LESSON 2

Site Selection for General-Level SO_2 Monitoring Stations

Goal

To familiarize you with the siting of regional, neighborhood, and general-level middle scale SO_2 monitoring stations.

Objectives

At the end of this lesson, you will be able to:

1. recognize the appropriate SO_2 concentration gradient for regional scale SO_2 monitoring sites.
2. determine the number of SO_2 monitoring sites required to represent SO_2 concentrations over an area.
3. select the general siting area for regional mean concentration SO_2 monitoring stations.
4. select the general siting area for SO_2 transport monitoring stations.
5. select the general siting area for SO_2 emergency monitoring stations.
6. select the general siting area for population exposure and projected growth neighborhood scale SO_2 monitoring stations.
7. select the general siting area for peak concentration general-level middle scale SO_2 monitoring stations.

Procedure

1. Read pages 27-52 of EPA-450/3-77-013 *Optimum Site Exposure Criteria for SO_2 Monitoring.*
2. Complete the review exercise for this lesson.
3. Check your answers against the answer key following the exercise.
4. Review the pages in the reading for any questions you missed.
5. Take Quiz 1 in the back of this book. Review the pages in the reading for any questions you missed.
6. Continue to Lesson 3.

Estimated student completion time: 6 hours

Reading Assignment Topics

- Site selection aids and background material
- Locating general-level regional scale SO_2 monitoring stations
- Locating general-level neighborhood scale SO_2 monitoring stations
- Locating general-level middle scale SO_2 monitoring stations

Reading Guidance

Because *Optimum Site Exposure Criteria for SO_2 Monitoring* was published before the promulgation of 40 CFR 58, the monitor probe heights specified in the document do not agree with the required probe heights of 40 CFR 58. Probe heights specified in 40 CFR 58 are addressed in Lesson 7 of this book.

Wind roses are discussed in this reading assignment. A wind rose is a graphical representation of wind directional frequency. The farther that the bar extends from the circle, the more frequently the wind blows *from* that direction.

In this reading assignment, the winter wind rose is recommended for use in selecting SO_2 monitoring sites. The basis for this recommendation is that for many areas, especially northern areas of the United States, winter is the season associated with maximum emissions of SO_2 because of space heating. However, you should determine the season associated with maximum SO_2 emissions for your specific monitor siting situation.

Refer often to the flowcharts and figures of the assigned reading material as you progress through the assignment.

Review Exercise

Now that you've completed the assignment for Lesson 2, please answer the following questions to determine whether or not you are mastering the material.

1. The measurements from a single SO_2 monitoring site will represent concentrations over the regional spatial scale if the concentration gradient over the area of interest does not exceed about ________ mg/m^3 per kilometer.

   a. 0.5

   b. 0.1

   c. 1.0

   d. 3.0

2. If the SO_2 concentration extremes over the area of interest are not within about ________ percent of the average value, then more than one SO_2 monitoring site will be needed to represent SO_2 concentrations over the area.

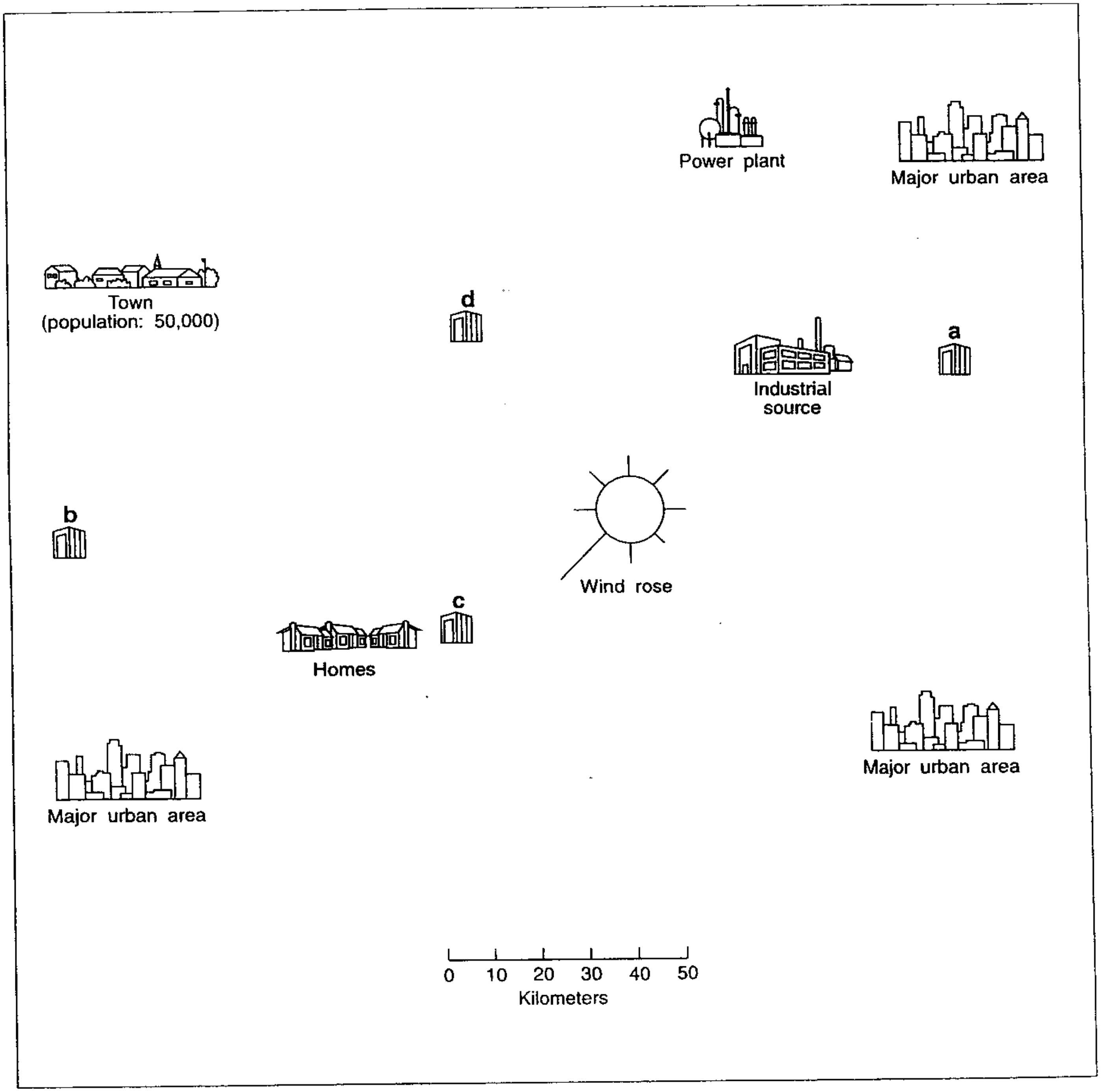
   a. 5

   b. 10

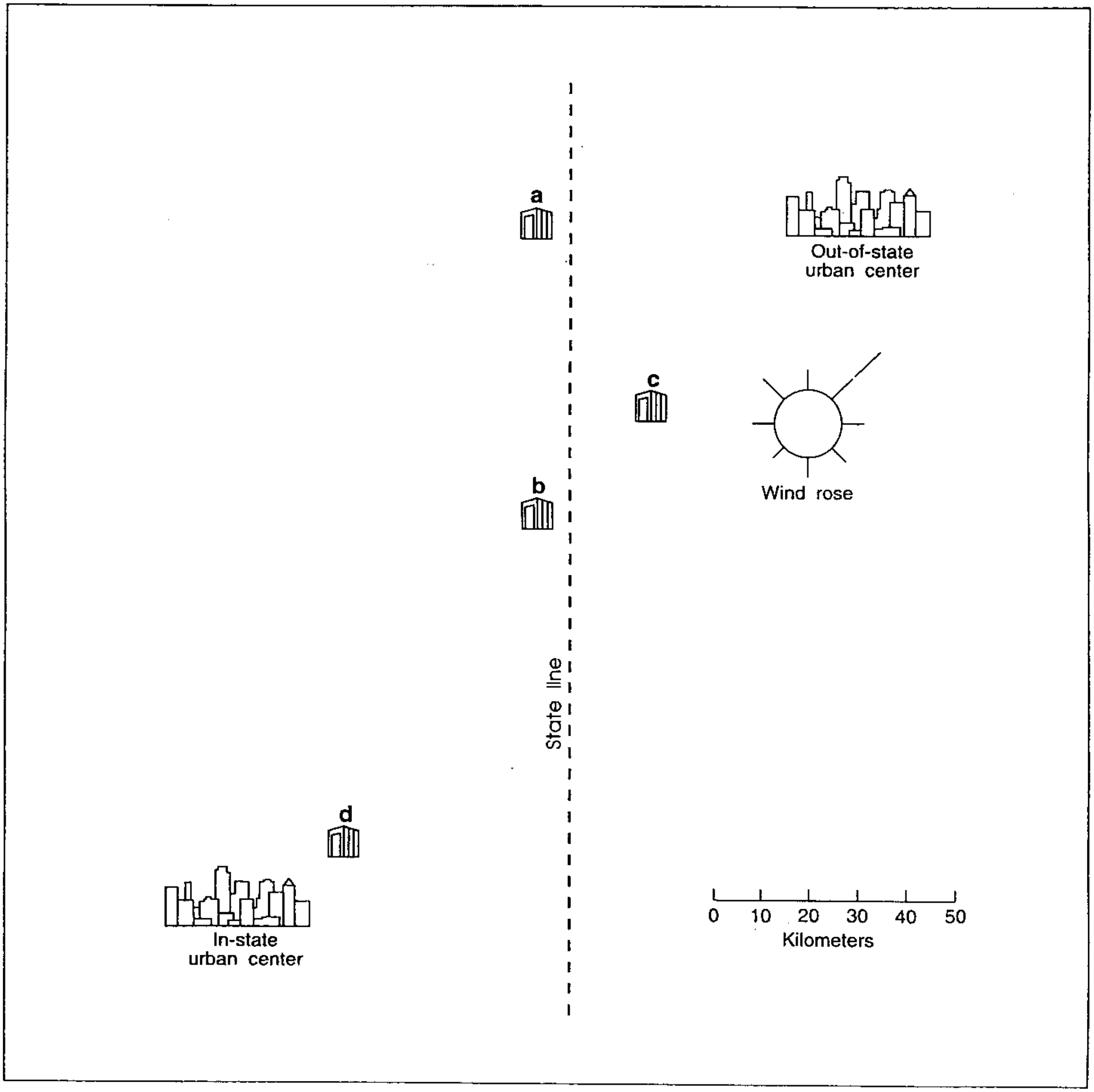
   c. 25

   d. 50

3. Which of the four general siting areas, labeled a through d, is the best siting area for an SO_2 regional mean concentration monitoring station?

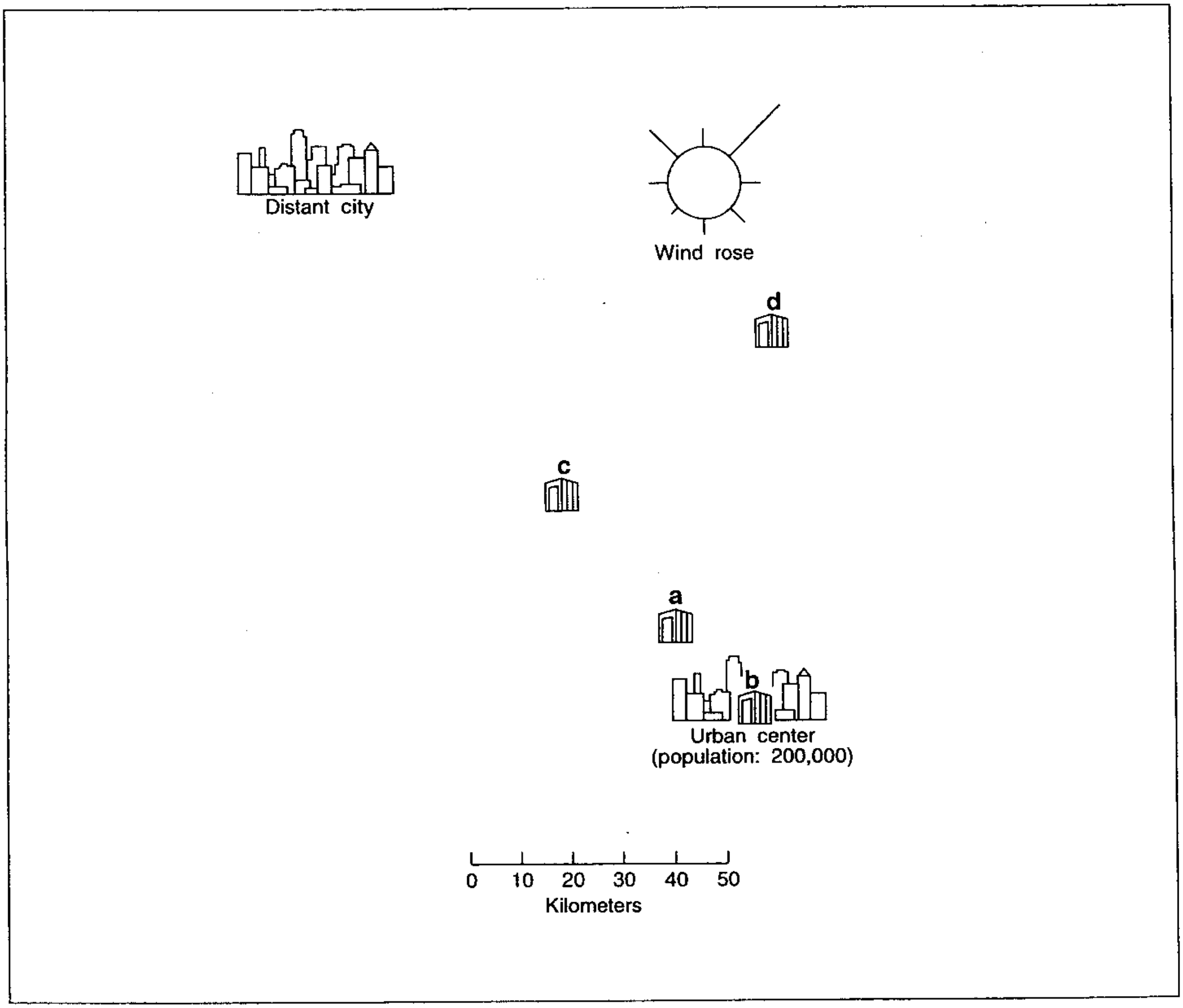


4. Which of the four general siting areas, labeled a through d, is the best siting area for measuring the *maximum* in-state SO_2 concentration resulting from the out-of-state urban center?

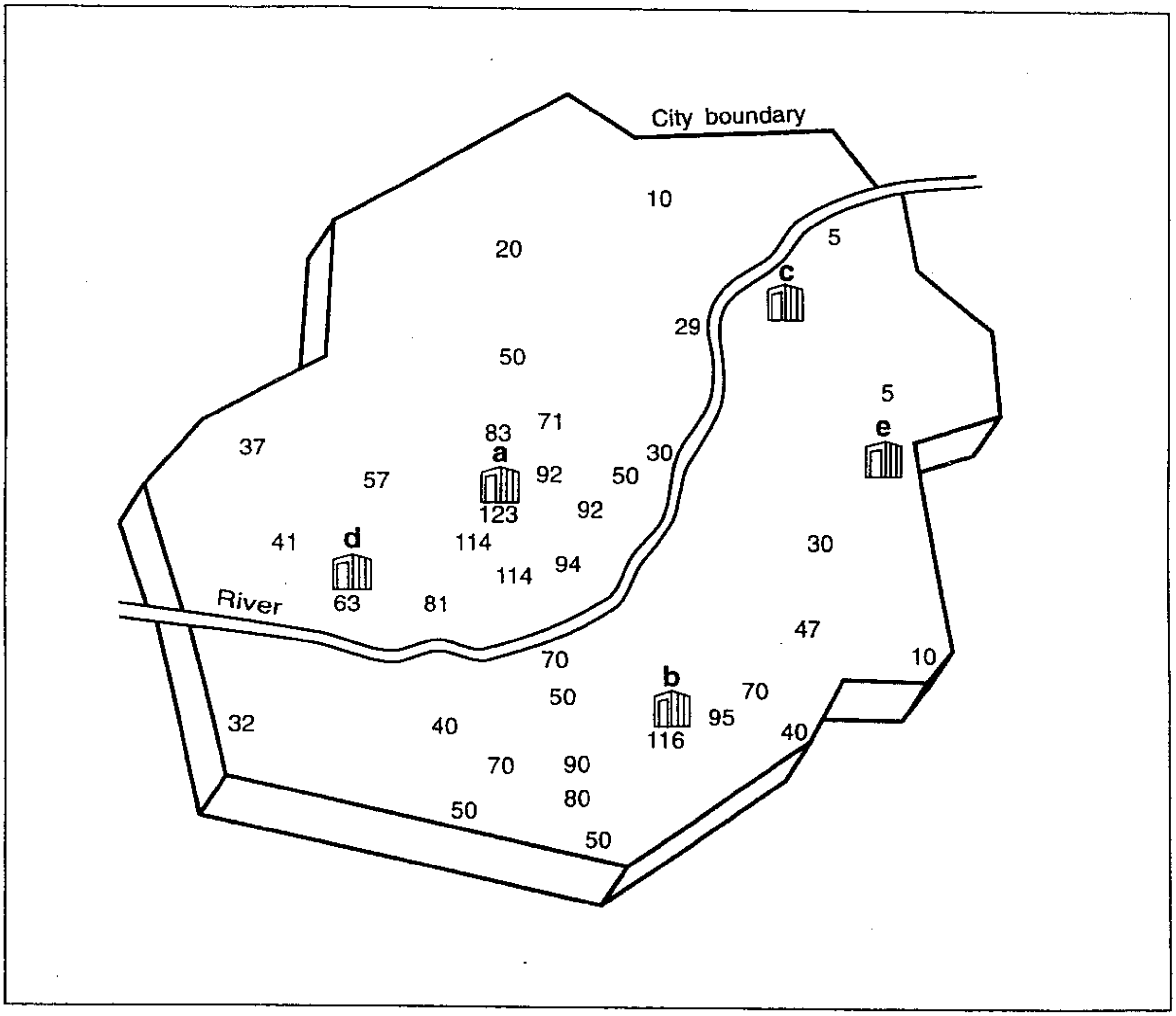


5. Which of the four general siting areas, labeled a through d in question 4, is the best siting area for measuring the *most frequent* in-state SO_2 concentrations resulting from the out-of-state urban center?

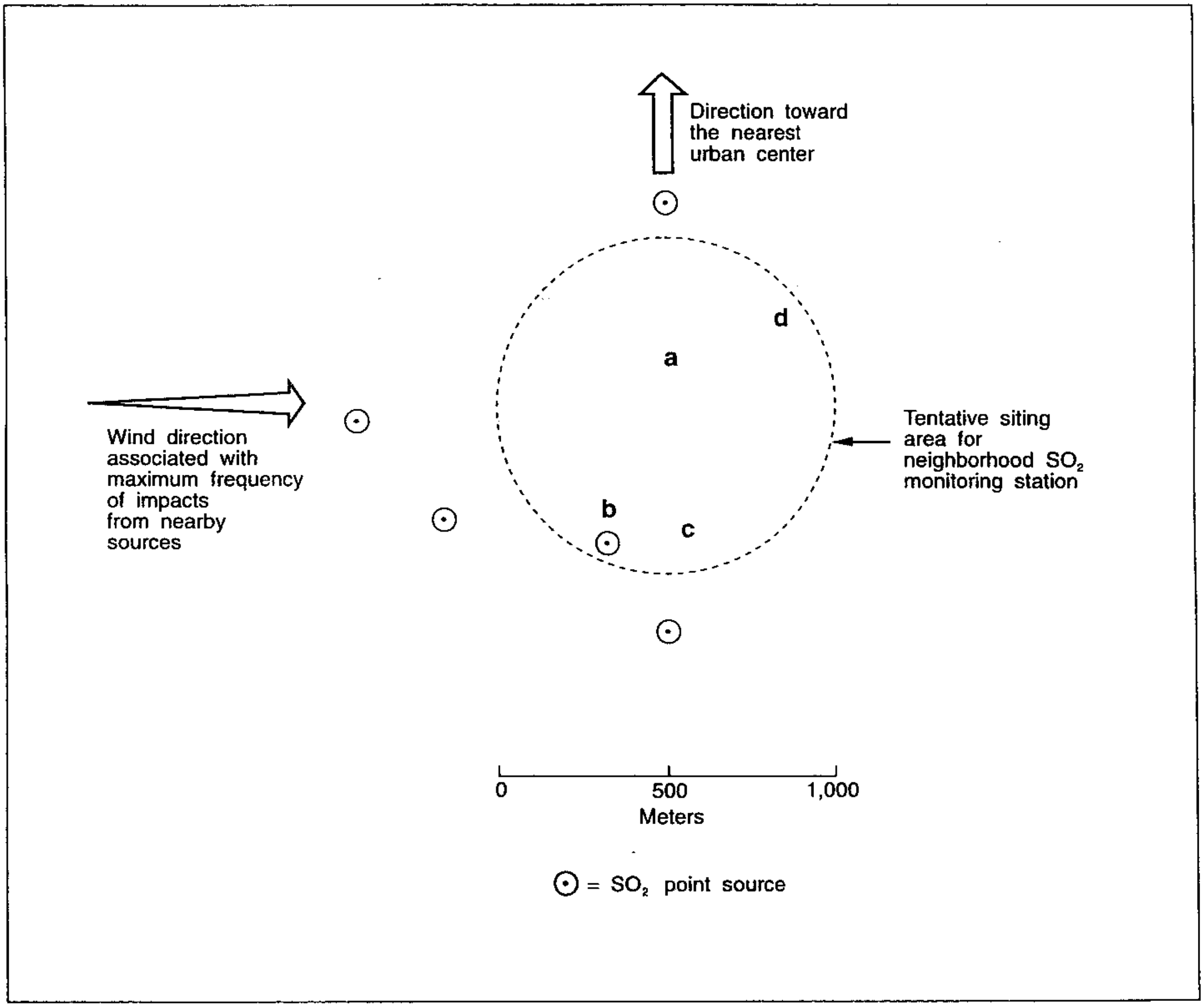
6. Which of the four general siting areas, labeled a through d, is the best siting area for assessing the transport of SO_2 from the distant city into the urban center?



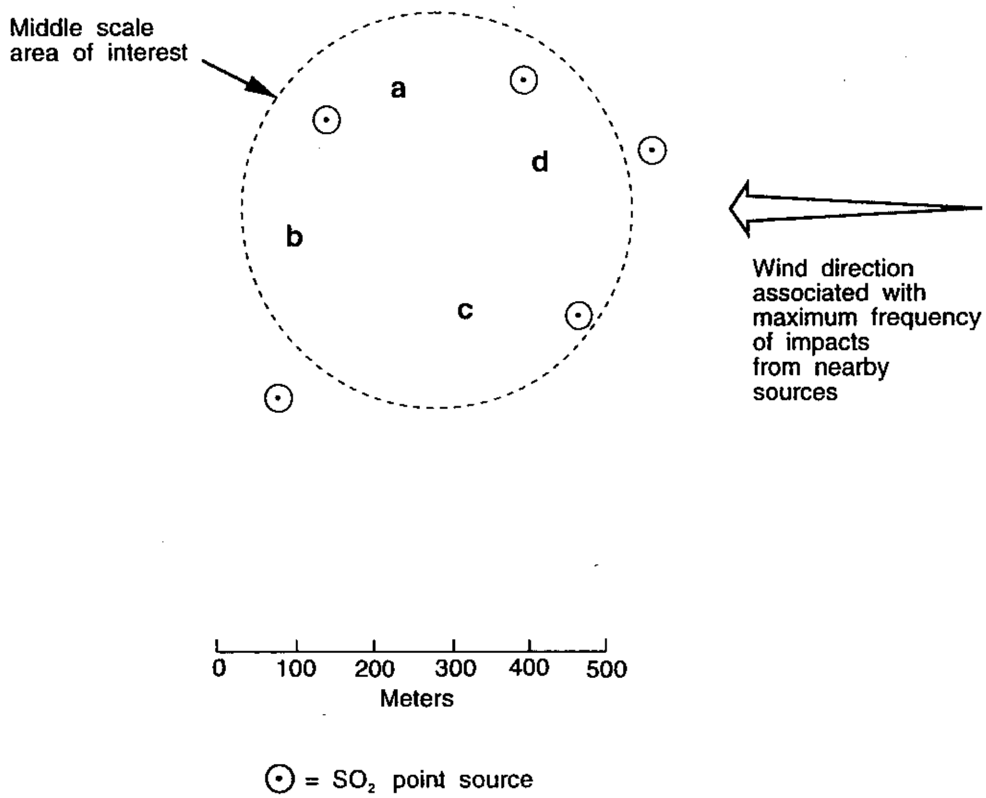
7. The figure below represents a city area with relative sulfur dioxide emission rates plotted. Which of the five general siting areas, labeled a through e, are the best *two* sites for SO_2 emergency episode monitoring?



