONCENTRATION
C        BY STABILITY CLASS.
C
C
C * * *  REFERENCES
C
C        IRWIN, J. S., T. CHICO, AND J. A. CATALANO.  1985.  CDM-2.0 -
C        CLIMATOLOGICAL DISPERSION MODEL VERSION 2.0.  EPA-___/_-__-__
C        U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK
C        NC.  ___ PP.
C
C
C * * *  STRUCTURE AND MODULE SUMMARY
C
C                              CDM-2.0
C              _________________________|___________________
C             |            |            |                   |
C           CLINT         CALQ         AREA                POINT
C         ____|____                     |        ____________|____________
C        |         |                    |       |        |        |       |
C   DFAULT       VIRTX               SIGMAZ   VIRTX   PLRISE    STDW   SIGMA
C                  |                            |
C                  |                            |
C                SIGMAZ                       SIGMAZ
C
C        THE SUBROUTINE ORDER IN THE LISTING IS AS FOLLOWS:  CLINT,
C        DFAULT, CALQ, AREA, POINT, PLRISE, STDW, VIRTX, SIGMAZ, AND
C        BLOCK DATA.
C
C
C * * *  INPUT/OUTPUT INFORMATION
C
C        FORTRAN       DATA SET                    I/O UNIT
C         UNIT
C          5           CONTROL INPUT (RECORD       DISK
C                        TYPES 1-3)
C         IRD*         CONTROL INPUT (RECORD       DISK
C                        TYPES 4-18)
C         IWR*         OUTPUT LISTING              PRINTER OR DISK
C         IPU*         CONCENTRATION DATA          DISK OR MAGNETIC TAPE
C
C        *  SEE RECORD TYPE 3 BELOW.
C
C
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)
      DIMENSION DX(4),DY(4),A(4),KPX(38),TCON(2),CCON(2),FRECPT(16)
C        THE PARAMETER STATEMENT PERMITS STORAGE ASSIGNMENT
C          ACCORDING TO THE NEEDS OF EACH PROBLEM.  IF THE USER'S
C          FORTRAN COMPILER DOES NOT SUPPORT PARAMETER, THE DESIRED
C          NUMBER OF NPTS, NQLIM, NASE, AND NASN WILL HAVE TO BE
```

```
C          HARDCODED.  THE BEST WAY TO DO THIS IS THROUGH GLOBAL
C          CHANGES WITH AN EDITOR.
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU
      COMMON /C6/ ICHK
      COMMON /QCOM/ N,DR,IX,IY,TT(36,21),KTC,IXX,IYY,RAD,TD,
     *              Z(NASE,NASN,3)
      COMMON /ACOM/ PI,SZA(6),ABAR(2),AROSE(36,2),XS(6)
      COMMON /PCOM/ PH(NPTS),PR(NPTS),PS(NPTS,4),PX(NPTS),PY(NPTS),
     *              WA(36),WB(36),PROSE(36,2),CV,IPS,RAT,PBAR(2),TOA,
     *              VS1(NPTS),T1(NPTS),D1(NPTS),FRN(NPTS),BFLUX(NPTS)
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NGRAD,NSTDW,KLOW,KHIGH,
     *             PPAR(2,6),APAR(2,6),WHA(6),FAC,RCEPTZ,KELVIN,NDEF
      COMMON /TITLE/ HEADNG(20),PNAME(2),D16(32),D36(72),DISP(8,7),
     *               TTITLE(3)
C
C         FORM OF INPUT TO CDM-2.0 (BATCH)
C
C     VARIABLE
C     NAME    COLMN  FRMT            DESCRIPTION
C
C  RECORD TYPE 1 * * * RUN TITLE * * *
C
C     HEADNG 1-80   20A4             DESCRIPTION OR TITLE OF MODEL RUN.
C
C  RECORD TYPE 2 * * * POLLUTANTS * * *
C
C     NSO2    1      I1              POLLUTANT NUMBER FOR SO2
C                                      = 0, SO2 NOT CONSIDERED IN RUN
C                                      = 1, POLLUTANT 1 IS SO2
C                                      = 2, POLLUTANT 2 IS SO2
C     PNAME  5-12   2A4              NAMES OF TWO POLLUTANTS TO BE MODELE
C
C  RECORD TYPE 3 * * * PARAMETERS * * *
C
C     AROS    1-8   2A4  AAAA        ALPHA AREA ROSE OUTPUT ID
C     PROS    9-16  2A4  AAAA        ALPHA POINT ROSE OUTPUT ID
C     IRUN   17-21  I5   XXXXX       USER DEFINED RUN ID NUMBER
C     NLIST  22-26  I5   XXXXX       CONTROL FOR PRINTED OUTPUT
C                                    IF NLIST > 0 ECHO SETUP INFO + METEO
C                                                 LIST CONC. RESULTS
C                                    IF NLIST = 0 ECHO SETUP INFO + METEO
C                                                 ECHO SOURCE INFO INPUT
C                                                 LIST CONC. RESULTS
C                                    IF NLIST < 0 LIST ONLY CONC. RESULTS
C     IRD    27-31  I5   XXXXX       FORTRAN LOGICAL UNIT NUMBER (READ)
C     IWR    32-36  I5   XXXXX       FORTRAN LOGICAL UNIT NUMBER (PRINTER
C     IPU    37-41  I5   XXXXX       FORTRAN LOGICAL UNIT NUMBER (PUNCH)
C     CA     42-59  2F9.0 XXXXXX.XX  INTERCEPT OF CALIBRATION
C     CB     60-77  2F9.0 XXXXXX.XX  SLOPE OF CALIBRATION
C
C  RECORD TYPE 4 * * * PARAMETERS * * *
C
C     N1636   (FREE FORMAT)          NUMBER OF WIND DIRECTIONS USED IN
C                                    METEOROLOGICAL JOINT FREQUENCY
C                                    FUNCTION (EITHER 16 OR 36).
C
C     NP50    (FREE FORMAT)          INITIAL DISPERSION OPTION
C                                      < OR = 0, NO ACTION TAKEN ON POINT
C                                        SOURCES WITH RELEASE HEIGHTS
C                                        BELOW 50 M.
C                                      > 0, INITIALLY DISPERSE AS
C                                        DESCRIBED IN CDM-2.0 USER'S GUID
C
C     NPDH    (FREE FORMAT)          BUOYANCY-INDUCED DISPERSION OPTION
C                                      < OR = 0, NO ACTION TAKEN
C                                      > 0, INCLUDE BUOYANCY INDUCED
C                                        DISPERSION EFFECTS, PASQUILL
C                                        (1976), IN POINT SOURCE DISPER-
C                                        SION AND SET PLUME AT FINAL
C                                        EFFECTIVE HEIGHT FOR ALL
C                                        DISTANCES.
```

```
C
C    NSTDW  (FREE FORMAT)          STACK DOWNWASH OPTION
C                                    < 0, BJORKLUND AND BOWERS (1982)
C                                         STACK DOWNWASH CONSIDERED
C                                    = 0, NO ACTION TAKEN
C                                    > 0, BRIGGS (1973) STACK DOWNWASH
C                                         CONSIDERED
C
C    NGRAD  (FREE FORMAT)          GRADUAL PLUME RISE OPTION
C                                    < OR = 0, NO ACTION TAKEN
C                                    > 0, GRADUAL PLUME RISE CONSIDERED
C
C    FAC    (FREE FORMAT)          EFFLUENT RISE FOR AREA SOURCES
C
C    RCEPTZ (FREE FORMAT)          HEIGHT (M) ABOVE GROUND OF ALL
C                                  RECEPTORS
C
C    KELVIN (FREE FORMAT)          UNITS FLAG FOR STACK TEMPERATURE
C                                    < 0, DEGREES F
C                                    = 0, DEGREES C
C                                    > 0, DEGREES KELVIN
C
C    NDEF   (FREE FORMAT)          DEFAULT OPTION
C                                   < OR = 0, NO ACTION TAKEN
C                                   > 0, IMPLEMENT DEFAULT OPTION
C
C  RECORD TYPE 5 * * * PARAMETERS * * *
C
C    KLOW   (FREE FORMAT)          DISPERSION PARAMETER SCHEME FOR AREA
C                                  SOURCES.  SEE COMMENTS ON KTYPE IN
C                                  SUBROUTINE SIGMAZ.  THE CDM-2.0 USER
C                                  GUIDE ALSO DESCRIBES THIS PARAMETER.
C
C    ICA    (FREE FORMAT)          ARRAY OF SIX (6) VALUES DEFINING
C                                  DISPERSION CURVES (AS DEFINED BY
C                                  KLOW) TO BE USED FOR THE SIX
C                                  STABILITY CATEGORIES SUMMARIZED IN
C                                  THE JOINT FREQUENCY FUNCTION.
C
C  RECORD TYPE 6 * * * PARAMETERS * * *
C
C    KHIGH  (FREE FORMAT)          DISPERSION PARAMETER SCHEME FOR POIN
C                                  SOURCES.  SEE COMMENTS ON KTYPE IN
C                                  SUBROUTINE SIGMAZ.  THE CDM-2.0 USER
C                                  GUIDE ALSO DESCRIBES THIS PARAMETER.
C
C    ICP    (FREE FORMAT)          ARRAY OF SIX (6) VALUES DEFINING
C                                  DISPERSION CURVES (AS DEFINED BY
C                                  KHIGH) TO BE USED FOR THE SIX
C                                  STABILITY CATEGORIES SUMMARIZED IN
C                                  THE JOINT FREQUENCY FUNCTION.
C
C  RECORD TYPE 7 * * * PARAMETERS * * *
C
C    DELR   1-6    F6.0 XXXXX.     RADIAL INCREMENT (M)
C    RAT    7-12   F6.0 XXX.XX     LENGTH OF A BASIC EMISSION GRID
C                                  SQUARE IN USER UNITS
C    CV     13-18  F6.0 XXXX.X     CONVERSION FACTOR,
C                                  CV * RAT = EMISSION GRID INTERVAL (M
C    XG     19-24  F6.0 XXX.XX     X MAP COORD. OF THE SW CORNER OF THE
C                                  EMISSION GRID ARRAY
C    YG     25-30  F6.0 XXX.XX     Y MAP COORD. OF THE SW CORNER OF THE
C                                  EMISSION GRID ARRAY
C    TOA    31-36  F6.0 XXX.XX     MEAN ATMOSPHERIC TEMPERATURE (DEG C)
C    TXX    37-42  F6.0 XXXXX.     WIDTH OF BASIC EMISSION SQUARE (M)
C
C  RECORD TYPE 8 * * * PARAMETERS * * *
C
C    DINT   1-6    F6.0 XXXXX.     NUMBER OF SEGMENTS DESIRED IN DELTA
C                                  DEGREE SECTORS.  RANGES FROM 2 TO 20
C                                  INCLUSIVE.
C    YD     7-12   F6.0 XXX.XX     RATIO OF THE DAYTIME EMISSION RATE
C                                  TO THE AVERAGE 24-HOUR EMISSION RATE
C    YN     13-18  F6.0 XXX.XX     RATIO OF THE NIGHTTIME EMISSION RATE
C                                  TO THE AVERAGE 24-HOUR EMISSION RATE
```

```
C     SZA    19-54 6F6.0 XXX.XX       INITIAL SIGMA-Z FOR AREA SOURCES (M)CDM02260
C     GB     55-66 2F6.0 XXXXX.       DECAY HALF-LIFE (HR) FOR THE TWO    CDM02270
C                                     POLLUTANTS                          CDM02280
C                                                                         CDM02290
C  RECORD TYPE 9 * * * WIND PROFILE EXPONENTS * * *                       CDM02300
C                                                                         CDM02310
C     UE       (FREE FORMAT)          ARRAY OF SIX (6) VALUES DEFINING WINCDM02320
C                                     PROFILE EXPONENTS TO BE ASSOCIATED  CDM02330
C                                     WITH THE SIX STABILITY CATEGORIES   CDM02340
C                                     SUMMARIZED IN THE JOINT FREQUENCY   CDM02350
C                                     FUNCTION.                           CDM02360
C                                                                         CDM02370
C  RECORD TYPE 10 * * * WIND SPEEDS * * *                                 CDM02380
C                                                                         CDM02390
C     U        (FREE FORMAT)          ARRAY OF SIX (6) VALUES DEFINING WINCDM02400
C                                     SPEEDS (M/SEC) TO BE ASSOCIATED WITHCDM02410
C                                     THE SIX WIND SPEED CATEGORIES SUMMARCDM02420
C                                     IZED IN THE JOINT FREQUENCY FUNCTIONCDM02430
C                                     TYPICALLY THE HARMONIC AVERAGE WIND CDM02440
C                                     SPEED IS USED.                      CDM02450
C                                                                         CDM02460
C  RECORD TYPE 11 * * * MIXING HEIGHTS * * *                              CDM02470
C                                                                         CDM02480
C     HL       (FREE FORMAT)          ARRAY OF SIX (6) VALUES DEFINING    CDM02490
C                                     MIXING HEIGHTS TO BE ASSOCIATED WITHCDM02500
C                                     THE SIX STABILITY CATEGORIES SUMMAR-CDM02510
C                                     IZED IN THE JOINT FREQUENCY FUNCTIONCDM02520
C                                                                         CDM02530
C  RECORD TYPE 12 * * * FORMAT STATEMENT * * *                            CDM02540
C                                                                         CDM02550
C     FMETEO 1-64  16A4               FORMAT STATEMENT, INCLUDING BEGINNINCDM02560
C                                     AND ENDING PARENTHESIS, FOR THE     CDM02570
C                                     METEOROLOGICAL JOINT FREQUENCY      CDM02580
C                                     FUNCTION.  OLD CDM FORMAT WAS,      CDM02590
C                                     (9X,6F9.0)                          CDM02600
C                                                                         CDM02610
C  RECORD TYPE 13 * * * JOINT FREQUENCY FUNCTION                          CDM02620
C                                                                         CDM02630
C     F        (SEE CARD TYPE 12)     F(I,J,K)      (PERCENT)             CDM02640
C                                                                         CDM02650
C  RECORD TYPE 14 * * * FORMAT STATEMENT * * *                            CDM02660
C                                                                         CDM02670
C     FSOURC 1-64  16A4               FORMAT STATEMENT, INCLUDING BEGINNINCDM02680
C                                     AND ENDING PARENTHESIS, FOR THE     CDM02690
C                                     SOURCE INVENTORY.  OLD CDM FORMAT WACDM02700
C                                     (F6.0,2F7.0,2F8.0,F7.0,F5.0,2F7.0,  CDM02710
C                                     F5.0)                               CDM02720
C                                                                         CDM02730
C  RECORD TYPE 15 *** SOURCE INVENTORY (VARIABLE NUMBER OF RECORDS) ***CDM02740
C                                                                         CDM02750
C     X       (SEE RECORD TYPE 14)    X MAP COORD OF SOURCE (RE USER GUIDECDM02760
C     Y                 "             Y MAP COORD OF SOURCE (RE USER GUIDECDM02770
C     TX                "             WIDTH OF AREA SOURCE.  ENTER ZERO ORCDM02780
C                                     LEAVE BLANK FOR POINT SOURCES.      CDM02790
C     S1                "             EMISSION RATE OF POLLUTANT 1 (G/SEC)CDM02800
C     S2                "             EMISSION RATE OF POLLUTANT 2 (G/SEC)CDM02810
C     SH                "             SOURCE HEIGHT (M)                   CDM02820
C     D                 "             STACK DIAMETER (M).  LEAVE BLANK FORCDM02830
C                                     AREA SOURCES.                       CDM02840
C     VS                "             EXIT VELOCITY (M/SEC).  LEAVE BLANK CDM02850
C                                     FOR AREA SOURCES.                   CDM02860
C     T                 "             STACK GAS TEMPERATURE (C).  LEAVE   CDM02870
C                                     BLANK FOR AREA SOURCES.             CDM02880
C     SA                "             PLUME RISE OPTION,                  CDM02890
C                                       < OR = 0, BRIGGS PLUME RISE       CDM02900
C                                       > 0, ENTER PRODUCT OF PLUME RISE  CDM02910
C                                         AND WIND SPEED (M**2/SEC)       CDM02920
C                                                                         CDM02930
C  RECORD TYPE 16 * * * BLANK SENTINEL CARD * * *                         CDM02940
C                                                                         CDM02950
C  RECORD TYPE 17 * * * FORMAT STATEMENT * * *                            CDM02960
C                                                                         CDM02970
C     FRECPT 1-64  16A4               FORMAT STATEMENT, INCLUDING BEGINNINCDM02980
C                                     AND ENDING PARENTHESIS, FOR THE     CDM02990
C                                     RECEPTOR CARDS.  OLD CDM FORMAT WAS,CDM03000
```

