EPA-450/4-84-010

DRAFT

PROCEDURES FOR ESTIMATING PROBABILITY OF NONATTAINMENT OF A PM_{10} NAAQS USING TOTAL SUSPENDED PARTICULATE OR INHALABLE PARTICULATE DATA

by

Thompson G. Pace
Air Management Technology Branch

and

Neil H. Frank
Monitoring and Reports Branch

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Monitoring and Data Analysis Division
Research Triangle Park, North Carolina 27711

February 1984

This report has been reviewed by The Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, and has been approved for publication. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use.

Technical Note

In order adequately to illustrate the procedure described in this report, it was necessary to assume a cutpoint and values for the annual and 24-hour NAAQS. The decision concerning the appropriate values for the NAAQS has not yet been made. We have arbitrarily chosen to illustrate the procedure, assuming values at the lower edge of the range of standards proposed by the Administrator. Should the Administrator choose to promulgate NAAQS different from those assumed in this report, several of the curves (i.e., Figures A, B, 3, and 4, and Table 1) may have to be revised. However, the procedure described herein would be similar. We have also included sets of curves applicable for other values of the proposed range of NAAQS. In applying the methodology, one would simply substitute these curves for their counterparts as indicated in the text.

U.S. Environmental Protection Agency

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The newly proposed National Ambient Air Quality Standards (NAAQS) for Particulate Matter (PM) specify ambient concentrations for particles smaller than 10 micrometer aerodynamic diameter (PM_{10}), as well as Total Suspended Particulates (TSP). Unless measured PM_{10} ambient concentrations are available, ambient measurements of other PM size fractions, such as Total Suspended Particulate or Inhalable Particulate (IP), which is an earlier terminology for PM < 15 μm aerodynamic diameter, must be used to provide estimates of PM_{10} concentrations. In this document, emphasis is placed on a methodology for using available TSP or IP measurements to estimate whether or not the annual and/or 24-hour NAAQS for PM_{10} are likely to be exceeded (probability of nonattainment). The document also suggests appropriate methods for determining the apatial extent of the nonattainment situations. It should be noted that further research is being done with the PM_{10} data which may affect the final version of this document.

The probability of nonattainment is defined by a series of calculations which are based on data from a nationwide network of collocated ambient TSP and IP samplers operated by or for the U.S. Environmental Protection Agency (EPA) during 1980-82. These data include TSP as measured by the high volume sampler and IP and PM_{10}, both as measured by the dichotomous sampler. Transition from IP to PM_{10} is based on data from a limited number of sites having collocated TSP, IP and PM_{10} samplers. The calculated probability represents the likelihood that either NAAQS for PM_{10} was violated at the sampling site. The probability of nonattainment will be one of the criteria which may be used to specify action States are to take in developing PM_{10} monitoring requirements and State Implementation Plans.

The following hierarchy is defined for using available ambient measurements to determine attainment/nonattainment directly or to estimate the probability of PM_{10} nonattainment. The first preference is to use ambient PM_{10} data, providing a site has complete sampling. PM_{10} data should be used if sufficient (i.e., with sampling every day with a 75% data capture [see Section 2.4 of proposed Appendix K to 40 CFR, Part 50]) data are available. The second preference is to use IP measurements obtained with a dichotomous sampler.* As described in this document, these measurements times a correction factor of 0.8 may be assumed equivalent to PM_{10}, and sufficient for attainment/nonattainment determination, providing at least one full year (every day sampling, 75% data capture) of IP data is available. Use of this constant correction factor is an interim procedure pending availability of more PM_{10} data. A third preference is to use PM_{10} or IP data with less complete sampling in conjunction with TSP data to draw inferences about PM_{10} nonattainment. The fourth preference is to use TSP data alone to draw inferences about the probability of PM_{10} nonattainment. Such inferences are drawn on the basis of IP and PM_{10} to TSP ratios observed at selected sites in the National IP Monitoring Network.

For the annual NAAQS, IP/TSP ratios are computed from arithmetic mean concentrations of IP and TSP at different sampling sites. These ratios are multiplied by 0.8 to convert IP to PM_{10}, thus obtaining site average PM_{10}/TSP

* If size selective hi volume samples were collected on quartz fiber filters, these concentrations may be treated as dichotomous sampler measurements. Otherwise, the use of the term IP in this document refers to those particles collected by the dichotomous sampler with a 15μ size discriminating inlet and teflon filters.

ratios. Frequency distributions of the resulting PM_{10}/TSP ratios have been plotted and used to derive figures such as Figure A. Using Figure A, the probability of nonattainment of the annual PM_{10} NAAQS can be estimated directly from the average TSP concentration for the most recent three complete years of sampling. An example is presented in Section 4.0.

In the case of 24-hour data, observed PM_{10}/TSP ratios have been used to derive a frequency distribution of ratios. This distribution is then used in conjunction with TSP data to estimate the likelihood of not attaining a 24-hour NAAQS for PM_{10}. For example, at sites sampling TSP less frequently than once every 3 days, these estimates are made using Figure B and equations (a) and (b).

$$P_o = \prod_{i=1}^{n} q_i \qquad \text{(a)}$$

where

P_o = probability of observing no PM_{10} concentrations greater than the level of the PM_{10} NAAQS

$q_i = (1-p_i)$ = the probability that an observed TSP value, TSP_i, does not correspond with a PM_{10} value greater than the level of the PM_{10} NAAQS

n = the number of TSP values greater than the level of the PM_{10} NAAQS

$\prod$ = multiplication symbol such that $\prod_{i=1}^{3} q_i = (q_1)(q_2)(q_3)$

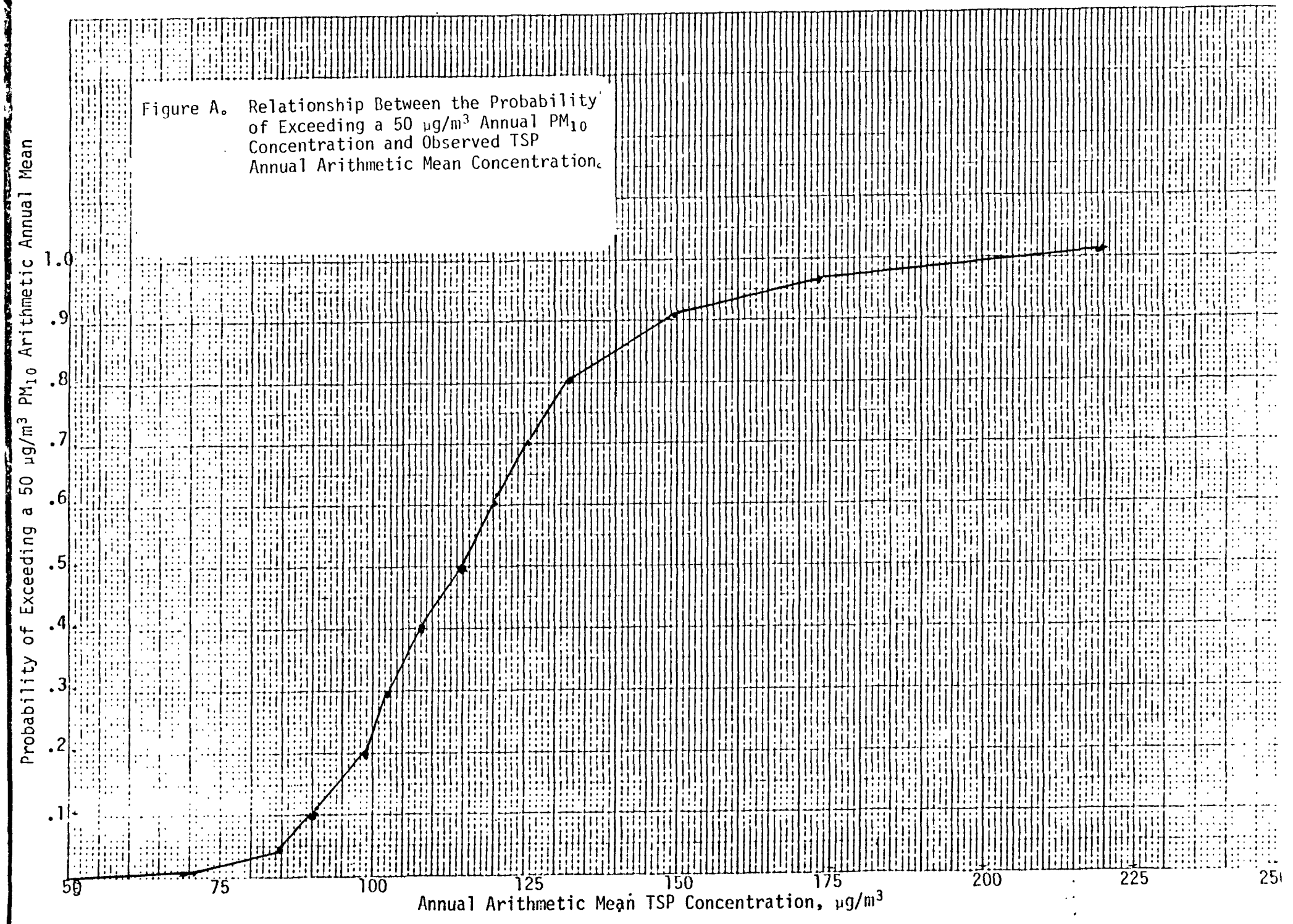
and

$$P_F(0) = 1 - P_o \qquad \text{(b)}$$

where

$P_F(0)$ = probability of failing the attainment test (i.e., observing one or more PM_{10} concentrations greater than the level of the PM_{10} NAAQS).