8. Which of the four general siting areas, labeled a through d, is the best siting area for an *urban* population exposure/projected growth neighborhood scale SO_2 monitoring station?



9. Which of the four general siting areas, labeled a through d, is the best siting area for a general-level middle scale monitoring station for determining peak SO_2 concentrations?



Review Exercise Answers

		Page*
1.	a	29
2.	c	29
3.	d	31
4.	a	31
5.	b	31
6.	c	31
7.	a and b	38
8.	d	41-44
9.	b	48-50

Now take Quiz 1 in the back of this book. Review the pages in the reading for any questions you missed.

Then continue to Lesson 3.

* Refer to pages 27-52 of EPA-450/3-77-013 *Optimum Site Exposure Criteria for SO_2 Monitoring.*

4.0 SITE SELECTION PROCEDURES AND CRITERIA

Procedures and criteria for selecting specific monitoring site locations and instrument inlet exposures have been developed for the relevant monitoring site types and are presented in this section. They are generally uniform for each siting objective associated with a given site type. It was not possible to develop specific siting criteria to satisfy some siting objectives (e.g., isolated point source monitoring in extremely rough or mountainous terrain). In these instances, general guidelines addressing "points to consider" are presented.

The site selection process itself is an elimination process; general siting areas are selected, then specific prospective sites within the areas are gradually eliminated in accordance with specific criteria until a small subset of acceptable sites remains. The final selection is made from this subset.

It should be made clear at this point to state that not every AQCR is required to have each type of monitoring site described in this section; the types of sites required would depend on the nature of the SO_2 problems in the AQCR. These are judgements to be made by the control agency or site selector.

The organization of much of this section is based on that of the report by Ludwig and Kealoha (1975)--essentially flow charts showing the basic structure and flow of the procedural logic followed by discussion of the elements of the flow chart. Much of the material is presented without discussion of the justification or rationale for the various steps of the procedures; this is reserved for Chapter 5.0 to maintain the clarity and continuity of the procedures as discussed here.

4.1 DESCRIPTION OF SITE SELECTION AIDS AND BACKGROUND MATERIAL

An integral part of the site selection process is the acquisition and/or development of background material, data, and, in some situations, the use of auxiliary equipment (e.g., portable wind station). Such material is needed to provide the site selector with information mainly regarding the physical characteristics of the siting area. This information may include the terrain and land-use setting of the prospective monitor siting area, the proximity of large water bodies, the distribution of SO_2 sources in the area, the location of appropriate National Weather Service (NWS) airport stations from which weather data may be obtained, etc. Depending on the siting objective, this material may take the form of:

- Isopleth maps SO_2 air quality,
- Emissions inventories,
- Meteorological data,
- Wind roses,
- Portable wind equipment,
- Topographic/population/land-use maps, and
- Mobile sampling equipment.

The purpose of each item will be described briefly below prior to the presentation of the site selection procedures. A more complete discussion of this material and its sources can be found in the appendices and in Section 5.0.

Isopleth maps, particularly those generated by diffusion models is recommended for use in determining the general location of a prospective monitoring site, or a prospective siting area within which the final site is to be selected. For siting monitors in urban areas, multi-source models such as the Air Quality Display Model (AQDM) are recommended. For isolated point source monitoring in relatively uncomplicated terrain, various point source models (PTMPT, PTDIS, PTMAX; see Appendix E) or graphical solutions of the Gaussian point source equation are suggested. (It will be seen that the guidelines presented herein are strongly diffusion-model-output oriented.)

Emission inventory information for point sources is available from the U.S. Environmental Protection Agency (EPA) for any area of the country for annual and seasonal averaging times. Specific information characterizing the emissions and large point sources for the shorter averaging times (diurnal variations, load curves, etc.) can often be obtained from the source. Area source emission data by season, although not available from the EPA, can be generated by apportioning annual totals according to degree days. This kind of information provides some of the input to the diffusion models and are also important for other reasons that will be discussed later.

The nature of the elements of Table 3-3 in Section 3.0 determine the meteorological and diffusion parameter input to the diffusion models. In most cases, the meteorological data originating from the most appropriate (not necessarily the nearest) NWS airport station in the vicinity of the prospective siting area will adequately reflect conditions over the area of interest, at least for annual and seasonal averaging times. In developing data in complex meteorological and terrain situations, diffusion meteorologists should be consulted. A complete list of NWS stations that can provide most of the relevant weather information in support of siting activities anywhere in the country can be found in Appendix A. Such information includes joint frequency distributions of winds and atmospheric stability (stability-wind roses). These are provided by the output of the National Climatic Center "STAR" computer program. For the shorter averaging times or in complex terrain situations, the use of portable wind equipment, smoke bombs, time-lapse photography may be necessary. Land use types and topographical characteristics of specific areas of interest can be determined from U.S. Geological Survey (USGS) and land use maps. Detailed information on urban physiography (building/street dimensions, etc.) can be obtained from Sanborn maps (see Appendix D). Additional information may have to be obtained by visual observations, aerial photography, and surveys to supplement that available from the above sources. Such information may be required to determine the appropriate diffusion coefficients and SO_2 half-life values to be used by the models as well as determining the locations of local sources in and around the prospective siting areas.

Finally, after the general location of a site or prospective siting area has been established, mobile sampling may be required to determine the optimum site location, particularly in regard to isolated point source monitoring (see Appendix C).

4.1.1 The Critical Role of Diffusion Modeling in the Site Selection Process

As discussed in Section 3.2.1, the SO_2 background concentration gradient over an area essentially determines the spatial scale represented by measurements taken at a single station located in that area. Also, it was seen that in Section 3.3 that some siting objectives may be associated with specific features of the SO_2 pattern while others may be associated with fixed geographical areas that are independent of such features. Since the only objective means of obtaining such gradients and patterns is by diffusion modeling, the modeling of the area of interest will usually be a prerequisite for selecting monitoring sites.

In Sections 4.1.1 and 4.1.2 below, the role of diffusion models in the site selection process is discussed in general terms to orient the reader. The model's role in the selecting of sites to satisfy specific siting objectives is discussed in more detail later in the appropriate sections.

4.1.1.1 Siting Objectives Associated with Fixed Geographical Areas

For siting objectives associated with fixed geographical areas (see Table 3-1), measurements from a single monitoring station within such an area can represent concentrations over any spatial scale. In a given scenario, the particular spatial scale represented would depend directly on the background concentration gradient prevailing over the area of interest. In developing the siting criteria in these situations, we arbitrarily chose specific concentration gradients that we felt appropriately characterized the various spatial scales (see Section 5.3.3 for rationale) as follows:

1) If the concentration gradient over the area of interest does not exceed about 0.5 $\mu g/m^3$-km, the measurements from a single site will represent concentrations over regional spatial scales.

2) If the concentration extremes over the area of interest are not within about 25% of the mean value, then more than one site is required to represent concentrations over the area. To establish the number of stations, the area is divided into the number of

parcels required to bring the extreme concentrations over each parcel to within 25% of the mean of each parcel. Measurements from single sites located near the center of each parcel should adequately characterize the concentration over that parcel. The spatial scales represented by the measurements will be the same as the spatial scales of the parcel, namely neighborhood (0.5 to 4.0 km) or middle (0.1 to 0.5 km) scales.

4.1.1.2 Siting Objectives Associated With Features of the SO_2 Pattern

The peak SO_2 concentration is usually the most important feature considered for siting objectives associated with features of the SO_2 pattern (see Table 3-1). The peak concentrations may be due to either single or multiple sources. The diffusion model is used to determine the approximate location of the peak and can consider annual patterns as well as near worst case 3-hour and 24-hour patterns. Because the concentration gradient in the vicinity of the peak is often steep and/or irregular, the middle scale is the most likely scale to be represented by measurements from a single station located near the peak.

The use of models to aid in determining regional scale site locations in rural areas is optional. In these situations, the model is used to verify that the prevailing concentration gradient is relatively flat.

4.2 GENERAL-LEVEL REGIONAL-SCALE STATIONS

Figure 4-1 shows the recommended procedure siting objectives for establishing general-level regional stations. There are two basic siting objectives for which regional stations are established: (1) to measure regional mean background concentrations; and (2) to assess pollutant transport.

The following material should be assembled to provide inputs to the decision-making process:

- Wind roses,
- Regional maps of various scales showing topography and developed areas,
- Population data (by town),
- Emissions inventory of point and area sources.
- Diffusion model output (optional).

Climatological wind data in the form of a statistical table such as that shown in Table 4-1, or a wind rose shown in Figure 4-2, are the forms most useful in selecting general-level regional stations. These are examples of some of the kinds of data that are available from the National Climatic Center (NCC) Asheville, North Carolina. The wind rose is particularly useful in depicting the wind direction frequency over the area of interest.

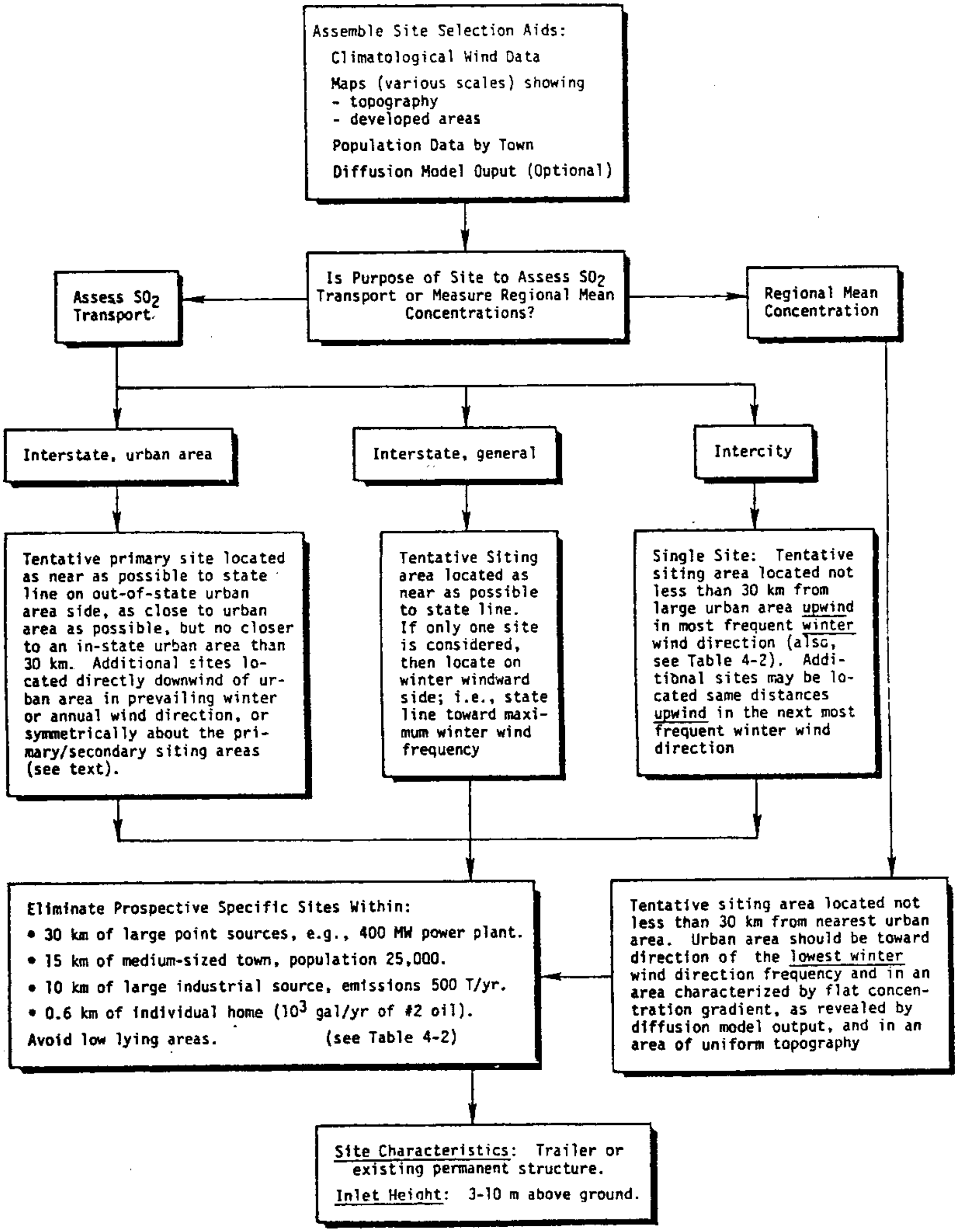


FIGURE 4-1. Flow chart showing procedures for locating general-level regional-scale stations.

TABLE 4-1

Example of a Tabulated Wind Summary
(taken from the National Climatic Center, Asheville, N.C.)

PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR)										AV SPEED
	0 – 3	4 – 7	8 – 12	13 – 18	19 – 24	25 – 31	32 – 38	39 – 46	47 OVER	TOTAL	
N	+	1	2	1	+	+				4	11.4
NNE	+	1	2	1	+	+				4	10.5
NE	+	1	3	2	+	+				6	11.7
ENE	+	1	2	1	+					4	11.4
E	+	1	1	+	+					3	9.0
ESE	+	1	1	+						2	8.6
SE	+	1	2	1	+	+				4	8.9
SSE	+	1	2	1	+	+				4	11.0
S	1	2	2	3	2	1	+			10	13.3
SSW	+	1	1	3	2	1	+			8	14.4
SW	+	1	1	3	2	1	+	+		8	15.5
WSW	+	1	3	4	4	1	+	+	+	14	17.3
W	+	1	3	5	3	+	+	+		12	15.3
WNW	+	1	2	3	1	+	+			7	14.6
NW	+	1	2	2	1	+				6	13.1
NNW	+	1	1	1	+	+				4	12.0
CALM	+									+	
TOTAL	4	13	30	30	17	5	1	+	+	100	13.5

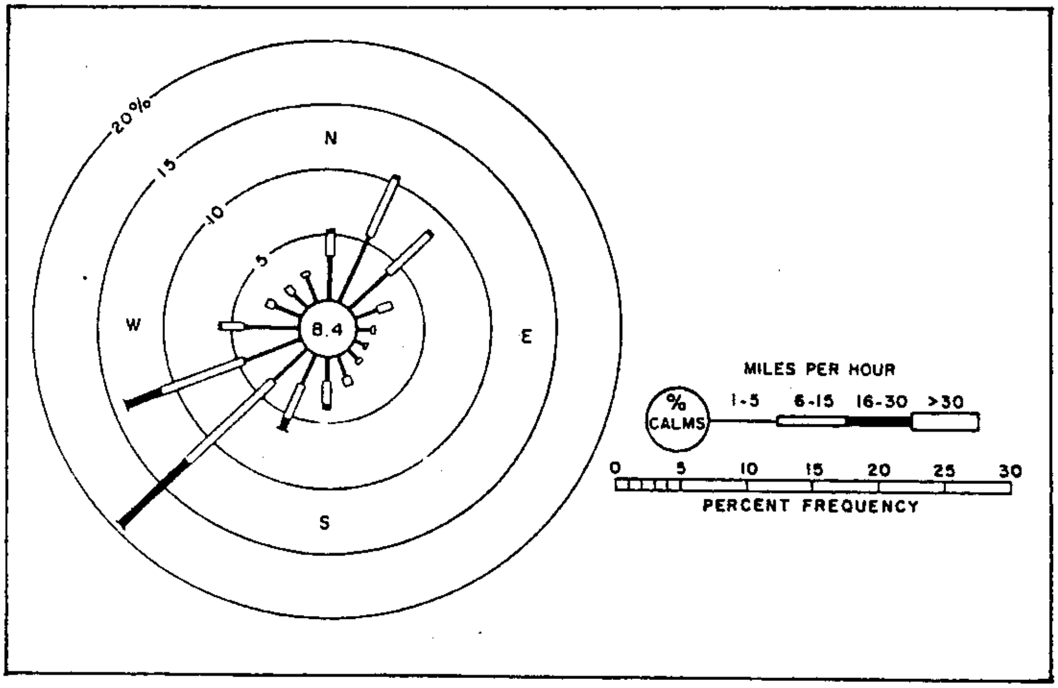


FIGURE 4-2. A typical wind rose with wind-speed information (taken from Slade, 1968).

Maps showing the physical features--natural and man-made--of the region are important since the monitoring purpose and location of the monitors are based on the nature and distribution of these features. Demographic and emission inventory data will provide additional useful inputs.

The selection process begins by deciding on the siting objective after which a specific series of steps is followed. This process is presented below.

4.2.1 Regional Mean (Background) Concentration Stations

A tentative siting area should be established no closer than about 30 km from the jurisdictional boundary of any major urban SO_2 source area in the region. (Consider a city with a population of 2×10^5 or more as constituting a major urban area.) The nearest major urban area should be toward the direction of the lowest winter (Dec, Jan, Feb) wind frequency. If available, a winter seasonal (or annual concentration map generated by a diffusion model can be utilized to ensure that the tentative siting area is not located in an area characterized by a steep concentration gradient ($>\sim 0.5\ \mu g/m^3$ - km).

The topography of the region containing the urban SO_2 source areas, the tentative siting area, and the NWS station from which the wind rose data originated should be reasonably uniform.

4.2.1.1 Local Characteristics, Interferences and Inlet Placement

Guidelines for considering local physical characteristics, proximity of interfering sources in the vicinity of the final site and instrument inlet placement are the same for all regional scale stations. Once the siting areas have been established, individual prospective sites should be eliminated on the basis of the proximity of small, local SO_2 sources that may unduly influence the measurements. These sources, or source types, and corresponding "interference" distances* are shown in Table 4-2. Regional scale SO_2 monitors should be sited no closer to these sources than the interference distances.

Since low lying areas are associated with relatively higher inversion frequencies, they should be avoided. Open or sparsely forested areas are recommended with the instruments housed in an existing permanent structure or trailer Since all pollutants are well-mixed in the vertical over outlying areas, exact inlet height is not important. A height range of from 3 to 10 m above the ground would be reasonable. In densely forested areas, the inlet tube should be raised a few meters above the tops of the surrounding trees.

Figure 4-3 is a schematic illustrating the tentative siting area for a regional mean concentration station.

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* The interference distances are defined in Section 5.0. They were developed via solutions to the Gaussian point source formula by assuming certain "worst case" conditions.

TABLE 4-2

Source Types and Related Interference Distances for Regional Scale Monitoring Stations

Source Type	Interference Distance
Large point source (e.g., a 400 MW power plant)	30 km
Industrial source (500 tons SO_2 per year)	10 km
Towns (various size population)	
50,000	22 km
25,000	15 km
12,500	10 km
6,000	7 km
Individual home	0.6 km

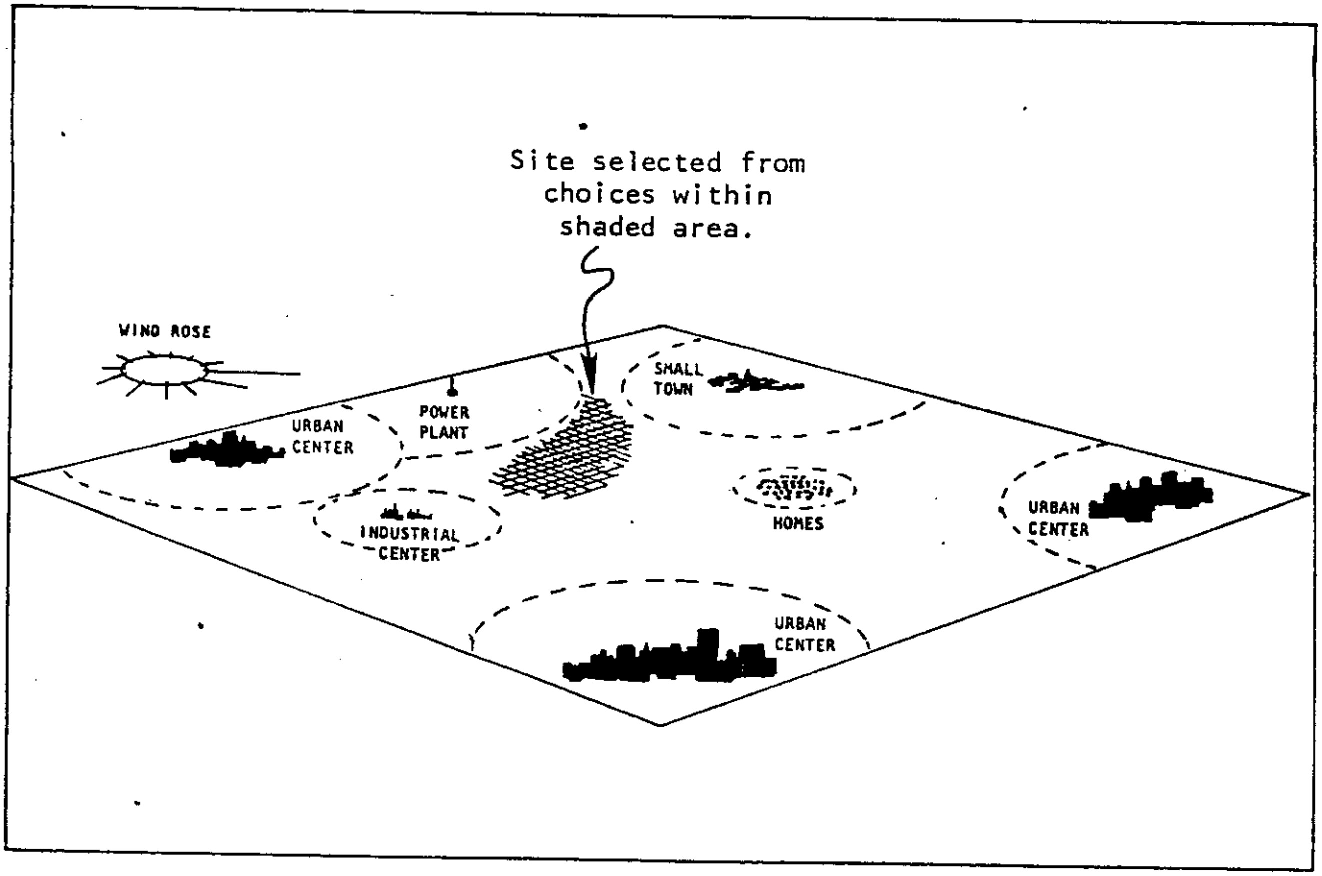

FIGURE 4-3. Schematic illustration showing tentative siting area for regional mean background concentration stations.

4.2.2 SO_2 Transport Stations

SO_2 transport stations may satisfy several siting objectives. Three such objectives and the siting procedures for establishing the stations are discussed below.

- Interstate SO_2 Urban Transport Sites. These sites are established for measuring incoming interstate SO_2 that originates from a large urban complex outside of the state (e.g., New York City/Connecticut; Chicago/Indiana). A primary siting area should be located as close as possible to the state line opposite the out-of-state urban area, but no closer than 30 km to an in-state major urban area. If the state or part of the state is directly downwind of the out-of-state urban area in the winter prevailing direction, a secondary siting area could be established near the state line, as described above, but directly downwind (winter) of the urban area. These are illustrated in Figure 4-4. Alternatively, a series of stations could be placed symmetrically about the primary or secondary siting areas (to obtain horizontal profiles of incoming pollutant, for example).