```
C                                       (2F8.2,14X,I4,3X,I4,I5)
C
C  RECORD TYPE 18 *** RECEPTOR CARDS (VARIABLE NUMBER OF RECORDS) ***
C
C     RX      (SEE RECORD TYPE 17)  X MAP COORD. OF THE RECEPTOR
C     RY              "             Y MAP COORD. OF THE RECEPTOR
C     KPX9            "             OBSERVED CONC. OF POLLUTANT 1 AT THE
C                                   RECEPTOR, IF KNOWN
C     KPX10           "             OBSERVED CONC. OF POLLUTANT 2 AT THE
C                                   RECEPTOR, IF KNOWN
C     NROSE           "             OPTION FOR POLLUTANT CONC. ROSES
C                                      > 0, PRINT CONCENTRATION ROSES
C                                      < OR = 0, NO CONCENTRATION ROSES
C
C
      CALL CLINT(ICOND)
C
      IF (ICOND .EQ. 0) GO TO 20
         WRITE(IWR,10)
   10    FORMAT('0*** EXECUTION TERMINATED.')
         GO TO 620
   20 DELO2 = DELTA/2.0
C
C          READ RECORD TYPE 17.
C
      READ(IRD,30) FRECPT
   30 FORMAT(16A4)
C
C          INITIALIZE CONCENTRATION ARRAYS
C
   40 DO 60 I=1,2
         DO 50 IDUM=1,6
            PPAR(I,IDUM) = 0.0
            APAR(I,IDUM) = 0.0
   50    CONTINUE
         ABAR(I)=0.
         PBAR(I)=0.
         DO 55 K=1,N1636
            AROSE(K,I)=0.
            PROSE(K,I)=0.
   55    CONTINUE
   60 CONTINUE
C
C          READ RECORD TYPE 18 (RECEPTOR INFORMATION).
C           AT END OF FILE STOP EXECUTION.
C
      READ(IRD,FRECPT,END=620)RX,RY,KPX(9),KPX(10),NROSE
C          RX:        X MAP COORD. OF THE RECEPTOR
C          RY:        Y MAP COORD. OF THE RECEPTOR
C          KPX(9):    OBSERVED CONC. OF POLLUTANT 1 AT THE RECEPTOR, IF
C                        KNOWN
C          KPX(10):   OBSERVED CONC. OF POLLUTANT 2 AT THE RECEPTOR, IF
C                        KNOWN
C          NROSE:     OPTION FOR POLLUTANT CONCENTRATION ROSES
C
      ICHK = 0
C
C           ICHK IS USED IN CALQ TO CONTROL THE PRINTING OF THE
C            WARNING MESSAGE ABOUT EXCEEDING 100 ARCS.  WE SET ICHK
C            TO ZERO WHENEVER WE READ IN A NEW RECEPTOR.  A
C            WARNING MESSAGE IS PRINTED ONLY WHEN NEEDED AND ONLY
C            WHEN ICHK = 0.  WHEN THE MESSAGE IS PRINTED, ICHK IS
C            SET TO THE VALUE OF 1 IN CALQ.  IN THIS MANNER, WE
C            PRINT THE WARNING ONLY ONCE PER RECEPTOR EVEN IF
C            MORE THAN 100 ARCS IS CALLED FOR IN MORE THAN ONE
C            SECTOR.
C
C          CONVERT COORDINATES TO EMISSION GRID UNITS
      RI=(RX-XG)/RAT+0.5
      RJ=(RY-YG)/RAT+0.5
      IF(NROSE.GE.1) GO TO 110
      IPG=IPG+1
C          START NEW PAGE IF LINE COUNT GE 50
      IF(IPG.LT.44) GO TO 110
      IPG=0
```

```
      WRITE(IWR,70)IVER,IRUN,HEADNG
   70 FORMAT('1',35X,'CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0',/
     *        1X,48X,'CODE VERSION ',I5,/
     *        1X,53X,'RUN ',I5,//,
     *        1X,20A4,//)
      WRITE(IWR,80)
   80 FORMAT(1X,39X,'CONCENTRATIONS (MICROGRAMS/CU. METER)',//)
      WRITE(IWR,90) PNAME(1),PNAME(2),PNAME(1),PNAME(2),PNAME(1),
     *              PNAME(2),PNAME(1),PNAME(2),PNAME(1),PNAME(2)
   90 FORMAT(1X,22X,'AREA  SOURCES      POINT  SOURCES      -----TOTAL',
     *       '-----       --CALIBRATED--      ---OBSERVED---',/
     *       1X,'X COORD    Y COORD',5X,5(A4,5X,A4,7X),/)
C
C         INITIALIZE SECTOR DIRECTION
C          K: PROGRESSES 1 THROUGH N1636 CONTROLLING SECTOR DIRECTION
C
  110 K=1
C
C         IF THERE ARE NO AREA SOURCES TO EVALUATE GO TO 340 AND CHECK
C          FOR POINT SOURCES
C
      IF(IAS.LT.1) GO TO 340
C
C         THERE ARE AREA SOURCES TO EVALUATE.
C          DETERMINE MAXIMUM AND MINIMUM DISTANCES FROM THE RECEPTOR
C          TO THE EMISSION GRID BOUNDARIES.
C
      DX(1)=(IX-0.5)-RI
      DX(2)=(IXX+0.5)-RI
      DX(3)=DX(2)
      DX(4)=DX(1)
      DY(1)=(IY-0.5)-RJ
      DY(2)=DY(1)
      DY(3)=(IYY+0.5)-RJ
      DY(4)=DY(3)
      TX=(DX(1)*DX(1)+DY(1)*DY(1))**0.5
      TN=TX
      TM=(DX(2)*DX(2)+DY(1)*DY(1))**0.5
      IF(TM.GT.TX) TX=TM
      IF(TM.LT.TN) TN=TM
      TM=(DX(2)*DX(2)+DY(3)*DY(3))**0.5
      IF(TM.GT.TX) TX=TM
      IF(TM.LT.TN) TN=TM
      TM=(DX(1)*DX(1)+DY(3)*DY(3))**0.5
      IF(TM.GT.TX) TX=TM
      IF(TM.LT.TN) TN=TM
      MX=TX/DR
C
C         IF THE RECEPTOR IS OUTSIDE THE EMISSION GRID BOUNDARIES THEN
C            GO TO 120
C
      IF(RI+0.5.LT.IX.OR.RI-0.5.GT.IXX) GO TO 120
      IF(RJ+0.5.LT.IY.OR.RJ-0.5.GT.IYY) GO TO 120
C
C         SET FLAG (IB) TO REMEMBER RECEPTOR IS WITHIN GRID BOUNDARIES
C
      IB=1
      MN=1
      GO TO 330
C
C         SET FLAG (IB) TO REMEMBER RECEPTOR IS OUTSIDE GRID BOUNDARIES
C
  120 IB=2
C
C         DETERMINE MINIMUM DISTANCE FROM RECEPTOR TO AREA SOURCES
C
      TMN=TN/DR
      TXI=0.
      TNI=400.
      DO 240 I=1,4
         IF(DX(I))130,150,190
  130    IF(DY(I).EQ.0.) GO TO 140
         TA(I)=ATAN(DY(I)/DX(I))*RAD+180.
         GO TO 230
  140    TA(I)=180.
```

```
      GO TO 230
150   IF(DY(I))160,170,180
160   TA(I)=270.
      GO TO 230
170   TA(I)=0.
      GO TO 230
180   TA(I)=90.
      GO TO 230
190   IF(DY(I))200,210,220
200   TA(I)=ATAN(DY(I)/DX(I))*RAD+360.
      GO TO 230
210   TA(I)=360.
      GO TO 230
220   TA(I)=ATAN(DY(I)/DX(I))*RAD
230   IF(TA(I).GT.TXI) TXI=TA(I)
      IF(TA(I).LT.TNI) TNI=TA(I)
240 CONTINUE
    TDIF=TXI-TNI
250 DO 260 I=1,4
260   A(I)=TA(I)
    TX=TXI
    TN=TNI
    IF(TDIF.GT.180.) GO TO 290
    TM=90.-TK(K)
    IF(TM.LT.0.) TM=TM+360.
270 IF(TM.GE.TN-DELO2) GO TO 280
    IF(TM.GE.DELO2) GO TO 340
    TM=TM+360.
280 IF(TM-(TX+DELO2))320,320,340
290 TM=180.-TK(K)
    IF(TM.LT.0.) TM=TM+360.
300 TX=0.
    TN=400.
    DO 310 I=1,4
      A(I)=A(I)+90.
      IF(A(I).GE.360.) A(I)=A(I)-360.
      IF(A(I).GT.TX) TX=A(I)
      IF(A(I).LT.TN) TN=A(I)
310 CONTINUE
    IF(TX-TN.LE.180.) GO TO 270
    TM=270.-TK(K)
    IF(TM.LT.0.) TM=TM+360.
    GO TO 300
320 DIF=(TX-TN)/(2.*RAD)
    MN=TMN*COS(DIF)
C        NEGATE POSSIBLE ERROR IN COSINE FUNCTION.
    L=MOD(MN,INC(4))
    IF(L.LE.0) L=INC(4)
    MN=MN-L
C        MN ALWAYS EQUALS 1 IF RECEPTOR WITHIN AREA SOURCE GRID
    IF(MN.LT.1) MN=1
330 N=MN
C
C        CALCULATE THE AREA SOURCE VECTOR
C
    CALL CALQ
C
C        CALCULATE SECTOR CONCENTRATION FROM THE AREA SOURCE VECTOR
C
    CALL AREA
C
C        IF NO POINT SOURCES, GO TO NEXT SECTOR
C
340 IF(IPS.LE.0) GO TO 350
C
C        CALCULATE SECTOR CONCENTRATION FROM THE POINT SOURCES
C
    CALL POINT
C
C        IF ALL THE SECTORS HAVE BEEN ANALYZED THEN PRINT AND STORE
C         THE RESULTS
C
350 IF(K.GE.N1636) GO TO 370
C
C        NEXT DIRECTION SECTOR. K LOOPS THROUGH N1636 SECTORS.
```

