United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/4-91-005b
September 1990

Air

EPA

FEASIBILITY OF INCLUDING FUGITIVE PM-10 EMISSIONS ESTIMATES IN THE EPA EMISSIONS TRENDS REPORT

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EPA Contract No. 68-02-4400

EPA Project Officer: E. L. Martinez

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U. S. Environmental Protection Agency
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September 1990

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FOREWORD

This report describes the results of Part 2 of a two part study. Part 2 evaluates the feasibility of developing regional emission trends for PM-10. Part 1, presented in a separate report, evaluates the feasibility of developing regional emission trends for VOC. These studies are part of the effort underway to improve national emission trends.

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INTRODUCTION

Each year the National Air Data Branch (NADB) produces a publication on trends for the emissions of criteria air pollutants (particulate, sulfur dioxide, nitrogen oxides, volatile organic compounds, carbon monoxide and lead). These data are compiled into reports (Office of Air Quality Planning and Standards Data Files of Nationwide Emissions) used internally by OAQPS for the evaluation of observed trends in ambient air quality measurements. The emissions data are also needed for reports by the EPA Administrator to Congress and for reports to the general public on EPA progress in air quality management activities. The emission trends data are developed using a large number of reference materials including data from EPA's National Emissions Data System (NEDS), standard air pollutant emission factors from the EPA publication Compilation of Air Pollutant Emission Factors, AP-42, Fourth Edition, September 1985, as supplemented October 1986 and September 1988, and data published by other Federal agencies and private sector statistical reporting organizations.

Because of regional differences in emission sources, control programs, climatic effects, etc., there is a need to investigate and possibly publish information on pollutant trends on a regional basis. The purpose of this study was to 1) evaluate the feasibility of developing regional emission trends for volatile organic compounds (VOC) and particulate matter (PM) less than or equal to 10 microns (PM_{10}) and 2) produce preliminary estimates of these emissions for several representative source categories. The feasibility analysis and development of regional emission trends for VOC is presented in a separate report. This report addresses the feasibility of developing regional PM_{10} emissions estimates. The focus of this study was on large potential contributors to PM_{10} emissions which have been excluded from past analyses of PM. Twelve categories of natural source PM_{10} emissions were examined. These categories were determined based upon previous inventory estimates (which have been TSP inventories). The categories evaluated for the feasibility of developing regional emissions estimates were:

Unpaved Roads
Paved Roads
Wind Erosion
Agricultural Tilling
Construction Activities
Feedlots
Burning
Landfills
Mining and Quarrying

Unpaved Parking Lots
Unpaved Airstrips
Storage Piles

This report presents the results of the feasibility analysis and regional emissions estimates for paved roads, unpaved roads and wind erosion.

In previous emissions inventories (which have typically represented TSP inventories), the first eight categories have comprised more than 95% of all natural area source particulate emissions. Table 1 below lists the estimated TSP emissions from several of the above sources for two of these inventories. The inventories represented here are ones determined by Evans and Cooper (1980) and by EPRI (1988). The value in the Average column represents either the average emissions from the two inventories or the single value for that source when only one inventory value was available. Table 1 gives an indication of the magnitude of each of the sources considered above, although it is possible that some of the sources not inventoried in the past are of equal or larger magnitude than those reported here. All values are in short tons.

Table 1 indicates that wind erosion and unpaved roads are the major contributors to fugitive particulate emissions. In the inventories examined, these sources have emissions that are an order of magnitude higher than any other source.

Table 1. TSP Emissions Inventories Estimates

Source	Evans and Cooper	EPRI (Heisler)	Average
Wind Erosion	229,655,000	956,300,000	592,977,500
Unpaved Roads	272,050,000	120,400,000	196,225,000
Agricultural Tilling	39,012,000	5,950,000	22,481,000
Construction	21,547,000	9,432,000	15,489,500
Mining and Quarrying	9,588,800		9,588,800
Paved Roads	8,763,000	5,089,000	6,926,000
Burning	1,939,000	848,000	1,393,500
Feedlots		440,000	440,000
Unpaved Airstrips		9,000	9,000
Landfills			
Unpaved Parking Lots			
Storage Piles			

SECTION 2

FEASIBILITY ANALYSIS

In order for regional emissions estimates of PM_{10} to be feasible, two primary requirements must be met. These requirements are:

1. A PM_{10} emission factor for the source must be available and,
2. Regional estimates of the source extent (activity factor) must either be available or estimable from national data.

A recently published EPA document (Midwest Research Institute, 1988) contains PM_{10} emission factors for several of the sources listed above, however, these emission factors are typically based upon engineering judgement or a very limited number of tests.

UNPAVED ROADS

Introduction

Unpaved roads are perhaps one of the easiest sources to develop regional PM_{10} emissions estimates for, because of the availability of a PM_{10} emission factor and source extent estimates. There is an established PM_{10} emission factor available in AP-42. The background behind the development of that emission factor, other unpaved road TSP emission factor development studies and the work carried out as part of the 1985 NAPAP effort to develop a PM_{10} emission factor for this source indicate that there is a large degree of uncertainty associated with an emission factor for this source.

Total U.S. emissions of total particulate (TSP) have been estimated previously (Heisler, 1988; Evans and Cooper, 1980). These estimates indicated that 272.1 and 120.4 million tons of particulate were produced by this source for the years 1982 and 1976 respectively.

Data Requirements

Calculation of PM_{10} emissions from unpaved roads requires information regarding an emission factor and the source extent. For unpaved roads, the source extent is vehicle miles of travel (VMT) on unpaved roads. As indicated above, EPA publication AP-42 contains an established PM_{10} emission factor for this source. However, in order to utilize that emission factor for the calculation of regional emissions estimates, regional information on the "correction parameters" that are included in the emission factor equation are necessary. The emission factor for PM_{10} emissions from unpaved roads is given as:

$$e = k(5.9)\ (s/12)\ (S/30)\ (W/3)^{0.7}\ (w/4)^{0.5}\ ((365-p)/365) \qquad (1)$$

where:
- e = emission factor (lb/VMT)
- k = particle size multiplier (dimensionless; 0.36 for PM_{10})
- s = silt content of road surface material (% - fraction of surface material less than 75 microns in diameter)
- S = mean vehicle speed (mph)
- W = mean vehicle weight (tons)
- w = mean number of wheels
- p = number of days with at least 0.01 inch precipitation per year

Equation 1 indicates that regional emission factors can be developed in order to calculate regional emissions estimates from unpaved roads, if regional values for s, S, W, w and p are available or can be estimated.

Reasonable estimates of the mean vehicle weight and the mean number of wheels for vehicles traveling on unpaved roads can be determined using data available from the U.S. Department of Transportation (DOT). This data is not published, but is available upon request from DOT (Jeff Haugh, personal communication). Reasonable estimates of vehicle speed based upon the functional classification of the various unpaved roads can also be made. Although this is not truly regional information, there is no reason to assume that vehicle weights, number of wheels or vehicle speed on similar functional class roads should change significantly from region to region.

Information on the silt content of unpaved roads and the number of days with at least 0.01 inch of precipitation per year would be expected to vary from region to region. Estimates of the number of days with a least 0.01 inches of precipitation can be readily obtained from monthly summary information for meteorological stations located within each state.

Silt content is much more difficult to obtain on a regional basis. AP-42 contains some information on the silt content of various unpaved roads. The information contained in AP-42 represents 103 samples. However, the majority of these road samples (89 of 103) represent industrial unpaved roads, not normal highway traffic unpaved roads. In many cases, industrial unpaved roads utilize process byproducts (such as slag) for surfacing material rather than materials that would be utilized for normal highway traffic unpaved roads. Since the surface material utilized may have a significant impact on the silt content, the information in AP-42 may not be representative of the silt content found in a particular region. Additionally, the information given in AP-42 is not presented on a regional basis.

There is, however, a significant database of normal highway traffic unpaved road silt content information available. Researchers at the Illinois State Water Survey (ISWS) have sampled and analyzed the silt content of over 200 unpaved road surface material samples from over 30 states (Gary Stensland and Allen Williams, personal communication) as part of the National Acid Precipitation Assessment Program (NAPAP) alkaline particulate inventory effort. Thus, regional information on the silt content of unpaved roads is available for developing regional unpaved road PM_{10} emissions estimates. This assumes that the average regional silt content does not change over time. This assumption is probably adequate, unless large scale changes occur in the type of surface material utilized by the states in a region.