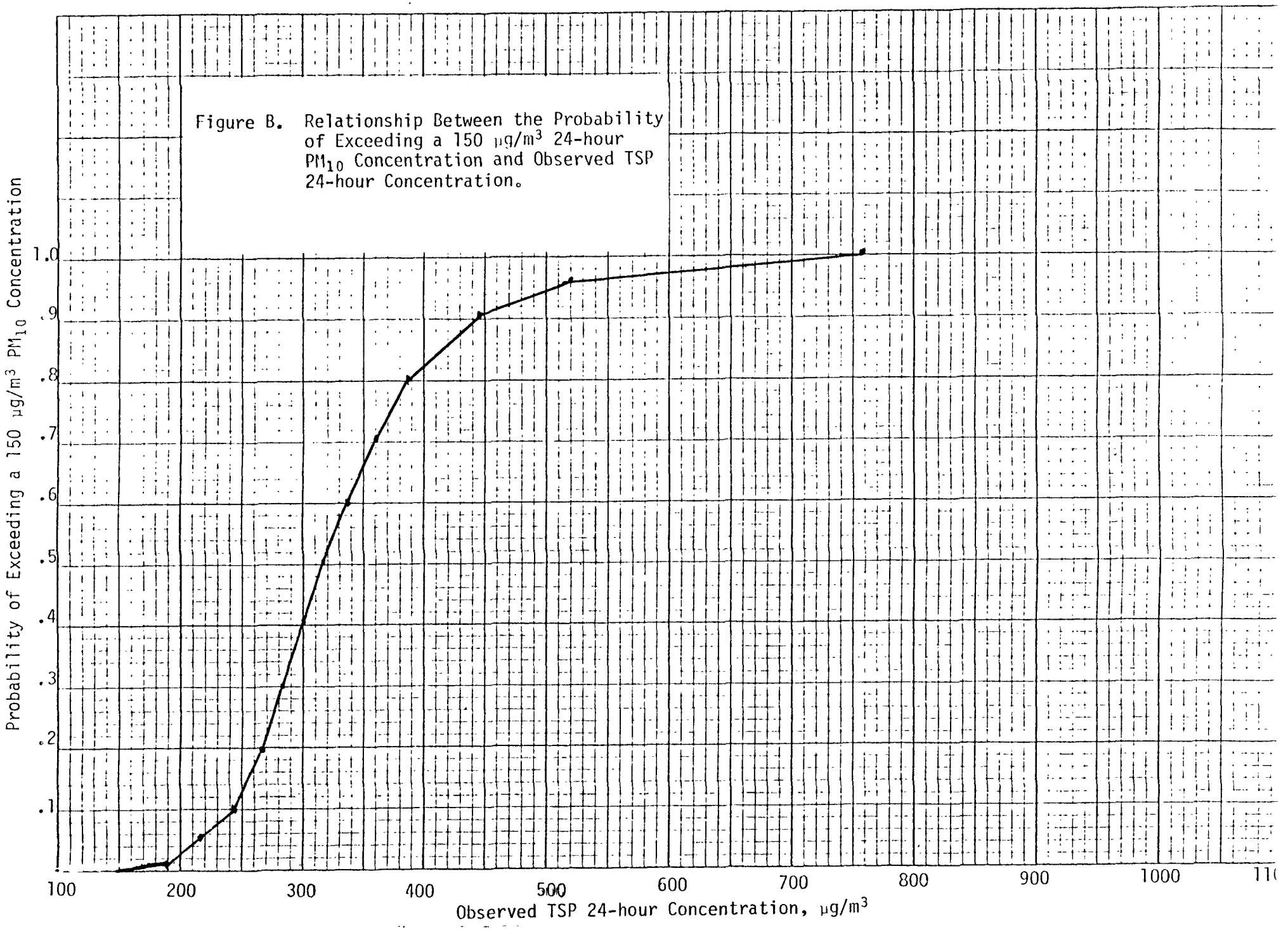
Figure A. Relationship Between the Probability of Exceeding a 50 μg/m³ Annual PM_{10} Concentration and Observed TSP Annual Arithmetic Mean Concentration.



As equation (a) suggests, for each 24-hour TSP concentration greater than 150 $\mu g/m^3$ there is an associated probability, p_i, that the corresponding PM_{10} concentration is also greater than the level of the NAAQS (i.e., 150 $\mu g/m^3$). This probability, p_i, is determined for each high TSP value by using Figure B. For example, if a site has three 24-hour TSP concentrations greater than 150 $\mu g/m^3$, Figure B is used three times to estimate the probabilities associated with each of the three high TSP values. The p_i determined from Figure B are then used in equation (a) to estimate the probability of observing no PM_{10} concentrations greater than the level of the PM_{10} NAAQS. For sites sampling less frequently than once every 3 days over a 3 year period or less, there can be no observed PM_{10} concentrations greater than the level of the PM_{10} NAAQS if the NAAQS is to be met. Hence, the probability of violating the PM_{10} NAAQS at a site is simply the probability of observing one or more PM_{10} concentrations greater than 150 $\mu g/m^3$ (i.e., the level of the NAAQS) at the site. This is simply the complement of observing no PM_{10} values above 150 $\mu g/m^3$, and is computed using equation (b). This is illustrated by Example 3 in the text.

If samples are collected at a site at least as frequently as once every 3 days over a 3 year period, the NAAQS does allow one or more PM_{10} concentrations greater than the level of the NAAQS to be observed. For example, if sampling occurred once every 2 days over a 3 year period, one observed exceedance would be allowed during the 3 year period. In this case, the probability that a site is not in compliance with the NAAQS is the probability of observing two or more PM_{10} concentrations greater than the level of the NAAQS, and is given by equation (c).

Figure B. Relationship Between the Probability of Exceeding a 150 µg/m³ 24-hour PM_{10} Concentration and Observed TSP 24-hour Concentration.



$$P_F(1) = 1 - (P_0 + P_1) \qquad (c)$$

where

$P_F(1)$ = probability of observing more than one PM_{10} concentration greater than the level of the NAAQS

P_1 = probability of observing one exceedance, as determined using procedures described in Section 5.2.2

Although the methodology is slightly more time consuming for sites sampling at least once every 3 days over a 3 year period, it is straightforward and is described in Section 5.2.2 and illustrated by Example 4 in the text.

As with the annual NAAQS, the 24-hour procedure is simplifed somewhat if ambient PM_{10} data exist. In this case, the estimated number of exceedances in a given year, E_i, is calculated by equation (d).

$$E_i = e_i\ (N)/n_i \qquad (d)$$

where

E_i = the estimated number of exceedances for year i

e_i = the observed number of exeedances for year i

n_i = the number of data values observed for year i

N = total number of possible values in a year (e.g., 365)

The estimated number of exceedances over a 3 year period would be based on the average of the E_i for each of the 3 years, as shown in Examples 1 and 2 in the text. If only one or two years of PM_{10} data are available, the methodology is discussed in the text and illustrated in Examples 5 and 6.

If a statistically defensible site-specific frequency distribution of PM_{10} to TSP ratios for the 24-hour NAAQS can be developed, it may be used.

Otherwise, the national distribution should be used for the years with TSP data. If IP (rather than PM_{10}) data are used, the IP/TSP ratios comprising the distribution are multiplied by the correction factor of 0.8. For both annual and 24-hour data, a site specific ratio or distribution can be based on a nearby, similar site. To do this, it must be demonstrated that the two sites are similar and that the ratio or distribution would be more applicable than the national distribution. Table A summarizes the use of national and site specific ratios and frequency distributions.

Determining the spatial extent of a nonattainment situation area requires subjective judgment. Three procedures are identified in Section 6.0 as useful in helping to arrive at this conclusion. These are:

(1) a qualitative analysis of the area of representativeness of the monitoring site, together with consideration of terrain, meteorology and sources of emissions;

(2) spatial interpolation of air quality monitoring data;

(3) air quality simulation by dispersion modeling.

Choice of which procedure or combination of procedures to use depends on the available information and the complexity of the PM_{10} problem area.

Table A. Summary of the Appropriate Use of National Frequency Distributions, Site Specific Ratios, Site Specific Frequency Distributions and Direct Use of PM_{10} and IP Data.

Data Available at Study Site for Year of Interest

Type of Data	Annual	24-Hour
PM_{10}	direct use of data*	direct use of data*
IP	convert data* to PM_{10} using IP x 0.8	convert data* to PM_{10} using IP x 0.8
TSP	national frequency distribution	national frequency distribution

Data From Study Site in Different Year or Data From Similar Site

Type of Data	Annual	24-Hour
PM_{10}	convert data at study site using $\frac{PM_{10}}{TSP}$ x (valid TSP mean at study site for the year of interest)	$\frac{PM_{10}}{TSP}$ used to develop site specific frequency distribution to replace national distribution**
IP	$\frac{IP}{TSP}$ x 0.8 x (valid TSP mean at study site for the year of interest)	$\frac{IP}{TSP}$ x 0.8 used to develop site-specific distribution to replace national frequency distribution*

---

* # years of data	Completeness Requirements for NAAQS Attainment Test (# of observations)	
	Annual	24-hour
1	274	274
2	48 (12/Qtr)	183
3	48 (12/Qtr)	48 (12/Qtr)

** Provided a statistically defensible site-specific distribution can be developed. If not, use national distribution.

1.0 INTRODUCTION

The promulgation of the National Ambient Air Quality Standard (NAAQS) for Particulate Matter (PM) will require the revision of State Implementation Plans (SIPs) to account for the new standards. Along with a secondary NAAQS applicable to Total Suspended Particulate (TSP), the revised standards include an annual and a 24-hour NAAQS specified in terms of PM nominally 10 micrometers and smaller in terms of aerodynamic diameter (PM_{10}).* Unfortunately, there are few measured data for this size fraction of PM. Other ambient data such as TSP and Inhalable Particulate (IP), which include PM_{10} but with larger particles as well, are available. The purpose of this document is to describe a methodology for using these data to estimate the probability of nonattainment of the annual and 24-hour NAAQS for PM_{10} at various sampling sites in the country. The probability estimates will be used in conjunction with the Environmental Protection Agency (EPA) policy to help define where certain actions will be required.

This document first discusses various measurement methods used to obtain the underlying rationale and methodologies for inferring ambient PM_{10} levels from available data. Methodologies for estimating the likelihood of not attaining PM_{10} NAAQS are presented, given ambient TSP data obtained with a high volume sampler. A procedure for estimating PM_{10} levels using IP data obtained with a dichotomous sampler** is also described. Finally, limitations of the above methodologies are identified.

---

* A method of specifying particle diameter which considers both physical diameter and particle density.

** In this document, the term IP is used to denote particulate data collected with a dichotomous sampler that has a 50% collection efficiency of 15 μm particles. If size selective hi-volume samples were collected on quartz fiber filters, these concentrations may be treated as dichotomous sampler measurements.

2.0 AVAILABLE AMBIENT PARTICULATE MATTER DATA

The most desirable way to determine nonattainment of the proposed PM_{10} NAAQS is to measure PM_{10} directly. Several monitoring instruments are currently under development and being tested by the EPA. These instruments appear promising for future use. Unfortunately, sufficient data collected by these instruments are not yet available at most locations. To minimize discontinuity in PM abatement efforts in locations where attainment of the new NAAQS may still be a problem, other ambient data must be used to direct abatement programs.

2.1 Total Suspended Particulate (TSP)

The most common measurement of PM concentration available is TSP, as measured by the high volume sampler (hi-vol).(1) The hi-vol is generally considered to measure PM less than 100 μm aerodynamic diameter, but the collection efficiency (ability to capture) the very large particles is very poor. With average wind speeds, the sampler is about 50% efficient in collecting particles of 25-45 μm aerodynamic diameter. Thus, the sampler is said to have a D_{50} of 30 μm, where D_{50} is the particle diameter for 50% collection efficiency. For the purpose of this discussion, the hi-vol is considered to capture 100% or all particles smaller than 10 μm.

The hi-vol is generally considered to have several deficiencies which can cause problems in data interpretation. The D_{50} is dependent on wind-speed and the orientation of the sampler. Also, the glass fiber filter has been shown to collect artifact sulfate of as much as 5 $\mu g/m^3$ or higher in high sulfate areas of the country.(2) Other artifact components such as

nitrate and organic particulates may be significant in some areas. Another problem is the design of the hi-vol inlet which allows particles to be blown into the shelter and settle onto the filter during periods when the sampler is not operating.(3) Despite these problems, the hi-vol has been the standard reference method for TSP for many years and a vast data base is available for immediate use in screening potential nonattainment areas. Basing PM_{10} estimates on empirically derived relationships between PM_{10} and TSP lessens the degree to which these problems affect the validity of the final designations.