```
C
      K=K+1
      DO 360 I=1,2
         AROSE(K,I)=0.
         PROSE(K,I)=0.
  360 CONTINUE
C
C          IF NO AREA SOURCES, CHECK POINT SOURCES
C
      IF(IAS.LT.1) GO TO 340
C
C          BRANCH TO 330 OR 250 DEPENDS ON WHETHER RECEPTOR INSIDE (IB=1
C           OR OUTSIDE (IB=2) AREA SOURCE
C
      GO TO (330,250),IB
C
C          PRINT AND STORE RESULTS
C
  370 DO 380 I=1,2
         TCON(I)=PBAR(I)+ABAR(I)
         CCON(I)=CA(I)+CB(I)*TCON(I)
  380 CONTINUE
C          TCON: TOTAL CONCENTRATION
C          CCON: CALIBRATED CONCENTRATION
      IF(NROSE .LT. 1) GO TO 390
      WRITE(IWR,70)IVER,IRUN,HEADNG
      WRITE(IWR,80)
      WRITE(IWR,90) PNAME(1),PNAME(2),PNAME(1),PNAME(2),PNAME(1),
     *                  PNAME(2),PNAME(1),PNAME(2),PNAME(1),PNAME(2)
  390 WRITE(IWR,400)RX,RY,ABAR,PBAR,TCON,CCON,KPX(9),KPX(10)
  400 FORMAT(1X,2(F7.2,3X),4(F6.1,3X,F6.1,5X),2X,2(I4,5X))
C          ABAR: CONTRIBUTION FROM AREA SOURCES
C          PBAR: CONTRIBUTION FROM POINT SOURCES
C          KPX:  CARD OUTPUT VECTOR
      KPX(1)=ABAR(1)+0.5
      KPX(2)=ABAR(2)+0.5
      KPX(3)=PBAR(1)+0.5
      KPX(4)=PBAR(2)+0.5
      KPX(5)=TCON(1)+0.5
      KPX(6)=TCON(2)+0.5
      KPX(7)=CCON(1)+0.5
      KPX(8)=CCON(2)+0.5
      WRITE(IPU,410)RX,RY,IRUN,(KPX(L),L=1,10)
  410 FORMAT(1X,2F10.2,I5,'I',10I4)
      IF(NROSE.LT.1) GO TO 40
C          WRITE OUT PARTIAL CONCENTRATIONS ESTIMATED FOR
C           EACH STABILITY CATEGORY (LIST SEPARATELY THE
C           CONTRIBUTIONS FROM POINT AND AREA SOURCES).
C
      WRITE(IWR,430)
  430 FORMAT(//,1X,41('*'),' AVERAGE CONCENTRATIONS BY STABILITY ',
     *       41('*'),//)
      WRITE(IWR,440)(IDUM,IDUM=1,6)
  440 FORMAT(1X,38X,'TYPE OF    -------------STABILITY CATEGORY',
     *       '--------------',/,
     *       1X,26X,'POLLUTANT   SOURCE',6(6X,I2)/)
      KPX(37)=RX*100.
      KPX(38)=RY*100.
      DO 470 JDUM=1,2
         WRITE(IWR,450) JDUM,PNAME(JDUM),(APAR(JDUM,IDUM),IDUM=1,6)
         WRITE(IPU,455) AROS(JDUM),(APAR(JDUM,IDUM),IDUM=1,6),KPX(37),
     *                  KPX(38)
  450    FORMAT(1X,26X,I2,' (',A4,')',4X,'AREA ',1X,6(2X,F6.1),/)
  455    FORMAT(1X,A4,6F7.1,2I8)
         WRITE(IWR,460) JDUM,PNAME(JDUM),(PPAR(JDUM,IDUM),IDUM=1,6)
         WRITE(IPU,455) PROS(JDUM),(PPAR(JDUM,IDUM),IDUM=1,6),KPX(37),
     *                  KPX(38)
  460    FORMAT(1X,26X,I2,' (',A4,')',4X,'POINT',1X,6(2X,F6.1),//)
  470 CONTINUE
      IBUM = 8
      IF(N1636.EQ.36) IBUM = 12
      WRITE(IWR,480)
  480 FORMAT(/,1X,42('*'),' AREA ROSES (MICROGRAMS/CU. METER) ',
     *       42('*'),//)
      IF (N1636 .EQ. 16) WRITE(IWR,490)(D16(I),I=1,2*N1636,2)
```

```
  490 FORMAT(1X,6X,'POLLUTANT',5X,4(A4,A4,3X,A4,1X,A4,4X)/)
      IF (N1636 .EQ. 36) WRITE(IWR,500)(ISECTR,ISECTR+18, ISECTR=1,18)
  500 FORMAT(1X,'POLLUTANT',3X,18(I2,'&',I2,1X)/)
      DO 550 J=1,2
         DO 510 I=1,N1636
            KPX(I)=AROSE(I,J)+0.5
  510    CONTINUE
         IJ = 0
  520    IJ = IJ + 1
         ISTART = (IJ-1)*IBUM + 1
         IFIN = (IJ-1)*IBUM + IBUM
         WRITE(IPU,560) AROS(J),(KPX(I),I=ISTART,IFIN),KPX(37),KPX(38)
         IF(IFIN.LT.N1636) GO TO 520
         IF (N1636 .EQ. 16) WRITE(IWR,530)J,(KPX(I),I=1,N1636)
  530    FORMAT(1X,10X,I1,5X,16I6,/)
         IF (N1636 .EQ. 36) WRITE(IWR,540)J,(KPX(I),I=1,N1636/2),
     *                                      (KPX(I),I=N1636/2+1,N1636)
  540    FORMAT(1X,4X,I1,6X,18I6,/,1X,11X,18I6,/)
  550 CONTINUE
  560 FORMAT(1X,A4,8I5,2I8)
      WRITE(IWR,570)
  570 FORMAT(/,1X,41('*'),' POINT ROSES (MICROGRAMS/CU. METER) ',
     *        42('*'),//)
      IF (N1636 .EQ. 16) WRITE(IWR,490)(D16(I),I=1,2*N1636,2)
      IF (N1636 .EQ. 36) WRITE(IWR,500)(ISECTR,ISECTR+18, ISECTR=1,18)
      DO 600 L=1,2
         DO 580 K=1,N1636
            KPX(K)=PROSE(K,L)+0.5
  580    CONTINUE
         IJ = 0
  590    IJ = IJ + 1
         ISTART = (IJ-1)*IBUM + 1
         IFIN = (IJ-1)*IBUM + IBUM
         WRITE(IPU,560) PROS(L),(KPX(I),I=ISTART,IFIN),KPX(37),KPX(38)
         IF(IFIN.LT.N1636) GO TO 590
         IF (N1636 .EQ. 16) WRITE(IWR,530)L,(KPX(I),I=1,N1636)
         IF (N1636 .EQ. 36) WRITE(IWR,540)L,(KPX(I),I=1,N1636/2),
     *                                      (KPX(I),I=N1636/2+1,N1636)
  600 CONTINUE
      WRITE(IWR,610)
  610 FORMAT(1X,119('*'))
      IPG = 70
C
C         GO BACK AND READ NEXT RECEPTOR
C
      GO TO 40
C
  620 STOP
      END
C
C**********************************************************************
C
      SUBROUTINE CLINT(ICOND)
C                SUBROUTINE CLINT   (VERSION 85293), PART OF CDM-2.0.
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)
      DIMENSION FMETEO(16),FSOURC(16),DUM(6),CURVE(7),PCURVE(6),
     *          ACURVE(6)
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD
      COMMON /C3/ IBUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU
      COMMON /QCOM/ N,DR,IX,IY,TT(36,21),KTC,IXX,IYY,RAD,TD,
     *              Z(NASE,NASN,3)
      COMMON /ACOM/ PI,SZA(6),ABAR(2),AROSE(36,2),XS(6)
      COMMON /PCOM/ PH(NPTS),PR(NPTS),PS(NPTS,4),PX(NPTS),PY(NPTS),
     *              WA(36),WB(36),PROSE(36,2),CV,IPS,RAT,PBAR(2),TOA,
     *              VS1(NPTS),T1(NPTS),D1(NPTS),FRN(NPTS),BFLUX(NPTS)
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NSTDW,NGRAD,KLOW,KHIGH,
     *             PPAR(2,6),APAR(2,6),WHA(6),FAC,RCEPTZ,KELVIN,NDEF
      COMMON /TITLE/ HEADNG(20),PNAME(2),D16(32),D36(72),DISP(8,7),
     *              TTITLE(3)
      DATA CURVE /'  A ','  B ','  C ',' D1 ',' D2 ','  E ','  F '/
      ICOND = 0
C
```

```
C          READ RECORD TYPE 1
C
      READ(5,5) HEADNG
C          HEADNG:  DESCRIPTION OR TITLE OF MODEL RUN
    5 FORMAT(20A4)
C
C          READ RECORD TYPE 2
C
      READ(5,10) NSO2,PNAME
C          NSO2:    POLLUTANT SOURCE NUMBER FOR SO2
C          PNAME:  NAMES OF TWO POLLUTANTS TO BE MODELED
   10 FORMAT(I1,3X,2A4)
      IF ((NSO2 .EQ. 0) .OR. (NSO2 .EQ. 1) .OR. (NSO2 .EQ. 2)) GO TO 20
      WRITE(6,15) NSO2
   15 FORMAT('0*** VALID VALUES FOR NSO2 ARE 0, 1, OR 2.',/,
     *       ' *** USER INPUT NSO2 = ',I4)
      ICOND = 1
C
C          READ RECORD TYPE 3
C
   20 READ(5,25)AROS,PROS,IRUN,NLIST,IRD,IWR,IPU,CA,CB
C          AROS:   ALPHA AREA ROSE OUTPUT ID
C          PROS:   ALPHA POINT ROSE OUTPUT ID
C          IRUN:   USER DEFINED RUN ID NUMBER
C          NLIST: CONTROL FOR PRINTED OUTPUT
C          IRD:    FORTRAN LOGICAL UNIT NUMBER (READ)
C          IWR:    FORTRAN LOGICAL UNIT NUMBER (PRINTER)
C          IPU:    FORTRAN LOGICAL UNIT NUMBER (PUNCH)
C          CA:     INTERCEPT OF CALIBRATION
C          CB:     SLOPE OF CALIBRATION
   25 FORMAT(4A4,5I5,4F9.0)
C
C          READ RECORD TYPE 4
C
      READ(IRD,*) N1636,NP50,NPDH,NSTDW,NGRAD,FAC,RCEPTZ,KELVIN,NDEF
C          N1636:   NUMBER OF WIND DIRECTIONS USED IN METEOROLOGICAL JOIN
C                   FREQUENCY FUNCTION.
C          NP50:    INITIAL DISPERSION OPTION
C          NPDH:    BUOYANCY-INDUCED DISPERSION OPTION
C          NSTDW:   STACK DOWNWASH OPTION
C          NGRAD:   GRADUAL PLUME RISE OPTION
C          FAC:     EFFLUENT RISE OF AREA SOURCES
C          RCEPTZ: HEIGHT (M) ABOVE GROUND OF ALL RECEPTORS
C          KELVIN: UNITS FLAG FOR STACK TEMPERATURE
C          NDEF:    DEFAULT OPTION
      IF ((N1636 .EQ. 16) .OR. (N1636 .EQ. 36)) GO TO 40
      WRITE(IWR,30) N1636
   30 FORMAT('0*** VALID VALUES FOR N1636 ARE 16 OR 36.',/
     *       ' *** USER INPUT N1636 =',I4)
      ICOND = 1
   40 IF ((FAC .GE. 0.) .AND. (FAC .LE. 1.)) GO TO 60
      WRITE(IWR,50) FAC
   50 FORMAT('0*** VALID VALUES FOR FAC RANGE FROM 0 TO 1.',/
     *       ' *** USER INPUT FAC =',F6.2)
      ICOND = 1
C
C          READ RECORD TYPE 5
C
   60 READ(IRD,*) KLOW,ICA
C          KLOW:    DISPERSION PARAMETER SCHEME FOR AREA SOURCES
C          ICA:     ARRAY OF SIX (6) VALUES DEFINING DISPERSION CURVES
C                     (AS DEFINED BY KLOW) TO BE USED FOR THE SIX
C                     STABILITY CATEGORIES SUMMARIZED IN THE JOINT
C                     FREQUENCY FUNCTION.
      IF (((KLOW .GE. 1).AND.(KLOW .LE. 7)).OR.(NDEF .GT. 0)) GO TO 80
      WRITE(IWR,70) KLOW
   70 FORMAT('0*** VALID VALUES FOR KLOW RANGE FROM 1 TO 7.',/
     *       ' *** USER INPUT KLOW =',I4)
      ICOND = 1
   80 DO 100 I = 1,6
         IF (((ICA(I).GE.1).AND.(ICA(I).LE.7)).OR.(NDEF.GT.0)) GO TO 10
         WRITE(IWR,90) I,ICA(I)
   90    FORMAT('0*** VALID VALUES FOR ICA RANGE FROM 1 TO 7.',/
     *          ' *** USER INPUT ICA(',I1,') =',I4)
         ICOND = 1
```

```
  100 CONTINUE
C
C         READ RECORD TYPE 6
C
      READ(IRD,*) KHIGH,ICP
C         KHIGH:  DISPERSION PARAMETER SCHEME FOR POINT SOURCES
C         ICP:    ARRAY OF SIX (6) VALUES DEFINING THE DISPERSION CURVE
C                   (AS DEFINED BY KHIGH) TO BE USED FOR THE SIX
C                   STABILITY CATEGORIES SUMMARIZED IN THE JOINT
C                   FREQUENCY FUNCTION.
      IF (((KHIGH.GE.1).AND.(KHIGH.LE.7)).OR.(NDEF.GT.0)) GO TO 120
      WRITE(IWR,110) KHIGH
  110 FORMAT('0*** VALID VALUES FOR KHIGH RANGE FROM 1 TO 7.',/
     *       ' *** USER INPUT KHIGH =',I4)
      ICOND = 1
  120 DO 140 I = 1,6
         IF (((ICP(I).GE.1).AND.(ICP(I).LE.7)).OR.(NDEF.GT.0)) GO TO 14
         WRITE(IWR,130) I,ICP(I)
  130    FORMAT('0*** VALID VALUES FOR ICP RANGE FROM 1 TO 7.',/
     *          ' *** USER INPUT ICP(',I1,') =',I4)
         ICOND = 1
  140 CONTINUE
      IF (ICOND .NE. 0) GO TO 810
C
C         INITIALIZE ARRAY SOURCE AND WIND DIRECTION ARRAYS
C
      DO 150 I=1,NASE
         DO 150 J=1,NASN
C              EFFECTIVE STACK HEIGHT MUST BE GE 1.
            Z(I,J,3)=1.
            DO 150 K=1,2
               Z(I,J,K)=0.
  150 CONTINUE
      TK(1)=0.
      DELTA = 22.5
      IF(N1636.EQ.36) DELTA = 10.0
      RDELTA = DELTA/RAD
      TTAN = TAN(RDELTA/2.0)
      DO 160 I=2,N1636
         TK(I)=TK(I-1)+DELTA
  160 CONTINUE
C
C         READ RECORD TYPE 7
C
      READ(IRD,170)DELR,RAT,CV,XG,YG,TOA,TXX
C         DELR:  RADIAL INCREMENT (M)
C         RAT:   WIDTH OF A BASIC EMISSION GRID SQUARE (USER UNITS)
C         CV:    CONVERSION FACTOR, CV*RAT = EMISSION GRID INTERVAL (M)
C         XG:    X MAP COORD. OF THE SW CORNER OF THE EMISSION GRID
C                  ARRAY
C         YG:    Y MAP COORD. OF THE SW CORNER OF THE EMISSION GRID
C                  ARRAY
C         TOA:   MEAN ATMOSPHERIC TEMPERATURE (DEG C)
C         TXX:   WIDTH OF BASIC EMISSION GRID SQUARE (M)
  170 FORMAT(12F6.0)
      IF (TXX .EQ. 0) GO TO 175
      CHK = ABS(1.0 - (RAT*CV/TXX))
      IF (CHK .LE. 0.01) GO TO 185
  175 WRITE(IWR,180)
  180 FORMAT('0*** THE PRODUCT OF RAT AND CV MUST EQUAL TXX.',/
     *       ' *** THE VALUES PROVIDED BY THE USER DO NOT CONFORM TO ',
     *       'THIS RELATIONSHIP.')
      ICOND = 1
      GO TO 810
C
C         COMPUTE MAXIMUM LENGTH (M) OF SIDE OF EMISSION
C          GRID SQUARE MATRIX ( THE 'Z ARRAY')
C
  185 TXXTE = NASE*TXX
      TXXTN = NASN*TXX
C
C         READ RECORD TYPE 8
C
      READ(IRD,170)DINT,YD,YN,SZA,GB
C         DINT:   NUMBER OF SEGMENTS DESIRED IN DELTA DEGREE SECTORS.
```