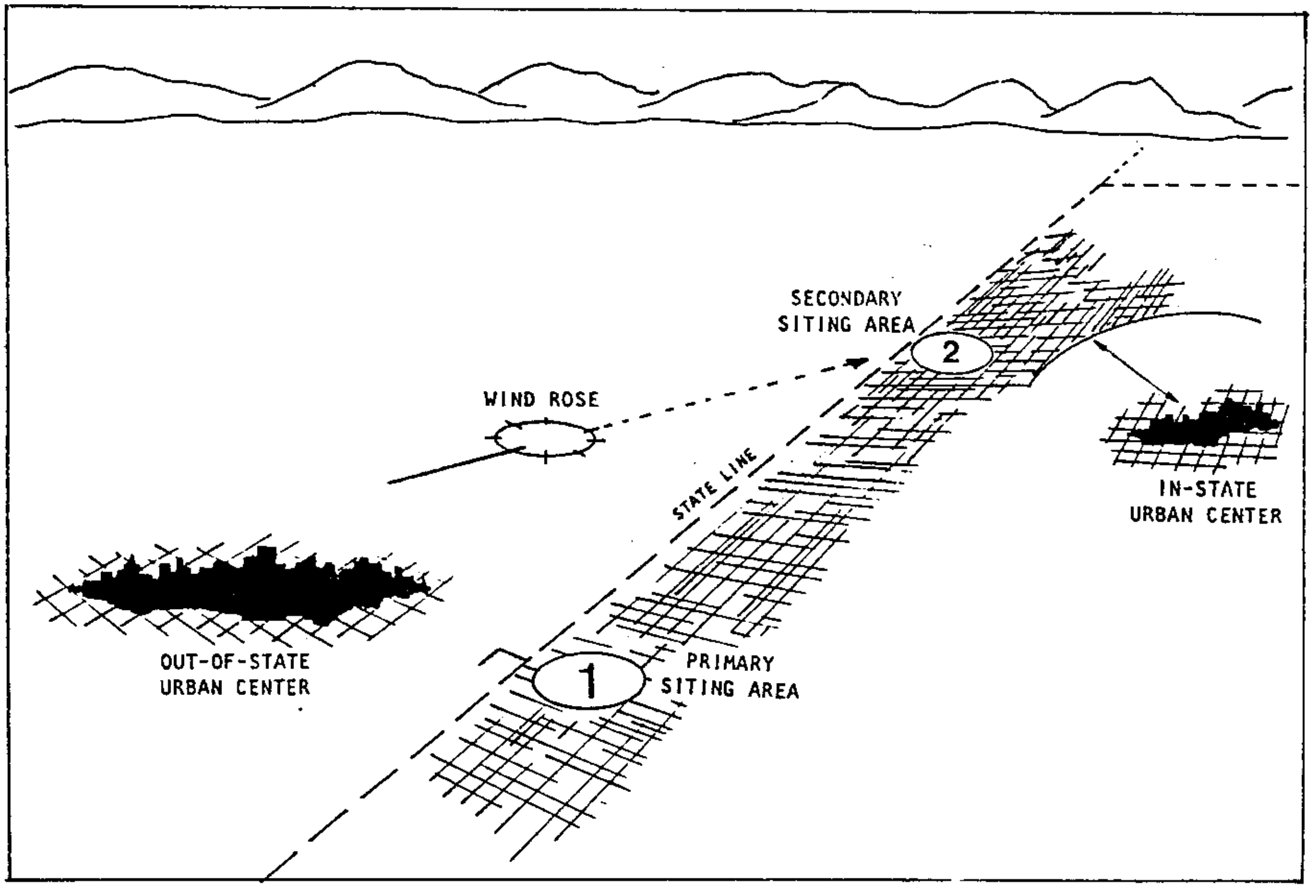

FIGURE 4-4. Schematic illustration showing primary and secondary siting areas for interstate urban transport stations.

- Interstate SO_2 Transport-General. If there are no major out-of-state urban areas contributing significantly to incoming SO_2, a general SO_2 transport station can be established anywhere (but no closer than 30 km to an in-state major urban area) along the winter windward state line.

- Intercity SO_2 Transport Sites. If SO_2 flux entering a city is desired to be measured, a primary siting area may be established upwind of the city boundary in the most frequent winter wind direction, at distances which depend on city size. These distances arange from about 30 km for cities of 2×10^5 population or more to 15 km for small towns of 25,000 population (see also Table 4-2, "Towns"). Secondary siting areas can also be established toward the next most frequent direction, etc. Figure 4-5 shows the location of the siting areas for intercity SO_2 transport stations. Alternatively, other sites may be established directly between two cities, without regard to wind direction, to assess the exchange of SO_2 between the two cities. Similarly, as for the siting areas for regional mean concentration stations, the topography of the entire region should be reasonably uniform.

Guidelines for considering local characteristics, interference distances, and inlet placement are the same as for regional mean concentration stations (see Section 4.2.1.1).

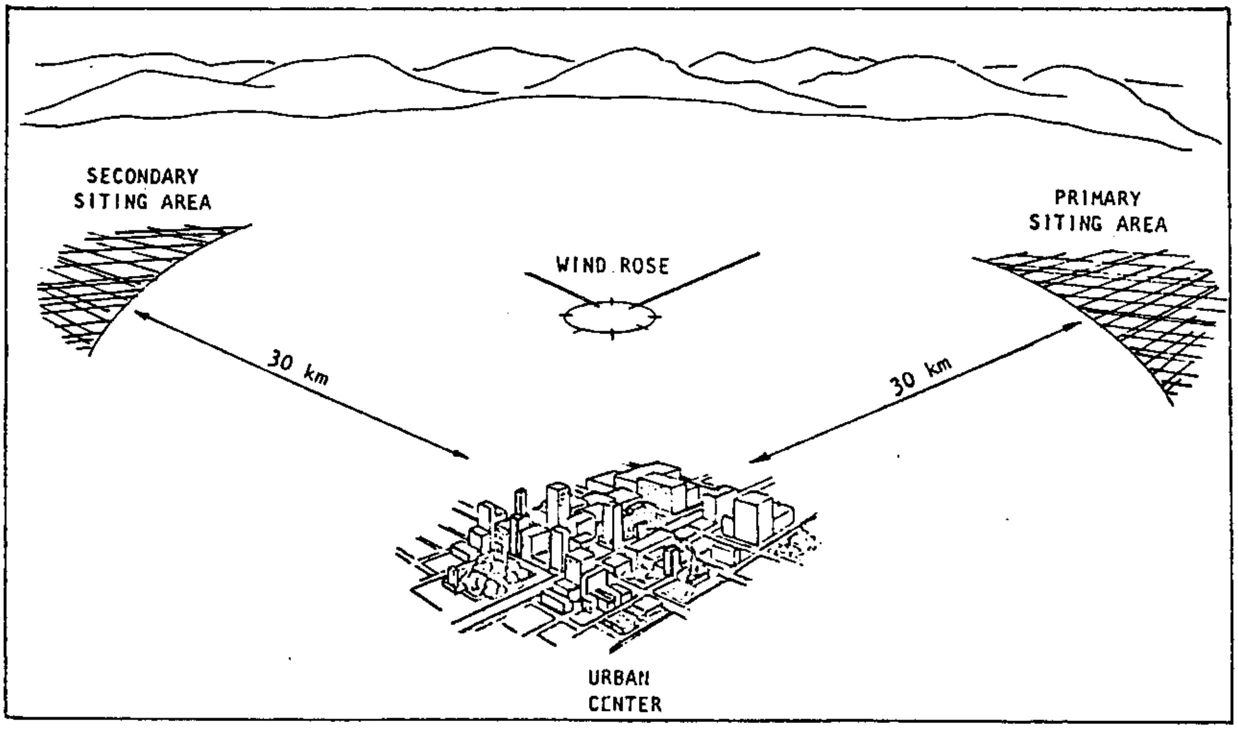

FIGURE 4-5. Schematic illustration showing primary and secondary siting areas for intercity background stations.

4.3 GENERAL-LEVEL, NEIGHBORHOOD-SCALE STATIONS

There are three major siting objectives associated with neighborhood-scale stations--monitoring emergency episodes, determining baseline concentrations in areas of projected growth, and monitoring SO_2 concentrations to which certain human populations are exposed. The specific objectives chosen for which monitoring will be undertaken will determine, in large measure, the siting procedure and kind of background information required.

Figure 4-6 shows the recommended procedure for locating the three kinds of general-level, neighborhood-scale stations. The first step is to decide on the objective of the monitoring, after which follows the gathering of background information and the site selection process itself, as discussed below.

4.3.1 Emergency Episode Stations

The background information required for the proper siting of emergency episode stations includes:

- Emissions inventory of point and area sources,
- USGS map of urban area, and
- Sanborn map of urban area (see Appendix D).

Prospective emergency episode stations should be located near the center of the maximum low-level emission zone(s) of the urban core. The maximum emission zone can be found by plotting the SO_2 emission rates of the area source fraction of the inventory, in tons per year per UTM grid square*, on a gridded USGS map of the urban area. Isopleths of constant emission rate may be drawn as an option to reveal the center(s) of the zone(s). Mobile sampling may also be undertaken during an actual episode or in near-episode conditions (e.g., in the morning when winds are light and variable) to better define the general area of maximum concentration. Figure 4-7 is a schematic illustrating the general location of the prospective siting area.

The final site is selected from a list of candidate sites located near the center of the zone in accordance with the desirable site characteristics and inlet placement criteria as shown in Table 4-3. In general, because very little turbulence and unsteady winds usually prevail during atmospheric stagnations, undue influence from an individual nearby source is minimal. However, if the data from this site is to be used to supplement data from peak concentraion stations, then the site characteristics should be consistent with the criteria shown in Table 4-5 (see Page 45).

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* Emission inventory grid systems normally utilize the kilometer-based Universal Transverse Mercator (UTM) system. UTM tick marks are shown in the margin of most USGS maps.

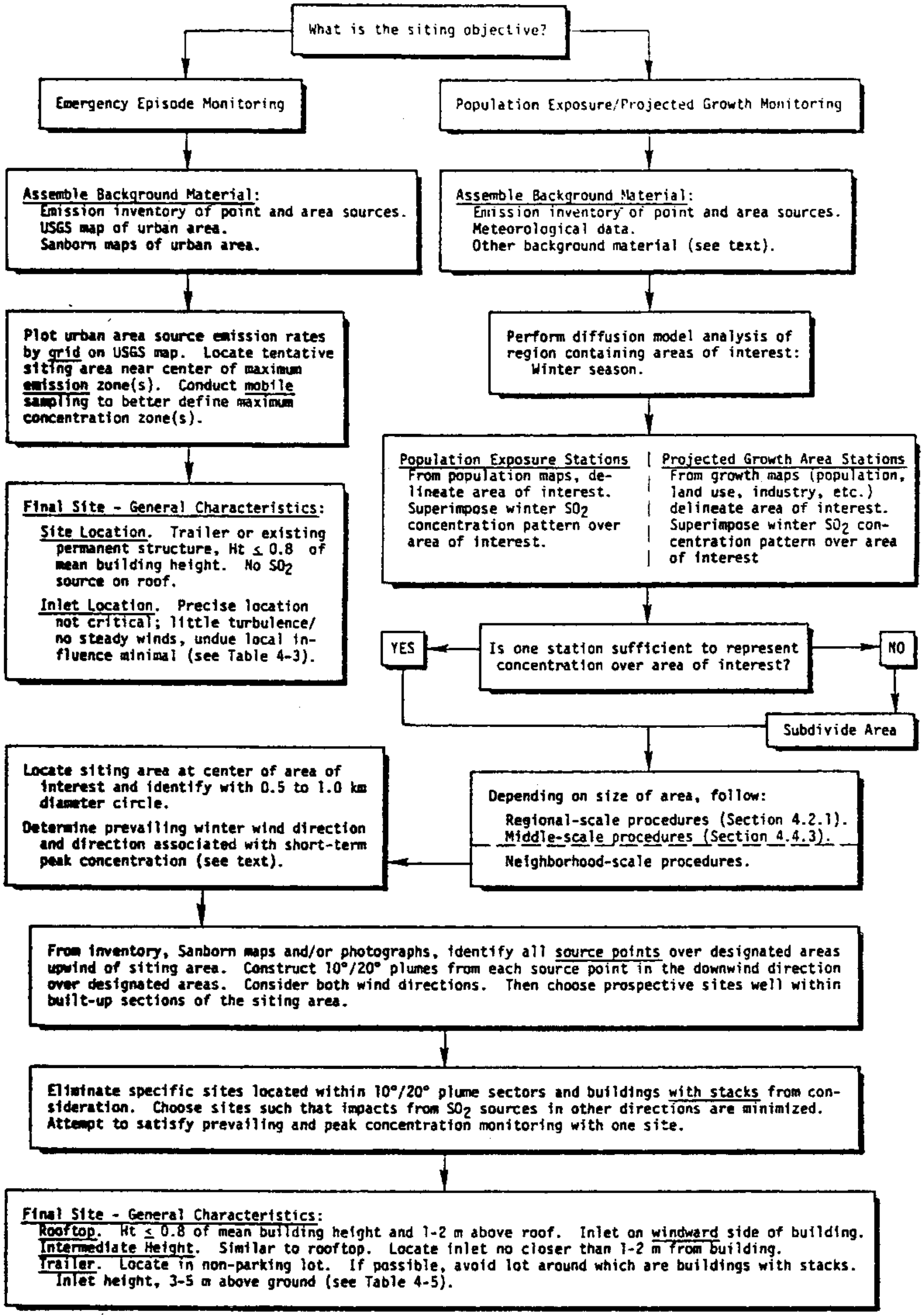

FIGURE 4-6. Flow chart showing procedures for locating general-level neighborhood-scale stations.

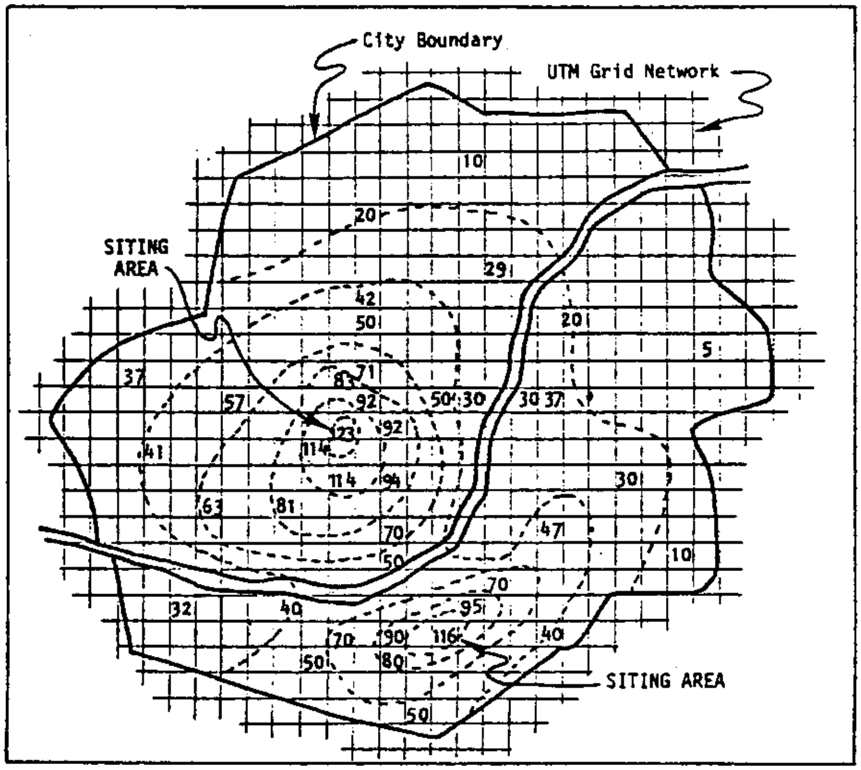

FIGURE 4-7 General location of emergency episode siting area. Numbers indicate relative emission rates. Each grid square equals 1 square kilometer.

TABLE 4-3

Site Characteristics and Inlet Placement Criteria for Emergency Episode Stations

Station Location	Inlet Placement Criteria				
	Height Above Ground	Height Above Roof	Horizontal Clearance Beyond Structure	Horizontal of Inlet Placement	Remarks
Rooftop	Somewhat less than mean height of buildings in zone or lower($\leq -0.8\bar{H}$)*	Not critical. Between 1-2 m, and away from dirty/ dusty areas.	Not Applicalbe (NA)	Inlet may be placed anywhere on roof, but away from dirty/dusty areas.	No SO_2 source on roof
Intermediate Height on Building	Same as Rooftop	NA	> 2 meters	Inlet may be located on any side of building, preferable the side away from nearest sources.	No SO_2 source on roof
Trailor	3-5 meters	1-2 meters	NA	NA	If possible, avoid parking lots and other lots around which are buildings with stacks. If located in park, avoid sites under thick "forest" canopy.

* $\bar{H}$ = mean building height in zone.

As a supplementary procedure, population figures could be utilized in a manner similar to that described above for SO_2 emission rates, to determine population densities and characteristics (e.g., age frequencies in the maximum emission zone.

4.3.2 Population Exposure and Projected Growth Monitoring Stations

Siting procedures for these two siting objectives are very much the same after the subject population areas and projected growth (residential, industiral, etc.) areas have been identified and delineated. Since the monitoring of air quality in regions of projected growth is related to the EPA-mandated AQMP process, the reader is referred to Vol. IX of the EPA's *Maintenance Planning Guideline* series of documents (discussed briefly in Section 2.2.7 of this report) for additional information. The siting procedures for projected growth monitoring sites presented below are consistent with the concepts discusses in that document.

The background information and other aids that would be useful for selecting population exposure and projected growth stations include:

- Emission inventory of point and area sources.
- Meteorological data reflecting conditions imposed by topographical and land use setting;* winter season.
- USGS/land use/population mpas of area.
- Air Quality Maintenance Plan (AQMP).
- Sanborn maps of urban area.
- Air Quality Display Model (AQDM) or equivalent.

The emissions inventory and meteorological data will provide the required input to the AQDM for generating an SO_2 concentration field over the areas of interest as well as providing information on the location and strengths of all point sources in the urban area.

After assembling the required background materials, delineate the subject population area and/or the projected growth area, depending on the monitoring objective chosen. Simulate an SO_2 concentration field over the region containing these areas using the AQDM with the emission inventory and meteorology reflecting winter quarter conditions. If the areas of interest are located in large urban areas (population $\geq 10^6$), use a half-life of 1 hour, otherwise use a 3-hour half life. Superimpose the concentration map over the areas of interest. At this point, it must be determined whether measurements from a single site located within the area of interest will represent the entire area of interest. The following general procedure (and illustration shown in Figure 4-8) is recommended for making this determination.

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* Consult diffusion meteorologist to estimate conditions.

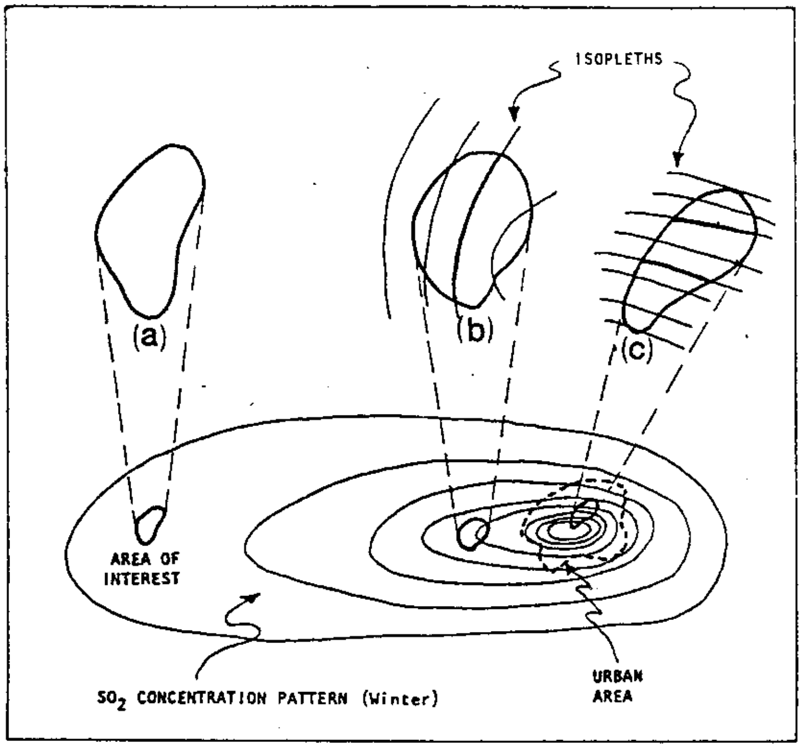

FIGURE 4-8.

Schematic illustrating typical concentration pattern over delineated population or growth areas of interest; (a) area in flat part of gradient, one station probably adequate to represent concentrations over area; (b) probably two sites required; and (c) possibly three sites required: urban setting, representing neighborhood or middle spatial scales.

- If the concentration gradient over the area of interest is no more than about 0.5 $\mu g/m^3$ km, or if the distance between the center of the area and the nearest sources are at least equal to those shown in Table 4-2 (assume monitoring site is near the center of the area), then measurements from a single station located near the center of the area of interest will probably represent the entire area of interest (see Figure 4-8a). Use regional-scale station procedures to determine site characteristics and inlet placement (Section 4.2.1).

- If the extreme concentrations over the area are not within about 25 percent of the mean concentration, then a single site may not be representative of the entire area and more than one station will be necessary to represent the range of concentrations over the area of interest. Divide the area into sub-areas (preferably along an isopleth) until the extreme concentrations over each sub-area are within 25 percent of the mean value (see Figure 4-8b,c). Siting areas should be located near the center of each sub-area. If the sizes of the sub-areas are in the middle scale range (<0.5 km), then middle-scale procedures should be followed (see Section 4.4.3).

The tentative siting area within each sub-area (neighborhood) should be in the vicinity of the mean concentration point of the neighborhood, which is near the center of the neighborhood. Identify the siting area by drawing a circle (0.5 to 1.0 km diameter) near the center of the neighborhood as shown in Figure 4-9. Locate all prospective sites within the siting area and well inside of any built-up area. Eliminate from consideration all buildings with SO_2 source points (stacks). At this point, an elimination process begins, the result of which is the selection of the final site location; Figures 4-9 through 4-11 illustrate the process. The first step is to establish two "upwind" directions (Figure 4-9). One direction is toward the prevailing winter wind direction* and the other is the direction toward the center of the maximum emission zone of the nearest urban area from the tentative siting area. The latter direction represents the most probable direction associated with the maximum short-term concentrations (high background from urban center plus undue local influences). Construct "sector boundaries" upwind of the siting area in both directions as shown. These boundaries enclose the areas containing the most important potential "interfering" SO_2 sources. An arc is then drawn at a distance from each prospective site equal to the "point source interference distance" (PSID).** These distances, for 3 degrees of land use intensity, are shown in Table 4-4 (see Section 5.1 for discussion). Then, from emissions inventory data, Sanborn maps and/or photographs, identify and plot the locations of all SO_2 point sources† within the siting area itself and the area enclosed by the sector boundaries up to the PSID as chosen in Figure 4-10.