The final data requirement necessary for calculating regional unpaved road PM_{10} emissions estimates is regional source extent information. For unpaved roads, this would be regional VMT on unpaved roads. DOT publishes information on the mileage of unpaved roads for several road functional classes in the Annual Highway Statistics, but does not provide VMT information for these roads. National VMT information for unpaved roads is presented in the Highway Statistics report, and this information reveals that the majority of unpaved road travel is on local functional class unpaved roads. Unfortunately, local functional class unpaved road mileage by state is not reported in the Highway Statistics, so developing an algorithm to assign regional unpaved VMT based on unpaved road mileage from the information presented in that document is not possible. Conversations with DOT personnel (Don Kestyn, personal communication) indicated that most states do provide information on the number of miles of local functional class unpaved roads broken down by Average Daily Traffic Volume (ADTV). This information is compiled annually in a spreadsheet, and can be obtained from DOT. This information can be utilized to calculate estimates of state-level VMT on local functional class unpaved roads.

<u>Summary</u>

Regional estimates of unpaved road PM_{10} emissions are feasible with currently available data. State (Allen Williams, ISWS, personal communication) and county (Barnard, 1990) level PM_{10} emissions for the year 1985 have already been made as part of the NAPAP research effort. Estimates of PM_{10} emissions from this source are presented in the next section for a five year period.

PAVED ROADS

<u>Introduction</u>

Emissions of particulate matter from vehicle travel on paved roads arise from a variety of processes. Among these processes are tailpipe emissions, tire wear, brake wear, road sanding and salting and resuspension of dust tracked or deposited onto the road surface by vehicle traffic itself. The majority of reentrained traffic dust has been found to consist primarily of mineral matter similar to sand or soil. Additionally, a small component of the reentrained dust is derived from direct emissions from vehicles (tailpipe, brake or tire wear).

Total U.S. emissions of total particulate (TSP) have been estimated previously (Heisler, 1988; Evans and Cooper, 1980). The total resuspended dust estimates from these inventories were 5.089 and 8.763 million tons for the years 1982 and 1976 respectively. These estimates included only the resuspended component of paved road emissions and did not include tailpipe emissions, tire wear or brake wear or emissions from road sanding and salting for snow removal. The estimates produced by Evans and Cooper were also produced on a state-by-state basis and thus regional emissions estimates for total particulate emissions from paved roads for the year 1976 can be derived.

In evaluating the feasibility of preparing PM_{10} emissions estimates for paved roads, only two sources of particulate emissions were considered: resuspended dust and sanding and salting of paved roads for snow removal.

Data Requirements

Resuspended Dust

In order to calculate PM_{10} emissions on a regional basis for paved roads, certain data are necessary. At a minimum, an emission factor and the source extent to which that emission factor applies are required. For paved roads, the source extent is the VMT. EPA publication AP-42 contains an emission factor for urban paved roads that can be applied to develop PM_{10} emissions estimates. However, in order to determine regional emissions estimates, regional information on the parameters necessary to calculate emissions are necessary. The emission factor for PM_{10} emissions for paved road dust resuspension is given as:

$$e = k\,(sL/0.7)^p \qquad (2)$$

where:
- e = emission factor (lb/VMT)
- s = surface silt content (fraction of particles below 75 microns diameter)
- L = total road surface dust loading (grains/ft^2)
- k = base emission factor (lb/VMT)
- p = exponent (dimensionless)

For PM_{10} emissions, k = 0.0081 lb/VMT and p = 0.8. The product of s and L yields the silt loading. Thus, to develop regional emission factors for PM_{10}, regional information on s and L (or the product sL) must be available, since the other parameters are not region specific.

AP-42 Table 11.2.5-3 contains a summary of silt loadings (sL) for a variety of roadway categories. However, the data base utilized for this table represents only 44 samples from 5 major cities. Thus, if this information was utilized to develop regional emission factors, the spatial coverage would be limited. Additionally, this emission factor is designed to cover emissions from paved urban roads, and there is no emission factor listed in AP-42 for paved rural roads.

Information contained in a report by Cowherd et al. (1988) indicates that the urban paved road emission factor can be utilized for estimating emissions from all public paved roads (both urban and rural) and that the silt loading (sL) term can be estimated by the following equation:

$$sL = 30.54/(V^{0.41}) \quad (3)$$

where: sL = surface silt loading (grains/ft^2)
V = average daily traffic volume (vehicles/day)

Thus, if region specific values can be obtained for V, then regional silt loading values can be calculated.

In addition to regional emission factors, the second component necessary to determine regional emissions estimates is development of regional estimates of the source extent. For paved road emissions, this would be VMT.

Each year, DOT publishes Highway Statistics. Included among the information in this publication are data on the number of vehicle miles of travel for each state broken down by highway functional classification for both rural and urban VMT. Thus, regional estimates of the source extent are available from DOT on an annual basis.

Also included in the data provided in the Highway Statistics publication are the number of miles of road in each highway functional classification. As a consequence, the average daily traffic volume in each state can be calculated. Thus, the silt loading term in equation 3 necessary to calculate region specific emission factors (i.e. state-level) can be calculated.

Road Sanding and Salting

There is a "gap filling" PM_{10} emission factor (MRI, 1988) available for sanding and salting paved roads, but it is based on a very limited amount of data. The recommended PM_{10} emission factor for sand application is:

$$e = 2{,}000\ f\ (s/100) \quad (4)$$

where: e = emissions (lb/ton of sand applied)
f = proportion of PM_{10} in the silt fraction of sand
s = silt content of the sand (percent)

The recommended PM_{10} emission factor for salt application is given as a single value of 10 lb/ton of salt applied.

In order to utilize the emission factor in equation 4, a regional database for f and s would be required. Currently, no such database exists. However, default values are given that cause the emission factor to evaluate to 0.018 lb/ton of sand applied. This value could be utilized in conjunction with an understanding of either the amount of sand applied in each region or the number of miles of road treated in each region along with the application rate per mile to determine the PM_{10} emissions. Typically, the application rate (along with the salt/sand ratio) are available from state highway departments (Dennis Carter, North Carolina DOT, personal communication). Indeed, the "gap filling" document lists some typical sand/salt ratios, one of which is very similar to that obtained for North Carolina. The "gap filling" document also lists the number of miles of treated road for the majority of states, thus allowing state-level computations of paved road sanding and salting PM_{10} emissions.

Summary

PM_{10} regional emissions from paved roads can be calculated on an annual basis with existing data. This would include emissions from road sanding and salting, although emissions from this component of paved road emissions would require more assumptions than paved road resuspension estimates.

WIND EROSION

Introduction

Although this source was characterized in the 1985 NAPAP Emission Inventory and the emission factor and source extent were developed, the estimates developed are not year-specific (they represent a statistical average using a 30 year wind record), they are not easily reproduced and they represent emissions of particles $\leq$ 20 microns. A variety of emission factors have been utilized over the years for estimating wind erosion TSP emissions. Typically, the early ones (including the estimates presented in Table 1) involved utilizing the Universal Soil Loss equation in some form to convert horizontal erosional losses to vertical fluxes. More recent estimation procedures have involved utilizing an erodibility index coupled with some measure of the threshold friction velocity to evaluate the vertical wind erosion emissions.

The current AP-42 industrial wind erosion emission factor utilizes this second approach, but is not intended to be utilized to estimate large scale (i.e. regional) emissions. As a consequence, additional work to develop an emission factor that can be readily applied to calculate regional level information on an annual basis would be necessary. It is possible that the same (or similar) approach utilized for the 1985 NAPAP inventory could be used, but with some modifications in the utilization of the wind data required. Additionally, the developer of the current NAPAP method has indicated that the current method is computationally time consuming. Modification of the current NAPAP emission estimation procedure would also require that it be modified to predict PM_{10} emissions, since the 1985 NAPAP emissions estimates were for particles $\leq$ 20 microns.

The California Air Resources Board (CARB) has recently funded a survey in an effort to identify the best available emission factors and emission estimation methodologies for wind erosion from agricultural and desert lands (Dickson et al., 1988). For agricultural lands, the survey concluded that the estimates made using the Universal Soil Loss equation were the best available given the existing data. The only suggestions for improvement to this estimation technique were to adjust the climatic factor used in this equation to account for irrigation practices and to utilize the mean energy velocity rather than the mean wind velocity in calculating the climatic factor. Emissions of PM from desert land were determined using the following equation:

$$F = 1.78\times10^{-16}\ U^{2.782} \qquad (5)$$

where:
F = aerosol flux, (g/cm^2-s)
U = wind speed at 10 meters (cm/sec)

The study noted that several assumptions were required for utilizing this equation to estimate PM emissions from desert lands. All improvements to the estimation of wind erosion estimates from desert lands suggested by the study would require a high level of effort. It was also noted that activity data (acreage) for disturbed desert land (which have much higher emission rates than undisturbed desert land) have thus far not been defined or quantified.