2.2 Inhalable Particulate (IP)

The dichotomous sampler (DS) has been used in a national IP network of 164 sites operated by the U.S. EPA since 1979.(4,5) This network generally represents sites in urban areas with high concentrations. However, since these high sites are of the most interest in estimating nonattainment areas, the network is considered representative for the purpose of this document. A total of 254 site years (5733 IP observations) were used in this analysis.

IP data are collected by a dichotomous sampler whose inlet is designed to collect particles of 15 μm at 50% efficiency. The sampler separates the particles which pass through the inlet into two flowstreams (fine, <2.5 μm and coarse, 2.5-15 μm) and deposits them on two filters. However, wind tunnel tests of the inlet have shown that this sampler had a D_{50} of less than 15 μm at most windspeeds.(6)

Other potential problems which would bias reported IP results downward include internal wall losses (believed to be small) and the loss of particles from the coarse filter. This loss has been shown to occur on highly loaded filters during handling and shipment but is not believed to be a problem during routine network operation.(7)

2.3 PM_{10}

The national IP network also operated 39 sites equipped with dichotomous samplers measuring 10 μm. (Note: 19 site years of data (287 observations) are presently available for analysis. Further analysis will be made as data become available.) These samplers are identical to those IP samplers described above, except for the inlet which is designed to collect particles of 10 μm at 50% efficiency. In some cases the TSP, IP and PM_{10} samplers have been operated concurrently and in other cases the IP sampler has been discontinued and only TSP and PM_{10} continue to be collected.

3.0 USE OF AVAILABLE DATA TO DRAW INFERENCES ABOUT PM_{10} LEVELS

The EPA Inhalable Particulate Network mentioned previously offers an excellent data base on TSP, IP and PM_{10} at collocated sites.(8) These samplers were operated at 164 sites nationwide in the IP network, beginning as early as 1979 at some locations. The sites were located in urban and suburban locations to reflect maximum concentration and population exposure due to urban and industrial sources, and at nonurban sites to provide information on background levels. The data from these sites are used, to draw conclusions about relationships among PM_{10}, IP and TSP. Individual dichotomous sampler sites are listed in Appendix A.

The data used for investigation of the individual observations were collected from January 1980 - December 1982 and were those available in the data base on November 10, 1983. These data from the IP network were screened and validated by the EPA's Environmental Monitoring Systems Laboratory (EMSL). Six sites were deleted later, upon EMSL's recommendations.(9,10,11,12)

3.1 Ratio of PM_{10} and IP to TSP

The ratio of IP/TSP and PM_{10}/TSP was examined at the sites comprising the data base in the hope that a simple ratio could be calculated which would permit the direct adjustment of TSP and IP to PM_{10}.

In order to determine whether the variability in the number of observations at any site is likely to introduce any bias to subsequent calculations, observations in a given city were weighted by the proportion of observations with high TSP values in each city. Thus, if city A had 200 observations of which 20 corresponded with high TSP and city B had 100 observations with 20 corresponding high TSP values, ratios used from city B

to help derive a national distribution of IP/TSP ratios were weighted twice as heavily as those from city A. The ratios of IP to TSP were calculated for each 24-hour observation, and the mean of these 24-hour ratios was calculated for each site. The weighting scheme did not make any difference in the distribution of ratios, so it was not used in the preparation of the final distributions. Unfortunately, there was a high degree of variation in the value of the ratios. The high variability in these ratios is due in part to inter-site variability.

Several attempts have been made to find an explanatory site descriptor which could account for the disparity in the ratios among sites (i.e., inter-site variability). In the first attempt, such site descriptors as urban versus suburban were compared; however, no statistically significant difference was found. Geographic area (East, Southwest, West Coast, etc.) and site type (industrial, commercial or residential) likewise revealed insignificant differences in the ratios.(10) A more extensive investigation of geographic differences was then performed on the complete data base described above. Some geographic differences among individual sites were found, but the differences among larger groupings of sites were generally very small and difficult to explain on a physical basis. Geographic differences based on climatological factors could not be found. Because there were more IP sites and they have been in operation longer, the studies of geographic and climatological differences were made using IP/TSP ratios instead of the more limited PM_{10}/TSP data base. The results of attempts to identify geographical differences in the IP/TSP relationship on the complete data base have been documented in References 11 and 12.

These investigations conclude that unless sufficient data to calculate a site specific PM_{10}/TSP ratio are available, the existing data base does not justify use of different distributions of ratios for different parts of the country.

It was first suggested by Watson that the ratios may be dependent on TSP concentration. That is, sites or days with higher TSP concentrations have lower ratios.(12) This finding is potentially significant, because the days with high concentrations and the sites with high annual arithmetic mean concentrations are of most concern. Because ambient TSP must be greater than PM_{10}, only those sites with relatively high annual arithmetic mean TSP and/or 24-hour concentrations may exceed the PM_{10} NAAQS. Because the IP/TSP ratio may be dependent on the ambient level of TSP, and because only the high concentrations are of concern, Thrall and Burton made some preliminary calculations in which only sites with annual arithmetic mean TSP greater than 55 $\mu g/m^3$ were used in the site average analysis and only 24-hour concentrations greater than 150 $\mu g/m^3$ were used in the individual day analysis.(11) For concentrations above these values, the ratios appeared to stabilize and certaintly did not decrease appreciably over the range of concentrations available. In the most recent analysis, including another year of data and with additional screening of suspect high ratios at low concentrations, Thrall and Hudischewskyj concluded that there was no substantial difference associated with concentration and recommended that the larger (undifferentiated) data base be used.

The previously described investigations of geographic, climatological, concentration range or site type classifiers was an attempt to reduce or account for part of the variability in PM_{10} or IP to TSP ratios. As discussed

in Section 2.0, there are several issues associated with the precision of the TSP, IP and PM_{10} measurements which affect intra-site variance. These factors include windspeed dependence, weighing problems, artifact formation and sampler wall losses. Thus, the inter-site variance can potentially be eliminated by the use of site specific data, but the intra-site variance can only be partially reduced by careful operating procedures.

The previously described variance among IP/TSP or PM_{10}/TSP ratios suggests the need to examine the frequency distribution of ratios rather than relying on a single value for the ratio. The cumulative frequency distribution of IP/TSP is plotted in Figure 1 for site average (arithmetic mean) ratios. Unfortunately, there are not enough sites reporting PM_{10} data through 1982 to develop a distribution for the ratio of annual mean PM_{10} to annual mean TSP (i.e., PM_{10}/TSP). Section 3.2 provides an adjustment factor from IP to PM_{10} which allows us to derive a distribution for PM_{10}/TSP indirectly. The data are sufficient however to allow us to derive a distribution for PM_{10}/TSP for individual days. This distribution is presented in Figure 2. In Figures 1 and 2, the cumulative frequency of observed ratios below a given value may be read along the bottom axis. For example, from Figure 1 we see that the IP/TSP ratio is less than .69 in 90% of the cases observed. The upper axis in these figures represents the frequency of occurrence of ratios above a given value, which is the same as saying the frequency of exceeding a given ratio (PM_{10}/TSP). Upper axis values are simply complements of the corresponding lower axis values.

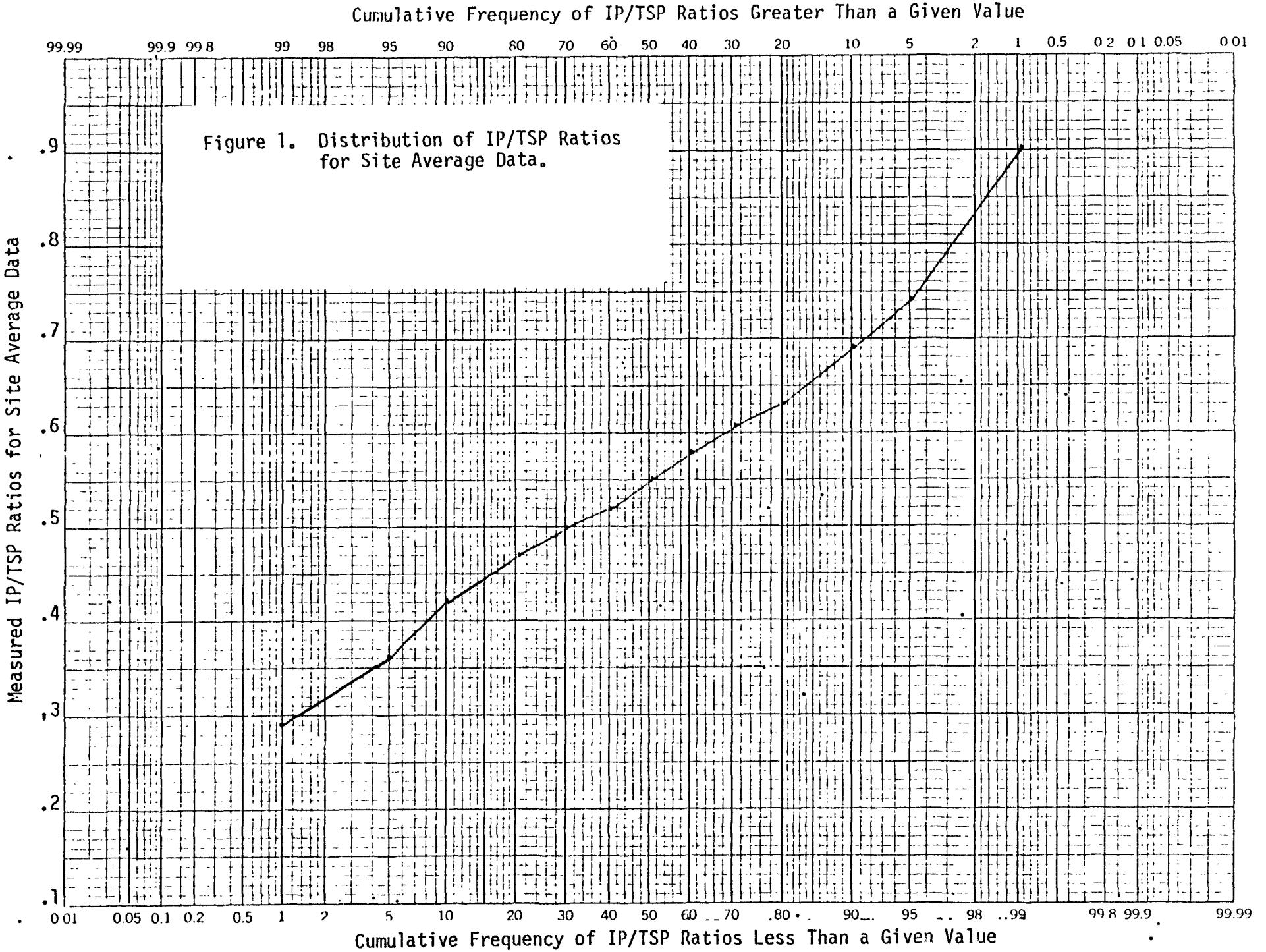


Figure 1. Distribution of IP/TSP Ratios for Site Average Data.