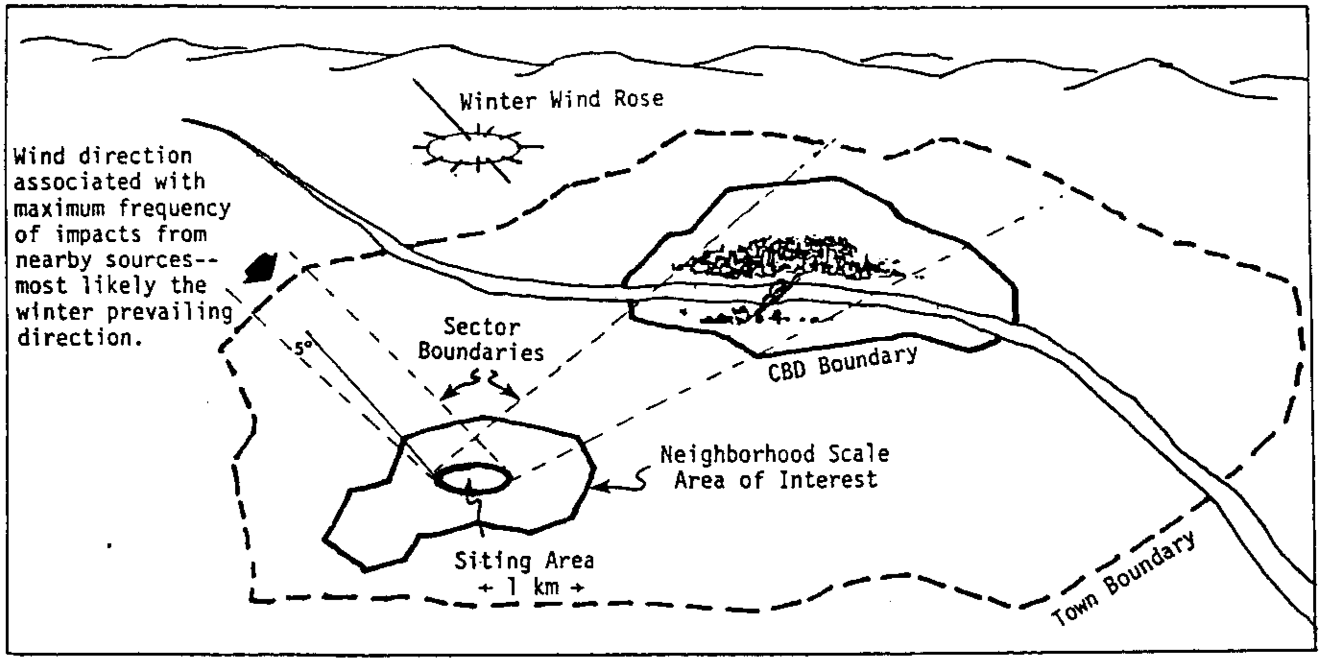

FIGURE 4-9. Schematic illustration of intermediate step by which neighborhood-scale stations are located; identification of siting area, and establishment of sector boundaries within which sources are of concern.

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* This wind direction should be associated with the maximum frequency of occurrence of impacts from nearby sources within the siting area. Directions other than the winter prevailing may be chosen; appraisal by agency may be necessary.

** The point source interference distance (PSID) is the distance beyond which point source impacts are no longer significant at the monitoring site.

† Point sources include all sources identified as such in the emissions inventory.

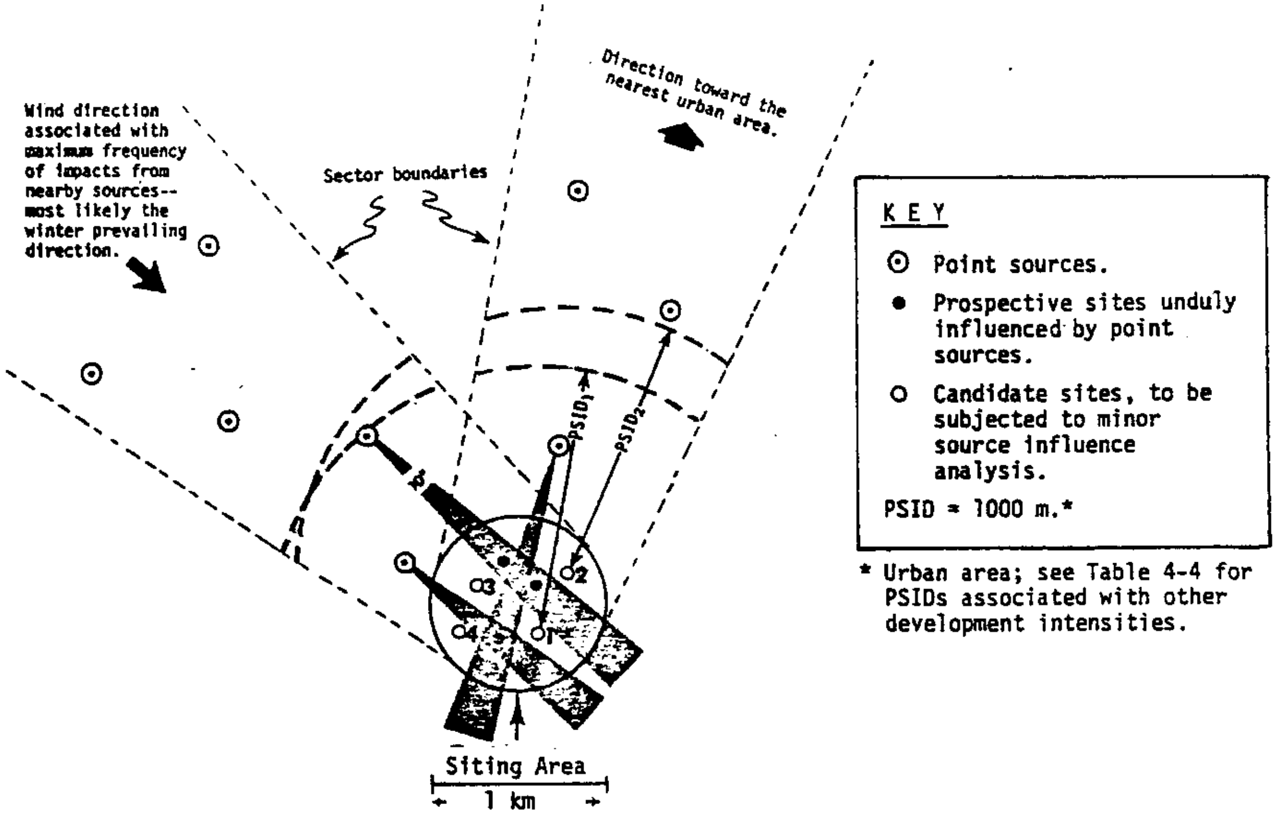

FIGURE 4-10. Plan view blowup of siting area of Fig. 4-9 illustrating the techniques by which final candidate sites are selected.

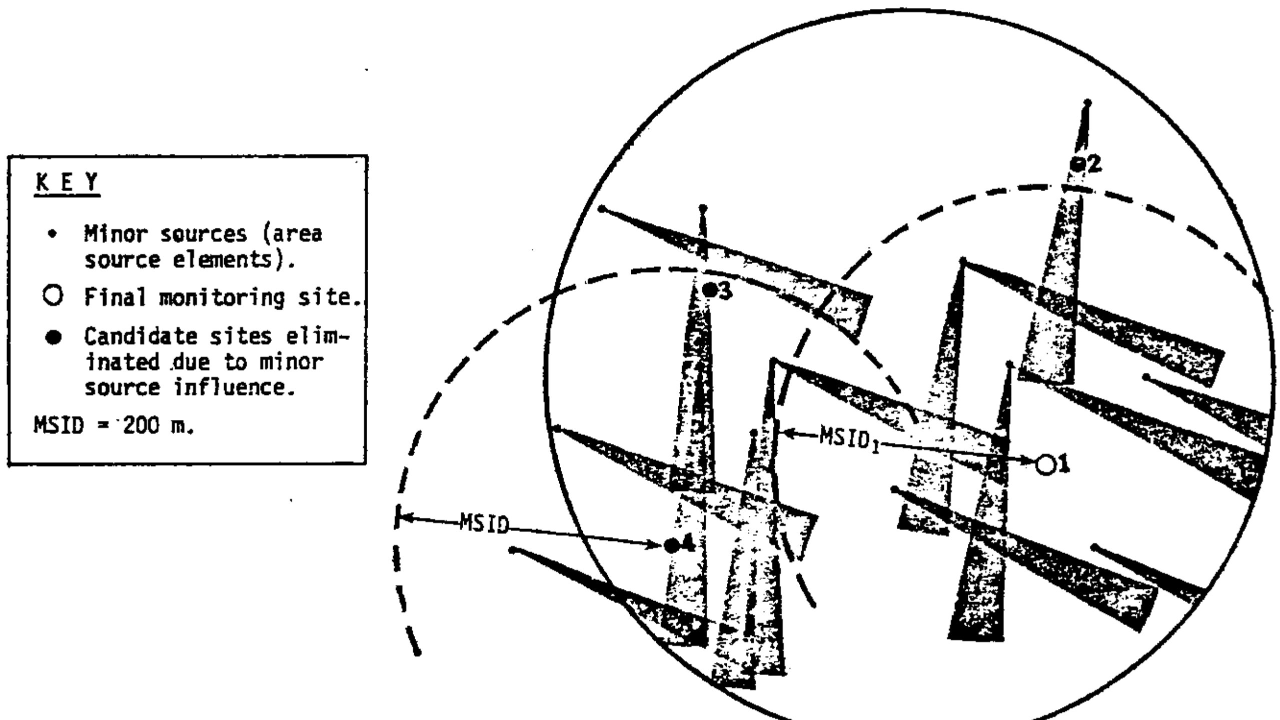

FIGURE 4-11. Blowup of Fig. 4-10 illustrating the technique by which the final site is selected.

TABLE 4-4

Interference Distances for Three Development Intensities*

	Interference Distances	
	Minor Sources (MSID)	Point Sources (PSID)
Urban	200 m	1,000 m
Suburban	100 m	2,200 m
Rural	60 m	3,200 m

The final candidate sites are determined from the following analysis:

- Construct 10° plume sectors downwind of each point source within the PSID of each candidate site.
- Use 20° for the nearest sources (within a city block or two).
- Eliminate prospective sites that fall within any 10° and 20° sector (eliminates undue influences from nearby sources).

The remaining sites represent the set from which the final site will be selected. In a similar manner, identify and plot the locations of all area source elements** within the area enclosed by the sector boundaries up to the minor source interference distance (MSID)† as shown in Figure 4-11. Construct 10° and 20° (nearby sources only) plume sectors downwind of each source and eliminate affected sites. From the remaining sites, select a single site that will satisfy both winter prevailing and short-term peak concentration directions, if possible. Also, the site should be selected such that effects from sources in the other directions from the site are minimal, especially if the wind direction frequency distribution is bi-modal (i.e., high frequencies from two directions, one being the prevailing direction). The procedures used for the prevailing winter direction analysis may be used for this analysis. Figure 4-12 shows the siting area and site locations in better spatial perspective.

If the environment of the siting area is rural in character, the desirable site characteristics and inlet placement are identical to those for regional-scale stations. The desirable site characteristics and inlet placement criteria for sites in suburban and urban environments are shown in Table 4-5.

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* For discussion, see Section 5.1.

** Area source elements are the individual components of an area source such as an individual home or small office building. They can be identified on Sanborn maps or photographs.

† The minor source interference distance (MSID) is the analog of the "PSID" but applicable to the minor sources or individual area source elements.

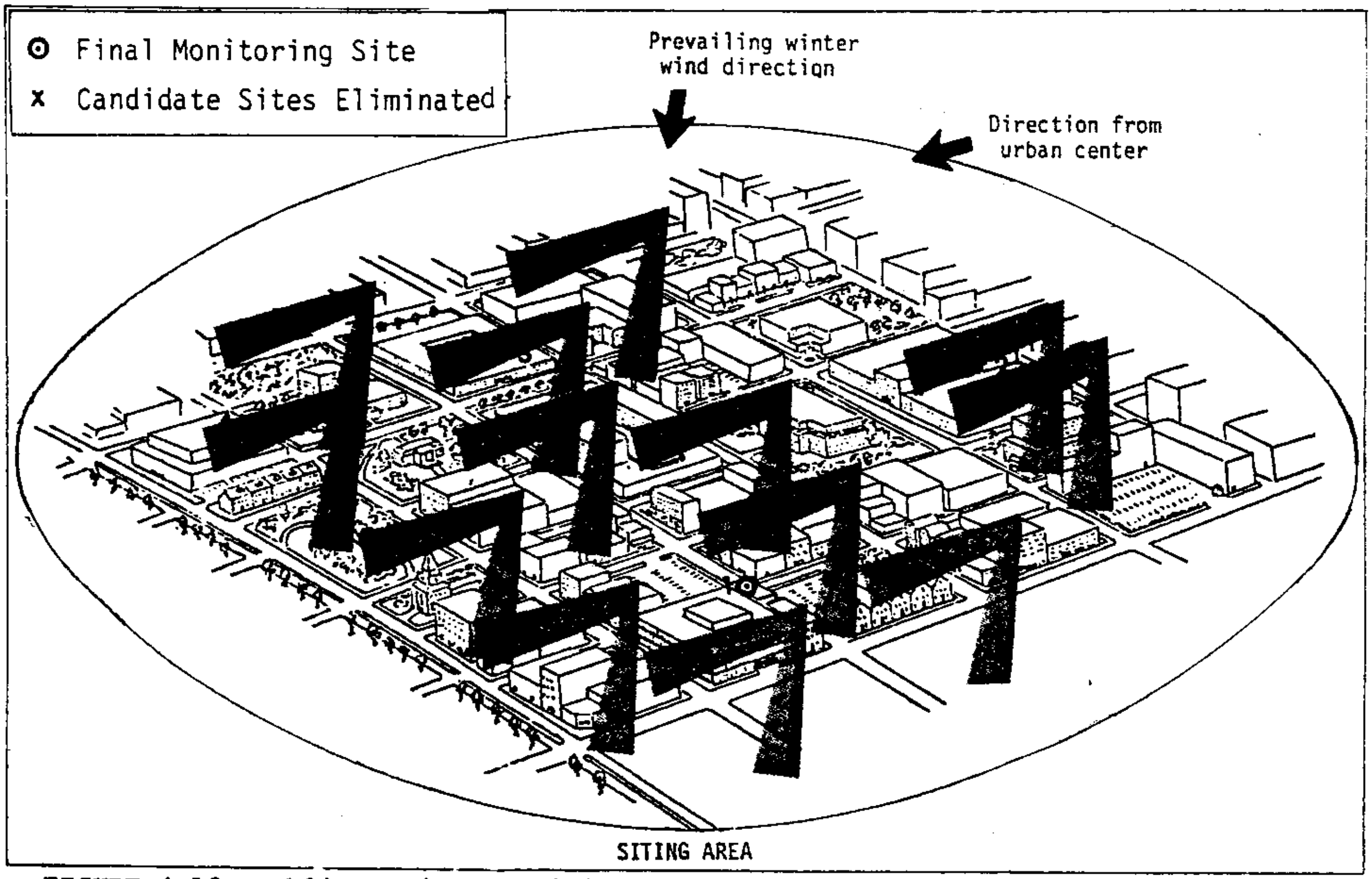

FIGURE 4-12. Oblique view of siting area of Fig. 4-11 showing site locations and urban structure.

TABLE 4-5

Site Characteristics and Inlet Placement Criteria for Neighborhood Stations

Station Location	Inlet Placement Criteria				
	Height Above Ground	Height Above Roof	Horizontal Clearance Beyond Structure	Horizontal of Inlet Placement	Remarks
Rooftop	A little less than the mean height of buildings in neighborhood or lower ($\leq 0.8\bar{H}$*)†	Between 1 - 2 m and away from dirty/dusty areas	Not Applicable (N.A.)	Locate inlet on windward side of building relative to the prevailing winter wind direction, particularly if bluff side of building is toward prevailing direction.	No SO_2 source on roof of building.
Intermediate Height on Building	Same as Rooftop	N.A.	1 to 2 meters	Same as Rooftop	No SO_2 source on roof of building.
Trailer	3 to 5 meters	1 to 2 meters	Not Critical	Not critical	If possible, avoid parking lots and lots around which are buildings with stacks, particularly if nearest building upwind has a large stack. If located in park, avoid sites under thick forest canopy.

* $\bar{H}$ = mean height of buildings in neighborhood (or in middle-scale area of interest for middle-scale stations or in zone of maximum emission densities for emergency episode stations).

† In suburban areas choose a building of low height--preferably one-story.

4.4 GENERAL-LEVEL, MIDDLE-SCALE STATIONS

Middle spatial scales are the smallest practical scales of measurement in routine SO_2 monitoring. Indeed, in an area characterized by a steep SO_2 concentration gradient (in a general-level sense, not an individual plume) measurements made at any one site within the area may represent concentrations on a scale no larger than the middle (see Section 4.3.2).

The major siting objective associated with such scales, in a general-level sense, is to determine peak levels in urban areas. Other siting objectives are the population exposure and projected growth objectives discussed in Section 4.3.2 (normally associated with neighborhood spatial scales) for such areas located in regions of steep concentration gradients.

Figure 4-13 is a schematic illustration of an annual SO_2 concentration profile and associated ground-level pattern that may be observed over an ideally configured city and shows the steep SO_2 gradient that is typically observed. It is within the area of steep gradients that single sites may be located to measure concentrations representing middle-spatial scales. Also shown in Figure 4-13 are example relative locations of stations sited for the above objectives. Actually, most cities are irregularly configured or have industrial complexes and power plants off to one side resulting in irregular SO_2 concentration patterns; nevertheless, the above representation is still relevant.

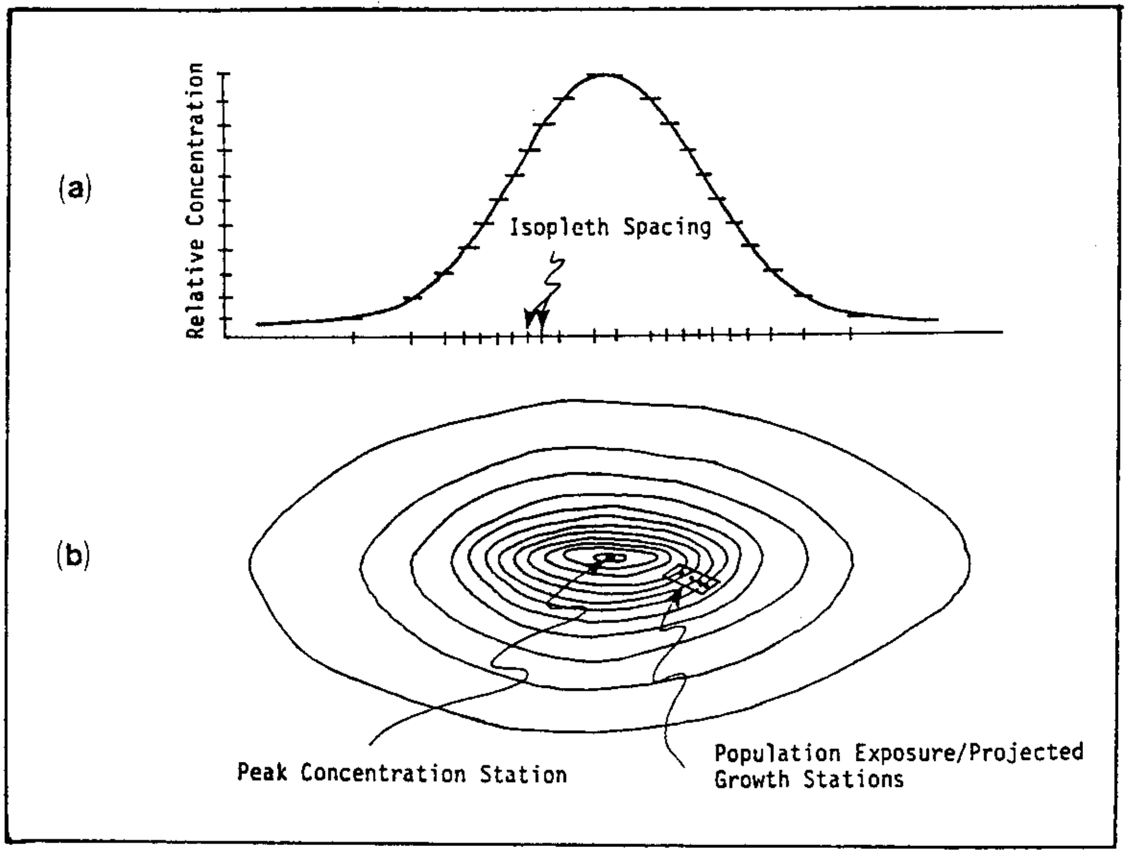

FIGURE 4-13. Schematic illustration of (a) idealized SO_2 concentration profile; and (b) its associated ground-level pattern and example site locations.

Peak concentration stations are "pattern oriented"; i.e., the location of the peak concentration point of the concentration field determines where the site is established. Diffusion modeling plays the primary role in making this determination. The population and growth sites, on the other hand, are associated with fixed geographical areas and are located within these fixed areas regardless of the features or characteristics of the SO_2 pattern over the areas. The procedures for siting these two kinds of monitoring stations are discussed separately below.

Figure 4-14 is a flow chart showing the recommended procedure for selecting general-level middle-scale stations. If the objective of the monitoring is to assess population exposures to SO_2, or areas of projected growth (neighborhood-scale procedure having been deemed inappropriate, Section 4.3.2) the final steps for determining these sites are discussed later in this section. Otherwise, the first step is to assemble the required background material related to the selection of sites to establish peak concentration stations:

- Emissions inventory of point and area sources.
- Meteorological data (see Appendix A)
- USGS map of area.
- Sanborn maps.
- AQDM or equivalent model.

4.4.1 Peak Concentration Stations

Perform an SO_2 simulation analysis of the urban area using the AQDM (or equivalent model) with meteorological data and point and area source emission rates reflecting winter conditions (Dec, Jan, Feb).* For large urban areas (population $\geq 10^6$), use an SO_2 half-life of one hour. For other urban areas, use a three-hour half life. Generate the winter mean, 24-hour "worst case" and three-hour "worst case" SO_2 concentration patterns over the area. An approach for generating such short-term worst case patterns is suggested in Appendix B. In any case, a diffusion meteorologist should be consulted.

4.4.1.1 Winter or Annual Peak Concentration Station

Identify the location of the maximum concentration point on a USGS or detailed city map. (This can be accomplished quite easily if one-kilometer model output grid spacing and isopleth analysis is used.) Then, draw a 500-meter

* If the location of the annual concentration peak would be better estimated by averaging four seasonal simulations rather than the winter pattern alone, then this should be done; for example, in cities where there are power plants, many of which emit peak or near-peak SO_2 rates in summer. For cities having less than about 1500-2500 heating degree days per year, a single annual simulation should suffice, unless industrial sources and/or power plants exhibit seasonal emission patterns.

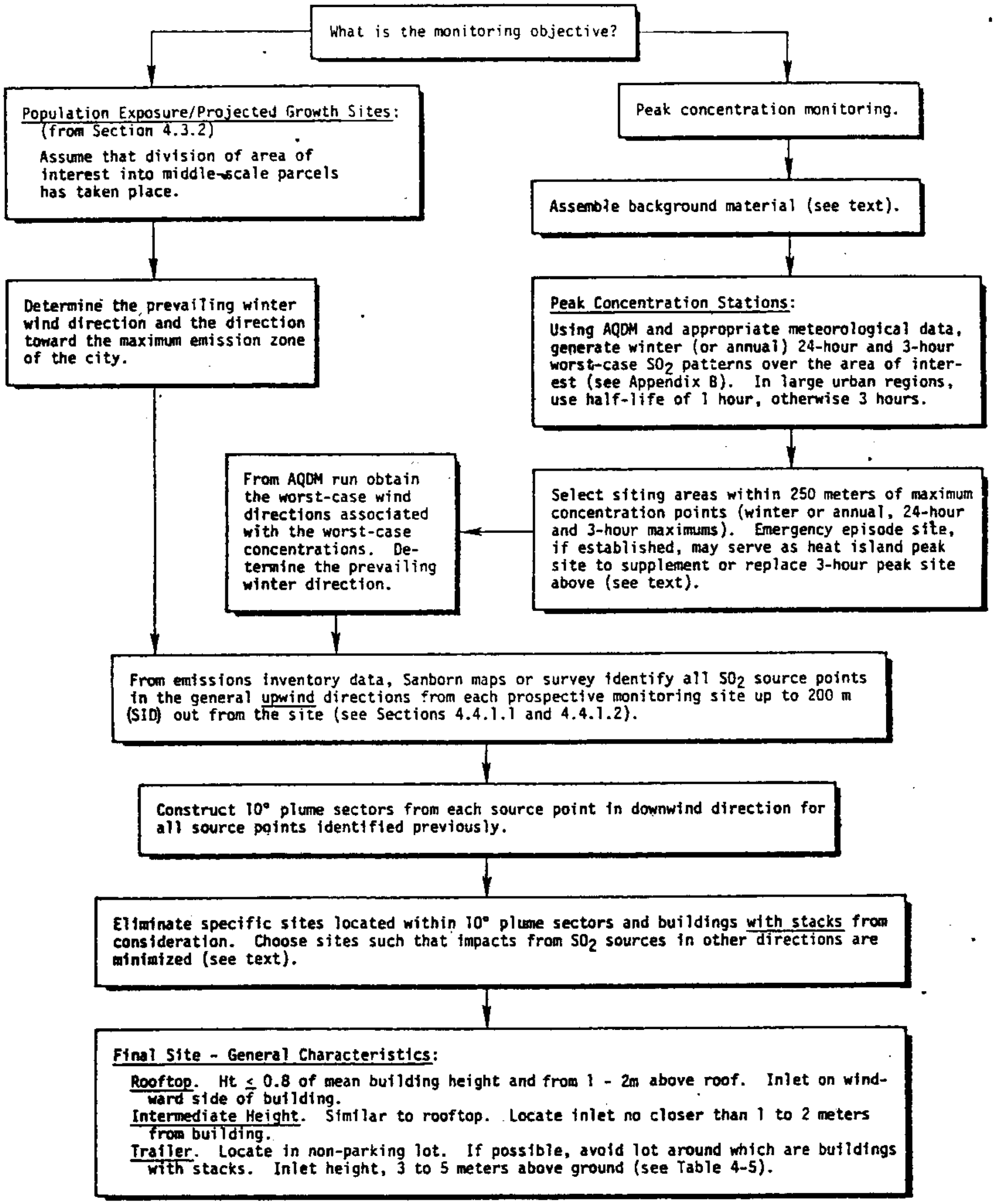

FIGURE 4-14. Flow chart showing procedures for locating general-level middle-scale stations.

diameter circle centered on that point. This circular area represents the upper limit of the middle spatial scale and defines the most probable area within which the maximum winter (and annual) peak concentrations occur.