The U.S. Department of Agriculture is in the process of developing a wind erosion prediction system. This system is intended to be a PC based system involving a modular structure. The modules will deal with weather, crops, tillage, soil properties, water and energy balances and wind erosion mechanics (Hagen, 1989). This computer system is intended to replace the Universal Soil Loss equation. Several problems exist with trying to incorporate this system into developing regional emission estimates. First, the system is not scheduled for completion until 1991 and a user-friendly version is not due until 1993. Second, the system is set up to predict field scale wind erosion, not regional scale wind erosion. Third, the system is designed for agricultural applications, and current plans do not include consideration of wind erosion from non-agricultural land. Finally, although the system does predict a suspension component, this component generally represents particles $\leq$ 100 microns.

Thus, using this system to predict PM_{10} emissions will involve making assumptions as to the fraction of the suspension component that is $\leq$ 10 microns.

Data Requirements

In order to calculate regional emissions, a regional emission factor is needed. Although the Universal Soil Loss equation has been and is still being utilized to predict wind erosion emissions, all researchers involved in determining wind erosion emissions concede that it is an inadequate method to predict suspended particulate emissions, especially PM_{10}. Although other potential approaches have been developed and utilized, these methods typically do not lend themselves to relatively straight forward application to regional emissions estimates. It may be possible, however, to develop a reasonable method for predicting wind erosion on a regional level.

Adequate source extent information is available from a variety of sources, although some additional research is needed to evaluate the best sources of information and to ascertain how frequently the source extent information is updated. The source extent utilized in the development of the 1985 NAPAP inventory was the National Resource Inventory. This soils database is updated on approximately a five year basis. As a consequence, development of annual regional emissions estimates to evaluate trends could be hampered even if an adequate emission factor is developed if the source extent estimates are invariant over long periods of time.

Summary

If EPA is willing to use the Universal Soil Loss equation and if the source extent information utilized is updated on an annual basis, then estimation of regional PM_{10} emissions would be feasible. However, if those conditions are not adequate, then estimation of emissions from this source would not be feasible at this time. Regional estimates of PM_{10} emissions from wind erosion for 1985 developed from the 1985 NAPAP inventory are presented in the next section.

AGRICULTURAL TILLING

Introduction

Agricultural tilling emissions were estimated for the 1985 NAPAP emission inventory by using a previously developed TSP emission inventory (Evans and Cooper, 1980) coupled with information from AP-42 on the fraction of particles $\leq$ 10 microns. In addition, a plume depletion factor of 0.1 was utilized to represent the potential for particles traveling long distances from their source (and thus having the potential to neutralize acids in precipitation since this was the emphasis of the NAPAP research program). Although this information was reported as part of the 1985 inventory, the actual data represents 1976.

The emission factor in AP-42 for this source category (upon which the 1985 NAPAP emission inventory was based) was developed based on a very limited data set and the development work was primarily carried out in the mid-70's to early 80's. The emission factor available in AP-42 for agricultural tillage is:

$$e = k\,(4.80)\,(s)^{0.6} \qquad (6)$$

where:
- e = emission (lb/acre)
- s = silt content (%)
- k = particle size multiplier (= 0.21 for PM_{10})

Data Requirements

A regional PM_{10} emission factor is necessary to calculate regional emissions estimates for this source. From equation 6, it is clear that in order to develop regional emission factors, data on the soil silt content for the region must be available. Information on this parameter may be available in certain soil databases such as the National Resources Inventory or it may be possible to estimate this parameter using soil type maps and generalized soil characteristics information. Although this information may not be updated on an annual basis (i.e. the time frame over which trends estimates would be developed), that may be less important for evaluating the silt content than for estimating the source extent (as was indicated in the Wind Erosion section above). It is possible that the silt content does not vary significantly from year to year.

The source extent information is much more likely to be available on a yearly basis for agricultural tilling, since tilling activity is crop related and the annual acreage of the various types of crops is estimated on an annual basis.

Summary

Since an existing emission factor is available and since adequate source extent information could be obtained, regional PM_{10} emissions estimates are feasible for this source. One potential problem for estimation of emissions for this source, however, is that no climatic parameters are considered in the emission factor. For instance, if the seasons just prior to tilling are very dry, it seems likely that emissions for tillage operations would be greater than those carried out for a year with greater precipitation in the preceding seasons. The current emission factor does not account for this type scenario.

CONSTRUCTION ACTIVITIES

Introduction

Construction activities can be divided into two broad categories, building construction and road construction. A general estimate for the emission factor for building construction was made in the early 70's. That value (1.2 tons/acre of construction/month), is based on field measurements of TSP emissions from apartment and shopping center construction projects. Some additional work has been carried out more recently, that looked at PM_{10} emission factors for topsoil removal, earthmoving and aggregate hauling (MRI, 1988). Based on that information, the following emission factors for PM_{10} were derived:

For topsoil removal	20 lb/VMT
For earthmoving (cut and fill)	4.3 lb/VMT
For truck haulage	10 lb/VMT

These emission factors are based on TSP emission factors determined using dispersion modeling multiplied by the PM_{10}/TSP ratio to obtain the PM_{10} emission factor. No more than four tests were carried out to develop these emission factors, however.

Data Requirements

Again, a PM_{10} specific emission factor for the region is necessary to calculate regional PM_{10} emissions. As noted above, there is a general TSP emission factor for total construction activity and PM_{10} specific emission factors for three processes involved in construction activity. Thus, a PM_{10} emission factor is available.

However, in order to calculate regional PM_{10} emissions estimates from this source, the source extent must also be available on a regional basis. With the new PM_{10} emission factors developed for this source, the required information is the number of vehicle miles traveled during construction activities. This data is simply not available and would have to be estimated. With the old TSP emission factor, only the number of acres and months that construction occurred were necessary to calculate PM emissions estimates. Previous large scale TSP inventories (Evans and Cooper, 1980; Heisler, 1988) utilized a conversion factor to evaluate the number of acres under construction from annual data on construction receipts. Smaller scale inventories (Cowherd and Guenther, 1976) have utilized the actual acreage of construction for estimating emissions. In addition, the number of months that each type of construction activity is performed is required. Estimation procedures for this have already been developed (Cowherd and Guenther, 1976). Thus, the source extent estimation methodology is already in place for TSP emissions estimation, but would have to be completely developed for the PM_{10} emission factors.

Summary

Unless a method for estimating the source extent for use with the PM_{10} emission factors can be found, development of regional PM_{10} emissions estimates cannot be made at this point.

FEEDLOTS

Introduction

Very little work has been done to develop an emission factor for feedlot particulate emissions. Again, the work that has been done was completed in the late 70' s and early 80's. The TSP emission factor that was developed at that time depended upon either the feedlot capacity or throughput. PM_{10} emission factors have been developed from the TSP emission factor by using the PM_{10}/TSP ratio for agricultural tilling (MRI, 1988).

Data Requirements

Although the PM_{10} emission factor for this source is very crude (due to the way it was developed), one does exist. Current PM_{10} emission factors are:

e = 180 lb/day/1,000 head capacity, or
e = 17 tons/1,000 head throughput

Source extent information could be extracted from the Census of Agriculture developed by the Bureau of the Census. Additional information may be available from the various state agricultural agencies. If information on the source extent was developed from the Census of Agriculture, it is possible that that source of information is not updated on an annual basis, thus estimates for trends purposes would not truly reflect the trend in emissions.

Summary

Both a PM_{10} emission factor and source extent information are available, so regional emissions estimates could be calculated. However, several potential problems exist with calculating PM_{10} regional emissions estimates based on the existing information. First, the emission factor contains no climate correction factor, even though the "gap filling" document where it was derived states that emissions are related to climate, soil texture, season, cattle density, natural mitigation of cattle in holding pens and pen cleaning cycles. None of these parameters are incorporated into the emission factor. Additionally, it is not clear whether or not the source extent is available on an annual basis as would be required of trends calculations.

BURNING

Introduction

This category includes burning from both forest wildfires and prescribed burning. There is an available PM_{10} emission factor from AP-42. Included in these emission factors are regional emission factors for prescribed burning.

Data Requirements

Regional PM_{10} emission factors are available in AP-42 for prescribed burning and many of these could be applied to wildfire burning. AP-42 does indicate, however, that these regional emission factors should not be utilized for emission inventories or for planning purposes.

Source extent estimates for wildfires for a given year could be obtained from the U.S. Forest Service regional offices. Prescribed burning source extent and spatial distributions should be fairly easy to obtain, since these are set fires and the locations, number of acres, fuel type, etc. should be known. The current trends method uses data from 1978 and assumes that it has remained constant each year since then.

Summary

Since the emission factor is available and since the source extent should be relatively easy to obtain, regional PM_{10} emissions estimates are feasible.