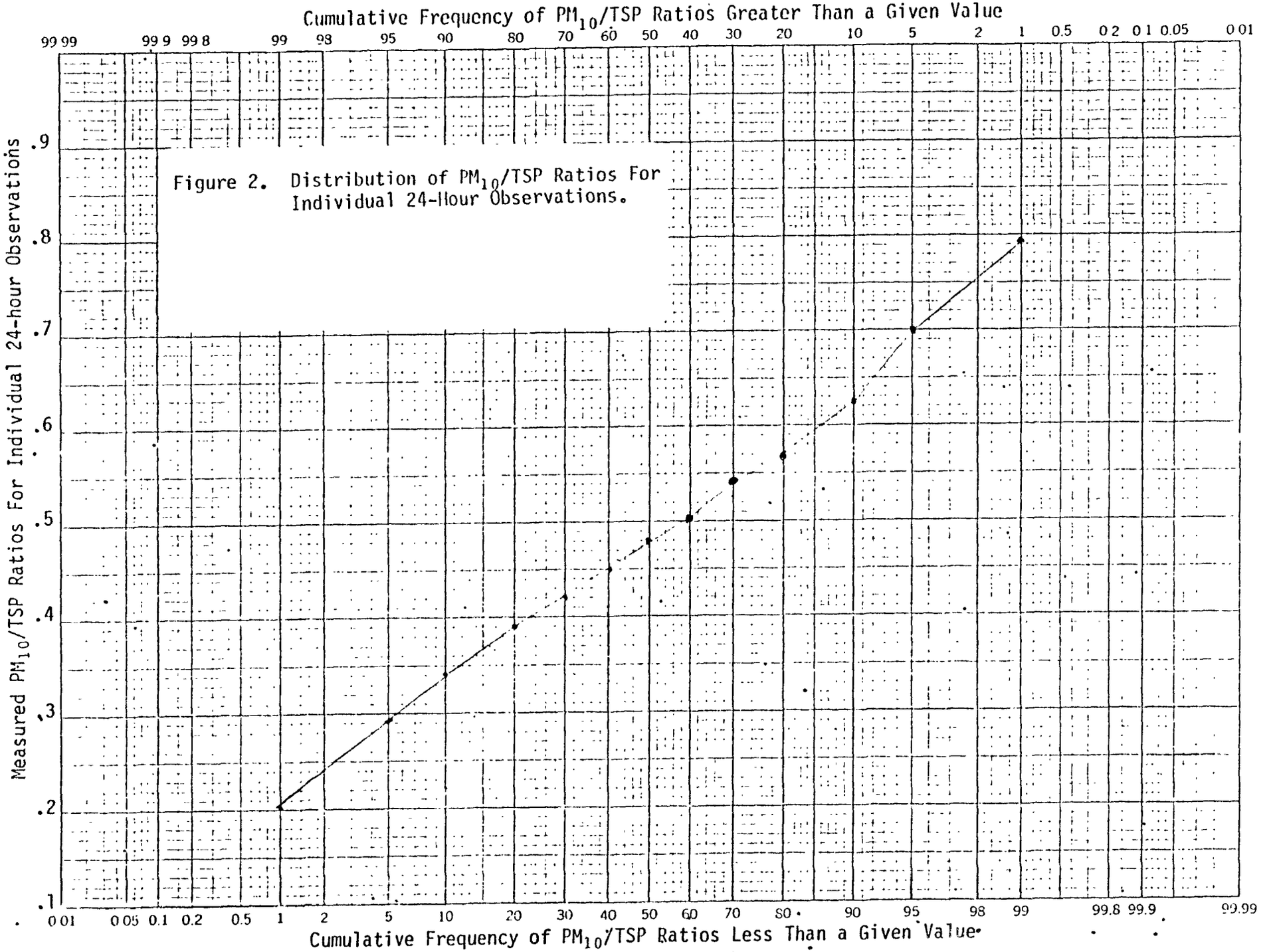


Figure 2. Distribution of PM_{10}/TSP Ratios For Individual 24-Hour Observations.

Another factor to consider is the development and use of site specific ratios or distributions for both annual and 24-hour cases. It seems logical that, if an area can justify a statistically different site or area specific distribution , its use should be encouraged. A site or area specific ratio of PM_{10}/IP or frequency distribution of PM_{10}/TSP may be developed if 1 year of PM_{10} or IP dichotomous sampler data is available. (Note: if the site specific data are IP instead of PM_{10}, each ratio of IP/TSP should be multiplied by an adjustment factor to obtain a PM_{10}/TSP ratio before plotting the site specific distribution.) A distribution based on another site in the area may be used only if it is demonstrated by an appropriate statistical procedure that the sites are similar and the specific distribution is a better representation of the data at that site than is the national distribution.

3.2 Ratio of PM_{10} to IP

Watson investigated the theoretical ratio of PM_{10} to IP collected by the dichotomous sampler for typical wind speeds. He found the ratios to be 0.9 for the dichotomous sampler rounded to one significant figure, based on a size distribution curve by Lundgren.(10) Actual data from collocated operation of 19 dichotomous samplers with 10 μm D_{50} inlets and 19 samplers with D_{50} 15 μm inlets were obtained from the EPA-IP network. Operation of these samplers began in January 1982. Analysis of data available thus far shows that the ratio of PM_{10}/IP is 0.8.(12) Ultimately, it may be possible to develop an annual mean PM_{10}/TSP frequency distribution for annual means by combining the IP/TSP and PM_{10}/DS distributions. However, this can not be done until the PM_{10} data base is much larger. As an interim, PM_{10}

concentrations may be approximated by multiplying IP values by 0.8 in the absence of measured PM_{10} data. In the event that ambient measurements were obtained using a size selective hi-volume sampler with quartz fiber filters, these measurements may be treated as IP dichotomous sampler measurements. The frequency distributions for IP/TSP in Figure 1 must be multiplied by 0.8 to give an estimate of the PM_{10}/TSP frequency distribution. This is in contrast to Figure 2 which depicts a distribution for PM_{10}/TSP ratios derived directly from a relatively large number of observed 24-hour concentrations of PM_{10} and TSP at collocated monitors.

4.0 METHODOLOGY FOR ESTIMATING THE PROBABILITY OF NONATTAINMENT FOR PM_{10} NAAQS - ANNUAL STANDARD

It is preferable to have sufficient ambient PM_{10} or IP data. The PM_{10} data may be used directly and the IP data (from a dichotomous sampler with a 15 μm inlet or a 15 μm size selective hi-vol with quartz filters) may be converted to PM_{10} by multiplying the IP by 0.8. However, the probability of nonattainment of one or both PM_{10} NAAQS can also be estimated for any location, given observed TSP data. The probability of not attaining the proposed annual standard, given annual arithmetic mean TSP data, is determined in a straightforward manner. A brief explanation and example are provided herein. Calculating the probability of not attaining the proposed 24-hour standard is more complicated. This requires a more detailed explanation, and will be discussed in Section 5.0.

It is possible to obtain an estimate of the probability of nonattainment of a 50 $\mu g/m^3$ level of the annual PM_{10} NAAQS by using annual arithmetic mean TSP data and the information in Figure 1. First, as previously discussed, we assume that the IP frequency distribution curve adjusted downward by 0.8 ($\overline{IP}/\overline{TSP}$ ratio x 0.8) is a reasonable approximation of the $\overline{PM_{10}}/\overline{TSP}$ frequency distribution. We can define TSP as:

$$TSP = \frac{\text{IP concentration}}{\text{IP/TSP ratio}}$$

substituting PM_{10} for IP,

$$TSP = \frac{PM_{10}\text{ concentration}}{\text{IP/TSP x 0.8}}$$

For any fixed level of PM_{10}, such as a proposed NAAQS for PM_{10} of 50 $\mu g/m^3$, the value of TSP which would correspond to a given probability of exceedance can be calculated. For example, in Figure 1 there is a 70% probability that the IP/TSP ratio will be greater than .50. Substituting into the above equation, a TSP concentration of 125 $\mu g/m^3$ is found. This is the TSP value that, if measured, would correspond to a 70% probability that the proposed PM_{10} NAAQS of 50 $\mu g/m^3$ would be exceeded. A series of these calculations was made to develop the plot in Figure 3.

The relationship in Figure 3 can be used to estimate the probability of nonattainment at any site with annual arithmetic mean TSP data. To use Figure 3, the average annual arithmetic mean TSP concentration is calculated for the site. The figure is entered for that TSP value and a corresponding probability of nonattainment is read. For example, if the average annual mean TSP were 150 $\mu g/m^3$, the probability of nonattainment would be .90 or 90%.

For the purpose of estimating the probability of nonattainment at a specific site, the average of the annual arithmetic means of the most recent three year's data should be used, if available. For example,

$$\overline{TSP} = \frac{(\overline{TSP})_{82} + (\overline{TSP})_{81} + (\overline{TSP})_{80}}{3} \qquad (1)$$

where $(\overline{TSP})_{82}$ is the <u>arithmetic</u> mean TSP concentration observed during 1982, $\mu g/m^3$, etc.