Locate all prospective monitoring sites within the circular area. Eliminate from consideration all buildings with SO_2 source points (stacks). Next, using a procedure similar to that described for neighborhood stations, establish the prevailing winter (or annual, whichever applies) upwind direction and draw arcs 200 meters from each prospective monitoring site in the upwind direction. This 200-meter distance is the "source interference distance" (SID).* See Figure 4-15 for an illustration of the procedure.

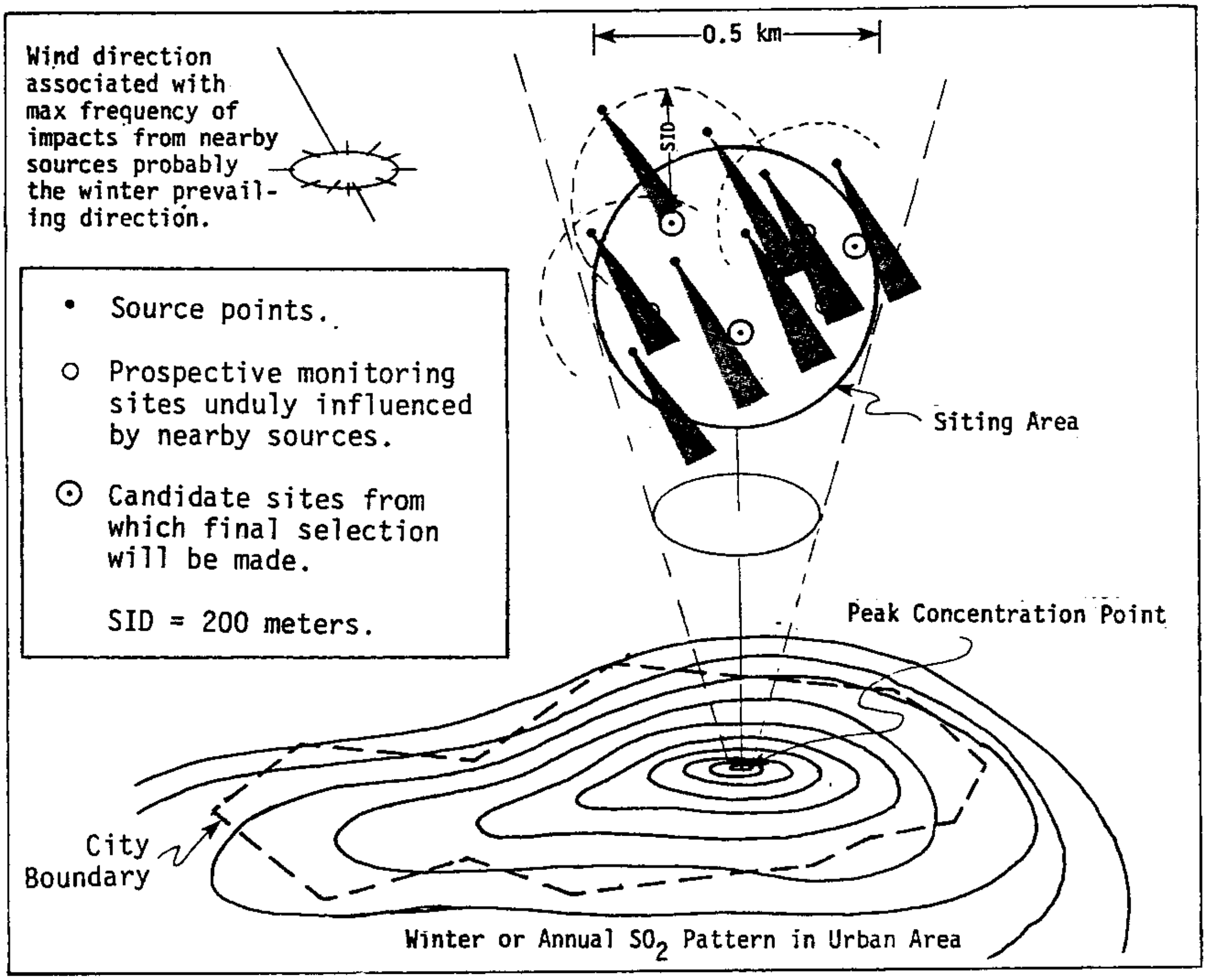

FIGURE 4-15. Schematic illustration of middle-scale siting procedure for peak concentration stations.

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* Since we want to measure the maximum collective annual impacts from all point sources, the SID applies only to area source elements. In that sense, the SID is analogous to the PSID.

From the emissions inventory, Sanborn maps and/or survey results identify and plot all SO_2 source points (stacks) within the siting area and up to the SID in the upwind direction. Draw 10° plumes downwind from all source points located within the SID of each prospective monitoring site as shown. The final site is selected from among those sites not intersected by a 10° plume. Since we are now dealing with spatial scales in which we are becoming interested in impacts from local sources, the use of 20° sectors is not so important and their use is optional.

The above analysis should be extended to other wind directions proceeding from the next most frequent until only one prospective site location remains. This will be the final site location and could be considered permanent. The physical characteristics of the site and inlet exposure are the same as those shown in Table 4-5 (see Page 45).

4.4.1.2 24-Hour and 3-Hour Maximum Concentration Stations

The procedure for locating these stations are the same as for the annual peak station except for the following points.

1) Assume that the short-term peaks occur in winter. Their locations will be determined on the basis of winter simulation analyses.*

2) The wind directions used will be those of the worst case meteorology--i.e., those which are associated with the 24-hour and 3-hour concentration peaks.

3) Regarding the peak 3-hour station, prospective stations should be considered temporary with the final site location refined on the basis of mobile sampling. Such sampling should be done when the 3-hour worst case meteorological conditions are forecast.

4) There is an alternative to the 3-hour site location as determined from the above analysis. It is possible that the 3-hour peak concentration occurs under an inversion situation with a general inflow of air toward the urban center ("heat island" effect). The urban center here can be considered the area of the maximum SO_2 emission density due to area and point sources, analogous to that associated with the emergency episode stations. It is not unlikely that the maximum temperature excess point, air inflow convergence point, and peak concentration point will be found near the center of this area. Thus, unless the addition of point sources to maximum emission zone calculations significantly changes the location of the zone based on area sources alone, or if the city is geographically complex, the emergency episode station(s) can be considered a heat-island related 3-hour peak station as well.

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* If only major point sources contribute significantly to urban SO_2, see Section 4.5.

It is possible that some or all of the peak concentrations (3-hour, 24-hour, and annual) occur near the same location. In these cases, only one site will be required and located/verified by using the procedures applicable to each averaging time involved.

If there is a choice between the 3-hour peak site based on diffusion model results versus the emergency episode station, consider both but make the final decision on the basis of mobile sampling (as addressed in Item 3 above) results. See Table 4-5 (Page 45) for site characteristics and inlet exposure criteria.

4.4.2 Population Exposure and Projected Growth Stations

The siting procedures for these stations are a continuation of the procedure described in Section 4.3.2 (second item of decision process for determining number of sites required for characterizing area of interest) and by Figure 4-8c (see Page 41). Therefore, at this point it can be assumed that the area of interest has already been divided into an appropriate number of middle scale parcels. The siting procedure continues by first establishing a siting area in each parcel. Try to limit the siting area to the central strip of the parcel as shown in Figure 4-16. Then, use the annual peak station siting procedure discussed in Section 4.4.1.1, but with one additional wind direction--that defined by the direction of the siting area and the center of the maximum emission zone of the city (for example, see Figure 4-9, Page 42). This wind direction defines the most probable direction associated with the shorter term peak concentrations resulting from center city sources, which almost certainly impact essentially uniformly over the entire parcel.

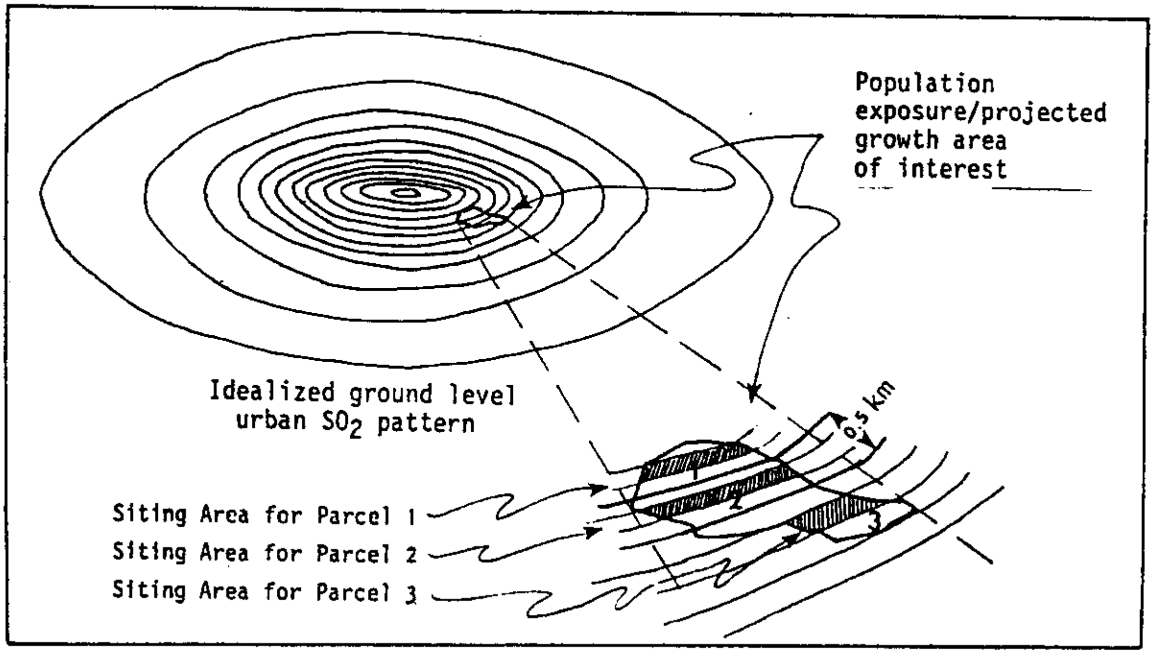


FIGURE 4-16. Schematic showing population exposure or projected growth area divided into middle-scale parcels and recommended siting areas.

The final site should be chosen such that nearby local sources in this direction also will not unduly impact at the monitoring site.

4.5 PROXIMATE, MIDDLE-SCALE STATIONS - Urban Sources

There are two siting objectives associated with proximate, middle-scale stations--assessing the impact of a major point source in a multi-source urban setting, and assessing the impact of an isolated point source. The procedures for siting monitors to satisfy the first objective are heavily dependent on the results of multi-source diffusion model simulations, point source diffusion calculations and "χ/Q" type analyses. For the second objective, knowledge of plume behavior in various terrain environments, special surveys, and mobile sampling results may also be required. Although middle-scale measurements are associated with both objectives, the selection procedures for siting monitors to achieve the two objectives are totally different. In this section, only the first objective is addressed. Isolated point source monitoring is discussed in Section 4.6.

Figure 4-17 is a schematic illustrating the concept of the impact of a major point source in an urban setting. In this situation, the specific siting objectives are to:

- measure the impact of the point source at the urban peak concentration point (Figure 4-17a, point χ), and
- measure the maximum impact of the point source itself (at point P of Figure 4-17a,b).

Averaging times of 3 hours, 24 hours, and one year should be considered, particularly the shorter averaging times.

Figure 4-18 is a flow chart showing the procedure for locating middle-scale stations for assessing the impact of individual urban point sources. The first step is to assemble all background information. This will include:

- Physical data from point source
  - peak and daily mean production rate of SO_2
  - stack parameters
  - exact plant location.
- Emission inventory of point and area sources.
- Meteorological data
  - stability wind roses (see Appendix A)
  - wind persistance tables (see Appendix B, Part I).
- USGS/Sanborn maps of urban area.
- Frequency statistics of hourly wind speed and direction (annual data).

Quiz 1

Take this quiz to determine whether you have mastered the objectives of reading assignments 1 and 2 before you take the final exam.

Do *not* use your notes or books. You may use a protractor and ruler. Take no more than thirty minutes to complete the quiz. Check your answers against the answer key that follows. Review the pages indicated for any questions you missed.

1. Middle scale measurements are associated with ambient air volumes with dimensions ranging from ________ kilometer(s).

   a. 0.1 to 0.5

   b. 0.5 to 4

   c. 4 to 50

   d. 5 to 10

2. Globally, about ________ percent of all SO_2 in the atmosphere comes from anthropogenic sources.

   a. 75

   b. 50

   c. 25

   d. 90

3. True or False? A coal-fired power plant is a point source of SO_2 emissions.

4. Neighborhood scale is the spatial scale of representativeness that is most likely to be represented by a single SO_2 measurement in a(n) ________ area.

   a. suburban

   b. urban

   c. rural

   d. regional

5. A ________ monitoring site is the appropriate type of site for assessing background SO_2 concentrations in a rural area.

   a. proximate middle scale

   b. general-level middle scale

   c. general-level neighborhood scale

   d. general-level regional scale

6. Neighborhood scale measurements are associated with ambient air volumes with dimensions ranging from ________ kilometer(s).

   a. 4 to 50

   b. 0.1 to 0.5

   c. 0.5 to 4

   d. 5 to 10

7. True or False? About 20 percent of SO_2 emissions occur in urban areas.

8. ________ sites are those associated with siting objectives that require information regarding impacts from a specific source or a group of specific sources.

   a. Proximate

   b. General-level

   c. Regional

   d. Neighborhood

9. True or False? Regional scale is the spatial scale of representativeness that is most likely to be represented by a single SO_2 measurement in a rural area.

10. True or False? A general-level regional scale monitoring site is the appropriate type of site for determining the peak SO_2 concentration in an urban area.

11. Urban scale measurements are associated with ambient air volumes with dimensions ranging from ________ kilometer(s).

    a. 4 to 50

    b. 5 to 10

    c. 0.1 to 0.5

    d. 0.5 to 4

12. True or False? Commercial/residential heating and fossil-fuel-fired power plants are major sources of SO_2 emissions in the northern United States.

13. ________ sites are those located in areas where information concerning the total air pollutant concentration is important, but where information concerning contributions from individual sources to the total concentration is relatively unimportant.

    a. Proximate

    b. General-level

    c. Microscale

    d. Middle scale

14. A ________ monitoring site is the appropriate type of site for determining the air quality impact of an isolated SO_2 point source.

    a. general-level regional scale

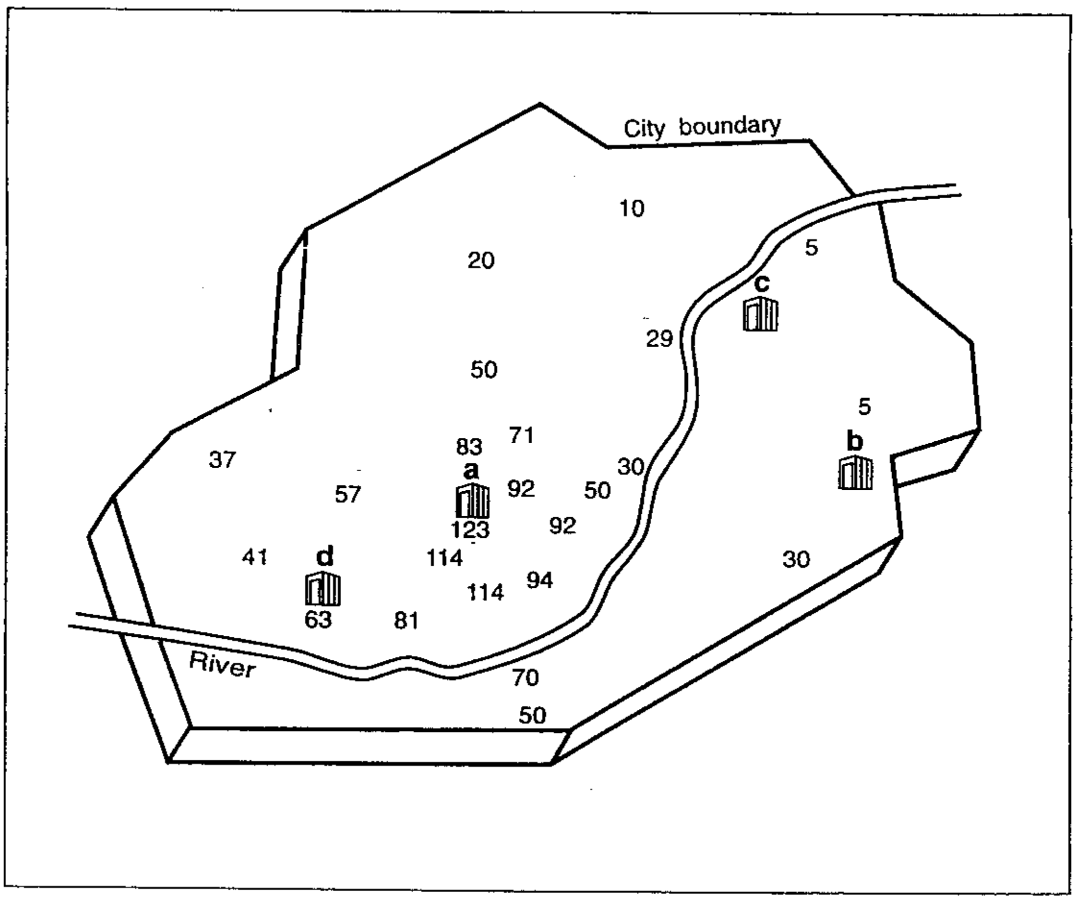
    b. general-level middle scale

    c. general-level neighborhood scale

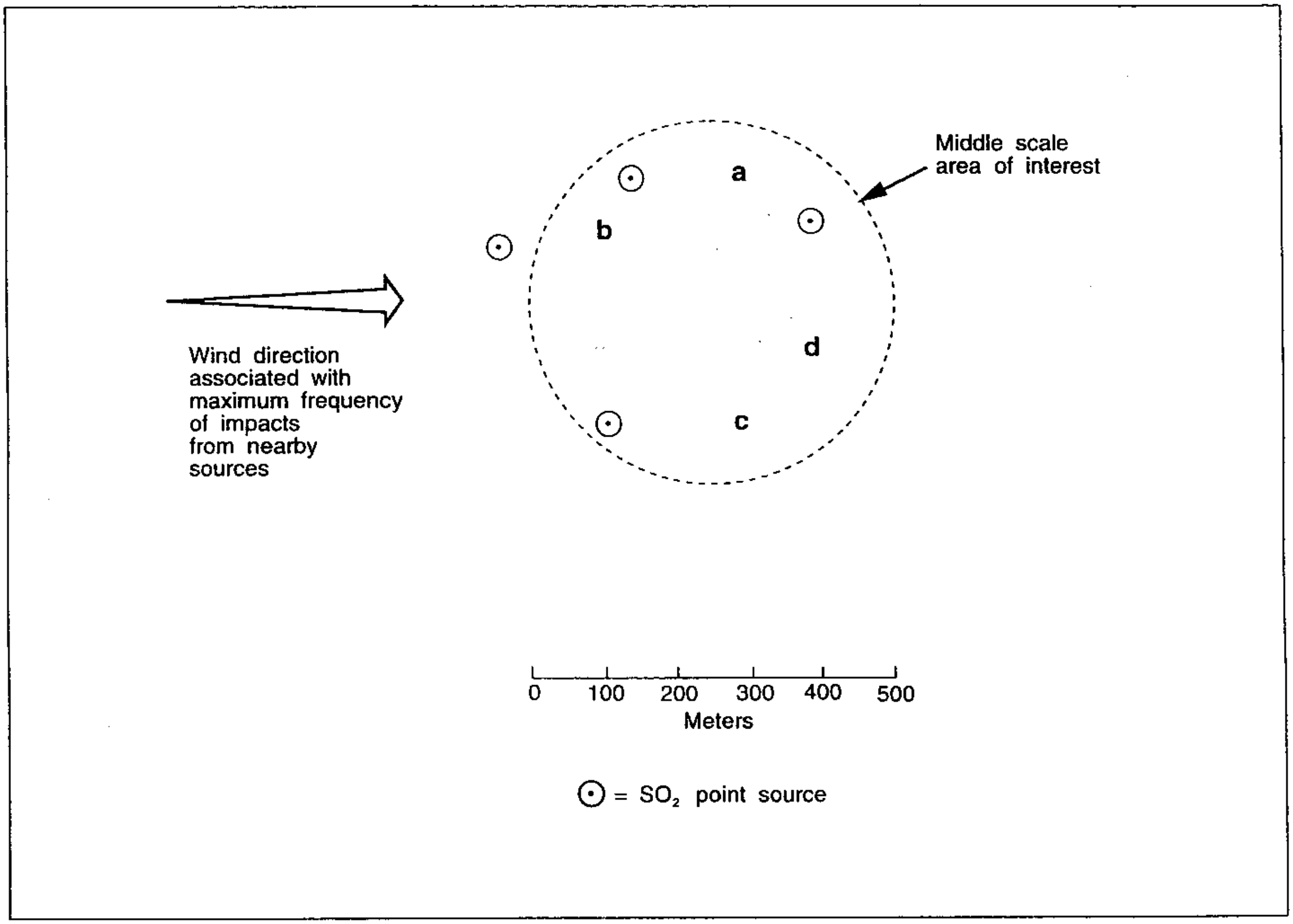
    d. proximate micro/middle scale

15. True or False? More than one SO_2 monitoring site will be needed to represent SO_2 concentrations over an area if the SO_2 concentration extremes over the area are not within about twenty-five percent of the average value.