LANDFILLS

Introduction

Particulate emissions from landfill operations are caused by traffic, materials handling, and covering wastes with soil. There is not a single value PM_{10} emission factor available for landfill operations, however, the processes performed in landfill operations are covered by emission factors in AP-42. Some recent work on two landfills in Chicago indicated that the major contributor to landfill PM_{10} emissions was due to traffic on unpaved areas. A suggested PM_{10} emission factor of 1 $lb/yd^3/mi$ of travel to the disposal site was developed for that study (MRI, 1988). Additional emission factor development work would be required to validate this for landfills in other areas of the country.

Data Requirements

While there is a suggested PM_{10} emission factor, it requires a knowledge of the source extent consisting of both the number of cubic yards of waste disposed of and the distance from the entrance to the disposal site. While information on the number of cubic yards of material disposed of in landfills can probably be obtained EPA's Office of Solid Waste (OSW), it is doubtful that the average distance from the entrance to the disposal area is available.

Summary

While a "gap filling" PM_{10} emission factor exists, information on the two parameters of the source extent required to use this emission factor is probably available for only one of these parameters. Assumptions would have to be made for the other parameter in order for regional PM_{10} emissions estimates to be made. Thus, regional emissions estimates are feasible but would require some degree of effort in order to develop estimation procedures.

MINING AND QUARRYING OPERATIONS

Introduction

A wide variety of activities contribute to PM_{10} emissions from this source. Included among these are vehicle loading and unloading, blasting, crushing, drilling, overburden removal and unpaved road travel. PM_{10} emission factors have been developed for the majority of these activities.

Data Requirements

A mentioned above, PM_{10} emission factors exist for the majority of the activities that comprise the source of emissions at mining and quarrying operations. However, many of these emission factors require correction parameters such as silt or moisture content. Thus, in addition to estimates of the source extent, regional estimates of these correction parameters would also be required.

An additional complication to calculating regional PM_{10} emissions estimates from this source is that not all of the emission factors require the same source extent information. For instance, the PM_{10} emission factors for crushed stone processing all require information on the number of tons of stone processed. However, for western surface coal mining operations, some emission factors require information on the number of tons of coal, the number of blasts (for blasting), the number of cubic meters of overburden removed, and the vehicle miles of travel. As a consequence, several different regional source extent estimates must be derived in order to utilize these emission factors to develop regional PM_{10} emissions estimates.

Summary

Although PM_{10} emission factors are available for this source for the variety of emission generating activities, several of these emission factors require knowledge of correction parameters that would need to be known on a regional basis. In addition, several of the emission factors needed to calculate emissions from this source require different source extent estimates. Several of the source extent estimates required would be very difficult to develop on a regional basis (i.e. the number of vehicle miles of travel at western surface coal mines). As a consequence, although it may be feasible to produce regional PM_{10} emissions estimates, it would require a large development effort to produce the source extent estimates necessary to calculate these emissions.

UNPAVED PARKING LOTS

Introduction

Since unpaved parking lots are similar to unpaved roads, some of the initial work to develop an emission factor for PM_{10} emissions for this source has already been done. Additional work has been carried out recently to evaluate emissions from this source, and has come up with a method for estimating emissions (MRI, 1988). However, no field validation of the method was carried out.

Data Requirements

As indicated above, a PM_{10} emission factor applicable to this source has already been developed. Correction parameter information could be developed relatively easily, even the silt content term since the surface material utilized for unpaved parking lots would probably have the same source as that for unpaved roads in the same region.

Source extent evaluation for this source would be extremely difficult. The authors know of no source for determining the number and size of unpaved parking lots. Some type of computational algorithm would need to be developed, in order to estimate the source extent, if regional PM_{10} emissions estimates were to be developed.

Summary

Although a PM_{10} emission factor exists for this source, development of regional PM_{10} emissions estimates is probably not possible at this time, given the difficulty of developing adequate source extent information.

UNPAVED AIRSTRIPS

Introduction

Unpaved airstrips are similar to unpaved roads and the PM_{10} emission factor applicable to unpaved roads has been suggested for use with this source (MRI, 1988). Addition of a wind erosion multiplier (equal to 2) to account for dust produced by the prop wake has been suggested. Since the unpaved road emission factor is the basis for emissions from this source, the same correction parameter requirements are applicable. Source extent for this source is the number of landing and takeoff (LTO) cycles performed per airport.

Data Requirements

A regional PM_{10} emission factor is available for this source. Adequate information on the correction parameters required for utilizing this emission factor can also probably be developed on a regional basis, since the majority of the information is the same as that required for unpaved roads.

In previous TSP emissions inventories that have been developed for this source (Cowherd and Guenther, 1976), a computer tape has been obtained from the Federal Aviation Administration (FAA) which was utilized to determine the number of airports utilizing dirt, turf or gravel runways. Personal communications with regional FAA personnel would be required to estimate the number of LTOs for these airports. By determining the number and the LTOs at these airports, the source extent can be determined.

Summary

Regional emissions estimates from this source are feasible. However, considering the amount of time that would be required to develop the source extent term, especially in light of the magnitude of emissions from this source, this source is probably not worth including in a regional PM_{10} emissions estimate. Indeed, EPA's own "gap filling" PM_{10} emission factor document (MRI, 1988) indicates that this source is a minor source of PM_{10}.

STORAGE PILES

Introduction

AP-42 has a PM_{10} specific emission factor for this source category. Since this emission factor uses the silt content of the stored material, additional work may be needed to improve the database on silt contents of various materials on a regional basis.

Data Requirements

As indicated above, a PM_{10} emission factor is available, although information on the correction parameters utilized by this emission factor to calculate emissions may not be available on a regional basis.

Source extent information on this source category is virtually non-existent and would have to be developed from scratch.

Summary

Development of regional PM_{10} emissions estimates for this source is probably not feasible at this time since an adequate source extent database does not exist.

SECTION 3

PRELIMINARY EMISSIONS ESTIMATES

INTRODUCTION

In order to demonstrate the feasibility of developing regional PM_{10} emissions estimates, preliminary estimates were made for two fugitive dust sources. Regional PM_{10} emissions estimates for unpaved and paved roads for the period 1984 to 1988 were made. For paved roads, two separate components of paved road emissions were considered. These two components were resuspension of dust from paved road surfaces and emissions from sanding and salting of paved roads during snow/ice conditions. In addition to developing emissions estimates for these two fugitive sources, estimates of PM_{10} emissions from wind erosion (developed as part of the 1985 NAPAP effort) are also presented. Emission estimation techniques, data sources, assumptions and problem areas encountered in the development of these estimates are also discussed.

UNPAVED ROADS

Methodology

Estimation of PM_{10} emissions from unpaved roads was carried out similarly to the methods outlined by Barnard (1989) and Barnard et al. (1987). This method requires estimation of unpaved road VMT from unpublished data available from the U.S. DOT. Data for state-level local functional class unpaved roads (which typically comprise 80-90% of all unpaved road mileage) is assembled each year in spreadsheets by DOT. The data is compiled by locale (rural, small urban and urban), road surface type (paved, gravel/soil surfaced and unimproved) and by ADTV class. By determining the midpoint of the average daily traffic volume class and multiplying that number by the number of miles of unpaved road in that class and by 365 days/year, the annual VMT for each ADTV class can be determined. Once the local functional class unpaved VMT was determined, then the average urban and rural ADTV on these roads was calculated. These values were used to determine the VMT on non-local functional class unpaved roads. Mileage for non-local functional class roads is available from the U.S. DOT Annual Highway Statistics publication. Information was obtained for the years 1984-1988.

For some states, local functional class unpaved road mileage information was not available. For these states, the estimation method developed by Barnard et al. (1987) was utilized. This method basically utilizes information available for surrounding states to develop the appropriate information for the state with missing data.

Once the source extent was determined, then appropriate emission factors needed to be determined. As can be seen from equation 1, the silt content, vehicle speed, vehicle weight, number of wheels and number of dry days per year are needed to determine the emission factor. In most cases, state-level information was utilized for these parameters. Silt content was derived from a database developed during the 1985 NAPAP effort by the Illinois State Water Survey. This database contains the silt content of over 200 unpaved roads from over thirty states. Average silt content of unpaved roads in a state were calculated for each state that had three or more samples for that state. For states that did not have the required number of samples, the average for all samples from all states was substituted.

The number of dry days per year in each state was determined by averaging (if two or more stations were available) the number of days with more than 0.01 inches of precipitation from the most rural meteorological stations available from Local Climatological Data (LCD) annual summaries. This information was obtained for the years 1984-1988.