```
C                  RANGES FROM 2 TO 20 INCLUSIVE.
C         YD:     RATIO OF THE DAYTIME EMISSION RATE TO THE AVERAGE
C                  24-HOUR EMISSION RATE
C         YN:     RATIO OF THE NIGHTTIME EMISSION RATE TO THE AVERAGE
C                  24-HOUR EMISSION RATE
C         SZA(N): INITIAL SIGMA-Z FOR AREA SOURCES (M)
C                  N = STABILITY CLASS
C         GB(N):  DECAY HALF-LIFE (HR) FOR THE TWO POLLUTANTS
C                  N = POLLUTANT NUMBER
      IF ((DINT.GE.2.).AND.(DINT.LE.20.)) GO TO 200
      WRITE(IWR,190) DINT
  190 FORMAT('0*** VALID VALUES FOR DINT RANGE FROM 2 TO 20.',/
     *       ' *** USER INPUT DINT = ',F5.1)
      ICOND = 1
      GO TO 810
C
C         READ RECORD TYPE 9
C
  200 READ(IRD,*) (UE(I),I=1,6)
C         UE(I):  ARRAY OF SIX (6) VALUES DEFINING WIND PROFILE
C                  EXPONENTS TO BE ASSOCIATED WITH THE SIX STABILITY
C                  CATEGORIES SUMMARIZED IN THE JOINT FREQUENCY
C                  FUNCTION.  I = STABILITY CLASS
C
C         READ RECORD TYPE 10
C
      READ(IRD,*) (U(I),I=1,6)
C         U(I):   ARRAY OF SIX (6) VALUES DEFINING WIND SPEEDS (M/SEC)
C                  TO BE ASSOCIATED WITH THE SIX WIND SPEED CATEGORIES
C                  SUMMARIZED IN THE JOINT FREQUENCY FUNCTION.
C                  TYPICALLY THE HARMONIC AVERAGE WIND SPEED IS USED.
C
C         READ RECORD TYPE 11
C
      READ(IRD,*) (HL(I),I=1,6)
C         HL(I):   ARRAY OF SIX (6) VALUES DEFINING MIXING HEIGHTS (M)
C                  TO BE ASSOCIATED WITH THE SIX STABILITY CATEGORIES
C                  SUMMARIZED IN THE JOINT FREQUENCY FUNCTION.
C                  I = STABILITY CLASS
C
C         READ RECORD TYPE 12
C
      READ(IRD,210) FMETEO
  210 FORMAT(16A4)
C
C         READ RECORD TYPE 13
C
      DO 220 I=1,6
         DO 220 K=1,N1636
            READ(IRD,FMETEO)(F(I,J,K),J=1,6)
C               F(I,J,K): JOINT FREQUENCY FUNCTION...
C                         I = STABILITY CLASS
C                         J = WIND SPEED CLASS
C                         K = WIND DIRECTION
            DO 220 JJ=1,6
               UBAR(I) = UBAR(I) + U(JJ)*F(I,JJ,K)
               DUM(I) = DUM(I) + F(I,JJ,K)
  220 CONTINUE
C
C         IF NDEF > 0, THEN SET DEFAULT VALUES.
C
      IF (NDEF.GT.0) CALL DFAULT(NSO2,CA,CB,NP50,NPDH,NSTDW,NGRAD,KLOW,
     *                           ICA,KHIGH,ICP,SZA,GB,UE)
C
C         COMPUTE AVERAGE WIND SPEED FOR EACH DIRECTION SECTOR
C
      DO 240 II=1,6
         IF(DUM(II).NE.0.) GO TO 230
            UBAR(II)=0.
         GO TO 240
  230       UBAR(II) = UBAR(II)/DUM(II)
  240 CONTINUE
C
C         DEFINE AMBIENT TEMPERATURE, SECTOR INTEGRATION PARAMETERS,
C          AND POLLUTANT HALF-LIFE.
```

```
C
      TOA=TOA+273.16
      DR=DELR/(CV*RAT)
      KTC=DINT+1.
      THETA=DELTA/DINT
      TANG = 90.0 - DELTA/2.0
      DO 250 I=1,N1636
         B=TK(I)/RAD
         WB(I)=SIN(B)
         WA(I)=COS(B)
         DO 250 J=1,KTC
            X=TANG-TK(I)+(J-1)*THETA
            IF(X.LT.0.) X=X+360.
            TT(I,J)=X/RAD
  250 CONTINUE
C        DEFINE HALF LIFE FOR P 1 AND  P 2
      GA(1)=GB(1)*3600./0.693
      GA(2)=GB(2)*3600./0.693
C
C          DEFINE INITIAL SIGMAS
C
      DO 270 JA=1,6
         JB=ICA(JA)
         WHA(JA) = FAC + (5.0/U(JA))*(1.0-FAC)
         HX(JA)=0.8*HL(JA)
         SA=SZA(JA)
         IF(SA.GT.0.) GO TO 260
         S=0.
         GO TO 270
  260    CALL VIRTX(KLOW,NPDH,JB,0.0,SA,S)
  270    XS(JA)=S
C
C          EVALUATE PRINTER CONTROL OPTION
C
      IF(NLIST.LT.0) GO TO 610
C
C          ECHO SETUP INFORMATION AND METEOROLOGICAL INPUT
C
      WRITE(IWR,280)IVER,IRUN,HEADNG
  280 FORMAT('1',35X,'CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0',/
     *          1X,48X,'CODE VERSION ',I5,/
     *          1X,53X,'RUN ',I5,//,
     *          1X,20A4,/)
      WRITE(IWR,290)N1636
  290 FORMAT(1X,'TECHNICAL OPTIONS:',/
     *          1X,'     NUMBER OF WIND DIRECTIONS USED IN METEOROLOGICAL '
     *             'JOINT',/,
     *          1X,'     FREQUENCY FUNCTION (N1636) ',30('.'),I5)
      WRITE(IWR,300)KLOW,(DISP(I,KLOW), I = 1,8),
     *                  KHIGH,(DISP(I,KHIGH), I = 1,8)
  300 FORMAT(1X,'     DISPERSION PARAMETER SCHEME FOR AREA SOURCES ',
     *             '(KLOW) ',7('.'),I5,12X,8A4/
     *          1X,'     DISPERSION PARAMETER SCHEME FOR POINT SOURCES ',
     *             '(KHIGH) ',5('.'),I5,12X,8A4)
      WRITE(IWR,310)FAC
  310 FORMAT(1X,'     EFFLUENT RISE FOR AREA SOURCES (FAC) ',22('.'),
     *             4X,1PE12.6)
      WRITE(IWR,320) RCEPTZ
  320 FORMAT(1X,'     HEIGHT ABOVE GROUND OF ALL RECEPTORS (RCEPTZ) ',
     *             13('.'),4X,1PE12.6,' M')
      WRITE(IWR,330) PNAME(1),CA(1),CB(1)
      WRITE(IWR,330) PNAME(2),CA(2),CB(2)
  330 FORMAT(1X,'     CALIBRATION CONSTANTS -- ',A4,/,
     *          1X,8X,'INTERCEPT OF CALIBRATION ',30('.'),4X,1PE12.6,
     *             ' MICROGRAMS/CU. METER',/
     *          1X,8X,'SLOPE OF CALIBRATION ',34('.'),4X,1PE12.6,
     *             ' DIMENSIONLESS')
      WRITE(IWR,340)NP50,NPDH,NSTDW,NGRAD,NDEF
  340 FORMAT(1X,'     INITIAL DISPERSION OPTION (NPS0) ',26('.'),I5,/,
     *          1X,'     BUOYANCY INDUCED DISPERSION OPTION (NPDH) ',
     *             17('.'),3X,I2,/
     *          1X,'     STACK DOWNWASH OPTION (NSTDW) ',29('.'),3X,I2,/,
     *          1X,'     GRADUAL PLUME RISE OPTION (NGRAD) ',25('.'),3X,I2,
     *          1X,'     DEFAULT OPTION (NDEF) ',37('.'),3X,I2,/)
      WRITE(IWR,360) NLIST
```

```
360 FORMAT('0PRINT OPTIONS:',/
   *        1X,'     CONTROL FOR PRINTED OUTPUT ',32('.'),I5)
    WRITE(IWR,370) IRD,IWR,IPU
370 FORMAT(1X,'     FORTRAN LOGICAL UNIT NUMBER (READ) ',24('.'),I5/
   *  1X,'     FORTRAN LOGICAL UNIT NUMBER (PRINTER) ',21('.'),I5/
   *  1X,'     FORTRAN LOGICAL UNIT NUMBER (PUNCH) ',23('.'),I5/)
    WRITE(IWR,380)XG
380 FORMAT(1X,'OPERATING PARAMETERS:',/
   *        1X,'     X-MINIMUM OF AREA EMISSION INVENTORY MAP GRID',
   *          ' (XG) ',8('.'),4X,1PE12.6,' USER UNITS')
    WRITE(IWR,390)YG,RAT
390 FORMAT(1X,'     Y-MINIMUM OF AREA EMISSION INVENTORY MAP GRID',
   *          ' (YG) ',8('.'),4X,1PE12.6,' USER UNITS',/
   *        1X,'     WIDTH OF A BASIC EMISSION GRID SQUARE (RAT) ',
   *          15('.'),4X,1PE12.6,' USER UNITS')
    WRITE(IWR,400)CV,TXX
400 FORMAT(1X,'     GRID CONVERSION FACTOR (CV) ',31('.'),
   *          4X,1PE12.6,' M/USER UNITS'/,
   *        1X,'     WIDTH OF A BASIC EMISSION GRID SQUARE (TXX) ',
   *          15('.'),4X,1PE12.6,' M')
    WRITE(IWR,410)DINT
410 FORMAT(1X,'     NUMBER OF SUBSECTORS CONSIDERED FOR EACH SECT',
   *          'OR (DINT) ',4('.'),4X,1PE12.6,' DIMENSIONLESS')
    WRITE(IWR,420)THETA,DELR
420 FORMAT(1X,'     ANGULAR WIDTH OF A SUBSECTOR (THETA) ',22('.'),
   *          4X,1PE12.6,' DEG',/
   *        1X,'     INITIAL RADIAL INCREMENT (DELR) ',27('.'),
   *          4X,1PE12.6,' M'/)
    WRITE(IWR,430)TOA
430 FORMAT(1X,'MISCELLANEOUS METEOROLOGICAL DATA:',/
   *        1X,'     AMBIENT AIR TEMPERATURE (TOA) ',29('.'),
   *          4X,1PE12.6,' K')
    WRITE(IWR,440)(I,HL(I),I=1,6)
440 FORMAT(1X,'     MIXING HEIGHTS BY STABILITY CLASS (HL):',/
   *          '      STABILITY CLASS:',I6,1X,33('.'),4X,1PE12.6,' M',/
   *        5(1X,27X,I2,1X,33('.'),4X,1PE12.6,' M',/))
    WRITE(IWR,280)IVER,IRUN,HEADNG
    WRITE(IWR,450)
450 FORMAT(1X,'MISCELLANEOUS METEOROLOGICAL DATA (CONTINUED):',//,
   *        1X,'     CENTRAL WIND SPEED OF THE SIX WIND SPEED CLAS',
   *          'SES (U):')
    WRITE(IWR,460)(I,U(I),I=1,6)
460 FORMAT(1X,'         WIND SPEED CLASS:  ',I2,1X,33('.'),
   *          4X,1PE12.6,' M/SEC',/
   *      5(1X,27X,I2,1X,33('.'),4X,1PE12.6,' M/SEC',/))
    WRITE(IWR,470)(I,UE(I),I=1,6)
470 FORMAT(1X,'     EXPONENTIAL OF THE VERTICAL WIND PROFILE (UE):'/
   *        1X,'         STABILITY CLASS:   ',I2,1X,33('.'),
   *          4X,1PE12.6,' DIMENSIONLESS'/
   *      5(1X,27X,I2,1X,33('.'),4X,1PE12.6,' DIMENSIONLESS'/)//)
    WRITE(IWR,480)PNAME(1),PNAME(2)
480 FORMAT(1X,'SOURCE DATA:',//,
   *        1X,'     POLLUTANTS TO BE MODELED ',34('.'),4X,A4,' & ',A4)
    WRITE(IWR,490)PNAME(1),GB(1),PNAME(2),GB(2)
490 FORMAT(1X,'     DECAY HALF-LIFE FOR ',A4,' (GB(1)) ',26('.'),
   *          4X,1PE12.6,' HR',/
   *        1X,'     DECAY HALF-LIFE FOR ',A4,' (GB(2)) ',26('.'),
   *          4X,1PE12.6,' HR')
    WRITE(IWR,500)YD,YN
500 FORMAT(1X,'     DAYTIME EMISSION WEIGHT FACTOR (YD) ',23('.'),
   *          4X,1PE12.6,' DIMENSIONLESS'/
   *        1X,'     NIGHTTIME EMISSION WEIGHT FACTOR (YN) '21('.'),
   *          4X,1PE12.6,' DIMENSIONLESS')
    WRITE(IWR,510)
510 FORMAT(1X,'     INITIAL SIGMA-Z FOR AREA SOURCES (SZA):')
    WRITE(IWR,520)(I,SZA(I),I=1,6)
520 FORMAT(1X,'         STABILITY CLASS:   ',I2,1X,33('.'),
   *          4X,1PE12.6,' M',/
   *      5(1X,27X,I2,1X,33('.'),4X,1PE12.6,' M',/))
    DO 530 I = 1,6
       IDUM = ICP(I)
       JDUM = ICA(I)
       PCURVE(I) = CURVE(IDUM)
       ACURVE(I) = CURVE(JDUM)
530 CONTINUE
```