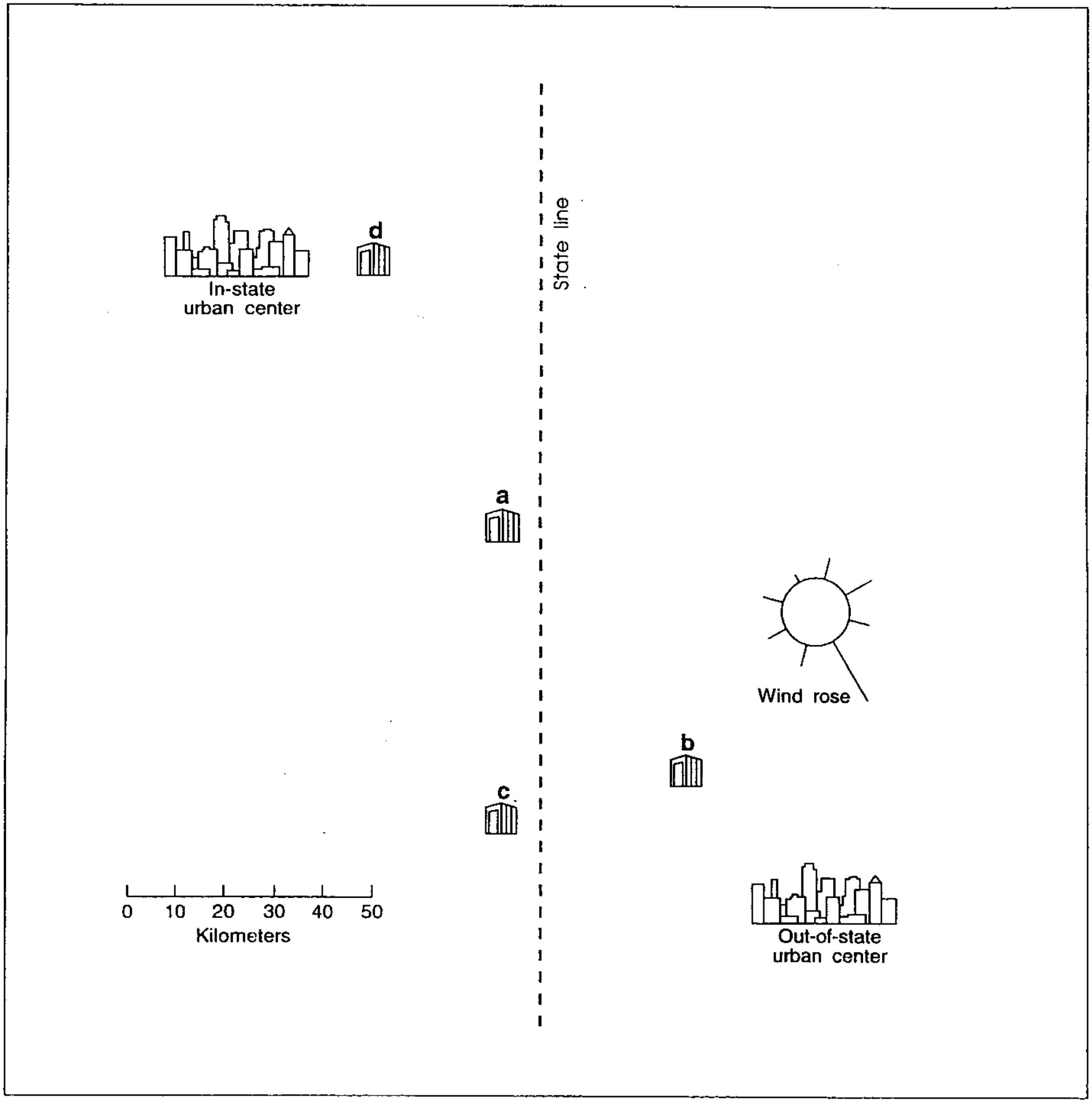
16. The figure below represents a city area with relative sulfur dioxide emission rates plotted. Which of the four general siting areas, labeled a through d, is the best site for emergency episode monitoring?



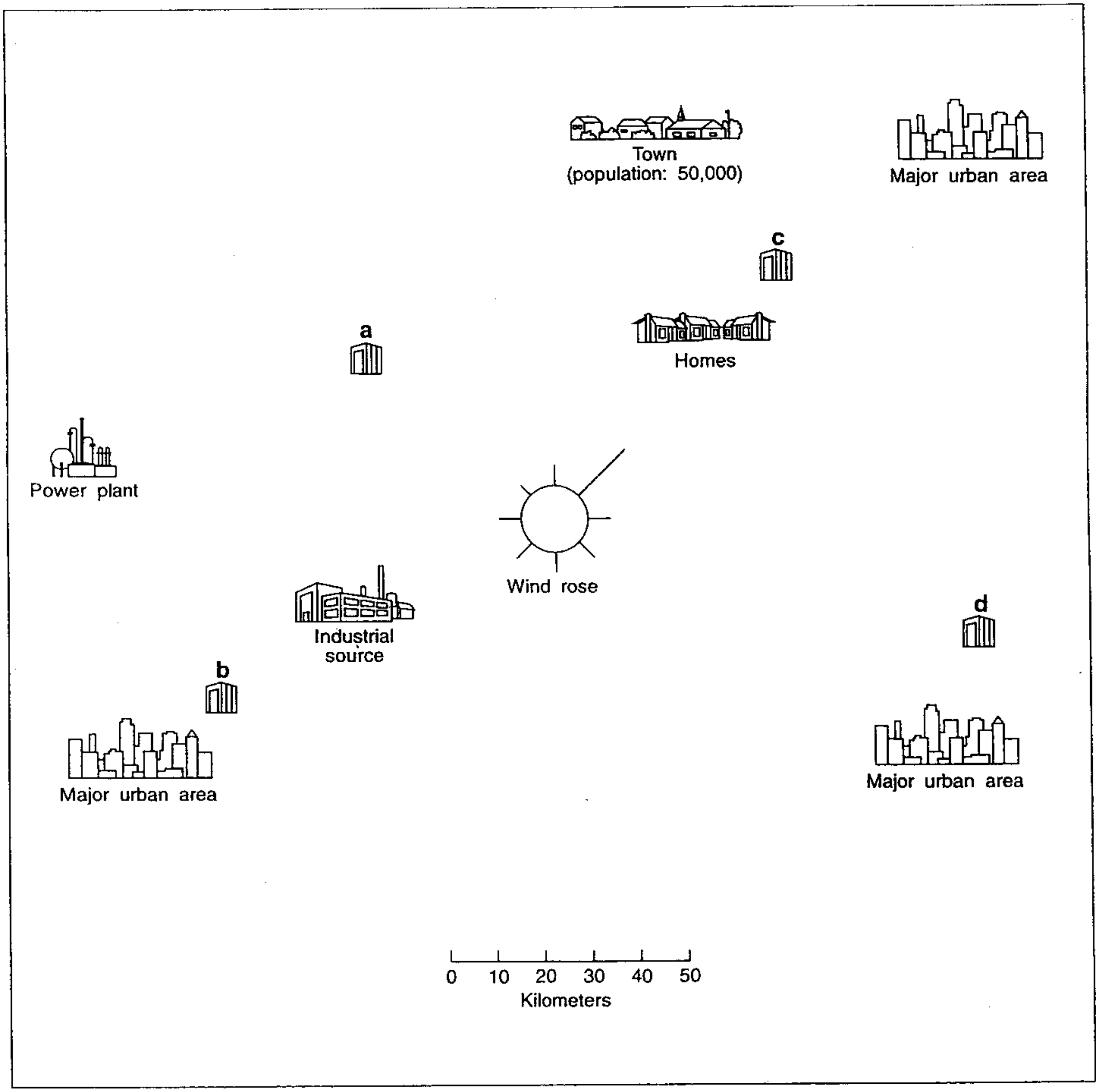
17. Which of the four general siting areas, labeled a through d, is the best siting area for a general-level middle scale monitoring station for determining peak SO_2 concentrations?



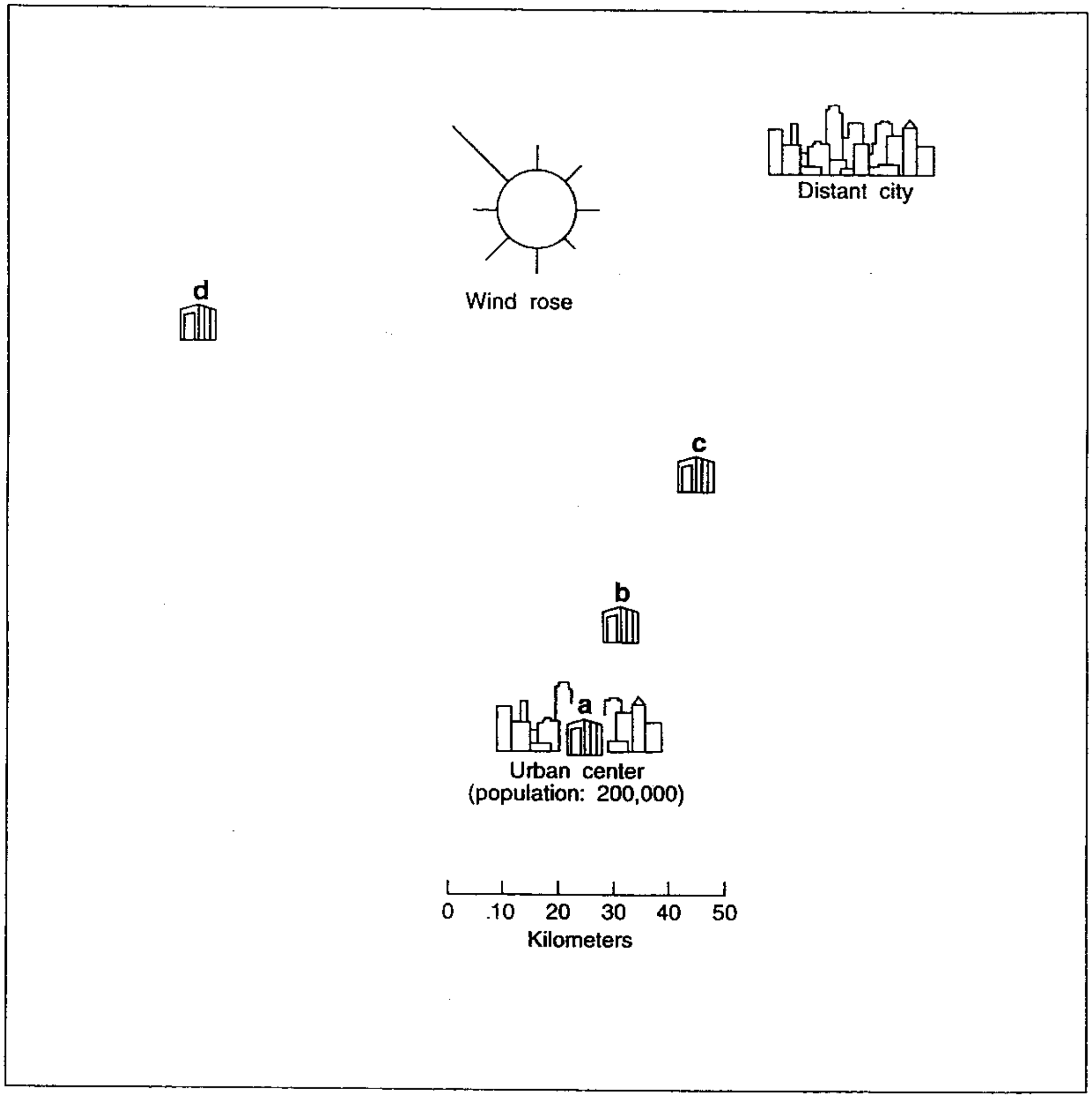
18. Which of the four general siting areas, labeled a through d, is the best siting area for measuring the *maximum* in-state SO_2 concentration resulting from the out-of-state urban center?



19. Which of the four general siting areas, labeled a through d, is the best siting area for an SO_2 regional mean concentration monitoring station?



20. Which of the four general siting areas, labeled a through d, is the best siting area for assessing the transport of SO_2 from the distant city into the urban center?



Quiz 1 Answer Key

		Page*
1.	a	17
2.	b	1
3.	True	5
4.	a	19
5.	d	24
6.	c	17
7.	False	4
8.	a	21
9.	True	24
10.	False	24
11.	a	18
12.	True	4
13.	b	21
14.	d	24
15.	True	29
16.	a	38
17.	d	48-50
18.	c	31
19.	a	31
20.	c	31

* Refer to EPA-450/3-77-013 *Optimum Site Exposure Criteria for SO_2 Monitoring.*

APPENDIX*

A

SOURCES OF CLIMATOLOGICAL AND METEOROLOGICAL INFORMATION

(adapted from Ludwig and Kealoha, 1975)

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* All references found in this appendix are listed in Section 6.0 (References) of the main text.

A. SOURCES OF CLIMATOLOGICAL AND METEOROLOGICAL INFORMATION

One of the most helpful publications specifically designed to assist potential users of climatological data is called "Selective Guide to Climatic Data Sources," Key to Meteorological Records Documentation Number 4.11, prepared by the staff at the National Climatic Center, Ashville, N.C., for sale by the Government Printing Office, Washington, D.C. Its format indicates the publication(s) in which various climatological categories (temperature, precipitation, wind, humidity, and so on) may be found. Although this publication refers primarily to published climatological data, a wealth of unpublished climatological summaries are also available on special order from the files of the National Climatic Center. An index to the summaries that can be ordered is given in the "Guide to Standard Weather Summaries," NAVAIR 50-IC-534, U.S. Navy, March 1968.

The National Climatic Center makes every effort to obtain a copy of all meteorological records collected in the United States. These data are available and can be ordered on microfilm, magnetic tape, hard copies, or as copies of raw data. The address and phone number are:

- Director, National Climatic Center
  Federal Building
  Ashville, North Carolina 28801
  Telephone: (704) 258-2850

The Center answers inquiries and analyzes, evaluates, and interprets data. Routine letters or telephone inquiries are usually answered without charge; other services are provided at cost.

The bulk of the data at the Climatic Center are meteorological observations made at airfields by the National Weather Service, the Federal Aviation Administration, and the Defense Department. Table A-1 shows an example of the kind of information to be found on a three-hourly tabulation for one month at one station. Climatic information is seldom available to the extent that it will be desired, but ingenuity can often be used to ferret out sources not generally available from the usual public data repositories.

At the State and regional level, fire stations, highway and transportation departments, environmental studies groups, air pollution districts, and utility districts may have continuing meteorological records or special weather studies available. A call directly to these agencies may result in a data source not available anywhere else.

TABLE A-1. Example of Meteorological Records Available from the NCC.

OBSERVATIONS AT 3-HOUR INTERVALS

Hour	Sky cover (tenths)	Ceiling (hund. of ft.)	Visibility (whole miles)	Visibility (16ths)	Weather	Dry bulb °F	Wet bulb °F	Rel. hum. %	Dew pt. °F	Wind dir.	Wind speed (knots)
DAY 01											
01	10	40	7			29	24	65	21	34	10
04	10	9	6		GF	26	25	88	23	34	14
07	10	11	6		GF	24	23	88	21	32	18
10	10	12	5		SWGF	25	24	85	21	32	18
13	8	13	7			28	26	72	20	31	15
16	5	UNL	7			28	26	75	21	24	23
19	10	12	7			24	25	85	22	24	16
22	10	11	6		SW	27	26	88	24	25	15
DAY 04											
01	0	UNL	10			18	17	77	12	24	12
04	0	UNL	10			20	19	84	16	24	14
07	2	UNL	10			22	20	74	15	24	20
10	6	100	8			27	25	75	20	24	25
13	10	60	7			30	28	82	25	24	19
16	10	30	7		SW	31	30	89	28	24	21
19	10	20	7		S	33	32	89	29	24	13
22	10	20	7		S	33	32	89	30	27	14
DAYS 02, 03, 05–31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

REFERENCE NOTES

CEILING COLUMN—
UNL indicates an unlimited ceiling.
CIR indicates a cirriform cloud ceiling of unknown height.

WEATHER COLUMN—

*	Tornado
T	Thunderstorm
Q	Squall
R	Rain
RW	Rain showers
ZR	Freezing rain
L	Drizzle
ZL	Freezing drizzle
S	Snow
SP	Snow pellets
IC	Ice crystals
SW	Snow showers
SG	Snow grains
E	Sleet
A	Hail
AP	Small hail
F	Fog
IF	Ice fog
GF	Ground fog
BD	Blowing dust
BN	Blowing sand
BS	Blowing snow
BY	Blowing spray
K	Smoke
H	Haze
D	Dust

WIND COLUMNS—

Directions are those from which the wind blows, indicated in tens of degrees from true North: i. e., 09 for East, 18 for South, 27 for West. Entry of 00 in the direction column indicates calm.

Speed is expressed in knots; multiply by 1.15 to convert to miles per hour.

ADDITIONAL DATA

Other observational data contained in records on file can be furnished at cost via microfilm or microfiche copies of the original records. Inquiries as to availability and costs should be addressed to:

Director
National Weather Records Center
Federal Building
Asheville, N. C. 28801

Schools, colleges, industrial complexes (such as oil refineries), agricultural research stations, radio-TV stations, and electrical power plants may cooperate with a data collection program if asked.

The following publications provide important information concerning useful data sources.

1) Air Pollution Control Association (1973-1974): *Directory, Government Air Pollution Agencies*, published in cooperation with the Office of Air Programs, EPA. This directory lists federal, state, regional, and county agencies conducting air pollution programs. Names of officials, titles, addresses, and telephone numbers are given. Wirte to W.T. Beery, Editor, Directory Governmental Air Pollution Agencies, Air Pollution Control Association, 4400 5th Ave., Pittsburg, Pa. 15213.

2) World Weather Records, Smithsonian Misc. Collections, Vol. 79, Publication 2913, Assembled and arranged for publication by H.H. Clayton, published by the Smithsonian Institution, August 1927. This reference book contains monthly and annual means of pressure, temperature, and totals of rainfall.

A more extensive collection consisting of climatological data for selected airfields and for the climatic areas in which they are located has been compiled by the USAF Environmental Technical Application Center (ETAC), Building 159, Navy Yard Annex, Washington, D.C. 20333. This series is also being published by the U.S. Naval Weather Serice, Navy Yard, Washington, D.C. 20390, under the title, *U.S. Naval Weather Service World-Wide Airfield Summaries*. Table A-2 lists the available volumes in this series. Volume VIII contains summaries for the United States. Information requests should be addressed to:

- The National Technical Information Service (NTIS)
  Springfield, Virginia 22151.

3) *The Climatic Atlas of the United States*, 1968, is a comprehensive series of monthly and annual analyses showing the national distirbution of mean, normal, and/or extreme values of temperature, precipitation, wind, pressure, relative humidity, dewpoint, sunshine, sky cover, heating degree days, solar radiation and evaporation. It was prepared by the Environmental Data Service, NOAA, U.S. Department of Commerce, for sale by the Superintendent of Documents, Washington, D.C.

4) *Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States*, by George C. Holzworth, illustrates seasonal and annual, morning and afternoon mean mixing heights, wind speeds, and normalized pollutant concentrations that were exceeded 10, 25, and 50 percent of the time for specified city sizes. Copies of this report Office of Air Programs Pub. No. AP-101) may be ordered from the Office of Tech. Information & Publs., Off. of Air Programs, EPA, Research Triangle Park, N.C. 27711.

TABLE A-2

Published Volumes of World-Wide Airfield Summaries

Volume	Name	NTIS Accession No.
I	Southeast Asia (revised)	AD-706-355
II	Middle East	
	Part 1	AD-662-425
	Part 2	AD-622-427
III	Far East	AD-662-426
IV	Canada-Greenland-Iceland	AD-662-424
V	Australia-Antarctica (including S. Pacific Is.)	AD-662-648
VI	South America	
	Part 1	AD-664-828
	Part 2	AD-664-829
VII	Central America	AD-671-845
VIII	United States of America	
	Part 1. W. Coast, Western Mtns., & Great Basin	AD-688-472
	Part 2. Rocky Mtns. and Northwest Basin	AD-689-792
	Part 3. Central Plains	AD-693-491
	Part 4. Great Lakes	AD-696-971
	Part 5. Mississippi Valley	AD-699-917
	Part 6. Southeastern Region	AD-701-719
	Part 7. East Coast and Appalachian Region	AD-703-606
	Part 8. Alaska and Hawaii	AD-704-607
IX	Africa	
	Part 1. Northern Half	AD-682-915
	Part 2. Southern Half	AD-682-915
X	Europe	
	Part 1. Scandinavia and Northern Europe	
	Part 2. Low Countries and British Isles	
	Part 3. Alps and Southwest Europe	
	Part 4. Mediterranean	

The National Climatic Center will prepare special data summaries. They also have standard computer programs available for special summaries. One of the most useful summaries for air pollution studies is that prepared by the STAR program. It is a joint frequency distribution of atmospheric stability and wind speed and direction. The atmospheric stability is calculated objectively from the cloud cover and wind data. This stability algorithm is based on the work of Pasquill (1961). The summaries can be based on any extended period of record with separate outputs for the months or seasons, as well as an annual summary. There are some pollution models that use the output of STAR program as part of their input requirements. The National Climatic Center has computed these summaries for over 250 weather stations in the United States. These stations are listed in Table A-3.

TABLE A-3

List of Stations for Which Stability-Wind-Rose Tables have been Prepared*

Stations for which Local Climatological Data are issued, as of January 1, 1969

ALABAMA	abc	Birmingham
	abc	Huntsville
	abc	Mobile
	abc	Montgomery
ALASKA	abc	Anchorage
	abc	Annette
	abc	Barrow
	abc	Barter Island
	abc	Bethel
	ab	Bettles
	ab	Big Delta
	abc	Cold Bay
	abc	Fairbanks
	ac	Farewell
	abc	Gulkana
	abc	Homer
	abc	Iliamna
	abc	Juneau
	abc	King Salmon
	abc	Kotzebue
	abc	McGrath
	ab	Nenana
	abc	Nome
	abc	St. Paul Island
	abc	Shemya
	abc	Summit
	abc	Talkeetna
	ab	Tanana
	abc	Unalakleet
	abc	Yakutat
ARIZONA	abc	Flagstaff
	abc	Phoenix
	abc	Tucson
	abc	Winslow
	abc	Yuma
ARKANSAS	abc	Fort Smith
	abc	Little Rock
CALIFORNIA	abc	Bakersfield
	ac	Bishop
	ac	Blue Canyon
	ac	Eureka
	abc	Fresno
	abc	Long Beach
		Los Angeles
	abc	Airport
	ac	Civic Center
	ac	Mt. Shasta
	abc	Oakland
	abc	Red Bluff
	abc	Sacramento
	ac	Sandberg
	abc	San Diego
		San Francisco
	abc	Airport
	ac	City
	ac	Santa Maria
	abc	Stockton
COLORADO	ac	Alamosa
	abc	Colorado Springs
	abc	Denver
	abc	Grand Junction
	abc	Pueblo
CONNECTICUT	abc	Bridgeport
	abc	Hartford
	ac	New Haven
DELAWARE	abc	Wilmington
DISTRICT OF COLUMBIA	abc	Washington
FLORIDA	ac	Apalachicola
	abc	Daytona Beach
	abc	Fort Myers
	abc	Jacksonville
	abc	Key West
	ac	Lakeland
	abc	Miami
	abc	Orlando
	abc	Pensacola
	abc	Tallahassee
	abc	Tampa
	abc	West Palm Beach
GEORGIA	abc	Athens
	abc	Atlanta
	abc	Augusta
	abc	Columbus
	abc	Macon
	ac	Rome
	abc	Savannah
HAWAII	abc	Hilo
	abc	Honolulu
	abc	Kahului
	abc	Lihue
IDAHO	abc	Boise
	ac	Lewiston
	abc	Pocatello
ILLINOIS	ac	Cairo
		Chicago
	abc	Midway Airport
	ab	O'Hare Airport
	abc	Moline
	abc	Peoria
	abc	Rockford
	abc	Springfield
INDIANA	abc	Evansville
	abc	Fort Wayne
	abc	Indianapolis
	abc	South Bend
IOWA	abc	Burlington
	abc	Des Moines
	ac	Dubuque
	abc	Sioux City
	abc	Waterloo
KANSAS	abc	Concordia
	abc	Dodge City
	abc	Goodland
	abc	Topeka
	abc	Wichita
KENTUCKY	abc	Lexington
	abc	Louisville
LOUISIANA	abc	Alexandria
	abc	Baton Rouge
	abc	Lake Charles
	abc	New Orleans
	abc	Shreveport
MAINE	ac	Caribou
	abc	Portland
MARYLAND	abc	Baltimore
MASSACHUSETTS		Boston
	abc	Airport
	ac	Blue Hill Obs.
	abc	Nantucket
	abc	Worcester
MICHIGAN	abc	Alpena
		Detroit
	abc	City Airport
	abc	Detroit Metro AP
	abc	Flint
	abc	Grand Rapids
	abc	Houghton Lake
	abc	Lansing
	ac	Marquette
	abc	Muskegon
	abc	Sault Ste. Marie

C O N T I N U E D

* Only those stations having at least the "b" indicated.

Table A-3. Continued.