For vehicle speed, the following assumptions were made:

Rural Roads	Speed (mph)
Minor arterial	45
Major collector	40
Minor collector	40
Local	35

Urban Roads	Speed (mph)
Other principal arterial	50
Minor arterial	45
Collector	40
Local	40

Estimates of vehicle weight and the number of wheels per vehicle were made using information provided by the U.S. DOT (Jeff Haugh, personal communication). This data indicated that the following weighted average values were appropriate for the following vehicle classes:

Vehicle Type	Weight (tons)	Wheels
Single Trailer Trucks	26.7	18
Multi-Trailer Trucks	31.5	20
Single Unit Trucks	9.55	7
Passenger vehicles	2.5	4

By utilizing the above information, emission factors for each vehicle type and for each road type could be determined. Once this was accomplished, national statistics provided by U.S. DOT on travel activity by vehicle type (Jeff Haugh, personal communication) were utilized to allocate the percentage of travel on each road type to each vehicle type. By doing this, a composite weighted emission factor that reflected the vehicle mix on each road type was developed. This emission factor was then multiplied by the source extent (i.e. VMT) on that road type to develop state-level emissions estimates. The state-level emissions were then compiled into EPA regional emissions.

Results

The results of the emissions estimates developed using the methodology described above are presented in Table 2 (all values in short tons). These values clearly show that unpaved road PM_{10} emissions are highest in Regions 5 and 6 for the years examined. Overall U.S. annual emissions vary between 17.9 and 19.6 million tons for the period 1984-1988. Figure 1 depicts the regional contributions to the overall U.S. emissions. There is no consistent overall trend for the years examined. This result is probably related to the differences in the state-level reporting of unpaved road mileage and from year-to-year differences in the meteorological correction term. It is important to remember that the states are not required to report local functional class unpaved road information (the most important class of unpaved roads) to the U.S. DOT and that the information reported is an estimate and not a true count of traffic patterns or number of miles on these roads.

As a point of comparison, unpaved road particulate emissions estimates were determined as part of the 1985 NAPAP Emissions Inventory. The PM_{10} emissions reported as part of that effort were 8.9 million tons for the total U.S. The major differences between the values reported as part of the NAPAP effort and the estimates reported here are caused by two factors. First, investigators at the Illinois State Water Survey responsible for preparing the state-level emissions estimates for the NAPAP inventory utilized a plume depletion factor to reduce the calculated emissions to 0.1 of their original value. This plume depletion factor was utilized to account for emissions capable of traveling long distances and interacting with precipitation (the major emphasis of the NAPAP work). Thus, the 1985 NAPAP estimates should be multiplied by 10 to yield numbers equivalent to those reported here. If this multiplication is carried out, the total U.S. PM_{10} emissions estimated for the 1985 NAPAP inventory would be approximately 89 million tons. This value is approximately 4 times the values estimated in this study.

The second difference between the NAPAP estimates and the estimates presented in this study is that the NAPAP inventory did not use the AP-42 emission factor for gravel/soil surfaced unpaved roads. The ISWS researchers utilized a new emission factor developed for passenger vehicles traveling on gravel roads, rather than the AP-42 emission factor. This emission factor uses correction parameters for vehicle speed, road silt content and the fraction of road surface material between 0.425 and 2 mm. No measurements involving vehicles other than passenger cars were used to develop this emission factor, and its reliability in predicting emissions from vehicles other than passenger cars has not been verified.

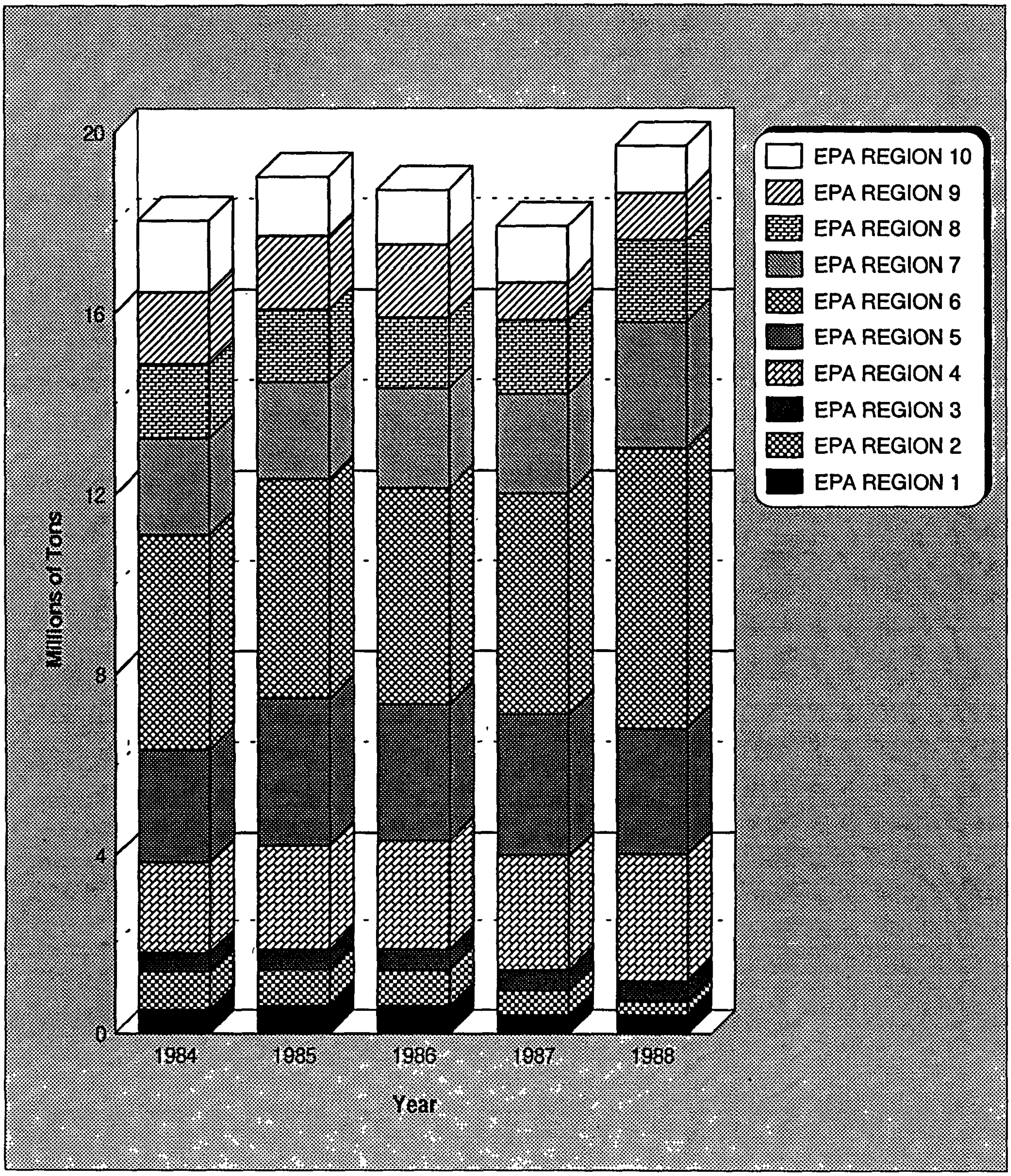
For unimproved surface unpaved roads, the ISWS investigators utilized the AP-42 emission factor equation, however, they used an older version of the equation that had the particle size multiplier (k, see equation 1 above) equal to 0.45 instead of 0.36. Thus, emissions for this road type were over-estimated by at least a factor of 1.25.

Because of these differences (and to be consistent with other TSP emission inventories), we decided to utilize the AP-42 emission factor for all unpaved road emissions estimates. Other differences between the NAPAP estimation technique and that utilized here are the use of only one vehicle speed and a single vehicle weight to calculate emissions for the NAPAP inventory. Our technique (as described above) utilizes information on the vehicle distribution on unpaved roads (and the consequent weight and number of tire differences) to develop a weighted emission factor that reflects the traffic distribution. Estimates of vehicle speed on the various unpaved road functional classifications were also utilized in our estimation method.

Table 2. Regional PM_{10} Emissions Estimates from Unpaved Roads

REGION	1984	1985	1986	1987	1988
U.S.	18,047,498	19,009,713	18,723,489	17,919,076	19,698,434
EPA 1	529,089	607,772	609,177	397,133	409,081
EPA 2	852,973	819,879	802,135	560,562	302,572
EPA 3	405,987	436,440	454,937	457,229	455,106
EPA 4	2,048,798	2,362,001	2,477,899	2,595,136	2,848,614
EPA 5	2,520,738	3,247,627	3,000,998	3,112,027	2,789,425
EPA 6	4,747,981	4,873,525	4,798,563	4,900,560	6,212,560
EPA 7	2,139,928	2,131,620	2,190,986	2,199,667	2,778,000
EPA 8	1,631,882	1,611,792	1,564,683	1,629,575	1,808,317
EPA 9	1,588,718	1,605,203	1,600,053	819,741	1,042,792
EPA 10	1,581,403	1,313,854	1,224,059	1,247,447	1,051,968

Figure 1. Regional Contributions to Unpaved Road PM_{10} Emissions



PAVED ROADS

Methodology

Resuspended Dust

Regional PM_{10} emissions estimates were made for two components of paved road emissions. The first component was paved road resuspension. The second component was an estimate of the emissions from paved roads as the consequence of road sanding and salting operations.