```
      WRITE(IWR,540) (I,PCURVE(I),ACURVE(I), I = 1,6)
  540 FORMAT(1X,'DISPERSION CURVE USED FOR EACH STABILTY CLASS',/,
     *             4X,'STABILITY          POINT           AREA',/,
     *             4X,'  CLASS          SOURCES         SOURCES',/,
     *         6(7X,I2,12X,A4,11X,A4,/))
      DO 610 I=1,6
         IF((N1636.EQ.16) .AND. ((I/2)*2.EQ.I)) GO TO 560
         WRITE(IWR,280)IVER,IRUN,HEADNG
         WRITE(IWR,550)
  550    FORMAT(1X,38X,'METEOROLOGICAL JOINT FREQUENCY FUNCTION',//)
  560    WRITE(IWR,570)I
  570    FORMAT(1X,'STABILITY CLASS',I2,47X,'WIND SPEED CLASS',//
     *          1X,4X,'WIND DIRECTION     SECTOR',
     *          11X,'1',12X,'2',12X,'3',12X,'4',12X,'5',12X,'6',/)
         DO 590 K=1,N1636
            IF(N1636 .EQ. 36)
     *         WRITE(IWR,580)D36(2*K-1),D36(2*K),K,(F(I,J,K),J=1,6)
            IF(N1636 .EQ. 16)
     *         WRITE(IWR,580)D16(2*K-1),D16(2*K),K,(F(I,J,K),J=1,6)
  580          FORMAT(1X,7X,2A4,9X,I2,9X,6(F8.6,5X))
  590    CONTINUE
         WRITE(IWR,600)UBAR(I)
  600    FORMAT(/,1X,55X,'COMPUTED MEAN SPEED = ',F5.2,' M/SEC',2(/))
  610 CONTINUE
C
C        READ RECORD TYPE 14
C
      READ(IRD,210) FSOURC
      CON1 = FLOAT(N1636)/(2.0*3.14159)
      CON2 = CON1*PI
C
C        READ SOURCE INPUT DATA (I.E., RECORD TYPE 15)
C
  620 READ(IRD,FSOURC)X,Y,TX,S1,S2,SH,D,VS,T,SA
C        X:   X MAP COORDINATE OF SOURCE
C        Y:   Y MAP COORDINATE OF SOURCE
C        TX:  WIDTH OF AREA SOURCES
C        S1:  EMISSION RATE OF POLLUTANT 1 (G/SEC)
C        S2:  EMISSION RATE OF POLLUTANT 2 (G/SEC)
C        SH:  SOURCE HEIGHT (M)
C        D:   STACK DIAMETER (M)
C        VS:  EXIT VELOCITY (M/S)
C        T:   STACK GAS TEMPERATURE (DEG F, C, OR K)
C        SA:  PLUME RISE OPTION
      IF (NDEF .GT. 0) SA = 0.0
      XSS = X
      YSS = Y
C
C        TEST END OF SOURCE DATA (BLANK CARD)
C
      IF(S1+S2.LE.0.) GO TO 790
C
C        EVALUATE PRINTER CONTROL OPTION
C
      IF(NLIST.NE.0) GO TO 680
C
C        ECHO SOURCE INPUT DATA
C
      IF(IPG.LT.44) GO TO 660
      IPG=0
      WRITE(IWR,280)IVER,IRUN,HEADNG
      WRITE(IWR,630)
  630 FORMAT(1X,42X,'AREA AND POINT SOURCE INVENTORY',//,
     *        1X,84X,'STACK      STACK       OPTIONAL',/,
     *        1X,27X,'WIDTH OF      ----EMISSION RATE----     SOURCE     ',
     *        'STACK     EXIT       GAS        PLUME RISE')
      WRITE(IWR,640)PNAME(1),PNAME(2)
  640 FORMAT(1X,'  X MAP          Y MAP        GRID SQUARE',5X,A4,9X,A4,6X,
     *        'HEIGHT     DIAM      SPEED      TEMP      COEFFICIENT')
      I = 1
      IF (KELVIN .EQ. 0) I = 2
      IF (KELVIN .GT. 0) I = 3
      WRITE(IWR,650) TTITLE(I)
  650 FORMAT(1X,'COORDINATE   COORDINATE         (M)          (G/SEC)',
     *        '          (G/SEC)       (M)        (M)     (M/SEC)    (DEG',A4,
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     *          '    (M**2/SEC)',/)
  660 IPG=IPG+1
      WRITE(IWR,670)X,Y,TX,S1,S2,SH,D,VS,T,SA
  670 FORMAT(1X,1X,F7.2,6X,F7.2,7X,F6.0,6X,F8.2,5X,F8.2,4X,F6.2,
     *       4X,F5.2,4X,F5.2,5X,F5.1,7X,F6.2)
C         EFFECTIVE STACK HEIGHT MUST BE GE 1.
  680 IF(SH.LT.1.) SH=1.
C
C         IF POINT SOURCE THEN GO TO 750
C
      IF(TX.LE.0.) GO TO 750
C
C         SOURCE IS AREA TYPE.  MODIFY SOURCE COORDINATES, DIMENSIONS,
C          AND EMISSION RATE TO CONFORM TO CDM-2.0 REQUIREMENTS.
C
      D=TX*0.5/CV
      X=X+D
      Y=Y+D
      W=TX/TXX
      S=TX*TX
      B=S1/S
      D=S2/S
C         BECAUSE OF THE METHOD OF INTEGRATION, AREA SOURCES ARE
C          DIVIDED BY TWO AT THIS POINT FOR MORE EFFICIENT EXECUTION
C          OF SUBROUTINE AREA.
      B=B*0.5
      D=D*0.5
      X=(X-XG)/RAT+1.
      Y=(Y-YG)/RAT+1.
      IF(W.GT.1.) GO TO 690
      M=X
      N=Y
      K=M
      L=N
      GO TO 700
  690 S=W*0.5
      K=(X-S)+0.55
      L=(Y-S)+0.55
      M=(K+W)-0.45
      N=(L+W)-0.45
  700 CONTINUE
C
C         IF SOURCE DIMENSIONS ARE OUTSIDE CDM-2.0 LIMITS THEN PRINT
C          ERROR MESSAGE AND READ NEXT SOURCE
C
      IF (M.GT.NASE.OR.N.GT.NASN) GO TO 710
      IF (M.LE.0.OR.N.LE.0) GO TO 710
      IF (L.GT.NASN.OR.K.GT.NASE) GO TO 710
      IF (L.LE.0.OR.K.LE.0) GO TO 710
      IF (M.LT.K) GO TO 710
      IF (N.LT.L) GO TO 710
      GO TO 730
C         PRINT ERROR MESSAGE FOR THIS AREA SOURCE
  710 WRITE(IWR,720) XSS,YSS,TXXTE,TXXTN
  720 FORMAT('0',7X,'NOTE:  AREA SOURCE WITH X COORD ',F10.2,
     * ' AND Y COORD ',F10.2,', VIOLATES',/,15X,
     * 'AREA SOURCE ARRAY LIMITS.  AREA SOURCES MUST LIE ENTIRELY ',
     * 'WITHIN A ',F11.2,' BY ',F11.2,/,15X,
     * 'METER SQUARE WITH SOUTHWEST CORNER AT THE USER-DEFINED ',
     * 'ORIGIN (XG,YG).  THIS',/,15X,
     * 'SOURCE  WILL NOT BE INCLUDED IN THIS CALCULATION.',/)
      GO TO 620
C
C         STORE AREA SOURCE INFORMATION
C
  730 DO 740 I=K,M
          DO 740 J=L,N
             Z(I,J,1)=B
             Z(I,J,2)=D
  740        Z(I,J,3)=SH
      IF(M.GT.IXX) IXX=M
      IF(N.GT.IYY) IYY=N
C
C         INCREMENT AREA SOURCE COUNTER
C
```

```
      IAS=IAS+1
C
C         GO BACK AND READ NEXT SOURCE
C
      GO TO 620
C
C         INCREMENT POINT SOURCE COUNTER
C
  750 IPS=IPS+1
C
C         STORE POINT SOURCE INFORMATION
C
      PX(IPS)=(X-XG)/RAT+0.5
      PY(IPS)=(Y-YG)/RAT+0.5
      PS(IPS,1)=S1*CON2
      PS(IPS,2)=S2*CON2
      PS(IPS,3)=S1*CON1
      PS(IPS,4)=S2*CON1
      PH(IPS)=SH
      PR(IPS)=SA
      IF(KELVIN.GE.0) GO TO 755
      T=(T-32.0)*(5./9.)+273.16
      GO TO 760
  755 IF(KELVIN.GT.0) GO TO 760
      T=T+273.16
  760 IF(D .LE. 0.) D = 0.01
      VS1(IPS)=VS
      T1(IPS) = T
      D1(IPS) = D
      FRN(IPS)=VS*VS*TOA/(9.80616*D*(T-TOA))
      BFLUX(IPS) = (9.80616 * VS * D * D * (T - TOA))/(4. * T)
C
C         GO BACK AND READ NEXT SOURCE
C
      GO TO 620
C
C         PREPARE TO RETURN TO MAIN
C
  790 IPG=70
C
C         COMPUTE NE CORNER OF NE GRID SQUARE
C
      TDA=0.5-TD
      TDB=IXX+0.5+TD
      TDC=IYY+0.5+TD
C
C         PRINT NUMBER OF POINT AND AREA SOURCES
C
      WRITE(IWR,800)IAS,IPS
  800 FORMAT('0',I10,' AREA SOURCES.',I10,' POINT SOURCES.')
  810 RETURN
      END
C
C*****************************************************************
C
      SUBROUTINE DFAULT(NSO2,CA,CB,NP50,NPDH,NSTDW,NGRAD,KLOW,ICA,KHIGH
     *                  ICP,SZA,GB,UE)
C          SUBROUTINE DFAULT   (VERSION 85293), PART OF CDM-2.0.
C
C       PARAMETER LIST:
C         INPUT:    NSO2  - POLLUTANT NUMBER FOR SO2
C         OUTPUT:   CA    - INTERCEPT OF CALIBRATION
C                   CB    - SLOPE OF CALIBRATION
C                   NP50  - INITIAL DISPERSION OPTION
C                   NPDH  - BUOYANCY-INDUCED DISPERSION OPTION
C                   NSTDW - STACK DOWNWASH OPTION
C                   NGRAD - GRADUAL PLUME RISE OPTION
C                   KLOW  - DISPERSION PARAMETER SCHEME FOR AREA SOURCES
C                   ICA   - ARRAY OF SIX VALUES DEFINING DISPERSION
C                             CURVES (AS DEFINED BY KLOW) TO BE USED FOR
C                             THE SIX STABILITY CATEGORIES SUMMARIZED IN
C                             THE JOINT FREQUENCY FUNCTION
C                   KHIGH - DISPERSION PARAMETER SCHEME FOR POINT SOURCE
C                   ICP   - ARRAY OF SIX VALUES DEFINING DISPERSION
C                             CURVES (AS DEFINED BY KHIGH) TO BE USED FOR
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```
C                           THE SIX STABILITY CATEGORIES SUMMARIZED IN
C                           THE JOINT FREQUENCY FUNCTION
C                  SZA    - INITIAL SIGMA-Z FOR AREA SOURCES (METERS)
C                  GB     - DECAY HALF-LIFE (HRS) FOR THE TWO POLLUTANTS
C                  UE     - ARRAY OF SIX VALUES DEFINING WIND PROFILE
C                           EXPONENTS TO BE ASSOCIATED WITH THE SIX
C                           STABILITY CATEGORIES SUMMARIZED IN THE
C                           JOINT FREQUENCY FUNCTION.
C
C       CALLING ROUTINE:
C         CLINT
C
C       DESCRIPTION:
C         THIS SUBROUTINE SETS PARAMETERS ACCORDING TO REGULATORY
C         GUIDANCE ESTABLISHED IN "GUIDELINE ON AIR QUALITY MODELS."
C         THIS MODULE WAS ADDED TO THE CODE AS A CONVENIENCE FOR THE
C         USER TO HELP AVOID INADVERTANT ERRORS IN SETTING THE
C         APPROPRIATE OPTIONS FOR REGULATORY USES.
C
      DIMENSION CA(2),CB(2),ICA(6),ICP(6),SZA(6),GB(2),UE(6)
C
C         SET CALIBRATION CONSTANTS
C
      DO 10 I = 1,2
         CA(I) = 0.0
         CB(I) = 1.0
   10 CONTINUE
C
C         SET PROGRAM CONTROL PARAMETERS
C
      NP50  = 0
      NPDH  = 1
      NSTDW = 1
      NGRAD = 0
C
C         SET DISPERSION SCHEME, DISPERSION CURVES, AND INITIAL SIGMAS
C
      KLOW  = 2
      KHIGH = 2
      DO 20 I = 1,6
         ICA(I) = I
         ICP(I) = I
         SZA(I) = 30.
   20 CONTINUE
C
C         SET WIND PROFILE EXPONENTS
C
      UE(1) = .15
      UE(2) = .15
      UE(3) = .20
      UE(4) = .25
      UE(5) = .25
      UE(6) = .30
C
C         SET POLLUTANT HALF-LIFE
C
      IF ((NSO2 .EQ. 1) .OR. (NSO2 .EQ. 2)) GO TO 30
         GB(1) = 999999.
         GB(2) = 999999.
         GO TO 999
   30 CONTINUE
      IF (NSO2 .EQ. 2) GO TO 40
         GB(1) = 4.0
         GB(2) = 999999.
         GO TO 999
   40 CONTINUE
         GB(1) = 999999.
         GB(2) = 4.0
C
  999 RETURN
      END
C
C*********************************************************************
C
      SUBROUTINE CALQ
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```
C             SUBROUTINE CALQ   (VERSION 85293), PART OF CDM-2.0.
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)
      DIMENSION C(3)
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU
      COMMON /C6/ ICHK
      COMMON /QCOM/ N,DR,IX,IY,TT(36,21),KTC,IXX,IYY,RAD,TD,
     *              Z(NASE,NASN,3)
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NSTDW,NGRAD,KLOW,KHIGH,
     *             PPAR(2,6),APAR(2,6),WHA(6),PAC,RCEPTZ,KELVIN,NDEF
C        CALCULATE SECTOR AREA SOURCE VECTOR Q(NQ,I)
C           N = INDEX OF RADIAL ARC
C           I = 1: P 1 EMISSION RATE
C           I = 2: P 2 EMISSION RATE
C           I = 3: AREA STACK HEIGHT
C
C        INITIALIZE ARC COUNTER
C
      NQ=0
C
C        INCREMENT ARC COUNTER
C
   10 NQ=NQ+1
C
C        IF THE NUMBER OF ARCS EVALUATED IS LESS THAN THE LIMIT SET
C         BY CDM-2.0 (NQLIM) GO TO 30
C
      IF(NQ.LT.NQLIM) GO TO 30
C
C        THE NUMBER OF ARCS EXCEEDS THE LIMIT SET BY CDM-2.0 PRINT ERR
C         MESSAGE AND RETURN TO MAIN
C
      NQ = NQLIM - 1
      IF(ICHK.EQ.1) GO TO 330
      ICHK = 1
      Q(NQ+1,4) = (N-1)*DELR
      XDIS = Q(NQ+1,4)/1000.0
C        PRINT WARNING MESSAGE
      WRITE(IWR,20) NQLIM,XDIS
   20 FORMAT('0',9X,'WARNING:  MORE THAN',I4,'ARCS ARE REQUIRED FOR ',
     * 'CALCULATION OF AREA CONTRIBUTION.',/,20X,'AREA SOURCES BEYOND'
     *  1X,F5.1,'KM ARE NOT INCLUDED IN THIS CALCULATION.')
      GO TO 340
C
C        THE NUMBER OF ARCS IS WITHIN THE LIMITS SET BY CDM-2.0.
C
   30 DO 40 I=1,3
         Q(NQ+1,I) = 0.0
   40    Q(NQ,I)=0.
      Q(NQ,4)=(N-1)*DELR
      R=(N-1)*DR
C        R:   RADIAL UPWIND DISTANCE
      KT=(N-1)*DELR/2500.+1.
C        KT:  CONTROLS INCREMENT TO NEXT ARC
      IF(KT.GT.4) KT=4
      HN=0.
C
C        LOOP OVER SECTOR INTERVAL COUNTER
C         KTC: CONTROLS NUMBER OF POINTS ALONG ARC (DINT+1)
C
      DO 290 LL=1,KTC
      T=TT(K,LL)
      TI=RI+R*COS(T)
      TJ=RJ+R*SIN(T)
C
C        IF RADIAL ARC OUTSIDE OUTSIDE AREA EMISSION GRID GO TO 290
C         DETERMINE WHICH AREA SOURCE THE POINT FALLS ON.  IF ON THE
C         LINE TWO ARE AVERAGED.  IF ON AN INTERSECTION, FOUR ARE
C         AVERAGED.
C
      IF(TI.LT.TDA.OR.TI.GT.TDB) GO TO 290
      IF(TJ.LT.TDA.OR.TJ.GT.TDC) GO TO 290
```

```
C
C         DETERMINE WHICH AREA SOURCE THE POINT FALLS ON
C
      I=TI
      J=TJ
      IF(I.LT.1) I=1
      IF(J.LT.1) J=1
      D=TI-I
      IF(ABS(D-0.5).LE.TD) GO TO 50
      IF(D-0.5)90,50,130
   50 D=TJ-J
      IF(ABS(D-0.5).LE.TD) GO TO 60
      IF(D-0.5)70,60,80
   60 IA=1
      JA=5
      GO TO 170
   70 IA=2
      JA=3
      GO TO 170
   80 IA=2
      JA=4
      GO TO 170
   90 D=TJ-J
      IF(ABS(D-0.5).LE.TD) GO TO 100
      IF(D-0.5)110,100,120
  100 IA=3
      JA=2
      GO TO 170
  110 IA=3
      JA=3
      GO TO 170
  120 IA=3
      JA=4
      GO TO 170
  130 D=TJ-J
      IF(ABS(D-0.5).LE.TD) GO TO 140
      IF(D-0.5)150,140,160
  140 IA=4
      JA=2
      GO TO 170
  150 IA=4
      JA=3
      GO TO 170
  160 IA=4
      JA=4
  170 CN=0.
      IF(I.EQ.IXX) IA=3
      IF(J.EQ.IYY) JA=3
      DO 180 LD=1,3
  180    C(LD)=0.
      DO 200 IR=1,4
         IV=I+IAD(IR,IA)
         JV=J+IAD(IR,JA)
         DO 190 L=1,2
  190       C(L)=C(L)+Z(IV,JV,L)
         IF(Z(IV,JV,3).LE.0.1) GO TO 200
         CN=CN+1.
         C(3)=C(3)+Z(IV,JV,3)
  200 CONTINUE
      C(1)=C(1)/4.
      C(2)=C(2)/4.
      IF(CN.GT.0.5) GO TO 210
      C(3)=1.
      GO TO 220
  210 C(3)=C(3)/CN
  220 IF(R.GT.0.) GO TO 240
      DO 230 LA=1,3
  230    Q(NQ,LA)=C(LA)
      GO TO 320
  240 IF(LL.NE.1.AND.LL.NE.KTC) GO TO 260
C          TRAPEZOIDAL INTEGRATION APPLIED
      DO 250 LB=1,2
  250    C(LB)=C(LB)*0.5
  260 DO 270 LC=1,2
  270    Q(NQ,LC)=Q(NQ,LC)+C(LC)
```

```
      IF(C(1)+C(2).LE.0.) GO TO 290
      Q(NQ,3)=Q(NQ,3)+C(3)
  280 HN=HN+1.
  290 CONTINUE
C
C         COMPUTE AVERAGE EMISSION RATE OVER THE ARC
C
      DO 300 LD=1,2
  300    Q(NQ,LD)=Q(NQ,LD)/DINT
      IF(HN.GT.0.5) GO TO 310
      Q(NQ,3)=1.
      GO TO 320
  310 Q(NQ,3)=Q(NQ,3)/HN
  320 N=N+INC(KT)
C
C         IF NEXT ARC IS WITHIN AREA GRID, GO TO 10 AND INCREMENT ARC
C          COUNTER
C
      IF(N.LE.MX+1) GO TO 10
  330 Q(NQ+1,4)=(N-1)*DELR
  340 RETURN
      END
C
C*********************************************************************
C
      SUBROUTINE AREA
C             SUBROUTINE AREA     (VERSION 85293), PART OF CDM-2.0.
C
C         THIS SUBROUTINE CALCULATES THE SECTOR CONCENTRATION FROM THE
C          AREA SOURCE VECTOR (Q).
C
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)
      DIMENSION C(2)
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU
      COMMON /ACOM/ PI,SZA(6),ABAR(2),AROSE(36,2),XS(6)
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NSTDW,NGRAD,KLOW,KHIGH,
     *             PPAR(2,6),APAR(2,6),WHA(6),FAC,RCEPTZ,KELVIN,NGREG
      Y=YD
C
C         LOOP OVER STABILITY CLASS
C
      DO 170 IS=1,6
C        IS: CONTROLS STABILITY CLASS
      IF(IS.EQ.5) Y=YN
      IC=ICA(IS)
C
C         LOOP OVER WIND SPEED CLASS
C
      DO 170 IU=1,6
C        IU: CONTOLS WIND SPEED CLASS
C         IF FREQUENCY IS ZERO, SKIP
      IF(F(IS,IU,K).LE.0.) GO TO 170
C
C         INITIALIZATION
C
      C(1)=0.
      C(2)=0.
      IR=1
      DVLRI=Q(2,4)-Q(1,4)
   10 R=Q(IR,4)
      DVLR=DVLRI
      DVLRI=Q(IR+1,4)-R
      QQQ = 0.1*Q(IR,3)*FAC
      IF(QQQ.LT.0.1) QQQ = 0.1
      PQQQ = UE(IS)
      WZ = QQQ**PQQQ
      WS=U(IU)*WZ
      DO 20 JA=1,2
         DF=WS*GA(JA)
   20    DECAY(JA)=EXP(R/DF)
      RXS=R+XS(IS)
```

```
C
      CALL SIGMAZ(KLOW,NPDH,IC,RXS,0.0,SZ)
C
      IF(SZ.LE.0.) GO TO 140
C
C         IF THE VERTICAL DISPERSION PARAMETER IS GREATER THAN OR
C          EQUAL TO 0.8 X MIXING HEIGHT COMPUTE CONCENTRATION USING
C          A BOX MODEL
C
      IF(SZ.GE.HX(IS)) GO TO 30
C
C         LID HAS NOT BEEN REACHED; COMPUTE CONCENTRATION BY GAUSSIAN
C          FORMULA.
C
      STK1 = Q(IR,3)*WHA(IU) + RCEPTZ
      STK2 = Q(IR,3)*WHA(IU) - RCEPTZ
      SB1 = -0.5*STK1*STK1/(SZ*SZ)
      SB2 = -0.5*STK2*STK2/(SZ*SZ)
      SWW = 0.5*(EXP(SB1) + EXP(SB2))
      S = PI*SWW/(SZ*WS)
      GO TO 100
C
C         LID HAS BEEN REACHED; COMPUTE CONCENTRATION USING A BOX MODEL
C
   30 IRI=IR
   40 R=Q(IRI;4)
      DVLR=DVLRI
      DVLRI=Q(IRI+1,4)-R
      QQQ = 0.1*Q(IRI,3)*FAC
      IF(QQQ.LT.0.1) QQQ = 0.1
      PQQQ = UE(IS)
      WZ = QQQ**PQQQ
      WS=U(IU)*WZ
      S=1./(WS*HL(IS))
      DO 50 JB=1,2
         DF=WS*GA(JB)
   50    DECAY(JB)=EXP(R/DF)
      IF(IRI.EQ.1.OR.IRI.EQ.NQ) GO TO 70
      DO 60 JC=1,2
   60    C(JC)=C(JC)+(Q(IRI,JC)*S*(DVLR+DVLRI))/DECAY(JC)
      GO TO 90
C         TRAPEZOIDAL INTEGRATION APPLIED
   70 DO 80 JF=1,2
   80    C(JF)=C(JF)+(Q(IRI,JF)*S*DVLR)/DECAY(JF)
   90 IRI=IRI+1
C         LOOPS TO RHO(MAX)
      IF(IRI.LE.NQ) GO TO 40
      GO TO 150
  100 IF(IR.EQ.1.OR.IR.EQ.NQ) GO TO 120
C
C         LID HAS NOT BEEN REACHED
C          TRAPEZOIDAL INTEGRATION APPLIED
C
      DO 110 JI=1,2
  110    C(JI)=C(JI)+(Q(IR,JI)*S*(DVLR+DVLRI))/DECAY(JI)
      GO TO 140
C         TRAPEZOIDAL INTEGRATION APPLIED
  120 DO 130 JK=1,2
  130    C(JK)=C(JK)+(Q(IR,JK)*S*DVLR)/DECAY(JK)
  140 IR=IR+1
C         LOOPS TO RHO(MAX)
      IF(IR.LE.NQ) GO TO 10
C
C         STORE CONCENTRATION ACCORDING TO WIND DIRECTION SECTOR
C
  150 X=Y*YCON*F(IS,IU,K)
      DO 160 JL=1,2
         AROSE(K,JL)=AROSE(K,JL)+C(JL)*X
         APAR(JL,IS) = APAR(JL,IS) + C(JL)*X
  160    ABAR(JL)=ABAR(JL)+C(JL)*X
  170 CONTINUE
      RETURN
      END
C
C**********************************************************************
```

```
C
      SUBROUTINE POINT
C           SUBROUTINE POINT     (VERSION 85293), PART OF CDM-2.0.
C
C          THIS SUBROUTINE CALCULATES THE SECTOR CONCENTRATION FROM
C           POINT SOURCES.
C
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)
      DIMENSION S(2)
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU
      COMMON /PCOM/ PH(NPTS),PR(NPTS),PS(NPTS,4),PX(NPTS),PY(NPTS),
     *              WA(36),WB(36),PROSE(36,2),CV,IPS,RAT,PBAR(2),TOA,
     *              VS1(NPTS),T1(NPTS),D1(NPTS),FRN(NPTS),BFLUX(NPTS)
      COMMON /SET/ N1836,DELTA,TTAN,NP50,NPDH,NSTDW,NGRAD,KLOW,KHIGH,
     *             PPAR(2,6),APAR(2,6),WHA(6),FAC,RCEPTZ,KELVIN,NDEF
C
C          INITIALIZE POINT SOURCE COUNTER.
C           IP LOOPS TO IPS (NUMBER OF POINT SOURCES)
      IP=1
C
C          FIND UPWIND (XP) AND CROSSWIND (YP) DISTANCES FROM RECEPTOR
C           TO SOURCE
C
   10 VX=PX(IP)-RI
      VY=PY(IP)-RJ
      XP=(VY*WA(K)+VX*WB(K))*RAT*CV
      IF(XP.LE.0.) GO TO 180
      YP=ABS((VY*WB(K)-VX*WA(K))*RAT*CV)
      TM=XP*TTAN
C
C          IF SOURCE MAKES NO CONTRIBUTION TO RECEPTOR, SKIP TO NEXT
C
      IF(YP.GT.TM) GO TO 180
      IF(PH(IP).GE.50.) GO TO 20
      IF(NP50.LE.0) GO TO 20
      SZI=50.-PH(IP)
      IF(SZI.GT.30.) SZI=30.
      GO TO 30
   20 SZI=0.
   30 Y=YD
C
C          BEGIN LOOP OVER STABILITY CLASS
C
      DO 170 IS=1,6
C          IS: CONTROLS STABILITY CLASS
      IF(IS.EQ.5) Y=YN
      IC=ICP(IS)
      WZ=(PH(IP)*0.1)**UE(IS)
      IF(SZI.LE.0.) GO TO 40
      CALL VIRTX(KHIGH,NPDH,IC,0.0,SZI,XS)
      GO TO 50
   40 XS=0.
   50 DIST=XP+XS
C
C          BEGIN LOOP OVER WIND SPEED CLASS
C
      DO 160 IU=1,6
C          IU: CONTOLS WIND SPEED CLASS
C           IF FREQUENCY IS ZERO, SKIP
      IF(F(IS,IU,K).LE.0.) GO TO 160
      WS=U(IU)*WZ
      DO 60 JA=1,2
         DF=WS*GA(JA)
   60    DECAY(JA)=EXP(XP/DF)
C
C          IF PR(IP) IS LESS THAN OR EQUAL TO ZERO COMPUTE PLUME RISE
C           ACCORDING TO BRIGGS.
C
      IF(PR(IP).LE.0.) GO TO 70
C
C          HOLLANDS EQN.
```

```
C
      DH=PR(IP)/WS
C         CALCULATE PLUME RISE
      IK = IC
      IF(IK.GT.4) IK = IK - 1
      DH=DH*(1.4-0.1*IK)
      HP = PH(IP)
      DHM = DH
C         CALCULATE STACK DOWNWASH EFFECTS
C
      CALL STDW(NSTDW,VS1(IP),D1(IP),FRN(IP),WS,HP,DHM)
      PHDH = HP + DHM
      GO TO 120
C
C         CALCULATE BRIGGS PLUME RISE  (1969, 1971, AND 1975)
C
   70 KST = IC
C         CALCULATE PLUME RISE AND DISTANCE TO FINAL RISE.
      CALL PLRISE(VS1(IP),T1(IP),D1(IP),BFLUX(IP),TOA,WS,KST,DISTF,DH)
      HP = PH(IP)
      DHM = DH
C         CALCULATE STACK DOWNWASH EFFECTS
      CALL STDW(NSTDW,VS1(IP),D1(IP),FRN(IP),WS,HP,DHM)
      PHDH = HP + DHM
C         CONSIDER GRADUAL PLUME RISE IF RECEPTOR DOWNWIND DISTANCE IS
C         LESS THAN THE DISTANCE TO FINAL RISE
      IF (DIST .GE. DISTF) GO TO 120
C         CONSIDER GRADUAL PLUME RISE IF THE GRADUAL PLUME RISE OPTION
C         IS TURNED ON AND/OR THE BUOYANCY-INDUCED DISPERSION OPTION IS
C         TURNED ON
      IF ((NGRAD .LE. 0) .AND. (NPDH .LE. 0)) GO TO 120
C
C         CALCULATE GRADUAL PLUME RISE
C
      GDELH = (160. * BFLUX(IP)**0.333333 * DIST**0.666667)/WS
      IF (GDELH .LT. DHM) DHM = GDELH
C         MODIFY THE FINAL EFFECTIVE HEIGHT ONLY IF THE GRADUAL PLUME
C         RISE OPTION IS TURNED ON
      IF (NGRAD .GT. 0) PHDH = HP + DHM
C
  120 CONTINUE
C
C    CHECK TO SEE IF PLUME IS ABOVE UNSTABLE OR NEUTRAL MIXING DEPTH
C
      IF(IC.LE.5) THEN
      IF(PHDH.GT.HL(IS) ) GO TO 160
      END IF
C
      CALL SIGMAZ(KHIGH,NPDH,IC,DIST,DHM,SZ)
C
      HHH1=PHDH+RCEPTZ
      HH21 = HHH1*HHH1
      HHH2=PHDH-RCEPTZ
      HH22 = HHH2*HHH2
      PHDH=PHDH*PHDH
C
C           FOR UNSTABLE AND NEUTRAL CONDITIONS (A - D2) SEE
C           IF THE VERTICAL DISPERSION PARAMETER IS GREATER THAN OR
C           EQUAL TO 0.8 X MIXING HEIGHT, COMPUTE CONCENTRATION BY A
C           BOX MODEL
C
      IF(IC.LE.5) THEN
      IF(SZ.GE.HX(IS)) GO TO 130
      END IF
C
C         LID HAS NOT BEEN REACHED; COMPUTE CONCENTRATION BY GAUSSIAN
C           FORMULA.
C
      B=-0.5*(PHDH/(SZ*SZ))
      IF(ABS(B).GT.80.) GO TO 160
      WW=WS*XP*SZ
      S(1)=PS(IP,1)/WW
      S(2)=PS(IP,2)/WW
      B1 = -0.5*HH21/(SZ*SZ)
      B2 = -0.5*HH22/(SZ*SZ)
```

```
      WW = 0.5*(EXP(B1) + EXP(B2))
      S(1)=S(1)*WW
      S(2)=S(2)*WW
      GO TO 140
C
C         LID HAS BEEN REACHED, COMPUTE CONCENTRATION BY A BOX MODEL.
C
  130 WW=WS*XP*HL(IS)
      S(1)=PS(IP,3)/WW
      S(2)=PS(IP,4)/WW
C
C         STORE CONCENTRATION ACCORDING TO WIND DIRECTION SECTOR
C
  140 B=Y*YCON*F(IS,IU,K)
      DO 150 JB=1,2
         X=S(JB)*B/DECAY(JB)
         PROSE(K,JB)=PROSE(K,JB)+X
         PPAR(JB,IS) = PPAR(JB,IS) + X
  150    PBAR(JB)=PBAR(JB)+X
  160 CONTINUE
  170 CONTINUE
C
C         INCREMENT POINT SOURCE COUNTER
C
  180 IP=IP+1
C
C         LOOP UNTIL ALL POINT SOURCES EVALUATED
C
      IF(IP.LE.IPS) GO TO 10
      RETURN
      END
C
C*********************************************************************
C
      SUBROUTINE PLRISE(VS,TS,D,F,T,U,KST,DISTF,DELH)
C              SUBROUTINE PLRISE   (VERSION 85293), PART OF CDM-2.0.
C
C       PARAMETER LIST:
C         INPUT:    VS    - STACK GAS VELOCITY (M/SEC)
C                   TS    - STACK GAS TEMPERATURE (KELVIN)
C                   D     - STACK INSIDE DIAMETER (METERS)
C                   F     - BUOYANCY FLUX (M**4/SEC**3)
C                   T     - AMBIENT AIR TEMPERATURE (KELVIN)
C                   U     - WIND SPEED AT STACK HEIGHT (M/SEC)
C                   KST   - STABILITY CLASS
C         OUTPUT:   DISTF - DISTANCE TO FINAL RISE (METERS)
C                   DELH  - PLUME RISE (METERS)
C
C       CALLING ROUTINE:
C         POINT
C
C       DESCRIPTION:
C         THIS SUBROUTINE CALCULATES PLUME RISE ACCORDING TO METHODS BY
C         BRIGGS (1969, 1971, AND 1975)
C
      G = 9.80616
C
C         CALCULATE UNSTABLE-NEUTRAL MOMENTUM RISE REGARDLESS OF
C          STABILITY
C
      DELHM = 3.0 * VS * D/U
      IF (KST .GT. 5) GO TO 100
C
C         PLUME RISE FOR UNSTABLE-NEUTRAL CONDITIONS
C
      IF (TS .LT. T) GO TO 200
      IF (F .GE. 55.) GO TO 50
C        COMBINATION OF BRIGGS' (1971) EQS. 6&7, PAGE 1031, FOR F ° 55
      DELH = (21.425 * F**0.75)/U
      IF (DELHM .GT. DELH) GO TO 200
      DISTF = 49. * F**0.625
      GO TO 999
C        COMBIMATION OF BRIGGS' (1971) EQS. 6&7, PAGE 1031, FOR F *= 5
   50 DELH = (38.71 * F**0.6)/U
      IF (DELHM .GT. DELH) GO TO 200
```

```
      DISTF = 119. * F**0.4
      GO TO 999
C
C         PLUME RISE FOR STABLE CONDITIONS
C
  100 DTHDZ = 0.02
      IF (KST .GT. 6) DTHDZ = 0.035
      S = G * DTHDZ/T
C         CALCULATE STABLE MOMENTUM RISE (BRIGGS' (1969) EQ. 4.28,
C          PAGE 59)
      DHA = 1.5 * (VS*VS * D*D * T/(4. * TS * U))**0.333333/S**0.166667
      IF (DHA .LT. DELHM) DELHM = DHA
      IF (TS .LT. T) GO TO 200
C         CALCULATE STABLE BUOYANCY RISE (WITH WIND)
      DELH = 2.6 * (F/(U * S))**0.333333
C         CALCULATE STABLE BUOYANCY RISE (CALM)
      DELHC = 4.0 * F**0.25 / S**0.375
      IF (DELHC .LT. DELH) DELH = DELHC
      IF (DELHM .GT. DELH) GO TO 200
      DISTF = 2.0715 * U/SQRT(S)
      GO TO 999
C
C         CASE WHERE MOMENTUM RISE DOMINATES OR IS GREATER THAN
C          BUOYANCY RISE
C
  200 DELH = DELHM
      DISTF = 0.0
C
  999 RETURN
      END
C
C*****************************************************************
C
      SUBROUTINE STDW(NSTDW,VS,D,FR,U,H,DELH)
C            SUBROUTINE STDW     (VERSION 85293), PART OF CDM-2.0.
C
C       PARAMETER LIST:
C         INPUT:  NSTDW - STACK DOWNWASH OPTION
C                 VS    - STACK GAS EXIT VELOCITY (M/SEC)
C                 D     - STACK INSIDE DIAMETER (METERS)
C                 FR    - FROUDE NUMBER
C                 U     - WIND SPEED AT STACK HEIGHT (M/SEC)
C         I/O:    H     - MODIFIED PHYSICAL STACK HEIGHT (METERS)
C                 DELH  - MODIFIED PLUME RISE (METERS)
C
C         CALLING ROUTINE:
C           POINT
C
C         DESCRIPTION:
C           THIS SUBROUTINE CALCULATES STACK DOWNWASH EFFECTS.
C           IF NSTDW < 0, THEN STACK DOWNWASH CALCULATED ACCORDING TO
C                         BJORKLUND AND BOWERS (1982).
C           IF NSTDW = 0, THEN STACK DOWNWASH NOT CONSIDERED.
C           IF NSTDW > 0, THEN STACK DOWNWASH CALCULATED ACCORDING TO
C                         BRIGGS (1973).
C
      IF (NSTDW) 100,999,200
C
C         CALCULATE STACK DOWNWASH ACCORDING TO BJORKLUND AND
C          BOWERS (1982)
C
  100 IF (FR .LT. 3.0) GO TO 110
         F = (3.*VS - 3.*U)/VS
         IF (F .GT. 1.0) F = 1.0
         IF (F .LT. 0.0) F = 0.0
         GO TO 120
  110 CONTINUE
         F = 1.0
  120 CONTINUE
      DELH = F * DELH
      GO TO 999
C
C         CALCULATE STACK DOWNWASH ACCORDING TO BRIGGS (1973)
C
  200 IF (VS/U .GE. 1.5) GO TO 210
```