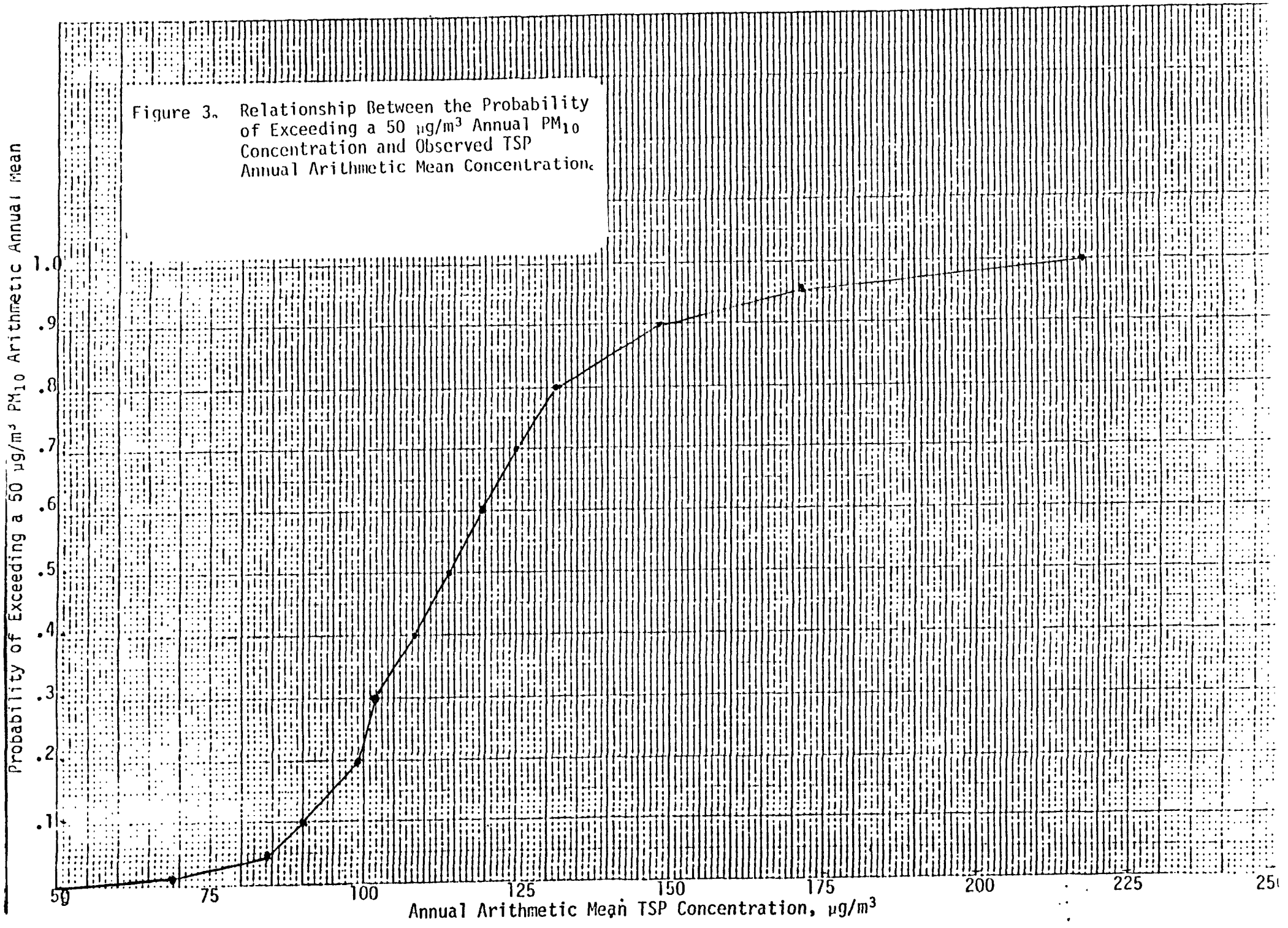


Figure 3. Relationship Between the Probability of Exceeding a 50 µg/m³ Annual PM_{10} Concentration and Observed TSP Annual Arithmetic Mean Concentration.

As an example, if the arithmetic mean TSP concentrations for the years 1980, 81 and 82 were 135, 142 and 158, the $\overline{TSP}$ would be (135 + 142 + 158)/3 = 145 $\mu g/m^3$. Figure 3 would indicate a 88% likelihood of exceeding an arithmetic mean PM_{10} NAAQS of 50 $\mu g/m^3$. This is quite different from a determination of the attainment status for the current annual TSP NAAQS. The current TSP NAAQS considers the geometric rather than arithmetic mean. Further, no probability calculation is required since direct measurements of TSP are available.

If a full year of valid data (i.e., at least 12 samples per quarter) of PM_{10} or IP is available, it may be used to develop a site specific ratio for PM_{10} to TSP. The IP data would be multiplied by 0.8. For example, if the IP measured 50 $\mu g/m^3$ annual arithmetic mean, the PM_{10} estimate would be 0.8 x 50 or 40 $\mu g/m^3$. The annual arithmetic mean should be computed by taking the mean of the quarterly mean concentrations as described in Appendix K to Part 50, Code of Federal Regulations (CFR).

The PM_{10} annual mean, divided by the annual mean of collocated and concurrent TSP data gives a site specific ratio which can be used to estimate PM_{10} for the two previous years. The mean of these PM_{10} estimates would be compared directly to the NAAQS and no probability estimate would be needed.

$$SSR_i = PM_{10i}/TSP$$
$$PM_{10i-1} = TSP_{i-1} \times SSR_i$$
$$PM_{10i-2} = TSP_{i-2} \times SSR_i$$

where

SSR_i = site specific ratio for the year available (i)

$PM_{10i-1,2}$ = the estimated PM_{10} annual mean for the preceding year(s), based on TSP in those years and the SSR

Thus, the PM_{10} for the three year's data would be

$$\overline{PM_{10}} = (PM_{10i} + PM_{10i-1} + PM_{10i-2})/3$$

In summary, the annual PM_{10} NAAQS attainment status may be estimated directly using PM_{10} data or by using IP data and multiplying the arithmetic mean by 0.8. The probability of nonattainment may be estimated using TSP data and the frequency distribution method described above.

The following steps apply in inferring PM_{10} levels at sites in which only TSP data are measured:

(1) calculate the average arithmetic mean TSP, as described in Appendix K to Part 50, Code of Federal Regulations;

(2) enter Figure 3 (for TSP) and read the corresponding probability of nonattainment of the annual arithmetic mean NAAQS for PM_{10}.

5.0 METHODOLOGY FOR ESTIMATING THE PROBABILITY OF NONATTAINMENT FOR PM_{10} NAAQS - 24-HOUR STANDARD

The 24-hour NAAQS for particulate matter (PM) specifies that the expected number of exceedances must be less than or equal to one per year. The attainment test consists of using monitoring data to estimate the average number of exceedances expected with complete sampling over a multi-year time period. The test specifies that the average number of estimated exceedances be rounded to the nearest tenth (.05 rounds up). Thus, an estimated number of 1.05 (which becomes 1.1) exceedances per year would be required in order to fail the attainment test. Although 3 years is recommended for the time period, 1 or 2 years may also be used if 3 years of data are not available.

During the transition stages of implementation of the PM_{10} NAAQS when actual PM_{10} monitoring data may not be available, assessment of attainment (probability of nonattainment) can be based on available TSP data. As PM_{10} monitoring is initiated, these data would also be incorporated into the nonattainment probability assessment. The following discussion addresses attainment/nonattainment assessment for three cases: (1) adequate PM_{10} data, (2) no PM_{10} data, and (3) some PM_{10} data.

5.1 Attainment Assessment Based on Adequate PM_{10} Data

If 3 years of PM_{10} data are available, the application of the attainment test is relatively straightforward. The approach consists of estimating the number of exceedances per year from the observed monitoring data and then averaging these estimates over a 3-year period. If 2 years

of PM_{10} data are available, this approach may also be considered. The data requirements for application of this procedure are described in Appendix K to CFR Part 50.

The formula for estimation of exceedances, E_i from a year of PM_{10} monitoring data is as follows:

$$E_i = e_i \times N / n_i \qquad (2)$$

where

E_i = the estimated number of exceedances for year i, assuming complete sampling

e_i = the observed number of exceedances for year i

n_i = the number of data values observed in year i, and

N = the total number of possible values in year (e.g., 365)

Note that E_i is also called the estimated exceedance rate.

Example 1

In 1980, a hypothetical site measured 49 PM_{10} values. Two exceedances of the level of the NAAQS were observed. The recorded concentrations were 220 and 260 $\mu g/m^3$. The estimated number of exceedances is calculated using equation (2) as

$$E_{80} = (2) \times (365) / 49 = 14.9$$

Note that the concentration magnitudes of the observed exceedances were not considered. The magnitudes would be important, however, when the amount of required control is evaluated.

The estimated number of exceedances over a 3-year period would be based on the average of the estimated number of exceedances for each year. If the numbers of estimated exceedances (E_i) for three successive years were 7.1, 0, and 14.9, respectively, then the average number of estimated exceedances, rounded to the nearest tenth, would be 7.3. Since 7.3 is greater than 1.0, this site would fail the attainment test.

Although attainment of the 24-hour expected exceedance NAAQS can be determined in terms of the average number of estimated exceedances (as in the above example), the attainment test can also be done in terms of an allowable number of observed exceedances for a specific number of sampling days.

The number of allowable observed exceedances over 3 years as a function of sample size, (i.e., combined 1, 2 or 3 year sample size), is shown in Table 1. With the use of this table, it is assumed that the sampling rates are similar in each year. For the once in 6-day sampling rate historically applied to TSP, 0 exceedances would be allowed in 1, 2 or even 3 years of sampling data. This follows because a site with a sample size as small as 183 (i.e., 3 x 61 samples/year) would fail the attainment test if it had 1 or more observations greater than the level of the NAAQS, according to Table 1.

Example 2

As stated in Example 1, two exceedances were observed for a site in 1980 that sampled 49 PM_{10} values. Suppose that in the two preceding years,

TABLE 1. Allowable Observed Exceedances As A Function Of Sample Size For A One Expected Exceedance Standard.

Allowable Number of Observed Exceedances	Sample Size, Observations in 1-3 Years
0	< 347
1	348- 695
2	696-1042
3	1043-1096

1 and 0 PM_{10} exceedances were observed and that the number of sampling days was 55 in both of these years. For the 3 years, there was a total sample size of 159 observations and from Table 1, we see that no exceedances are allowed at this sampling rate. Thus, the three observed exceedances cause a failure of the attainment test.

5.2 Attainment Assessment Without PM_{10} Data

Unlike the 'yes-no' situation with actual PM_{10} monitoring data, the failure of the PM_{10} attainment test using TSP data will be expressed as a probability. This probability will take into account the chance of a PM_{10} NAAQS exceedance on each TSP sampling day. The probability of failure is defined in terms of the likelihood of observing more than the number of allowable PM_{10} NAAQS exceedances. The conditions specifying failure of the attainment test depend on TSP sampling frequency as outlined in Section 5.1 (see Table 1).

The chances of a PM_{10} NAAQS exceedance on each TSP sampling day is derived from the estimated probability distribution of the relative PM_{10} portion of TSP (Figure 2). This distribution specifies the probability that the PM_{10} portion of the TSP would have exceeded a stated fraction. For a specific TSP concentration, these ratio probabilities translate into the probability that the concentration of the PM_{10} portion of the TSP would have exceeded a given PM_{10} concentration level. A curve of "exceedance" probabilities for a PM_{10} concentration $\geq$ 150 $\mu g/m^3$ is shown in Figure 4.

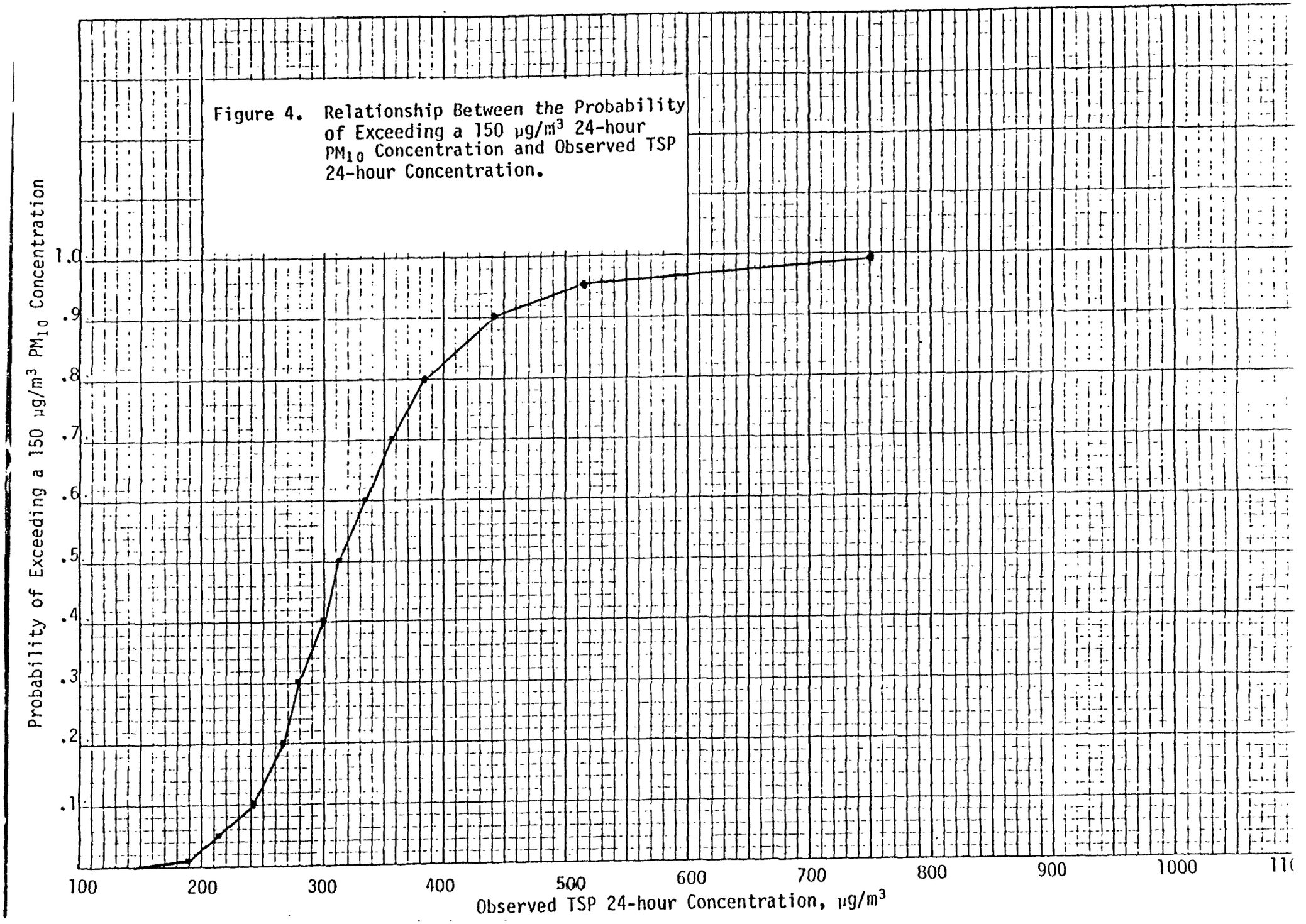


Figure 4. Relationship Between the Probability of Exceeding a 150 µg/m³ 24-hour PM_{10} Concentration and Observed TSP 24-hour Concentration.

5.2.1 Failing the Attainment Test for Sites Sampling Less Frequently Than Once in Three Days

The probability of failing the attainment test is defined as the probability of observing more than the allowable number of exceedances. Typically, TSP monitoring sites sample on a once in 6 day schedule and thus the number of TSP samples is usually less than 61 per year or 183 over a 3 year period. For these and other sites producing fewer than 348 observations in 1 to 3 years, the probability of failing the attainment test is the probability of observing zero PM_{10} exceedances over the sampling time period (from Table 1). If p_i represents the PM_{10} exceedance probability for the ith TSP sample, then the probability, P_0, of observing no allowable exceedances is

$$P_0 = \prod_{i=1}^{n} q_i \qquad (3)$$

where $q_i = 1-p_i$ (the probability that an observed TSP value, TSP_i, does not correspond with a PM_{10} value greater than the level of the 24-hour PM_{10} standard), and

n = the number of TSP values greater than the level of the 24-hour PM_{10} standard.

The probability of failing the attainment test, based on no allowable exceedances, is

$$P_F(0) = 1-P_0 \qquad (4)$$

5.2.2 Failing the Attainment Test Based on Sampling Once in Three Days or More Frequently

If the TSP data were sampled once in 3 days (or more than 347 times in 3 years), then some exceedances may be allowed by the standard over a 3-year period. For example, with 600 TSP samples over a 3-year period, Table 1 indicates that 1 observed exceedance is allowed by the standard. For this situation, the failure probability is defined as the probability of observing more than 1 exceedance.

With 3 years of TSP data (sampling every day), up to three exceedances may be allowed (Table 1). Depending on TSP sample size, the failure probability may be defined as the probability of observing more than 1, 2 or 3 exceedances. These probability computations depend on the chance of observing exactly 1, 2 or 3 exceedances. The remainder of this section provides the equations for these calculations. Their use assumes that the annual TSP sampling rates are similar, as defined by the ranges in Table 1.

The probability of observing exactly 1 exceedance is

$$P_1 = P_0 \, C_1 \tag{5}$$

where P_0 is defined in equation (3) and

$$C_1 = \sum_{i=1}^{n} \left(\frac{p_i}{q_i} \right) \tag{6}$$

where p_i, q_i and n are also as defined in equation (3).

Example 3

In this example, the level of the PM_{10} NAAQS is assumed to be 150 $\mu g/m^3$. A hypothetical site began monitoring TSP in 1980. The relevant data for this site are as follow:

Year	Sample Size	Observed TSP Concentrations Greater Than 150 $\mu g/m^3$
1980	60	250
1981	50	290,200
1982	50	400,280

Using Figure 4, the PM_{10} exceedance probabilities for each TSP value are as follow:

TSP	PM_{10} Exceedance Probability
400	.82
290	.34
280	.30
250	.16
200	.03

Based on equation (3), the probability of observing no exceedance is

$$P_0 = (1-0.82)(1-0.34)\cdots(1-0.03), \text{ or}$$

$$P_0 = .0677$$

Using equation (4), the failure probability is

$$P_F(0) = 1-.0677 = 0.932 \text{ or } .93$$

Thus, this site has a .93 probability of getting at least 1 PM_{10} exceedance and failing the PM_{10} attainment test. In other words, the probability of nonattainment is 93%.

The formulas for the probability of exactly two exceedances, P_2, and exactly three exceedances, P_3, are

$$P_2 = \frac{1}{2}[P_1C_1 - P_0C_2], \text{ and} \tag{8}$$

$$P_3 = \frac{1}{3}[P_2C_1 - P_1C_2 + P_0C_3], \tag{9}$$

$$\text{where } C_r = \sum_{i=1}^{n} \left(\frac{p_i}{q_i}\right)^r, \; r = 1, 2 \text{ or } 3 \tag{10}$$

The probability of failing the attainment test for two or three allowable exceedances is

$$P_F(2) = 1-(P_0+P_1+P_2) \tag{11}$$

$$P_F(3) = 1-(P_0+P_1+P_2+P_3) \tag{12}$$

The computational form of equations 5, 6, 8, 9 and 10 follows from the probability generating function of a Bernoulli process with variable probabilities and have been derived elsewhere.(15,16)

5.3 Attainment Assessment Based on Some PM_{10} Data

If 1 or 2 years of PM_{10} data are available, then a 3-year attainment test can still be applied, using TSP data for the remaining years. This would be of interest if (1) the PM_{10} data did not meet the data requirements specified by Appendix K to Part 50, and (2) there had been no significant change in the emission sources contributing to PM_{10} and it is also felt that the TSP data can be properly used to estimate the PM_{10} situation. The use of the additional data can have a stablizing effect on the expected exceedance estimates and reduce the effect of anomalous meteorology.

The probability of failing the attainment test with 1 allowable exceedance is the probability of not observing 0 or 1 exceedances, and is given by

$$P_F(1) = 1-(P_0+P_1) \qquad (7)$$

Example 4

Suppose that the sampling rates were triple those of Example 3, but the observed TSP concentrations greater than 150 $\mu g/m^3$ were the same. With 180+150+150=480 TSP samples, Table 1 indicates that 1 exceedance would be allowed. Using equation (5), the probability of observing 1 exceedance,

$$P_i = P_0 \sum_{i=1}^{n} \left(\frac{p_i}{q_i}\right), \text{ where } P_0 \text{ is the same as derived in Example 3}$$

$$\text{Thus, } P_i = (0.07)\left[\frac{.82}{.18} + \frac{.34}{.66} + \frac{.30}{.70} + \frac{.16}{.84} + \frac{.03}{.97}\right]$$

$$= (.07)\ (5.72)$$

$$= .40$$

The probability of failing the attainment test, given by equation (7) is

$$P_F(1) = 1-(P_0 + P_1)$$

$$= 1-(.07 + .40)$$

$$= .47$$

Thus, with more TSP data (compared to Example 3), the same observed high TSP concentrations translated into a lower failure probability of .47, i.e., 47% probability of nonattainment.

The approach is based on the idea that the total number of exceedances over the 3-year period is a sum of the PM_{10} exceedances estimated from the observed PM_{10} data and the PM_{10} exceedances estimated from the TSP data. With each year of actual PM_{10} data, we can use observed exceedances to estimate the annual number of PM_{10} exceedances. For the remaining years for which there are TSP data, the expected exceedances are estimated using the probability that the PM_{10} portion of each observed TSP value exceeds the NAAQS. In this case, a site specific frequency distribution of ratios should be used to develop a site specific version of Figure 4, providing a statistically defensible site-specific frequency distribution is available. Otherwise, the national distribution is used. The distribution should be used to estimate the probabilities (i.e., the p_i) for use in equation (3).

If a partial year of PM_{10} or DS data is available, then actual or estimated PM_{10} concentrations may be substituted for concurrent, collocated TSP measurements. The PM_{10} exceedance probabilities would be 1.0 of the PM_{10} measurement (rounded to the nearest 10 $\mu g/m^3$, as specified by Appendix K) was greater than the level of the standard and 0.0 otherwise.

The estimated PM_{10} exceedances derived from the actual PM_{10} data are viewed as being fixed, while the estimated PM_{10} exceedances derived from the TSP data are viewed as a random variable. Thus, the probability of failing the attainment test can be defined solely in terms of the additional PM_{10} exceedances estimated from the TSP data.

Equations 4 or 7 or 11 or 12 will again be used to estimate the probability of failing the attainment test. For the case with a mixture

of data, however, a revised number of allowable exceedances will be required. This will account for the number of PM exceedances observed from actual PM data.

The revised number of allowable exceedances will be defined as

$$A' = A - E \qquad (13)$$

When PM and TSP are sampled with about the same frequency (i.e., using the 3-year ranges in Table 1), then

A is the allowable number of exceedances based on the total number of PM and TSP samples, and

E is the observed number of actual PM exceedances.

If E is greater than A, the attainment test is automatically failed and probability calculations are not required. Specifically, for combined PM and TSP sample sizes less than 347, no exceedances are allowed (Table 1). Thus, 1 PM_{10} exceedance causes a site to fail the attainment test. With more than 347 samples, a single observed PM exceedance would be allowed. The following example illustrates the calculations needed when PM_{10} and TSP have the same sampling rates.

Example 5

Suppose there are 180 PM_{10} samples in 1982 showing 1 NAAQS exceedance and 180 TSP samples collected annually during 1980-1981. Based on 540 PM_{10} plus TSP samples, the allowable number of exceedances, A, is equal to 1 (from Table 1, Section 5.2). Since 1 actual PM_{10} NAAQS exceedance was observed, the revised allowable number, A', is 1-1 = 0. Therefore for this case, failure of the attainment test is defined as the probability of observing 1 or more exceedances (equation 4).

$$E = (1 \times 180) / 360 = 0.5$$

Now $A' = 1.5 - 0.5 = 1.0$ [from equation (13)]

In effect, with more PM_{10} samples, we are applying less weight to the single observed PM_{10} NAAQS exceedance and thus the standard still allows 1 additional exceedance. An alternative way of explaining this is that with low PM_{10} sampling rates there is a larger penalty for missing data. When PM_{10} and TSP sampling rates were both 180 samples per year, the single PM_{10} NAAQS exceedance carried more weight and no additional exceedances would have been permitted during the TSP sampling time period.

When PM_{10} and TSP are sampled at different rates (based on the entries of Table 1), then the allowable number of PM_{10} NAAQS exceedances and the observed number of exceedances must be adjusted to the TSP sampling rate. To do this we must first adjust the PM_{10} sample size and observed PM_{10} NAAQS exceedances according to the TSP sampling rate. After this step, the revised number of allowable exceedances and the corresponding probability calculations are determined.

Example 6

In the previous example, PM_{10} was sampled 180 times in 1982, showing 1 exceedance, and TSP was sampled 180 times per year in 1979 and 1980. Suppose that PM_{10} was sampled 360 times in 1982 (instead of 180) and still showed 1 exceedance. We will see that this has the effect of raising the allowable number of observed exceedances. We will first adjust the parameter "A" on the basis of the 3 years of data. Using the required TSP sampling rate, the total number of observations in 3 years would be 540 (i.e., 3 x 180). The adjusted number of allowable exceedances, A, based on the TSP sampling rate, is defined by the following equation.

$$A = \frac{3.1 \times 540}{3 \times 365} = 1.5$$

The number "3.1" is based on the number of allowable exceedances with complete sampling in 3 years (before rounding). The observed number of PM_{10} exceedances, based on 360 samples in 1 year, must also be adjusted to the TSP sample rate of 180 samples per year, so

6.0 ESTIMATING SPATIAL EXTENT OF NONATTAINMENT SITUATIONS

6.1 Introduction

As described in earlier sections, assessing attainment/nonattainment of the National Ambient Air Quality Standards (NAAQS) for PM_{10} requires the use of ambient monitoring data. If the data and the assessment procedures described earlier in coordination with EPA policy result in the requirement for control strategy development, the question remains as to what is the spatial extent of the nonattainment problem. Even though there will be no designation of PM_{10} nonattainment areas, the extent of air quality violations still must be determined for control strategy development. Defining the spatial extent of the problem is not a simple, straightforward technical matter, as is evidenced by the differences in the size of boundaries for nonattainment areas for the other criteria pollutants and the original TSP NAAQS. For example, some nonattainment area boundaries are county or city-wide, some include entire townships or parishes, while others encompass the central business district or an area bounded by designated streets.

Such differences occur because the size of the boundaries are influenced by a variety of technical factors such as the pollutant itself, its reactivity, type and density of emissions, meteorology, topography, etc. In addition to these technical considerations, final boundaries are also influenced by nontechnical factors such as the amount of time and resources available to effectively define their limits, as well as the jurisdictional borders of the areas surrounding the nonattainment monitoring site.

States have used several techniques, including dispersion modeling, isopleth analysis, source receptor models, and monitoring site scales of representativeness in defining nonattainment boundaries for other pollutants. These techniques are also used for other purposes and are fairly complex and detailed. Since they are not unique to nonattainment boundary definitions, and are adequately described and discussed elsewhere in the literature, they are not covered here in any great detail; rather, they are listed as techniques or approaches that are recommended for use as guidance in defining the extent of a nonattainment problem.

6.2 Use of Acceptable Air Quality Data

The use of acceptable air quality data is required in determining the attainment/nonattainment status of a monitoring site. In determining data acceptability, three items which need to be evaluated are: the type of sampler used, sampler location, and quality of the data.

6.2.1 Type of Sampler

When using TSP data for estimating the probability of nonattainment for PM_{10}, the TSP sampler must be a reference method, as defined in Appendix B to 40 CFR Part 50. For those situations where inhalable particulate (IP) data will be used for estimating the probability of nonattainment for PM_{10}, the determination of the acceptability of the type of IP sampler will have to be done on a case-by-case basis, as there is no existing designated reference method for IP. Data collected from dichotomous samplers used in EPA's national sampling network for inhalable particulates are considered acceptable. As a general rule when using IP data, the sampler should be similar to those used in the EPA IP network

which were based on the principles of inertial separation and filtration. The Environmental Monitoring Systems Laboratory (EMSL), Research Triangle Park, North Carolina, will provide guidance to assist in making this determination.

6.2.2 Sampler Location

Appendices D and E of 40 CFR 58 included network design and siting criteria for TSP samplers and proposed criteria for PM_{10} samplers, but not for IP. If TSP data are to be used in the assessment of attainment/nonattainment for PM_{10}, then these samplers must conform to the requirements of Appendices D and E.

6.2.3 Data Quality

The Agency's quality assurance policy is that all environmental data generated, processed, or used for implementing Clean Air Act requirements, will be of known precision and accuracy and, to the extent possible, be complete, comparable, and representative.

Consistent with this policy, TSP samplers must conform to the reference method requirements and the data must be collected in accordance with the quality assurance criteria contained in Appendix A of Part 58. For IP data, the samplers must be similar to those used in the EPA national sampling network for inhalable particulates, except that size-selective hi-volume samples collected with glass fiber filters should not be used. Minimum quality assurance activities that should have been conducted during the IP measurement process are quality control checks, data review and validation activities. The quality control activities include regularly scheduled flow calibrations where the flow measurement devices used to

measure sampling rate were also calibrated. Data review and validation procedures should be similar to those established for the other criteria pollutants.

6.3 Determining the Boundaries of a Nonattainment Area

As noted in Section 6.1, several techniques have been used by States to define the spatial extent of NAAQS violations expressed as boundaries of nonattainment areas. Basically, the approaches used can be placed into three categories:

1. a qualitative analysis of the area of representativeness of the monitoring site, together with consideration of terrain, meteorology and sources of emissions;
2. spatial interpolation of air monitoring data;
3. air quality simulation by dispersion modeling.

In determining the extent of a PM_{10} nonattainment situation, the use of any one or a combination of the above categories would be considered acceptable to the EPA. The choice of which technique to use depends on the complexity of the PM_{10} problem area.

6.3.1 Qualitative Analysis

This approach, unlike the others discussed below, is not intended to define any single analytical procedure for defining the extent of a nonattainment problem. On the contrary, it is intended to recognize as acceptable various approaches that consider such factors as ambient monitoring data, the spatial scales of representativeness of the monitoring station, the number

of areas in the community similar to that being measured by the monitoring station, the type of terrain, meteorology, and sources of PM_{10} emissions. Proposed revisions to Appendix D of Part 58 describe the topic of spatial scales of repesentativeness for PM_{10} stations, as well as procedures for locating such stations. The predominant spatial scales for PM_{10} stations include micro, middle and neighborhood, with a fewer number of stations represented by the urban and regional scale. Properly located stations that are specifically classified according to their spatial scale could, in certain instances, be solely used to define the limits of the nonattainment area. Other situations obviously will require a more detailed review and analysis of sources, pollutant transport and receptor.

6.3.2 Spatial Interpolation of Air Monitoring Data

Although it would be desirable to ensure that the entire area of a designated nonattainment area is actually nonattainment, air monitoring costs are so high as to prohibit full coverage of a large nonattainment area. There are, however, two methods available to arrive at refined estimates of the spatial variation of air quality. One method is spatial interpolation of air monitoring data, the other which will be discussed in Section 6.3.3, is air quality simulation by dispersion modeling.

The use of spatial interpolation of air monitoring data is the method most appropriate for situations in which monitors are located at relatively close proximity to one another. Over the past years, most cities and urban areas have established fairly dense air monitoring networks which enabled the technique to become more widely applicable. A complete description of the method is described in the publication,

"Guideline on Procedures for Constructing Air Pollution Isopleth Profiles and Population Exposure Analysis," U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711, EPA-450/2-77-024a, October 1977 (OAQPS No. 1.2-083).

The basic procedure involves the plotting of station locations and measured concentrations from these stations. For those areas of the map not covered by monitoring stations, a spatial interpolation scheme is used to estimate air quality concentrations. The technique can be done manually or through the use of computer mapping programs.

6.3.3 Air Quality Simulation by Dispersion Modeling

Determining the extent of the PM NAAQS nonattainment can also be accomplished by using dispersion models to simulate the spatial distribution of air quality under various conditions. Dispersion modeling is more appropriate than spatial interpolation of air monitoring data in areas where actual monitoring data are scarce. In order to use a dispersion model, source data, air quality data, and meteorological data are required. For dispersion modeling purposes, PM_{10} is treated as a nonreactive gas. The type of source (point, area, mobile, or stationary), type of standard (short term or annual), type of terrain (flat or rough), and the type of area (urban or rural) will of course affect the decision as to which model to use. The document, "Guideline on Air Quality Models," U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, OAQPS No. 1.2-080, April 1978, includes specific recommendations concerning air quality models, and also describes circumstances for which models, data and techniques other than those recommended in the guideline may be applied.

7.0 ACKNOWLEDGEMENTS

The authors wish to acknowledge the contribution of Mr. Stanley Sleva of the Monitoring and Reports Branch, OAQPS, who prepared Section 6.0 which discusses ways to estimate the size of nonattainment areas. Technical review by Dr. Edwin L. Meyer of the Air Management Technology Branch, OAQPS, Dr. William P. Smith of the Statistical Policy Staff of OPRM, Mr. Jack Suggs of the EMSL, and Dr. William F. Biller is also greatly appreciated. Special thanks is given to Mr. Roger Powell of the Control Programs Development Division, OAQPS, for his ongoing responsibility and advice in ensuring the consistency of this document with the overall regulatory effort. Finally, the excellent typing and clerical support by Mrs. Carole Mask is greatly appreciated.

8.0 REFERENCES

1. U.S. Environmental Protection Agency, "National Primary and Secondary Ambient Air Quality Standards. Appendix B - Reference Method for the Determination of Suspended Particulates in the Atmosphere (high volume method)," 40 CRF 50: 12-16, July 1, 1979.

2. R. W. Countant, "Effect of Environmental Variables on Collection of Atmospheric Sulfate." Environmental Science and Technology 11: 873-878, 1977.

3. Hardial S. Chalal and David J. Romano, "High Volume Sampling: Effect of Windborne Particulate Matter Deposited During Idle Periods." Journal of the Air Pollution Control Association, Volume 26, No. 9, pages 885-886, 1976.

4. A. R. McFarland and C. E. Rodes, "Characteristics of Aerosol Samplers Used in Ambient Air Monitoring." Presented at 86th National Meeting, American Institute of Chemical Engineers, Houston, Texas, April 2, 1979.