Emissions estimates from paved road resuspension were derived by utilizing the current AP-42 emission factor (see equation 2 above) in conjunction with U.S. DOT data on VMT on paved roads. AP-42 provides values for the base emission factor and coefficient for PM_{10} emissions in Table 11.2.5-1. Section 11.2.5 of AP-42 also provides information on the silt loading (sL) of paved roads, but the amount of data available is very limited. As a consequence, equation 3 (above) was utilized to determine the silt loading. In order to determine sL, the ADTV on various functional classes of paved roads was required. Since the U.S. DOT also provides road mileage statistics by functional class, ADTV values for the various paved road functional classes could be calculated by dividing the VMT by the mileage and then dividing by the number of days per year. These ADTV values were utilized in conjunction with equations 2 and 3 to determine functional class specific paved road emission factors. Once these emission factors were derived, then the PM_{10} emissions could be calculated for each paved road functional class.

Road Sanding and Salting

Regional PM_{10} emissions estimates from road sanding and salting operations were estimated by utilizing the emission factor given in the EPA "gap filling" document (MRI, 1988). For road sanding, an emission factor of 0.018 lb/ton was utilized. For salting operations, an emission factor of 10 lb/ton was used. In order to utilize these emission factors, the number of tons of sand and salt typically applied during sanding and salting operations was needed. Information in the "gap filling" document for Iowa indicated that 510 lb/mi of salt and 1000 lb/mi of sand are applied per snow day. Information from the North Carolina Department of Transportation (Dennis Carter, personal communication) indicated that between 200-500 lbs/two-lane mile are applied to roads in North Carolina, depending upon the temperature and the type of precipitation (wet snow, dry snow, sleet, freezing rain, etc.). The information received also indicated that the sand/salt ratio used in North Carolina was 20:1. This value is on the high end of the range indicated in the "gap filling" document. For calculating emissions, values of 500 lb/mi for salt and 5000 lb/mi for sand were assumed.

Source extent information was derived using Table 13 of the "gap filling" document. That table lists the number of single lane miles of road treated for various states. Arizona, Arkansas, Tennessee, South Carolina, Louisiana, Oklahoma, Texas and Nevada did not have data. For these states, the number of miles of treated road was approximated by determining the average for several surrounding states. The states utilized to derive the estimated mileage and the estimated treated miles of road (in thousands of miles) were as follows:

State	Surrounding States	Treated Mileage
AZ	NM, CA, UT, CO	7.1
AR	NM, KS, MS	12.2
TN	MS, AL, GA, NC, VA, KY, MO	11.9
SC	GA, NC	6.1
LA	MS, AL, GA	2.6
OK	MO, KS, NM	21.9
TX	NM, MS	5.3
NV	CA, OR, ID, UT	11.8

Table 13 of the "gap filling" document also presents data on the mean annual snow days for each state. However, since this study was designed to analyze the development of emission trends, we substituted mean annual snow days with year-specific information on the number of days with $\geq$ 1 inch of snow for the most urban meteorological stations that report annual Local Climatological Data information to the National Climatic Data Center.

Once the above information was obtained, the regional PM_{10} emissions estimates for road sanding and salting operation were calculated by multiplying the sand application rate by the emission factor times the number of miles of treated road times the number of days with $\geq$ 1 inch of snow. Salting emissions were calculated in an identical manner using the salt emission factor and the salt application rate.

Results

The results of these calculations are given in Tables 3 and 4 (all values in short tons). These regional PM_{10} emissions estimates show that paved road PM_{10} emissions attributable to resuspension are between 9.2 and 10.5 million tons. Additionally, with few exceptions, paved road resuspension PM_{10} emissions have tended to increase in each region each year of the five year period examined.

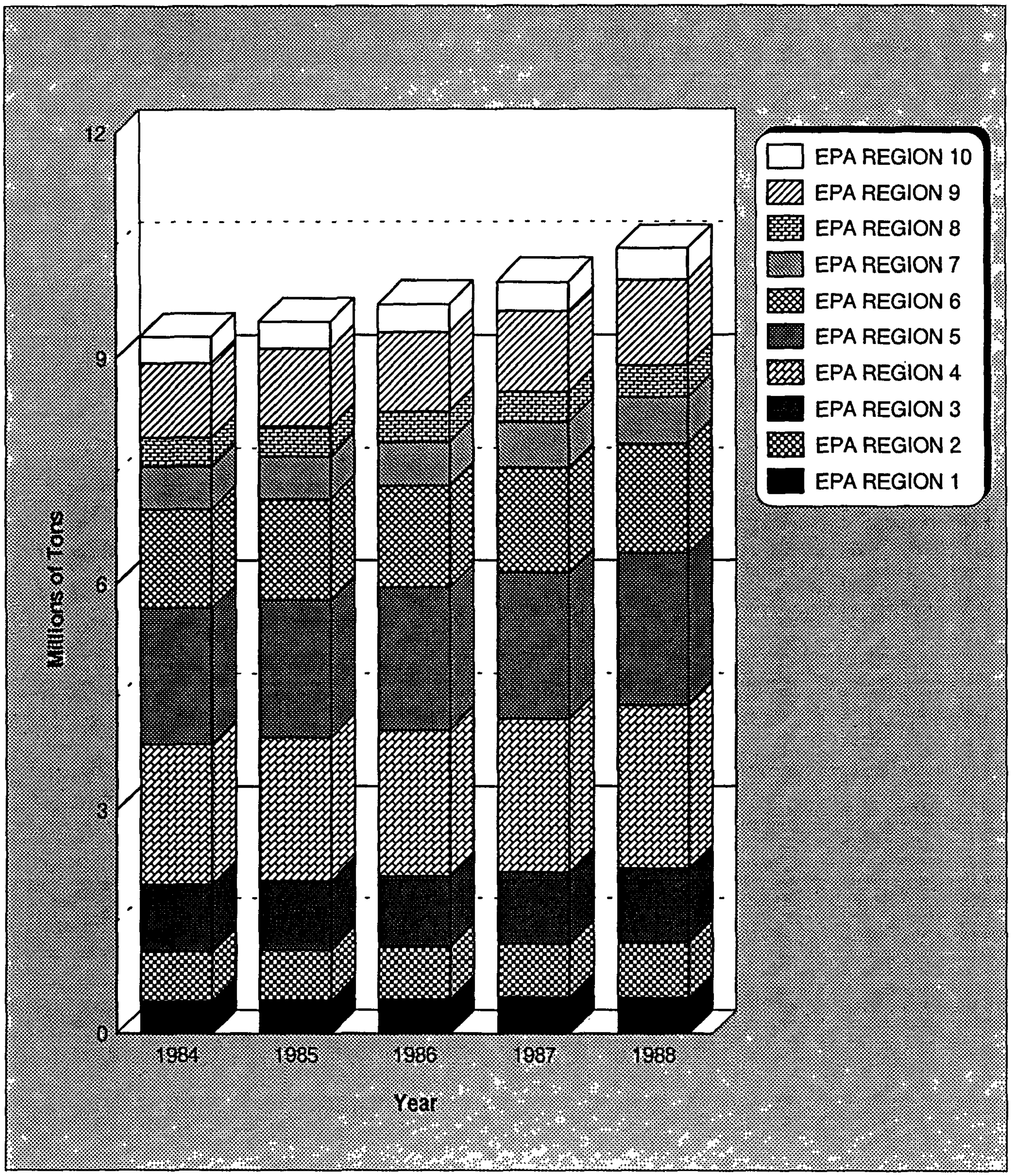
One interesting item to note in Table 3 is that the total U.S. PM_{10} emissions from paved road resuspension is approximately equal to the paved road TSP emissions estimates presented in Table 1. This is the result of a change in the emission factor between the time that the TSP inventories presented in Table 1 were calculated and the current emission factor for PM_{10}. The old TSP emission factor was approximately the same as the current PM_{10} emission factor.

Regional contributions to paved road resuspension PM_{10} emissions estimates are shown in Figure 2.