```
      H = H + 2 * D * (VS/U - 1.5)
        IF (H .LT. 0.0) H = 0.0
  210 CONTINUE
C
  999 RETURN
      END
C
C***********************************************************************
C
      SUBROUTINE VIRTX(KTYPE,KEY,KST,DH,GSZ,EX)
C           SUBROUTINE VIRTX      (VERSION 85293), PART OF CDM-2.0.
C
C         THIS SUBROUTINE COMPUTES THE VIRTUAL DISTANCE,
C          IN METERS, USING SUBROUTINE SIGMAZ.
C          THE ROUTINE IS BASICALLY A NEWTON RELAXATION SCHEME
C
      XMAX = 100.0*1000.0
      IF(KTYPE.NE.4) GO TO 10
      IF(KST.LE.4) GO TO 10
      IF(GSZ.LT.50.0) GO TO 10
      GO TO 70
   10 CONTINUE
      X = 1.0
   20 CALL SIGMAZ(KTYPE,KEY,KST,X,DH,SZ)
      IF(SZ.GT.GSZ) GO TO 30
      IF(X.GT.XMAX) GO TO 30
      X = 2.0*X
      GO TO 20
   30 IF(X.LE.1.0) GO TO 70
      IF(X.GE.XMAX.AND.SZ.LT.GSZ) GO TO 60
      X = 0.5*X
      STEP = 0.25*X
   40 CALL SIGMAZ(KTYPE,KEY,KST,X,DH,SZ)
      IF(SZ.GT.GSZ) GO TO 50
      X = X + STEP
      GO TO 40
   50 IF(STEP.LT.0.40) GO TO 70
      X = X - STEP
      STEP = 0.25*STEP
      GO TO 40
   60 EX = XMAX
      GO TO 80
   70 EX = X
   80 RETURN
      END
C
C***********************************************************************
C
      SUBROUTINE SIGMAZ(KTYPE,KEY,INKST,X,DH,SZ)
C           SUBROUTINE SIGMAZ      (VERSION 85293), PART OF CDM-2.0.
C
C         IN THIS SUBROUTINE WE COMPUTE THE VERTICAL DISPERSION USING
C          TWO BASIC FORMS.  THE BASIC FORMS USED TO COMPUTE SZ ARE AS
C          FOLLOWS:
C
C          FORM ONE. (BRIGGS, RURAL AND URBAN)
C             SZ = A*X/(1+B*X)**C
C
C          FORM TWO.  (BNL, KLUG, ST. LOUIS, PGCDM, AND PGSIG)
C             SZ = A*X**B
C
C         THE 7 VERTICAL DISPERSION SCHEMES ARE AS FOLLOWS:
C
C                   1     =  BRIGGS-RURAL, GIFFORD (1976)
C                   2     =  BRIGGS-URBAN, GIFFORD (1976)
C                   3     =  BNL, SINGER AND SMITH (1966)
C                   4     =  KLUG, VOGT (1977)
C                   5     =  ST. LOUIS, VOGT (1977)
C                   6     =  PGCDM, BUSSE & ZIMMERMAN (1973)
C                   7     =  PGSIG, PASQUILL (1961) AND GIFFORD (1960)
C
C-----------------------------------------------------------------------
C
C         TO ADD A DISPERSION SCHEME THE FOLLOWING MODIFICATIONS MUST
C          BE MADE TO THE CDM-2.0 SOURCE CODE:
```

```
C
C        IN SUBROUTINE SIGMAZ,
C          (1)  ADD STATEMENT LABEL TO COMPUTED GO TO
C          (2)  INSERT THE FOLLOWING JUST BEFORE STATEMENT 190
C                 - GO TO 190
C                 - CODE FOR DISPERSION SCHEME
C
C        IN BLOCK DATA,
C          (1)  MODIFY DIMENSIONS OF ARRAY DISP(8, __)
C          (2)  ADD DISPERSION SCHEME DESCRIPTION TO DATA STATEMENT
C               OF ARRAY DISP.  MAKE SURE THE DESCRIPTION DOES NOT
C               EXCEED 32 CHARACTERS.
C
C        IN SUBROUTINE CLINT,
C          (1)  MODIFY ERROR CHECK OF KLOW AFTER RECORD TYPE 5 IS
C               READ
C          (2)  MODIFY UPPER RANGE LIMIT OF FORMAT STATEMENT 70.
C          (3)  MODIFY ERROR CHECK OF KHIGH AFTER RECORD TYPE 6 IS
C               READ
C          (4)  MODIFY UPPER RANGE LIMIT OF FORMAT STATEMENT 110.
C
C-----------------------------------------------------------------------
C
      DIMENSION A(7,5),B(7,5),C(7,5),G(7,6),XCAT(9,7),AA(10,7),BB(10,7)
      DATA A/ 0.2000, 0.1200, 0.0800, 0.0600, 0.0600, 0.0300, 0.0160,
     *        0.2400, 0.2400, 0.2000, 0.1400, 0.1400, 0.0800, 0.0800,
     *        0.4000, 0.4000, 0.3300, 0.2200, 0.2200, 0.0600, 0.0600,
     *        0.0170, 0.0720, 0.0760, 0.1400, 0.1400, 0.2170, 0.2620,
     *        0.0790, 0.0790, 0.1310, 0.9100, 0.9100, 1.9300, 1.9300/
      DATA B/ 0.0000, 0.0000, 0.0002, 0.0015, 0.0015, 0.0003, 0.0003,
     *        0.0010, 0.0010, 0.0000, 0.0003, 0.0003, 0.0015, 0.0015,
     *        0.9100, 0.9100, 0.8600, 0.7800, 0.7800, 0.7100, 0.7100,
     *        1.3800, 1.0210, 0.8790, 0.7270, 0.7270, 0.6100, 0.5000,
     *        1.2000, 1.2000, 1.0460, 0.7020, 0.7020, 0.4650, 0.4650/
      DATA C/ 1.0000, 1.0000, 0.5000, 0.5000, 0.5000, 1.0000,  1.0000 ,
     *       -0.5000,-0.5000, 1.0000, 0.5000, 0.5000, 0.5000,  0.5000
     *        21*0.0/
      DATA G/2.539E-4,0.04936,0.1154,0.7388,0.7388,1.2969,1.5763,
     *      2.539E-4,0.04936,0.1014,0.2591,0.2591,0.2527,0.2017,
     *      0.0383,0.1393,0.1120,0.0856,0.0856,0.0818,0.0545,
     *      2.0886,1.1137,0.9109,0.5642,0.5642,0.4421,0.3606,
     *      2.0886,1.1137,0.9260,0.6869,0.6869,0.6341,0.6020,
     *      1.2812,0.9467,0.9100,0.8650,0.8650,0.8155,0.8124/
      DATA XCAT / 0.50, 0.40, 0.30, 0.25, 0.20, 0.15, 0.10, 0.00, 0.00,
     *            0.40, 0.20, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00,
     *            0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00,
     *            0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00,
     *           30.00,10.00, 3.00, 1.00, 0.30, 0.00, 0.00, 0.00, 0.00,
     *           40.00,20.00,10.00, 4.00, 2.00, 1.00, 0.30, 0.10, 0.00,
     *           60.00,30.00,15.00, 7.00, 3.00, 2.00, 1.00, 0.70, 0.20/
      DATA AA /453.85,346.75,258.89,217.41,179.52,170.22,158.08,122.80,
     *           0.0,0.0,
     *         109.30,98.483,90.673,0.0,0.0,0.0,0.0,0.0,0.0,0.0,
     *         61.141,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,
     *         33.504,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,
     *         44.053,36.65,33.504,32.093,32.093,34.459,0.0,0.0,0.0,0.0
     *         47.618,35.42,26.97,24.703,22.534,21.628,21.628,23.331,
     *           24.26,0.0,
     *         34.219,27.074,22.651,17.836,16.187,14.823,13.953,13.953,
     *           14.457,15.209/
      DATA BB /2.1166,1.7283,1.4094,1.2644,1.1262,1.0932,1.0542,0.9447,
     *           0.0,0.0,
     *         1.0971,0.98332,0.93198,0.0,0.0,0.0,0.0,0.0,0.0,0.0,
     *         0.91465,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,
     *         0.8098,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,
     *         0.51179,0.56589,0.60486,0.64403,0.81066,0.86974,0.0,0.0,
     *           0.0,0.0,
     *         0.29592,0.37615,0.46713,0.50527,0.57154,0.63077,0.7566,
     *           0.81956,0.8366,0.0,
     *         0.21716,0.27436,0.32681,0.41507,0.4649,0.54503,0.63227,
     *           0.68465,0.78407,0.81558/
C
      KST = INKST
      IF(KST.GT.7) KST = 7
C
```

```
      GO TO(20,20,30,40,40,50,70),KTYPE
C
C         BRIGGS RURAL AND URBAN, GIFFORD (1976)
C
   20 Z1 = A(KST,KTYPE)
      Z2 = B(KST,KTYPE)
      Z3 = C(KST,KTYPE)
      SZ = Z1*X/( 1.0+Z2*X)**Z3
      GO TO 190
C
C         BNL, SINGER AND SMITH (1966)
C
   30 Z1 = A(KST,KTYPE)
      Z2 = B(KST,KTYPE)
      SZ = Z1*X**Z2
      IF(KST.LE.4) GO TO 190
      IF(SZ.GT.50.0) SZ = 50.0
      GO TO 190
C
C         KLUG, VOGT (1977); ST. LOUIS, VOGT (1977)
C
   40 Z1 = A(KST,KTYPE)
      Z2 = B(KST,KTYPE)
      SZ = Z1*X**Z2
      GO TO 190
C
C         PGCDM, BUSSE & ZIMMERMAN (1973)
C
   50 IC = KST
      IZ = 1
      IF(X.GE.5000.0) GO TO 60
      IZ = 2
      IF(X.GE.500.0) GO TO 60
      IZ = 3
   60 IB = IZ + 3
      SZ = G(IC,IZ)*X**G(IC,IB)
      GO TO 190
C
C         PGSIG, PASQUILL (1961) AND GIFFORD (1960)
C
   70 X = X/1000.
C         ARRAYS ARE DESIGNED FOR DISTANCE IN KILOMETERS
      DO 80 ID = 1,9
         IF (X .GE. XCAT(ID,KST)) GO TO 90
   80 CONTINUE
      ID = 10
   90 SZ = AA(ID,KST) * X ** BB(ID,KST)
      IF (SZ .GT. 5000.) SZ = 5000.
      X = X * 1000.
C         CONVERT BACK TO METERS
C
  190 IF(KEY.LE.0) GO TO 200
      SZ = SQRT( SZ*SZ + (DH*DH)/(3.5*3.5))
  200 RETURN
      END
C
C***********************************************************************
C
      BLOCK DATA
C                    BLOCK DATA     (VERSION 85293), PART OF CDM-2.0.
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU
      COMMON /QCOM/ N,DR,IX,IY,TT(36,21),KTC,IXX,IYY,RAD,TD,
     *              Z(NASE,NASN,3)
      COMMON /ACOM/ PI,SZA(6),ABAR(2),AROSE(36,2),XS(6)
      COMMON /PCOM/ PH(NPTS),PR(NPTS),PS(NPTS,4),PX(NPTS),PY(NPTS),
     *              WA(36),WB(36),PROSE(36,2),CV,IPS,RAT,PBAR(2),TOA,
     *              VS1(NPTS),T1(NPTS),D1(NPTS),FRN(NPTS),BFLUX(NPTS)
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NSTDW,NGRAD,KLOW,KHIGH,
     *             PPAR(2,6),APAR(2,6),WHA(6),FAC,RCEPTZ,KELVIN,NDEF
      COMMON /TITLE/ HEADNG(20),PNAME(2),D16(32),D36(72),DISP(8,7),
```

```
*                TTITLE(3)                                          CDM21760
      DATA YCON/0.1E7/                                              CDM21770
      DATA INC,IPG,IPS,IX,IY/1,2,4,4,70,0,1,1/                      CDM21780
      DATA IXX,IYY,IAS/1,1,0/,TD/0.1E-3/                            CDM21790
      DATA RAD,PI/57.2958,0.797885/                                 CDM21800
      DATA IAD/0,0,1,1,0,1,0,1,4*0,4*1,0,1,1,0/                     CDM21810
      DATA IVER/85293/                                              CDM21820
      DATA D16/' N  ','    ',' NNE','    ',' NE ','    ',' ENE','    ',CDM21830
*             ' E  ','    ',' ESE','    ',' SE ','    ',' SSE','    ',CDM21840
*             ' S  ','    ',' SSW','    ',' SW ','    ',' WSW','    ',CDM21850
*             ' W  ','    ',' WNW','    ',' NW ','    ',' NNW','    '/CDM21860
      DATA D36/'000-','010 ','010-','020 ','020-','030 ','030-','040 ',CDM21870
*             '040-','050 ','050-','060 ','060-','070 ','070-','080 ',CDM21880
*             '080-','090 ','090-','100 ','100-','110 ','110-','120 ',CDM21890
*             '120-','130 ','130-','140 ','140-','150 ','150-','160 ',CDM21900
*             '160-','170 ','170-','180 ','180-','190 ','190-','200 ',CDM21910
*             '200-','210 ','210-','220 ','220-','230 ','230-','240 ',CDM21920
*             '240-','250 ','250-','260 ','260-','270 ','270-','280 ',CDM21930
*             '280-','290 ','290-','300 ','300-','310 ','310-','320 ',CDM21940
*             '320-','330 ','330-','340 ','340-','350 ','350-','360 '/CDM21950
      DATA DISP/'BRIG','GS-R','URAL',', GI','FFOR','D (1','976)','    'CDM21960
*             'BRIG','GS-U','RBAN',', GI','FFOR','D (1','976)','    'CDM21970
*             'BNL,',' SIN','GER ','AND ','SMIT','H (1','966)','    'CDM21980
*             'KLUG',', VO','GT (','1977',')   ','    ','    ','    'CDM21990
*             'ST. ','LOUI','S, V','OGT ','(197','7)  ','    ','    'CDM22000
*             'PGCD','M, B','USSE',' & Z','IMME','RMAN',' (19','73) 'CDM22010
*             'PGSI','G, P','ASQU','ILL,','GIFF','ORD(','1961',',60)'CDM22020
      DATA TTITLE/' F) ',' C) ',' K) '/                             CDM22030
      END                                                           CDM22040
```

Date_______________

Chief, Environmental Operations Branch
Meteorology and Assessment Division (MD-80)
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

I would like to receive future revisions to the "CDM-2.0 User's Guide."

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TECHNICAL REPORT DATA
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1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
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15. SUPPLEMENTARY NOTES

16. ABSTRACT

CDM-2.0 (Climatological Dispersion Model - Version 2.0) determines long-term (seasonal or annual) quasi-stable pollutant concentrations in rural or urban settings using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability. The Gaussian plume hypothesis forms the basis for the calculations. Contributions are calculated assuming the narrow plume hypothesis, Calder (1971, 1977), and involve an upwind integration over the area sources. Computations can be made for up to 200 point sources and 2500 area sources at an unlimited number of receptor locations. The number of point and area souces can be easily modified within the code. CDM-2.0 is an enhanced version of CDM including the following options: 16 or 36 wind-direction sectors, initial plume dispersion, buoyancy-induced dispersion, stack-tip downwash, and gradual (transitional) plume rise. The user has a choice of seven dispersion parameter schemes. Optional output includes point and area concentration roses and histograms of pollutant concentration by stability class.

17. KEY WORDS AND DOCUMENT ANALYSIS

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

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
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