5. B. W. Loo, R. S. Adachi, C. P. Cork, F. S. Goulding, J. M. Jaklevic, D. A. Landis, and W. L. Searles, "A Second Generation Dichotomous Sampler for Large Scale Monitoring of Airborne Particulate Matter," LBL-8725, Lawrence Berkeley Laboratory, Berkeley, California, January 1979.

6. J. B. Wedding, M. Weigand, W. John, and S. Wall, "Sampling Effectiveness of the Inlet to the Dichotomous Sampler." Environmental Sciences and Technology, 14: 1367-1370, 1980.

7. Kenneth Axetell, Jr. and Chatten Cowherd, Jr., Improved Emission Factors for Fugitive Dust from Western Surface Coal Mining Sources. Final Report to U.S. Environmental Protection Agency, Cincinnati, Ohio by PEDCo Environmental under Contract Number 68-02-2924, Volume I, page 4-1, July 1981.

8. Jack C. Suggs, Charles E. Rodes, E. Gardner Evans, and Ralph E. Baumgardner, Inhalable Particulate Network Annual Report: Operation and Data Summary (mass concentrations only), April 1979 - June 1980. U.S. Environmental Protection Agency Report Number EPA-600/4-81-037, Research Triangle Park, North Carolina, May 1981.

9. Memo from Barry Martin to T. G. Pace, "Limitations on the Use of Inhalable Particulate Network Data 1979-82," October 25, 1982.

10. Thompson G. Pace, "Estimating PM_{10} Concentrations from IP and TSP Data," APCA Paper 82-45.2, Presented at Annual Meeting of the Air Pollution Control Association, New Orleans, Louisiana, June 1982.

11. Anthony D. Thrall and C. Shepard Burton, Characterizing Ratios of Particulate Concentrations: A First Step in Assessing Likely Attainment Status Under a PM_{10} National Ambient Air Quality Standard (Final Report), Systems Applications, Incorporated, Publication No. 82316, April 4, 1983.

12. A. D. Thrall and A. B. Hudischewskyj, "An Update on the Use of Particulate Ratios To Assess Likely PM_{10} Attainment Status," technical memorandum, Systems Applications, Incorporated, January 13, 1984.

13. John G. Watson, Judith Chow and Jitindra Shah, Analysis of Inhalable and Fine Particulate Matter Measurements. Final Report to U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, by ER&T under Contract No. 68-02-2542, Task Order 6, pages 8-18, December 1982.

14. Neil H. Frank and Thomas C. Curran, "Statistical Aspects of a 24-hour National Ambient Air Qulaity Standard for Particulate Matter," Paper 82-23.8, 75th Annual APCA Conference, New Orleans, Louisiana, June 1982.

15. W. Feller, An Introduction to Probability Theory and Its Application, Volume I, 3rd Edition, John Wiley and Sons, 1968, page 282.

16. Memorandum from W. P. Smith to N. P. Ross, subject: "Recursive Algorithms for Computing Compliance Probabilities," November 1, 1982.

APPENDIX A

Monitoring Sites in the National IP Monitoring Network Used in the Analysis

Table A-1. Dichotomous Sampler Sites.

SAROAD NO.	STATE	CITY	SITE ADDRESS
010380003	AL	Birmingham	S. Birmingham, 720 20th Street
013200001	AL	Birmingham	Tarrant City, 1818 Pinson Street
054180103	CA	Los Angeles	West Los Angeles, 1535 S. Robertson Blvd.
056866003	CA	San Francisco	San Francisco EAst, 900 23rd Street
056980004	CA	San Jose	Near University, 1208 N 4th Street
070420003	CT	Hartford	Public Library, Main Street
171800011	KS	Kansas City	Fairfax Fire Station, 3115 Fairfax Road
220240013	MA	Boston	E. Boston Social Ctr., 68 Central Square
242260051	MN	Minneapolis	300 Nicollet Mall
262360002	MO	Kansas City	Fire Station, 1517 Locust
330660010	NY	Buffalo	Public School #28, 1515 S Park Avenue
334680011	NY	New York City	Green Point PCP, 301 Green Point Avenue
360060014	OH	Akron	J.D. Morley Health Bldg., 177 S. Broadway
361300013	OH	Cleveland	APC Div HQS, 2785 Broadway
397140003	PA	Philadelphia	500 S. Broad Street, Broad & Spruce Streets
397140019	PA	Philadelphia	Allegheny, Allegheny & Delaware Road
451310050	TX	Dallas	Convention Center, 727 Akard
451700002	TX	El Paso	Tillman Health Center
090020017	DC	Washington	24th and L Street, NW
010380026	AL	Birmingham	Inglenook, 3937 44th Avenue N
012540001	AL	Birmingham	Mountain Brook, 3015 Overton Road

Table A-1. Dichotomous Sampler Sites (continued).

SAROAD NO.	STATE	CITY	SITE ADDRESS
050500002	CA	Los Angeles	Azusa, 803 N. Loren Avenue
056535001	CA	Los Angeles	Rubidoux, 5888 Mission Blvd.
056300003	CA	San Francisco	Richmond, 1144 13th Street
090020017	DC	Washington	24th and L Street, NW
120370004	HI	Honolulu	Leewards Med Ctr., 860 Fourth Street, Pearl C
162500003	IA	Marshalltown	City Hall, 24 N Center Street
210120009	MD	Baltimore	SW Police Station, 434 S Foothill Avenue
260030001	MO	St. Louis	Trailer, 5962 Lindbergh Avenue
290580001	NV	Winnemucca	25 West 4th Street
361300013	OH	Cleveland	APC Div HQS, 2785 Broadway
361220020	OH	Cincinnati	Drake Hospital, Galbraith Road
397140024	PA	Philadelphia	Northeast Airport, Grant Avenue/Ashtown Road
397260021	PA	Pittsburgh	Hazelwood No. 2, 327 Hazelwood Avenue
454715001	TX	Houston	Seabrook (CAMS-20), Rural Road/School Yard
481560002	VA	Hopewell	Hopewell News Building, Route 10 & 36
491840057	WA	Seattle	Liquor Control Board, 4201 E. Marginal Way
491840073	WA	Seattle	Seattle City Light Company, 98th & Stone Street
010380023	AL	Birmingham	N. Birmingham, 3009 28th Street
130220003	ID	Boise	Fire Station #6, 1620 N Liberty
242260049	MN	Minneapolis	Regina HS, 4255 3d Avenue
320090001	NM	Bayard	Cobre Consol, School Mait Yd

APPENDIX B

Alternative Curves for Use With the Upper Range Values Proposed by the Administrator.

(Annual arithmetic mean = 65 $\mu g/m^3$, 24-hour NAAQS of 250 $\mu g/m^3$ not expected to be exceeded more than once per year).

For the upper range of proposed PM_{10} NAAQS ($250/65$)

Figure A' should replace Figure A in the text

Figure B' should replace Figure B in the text

Figure 3' should replace Figure 3 in the text

Figure 4' should replace Figure 4 in the text

Numbers used in examples on pages 8-9, in example 3 on page 17, and in example 4 on page 18 should be changed accordingly.

Figure A! Relationship Between the Probability of Exceeding a 65 µg/m³ Annual PM_{10} Concentration and Observed TSP
and
Figure 3' Annual Arithmetic Mean Concentration.

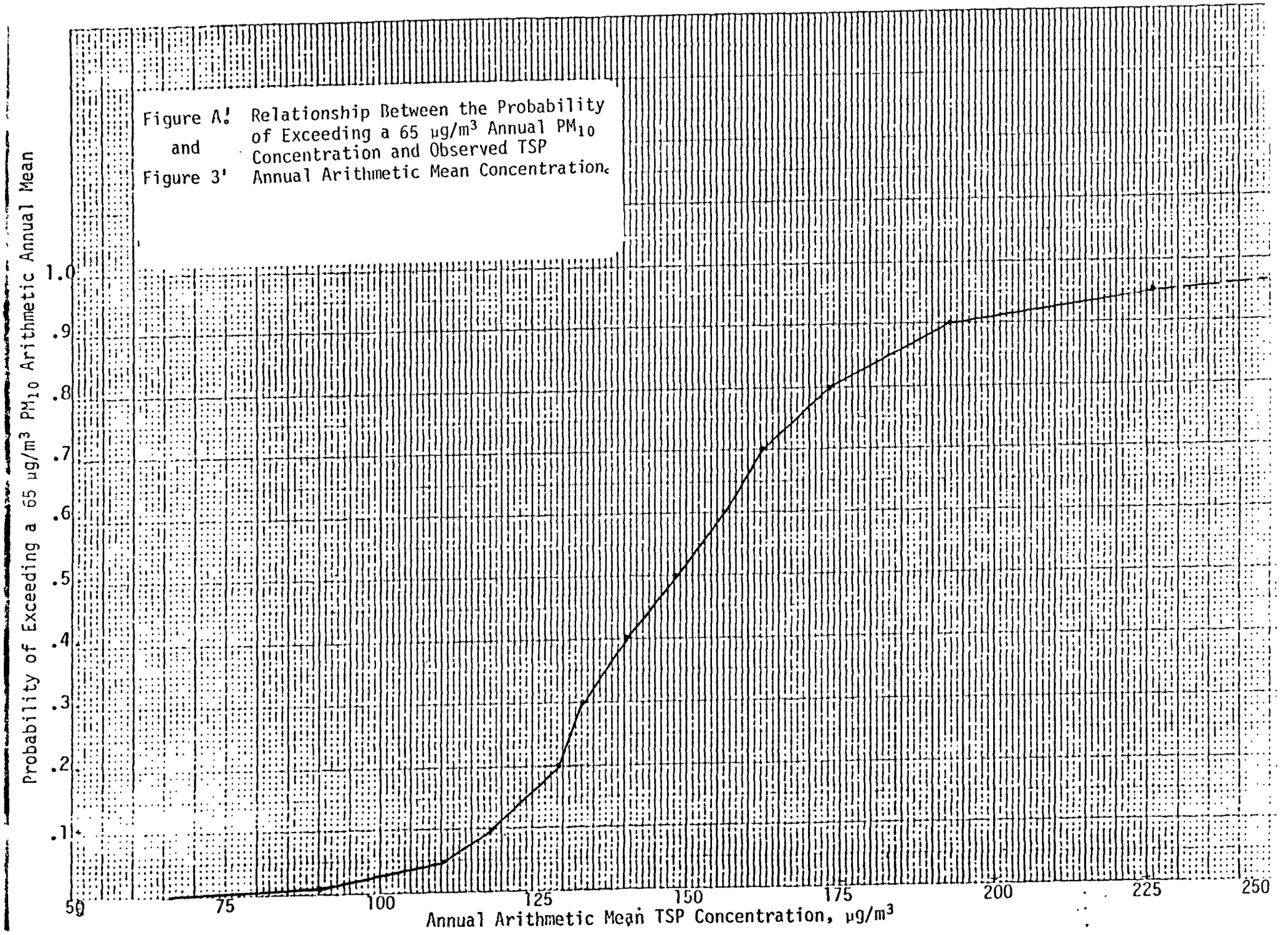


Figure B.' Relationship Between the Probability of Exceeding a 250 µg/m³ 24-hour PM_{10} Concentration and Observed TSP
and
Figure 4' 24-hour Concentration.