Table 3. Regional PM_{10} Emissions Estimates from Paved Road Resuspension

REGION	1984	1985	1986	1987	1988
U.S.	9,292,335	9,490,310	9,724,860	10,019,982	10,455,975
EPA 1	431,720	444,629	457,005	482,957	479,923
EPA 2	661,243	672,103	694,365	708,478	729,362
EPA 3	906,597	928,437	958,512	971,557	996,902
EPA 4	1,877,832	1,918,011	1,952,973	2,043,687	2,183,031
EPA 5	1,795,007	1,819,558	1,888,822	1,946,045	2,015,364
EPA 6	1,329,015	1,347,365	1,355,751	1,396,151	1,457,858
EPA 7	567,044	568,828	582,428	599,398	616,722
EPA 8	381,767	392,999	396,912	403,223	419,960
EPA 9	982,266	1,033,563	1,063,079	1,076,497	1,138,699
EPA 10	359,844	364,818	375,011	391,989	418,155

Figure 2. Regional Contributions to Paved Road Resuspension PM_{10} Emissions



Regional PM_{10} emissions estimates from paved road sanding and salting operations are presented in Table 4. The values shown in that table clearly indicate (at least for the assumptions utilized in these calculations) that paved road sanding and salting operations are a relatively insignificant source of PM_{10} emissions compared to the resuspension component of paved road PM_{10} emissions.

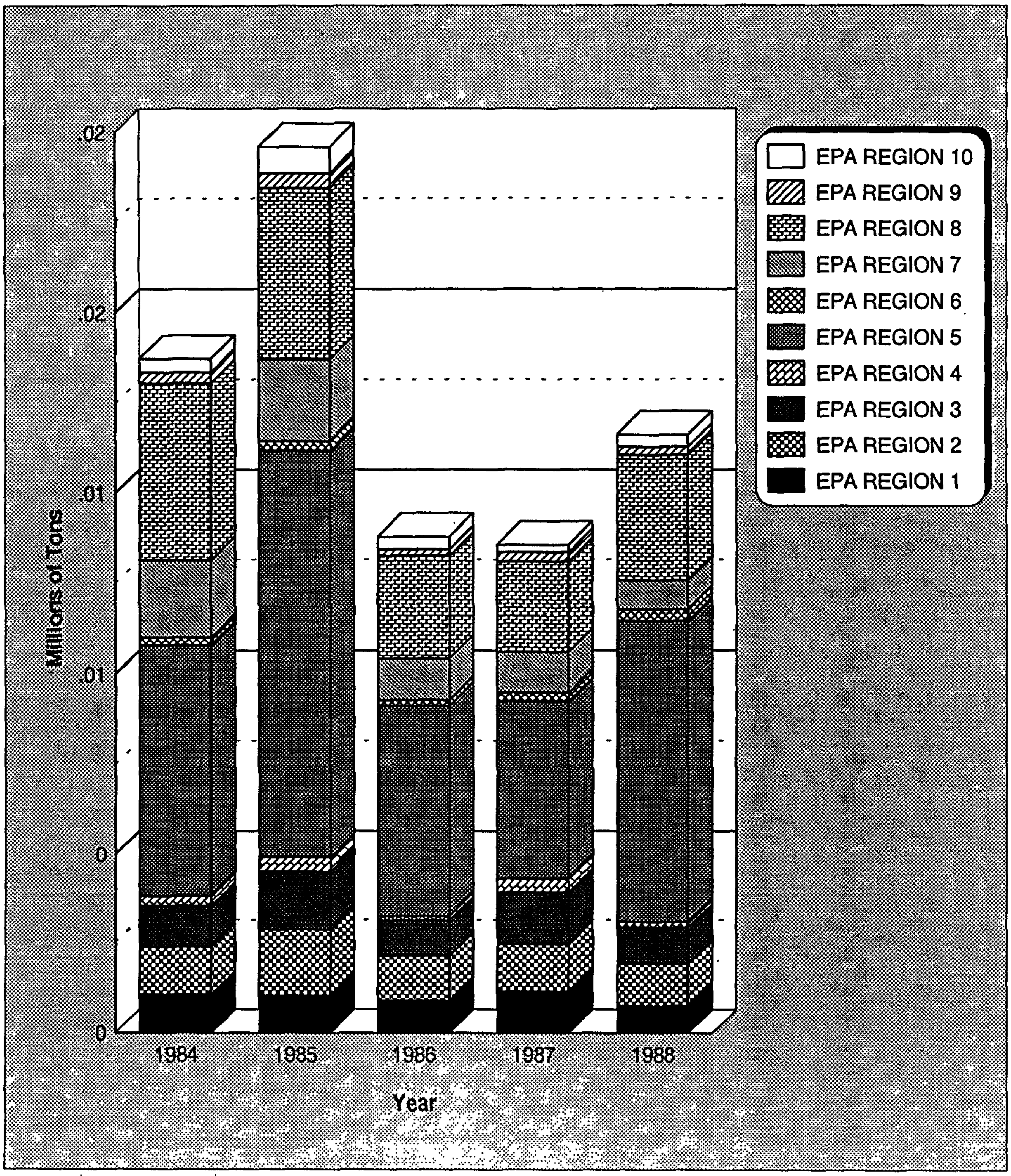
Information in Table 4 also clearly indicates the importance of meteorology in estimating these emissions. Since the number of treated miles and the sand and salt application rates were invariant over the period considered, the only variable left to influence emissions was the number of days with $\geq$ 1 inch of snow.

Regional contributions to paved road sanding and salting PM_{10} emissions are shown in Figure 3.

Table 4. Regional PM_{10} Emissions Estimates from Paved Road Sanding and Salting

REGION	1984	1985	1986	1987	1988
U.S.	14,984	19,683	11,034	10,852	13,300
EPA 1	843	811	717	915	588
EPA 2	1,075	1,493	988	1,054	943
EPA 3	913	1,306	801	1,167	809
EPA 4	214	322	98	299	129
EPA 5	5,597	9,007	4,682	3,951	6,698
EPA 6	172	215	138	202	248
EPA 7	1,699	1,812	913	897	642
EPA 8	3,939	3,803	2,267	1,989	2,787
EPA 9	238	327	150	211	186
EPA 10	296	587	279	167	269

Figure 3. Regional Contributions to Paved Road Sanding/Salting PM_{10} Emissions



WIND EROSION

Regional PM_{10} wind erosion emissions estimates were not calculated in this study, due to the complications in calculating emissions estimates from this source indicated in the feasibility section above. However, to facilitate comparison of the magnitude of this source to the estimates prepared for unpaved roads and paved roads, regional emissions estimates developed by Barnard (1990) as part of the 1985 NAPAP emission inventory effort are presented in Table 5. It should be realized, that these emissions estimates are for particles $\leq$ 20 microns. Particle size distributions determined using airplane sampling during wind erosion events indicates that approximately 90% of the particle mass was in particles smaller than 10 microns (Gillette et al., 1978), thus multiplication of the values in Table 5 by 0.9 would give an indication of the magnitude of PM_{10} emissions from this source.

Table 5. 1985 NAPAP Wind Erosion Emissions Estimates (all values in short tons)

REGION	Particulate
U.S.	4,711,539
EPA 1	0
EPA 2	909
EPA 3	1,040
EPA 4	5,462
EPA 5	366,011
EPA 6	2,340,545
EPA 7	395,476
EPA 8	1,516,533
EPA 9	83,398
EPA 10	2,164

The values in Table 5 indicate that PM_{10} emissions from wind erosion for the U.S. (as calculated as part of the 1985 NAPAP inventory) are approximately the same order of magnitude as emissions from paved road resuspension.

SECTION 4

RESULTS AND DISCUSSION

RESULTS

Feasibility Study

Table 6 summarizes qualitatively the feasibility of developing and the development effort required for generating regional PM_{10} emissions estimates for the sources considered in the feasibility section above.

Table 6 indicates that regional emissions estimates for the majority of the major PM_{10} fugitive dust sources can be developed. Of the largest sources, wind erosion will require the largest effort to develop regional emissions estimates, at least initially, since a determination of an appropriate emission factor and development of source extent information will be required. Several sources (unpaved roads, paved roads, and agricultural tilling) require a low level of effort. The remaining categories for which regional emissions estimates are feasible require either a moderate or moderate to high level of effort. Two categories are considered infeasible at this time (unpaved parking lots and storage piles). Unpaved airstrips (although feasible) are probably not worth the effort that would be necessary to develop emissions estimates, given the estimated magnitude of the source.

Preliminary Emissions Estimates

The preliminary emissions estimates determined for unpaved and paved roads in this study indicate that it is feasible to produce regional PM_{10} emissions estimates from fugitive dust sources. Based on these estimates, unpaved road PM_{10} emissions are approximately double those of paved roads. Additionally, PM_{10} emissions from sanding and salting operations on paved roads are significantly lower than emissions from resuspension of material on paved roads. Since the emission factors for tire and brake wear are much lower than those for resuspension (by approximately a factor of 350), and since the source extent is the same (VMT), these sources also would be much lower than the resuspension source.