	MINNESOTA
abc	Duluth
abc	International Falls
abc	Min'p'l's-St. Paul
abc	Rochester
ac	St. Cloud
	MISSISSIPPI
abc	Jackson
abc	Meridian
	MISSOURI
abc	Columbia
abc	Kansas City
abc	St. Joseph
abc	St. Louis
abc	Springfield
	MONTANA
abc	Billings
abc	Glasgow
abc	Great Falls
abc	Havre
abc	Helena
abc	Kalispell
c	Miles City
abc	Missoula
	NEBRASKA
abc	Grand Island
ac	Lincoln
ac	Norfolk
abc	North Platte
abc	Omaha
abc	Scottsbluff
ac	Valentine
	NEVADA
abc	Elko
abc	Ely
abc	Las Vegas
abc	Reno
abc	Winnemucca
	NEW HAMPSHIRE
abc	Concord
ac	Mt Washington
	NEW JERSEY
	Atlantic City
abc	Airport
a	State Marina
abc	Newark
ac	Trenton
	NEW MEXICO
abc	Albuquerque
ac	Clayton
abc	Roswell
	NEW YORK
abc	Albany
	Binghamton
abc	Airport
abc	Buffalo
	New York
abc	Central Park
abc	Int'l. Airport
abc	LaGuardia Field
abc	Rochester
abc	Syracuse
	NORTH CAROLINA
abc	Asheville
abc	Cape Hatteras
abc	Charlotte
abc	Greensboro
abc	Raleigh
abc	Wilmington
	NORTH DAKOTA
abc	Bismarck
abc	Fargo
abc	Williston
	OHIO
abc	Akron-Canton
	Cincinnati
ac	Abbe Obs.
abc	Airport
abc	Cleveland
abc	Columbus
abc	Dayton
abc	Mansfield
abc	Toledo
abc	Youngstown
	OKLAHOMA
abc	Oklahoma City
abc	Tulsa
	OREGON
abc	Astoria
abc	Burns
abc	Eugene
ac	Meacham
abc	Medford
abc	Pendleton
abc	Portland
abc	Salem
ac	Sexton Summit
	PACIFIC ISLANDS
ac	Guam
abc	Johnston
abc	Koror
abc	Kwajalein
abc	Majuro
abc	Pago Pago
abc	Ponape
abc	Truk (Moen)
abc	Wake
abc	Yap
	PENNSYLVANIA
abc	Allentown
abc	Erie
abc	Harrisburg
abc	Philadelphia
	Pittsburgh
abc	Airport
ac	City
ac	Reading
abc	Scranton
abc	Williamsport
	RHODE ISLAND
ac	Block Island
abc	Providence
	SOUTH CAROLINA
	Charleston
abc	Airport
a	City
abc	Columbia
abc	Greenville-Spartanburg
	SOUTH DAKOTA
abc	Aberdeen
abc	Huron
abc	Rapid City
abc	Sioux Falls
	TENNESSEE
abc	Bristol
abc	Chattanooga
abc	Knoxville
abc	Memphis
abc	Nashville
	Oak Ridge
a	Area Stations
ac	City
	TEXAS
abc	Abilene
abc	Amarillo
abc	Austin
abc	Brownsville
abc	Corpus Christi
abc	Dallas
abc	Del Rio
abc	El Paso
abc	Fort Worth
ac	Galveston
abc	Houston
abc	Lubbock
abc	Midland
abc	Port Arthur
abc	San Angelo
abc	San Antonio
abc	Victoria
abc	Waco
abc	Wichita Falls
	UTAH
ac	Milford
abc	Salt Lake City
ac	Wendover
	VERMONT
abc	Burlington
	VIRGINIA
ac	Lynchburg
abc	Norfolk
abc	Richmond
abc	Roanoke
a	Wallops Island
	WASHINGTON
abc	Olumpia
abc	Quillayute Airport
abc	Seattle-Tacoma AP
abc	Spokane
ac	Stampede Pass
ac	Walla Walla
abc	Yakima
	WEST INDIES
abc	San Juan, P. R.
ac	Swan Island
	WEST VIRGINIA
abc	Beckley
abc	Charleston
ac	Elkins
abc	Huntington
ac	Parkersburg
	WISCONSIN
abc	Green Bay
abc	La Crosse
abc	Madison
abc	Milwaukee
	WYOMING
abc	Casper
abc	Cheyenne
abc	Lander
abc	Sheridan

a. Monthly summary issued.

b. Monthly summary includes 3-hourly observations.

c. Annual Summary issued.

APPENDIX*

B

Suggested Approaches for Determining Worst Case SO_2 Patterns and Associated Meteorology

PART I. Multi-Source Urban Settings
PART II. Isolated Point Source Monitoring

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* All references found in this appendix are listed in Section 6.0 (References) of the main text.

B. SUGGESTED APPROACHES FOR DETERMINING WORST CASE SO_2 PATTERNS AND ASSOCIATED METEOROLOGY

This Appendix was prepared to serve as guidance for utilizing short-term diffusion model simulations in selecting monitoring sites. Such simulations may be required to determine approximate locations of monitoring sites for measuring short-term peak concentrations under near worst case conditions. Part I addresses the situation in multi-source urban settings. Part II addresses isolated point source monitoring.

It is strongly recommended that a diffusion meteorologist be consulted in developing procedures for specific applications. Presented below are approaches that address the problem areas; they should not be construed as constituting the only approaches.

B.I MULTI-SOURCE URBAN SETTINGS

This suggested approach utilizes the programming logic incorporated in the AQDM computer program. What is presented here is not a detailed listing of a program modification but a description of a suggested modification and how such a modification, when used in conjunction with wind direction persistence tables, can estimate the approximate locations where the short-term concentration peaks should occur. The program modifications themselves could be accomplished quite easily with the aid of a diffusion meteorologist.

The AQDM utilizes emission rates from a set of pollutant sources and a joint frequency distribution of wind speed, wind direction, and atmospheric stability (stability-wind-rose, SWR). The total concentration at a specific receptor is obtained by utilizing each element of the SWR to calculate the partial concentration that a source contributes to the receptor and summing over all sources. There are six wind speed classes each representing a wind speed range, five stability classes, and sixteen wind directions for a total of 480 elements or "cells" that comprise the SWR. However, normally only about one-half of the cells are "filled" and only those that establish the source as being upwind of a receptor are utilized.

Utilizing the winter quarter SWR (Dec-Jan-Feb) and making appropriate changes in "print" or "write" statements, it would be possible to print 480 (or a number equal to the number of filled cells) maps of pollutant concentrations, one map for each combination of wind speed range, wind direction, and stability class. All 480 maps could be stored on tape and only those five or so maps having the highest concentration peaks at any receptor need be printed out and analyzed. It is recommended that the SWR be "normalized" by changing the indicated frequency of occurrence of each meteorological combination (cell) to a constant value for all cells. This value could be "1" or the inverse of the number of cells filled, etc. The purpose of this procedure is to eliminate the bias due to relative frequencies of occurrence. For example, a high frequency of occurrence of a given combination could actually be composed of many short periods, no individual period being characterized by a high concentration; on the other hand, a low frequency of occurrence may consist of a single long period of persistent wind direction resulting in a high concentration peak. Therefore, the use of normalized meteorology along with wind direction persistence information will more likely reveal the location of the peak concentrations. Another important point is that the distribution of sources, source strengths and emission heights in combination with a unique meteorological condition results in the highest ground-level concentrations (the near worst case meteorological condition).

The persistence of the wind direction over the worst case condition determines the averaging time of the peak. Three basic time periods are recommended to be considered. For the three-hour peak analyses, the daytime period from 1000 to 1900 LST and the nighttime period (2000-0900LST) should be considered separately. For the 24-hour peak analysis, consider the 24-hour period 0000 to 2400 LST.

Wind direction persistence tables for the weather station of interest for each of the three basic time periods may be requested from the National Climatic Center or generated by a computer program using LCD data (wind). A suggested format is shown in Table B-1, or graphically, in Figure B-1. Since observations are taken at 3-hour intervals, two consecutive observations having the same wind direction would constitute a 3-hour persistence case; three consecutive observations, a 6-hour case; etc.

TABLE B-1

Tabulated Persistence Data for NW Wind Situation
(192 obs/yr, 7% of total wind obs)

NW Wind	Persistence (hours)							
	3	6	9	12	15	18	21	24
Frequency (#)	40	12	7	5	4	3	2	1
Frequency (%) (192 base)	21	6	4	3	3	2	1	1
Median[1] Speed / Modal[2] Speed (%)	15/17 (50)	11/9 (30)	9/11 (60)	12/10 (25)				

[1] Wind speed that divides sample in half.

[2] Most frequently occurring wind speed.

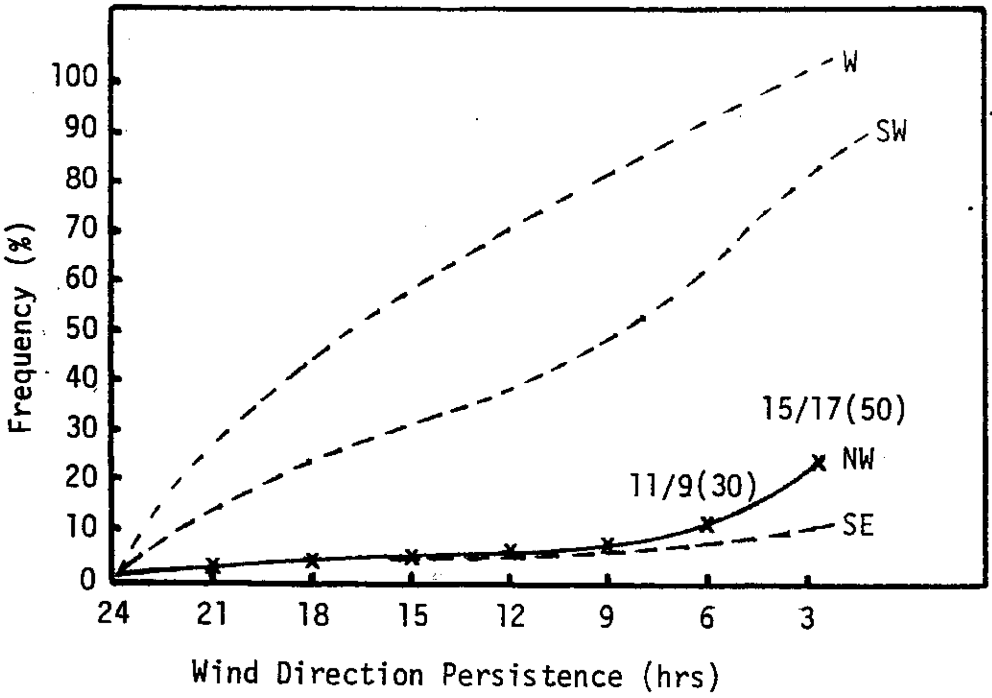


FIGURE B-1. Graphical presentation of persistence data, NW wind case from Table B-1. Graphs may be prepared by season, day/night, etc.

B.II ISOLATED POINT SOURCE MONITORING

This approach also utilizes standard Gaussian diffusion concepts. It is assumed that the reader is familiar with the various kinds of graphical solutions to the Gaussian point source diffusion equation such as that shown in Figure B-2. In any case, "Turner's Workbook" (Turner, 1974) contains most of the support information and should be consulted (also, see Appendix E, Sec.E.3).

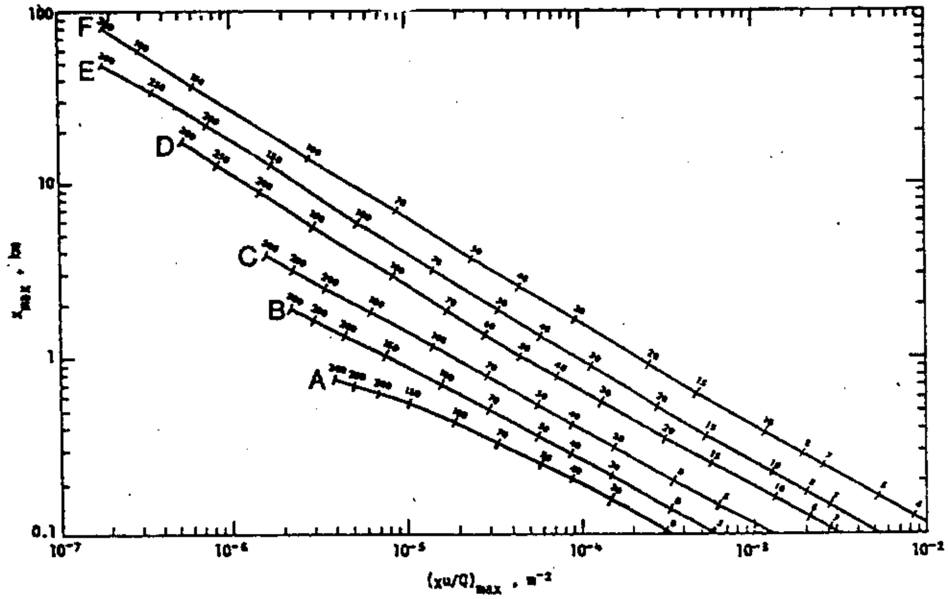


FIGURE B-2.

Distance of maximum concentration & maximum $\chi u/Q$ as a function of stability (curves) and effective height (m) of emission (numbers).

The approach presented here is generally applicable to terrain settings ranging from flat to moderately rough and irregular. Its application to rough and irregular terrain can be accomplished by substituting appropriate diffusion coefficients, such as those presented by Bowne (1973) for those valid only for flat terrain in the Gaussian point source equation. In this manner, graphical solutions can be prepared for various terrain settings. Suggested approaches for dealing with the 3-hour and 24-hour averaging times are given below.

B.II.1 Three-Hour Peak Concentrations, Their Locations, and Associated Meteorology

The critical wind speeds for each stability class (A, B, and C) are first determined; these winds produce the highest ground-level concentrations downwind of the plant. The wind directions associated with the critical wind speeds (see Table B-2 for example) establish the downwind azimuths along which candidate siting areas are established. Graphical solutions to the Gaussian equation in a form similar to Figure B-2 is used to determine their approximate distances downwind. Next, a decision has to be made regarding selecting the final site or sites. Since stability Class A will usually be associated with the highest peak but may not have the highest frequency of occurrence, two sites may be appropriate:

a) one site associated with the most unstable stability class to measure the highest peak;

b) the other site associated with a high peak that occurs very often (see Table B-2, second column).

The meteorology associated with each of the above situations is the worst case meteorological condition for those situations.

B.II.2 Twentyfour-Hour Peak Concentrations, Their Locations, and Associated Meteorology

The situation associated with the 24-hour average impact is somewhat different than that associated with the 3-hour impact. The plant will probably not be operating at its peak production rate for 24 hours and the atmospheric stabilities may involve the full range of classes.

The following procedure is recommended:

- Determine the critical wind speed for stability class D (represents 24-hour average stability); in the calculalation of effective stack height, stack parameters should reflect the average daily emission rate. From wind persistence tables (e.g., Figure B-1) representative of the area of interest, ascertain the most persistent wind directions (e.g., the five or so of longest duration. The median and modal speeds associated with the directions are then noted. These speeds can

TABLE B-2*

Illustration of Use of Stability-Wind-Rose for Determining Site Locations Monitoring Isolated Point Sources

[Assume a critical wind speed of 2 knots; NNE direction from source: azimuth for monitoring the highest peak concentration; NE direction from source: azimuth associated with frequently occurring high peaks. Use Fig. B-2 for determining downwind distances. Verify via mobile sampling.]

Direction	Frequency Distribution Speed (knots)							
	1-3	4-6	7-10	11-16	17-21	>21	Average Speed	Total
N	19	35	15	0	0	0	5.0	69
NNE	15	29	8	0	0	0	5.0	52
NE	6	11	3	0	0	0	4.8	21
ENE	2	9	4	0	0	0	5.6	15
E	7	10	4	0	0	0	4.8	21
ESE	2	6	3	0	0	0	5.2	11
SE	9	4	1	0	0	0	3.6	14
SSE	2	3	0	0	0	0	4.0	5
S	16	14	4	0	0	0	4.2	34
SSW →	[29]	34	22	0	0	0	4.9	85
SW →	22	[41]	13	0	0	0	4.8	76
WSW	15	13	7	0	0	0	4.6	35
W	12	22	5	0	0	0	4.7	39
WNW	15	18	13	0	0	0	5.1	46
NW	4	18	15	0	0	0	5.9	37
NNW	7	12	6	0	0	0	4.8	25
Average	2.6	5.2	7.3	0	0	0	3.5	
Total	182	250	123	0	0	0		

Number of Occurrences of A Stability = 805
Number of Calms with A Stability = 221

* Station = 14703 Chicopee Falls, Mass 60-64 240B (adapted from NCC printout).

be used to characterize each persistence period; the modal speed should be used if it occurs about one-third of the time or more--otherwise the median speed may be more representative. Next, a judgemental decision must be made regarding the selection of the probable direction associated with the highest concentration. For this purpose, it can be assumed that the maximum concentrations are associated with the longest persistence periods with characteristic speeds nearest the critical wind speed. Therefore, if there are several persistence periods exceeding 24 hours in duration, the direction whose characteristics speed is closest to the critical wind speed may be deemed the worst case condition. Otherwise, the most persistent direction, regardless of its characteristic wind speed, will best represent such conditions, Graphical solutions to the Gaussian equation similar to Figure B-2 may be used to determine the required distance downwind to the siting area.

A P P E N D I X *

C

MOBILE SAMPLING

* All references found in this appendix are listed in Section 6.0 (References) of the main text.

C. MOBILE SAMPLING

Mobile sampling can satisfy several important needs in SO_2 monitoring, particularly those related to isolated point source impacts. Among them are:

- to reveal ground-level SO_2 patterns, especially over complex terrain;
- to determine the location of the maximum ground-level impact point of a plume emitted by an elevated source; and
- to define the spatial distribution of plume material.

Several kinds of instruments are available for mobile sampling of SO_2. Those based on Flame Photometric Detection (FPD) are usually sensitive and fast-responding instruments. Also, remote sensing devices such as a correlation spectrometer may be used to measure the total vertical burden (or integral of the pollutant) over a point. A small vehicle may be used to transport the equipment.

Several sampling techniques can be utilized in mobile monitoring. Jepsen and Weil (1973) describe a rather successful approach in the State of Maryland's power plant impact studies. From their work, Figure C-1a shows an idealized mobile lab traverse route setup and Figure C-1b shows a typical plume dispersion pattern at ground-level and total burden in the vertical.

Martin, et al. (1967) describe a tracer study in which the spatial distribution of plume material is revealed by sampling at 30 to 50 sites along several crosswind arcs downwind of the release point (see Figure C-2). The crosswind dispersion parameter, σ_y can be computed from the data obtained and used in conjunction with values of other key variables (plume height, wind speed, etc.) to derive the vertical parameter, σ_z . Mobile sampling techniques can be utilized to accomplish the same thing by traversing along the arcs instead of measuring at 30 to 50 stationary points along the arcs.

In complicated terrain, plume patterns become distorted and a regular pattern may not be observed. Crosswind traversing is probably not possible either. Therefore, for additional guidance in these situations, the vertical sensing capability becomes more important; the total burden aloft over a point can indicate whether high concentrations will be found farther downwind.

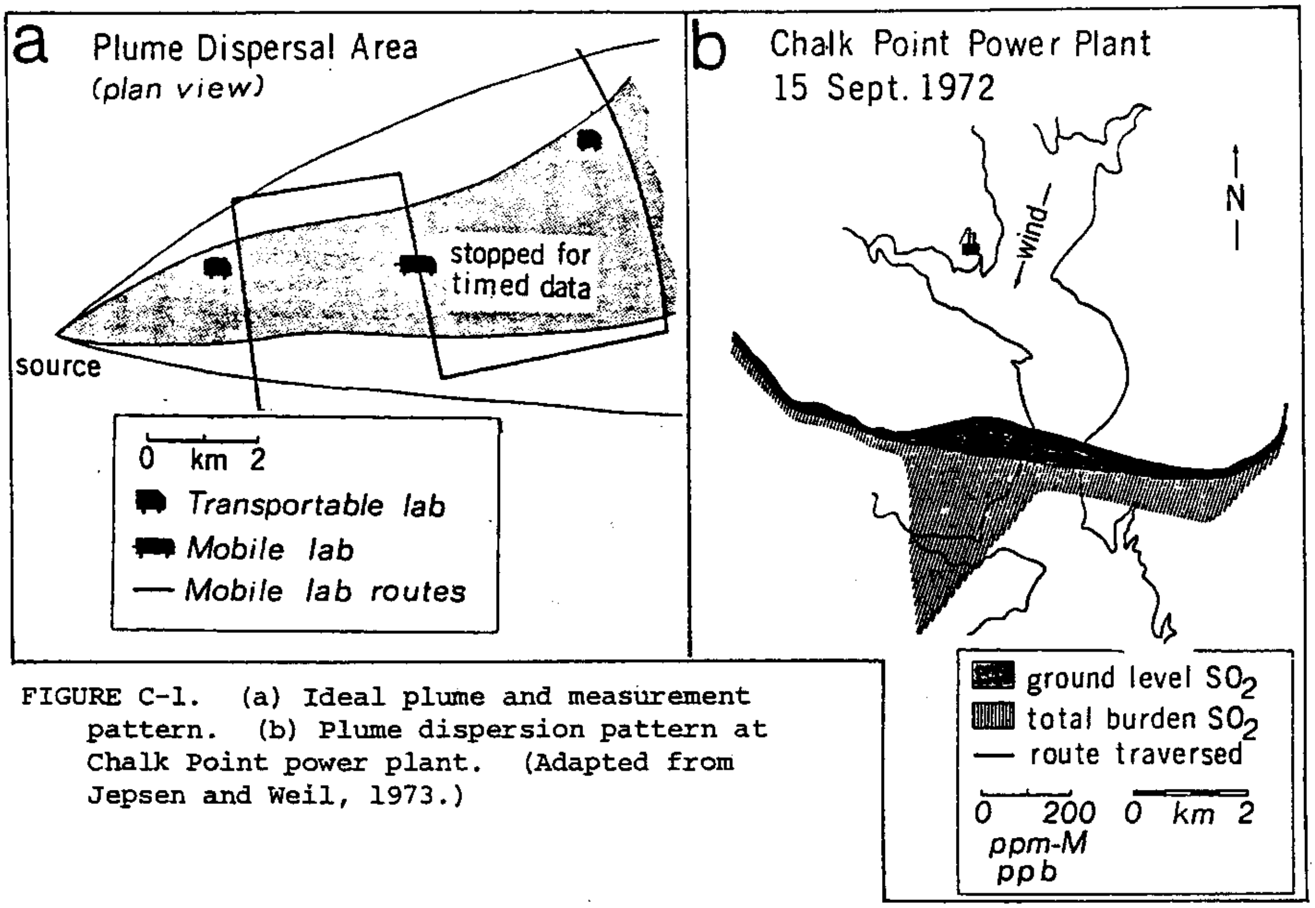


FIGURE C-1. (a) Ideal plume and measurement pattern. (b) Plume dispersion pattern at Chalk Point power plant. (Adapted from Jepsen and Weil, 1973.)

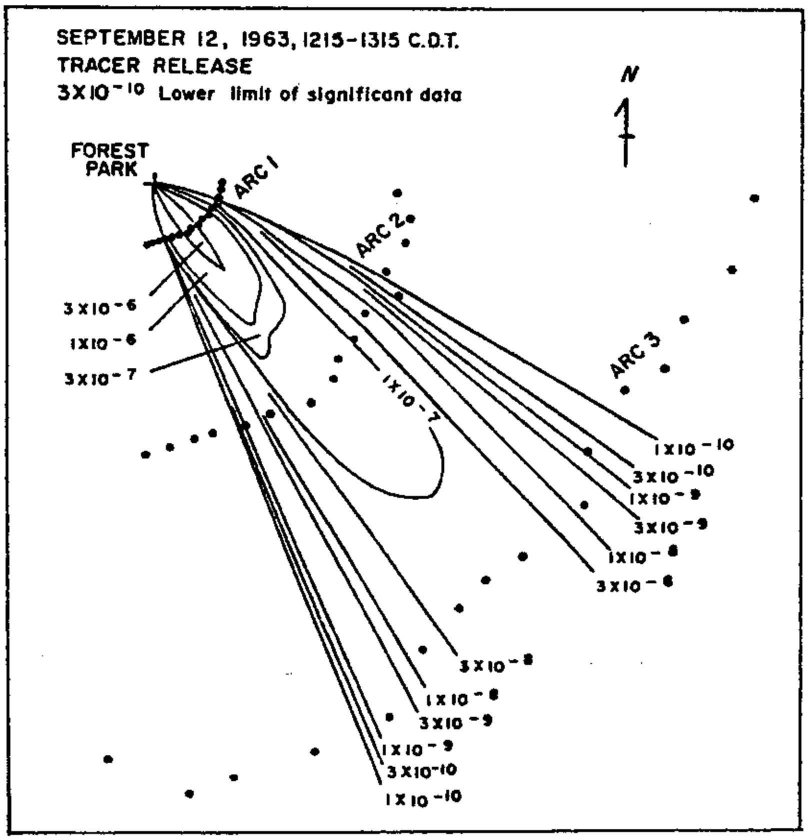


FIGURE C-2.

Ground-level pattern downwind of point source: Pattern of relative concentration, in grams per cubic meter (indicated by dots), for a daytime tracer experiment with steady winds (concentrations based on emission rate of 1 gram per second).
(Taken from Martin, et al., 1967.)

A P P E N D I X *

D

SOURCES OF LAND-USE AND TOPOGRAPHICAL INFORMATION

(adapted from Ludwig and Kealoha, 1975)

* All references found in this appendix are listed in Section 6.0 (References) of the main text.

D. SOURCES OF LAND-USE AND TOPOGRAPHICAL INFORMATION

The extent and availability of land use data is dependent on the specific area under study and what one chooses to call "land-use information". The more formal information can be obtained at different levels of government. Some states have developed sizable data bases as an aid in generalized state planning (i.e., Connecticut, Florida, Hawaii, Maine, and Vermont). The majority of states, however, are just beginning the information gathering process. Land-use information for nonurban areas is best obtained from State Planning and regional agencies.

Regional planning agencies (e.g., the Denver Council of Governments in Colorado, Southeastern Virginia, Planning District Commission, and the Comprehensive Planning Organization in San Diego) can be excellent sources of information. These regional agencies gather socioeconomic, existing land-use, and transportation data. Comprehensive regional plans can then be prepared to provide projections of long range demographic growth and land use.

Cities and counties will usually have current, readily available data on population, employment, existing and projected land use, general development plans, and zoning regulations. Also, they will be able to provide basic transportation information and maps of major arterials and proposed thoroughfares.

In cities with schools of urban and regional planning, planning professors can help the researcher meet specific needs. Also, their libraries can be researched for applicable graduate and doctoral theses which are frequently case studies of the immediate vicinity.

There are other sources of land-use information that are not specifically directed to the topic. Good maps or aerial photographs can provide a lot of useful information that may not be available from conventional land use sources. Useful sources of information for the United States are discussed next.

D.1 U.S. BUREAU OF THE CENSUS

Demographic and socioeconomic information of use to planners is available from the Department of the Census. Data developed by census tracts can be used to answer questions regarding a neighborhood's population and characteristics. Census tract information can be outdated, so it should be supplemented by material developed by the city, county, or regional planning bodies.

D.2 U.S. GEOLOGICAL SURVEY (USGS)

D.2.1 Topographic Maps

Topographic maps portray man-made and natural features, and the shape and elevation of the terrain. The usefulness of topographic maps is revealed in their accuracy, availability, economy, and wealth of detail. All maps are classified according to scale. The map scale expresses a ratio between the features shown on the map and the same features on the earth's surface. A scale of 1:24,000 states that one unit on the map represents 24,000 units on the ground. Figure D-1 is an example of three maps scales of the same area showing the type of information that is available in large, medium, and small scale maps. Table D-1 is a summary of the principal maps and their essential characteristics. A booklet describing topographic maps and symbols is available free upon request from the Geological survey. To order maps of a specific area, first obtain a state index map by asking for the "Index to Topographic Maps of (state)." An order form is included with each index as well as a list of local merchants that may stock topographic maps. Map reference facilities are also maintained in many public libraries. All maps for areas west of the Mississippi may be purchased by mail or over the counter from:

- Distribution Section
  U.S. Geological Survey
  Federal Center
  Denver, Colorado 80225

And for areas east of the Mississippi:

- Distribution Section USGS
  1200 S. Eads Street
  Arlington, Virginia 33303

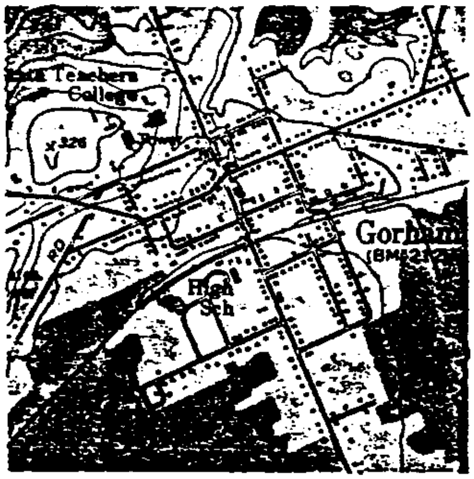
D.2.2 Photoimage Maps

Photoimage maps are available in the 1:24,000 scale. These are a new standard product called the orthophotoquad maps. An orthophotoquad portrays by aerial photoimagery a wealth of detail not found in conventional line maps. Yet there is the same positional accuracy as in standard topographic maps. Orthophotoquads are reproduced in black and white as photographic, diazo, or lithographic copies. Diazo or lithographic products are comparable in price with 7.5 minute topographic maps. To obtain an index of orthophotoquad availability, contact the:

- National Cartographic Information Center (703) 860-6045
  U.S. Geological Survey
  National Center, Stop 507
  Reston, Virginia 22092

Figure D-2 shows a portion of the orthophotquad index, legend, and a coded portion of the state of Florida (USGS, 1974).

(a) LARGE SCALE



1:24,000 scale,
1 inch = 2000 feet
Area shown,
1 square mile

(b) MEDIUM SCALE

1:62,500 scale,
1 inch = nearly 1 mile
Area shown,
6-3/4 square miles

(c) SMALL SCALE

1:250,000 scale,
1 inch = nearly 4 miles
Area shown,
107 square miles

FIGURE D-1. An example of the informational content of the large (a), medium (b), and small scale (c) topographic map. (Taken from USGS, 1969.)

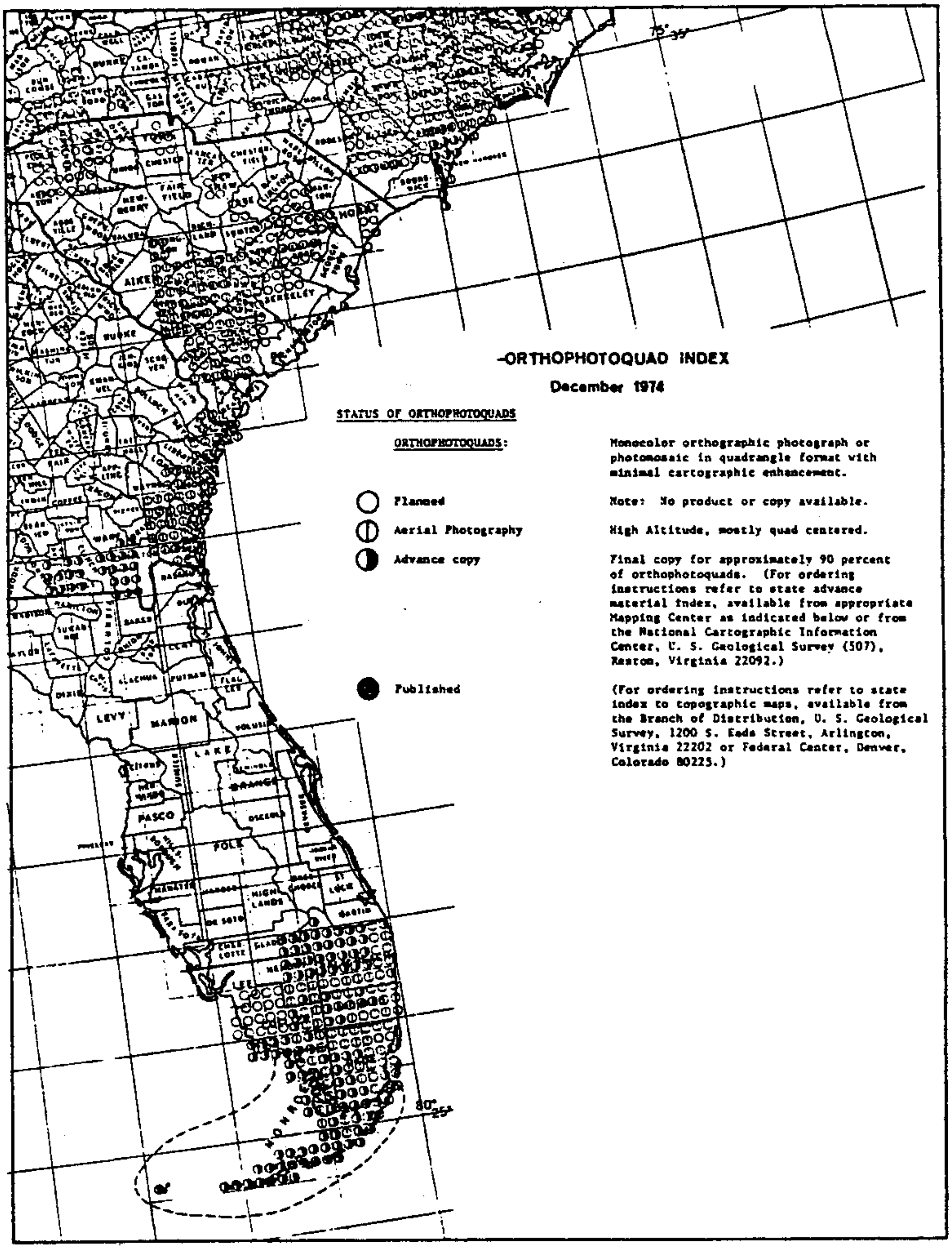


FIGURE D-2. A portion of the orthophotoquad index showing the legend and a portion of the state of Florida.

TABLE D-1

National Topographic Maps
(taken from USGC, 1969)

Series	Scale	1 inch represents	Standard quadrangle size (latitude-longitude)	Quadrangle area (square miles)	Paper size E-W N-S width length (inches)
7½-minute	1:24,000	2,000 feet	7½×7½ min.	49 to 70	[1] 22×27
Puerto Rico 7½-minute	1:20,000	about 1,667 feet	7½×7½ min.	71	29½×32½
15-minute	1:62,500	nearly 1 mile	15×15 min.	197 to 282	[1] 17×21
Alaska 1:63,360	1:63,360	1 mile	15×20 to 36 min.	207 to 281	[2] 18×21
U.S. 1:250,000	1:250,000	nearly 4 miles	[3] 1°×2°	4,580 to 8,669	[4] 34×22
U.S. 1:1,000,000	1:1,000,000	nearly 16 miles	[3] 4°×6°	73,734 to 102,759	27×27

[1] South of latitude 31° 7½-minute sheets are 23 × 27 inches; 15-minute sheets are 18 × 21 inches.
[2] South of latitude 62° sheets are 17 × 21 inches.
[3] Maps of Alaska and Hawaii vary from these standards.
[4] North of latitude 42° sheets are 29 × 22 inches. Alaska sheets are 30 × 23 inches.

D.2.3 Earth Resources Technology Satellite

The Earth Resources Technology Satellite (ERTS) has the multi-spectral sensors on board that "photograph" the earth's surface in the visible through near-infrared range. The potential of such a capability for land-use mapping, updating, and projection is currently a subject of extensive study. The images received from the satellite are available for sale as individual frames each covering an area approximately 1000 × 100 nautical miles with a 10 percent overlap along the spacecraft track. Table D-2 lists the picture products available from ERTS.

TABLE D-2

Picture Products Available from ERTS
(adapted from EDCDM Form 6)

Image Size	Scale	Material
70 mm (contact size)	1:3,369,000	Resin coated paper, film positive or negative
7½ × 7½ inches	1:1,000,000	Resin coated paper
15 × 15 inches	1:500,000	Resin coated paper
30 × 30 inches	1:250,000	Resin coated paper

For more information, contact the ERTS Data Center, Sioux Falls, S.D., tel. (605) 339-2270. The ERTS Data Center has substantial holdings of images acquired by aircraft throughout the United States. They invite inquire regarding availability of suitable coverage of your area of interest (USGSEDC).

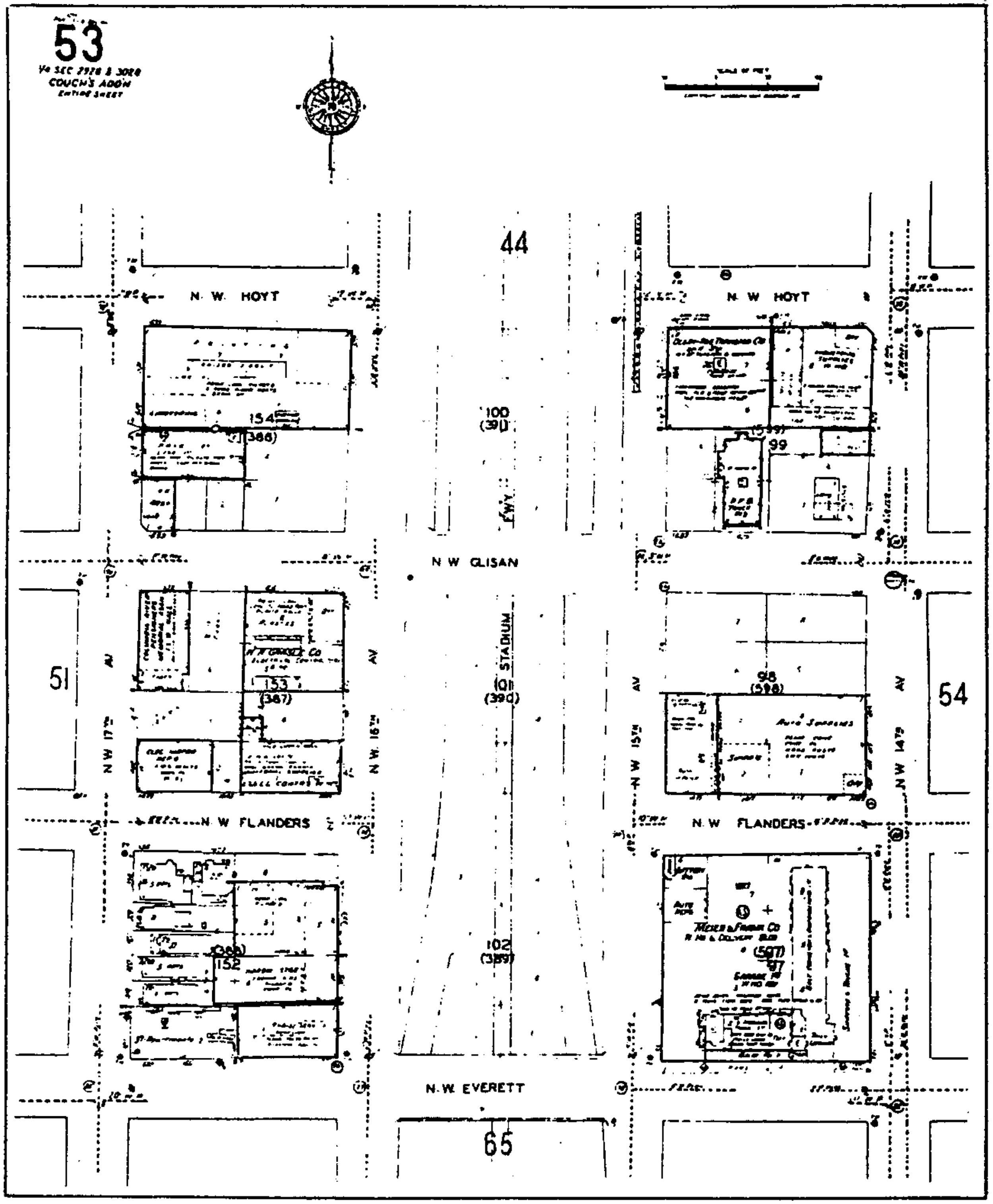


FIGURE D-3. A Sanborn map for a section of Portland, Oregon.

D.2.4 Sanborn Maps

Sanborn maps are land use maps prepared by the Sanborn Map Company. They are plotted to a scale of 1 inch to either 50 or 100 feet showing details such as streets, railroad tracks, lot lines, building dimensions, nature of the building material, number of stories, height of the building, and use of the building. Sanborn maps are used primarily for fire insurance purposes. Local sources may be fire insurance offices, realtors offices, city planning, and the county courthouse. For information, contact:

- The Sanborn Map Company, Inc.
  629 5th Avenue
  Pelham, New York 10803
  ATTN: G. Greeley Wells
  Tel. (914) 738-1649

Figure D-3 is an example of a Sanborn map for a section of Portland, Oregon.

APPENDIX*

E

AVAILABLE AIR QUALITY SIMULATION MODELS APPROPRIATE FOR SO_2 MONITOR SITING ACTIVITIES

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* All references found in this appendix are listed in Section 6.0 (References) of the main text.

E. AVAILABLE AIR QUALITY SIMULATION MODELS APPROPRIATE FOR SO_2 MONITOR SITING ACTIVITIES

This Appendix briefly describes several air quality simulation models that are appropriate for use in determining approximate locations for SO_2 monitors. Most have been widely used by government agencies and private groups for routine source impact assessments and control strategy evaluations. The model descriptions presented below were abstracted from user manuals or from other sources as indicated.

E.1 AIR QUALITY DISPLAY MODEL (abstracted from EPA, 1974e)

The Air Quality Display Model (AQDM) is a Gaussian plume urban dispersion model which is best used to determine the impact of a wide variety of stationary source classes on annual average concentrations of SO_2 and TSP. Short-term averages and single source assessments may also be obtained. The model has been applied to many multi-source urban areas with a high degree of success.

The model is based on the standard long-term concentration equation:

$$\chi(x,\theta) = \sum_S \sum_N \left\{ \frac{2Q\ f\ (\theta,S,N)}{\sqrt{2\pi}\ \sigma_{zS}\ u_N\left(\frac{2\pi\ x}{16}\right)} \exp\left[-\frac{1}{2}\left(\frac{H_u}{\sigma_{zS}}\right)^2\right] \right\} \qquad \text{(E-1)}$$

where $f(\theta,S,N)$ is frequency during the period of interest that the wind is from direction θ , for the stability condition S , and the wind speed class N ; and

- σ_{zS} is the vertical dispersion parameter evaluated at the distance x for the stability condition S ;
- u_N is the representative wind speed for class N ;
- H_u is the effective height of release for the wind speed u_N .

The model is used to determine the impact of all sources at a given receptor for a given set of meteorological conditions. It then weights this concentration by the frequency with which that particular set of meteorological conditions occurs and then sums over all meteorological conditions, thus producing a long-term average concentration. Basic inputs to the model are a comprehensive emissions inventory including both point sources and area sources. Meteorological input is a joint frequency distribution of wind speed (6 classes), wind direction (16 cardinal points), and stability class (Pasquill classes A-E) along with an annual average mixing height. The dispersion model can be used to estimate concentrations at any point downwind that is specified. Up to 1000 sources may be specified and concentrations may be calculated for up to 237 receptors. Although the original model did not contain a decay term, such a term can be easily incorporated. The AQDM produces a source contribution file which allows the impact of each individual source on air quality to be obtained. The AQDM is available from the National Technical Information Service (NTIS), NTIS PB 189 194.

E.2 EPA SINGLE SOURCE MODEL (unpublished EPA computer program; Meteorological Laboratory, 1972)

E.2.1 Basic Model

The model used to estimate ambient concentrations is one developed by the Meteorology Laboratory, EPA. This model is designed to estimate concentrations due to sources at a single location for averaging times from one hour to one year.

This model is a Gaussian plume model using diffusion coefficients suggested by Turner (1974). Concentrations are calculated for each hour of the year, from observations of wind direction (in increments of 10 degrees), wind speed, mixing height, and atmospheric stability. The atmospheric stability is derived by the Pasquill classification method as described by Turner (1974). In the application of this model, all pollutants are considered to display the dispersion behavior of non-reactive gases.

Meteorological data for 1964 are used as input to the model. The reasons for this choice are: (a) data from earlier years did not have sufficient resolution in the wind direction; and (b) data from subsequent years are readily available on magnetic tape only for every third hour.

Mixing height data are obtained from the twice-a-day upper air observations made at the most representative upper air station. Hourly mixing heights are estimated by the model using an objective interpolation scheme.

Calculations are made for 180 receptors (at 36 azimuths and five selectable distances from the source). The model used here can consider both diurnal and seasonal variations in the source. Separate variation factors can be applied on a monthly basis to account for seasonal fluctuations and on a hourly basis to account for diurnal variations. Another feature of the model is the ability to compute frequency distributions for concentrations of any averaging period over the course of a year. Percentages of various ranges in pollutant concentrations are calculated.

E.2.2 Complex Terrain Options

E.2.2.1 Terrain Elevations Below Plume Height

To simulate the effect of moderately elevated terrain in the vicinity of a plant, an optional form of the basic model may be used. This optional modeling program uses a terrain adjustment procedure which considers the difference between the plant elevation and the elevation at each receptor. Ground elevations on 10 degree radials as well as points of maximum elevation are determined from USGS quadrangle maps. The diffusion model then uses the difference between the plant elevation and receptor elevation to modify the effective stack height and thereby adjust the predicted concentrations.

E.2.2.2 Terrain Elevation Above Plume Height

In higher relief areas, the topography at certain plant sites is above the calculated plume height for at least one stack at the plant. In this case, an alternate model is used. The model used to estimate short-term concentrations is these situations is one previously developed by EPA for application to sources located in complex terrain (Valley Model). Elevations of receptor sites are derived from the USGS quadrangle maps of the area. The model calculates a daily average concentration at these receptor locations based on a 10 meter nearest-approach point of the plume and an assured persistence of meteorological conditions for 6 hours out of the 24 hours. During this period, the wind direction is assumed to be confined to a 22.5 degree sector. The model assumes stability class "E" and a wind speed of 2.5 m/sec. The plume is uniformly distributed horizontally over the 22.5 degree sector.

E.3 UNAMAP* MODELS PTMAX, PTDIS, AND PTMPT (abstracted from Hosler, 1975)

These models calculate hourly averaged concentrations resulting from point source emissions. Each model provides a different set of options for the user.

E.3.1 PTMAX

PTMAX is a computer program that performs an analysis of the maximum short-term concentration from a single point source as a function of stability and wind speed. A separate analysis is made for each stack. Required inputs

* Users Network for Applied Models of Air Pollution, a library of air quality simulation models stored at EPA's Computer Center at Research Triangle Park, N.C.; also available on tape via NTIS (Accession Number PB 229 771).

to the program include ambient air temperature, emission rate, physical stack height, and stack temperature; either stack gas volume flow or both the stack gas velocity and inside diameter at the top are required. The program computes effective height of emission, maximum ground level concentration, and distances of maximum concentration for each condition of stability and wind speed.

E.3.2 PTDIS

PTDIS is a computer program that calculates downwind ground-level concentrations for various downwind distances for specified meteorology. Input requirements include both source and meteorological conditions. The primary output of the program consists of a table with height of emission, concentration for each downwind distance, and a relative concentration normalized for wind speed and source strength. An optional feature of the program allows the user to enter a value of concentration to be used for the determination of half-width isopleths; for each distance, if the concentration exceeds the stated isopleth value, the half-width of an isopleth will be determined. The half-width will be compared in the form of a ratio to the half-width of a sector of given angular size in terms of degrees. The user is given the option of either specifying effective height of emission or having it calculated using Briggs' plume rise methods.

E.3.3 PTMPT

PTMTP calculates hourly concentrations at up to 30 receptors whose locations are specified from up to 25 point sources. Required inputs to the program consist of the number of sources to be considered, the emission rate, physical height, stack gas temperature, volume flow or stack gas velocity and diameter, and the stack locations, in coordinates. The number of receptors, the coordinates of each, and the height above ground are required. Concentrations for a number of hours up to 24 can be estimated, and an average concentration over this time period is calculated. The hourly meteorological information required consists of wind direction and speed, stability class, mixing height, and ambient air temperature.