Table 6. Feasibility of Developing Regional PM_{10} Emissions Estimates

Source	Regional Emissions Estimates Feasible?	Development Effort Required to Produce Regional Emissions Estimates
Wind Erosion	Yes	Moderate to High
Unpaved Roads	Yes	Low (preliminary estimates already made)
Agricultural Tilling	Yes	Low
Construction	Maybe (Depends upon development of adequate source extent information or use of older TSP emission factor with PM_{10} correction parameter)	Moderate to High
Mining and Quarrying	Maybe (Depends upon development of adequate source extent information)	Moderate to High
Paved Roads	Yes	Low (preliminary estimates already made)
Burning	Yes	Moderate
Feedlots	Yes	Moderate
Unpaved Airstrips	Yes	Moderate (but may not be worth effort considering size of source)
Landfills	Yes	Moderate to High
Unpaved Parking Lots	No (not at this time)	High
Storage Piles	No (not at this time)	High

Problem Areas

Several potential problems exist with producing regional estimates for fugitive PM_{10} emissions. Although emission factors and source extent estimates exist for the sources estimated here, the validity of these numbers may be open to question. For instance, information on unpaved roads in not required to be reported to the U.S. DOT, and examination of the reported data indicates that this information may not receive a great deal of attention by the states that do report it. As an example, Indiana evenly distributes the unpaved local functional class mileage between the ADTV categories. Since there are four categories, 25% of the total unpaved road mileage is allocated to each. Surrounding states such as Illinois, Ohio and Kentucky show that the majority of the mileage for unpaved roads in those states is found in the lowest two ADTV categories, especially for rural roads. However, since this is the "data" reported by Indiana, and is supposed to represent their "best" estimate, the reported information was utilized in developing emissions estimates for inclusion in the Region 5 results.

Emission factors may also lead to potential problems. The PM_{10} emission factor utilized to develop the emissions estimates for paved road resuspension includes no term for reducing emissions as the consequence of precipitation, even though the emission factor for unpaved roads does. It seems likely that precipitation would act similarly to water sweeping of paved roads and that such a term should be included in determining emissions from this source. The effect of such a term would be to reduce paved road resuspension PM_{10} emissions, especially in those regions with significant precipitation levels.

The emission factor for paved road resuspension is also singularly dependent upon the silt loading term included in equation 2. According to EPA guidance (Cowherd et al., 1988), the silt term can be evaluated if you know the ADTV. However, the ADTV is linearly related to the VMT. Since VMT is also the source extent for this source, you can perfectly predict the PM_{10} emissions by establishing a relationship between VMT and emissions.

Two items are important to remember in considering whether or not to determine regional PM_{10} emissions estimates as part of a trends estimation. First, the numbers developed for fugitive PM_{10} emissions will have a great deal of error associated with them due both to the state of the science for emission factors as well as the procedures utilized to evaluate the source extent. Second, given the first item, these are the only tools available for determining this type estimate and any other person or agency trying to produce similar estimates will be forced to utilize identical or very similar techniques. Thus, EPA's decision as to whether or not to develop these regional PM_{10} emissions estimates for trends estimation should give due consideration to these two items.

RECOMMENDATIONS

The following recommendations for development of fugitive dust PM_{10} regional emissions trends estimates are based on the results of this study in conjunction with conversations with EPA Technical Support Division (TSD) personnel.

1. For the 1989 Trends Report, EPA should include emission estimates for unpaved roads and wind erosion at the national and regional levels. For the other five categories (agricultural tilling, construction, mining and quarrying, paved roads, and burning), emission estimates at the national level only should be included. It is further recommended that for this single annual assessment, 1985 should be used for the year of assessment. 1985 is suggested as the year for presentation, since there is a critical mass of information available (i.e. the 1985 NAPAP emission inventory) for several of the categories suggested for inclusion.

   Of the above categories that should be included at the national level for the 1989 Trends reports, data on wind erosion and agricultural tilling should be developed from the 1985 NAPAP emissions inventory. Appropriate qualifying language detailing the methodology utilized to develop these estimates should be placed in the Trends reports, so that methodological differences leading to potential changes in future year estimates can be readily explained.

   Although the 1985 NAPAP emission inventory included emissions estimates from unpaved roads, it is recommended that the emissions estimates developed in this report for 1985 be included in the 1989 Trends reports. The methodology used to develop the estimates for this source presented in this report utilized the current AP-42 emission factor, rather than the emission factor developed as part of the NAPAP effort. In addition, this methodology accounts for the distribution of vehicle types (i.e. passenger vehicles, trucks, etc.) traveling on unpaved roads, variability in vehicle weights and number of wheels, and in vehicle speed on various unpaved road types. The emission factor developed as part of the 1985 emission inventory effort has never been validated for other than passenger cars, and the emissions estimation methodology assumed single values for vehicle speed, vehicle weight and number of wheels. We feel that the methodology utilized in this study is consistent with EPA guidance on development of emissions estimates from this source (i.e. utilization of AP-42 emission factors) and that the allocation of emissions based on the vehicle mix is a better approach than the single weight/speed/tires approach utilized in the NAPAP estimation method.

2. Starting with the 1990 Trends reports, emission estimates for the seven categories included in Recommendation 1 (see above) should be included at the regional level. These estimates should represent a minimum of a five year period so that a trend can be developed. As indicated in Recommendation 1, two categories (unpaved roads and wind erosion) should be presented on a regional level in the 1989 Trends reports since regional estimates for these two categories are feasible and are thought to provide a reasonable, initial characterization of regional emissions from these sources.

3. In order to provide the regional emissions estimates proposed in Recommendation 2 (see above), development work would be required in order to develop methods to produce regional emissions estimates for those sources for which emissions estimates were not developed in this feasibility study. These sources include: wind erosion, agricultural tilling, construction, mining and quarrying and burning. Methodology changes may be required between the production of national numbers for inclusion in the 1989 Trends report (see Recommendation 1) and subsequent regional trends emissions estimates. For instance, the 1985 NAPAP method of producing wind erosion estimates would be difficult to use for production of regional emissions estimates, thus development of a methodology to produce regional emissions estimates would be required prior to the 1990 Trends reports publication.

4. Some specific recommendations can be made with regard to the emissions estimation methods for several of the sources that should be included in future regional emissions estimates. These include:

   A. Addition of a "dry days" term to the emission factor equation for paved roads. The same term as is utilized for the unpaved road emission factor should be used. Addition of this term would help account for washing of paved roads due to precipitation and, although not a perfect solution to this problem, would be defensible, since a similar term is already utilized to reduce emissions from unpaved roads.

   B. Utilization of the single-valued construction emission factor with a PM_{10} multiplier to develop regional construction emissions estimates. The new "gap filling" emission factors, although representing a better method of estimating site-specific emissions estimates, would pose large problems in terms of estimating regional emissions estimates due to the nature of the source extent information required.

C. Wind erosion emissions estimates may require utilization of the Universal Soil Loss equation, with a multiplier to evaluate the vertical flux of PM_{10} material. Other potential methods of estimating emissions from this source should be considered, but the Universal Soil Loss equation may represent the best available method at this time.

D. A single-valued emission factor may be required for developing emissions estimates for mining and quarrying operations coupled with a multiplier to ascertain the PM_{10} fraction of these emissions. Utilization of the AP-42 PM_{10} emission factors may present considerable difficulties in developing adequate source extent information.

5. Regarding the other five source categories considered in this report (feedlots, landfills, unpaved parking lots, unpaved airstrips, and storage piles), these categories should not be included for development at this time in future Trends reports. The main reasons for not including these sources at this time are inadequate or non-existent information on the source extent (i.e. activity level) at the regional level or the expected level of emissions is a great deal lower than the seven categories that are recommended for development, or both.

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TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-450/4-91-005b	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Feasibility Of Including Fugitive PM-10 Emissions Estimates In The EPA Emissions Trends Report		5. REPORT DATE September 1990 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) William Barnard and Patricia Carlson		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Pechan & Associates, Inc. Durham, NC 27707		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. 68-02-4400
12. SPONSORING AGENCY NAME AND ADDRESS U.S. Environmental Protection Agency OAR, OAQPS, TSD, EIB (MD-14) Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
EPA Project Officer: E. L. Martinez

16. ABSTRACT

This report describes the results of Part 2 of a two part study. Part 2 was to evaluate the feasibility of developing regional emission trends for PM-10. Part 1 was to evaluate the feasibility of developing VOC emission trends, on a regional and temporal basis. These studies are part of the effort underway to improve the national emission trends. Part 1 is presented in a separate report. The categories evaluated for the feasibility of developing regional emissions estimates were: unpaved roads, paved roads, wind erosion, agricultural tilling, construction activities, feedlots, burning, landfills, mining and quarrying, unpaved parking lots, unpaved airstrips and storage piles.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Emission Trends	Agricultural Tilling		
Trends	Construction Activities		
PM-10	Feedlots		
Regional	Burning		
Temporal	Landfills		
Unpaved Roads	Mining and Quarrying		
Paved Roads	Unpaved Parking Lots		
Wind Erosion	Unpaved Airstrips		
	Storage Piles		

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 44
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE