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Environmental Protection
Agency

Air Pollution Training Institute (APTI)
Mail Drop E14301
Research Triangle Park, NC 27711

September 2004

Air

Preparation of Fine Particulate Emission Inventories

Instructor's Manual

APTI Course 419B

Developed by
ICES Ltd.
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Notice

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Availability

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Course Description

APTI 419B: *Preparation of Fine Particulate Emission Inventories* is a two-day, resident instructional course designed to present an advanced view of all major, practical aspects of developing an emission inventory for fine particulate matter. The course is intended primarily for employees that have a working knowledge of emission inventory terminology and techniques. The course focuses on the principal stationary nonpoint area and nonroad mobile source categories emitting PM fine particles. For select categories, the course provides a brief summary of how emissions are estimated for EPA's National Emissions Inventory (NEI), and how state/local/tribal agencies can improve upon those estimates. Case studies are used to provide real-world examples of how state or lo9cal agencies collected their own data to prepare inventories that are improvement to the NEI methods. The lessons include information on an overview of fine PM, an overview of the NEI, onroad mobile inventory development, onroad mobile inventory development, point source inventory development, area sources, fugitive dust area sources, combustion area sources, and other related topics.

The course is taught at an instructional level equivalent to that of an advanced, undergraduate university course. The Air Pollution Training Institute curriculum recommends APTI 419B: *Preparation of Fine Particulate Emission Inventories* as an advanced course for all areas of study. The student should have minimally completed a college-level education and APTI Course SI:419A – *Introduction to Emission Inventories* or have a minimum of six months of applicable work experience.

How to Use This Manual

This manual is to be used during classroom instruction and telecourse sessions. The workbook contains instructional objectives and materials for each of the thirteen subject areas.

Each chapter provides a lesson goal, instructional objectives, subject narrative, and reference materials that may guide your study. Each chapter also contains a reproduction of selected lecture slides intended to guide your notetaking. The slides are presented to generally follow the course outline; however, the instructor may on occasion vary the order of presentation or present material not included in the workbook. Each student, therefore, should take thorough notes of the lecture content throughout the course, but not rely solely upon graphic reproductions for the course content.

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This document does not constitute U.S. Environmental Protection Agency policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

TABLE OF CONTENTS

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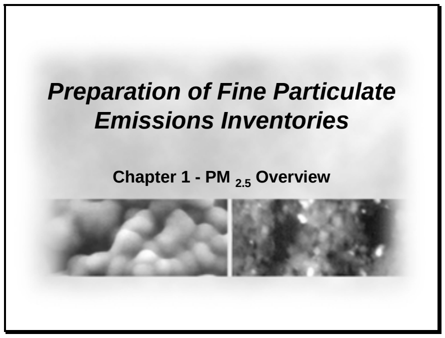
Chapter 1 - PM 2.5 Overview

1 - 1



After this lesson, participants will be able to describe:

- the general composition of fine particulate matter in the atmosphere,
- how fine particulate matter are formed, and
- sources that contribute to the formation of fine particulate matter.

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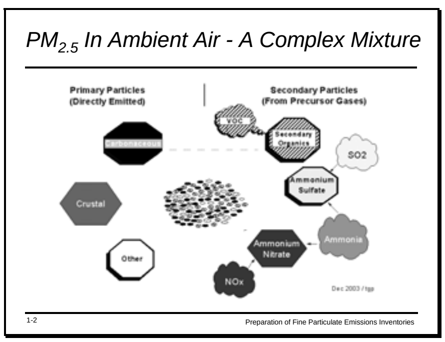

This graphic illustrates the difference between **primary**, or directly emitted particles and **secondary** particles, which are formed in the atmosphere from precursor gases.

Primary particles contain:

- elemental carbon (EC)
- primary organic aerosol (POA)
- small amounts of crustal matter and other materials.

Secondary particles contain:

- secondary organic aerosol (SOA) formed from volatile organic compounds
- ammonium sulfate formed from SO_2 and ammonia gases
- ammonium nitrate, formed from NOx and ammonia gases.

The term **total carbonaceous matter** is used to describe the combined mass of EC, POA, and SOA.

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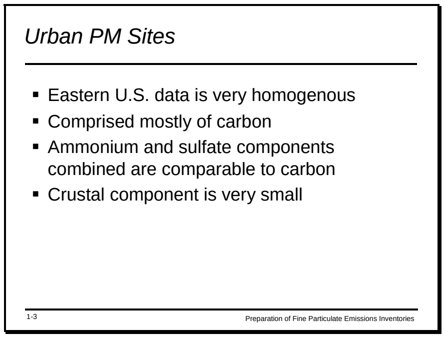

Data from EPA's urban speciation trends network show that:

- particulate matter in the eastern half of the United States is homogenous in composition
- particulate matter in eastern sites comprises mainly carbonaceous aerosol and ammonium sulfate in comparable amounts
- the crustal component of $PM_{2.5}$ is very small in both western and eastern urban monitoring sites (with the exception of some places in the southwest and the central valley of California)

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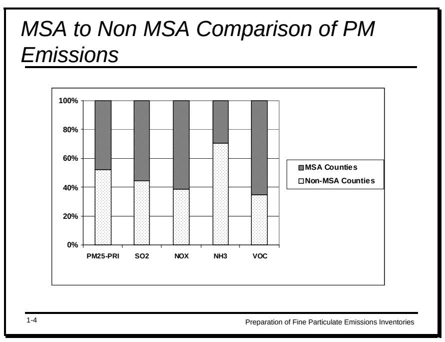

This graph depicts percentages of primary PM emissions (and their precursors) throughout the 37 states of eastern and central United States.

The data indicate that:

- roughly half of the primary PM is emitted in the Metropolitan Statistical Areas and about half in the rural areas.
- ammonia (NH_3) is the only precursor with greater emissions in rural areas than in urban areas;

Higher rural ammonia emissions are related to agricultural emissions. In urban areas, these emission can be attributed to agricultural and mobile sources.

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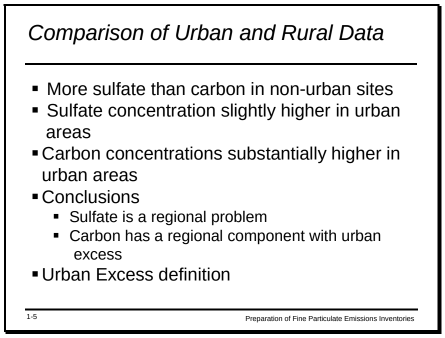

Ambient monitoring data from both urban and rural sites in the speciation trends network show:

- higher quantities of sulfate than carbon in the non-urban sites
- slightly higher sulfate concentrations in urban areas compared with surrounding non-urban areas
- substantially higher carbon concentrations in urban areas

Conclusions to be drawn:

- The monitoring data highlights the regional scope of the problem of sulfate emissions.
- There is a significant excess of carbon in the urban areas, as evidenced by its marked increase from rural to urban areas.

Urban air quality data is often compared to rural air quality data by noting the amount of “urban excess” for a particular component.

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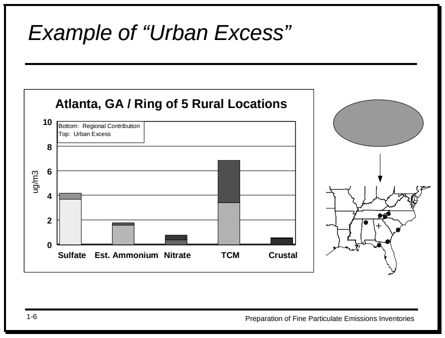

- Data from Atlanta, GA is presented in this graph to illustrate the “urban excess” concept, as depicted on the top part of the bars.

Note that:

- Nearly all sulfate is associated with the regional contribution; this indicates that the sulfate in Atlanta is only 10-15% higher in concentration than the sulfate that you find in the surrounding rural sites.
- Since most of the ammonium is associated with sulfate, ammonium concentrations follow a similar pattern.
- Nitrate and carbon concentrations are nearly twice as high in urban areas as in rural areas, a significant “excess”.
- The concentration of total carbonaceous material is greater than the sulfate concentrations in Atlanta and the concentration of crustal material is very small.

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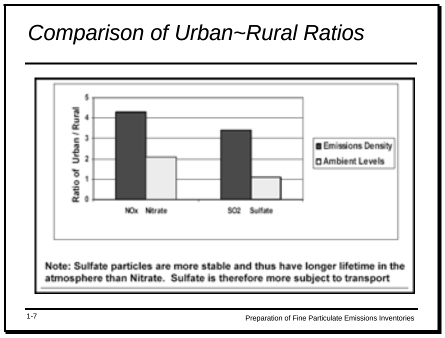

This bar chart compares emission densities with ambient concentrations for urban and rural areas.

- The density of NO_x emissions per square mile is about four times higher in urban areas than in rural areas
- Nitrate concentrations are roughly twice as high in urban areas as in the rural areas.
- The data suggest that the higher concentration of ammonium nitrate in urban areas is associated with the higher NO_x emissions in the urban areas.
- Sulfate has a higher density of emissions in urban areas, but this ratio is not reflected in the ambient data.

- The lack of an urban excess of sulfate in Atlanta is typical throughout the eastern United States.

Reasons for the difference between urban excesses for nitrates and sulfates:
- the NOx to nitrate reaction occurs fairly quickly, before it can be transported very far
- nitrate is less stable and may revert to other compounds during transport
- sulfate has a very long lifetime; once converted from SO_2, sulfate particles can last for weeks and be transported long distances.

- Although the emission density of SO_2 is much higher in urban areas than in rural areas, the concentrations are fairly uniform over broad geographic areas.
- Consequently, sulfate is considered a regional pollutant in terms of the impact on $PM_{2.5}$.

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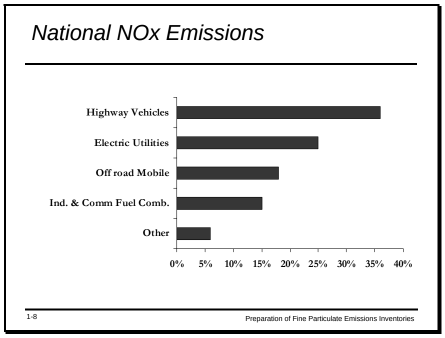

National data indicate that NO_x emissions are about 23 million tons a year.

This graph identifies NO emission sources as follows:

- 35% are from highway vehicles
- 25% are from electric utilities
- 18% are from mobile sources, and
- 15% are from industrial and commercial fuel combustion.

All of these NO_x emission sources are associated with fuel combustion. The "Other" category represents emissions from industrial processes.

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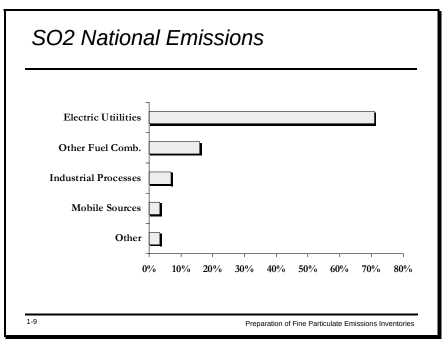

This graph identifies electric utilities as the source of 70-75% of national SO_2 emissions.

Although electric utility emissions tend to be more highly concentrated in urban areas, sulfate emissions impact large geographical areas.

This impact is due to the long lifetime of sulfate particles and their transportability over long distances.

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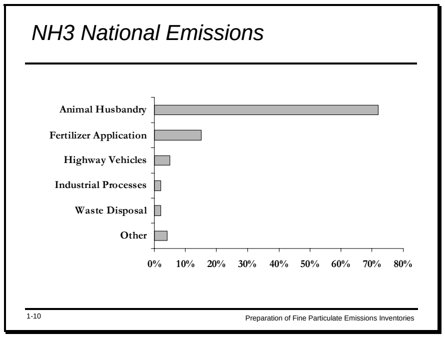

This graph identifies sources of national ammonia emissions as follows:

- Animal husbandry, specifically associated with cattle, hogs, and poultry, represents a significant source of ammonia emissions.
- Smaller amounts of ammonia emissions are associated with animal waste and waste processing procedures.
- Fertilizer application is a source of approximately 15-20% of the ammonia.
- Highway vehicles represent a small percentage of the emissions, which can be important in an urban area.

Ammonia emissions are dispersed across large portions of the east and the Midwest, regions with a higher concentration of farms where animals are raised.

This is consistent with the pattern of measured ammonium ion deposits from the National Atmospheric Deposition Program.

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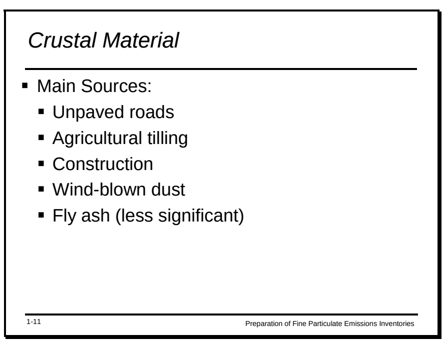

Crustal material mainly comes from fugitive dust.

The main sources of fugitive dust are unpaved roads, agricultural tilling, construction, and wind-blown dust, which primarily occurs in the arid areas of the western United States.

A less significant source of crustal material is fly ash from coal- or oil-fired boilers, which is chemically similar to crustal material.

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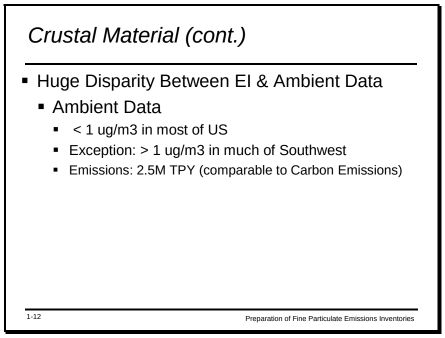
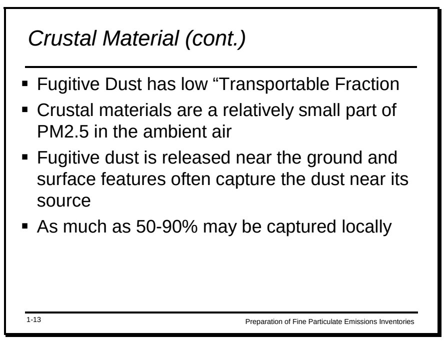


A disparity exists between the crustal data in an emissions inventory and the crustal material found in ambient air quality samples.

Ambient data indicate that less than one microgram per cubic meter of crustal material exists in the U.S., with the exception of the southwest.

Emissions inventory data indicate that $PM_{2.5}$ emissions are about 2.5 million tons a year, which is comparable to the carbon emissions.

1 - 13



Fugitive dust emissions:

- are emitted very close to the ground and get trapped in shrubbery, vegetation, buildings, etc.
- may not be transported far from where they are released
- air quality dispersion models fail to recognize that much fugitive dust will be deposited within a few hundred yards to a few miles of the source

Estimates indicate that about half of the fugitive dust emitted in eastern metropolitan areas is removed by surface features near the source.

This inventory adjustment only applies to regional chemical transport modeling. Thus, this adjustment is made in the emissions processor, not in the emissions inventory.

In summary:

- crustal materials are a relatively small part of $PM_{2.5}$ in the ambient air
- fugitive dust is released near the ground, and surface features often capture the dust near its source

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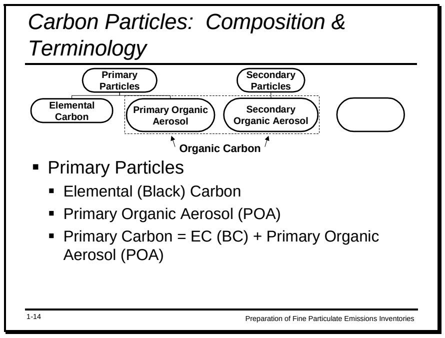

Carbon is a major component of $PM_{2.5}$ in the ambient air.

You may recall that carbon particles can be either primary (or directly emitted), or secondary organic aerosol particles that are formed in the atmosphere primarily from volatile organic compounds.

Primary carbon particles are made of:

- elemental or black carbon,
- primary organic aerosols.

Approximately 20% of the primary carbon emissions are EC and the other 80% are POA.

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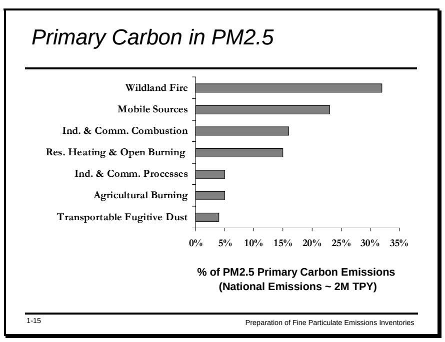

Data show that sources of primary carbon emissions nationwide are:

- wildfires
- mobile sources
- industrial and commercial combustion
- residential heating and open burning
- burning of construction debris
- industrial and commercial processes, agricultural burning
- fugitive dust

Nationally, crustal material is emitted at about 2.5 million tons per year, as compared to about 2 million tons per year of primary carbon emissions.

However, carbon emissions are more abundant in the ambient air.

1 - 16

POA & EC Characteristics of Primary Carbon Emissions

Category	Ratio of organic carbon mass* to elemental carbon mass (average)	Potential range of ratios
Forest Fires	9.9	6 – 28
Managed Burning	12	6 – 28
Agricultural Burning	12	2.5 – 12
Open Burning - Debris	9.9	
Non-road Diesel Engines & Vehicles	**0.4**	**0.4 – 3**
On-road Diesel Vehicles	**0.4**	**0.4 – 3**
Trains, Ships, Planes	**0.4**	**0.4 – 25**
Non-road Gas Engines & Vehicles	14	0.25– 14
On-road Gas Vehicles	4.2	0.25 – 14
Fugitive Dust - Roads	22	3 – 65
Woodstoves	7.4	3 – 50
Fireplaces	7.4	3 – 50
Residential Heating - Other	26	
Commercial Cooking	111	13 – 111

1-16 Preparation of Fine Particulate Emissions Inventories

The ratio of POA mass to EC mass for most sources is roughly 10 to 1.

Elemental carbon represents a higher ratio than organic carbon in diesel engines, diesel-powered vehicles, ships, trains, and planes.

The higher elemental to organic carbon ratio in diesels is due partially to the higher combustion temperatures in diesel-fueled engines, which tend to combust the organic carbon more completely.

Conversely, the lower temperature combustion processes will emit more organic matter, as a result of less complete combustion.

1 - 17

Primary Organic Aerosols (POA)

- Certain organic carbon excluded
- Organic carbon matter = primary organic aerosol (POA).
- The OC to POA multiplier for "fresh" POA in the emissions is usually estimated
- Particles "age" through oxidation.
- A different "multiplier" is applied to the POA by the chemical transport models to account for the "aging"

1-17 Preparation of Fine Particulate Emissions Inventories

Organic carbon reported from analysis of a source or ambient sample does not include the oxygens, hydrogens and other elements that comprise the organic carbonaceous matter.

Organic carbon matter is often called primary organic aerosol.

To approximate the amount of oxygen and hydrogen found in POA emissions use the formula:

- **POA = OC x 1.2**

Since particles in the atmosphere "age" through oxidation, a different "multiplier" is often applied to the POA to account for the further oxidation of the POA emissions:

- **POA = OC x 1.4 to 2.4**

1 - 18

Primary Organic Aerosols (cont.)

- Models only apply the additional multiplier to the POA, not the EC or SOA
- Multiplier is not related to the model's estimate of secondary organic aerosol formed in the atmosphere from precursor gases
- Only accounts for further oxidation of primary particle emissions as the aerosol "ages"
- Transport models contain a separate module to simulate the amount of secondary organic carbon formed in the atmosphere from precursor

1-18 Preparation of Fine Particulate Emissions Inventories

Atmospheric transport and transformation models contain the additional multiplier, but only apply it to the POA rather than the EC or SOA.

The multiplier is **not** related to the model's estimate of secondary organic aerosol formed in the atmosphere from precursor gases. It is only used to account for further oxidation of primary particle emissions as the aerosol ages.

Transport models contain a separate module to simulate the amount of secondary organic carbon formed in the atmosphere from precursor gases. The OCM of those particles is estimated directly by that module.

1 - 19

Primary Organic Aerosols (cont.)

- The derivation of a multiplier for ambient OC is much more complicated
- Use of a single multiplier introduces error
- A multiplier of 1.4 to 2.4 is often used for ambient data
- No agreed upon standard adjustment

1-19 Preparation of Fine Particulate Emissions Inventories

Deriving a multiplier for ambient OC is more complicated because the sample usually contains both POA and SOA, but the relative proportions of each are not known.

A single multiplier is applied to ambient OC, to adjust both primary and secondary OC in the sample.

Using a single multiplier introduces error, since multipliers probably would not be the same for both fractions.

A multiplier of 1.4 to 2.4 is often used for ambient data.

To date, there is no agreed upon standard adjustment that is consistently applied in either monitoring and modeling studies.

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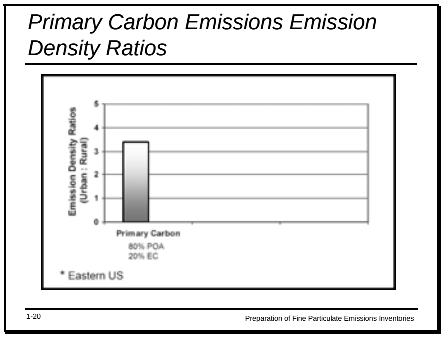

This graph compares emission density ratios for urban and rural carbon emissions.

Primary carbon emissions are approximately three times higher in urban areas than in rural areas.

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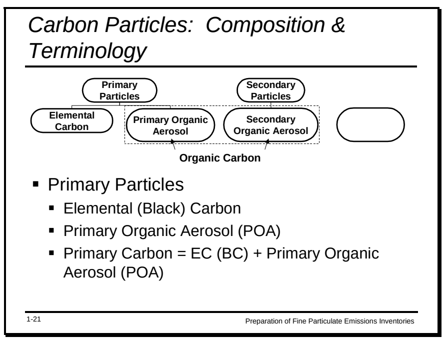

The primary particles comprise approximately 80% primary organic aerosols and 20% elemental carbon.

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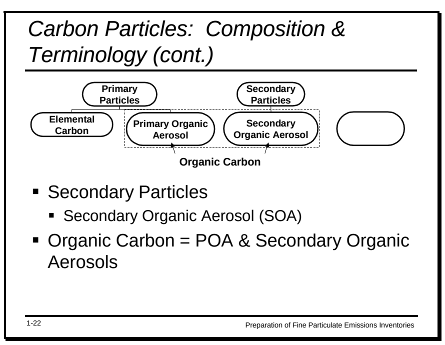
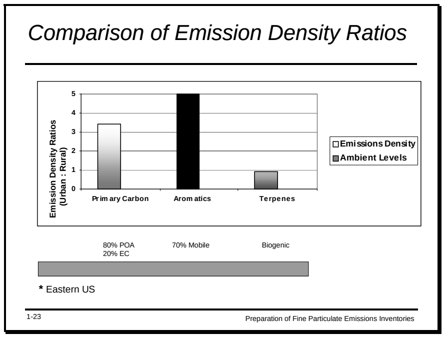


The condensable part of some EPA emission factors represents the vapor of organics when they are measured at stack temperatures.

The vapor condenses to form particles when the plume cools.

The condensable part of the emission factors is included in the POA emissions estimate.

1 - 23



Aromatics:

- VOC precursors that react to produce secondary organic aerosols
- Mobile sources produce 70 percent of aromatics (including benzene, toluene, and xylene)
- Toluene and xylene are the two aromatics that are generally associated with secondary aerosol formation
- The emission density of aromatics is about five times higher in urban areas than in the rural areas.
- The formation of SOA from these aromatic precursors is another potential cause of urban excess.

Terpenes:

- Major source of secondary organic aerosols
- Biogenic in origin as they are emitted by a variety of vegetation
- Emissions roughly equal when comparing a square mile of urban area to a square mile of rural area
- Trees in urban areas account for emissions there

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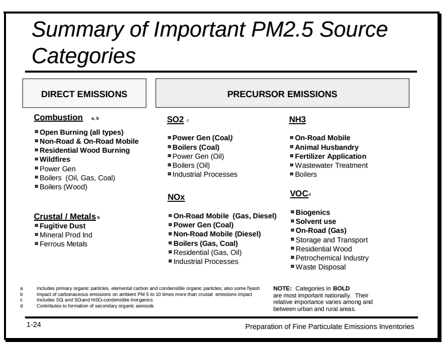

This chart summarizes the larger source categories of $PM_{2.5}$ direct and precursor emissions.

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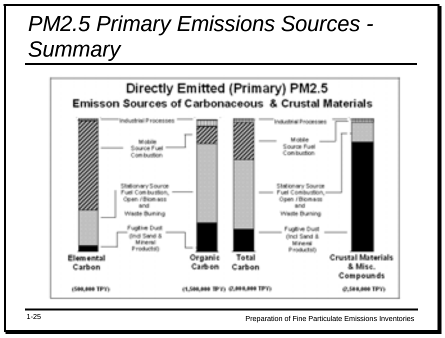
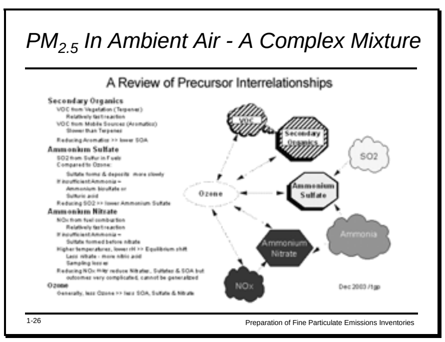


PM2.5 emissions:

- Combustion sources provide the majority of both elemental and organic carbon
- Most crustal materials are associated with fugitive dust
- Very little of the total carbon is associated with fugitive dust
- About 2 million tons of $PM_{2.5}$ emissions per year, one-fourth of which is elemental carbon.
- Similarly, the emissions of crustal materials is about 2.5 million tons per year.
- Due to EI adjustments for carbon and crustal materials, (carbon emissions are increased while crustal emissions are reduced), carbon is usually found in much greater quantity on ambient $PM_{2.5}$ samples.

1 - 26



Secondary organics:

- form from terpenes associated with VOC emissions (vegetation) occurs quickly
- form from aromatics associated with VOC emissions (mobile sources) occurs slower than the terpene reaction
- reducing aromatics can reduce SOA levels

Ammonium sulfate:

- forms from SO_2 emitted from the combustion of sulfur containing fuels
- forms and deposits slower than ozone
- can be transported much longer distances than either ozone or nitrate
- insufficient ammonia produces partially neutralized particles of ammonium bisulfate, or possibly sulfuric acid
- reducing emissions of SO_2 will lower ammonium sulfate concentrations

Ammonium nitrate:

- forms relatively quickly from NO_x emissions from fuel combustion

- insufficient ammonia reacts to form ammonium sulfate before forming ammonium nitrate
- higher temperatures and a lower relative humidity result in formation of less nitrate and more nitric acid
- reducing NO_x emissions may reduce nitrates, sulfates and secondary organic aerosols
- outcomes are complicated, involve ozone chemistry and can not be generalized

In conclusion, a reduction in VOC emissions would reduce ozone levels, resulting in less secondary organic aerosols, sulfate and nitrate formation.

The complex interactions among ozone formation, ozone precursors, sulfates, nitrates, and secondary organics must be collectively considered.

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Chapter 2 - The National Emissions Inventory and Emission Inventory Tools

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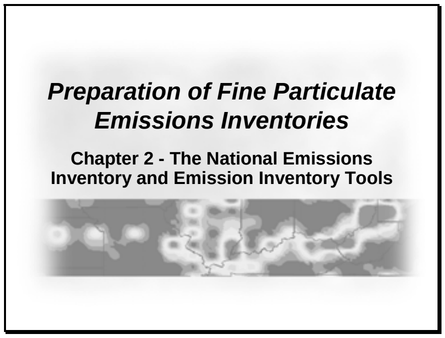
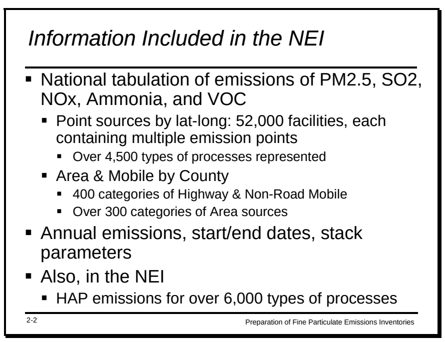


After this lesson, participants will be able to:

- explain the National Emissions Inventory and the process by which it was developed.
- describe current and future emissions inventory preparation tools.

2 - 2



NEI information includes:

- data on 52,000 point sources by latitude and/or longitude, with over 4,500 types of processes represented.
- approximately 400 categories of highway and non-road mobile sources
- approximately 300 categories of area sources in the NEI
- annual emissions (area and mobile sources are allocated by county)
- dates that sources started or stopped operations
- stack parameters
- HAP emissions for over 6,000 types of processes

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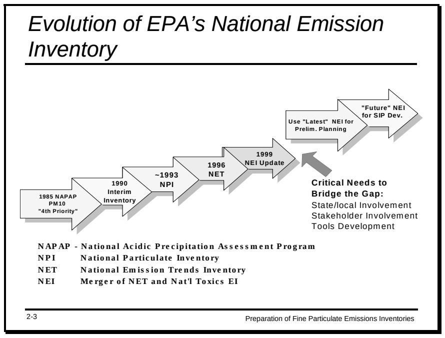

This graph represents a timeline showing the evolution of the National Emissions Inventory.

First NEI PM inventory -- 1985 National Acidic Precipitation Assessment Program. Represented inventory for PM_{10} and was developed without input from the states (states have become involved in NEI development)

Early 1990s, minimal activity on developing PM inventories; National Particle Inventory was prepared in 1993.

In 1996 it was called the National Emissions Trends Inventory.

The NET was updated in 1999 and was renamed the NEI.

Integration of the National Air Toxics Assessment Inventory began with the 1999 NEI and was completed with the 2002 NEI.

Improving and updating the NEI is a continuing process.

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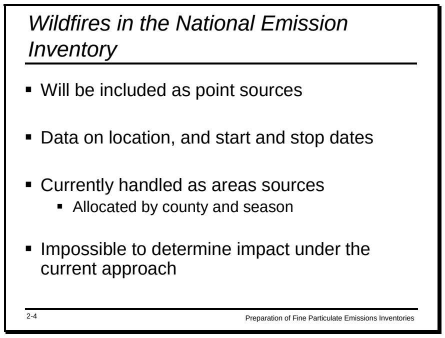

Wildfires:

- 2002 NEI began to include large fires as point sources for some areas of the United States.
- Data on when they started and ended, and the location are essential to accurately model impact on air quality.
- Smaller fires may continue to be treated as area sources and are allocated to county by using forested land area.
- Emissions are assigned to months of the year using temporal allocation factors.

Treating fires as point sources is important. For example:

- A fire may have a major impact on a Class 1 area; it could relate to the 20% worst days at that area.
- When fires are treated as area sources, it is impossible to know where or when the fire occurred.
- Consequently, it is impossible to determine if the particulate matter emissions in the Class 1 area are attributable to the fire.

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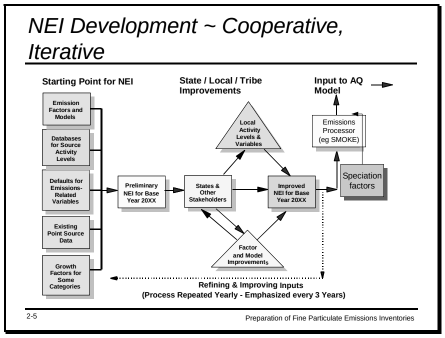


The process of developing the NEI includes the following:

- data on emission factors and models,
- various databases for source activity levels,
- default values for emissions related variables,
- existing point source data, and
- growth factors for source categories.

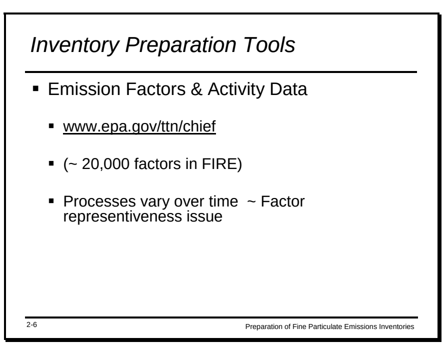
This data is combined to form what is called the preliminary NEI, which is provided to state and local air agencies for refinement and improvement.

The preliminary NEI becomes the improved NEI by:

- working with stakeholders,
- using factor and model improvements, and
- using local activity levels and variables provided by state and local agencies.

- This process is repeated yearly but, emphasized every three years.

2 - 6

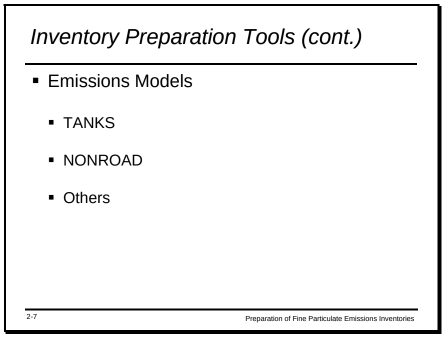


One of the tools used to prepare the NEI is the Factor Information and Retrieval database, accessible at the Web site shown.

Approximately 20,000 emission factors in this database are used in developing the NEI.

Industrial processes vary over time and according to facility; therefore, exercise caution when using the database.

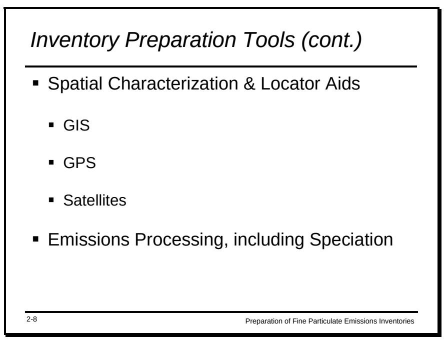
2 - 7



Some of the inventory preparation tools used are:

- Process-based emission models.
- TANKS—a model used for estimating storage tank emissions of VOCs.
- NONROAD—a model used to estimate emissions from non-road vehicles.
- BEIS—a model used to estimate biogenic emissions.

2 - 8



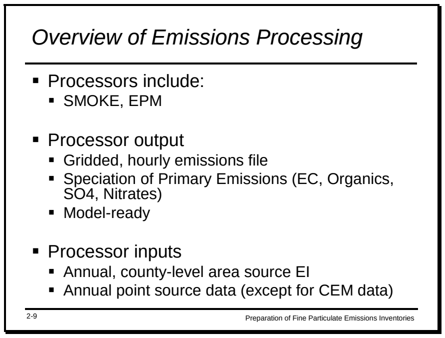
Other tools include special characterization and locator aids such as, Geographic Information Systems and Global Positioning Systems.

In Mexico and Canada, satellites are being used to locate fires.

Satellites are limited in their ability to locate certain fires, such as those below a certain size or masked by cloud cover.

The purpose of an emissions processor is to provide an efficient tool for converting emissions inventory data into the file format required by an air quality dispersion model.

2 - 9



Emissions processing:

- After developing NEI emissions data, it is processed by a modeling system, such as the Sparse Matrix Operator Kernel Emissions (SMOKE) system.
- The modeling system applies speciation factors to the emissions data when the inventory is to be used by air quality dispersion modelers.
- Emissions modeling depends on speciation factors, temporization factors, and species allocation factors.
- The data flow is from the NEI to the emissions processor and then into the air quality model.
- The output is a gridded, hourly emissions file speciated into elemental carbon, organics, primary sulfates, and primary nitrates.

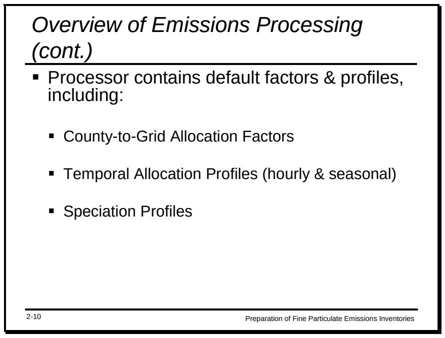
The speciated inventory data is especially useful in modeling for regional haze. For example:

- Carbon particles absorb and scatter light with a different efficiency than other particles.
- Consequently, it is necessary to consider different types of particles separately when doing regional haze work.

Data input:

- Area source data is input to the emissions processor as an annual county level inventory.
- Point source data is input as annual data, located by latitude and longitude.
- CEM data feeds into the emission processor through a separate database.

2 - 10



Emissions processor default factors and profiles:

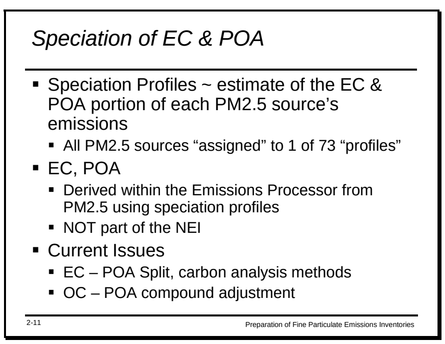
- county to grid allocation factors
- temporal allocation profiles
- speciation profiles

The emissions processor transforms annual or county level inventory into a gridded, hourly emission file.

The data is speciated into EC, POA, Primary SO4, Primary Nitrate and Other (crustal materials/fugitive dust and unidentified species).

It is then ready to be used as input to a dispersion model.

2 - 11



The emissions processor assigns all of the $PM_{2.5}$ sources to one of several dozen speciation profiles.

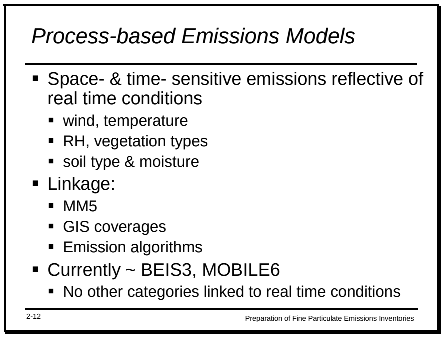
Elemental carbon and the primary organic aerosols are derived within the emission processor from $PM_{2.5}$ data using speciation profiles.

They are not part of the NEI inventory.

Carbon inventory issues:

- Analytical uncertainties surrounding the split between elemental carbon and primary organic aerosols
- Operational definition of what to call elemental carbon and what to call organic carbon under analysis
- Data provided for organic carbon, not the organic carbonaceous matter that accounts for all the oxygens and hydrogens; must use a multiplier or compound adjustment to go from organic carbon to primary organic aerosols

2 - 12



Process-based emission models models consider space- and time-sensitive emissions in an effort to reflect real world conditions such as:

- wind,
- temperature,
- relative humidity,
- vegetation type,
- soil type, and
- moisture.

These models will eventually include algorithms to develop a wind-blown dust inventory by examining the wind fields for the whole modeling domain and deciding when the wind is going to blow fast enough to create dust emissions.

Another model under development will estimate fire emissions by considering relative humidity, moisture, and wind speed.

These models would link to various databases such as the meteorological data processor (MM5). They would also link to GIS coverage of soil and vegetation types, and would contain emission algorithms that respond to these variables.

The MOBILE 6 model and the BEIS 3 model contain some aspects of process-based emission models, such as temperature. Consideration of temperature is critical for estimating biogenic emissions.

2 - 13

Process-based Emissions Models (cont.)

- Process-based emission model needs
  - Ammonia (fertilizer application, animal husbandry, removal)
  - Fugitive Dust (wind, unpaved roads, construction, tilling, removal)
  - Wildland Fires (fuels, fuel consumption, plume rise)
  - Residential Wood Burning
  - Evaporative Loss
  - Others ?

2-13 Preparation of Fine Particulate Emissions Inventories

There are a number of other needs for process-based emission models.

Some examples are listed here and include estimating emissions of ammonia and residential wood burning.

2 - 14

Status of Process-based Emissions Models (Integrated w/ Emissions Processor)

- Biogenics (always integrated w/ EP)
- On-Road (optional integration w/ EP)
- Ammonia (development just began)
- Fugitive Dust (under development)
- Wildland Fire (under development)

2-14 Preparation of Fine Particulate Emissions Inventories

In the future, some of the process-based models will be integrated with the emissions processor and some will be stand-alone models.

The biogenics model (BEIS) is always integrated with the emissions processor.

The onroad model MOBILE 6 can optionally be integrated with the emissions processor.

The development of process-based emissions models for ammonia, fugitive dust and wildland fires are currently underway.

2 - 15

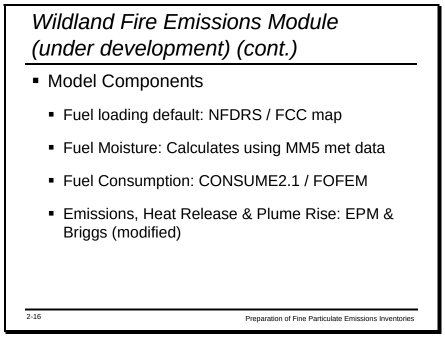
Wildland Fire Emissions Module (under development)

- Modular input to Emission Models (e.g., SMOKE, OpEM) to interface with the CMAQ modeling system.
- User Inputs: Fire locations, duration, size

2-15 Preparation of Fine Particulate Emissions Inventories

The inputs for the wildland fire model include fire locations, duration, and size.

2 - 16



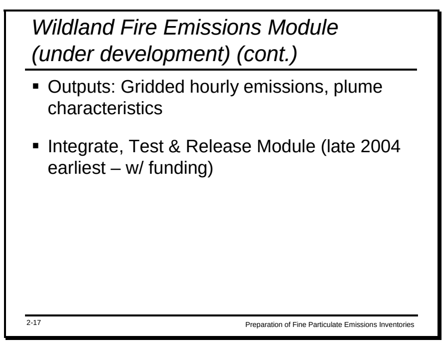
This model will access meteorological data for wind speed and moisture. It also uses fuel-loading defaults from a one-kilometer resolved national map of fuel loadings.

Although a fuel map currently exists, a project to develop a map with better fuel-loading data is being funded.

Fuel moistures are calculated using the MM5 data. Fuel consumption will be done using CONSUME or the First Order Fire Effects Model (FOFEM) for fuel consumption.

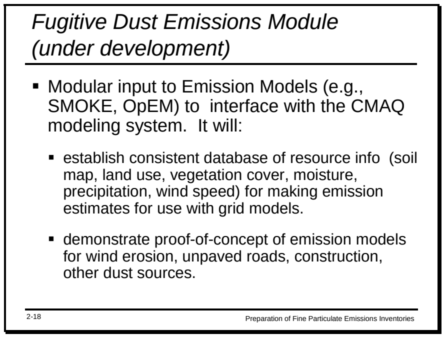
The emissions projection model will combine with the Briggs' Plume Rise equation modified for fires calculates emissions, heat release, and plume rise.

2 - 17



When complete, the wildland emissions module will provide a grid of hourly emissions and plume characteristics, reflecting real world meteorological conditions that effect fire behavior and emissions.

2 - 18

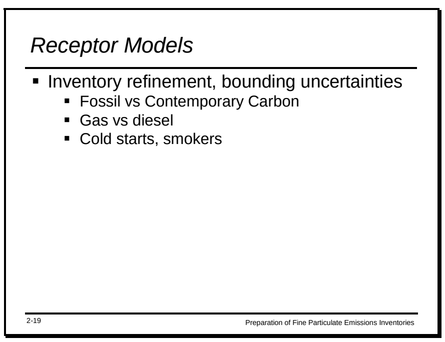


A fugitive dust model is currently under development.

The goal is to establish a consistent database of resource information such as soil, land use, vegetation, moisture, precipitation, and wind speed that can be used to estimate emissions for use with grid models.

Currently, a proof of concept of this emission model is being demonstrated for wind-erosion, unpaved roads, construction, and other dust sources.

2 - 19



Receptor modeling is an important tool to use in developing an emissions inventory.

Types of models:

- Radiocarbon analysis can be used to obtain an estimate of the amount of fossil versus contemporary carbon.
- Some receptor models use tracers to examine the organic compounds of gas and diesel particles.
- The tracers can identify whether the carbon particles are from gas or diesel engines, and whether they are emitted from cold starts or smokers.
- Another commonly used tracer is the Chemical Mass Balance, a dedicated weighted least squares model.
- This model infers source contribution estimates from ambient, speciated data and source profiles.
- Multivariate models are the Positive Matrix Factorization model and UNMIX, which is somewhat similar to PMF.

2 - 20

Specific PM2.5 Categories Needing Input from Federal / State / Local / Tribes

- Wildland Burning
  - Forests, Rangeland & especially private & State / tribal burners
  - (acreages burned, fuel loadings for largest fires, timing)
- Residential Open Burning
  - Household Waste, Yard waste (volumes & burning practices)
  - Regulations & their effectiveness, local surveys of burn activities)

2-20 Preparation of Fine Particulate Emissions Inventories

Several specific $PM_{2.5}$ categories need better emissions models and emissions data. This includes wildland burning of forests and rangeland.

Data on acreage burned, fuel loadings for the largest fires, and the timing of those fires are needed.

Another source category that needs better emissions data concerns residential open burning (household and yard waste).

Data on the volumes, burning practices, regulations and their effectiveness, and local surveys of burn activities are needed.

2 - 21

Specific PM2.5 Categories Needing Input from Federal / State / Local / Tribes (cont.)

- Construction Debris & Logging Slash
  - Regulations & their effectiveness, local surveys of burn activities
- Agricultural Field Burning
  - Acreages, fuel loadings, timing
- Residential Wood Combustion
  - Fireplaces, Wood Stoves
  - local surveys of fuel burned, fireplace vs wood stoves, local regulations

2-21 Preparation of Fine Particulate Emissions Inventories

Data on the effectiveness of regulations for construction debris and logging slash are needed. This includes local surveys of burn activities.

For agricultural field burning, data on acreages, fuel loadings, and timing of the burn events are needed.

Data from local surveys of fuel burn are needed for residential wood combustion, fireplaces and wood stoves. This includes data on whether the wood is being burned in a fireplace or a wood stove.

2 - 22

Specific PM2.5 Categories Needing Input from Federal / State / Local / Tribes (cont.)

- Area-specific industrial process sources
- Fugitive Dust as indicated by local conditions

2-22 Preparation of Fine Particulate Emissions Inventories

Area-specific industrial process sources are another category for which better data are needed.

However, since these sources constitute a small percentage of the industrial process sources, it is important to pick those sources that have the largest errors associated with them.

Finally, data on local conditions contributing to fugitive dust are needed in some cases.

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Chapter 3 – Onroad Mobile Sources

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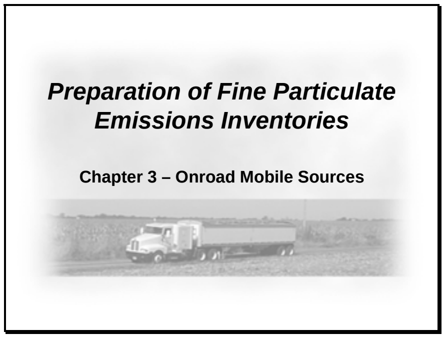
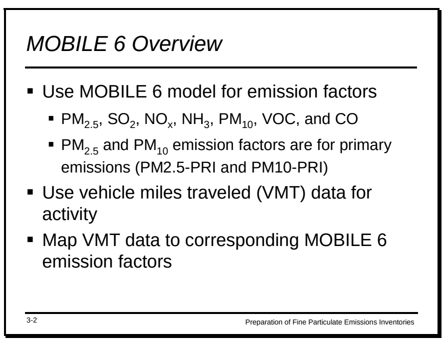


After this lesson participants will be able to:

- describe the EPA's MOBILE 6 model and the National Mobile Inventory Model
- explain how vehicle mileage is used to calculate emissions from onroad vehicles.

3 - 2

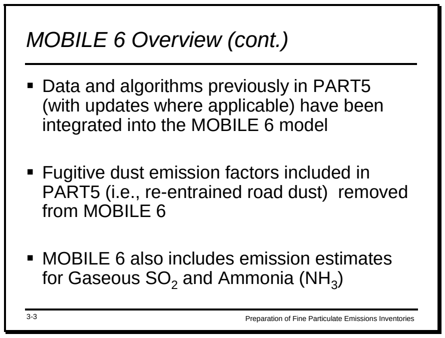


EPA's Office of Transportation and Air Quality or OTAQ (pronounced O-TAG) has developed MOBILE 6 to estimate emissions from mobile sources.

The MOBILE 6 model:

- includes emission factors for $PM_{2.5}$, SO_2, NH_3, PM_{10}, VOC and CO.
- can be downloaded with its User Guide from www.epa.gov/otaq/m6.htm.
- uses $PM_{2.5}$ and the PM_{10} emission factors to represent primary emissions.
- matches data on vehicle miles traveled to the corresponding MOBILE 6 emission factors to form the basis of emission calculations.

3 - 3



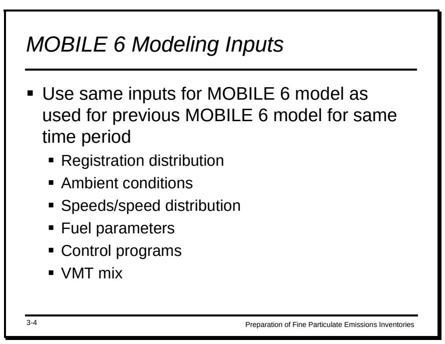
PART 5 was EPA's prior model for modeling PM emissions. Its data and algorithms have been integrated into the MOBILE 6 model, with some updates.

The fugitive dust emission factors included in PART 5 have been excluded from MOBILE 6.

Consequently, the calculation of emissions from re-entrained road dust is done separately outside the model.

Also, MOBILE 6 also includes emission estimates for gaseous SO_2 as well as ammonia.

3 - 4

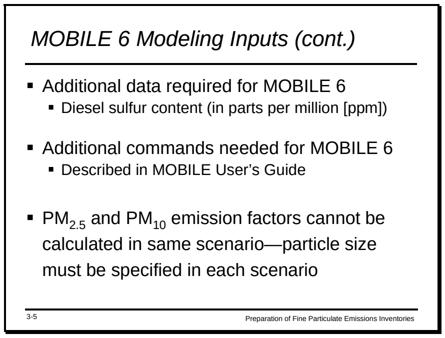


In most cases MOBILE 6 uses the same type of inputs that were required for prior versions.

This includes registration, distribution, ambient conditions such as temperature and humidity, speeds and speed distributions, and fuel parameters such as the Reid Vapor Pressure of gasoline and oxygenated fuel.

It also includes control programs such as Stage II or Inspection and Maintenance programs, and data on VMT by vehicle type.

3 - 5



One additional data input required for MOBILE 6 modeling that was not required in the past is the diesel sulfur content expressed in parts per million.

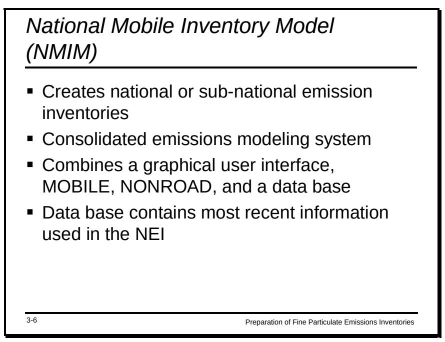
Also, there are additional commands needed for generating $PM_{2.5}$ inventories in MOBILE 6.

The commands are described in the MOBILE user's guides developed by OTAQ.

Note that when you develop a PM inventory, you cannot do a $PM_{2.5}$ and a PM_{10} inventory simultaneously.

As a result, it is necessary to specify just one particle size per each run.

3 - 6

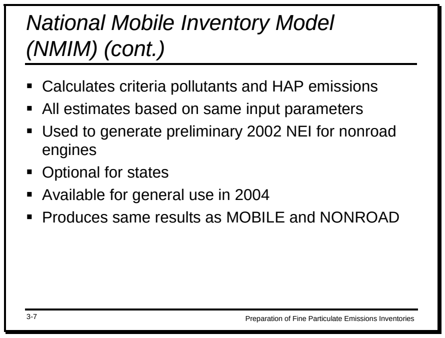


National Mobile Inventory Model:

- a tool developed by OTAG to create national or sub-national emission inventories for any calendar year
- uses county-specific input parameters
- a consolidated emissions modeling system for EPA's MOBILE and NONROAD models
- combines a graphical user interface, MOBILE, NONROAD, and a database with modeling information for each county in the United States

Currently this database contains the most recent information (e.g., fuel parameters, registration data, temperatures, etc.) used by EPA to generate the default National Emission Inventory estimates for each county.

3 - 7



NMIM:

- can calculate both criteria (including ammonia) and HAPs for the source categories included in the MOBILE6 and NONROAD models.
- consolidates all the model inputs into a single data base such that all the estimates are based on the same input parameters in each county (e.g., fuel programs, inspection/maintenance, humidity, temperatures).
- draft version used to generate the preliminary EPA default 2002 NEI inventories for nonroad engines
- is an optional tool for states to use in estimating mobile source inventories by organizing and automating emission inventory development for highway vehicles and NONROAD categories.
- is not a substantively different approach than directly using MOBILE 6 and NONROAD2002.

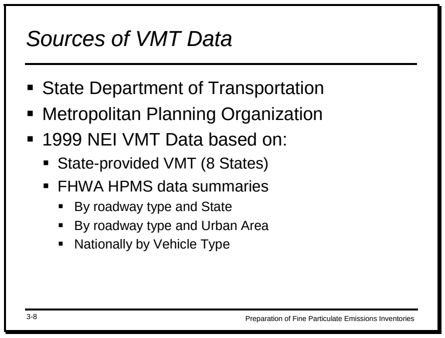
The EPA expects to complete NMIM and release it for general use in 2004 but states will not be required to use it to generate inventory estimates.

This tool was developed to make creating inventories easier and does not change the answers that are obtained from running MOBILE or NONROAD individually.

State use:

- States may wish to customize all or part of their own inventory generation process to the NMIM model approach.
- This will allow them to take advantage of its efficiency and transparency, and to align the NEI inventory results more closely with their own inventory estimates.
- State and local agencies will be able to use the database to view the county-level default values and to replace them with data that better represents their geographic areas.

3 - 8



State departments of transportation typically provide VMT data.

Metropolitan planning organizations track these data for certain areas. However, VMT data should be used from whatever source it is available.

As a case in point:

- The 1999 NEI included VMT data that was provided by eight states and this data was used in conjunction with MOBILE6 emission factors. VMT data for the remaining states were obtained from the Federal Highway Administration’s data summaries.
- The FHWA data contain vehicle miles traveled by roadway type, by state, as well as VMT by roadway type for specific urban areas.
- The 1999 NEI relied upon a national distribution for the VMT mix by vehicle type.
- As a result, the same mix of vehicles was assumed for all areas unless the state provided their own data.

Documentation for the 1999 NEI can be found at: www.epa.gov/ttn/chief/net/1999inventory.html.

3 - 9

VMT Approach

- Distributions of VMT by roadway type, vehicle type, by hour of day can be applied directly to VMT or included within MOBILE 6 input files
- Also need to have speeds matched to roadway types either as average speeds or as speed distributions by speed ranges

3-9 Preparation of Fine Particulate Emissions Inventories

In the case of the NEI, the VMT data was developed for use in conjunction with MOBILE 6 by using the distributions of VMT by roadway type and vehicle type. In some cases this activity data may be available by hour of the day.

Regardless of the format, these fractions can be applied directly to the total VMT, or they can be included within the MOBILE 6 input files in order to generate a weighted emission factor in MOBILE 6.

It is important to have speeds matched to the roadway types, either as an average speed or as speed distributions by speed ranges.

This latter approach is the approach needed for link-based VMT development and some transportation demand models.

3 - 10

Level of Detail of VMT Data

- By county
- By roadway type (or link level)
- By vehicle type
- Appropriate time period

3-10 Preparation of Fine Particulate Emissions Inventories

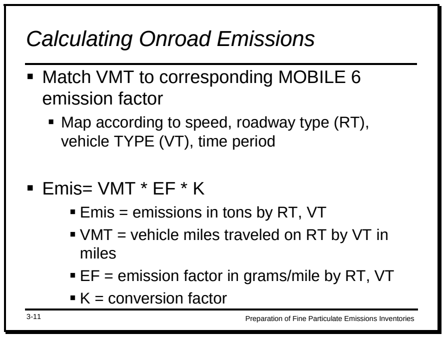
Ideally, the level of VMT data that should be used is by county and by the various roadway types or link level if modeling at that level is planned.

Using data by vehicle type is important since emission rates can vary greatly among the different vehicle types.

Using vehicle type data will allow the adjustments to be made to the national defaults that are typically used.

It is important to match the VMT data (daily or hourly) to the appropriate time period for modeling.

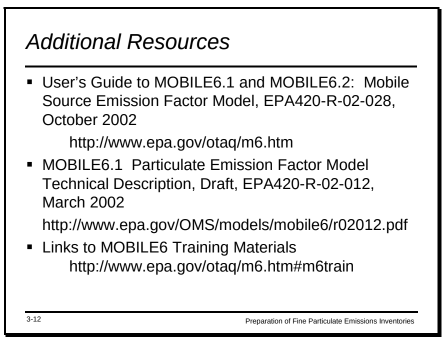
3 - 11



VMT data should be matched to a corresponding MOBILE 6 emission factor and mapped according to speed, roadway type, vehicle type, and time period.

Emissions are calculated by multiplying the VMT data by an emissions factor as shown in the equation on this slide.

3 - 12



There are a number of online resources to consult when developing an emissions inventory for onroad sources.

This includes EPA’s online user’s guide for using MOBILE 6.1 and 6.2, as well as technical documentation describing how the defaults were developed.

There are also links to training materials that have been developed as MOBILE 6 has been updated.

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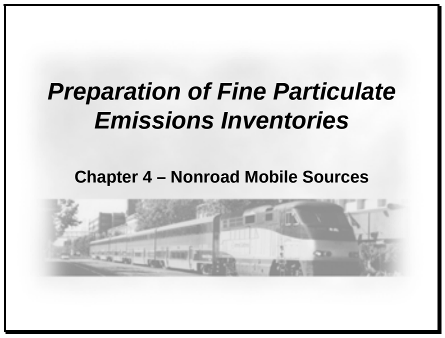
Chapter 4 – Nonroad Mobile Sources

4 - 1

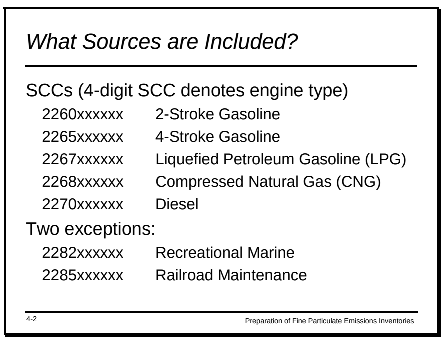


After this lesson, participants will be able to:

- describe EPA's NONROAD model
- explain the approaches for estimating PM emissions from aircraft, commercial marine vessels, and locomotives

The discussion of EPA's National Mobile Inventory Model presented in Chapter 3 is also applicable to the nonroad category, but will not be repeated.

4 - 2



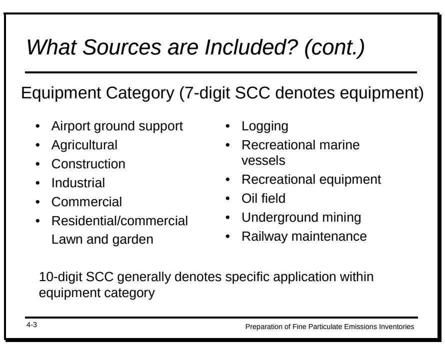
This slide lists the source categories that are included in the NONROAD model.

The four-digit source classification code generally denotes the engine type, or fuel that is used in the nonroad equipment.

The four-digit SCC denotes the equipment type instead of engine type in two categories:

- recreational marine, and
- railroad maintenance.

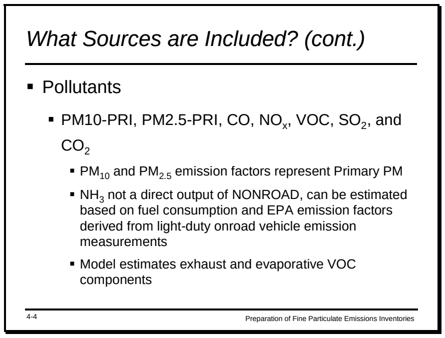
4 - 3



There are 12 different equipment categories denoted by the seven-digit SCC in the NONROAD model.

Each category may have multiple applications that are specified at the 10-digit SCC level.

4 - 4



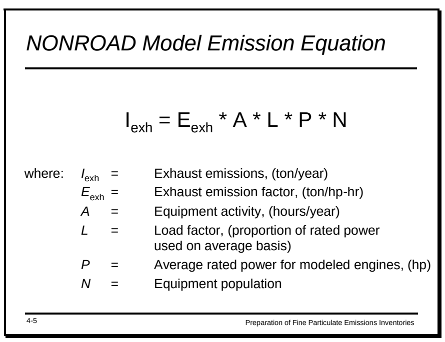
The pollutants included in the NONROAD model are PM_{10} and $PM_{2.5}$ (representing primary PM), CO, NO_x, VOC, SO_2 and CO_2.

Although ammonia is not a direct output of the NONROAD model, it can be estimated from fuel consumption estimates.

These fuel consumption estimates come from the model and the EPA emission factors are derived from light-duty onroad vehicle emission measurements.

In addition to exhaust pollutants, the NONROAD model estimates evaporative VOC components from crankcase emissions, spillage, and vapor displacement.

4 - 5



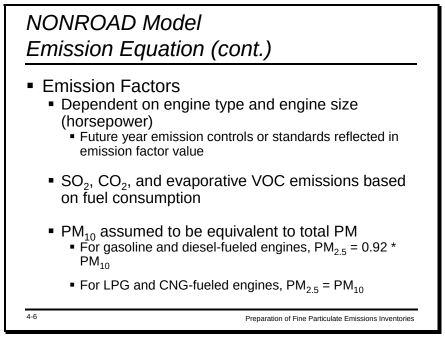
The NONROAD model calculates exhaust emissions by assuming that they are dependent on equipment activity.

Measures of equipment activity used in the model include:

- number of hours per year the equipment is used,
- the load factor at which the engine is operating,
- the average rate of horse power of the engine, and
- the equipment population (i.e., how many pieces of equipment are in use).

These equipment activity measures are multiplied by emissions factors in tons per horsepower-hour to obtain emission estimates as shown by the equation on the slide.

4 - 6



The emission factors are dependent on the engine type as well as the engine size, or horsepower.

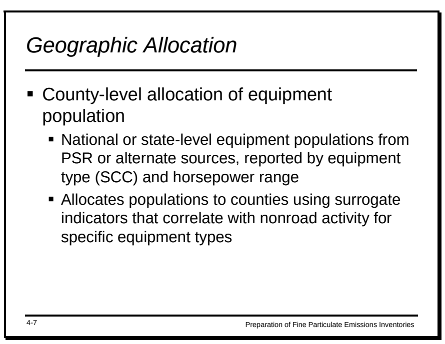
Future year emission controls or standards are reflected in revised emission rates, so that as older engines are scrapped and new engines replace them, revised emission rates are applied to the new engines to reflect the standards that they need to meet.

SO_2, CO_2 and evaporative VOC emissions are based on fuel consumption.

In the NONROAD model:

- PM_{10} is assumed to be equivalent to total PM and for gasoline and diesel engines
- $PM_{2.5}$ is assumed to be 0.92 times PM_{10}.
- all PM is assumed to be less than $PM_{2.5}$ for liquefied petroleum gas and compressed natural gas engines

4 - 7

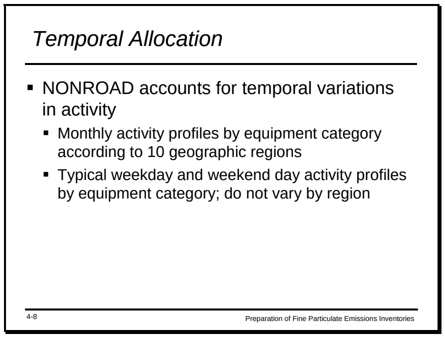


Because there are no estimates of county level populations, the NONROAD model estimates those populations using surrogate indicators.

Using national or state level equipment populations (either by equipment type or horsepower range), the model allocates them to the county level by using surrogate indicators.

These indicators correlate with nonroad activity for a specific equipment type.

4 - 8

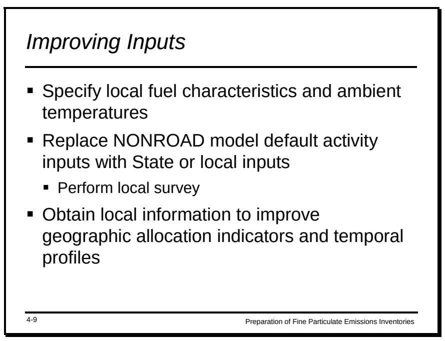


The NONROAD model also accounts for temporal variations in activity.

The temporal profiles vary by month and depend on the equipment category and the geographic region of the country.

The model contains typical weekday and weekend day activity profiles by equipment category, however, those do not vary by region.

4 - 9



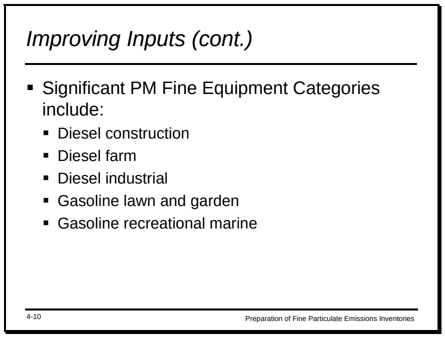
Suggested methods for improving EPA's latest 2002 model results:

- specify local fuel characteristics and the ambient temperatures specific to the area being modeled.
- replace the NONROAD default activity inputs with state or local data, if possible.

It can be resource intensive to obtain reasonable estimates to replace the default values. To obtain this data, it would be necessary to perform a local survey of equipment owners and users.

Another way to improve the model results is to obtain local information to improve the geographic allocation (i.e., going from state to county). Obtaining local data used for the temporal profiles can also improve the model results.

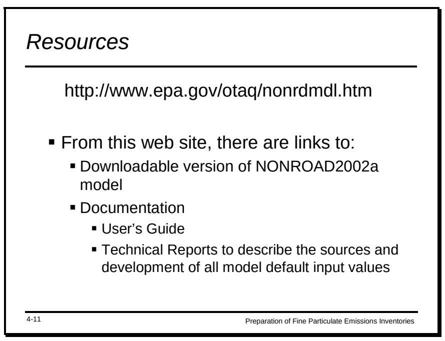
4 - 10



Another approach to improve the model results is to focus on priority categories and obtain better data for those categories.

For example, for fine PM, priority categories would be diesel construction, diesel farm, diesel industrial, gasoline lawn and garden, and gasoline recreational marine.

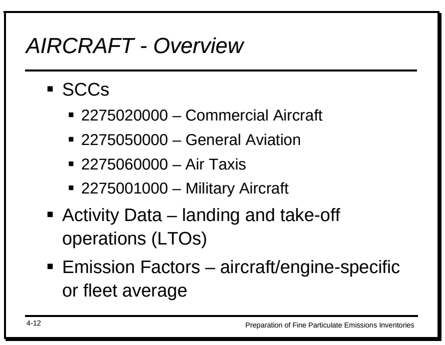
4 - 11



The latest version of EPA's NONROAD model can be accessed at the web address listed here.

This web site contains documentation, a user's guide, as well as technical reports to describe the sources and development of all the default input values (e.g., equipment populations, geographic allocations, growth factors, and emission rates).

4 - 12



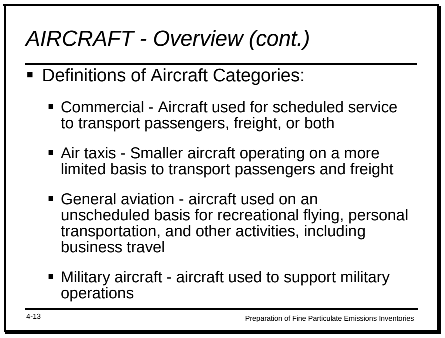
The SCCs representing the aircraft categories that have been historically reported in the NEI are listed here.

The activity data used for aircraft are known as a landing and takeoff operations, or LTO.

Emissions are estimated by applying emission factors to the LTO data that are either specific to an aircraft or engine type.

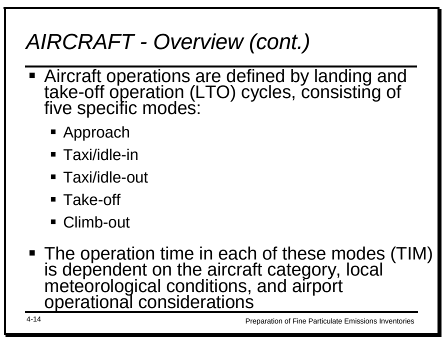
If the make-up of the aircraft fleet is unknown, fleet averages can be applied to the emission factors.

4 - 13



This slide lists the definitions of the aircraft categories that have been historically reported in the NEI.

4 - 14

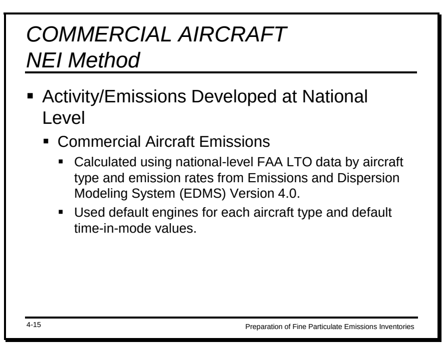


The LTO cycle consists of different modes including: the approach, taxi idle in, taxi idle out, take off, and climb out.

Operation time in each of these modes is dependent on the aircraft category, meteorological conditions, as well as how the airport is operating (e.g., the length of time waiting to take off).

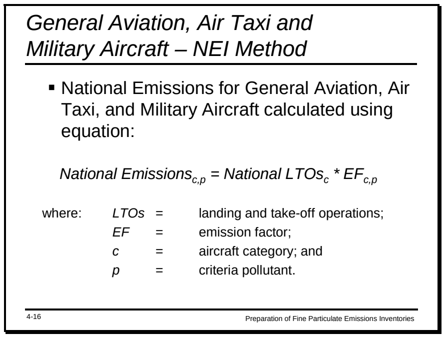
There can be substantial variations in these modes from airport to airport. Because different emission rates result when the aircraft are operating in each of these modes, it is important to consider all of these factors in estimating emissions from aircraft.

4 - 15



The NEI estimated emissions for commercial aircraft by using national-level FAA LTO data by aircraft type and emission rates from the Emissions and Dispersion Modeling System version 4.0.

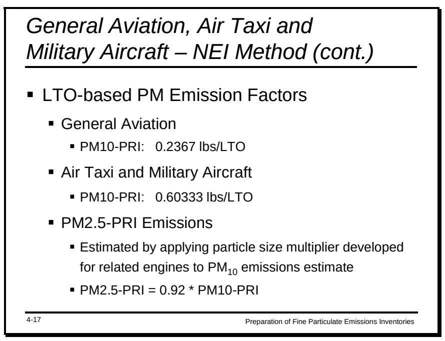
4 - 16



The NEI estimated emissions from the general aviation, air taxi, and military aircraft categories by also using national LTO data; however, data was not available for specific aircraft types within each of the aircraft categories.

Consequently, emissions for these three categories were estimated by multiplying total LTO by an emission factor as shown in the equation on this slide.

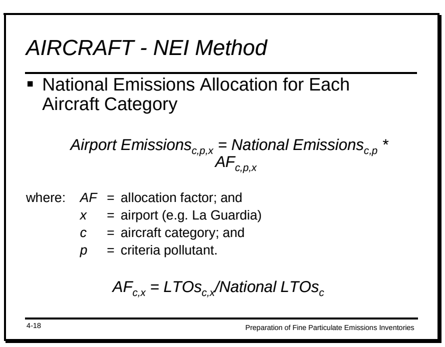
4 - 17



Using PM as an example, the emission factors are LTO-based and represent a fleet average emission factor for the general aviation, air taxi, and military aircraft categories. This slide lists these PM emission factors.

The $PM_{2.5}$ primary emissions are estimated, as they are for many combustion sources, by applying a particle-sized multiplier of 0.92 to the PM_{10}.

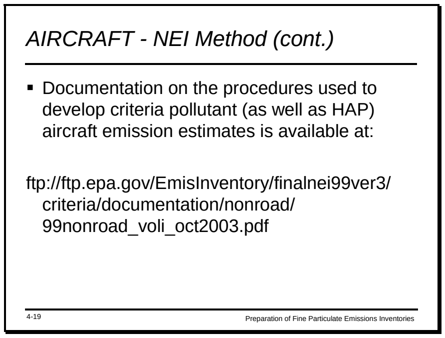
4 - 18



Once national emissions are calculated for the four aircraft categories, the NEI allocates them to the county level based on airport level LTO data as shown by this equation.

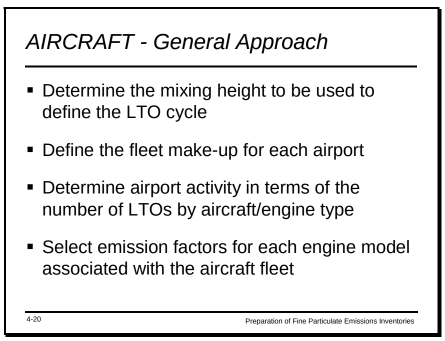
Using La Guardia airport as an example, the NEI assumes that a fraction of the total LTO is assigned to La Guardia, and the emissions calculated from this allocation are assigned to the corresponding county.

4 - 19



More information on the NEI methodology for estimating emissions from aircraft categories can be found at the web address listed here.

4 - 20



Although it may be acceptable to rely upon the NEI data for smaller airports in an area, a bottom up inventory should be developed for the larger airports.

There are seven steps for developing an aircraft inventory for a specific airport:

- **Step 1** - Determine the mixing height to be used to define the LTO cycle. The mixing height is important because above the mixing height, emissions are not expected to contribute much to ground level pollutant concentrations.
- **Step 2** - Define the fleet make-up for the airport.
- **Step 3** - Determine airport activity in terms of the number of LTO by aircraft and their associated engine-type.
- **Step 4** - Select emission factors for each engine model that is associated with the aircraft fleet at the airport being inventoried (Instead of using defaults that EDMS may apply for a specific aircraft type).

4 - 21

AIRCRAFT - General Approach (cont.)

- Estimate the time-in-mode (TIM) for the aircraft fleet at each airport
- Calculate emissions based on aircraft LTOs, emission factors for each aircraft engine model, and estimated aircraft TIM
- Aggregate the emissions across aircraft

4-21 Preparation of Fine Particulate Emissions Inventories

- **Step 5** – Estimate the time-in-mode for the aircraft fleet at the airport.
- **Step 6** – Calculate the emissions (based on the aircraft LTO data, the emission rates for each aircraft engine model, and the time-in-mode data).
- **Step 7** – Aggregate the emissions across aircraft to obtain a total for the airport.

4 - 22

COMMERCIAL AIRCRAFT
Improvements to NEI

- Determine engine types associated with local aircraft types, to replace default aircraft/engine assignments in EDMS
- Obtain information on climb-out, takeoff, approach times, as well as taxi/idle times

4-22 Preparation of Fine Particulate Emissions Inventories

Developing an emissions inventory for a local airport involves determining the engine types associated with the local aircraft types.

This data is an improvement over the assumptions used in the NEI for the commercial aircraft category.

In addition, developing information on climb-out, take-off, approach time, and taxi idle times will be an improvement over the defaults used in the NEI.

4 - 23

COMMERCIAL AIRCRAFT
Improvements to NEI (cont.)

- For PM_{10} and $PM_{2.5}$, match few emission factors from EPA's 1992 Volume IV, Mobile Sources Procedures document, to the aircraft engines in their fleet as best as possible
- EPA OTAQ working with FAA to develop updated aircraft PM emission factors
- Regional inventories have used PM-10/NO_x emission factor ratios for air taxi applied to commercial aircraft NO_x emissions

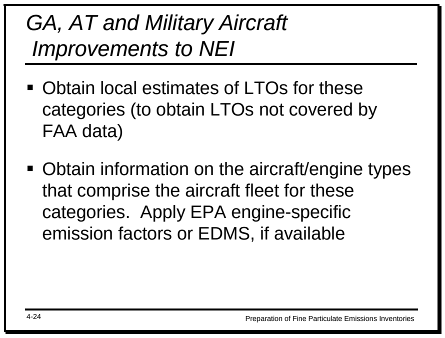
4-23 Preparation of Fine Particulate Emissions Inventories

Because the current version of EDMS does not include PM emission rates, EPA recommends that the few PM emission factors available in the 1992 Mobile Sources Procedures document be matched to the aircraft engines in the local fleet as best as possible.

EPA is aware of this limitation and work is underway to try to get better data on PM emission factors for commercial aircraft.

Some regional inventories have looked at using emission factor ratios to develop the PM emission rates for commercial aircraft. Specifically, the ratio based on the PM_{10} and NO_X emission factor ratios for air toxics was applied to the commercial aircraft NO_X emissions.

4 - 24



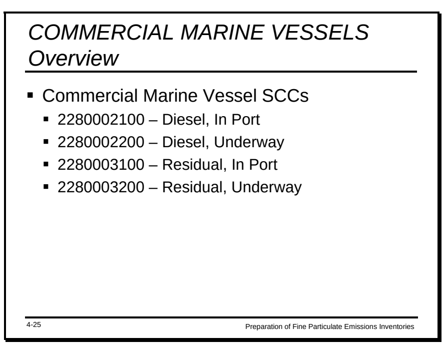
For the other categories (general aviation, air taxis, and military aircraft) the NEI can be improved by obtaining local LTO estimates, such as:

- data from smaller airports that may not be reporting to the FAA
- military bases (although heightened security measures have made it harder to obtain data from military operations)

Another improvement is to obtain information on the aircraft/engine types that comprise the fleet for these other categories. If data on the mix of aircraft types in a fleet are available, engine specific emission factors or EDMS could be used to estimate emissions.

Finally, the NEI can be improved by maintaining the latitude/longitude of the airport so the emissions are not "smeared" across the entire county.

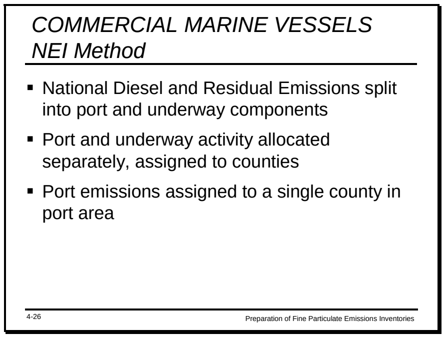
4 - 25



The SCCs representing the commercial marine vessel categories that are currently used in the NEI are listed on this slide.

This includes diesel activity for ships in port and underway, as well as residual or steamships for those two categories.

4 - 26

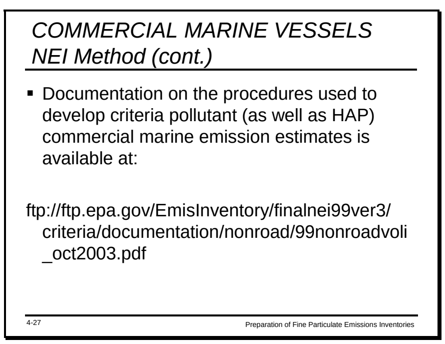


The NEI methodology for commercial marine vessels is a top down method that splits national diesel and residual emissions into port and underway components.

The methodology makes assumptions about what portion of the activity for both diesel and residual ships takes place in ports and what portion takes place underway (i.e., away from ports or on their way between ports).

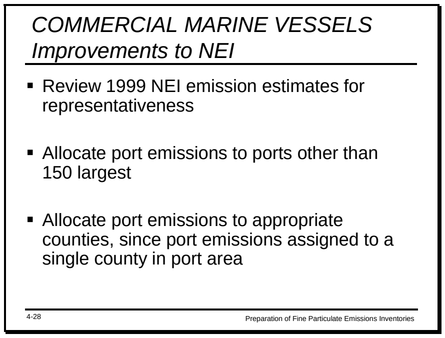
These are allocated separately since port activity surrounds a port area, while underway covers a larger area such as along a river system. Both port and underway emissions are assigned to counties, however, port emissions are assigned to a single county in a port area.

4 - 27



More information on the NEI methodology for estimating emissions from the commercial marine vessel categories can be found at the web address listed here.

4 - 28



One approach to improving NEI emission estimates for the commercial marine vessel category is to review the spatial allocation of commercial marine emissions included in the NEI.

Note that:

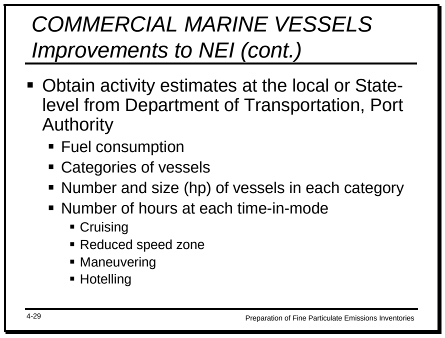
- NEI examines port traffic for the 150 largest ports in the United States and only allocates those emissions.
- Additional ports are not accounted for in the allocation method. Identifying smaller ports that are not accounted for in the NEI would be an improvement.

Another approach to improving the NEI method is to allocate port emissions to the appropriate counties.

Port emissions in the NEI are being assigned to a single county in the port area.

Some ports along the Mississippi and the Ohio Rivers that span multiple counties and even state boundaries. Assigning these port emissions to the appropriate counties and states is another way to improve the NEI results.

4 - 29



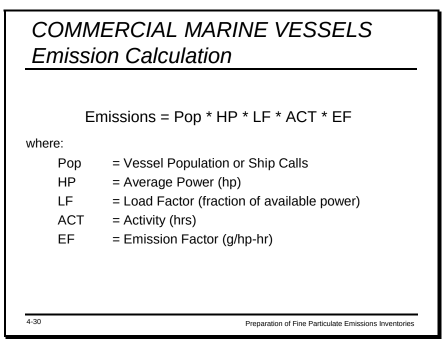
Another approach to improving the NEI results is to conduct a bottom-up inventory by obtaining activity estimates at the state or local level from the DOT or Port Authority.

This can include:

- data on fuel consumption
- data to define categories and characteristics of the vessels (number, size and horsepower in each category)

Similar to aircraft, there are different emission rates depending on the operating mode of the vessels, so data on the fraction of the time engines are spent in those modes would also be an improvement.

4 - 30

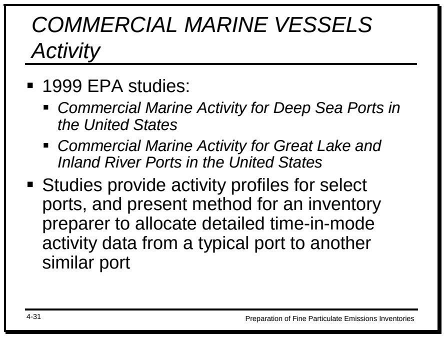


This slide lists the equation for calculating emissions from commercial marine vessels.

It requires data on vessel populations, horsepower, load factor, and the time-in-mode operation.

Applying this emission equation with this data will produce a better inventory.

4 - 31

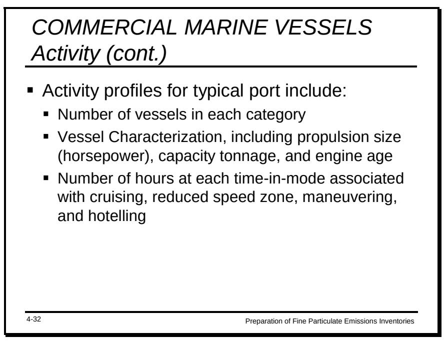


In 1999 EPA completed the two studies shown here.

The content of these studies:

- provides commercial marine activity profiles for select ports, and
- presents a method for allocating detailed time-in-mode activity data from a typical port to another similar port.

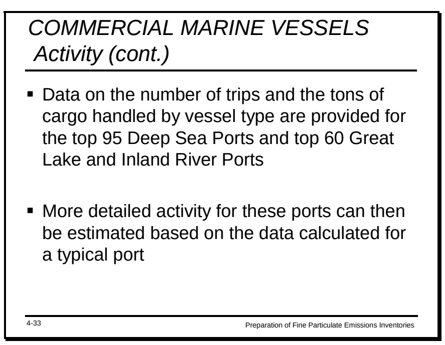
4 - 32



The specific variables that are collected for the typical ports in these studies include:

- the number of vessels in each category,
- the vessel characterization, including propulsion size, capacity tonnage, and engine age, and
- the number of hours at each time-in-mode associated with cruising, reduced speed zone, maneuvering, and hotelling.

4 - 33



These studies also contain data on the number of trips and the tons of cargo handled by vessel type for the top 95 deep-sea ports and the top 60 Great Lake and inland river ports.

Based on the data calculated for a typical port, more detailed activity can be estimated for these ports.

These reports also describe how the typical port inventories were developed and how they can be scaled for the port activity in a specific area.

4 - 34

COMMERCIAL MARINE VESSELS
Emission Factors

- Depending on activity data obtained:
  - Horsepower-based emission factors
  - Fuel-based emission factors
- EPA performing studies to develop updated emission rates
  - Category 3 Engine Final Rulemaking, January 2003

4-34 Preparation of Fine Particulate Emissions Inventories

Horsepower-based emission factors are available for use with activity data on the number and size of engines.

There are also fuel-based emission factors available for use with activity data on fuel consumption.

EPA has been performing studies to develop updated emission factors as part of their rulemaking activities, such as the Category 3 engine final rulemaking that was published in 2003.

4 - 35

COMMERCIAL MARINE VESSELS
Emission Factors (cont.)

- PM10-PRI EFs for Category 1 and Category 2 Engines:

Engine Category	PM10 [g/kW-hr]
Category 1: 37-75 kW	0.90
Category 1: 75-225 kW	0.40
Category 1: 225+ kW	0.30
Category 2 (5-30 l/cylinder)	0.32

4-35 Preparation of Fine Particulate Emissions Inventories

This table presents EPA recommended PM_{10} emission factors for specific categories of commercial marine engines, on a gram per kilowatt-hour basis for Category 1 and Category 2 engines (i.e., small commercial marine vessel engines).

4 - 36

COMMERCIAL MARINE VESSELS
Emission Factors (cont.)

- PM10-PRI EFs for Category 3 Engines (> 30 l/cylinder):

Mode: Engine	PM10 [g/kW-hr]
Cruise and Reduced Speed Zone: 2-stroke	1.73
Cruise and Reduced Speed Zone: 4-stroke	1.76
Maneuvering: 2-stroke	2.91
Maneuvering: 4-stroke	2.98
Hotelling: 2-stroke	0.32
Hotelling: 4-stroke	0.32
All Modes: Steam Generators	2.49

4-36 Preparation of Fine Particulate Emissions Inventories

EPA recommended PM_{10} emission factors for the larger engines are listed in this table.

These factors are listed by the different modes of operation.

4 - 37

COMMERCIAL MARINE VESSELS
Emission Factors (cont.)

- Emission factors in grams per gallon fuel consumed also available from *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, EPA-450/4-81-026d (Revised), U.S. EPA, OAQPS, July 1989
- PM2.5-PRI = 0.92 * PM10-PRI emissions

4-37 Preparation of Fine Particulate Emissions Inventories

Emission factors in grams per gallon of fuel consumed are also available from the document listed on this slide.

As with aircraft category, $PM_{2.5}$ emissions from commercial marine vessels are estimated to be 92% of the PM_{10} emissions.

4 - 38

LOCOMOTIVES
Overview

SCCs:

- 2285002006 – Diesel Class I Line Haul
- 2285002007 – Diesel Class II/III Line Haul
- 2285002008 – Diesel Passenger (Amtrak)
- 2285002009 – Diesel Commuter
- 2285002010 – Diesel Switchyard Locomotives

4-38 Preparation of Fine Particulate Emissions Inventories

The SCCs representing the locomotive categories that are currently used in the NEI are listed on this slide.

This includes larger Class I line haul locomotives that travel through many states, as well as the smaller Class II and III line haul locomotives that tend to operate in a smaller area.

The NEI also has information on passenger Amtrak trains, commuter trains, and switchyard operations.

4 - 39

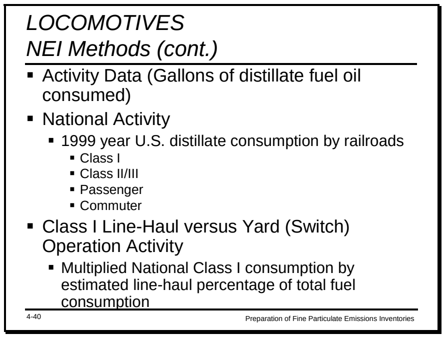
LOCOMOTIVES
NEI Methods

- PM Emission Factors (represent Primary PM)
  - Line-Haul
    - PM_{10}: 6.7 g/gallon
    - $PM_{2.5}$: 6.03 g/gallon
  - Yard
    - PM_{10}: 9.2 g/gallon
    - $PM_{2.5}$: 8.28 g/gallon

4-39 Preparation of Fine Particulate Emissions Inventories

The PM emission factors in that are used in the NEI for the line haul and yard operations are listed on this slide.

4 - 40



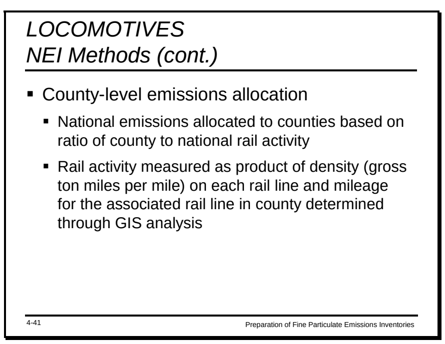
The activity data are based on a national estimate of the gallons of distillate fuel oil consumed.

This national fuel consumption is allocated among four of the five categories of railroads to develop a national activity value for these four categories.

Switchyard operation activity is estimated by multiplying the national Class I fuel consumption by the estimated line-haul percentage of the total fuel consumption. It is assumed that fuel consumption estimates for Class I line-haul locomotives include switchyard fuel consumption.

This assumption is based on the fact that the larger line-haul railroads are the ones that tend to operate in a switchyard.

4 - 41



The allocation of the activity data to the county level is based on a ratio of county to national rail activity.

This rail activity is measured as a product of density (gross tons per mile) for each rail line and mileage for the associated rail line in the county.

Mileage for each rail line in the county is measured using a GIS database that is available from the Bureau of Transportation Statistics.

4 - 42

LOCOMOTIVES
NEI Methods (cont.)

- Detailed documentation on the procedures used to develop criteria pollutant locomotive emission estimates for the 1999 NEI are available at:

ftp://ftp.epa.gov/EmisInventory/finalnei99ver3/criteria/documentation/nonroad/99nonroad_voli_oct2003.pdf

4-42 Preparation of Fine Particulate Emissions Inventories

Detailed documentation on the procedures used to develop criteria and HAP pollutant locomotive emission estimates for the 1999 NEI can be found at the web address listed here.

4 - 43

LOCOMOTIVES
Improving the NEI

- Review NEI emission estimates for representativeness
- Obtain more representative fuel consumption estimates at the local or State-level
- Determine relative contribution of line-haul versus yard activity at local or State-level

4-43 Preparation of Fine Particulate Emissions Inventories

The first step in improving the NEI locomotive emission estimates is to examine the NEI data for reasonableness.

If the NEI data does not represent emissions in a specific area, more representative fuel consumption at the local or state level should be obtained.

Also, because the NEI makes an assumption to estimate switchyard emissions, an improvement could be made by obtaining information on the actual switchyard activity in the study area.

4 - 44

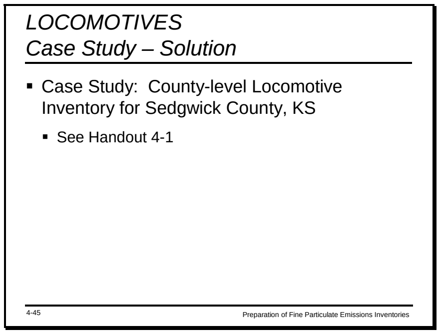
LOCOMOTIVES
Case Study - Overview

- Case Study: County-level Locomotive Inventory for Sedgwick County, KS
  - See Case Study Number 4-1

4-44 Preparation of Fine Particulate Emissions Inventories

This case study describes the development of a county level locomotive inventory for Sedgwick County, Kansas.
Direct student to Case Study Number 9-1 and discuss it with the students.

4 - 45



Distribute the solutions (Handout 4-1) to the case study. Review each question with the students. Encourage discussion among the class. Ask each group to report on the questions that were assigned to them. Ask the other groups to critique their responses.

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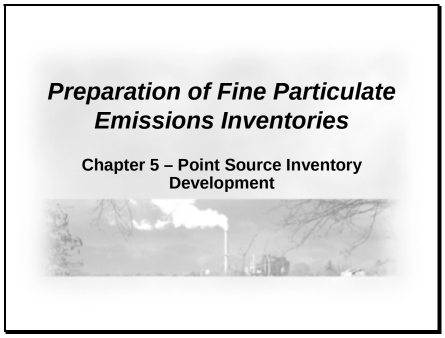
Chapter 5 – Point Source Inventory Development

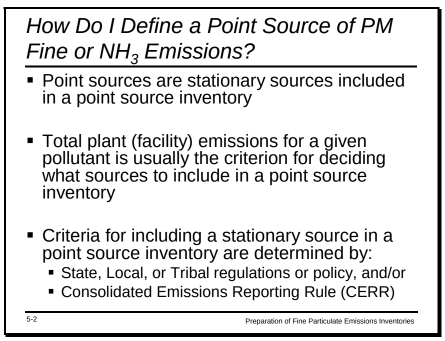
5 - 1



After completing this lesson, participants will be able to:

- identify point sources for inclusion in an emissions inventory, including the form of the particulate matter and the particle size
- describe methods used to estimate emissions
- explain overlap issues associated with point and nonpoint source emission inventories

5 - 2

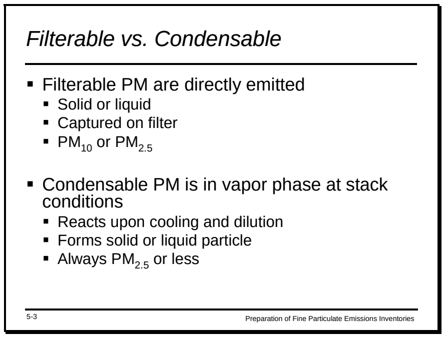


Point sources are stationary sources that are included in a point source inventory.

Total plant or facility emissions for a given pollutant is usually the criterion for deciding if a specific source should be included in a point source inventory or an nonpoint source inventory.

The criteria are defined by either state, local, or tribal regulations or policy. They may also be defined by the reporting thresholds contained in the Consolidated Emissions Reporting Rule.

5 - 3



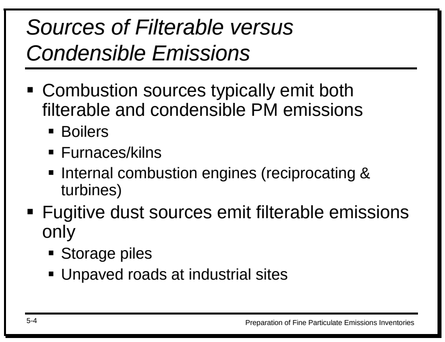
Filterable PM:

- solid or liquid particles directly emitted at stack or release conditions
- captured on the filter of a stack test train
- may be PM_{10} or $PM_{2.5}$

Condensable PM:

- material that is in the vapor phase at stack conditions
- condenses and/or reacts upon cooling and dilution in the ambient air
- forms a solid or a liquid particulate immediately after discharge from the stack
- usually $PM_{2.5}$ or less

5 - 4



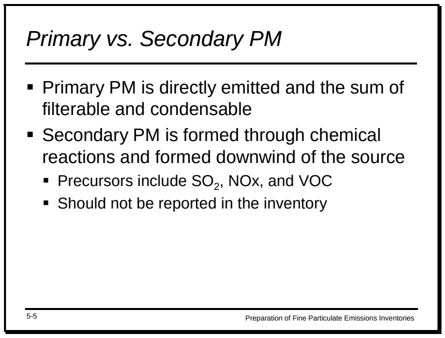
Combustion sources typically emit both filterable and condensable emissions.

Examples include boilers, furnaces and kilns, and both reciprocating internal combustion engines and turbines.

Fugitive dust sources emit filterable emissions only.

Examples of fugitive dust sources include storage piles and unpaved roads at industrial sites.

5 - 5



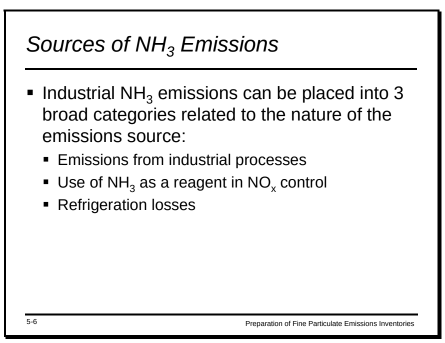
Primary PM:

- the sum of the filterable and the condensable PM
- particles are emitted directly from a stack

Secondary PM:

- particles that form through chemical reactions in the ambient air after dilution and condensation has occurred
- formed downwind of the source
- precursors include SO_2, NO_x, ammonia and VOC
- should not be reported in the emission inventory (only precursor emissions are reported)

5 - 6



Sources of ammonia emissions fall into three broad categories:

- industrial processes,
- use of ammonia as a reagent in NO_x control (e.g., selective catalytic reduction or selective non-catalytic reduction), and
- refrigeration losses.

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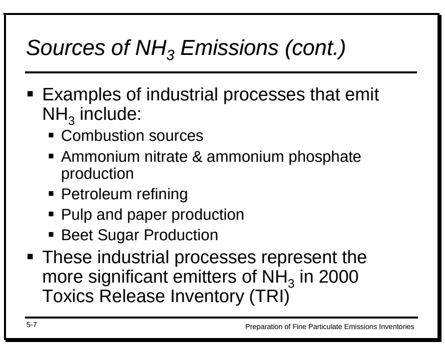

The industrial processes shown here contribute significant amounts of ammonia emissions, as reported in the 2000 Toxics Release Inventory.

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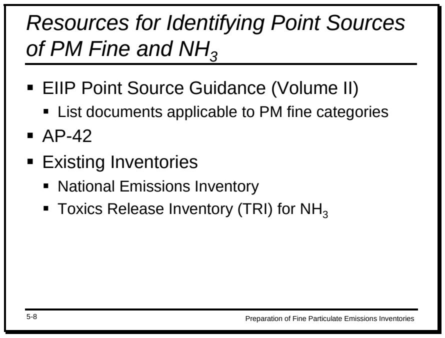

Resources for identifying point sources of fine PM and ammonia include:

- Volume II of the Emissions Inventory Improvement Program guidance document for point sources,
- AP-42 emission factors document, and
- existing inventories such as the NEI and the TRI (for ammonia).

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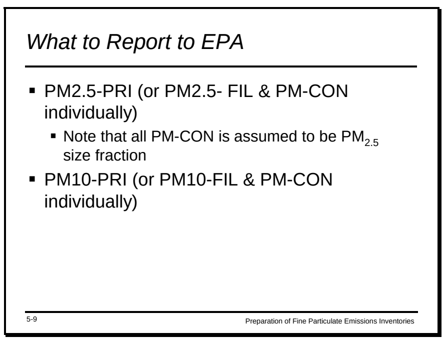
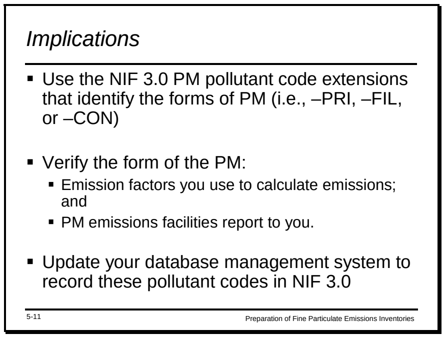


States may report their $PM_{2.5}$ primary emissions to the EPA as either $PM_{2.5}$ primary or the $PM_{2.5}$ filterable and PM condensable components.

All PM condensable is assumed to be in the $PM_{2.5}$ size.

States may report their PM_{10} primary emissions to the EPA as either PM_{10} primary, or as PM_{10} filterable and PM condensable components.

5 – 10



The NIF 3.0 PM pollutant code extensions:

- identify forms of the PM, should be used for reporting.
- include PRI for primary filterable, FIL for filterable, and CON for condensable

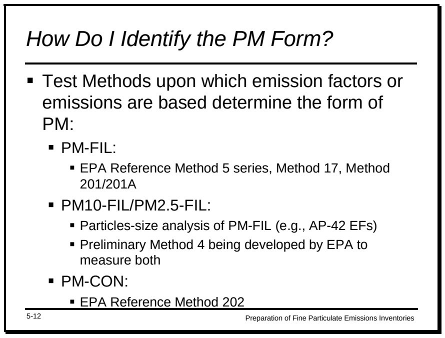
The form of the PM should be verified to ensure that PM emissions that are recorded as PM_{10} or $PM_{2.5}$ are correctly identified as filterable, condensable, or primary emissions. This may require an examination of the emission factors.

If the emissions were reported by facilities, the verification will require that States contact the facilities to ask them what emission factors were used to calculate the emissions.

Alternatively, if the emissions estimates provided by the sources are based on stack test data, the states must ask what method was used to measure the emissions in order to determine the form of PM.

The database management system should be updated to record these pollutant code extensions.

5 – 11



Examining the test method used to collect the data can identify the form of the PM.

EPA's Reference Method 5 series:

- used to measure total PM filterable emissions
- basis for most AP-42 emission factors (represent PM-filterable)

Method 17 is similar to the Method 5, however it is infrequently used. Method 201/201A is designed for PM_{10} filterable.

To calculate or measure the PM_{10} filterable or the $PM_{2.5}$ filterable:

- conduct a particle size analysis of the total PM to develop the size fractions or cut points for PM_{10} or $PM_{2.5}$.
- use this information to develop particle size specific emission factors in AP-42

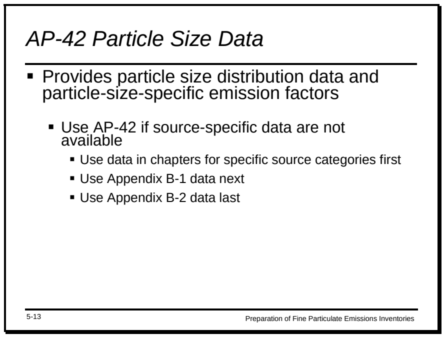
However, most of the emission factors in AP-42 are for filterable emissions, although there are some condensable emission factors for combustion sources. Sum the filterable and condensable emission factors to obtain a PM primary emission factor.

There are some exemptions so it is important to always understand the form of the PM that the emission factor represents.

The EPA is developing Preliminary Method 4 to measure both $PM_{2.5}$ filterable and condensable.

Method 202 is a method for condensable PM, but it is not used frequently, mainly because regulations do not require sources to measure condensable emissions.

5 – 12



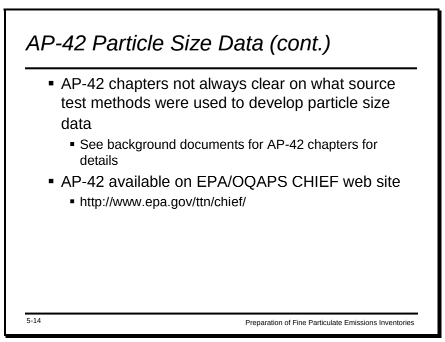
AP-42 provides particle size distribution data and particle size specific emission factors.

Some source categories (e.g., combustion) in AP-42 have particle size specific emission factors for PM. That data should be used first.

Examine source specific data at the local or state level prior to consulting AP-42, since this is usually the best data.

If such data does not exist, consult the resources listed.

5 – 13

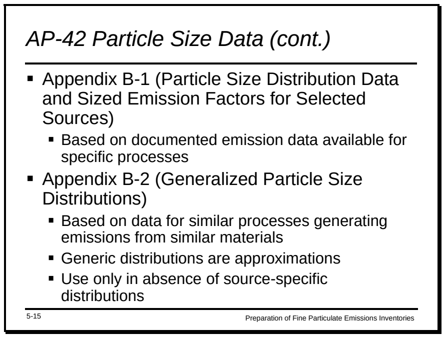


AP-42 chapters are not always clear on what source test methods were used to develop the particle size data.

You may need to consult the background information documents that were used to develop the chapters for AP-42.

AP-42 is available in EPA’s Clearinghouse for Inventories and Emission Factors website.

5 – 14



Appendix B1:

- use for source categories that do not have particle size specific emission factors
- contains particle size distribution data and particle size emission factors for selected sources
- based on documented emissions data available for specific processes

If Appendix B1 does not have particle size data for the source category of interest, use Appendix B2.

Appendix B2 contains generalized particle size distributions that are based on data for similar processes.

These distributions are approximations and should only be used in the absence of source specific particle size distribution data.

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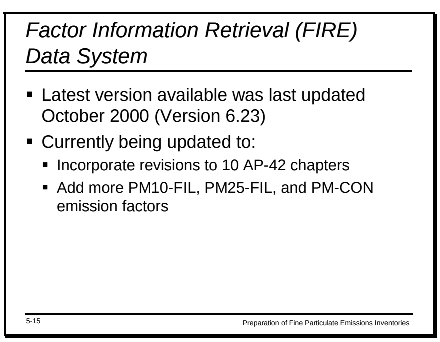
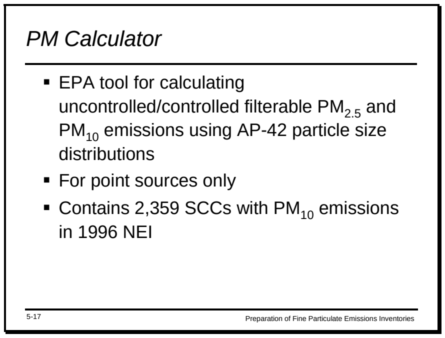


The Factor Information Retrieval System (FIRE) is a compilation of emission factors from AP-42 and other documents.

It is an electronic database that is available on the CHIEF web site.

EPA is in the process of developing a more complete set of PM_{10} and $PM_{2.5}$ filterable and PM condensable emission factors that will be incorporated into FIRE.

5 – 16



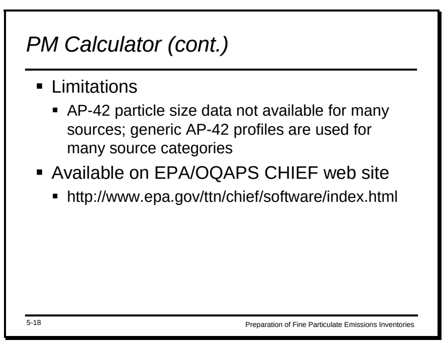
The PM Calculator is a tool developed by EPA to calculate uncontrolled and controlled filterable $PM_{2.5}$ and PM_{10} emissions using AP-42 particle size data.

For example, it can be used to calculate the $PM_{2.5}$ filterable emissions based on the PM_{10} filterable emissions contained in an inventory.

You can also calculate PM_{10} and $PM_{2.5}$ from the total PM filterable emissions.

The calculator only deals with the filterable emissions (i.e., it does not address the condensable portion) and is for point sources only. It contains over 2300 SCCs.

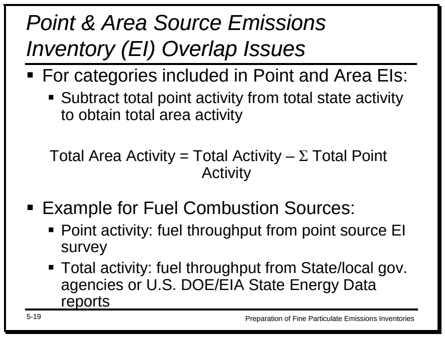
5 – 17



Although it contains over 2300 SCCs, the PM calculators main limitation is that it is based on AP-42 particle size data that is not available for many sources.

As a result, many times it uses the generic particle size data contained in Appendix B2 of AP-42 or other sources. It is also available on the CHIEF web site.

5 – 18

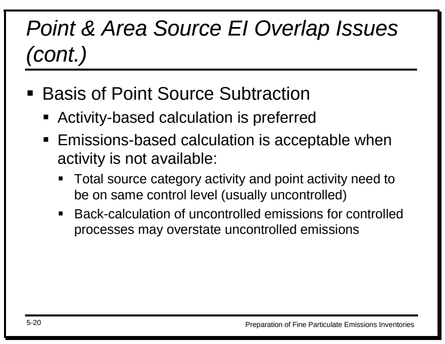


For categories included in the point and nonpoint source emission inventories, subtract total point activity from the total state activity to obtain a total nonpoint source activity.

Using the fuel combustion category as an example, the point source activity is the fuel throughput from the point source inventory.

Total activity is the statewide fuel throughput obtained from the state or local government agency, or from the state energy data reports published by the Interior Energy Administration in the U.S. Department of Energy.

5 – 19



Ideally, the point source subtraction is based on activity data. For example, the point source fuel throughput for a given year is subtracted from the total statewide fuel consumption for the same year.

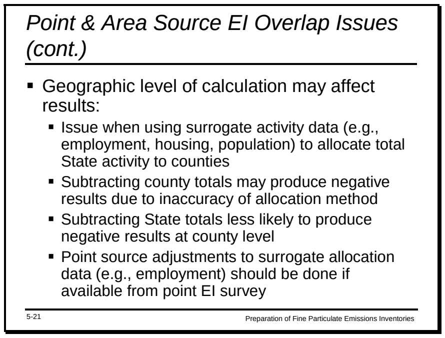
However, in many cases, the activity data for performing that calculation may not be available. In this case, an emissions based calculation is acceptable.

Under the emissions based approach:

- the total source category activity and the point activity should be on the same control level
- the control level should be an uncontrolled emissions basis because since total statewide activity represents uncontrolled sources

In this case, it is important to ensure that the point source emissions represent uncontrolled levels. It is also important to check the uncontrolled emissions to ensure that they seem reasonable.

5 – 20



The geographic level of the point source adjustment used to calculate the nonpoint source activity is an issue when surrogate activity data is used to allocate total state activity to the county level.

The EIIP method:

- uses employment for specific SIC codes to allocate total statewide natural gas combustion to the county level at industrial and commercial institutions
- requires you to sum point source throughput for a county and subtracting it from the total activity for the county may produce negative results
- indicates that point source consumption fuel use is higher than that calculated for the nonpoint sources
- can be an artifact of the allocation data used

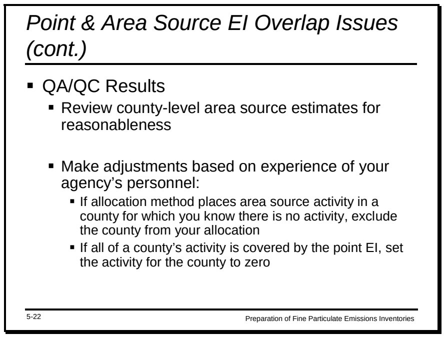
The preferred approach:

- sum up the point source fuel throughput consumption on the state level
- subtract this sum from the total consumption for the state prior to doing the county-level allocation

It is also preferable to obtain activity data such as employment data for the point sources included in the inventory.

In this way it is possible to make point source adjustments to the surrogate allocations to account for the amount of employment that is associated with the point sources.

5 – 21



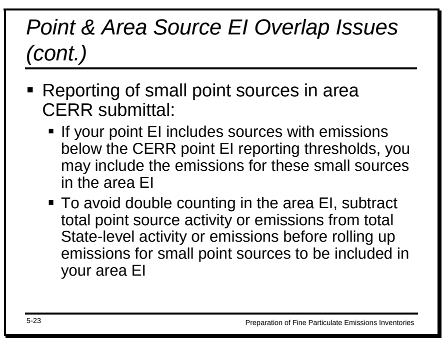
The county level nonpoint source estimates should be reviewed for reasonableness after the adjustment has been made.

Adjustments should be based on the experience of the agency personnel.

For example, if the allocation method places nonpoint source activity in a county for which it is known that there is no activity, that county should be excluded from the allocation.

Also, if all of a county's activity is covered by the point source emission inventory, the nonpoint source emissions should be zero.

5 – 22



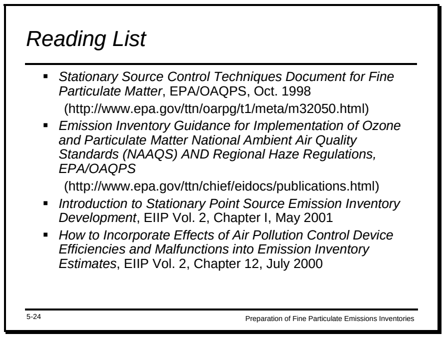
If the point emission inventory includes sources with emissions below the CERR point emission inventory reporting thresholds, the emissions for these small sources can be included in the nonpoint source emissions.

To avoid double counting in the nonpoint source inventory:

- subtract total point source activity from the total state activity, then
- roll up the small point source data to add to the inventory.

In this way the emissions for the small point sources in the area are not double counted.

5 – 23



A suggested reading list for preparing point source inventories for fine PM is presented here.

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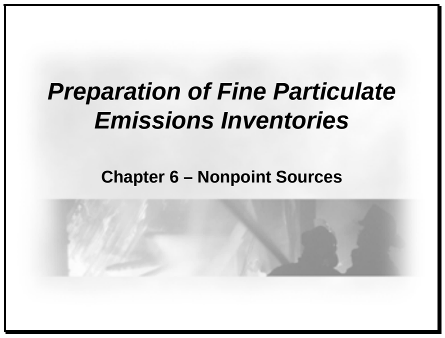
Chapter 6 – Nonpoint Sources

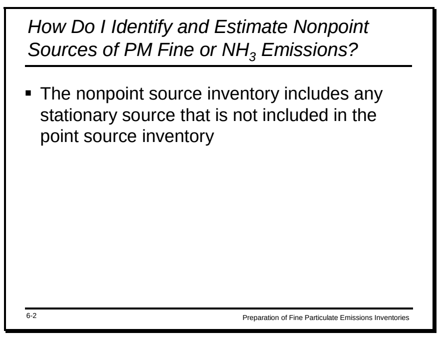
6 - 1



After completing this lesson, participants will be able to:

- describe the approach used to identify nonpoint sources for inclusion in an emissions inventory
- list the methodologies for estimating emissions from nonpoint sources
- reconcile fugitive emissions data with ambient data

6 - 2



A nonpoint source refers to any stationary source that is not included in the point source inventory. For emission inventory development purposes, EPA has traditionally used the term "area sources" to refer to stationary air pollutant emission sources that are not inventoried at the facility-level.

The Consolidated Emissions Reporting Rule specifies reporting thresholds for point and area sources of criteria air pollutants. These will vary depending on the pollutant and the attainment status of the county in which the source is located.

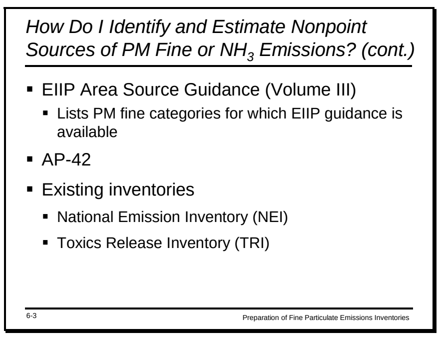
The Clean Air Act defines area sources of Hazardous Air Pollutants for the purpose of identifying regulatory applicability.

The CAA defines an area HAP source as "any stationary source that emits or has the potential to emit considering controls, in the aggregate, less than 10 tons per year of any HAP or 25 tons per year of any combination of HAPs."

Sources that emit HAPs above these thresholds are categorized as "major sources."

To reduce confusion between these two sets of area source definitions, EPA has adopted the term "nonpoint" to refer to all criteria air pollutant and HAP stationary emission sources that are not incorporated into the point source component of the NEI.

6 - 3



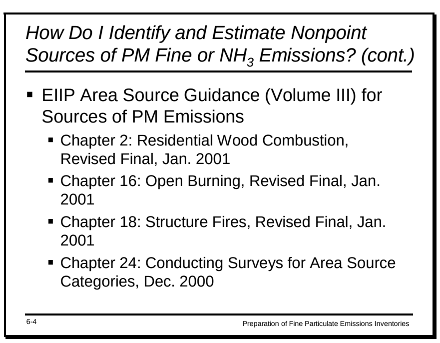
Volume III of the EIIP Area Source Guidance lists the PM fine categories for which the EIIP guidance is available.

AP-42 and existing emission inventories also can help identify nonpoint source categories that are sources of fine PM and ammonia emissions.

Existing inventories include:

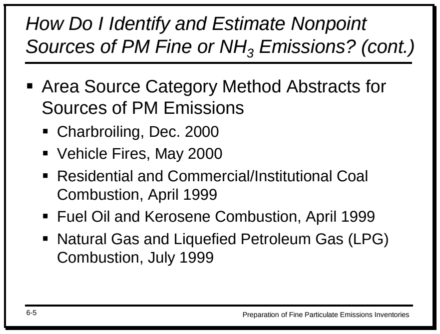
- National Emissions Inventory
- Toxics Release Inventory
- inventories developed through regional planning organizations or state and local agencies.

6 - 4



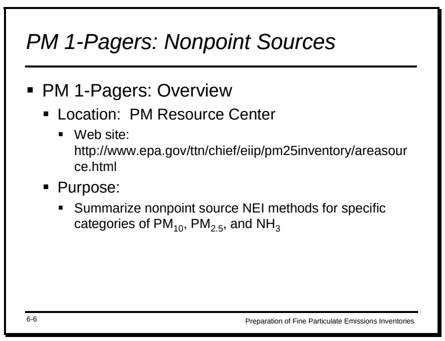
The chapters of Volume III of the EIIP Area Source Guidance that are useful for identifying nonpoint source categories of fine PM and ammonia are listed here.

6 - 5



The EIIP also has “area source category method abstracts” for charbroiling, vehicle fires, residential and commercial/institutional coal combustion, fuel oil and kerosene combustion, and natural gas and liquefied petroleum gas combustion.

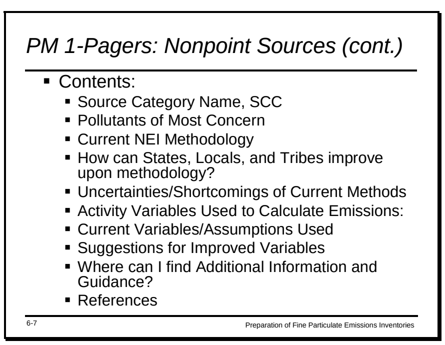
6 - 6



The PM2.5 Resource Center, which is available on the CHIEF website, contains “PM one-pagers.”

These documents contain an overview of the NEI methods and summarize nonpoint source NEI methods for specific categories of PM_{10}, $PM_{2.5}$, and ammonia.

6 - 7



The PM one-pagers provides the source category name and SCC, the pollutants of most concern, current NEI method, and how state, locals, and tribal agencies can improve on the NEI method, uncertainties and shortcomings.

They also contain activity variables used to calculate the emissions, current variables and assumptions used in the methods, suggestions for improving the variables, and where to find additional information and guidance for the categories.

6 - 8

PM 1-Pagers: Nonpoint Sources (cont.)

- Open Burning
  - Residential Yard Waste (Leaves) and Household Waste
  - Residential, Nonresidential, and Road Construction Land Clearing Waste
  - Structure Fires
  - Wildfires & Prescribed Burning
  - Managed Burning - Slash

6-8 Preparation of Fine Particulate Emissions Inventories

The open burning categories covered by the one-pagers include residential yard waste for leaves, household waste, residential, nonresidential, and road construction land clearing waste, structure fires, wildfires and prescribed burning, and managed or slash burning.

6 - 9

PM 1-Pagers: Nonpoint Sources (cont.)

- Fugitive Dust
  - Paved and Unpaved Roads
  - Residential Construction
  - Mining and Quarrying
- Residential Combustion - Fireplaces and Woodstoves

6-9 Preparation of Fine Particulate Emissions Inventories

Fugitive dust categories covered by the one-pagers include paved and unpaved roads, residential construction, and mining and quarrying.

There are also one-pagers covering residential combustion (i.e., fireplaces, woodstoves, and other residential home heaters that burn natural gas or fuel oil).

6 - 10

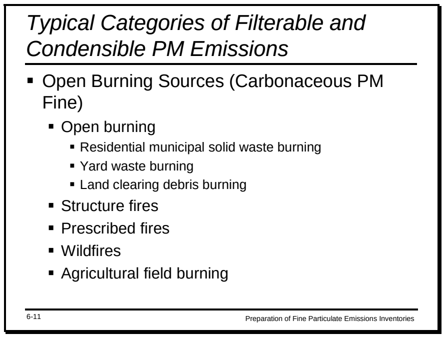
Typical Source Categories of Filterable PM Emissions

- Fugitive Dust Sources (Crustal PM Fine)
  - Construction
  - Mining and quarrying
  - Paved/unpaved roads
  - Agricultural tilling
  - Beef cattle feedlots

6-10 Preparation of Fine Particulate Emissions Inventories

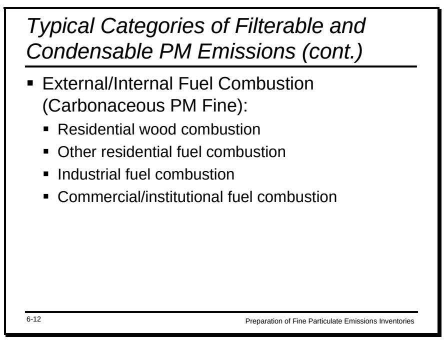
This list represents typical area source categories of fugitive dust sources of filterable PM emissions.

6 - 11



This list contains typical area source categories of open burning sources of filterable PM emissions.

6 - 12



This list shows typical area source categories of filterable and condensable PM emissions.

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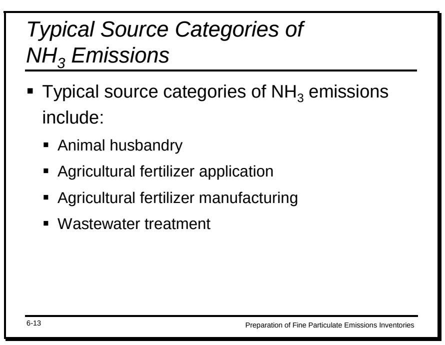
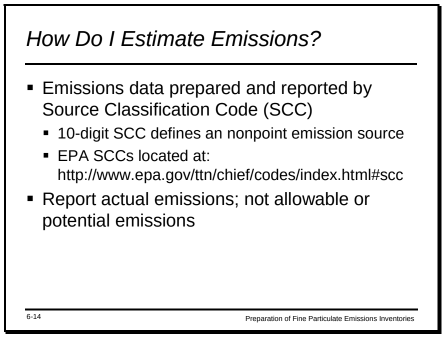


This list presents typical area source categories of ammonia sources.

6 - 14



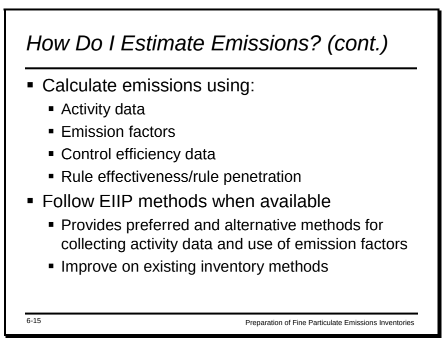
Nonpoint source inventories are prepared and reported by the 10-digit SCC source classification code.

EPA's master list of SCCs are available on the CHIEF website. This is a dynamic list that can be updated (with EPA's approval) to add SCCs.

For example, SCCs should be added if there are several subcategories within a general nonpoint source category and a state or local agency is estimating emissions at that level.

Also, actual emissions, not allowable or potential emissions are reported for the NEI.

6 - 15



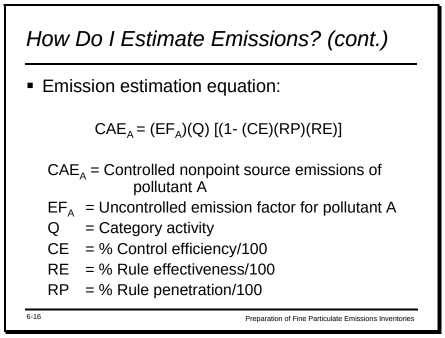
To calculate emissions from nonpoint sources, multiply the activity data by the emission factor, control efficiency data, rule effectiveness, and rule penetration.

EPA guidance specifically excludes applying default RE/RP assumption values for PM inventories.

You should follow EIIP methods, since these were developed with state and local input and they reflect the most current standardized procedures for preparing emission inventories.

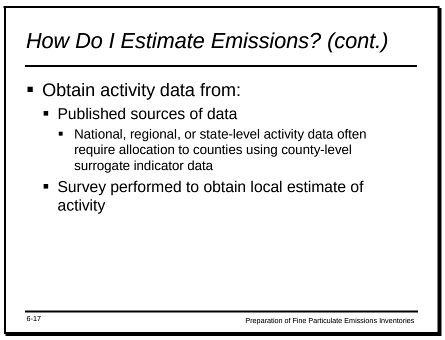
The EIIP provides preferred and alternative methods for collecting activity data and the use of emission factors, and contains suggested improvements on existing inventory methods.

6 - 16



This equation is used to estimate emissions.

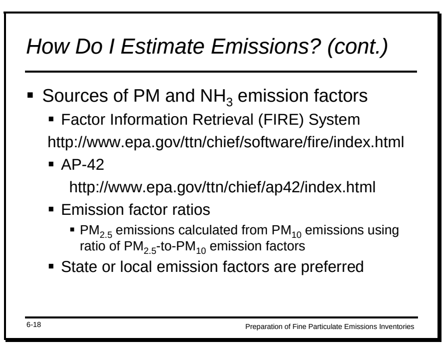
6 - 17



Activity data is obtained from various published sources of data or surveys. However, the use of use national, regional and state level activity data requires allocation to the counties using county-level surrogate indicator data.

Consequently, surveying is the preferred approach to obtain the local activity estimates(i.e., a bottom-up approach, rather than a top-down approach).

6 - 18

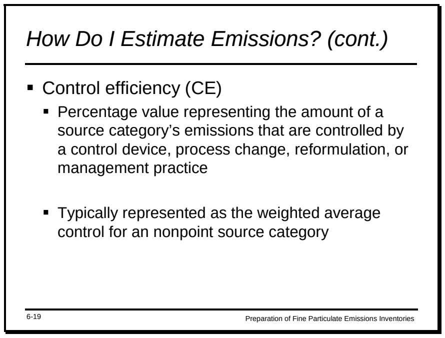


You can obtain emission factors for PM and ammonia from FIRE and AP-42.

As an alternative, you can use the emission factor ratio or particle size multiplier. This involves calculating the $PM_{2.5}$ emissions from the PM_{10} emissions using the ratio of $PM_{2.5}$ to PM_{10} emission factors in AP-42.

However, the use of state, local, and tribal emission factors are preferred over any other approach because they are always specific.

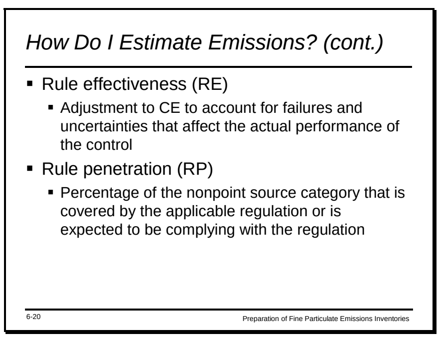
6 - 19



Control efficiency is the percentage value representing the amount of a source category’s emissions that is controlled by a control device, process change, reformulation, or a management practice.

Typically, the value is represented as the weighted average control for a nonpoint source category.

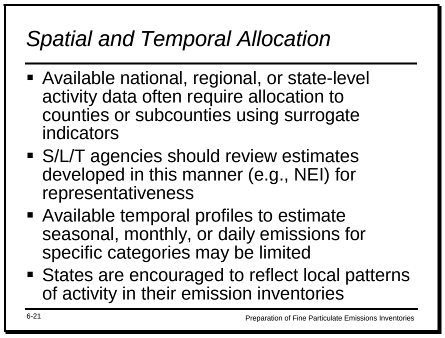
6 - 20



Rule effectiveness is an adjustment to the control efficiency to account for failures and uncertainties that affect the actual performance of the control method.

Rule penetration represents either the percentage of the nonpoint source category that is covered by the applicable regulation, or that which is expected to be in compliance with the regulation.

6 - 21



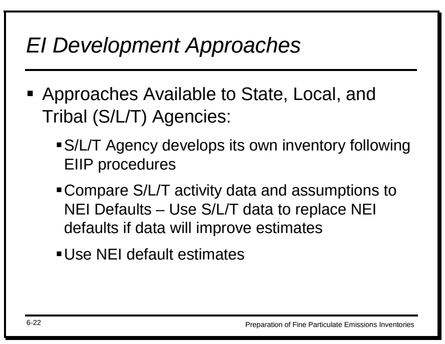
The available national, regional, or state-level activity data often require allocation to counties or subcounties using surrogate indicators.

State, local, and tribal agencies should review emission estimates developed in this manner for representativeness.

The available temporal profiles to estimate seasonal, monthly, or daily emissions for specific categories may be limited, so states are encouraged to reflect local patterns of activity in their emission inventories.

For example, residential home heating emissions from fuel oil combustion can be allocated to the county level by using the number of households in each county in the state.

6 - 22



The approaches that are available to state, local, and tribal agencies for developing an emissions inventory include:

- develop an emissions inventory following the EIIP procedures
- compare the state, local, tribal activity data and assumptions to the NEI defaults and replacing the defaults, as necessary
- use the NEI default estimates

6 - 23

Triage Approach to Improving the EI

- Consider each NEI Category - Is it important ?
  - What's its potential impact on AQ, considering emissions, receptor modeling & other available info
  - May give *some weight* to emission reductions potential
- If yes, focus improvement efforts on the important categories
- Review the available guidance (Course materials, one pagers, EIIP guidance)
- Decide what is feasible in the near and long term

6-23 Preparation of Fine Particulate Emissions Inventories

The triage approach to improving the emissions inventory involves:

- considering the importance of each NEI category
- examining the potential impact on air quality
- considering emissions, receptor modeling, and other available information

Improvements should be made to those categories that are determined to be important using the suggestions and references provided in this training course. This includes reviewing the available guidance and deciding on feasible approaches.

6 - 24

Crustal Materials (Mainly Fugitive Dust)

- Main Sources:
  - Unpaved roads
  - Agricultural tilling
  - Construction
  - Windblown dust, Fly ash

6-24 Preparation of Fine Particulate Emissions Inventories

The main sources of crustal materials are unpaved roads, agricultural tilling, construction, and wind-blown dust.

6 - 25

Crustal Materials (Mainly Fugitive Dust) (cont.)

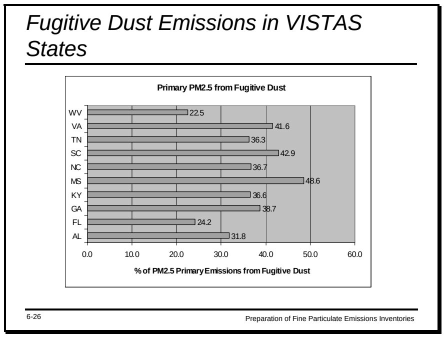
- Huge Disparity Between EI & Ambient Data
  - Ambient Data
    - < 1 ug/m3 in most of US
    - Exception: > 1 ug/m3 in much of Southwest, California
  - Emissions: 2.5M TPY (comparable to Carbon Emissions)
- Fugitive Dust has low "Transportable Fraction"

6-25 Preparation of Fine Particulate Emissions Inventories

There is a huge disparity between the crustal data in an emissions inventory and the ambient air quality data.

The amount of crustal material on the ambient filters is less than expected, given the large estimates of fugitive dust emissions in the NEI. The reason for this apparent anomaly is that fugitive dust has a low transportable fraction.

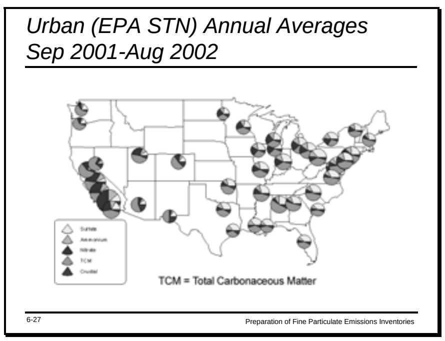
6 - 26



The data on this graph shows that $PM_{2.5}$ inventories in the states included in the VISTAS area have fugitive dust in the 20-40% range.

The rest of PM in the inventory is from sources that are primarily carbonaceous.

6 - 27



Comparing the data in the previous slide with the data presented in this figure shows that the ratio of crustal $PM_{2.5}$ emissions to total carbonaceous matter emissions does not match the ratio of crustal to total carbonaceous $PM_{2.5}$ based on the ambient data.

6 - 28

Role of Surface Cover (Vegetation & Structures) in Fugitive Dust Removal

- Early work by AQ Modelers
  - Stilling Zone – Lower 3/4 of canopy
- Windbreaks – wind erosion "staple"
  - Traditionally to slow wind on leeward side
  - Research by Raupach
    - Entrapment effects
    - Dust transmittance through a windbreak is close to the optical transmittance

6-28 Preparation of Fine Particulate Emissions Inventories

In the process of developing models, the stilling zone under the canopy of vegetation was recognized.

The air in this zone (the bottom three-fourths of the height of the vegetation) is still. This promotes gravitational settling and impaction and filtration by the vegetation.

In the western states it is common to see wind breaks. These are rows of trees or other tall vegetation designed to slow the wind speed on the leeward side.

The objective is to prevent the wind from picking up the soil and causing erosion.

Another important feature of windbreaks is the entrapment effect involving the transmittance of dust through a wind break. Research shows that the dust that goes through a wind break is similar to the optical transmittance of light through a wind break. The remainder is trapped in the windbreak.

6 - 29

Role of Surface Cover (Vegetation & Structures) in Fugitive Dust Removal (cont.)

- Capture Fraction (CF)
  - Portion of Fugitive Dust Emissions (FD) removed by nearby surface cover
- Transport Fraction (TF)
  - Portion that is transported from the source area

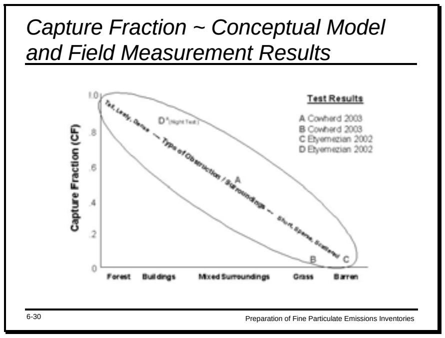
6-29 Preparation of Fine Particulate Emissions Inventories

Capture fraction is the portion of fugitive dust emissions that are removed by nearby surface cover.

Transport fraction is the portion that is transported out of the source area.

Adding the two sums produces the fugitive dust emissions inventory.

6 - 30



This graph plots a capture fraction value and the type of vegetation qualitatively described as going from densely forested to barren.

The test data plotted on this graph suggest a relationship between the amount of vegetation and the capture fraction.

Specifically, the data suggest that tall leafy dense vegetation has a high capture fraction and the short sparse scattered vegetation has a low capture fraction.

6 - 31

Estimates of CF for Specific Surface Conditions

Surface Cover Type	CF (Estimated)
Smooth, Barren or Water	0.03 – 0.1
Agricultural	0.1 - 0.2
Grasses	0.2 - 0.3
Scrub and Sparsely Wooded	0.3 - 0.5
Urban	0.6 - 0.7
Forested	0.9 - 1.0

6-31 Preparation of Fine Particulate Emissions Inventories

The conceptual model suggested by the data in the previous graph has yet to be integrated with air quality models, but it does allow for the assignment of capture fractions to the variety of vegetation shown here.

6 - 32

Example CF's for Counties in NV & GA

- CF (County) = ? CF (Land Use Types) * County Fractional Land Use
  - Types
    - TF = 1 - CF

Land Use Type	Barren & Water	Agri-culture	Grass	Urban	Scrub & Sparse Vegetation	Forest	CF	TF
CF	.03	.15	.2	.6	.3	.95		
Fractional Land Use in Churchill Co NV	.33	.03	.2	0	.36	.05	0.23	0.77
Fractional Land Use in Oglethorpe Co GA	0	.1	.14	0	0	.76	0.76	0.24

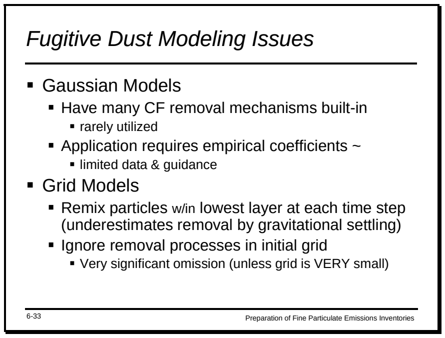
6-32 Preparation of Fine Particulate Emissions Inventories

By using land use databases that contain data on fractional land use in six different areas (barren and water, agriculture, grass, urban, scrub and sparse vegetation, and forest) it is possible to compute the capture fraction.

As shown in this table, the capture fraction for a given area is the sum of capture fraction by land use type times the county fractional land use amount. The transport fraction is equal to one minus the capture fraction.

For example, the transport fraction from the source in Churchill County, Nevada is much higher than the amount that gets away from the source in Oglethorpe County, Georgia. The main difference is the amount of trees in those two areas. In general, the transport fraction is fairly low in those areas of the country that are very heavily forested, or in cities with a lot of buildings.

6 - 33



There are modeling issues associated with using this approach to account for different transport characteristics of dust in different parts of the country.

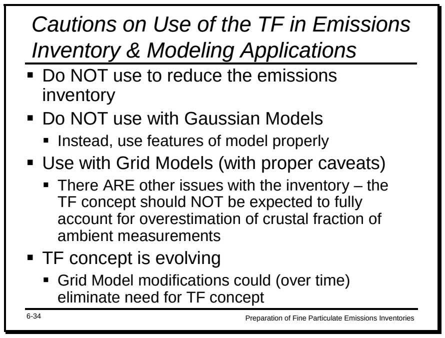
Gaussian models actually have removal mechanisms built in to them to accommodate capture fraction through the use of empirical coefficients. Unfortunately, there is limited data and guidance on how to apply these coefficients, so they are rarely used.

Grid models on the other hand are not equipped to handle particle transport. They tend to remix particles within the lowest layer during each time step, resulting in an underestimation of gravitational settling removal.

Within a time step of the model particles have had a chance to settle down, but not settle out. In the next time step they are remixed into the whole lower mixing cell, so they may never get out.

Also, in the initial grid removal processes, even gravitational settling is ignored. This is a very significant omission unless the grid is very small. However, modeling very small grids is not really practical.

6 - 34

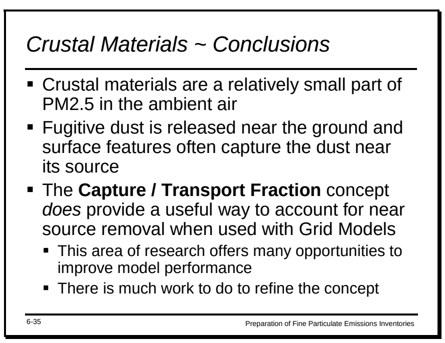


Transport fractions should not be used to reduce the emission inventory, nor should they be used with Gaussian models.

They can be used with grid models with the proper caveats. Because there are other issues with the inventory, there will not be instantaneous agreement between the fugitive dust emissions and the ambient data.

For example, there are issues with applying the unpaved road factors properly. The transport fraction concept is evolving and over time grid model modifications could eliminate the need for this approach.

6 - 35



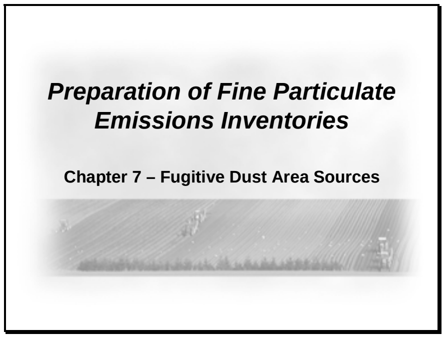
Crustal material is a relatively small part of $PM_{2.5}$ in the ambient air.

Fugitive dust is released near the ground and surface features often capture the dust near its source.

Finally, the capture/transport fraction concept provides a useful way to account for near source removal when used with grid models. This area of research offers many opportunities to improve model performance.

Chapter 7 – Fugitive Dust Area Sources

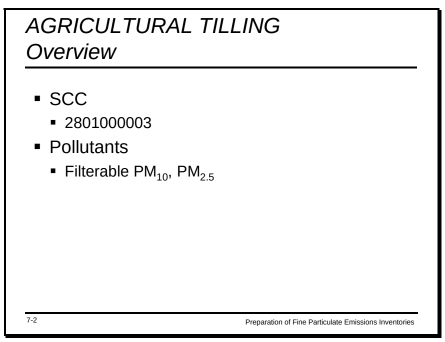
7 - 1



After this lesson, participants will be able to identify fugitive dust emissions from the following area sources:

- agricultural tilling,
- paved roads,
- unpaved roads, and
- residential, commercial, and road construction activities.

7 - 2



The SCC that is contained in the National Emissions Inventory for agricultural tilling emissions is 2801000003.

For this category the NEI contains estimates of filterable PM_{10} and $PM_{2.5}$. There are no condensibles associated with this category.

7 - 3

AGRICULTURAL TILLING
NEI Method

- Activity Data (no. of acres of land tilled)
  - 1998 County-Level Activity Data
    - Acres of crops tilled in each county by crop type and by tilling method obtained from CTIC
    - Five tilling methods include:
      - no till
      - mulch till
      - ridge till
      - 0 to 15 percent residue
      - 15 to 30 percent residue

7-3 Preparation of Fine Particulate Emissions Inventories

The activity data for the NEI was obtained from the Conservation Technology Information Center, which publishes a national crop residue management survey every two years that contains county level activity data.

The NEI used 1988 survey data. This database provides acres of crops tilled in each county by crop type and by tilling method.

The five tilling methods included in the database are listed here.

7 - 4

AGRICULTURAL TILLING
NEI Method (cont.)

- Emission Factor (mass of TSP per acre tilled)
  - Emission factor comprises:
    - Constant of 4.8 lbs/acre pass
    - Silt content of the surface soil
    - Number of tillings per year (conservation and conventional use)
    - Particle size multiplier for PM_{10} and $PM_{2.5}$

7-4 Preparation of Fine Particulate Emissions Inventories

The emission factor in the NEI is expressed as the mass of the total suspended particulate per acre tilled.

The emission factor comprises:

- a constant of 4.8 pounds per acre pass of PM
- the silt content of the surface soil
- the number of tillings per year (separated into conservation and conventional use)
- the particle size multiplier to calculate the PM_{10} or the $PM_{2.5}$ from the PM emissions

7 - 5

AGRICULTURAL TILLING
NEI Method (cont.)

- Emission Factor (cont.)
  - Silt content

Soil Type	Silt Content (%)
Silt Loam	52
Sandy Loam	33
Sand	12
Loamy Sand	12
Clay	29
Clay Loam	29
Organic Material	10-82
Loam	40

  - Soil types assigned to counties by comparing USDA surface soil and county maps

7-5 Preparation of Fine Particulate Emissions Inventories

The silt content values that are used for various soil types in the NEI are listed here.

These soil types are assigned to counties by using the USDA surface soil and county level maps to match the soil types to counties.

7 - 6

AGRICULTURAL TILLING
NEI Method (cont.)

- Emission Factor (cont.)
  - Number of Tillings

Crop	Conservation Use	Conventional Use
Corn	2	6
Spring Wheat	1	4
Rice	5	5
Fall-Seeded Small Grain	3	5
Soybeans	1	6
Cotton	5	8
Sorghum	1	6
Forage	3	3
Permanent Pasture	1	1
Other Crops	3	3
Fallow	1	1

7-6 Preparation of Fine Particulate Emissions Inventories

This chart shows the number of tillings that are assumed by crop type for both conservation and conventional use.

The no till, mulch till, and ridge till methods come from the county level inventory from the CTIC and are grouped into the conservation use category.

The acres reported for the zero to 15 percent residue and the 15 to 30 residue are grouped into the conventional use category.

As the data demonstrate, the conventional use category has more tilling passes per acre than the conservation use.

7 - 7

AGRICULTURAL TILLING
NEI Method (cont.)

- Emission Calculation

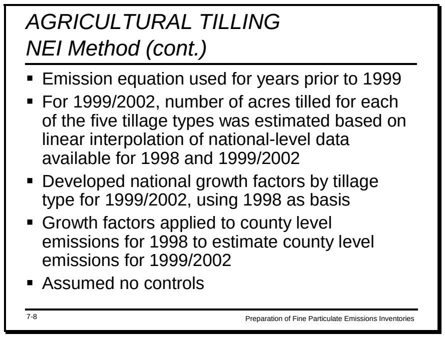
$$E = c * k * s^{0.6} * p * a$$

where: E = PM emissions, lbs per year
c = constant 4.8 lbs/acre-pass
k = dimensionless particle size multiplier (PM_{10}= 0.21; $PM_{2.5}$ = 0.042)
s = silt content of surface soil, defined as the mass fraction of particles smaller than 75 µm diameter found in soil to a depth of 10 cm (%)
p = number of passes or tillings in a year
a = acres of land tilled

7-7 Preparation of Fine Particulate Emissions Inventories

This equation is used in the NEI for calculating total PM emissions from agricultural tilling operations.

7 - 8



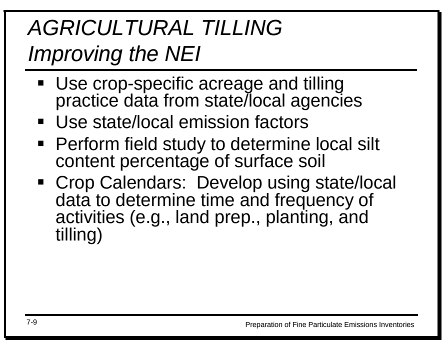
The equation in the previous slide has been used to estimate PM emissions from agricultural operations in the NEI prior to 1999.

Since 1999 the number of acres tilled for each of the five tillage types has been estimated based on a linear interpolation of national level data available for 1998, 1999 and 2002.

Using 1998 as the basis, national growth factors were developed by tillage type for 1998, 1999 and 2002.   These growth factors were applied to county level emissions for 1998 to estimate county level emissions for 1999 and 2002.

Note that the NEI emission calculation assumed no controls.

7 - 9



One way to improve upon the NEI method is to use crop-specific acreage and tilling practice data from the state or local agency or tribal authority. In addition, if state or local emission factors exist, they should be used.

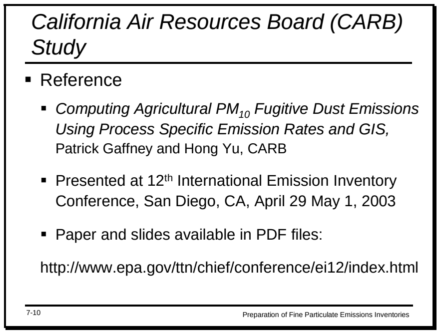
Another improvement is to perform a field study to determine the local silt content percentage of the surface soil.

Silt values used in the NEI are based on limited data and represent averages for the entire country

Local or state conditions may exist that warrant improving NEI values

Finally, the development of crop calendars to determine the time and frequency of the activities will be an improvement over the NEI data.

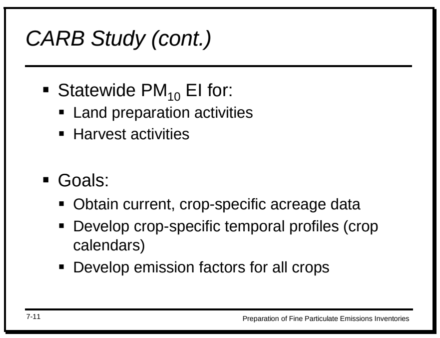
7 - 10



This discussion is based on the report "Computing Agricultural PM_{10} Fugitive Dust Emissions Using Process Specific Rates and GIS" by Patrick Gaffney and Hong Yu. The study was presented at the National Emissions Inventory Conference in San Diego during April 2003.

The paper and slides can be download from the CHIEF web site.

7 - 11

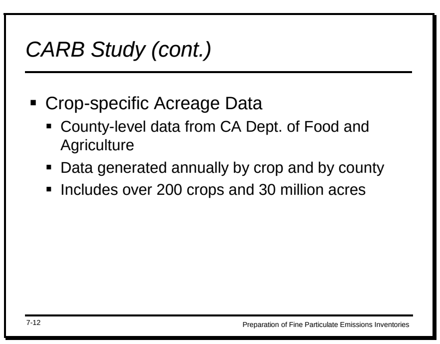


The California Air Resources Board prepared a statewide PM_{10} inventory for land preparation activities and harvest activities at the county level.

The goals were to:

- obtain current crop-specific acreage data
- develop crop-specific temporal profiles or crop calendars, and
- develop emission factors for all crops

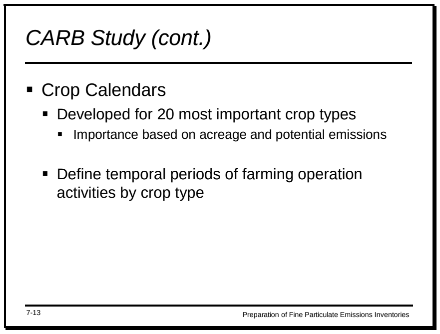
7 - 12



In developing the inventory CARB obtained county level crop-specific acreage data from the California Department of Food and Agriculture.

This department generates the crop data every year by county, and it includes over 200 crops and 30 million acres.

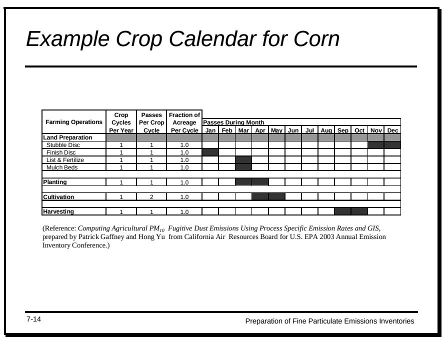
7 - 13



CARB also developed crop calendars for the 20 most important crop types with importance based on the acreage and the potential emissions associated with each crop type.

The crop calendars were used to define the temporal periods of farming operation activities for each of the crop types.

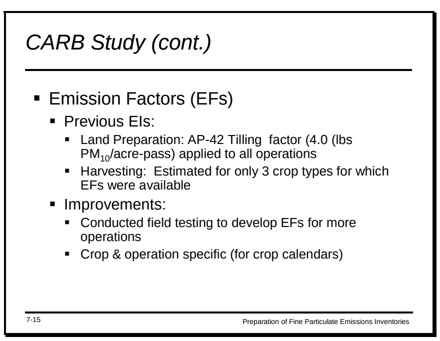
7 - 14



This is an example of a crop calendar for corn. These types of calendars are very informative in terms of identifying when specific activities occur.

As an example, stubble disking for corn occurred in November and December with one pass across the field. In contrast, the NEI assumes these emissions are annual and does not apply any temporal adjustments.

7 - 15

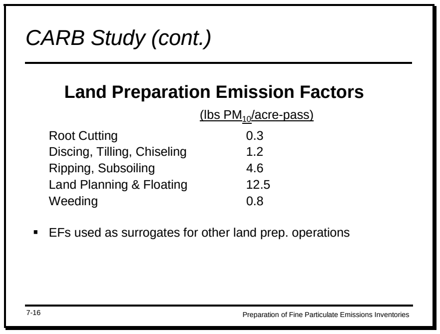


Prior to preparing the statewide PM_{10} inventory for land preparation activities and harvest activities, CARB used the AP-42 tilling emission factor of 4.0 lbs PM_{10}/acre-pass for all land preparation activities.

For harvesting, CARB only estimated emissions for three crop types for which emission factors were available.

In order to improve this approach, CARB conducted field testing over a seven-year period to develop emission factors for different activities that are crop specific and operation specific. These new data allowed CARB to develop the crop calendars.

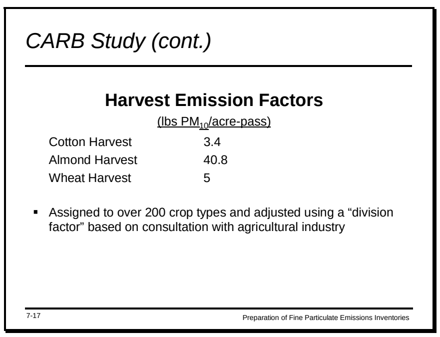
7 - 16



These are the land preparation emission factors that CARB developed for five different types of activities.

These emission factors were used as surrogates for other land preparation activities, such as wheat cutting, where specific factors were not available.

7 - 17

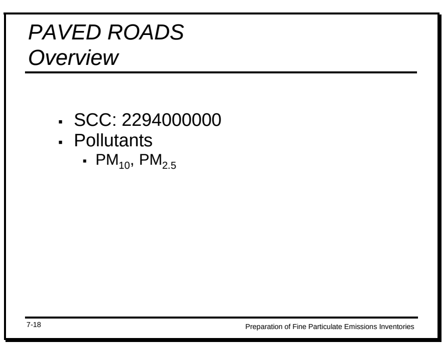


The harvest emission factors that CARB developed for three types of crops are shown here.

These factors were assigned to over 200 crop types and adjusted using a division factor developed in consultation with the state agricultural industry.

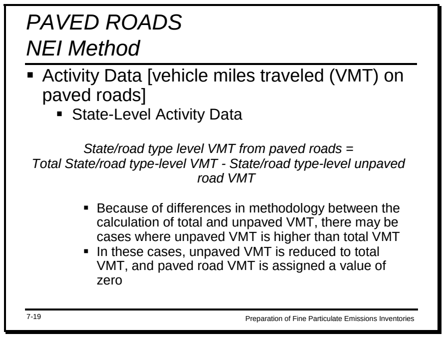
For example, wheat harvesting was assigned to another crop type, and then adjusted with a division factor. The adjusted factors were considered as the upper limit of emission factors for other crop types.

7 - 18



The SCC that is contained in the National Emissions Inventory for paved road emissions is 2294000000. For this category the NEI contains emission estimates for PM_{10} and $PM_{2.5}$.

7 - 19



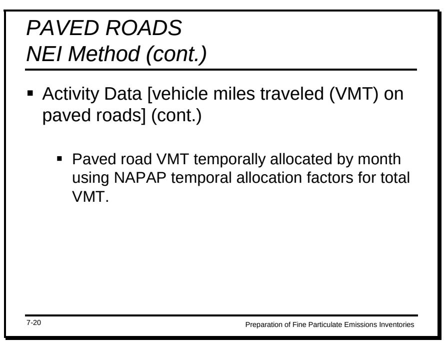
Vehicle miles traveled on paved roads are used as activity data for the NEI.

To estimate paved road VMT, subtract the state and road type-level unpaved road VMT from the total state road type-level VMT.

Because the Federal Highway Administration uses different methodologies to calculate unpaved road VMT and total road VMT, there are times (principally in western states) where the unpaved road VMT is higher than the total VMT.

When this occurs, the unpaved VMT is reduced to equal the total VMT, and the paved roads are assumed to be zero.

7 - 20



The NEI estimates monthly paved road VMT by applying temporal allocation factors to the annual paved road VMT estimate.

These factors were developed for the 1985 NAPAP study.

7 - 21

PAVED ROADS
NEI Method (cont.)

- Emission Factor
  - Empirical emission factor equation from AP-42

$$PAVED = PSDPVD * (PVSILT/2)^{0.65} * (WEIGHT/3)^{1.5} - C$$

where:

PAVED	=	paved road dust emission factor for all vehicle classes combined (grams per mile)
PSDPVD	=	constant for particles of less than 10 microns in diameter (7.3 g/mi for PM_{10})
PVSILT	=	road surface silt loading (g/m^2)
WEIGHT	=	average weight of all vehicle types combined (tons)
C	=	emission factor for 1980’s vehicle fleet exhaust, brake wear, and tire wear

7-21 Preparation of Fine Particulate Emissions Inventories

The December 2003 version of the emission factor equation in AP-42 only estimates PM emissions from resuspended road surface material.

PM emissions from vehicle exhaust, brake wear, and tire wear are estimated using EPA’s MOBILE6 model and are subtracted from the emission factor equation.

The formula shown here is used to calculate the paved road emission factor for all vehicle classes. The NEI used the pre-December 2003 version of the emission factor equation for estimating paved road emissions.

7 - 22

PAVED ROADS
NEI Method (cont.)

- Emission Factor (cont.)
  - Paved road silt loadings assigned to each of the twelve functional roadway classifications
    - Road types with average daily traffic volume (ADTV) < 5,000 vehicles per day = 0.20 g/m^2
    - Freeways = 0.015 g/m^2
  - See AP-42, Section 13.2.1 for more information
  - AP-42 emission factors for paved roads only apply to reentrained dust
  - Use MOBILE model for estimating PM from tailpipe exhaust, brake wear, and tire wear.

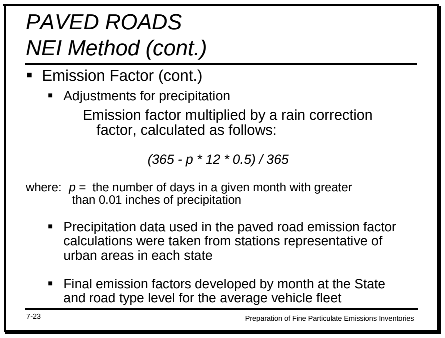
7-22 Preparation of Fine Particulate Emissions Inventories

The road surface silt loading varies according to the 12 functional roadway classifications contained in the NEI.

- For example, for road types with an average daily traffic volume of less than 5,000 vehicles per day the silt loading is 0.2 grams per square meter.
- For freeways, the silt loading is 0.015 grams per square meter.

See Ap-42, Chapter 13.2.1 for more information on determining appropriate silt loading factors.
Note that the AP-42 emission factors for paved roads now only apply to reentrained dust. EPA’s MOBILE model should be used to calculate PM emissions from tailpipe exhaust, brake wear, and tire wear.

7 - 23



Since the amount of fugitive dust emissions is related to the amount of rain, the NEI makes an adjustment for precipitation.

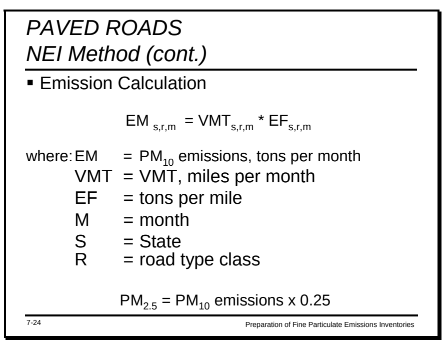
To adjust for precipitation:

- use the formula shown here to derive a rain correction factor
- multiply the emission factor by the rain correction factor

The precipitation data for the NEI was taken from one meteorological station representative of an urban area for each state.

By this method, the NEI developed emission factors on a monthly basis at the state and the road type level for the average vehicle fleet.

7 - 24



The formula used in the NEI to calculate PM_{10} emissions from paved roads from resuspended road surface material is shown.

PM emissions from vehicle exhaust, brake wear, and tire wear are estimated using EPA's MOBILE6 model.

$PM_{2.5}$ emissions are estimated by multiplying the PM_{10} emissions by a particle size multiplier of 0.25.

7 - 25

PAVED ROADS
NEI Method (cont.)

- Allocation of State Emissions to County Level
  - Paved road emissions are allocated to the county level according to the fraction of total State VMT in each county for the specific road type

$$PVDEMIS_{X,Y} = PVDEMIS_{ST,Y} * VMT_{X,Y}/VMT_{ST,Y}$$

where:
$PVDEMIS_{X,Y}$ = paved road PM emissions (tons) for county x and road type y
$PVDEMIS_{ST,Y}$ = paved road PM emissions (tons) for the entire State for road type y
$VMT_{X,Y}$ = total VMT (million miles) in county x and road type y
$VMT_{ST,Y}$ = total VMT (million miles) in entire State for road type y

7-25 Preparation of Fine Particulate Emissions Inventories

The equation for allocating the monthly paved road emissions at the state level to the county level is shown.

7 - 26

PAVED ROADS
NEI Method (cont.)

- Controls
  - Control efficiency of 79 percent applied to:
    - Urban and rural roads in serious PM NAAs; and
    - Urban roads in moderate PM NAAs
      - Corresponds to vacuum sweeping on paved roads twice per month
  - Rule penetration varies by road type and NAA classification (serious or moderate)

7-26 Preparation of Fine Particulate Emissions Inventories

The NEI methodology assumes that controls are only in place for urban and rural roads in serious PM non-attainment areas and for urban roads in moderate PM non-attainment areas.

A control efficiency of 79% is applied in these areas. This value corresponds to vacuum sweeping on paved roads twice per month. There is also an accounting of rule penetration that varies by road type and the non-attainment area classification.

7 - 27

PAVED ROADS
Improvements to NEI Method

- VMT on paved roads for local area

  (Source: State Dept. of Transportation, Mobile Source Section of Environmental Dept)

- Local registration data representing the average weight of vehicles (since this variable is weighted most heavily)

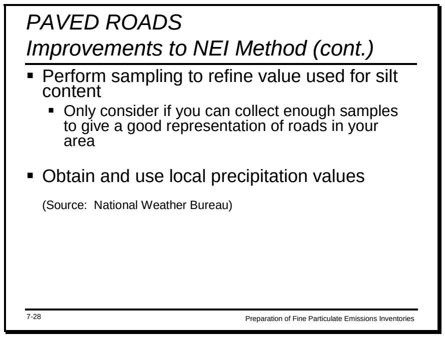
  (Source: State Dept. of Motor Vehicles, Mobile Source Section of Environmental Dept)

7-27 Preparation of Fine Particulate Emissions Inventories

One method to improve the NEI is to obtain VMT data for both paved and unpaved roads. This is preferable to the NEI approach of subtracting the unpaved road VMT from the total VMT.

Also, local registration data may be available that represents the average weight of the vehicles. This is preferable to the use of the NEI default value, particularly since this variable is weighted most heavily.

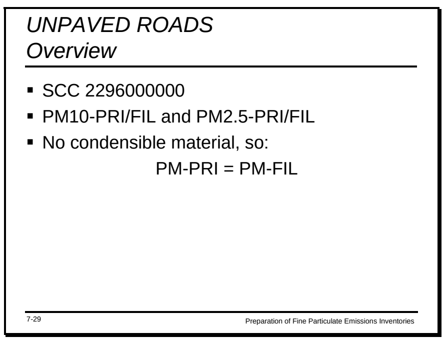
7 - 28



Also, you can perform sampling to refine the value used for silt content. However, this can be resource intensive and should only be used if enough samples can be collected to give a good representation of the roads in the inventory area.

Finally, using local precipitation data is an improvement over the NEI method.

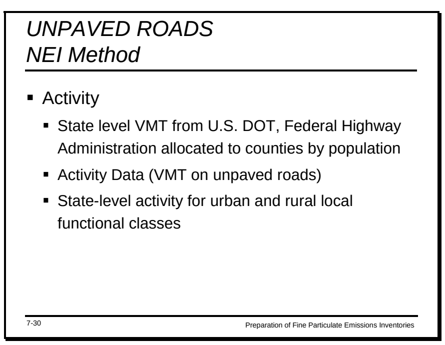
7 - 29



The SCC in the National Emissions Inventory for unpaved road emissions is 2296000000. For this category the NEI contains emission estimates for PM_{10} and $PM_{2.5}$.

There is no condensable material so the PM filterable is equivalent to PM primary.

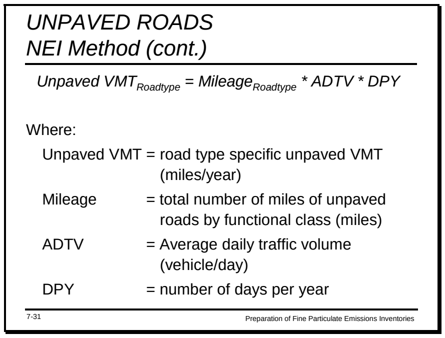
7 - 30



The activity data used by the NEI for unpaved roads is state level unpaved road VMT data that is available from the Federal Highway Administration. This data is allocated to counties by population.

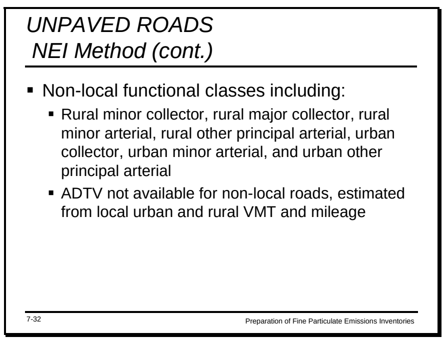
Because specific activity for the local classes is available, this calculation is done differently for urban and rural local functional classes (i.e., county maintained road types) than for the state and federally maintained roads.

7 - 31



The equation for calculating the vehicle mile traveled by road type is shown.

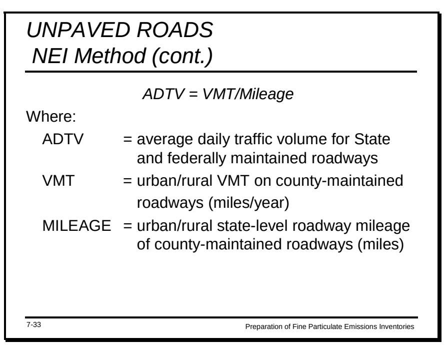
7 - 32



The non-local functional classes of roads tracked by the Federal Highway Administration include:

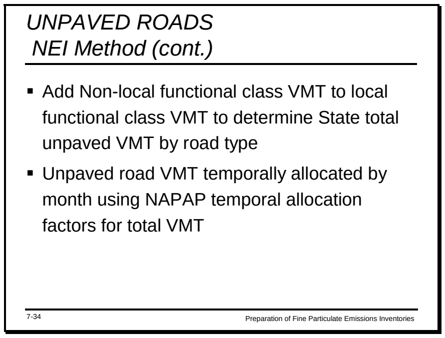
- rural minor collector
- rural major collector
- rural minor arterial
- rural other principal arterial
- urban collector
- urban minor arterial
- urban other principal arterial

7 - 33



Because there are no estimates of average daily traffic volume for the non-local roads, it is estimated from local urban and rural VMT and mileage data for the local roads using the equation shown.

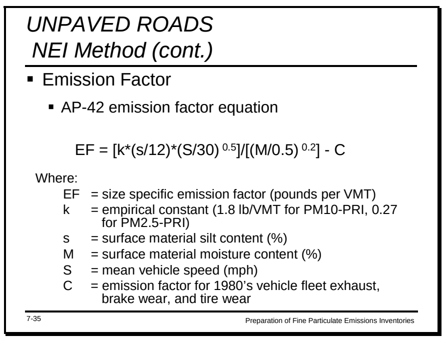
7 - 34



Calculate total state unpaved VMT by road type by adding the non-local functional class VMT to local functional class VMT.

The total state unpaved VMT is temporally allocated by month using NAPAP temporal allocation factors.

7 - 35



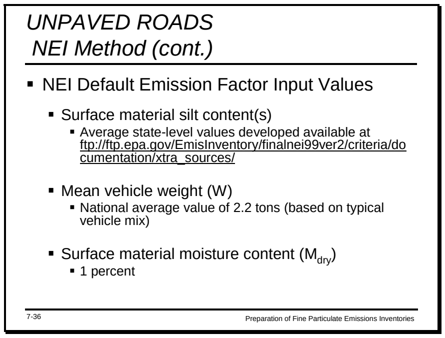
The unpaved road emission factor equation only estimates PM emissions from resuspended road surface material. This is similar to the AP-42 emission factor equation for paved roads.

PM emissions from vehicle exhaust, brake wear, and tire wear are estimated separately, using EPA's MOBILE6, and are subtracted out of the emission factor equation.

Note that the vehicle exhaust, brake wear, and tire wear component is relatively much less for unpaved roads than for paved roads.

The AP-42 empirical equation that is used to calculate the unpaved road emission factor is shown. It has some of the same variables as the paved road equation, but they are weighted differently. For example, there is more weight given to surface material silt content.

7 - 36

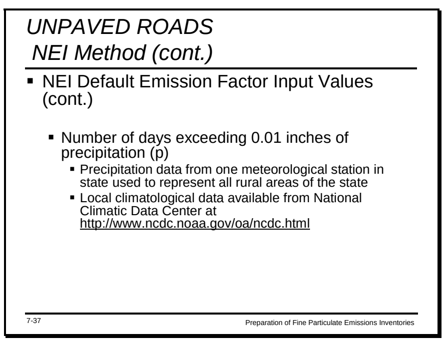


This slide summarizes the NEI default emission factor input values and the source of the values.

The web address for the surface materials silt content values links to a database for unpaved roads that provides the supporting documentation used. This includes a database of state level silt content.

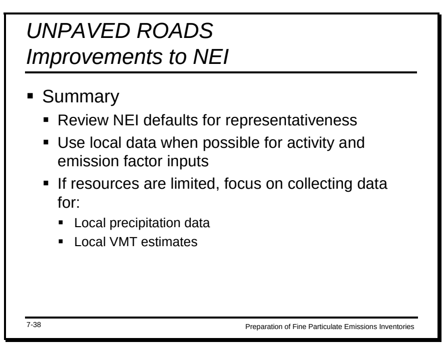
The calculation of unpaved road emissions in the NEI used the pre-December 2003 AP-42 emission factor equation. This equation considers mean vehicle weight.

7 - 37



Because unpaved road activity is expected to occur in rural areas, the precipitation data is obtained from one meteorological station that represents rural areas.

7 - 38

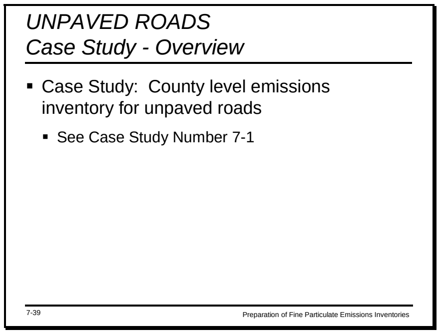


Short of developing independent estimates, the NEI defaults should be reviewed for representativeness.

Also, local data should be used when possible for the activity and emission factor.

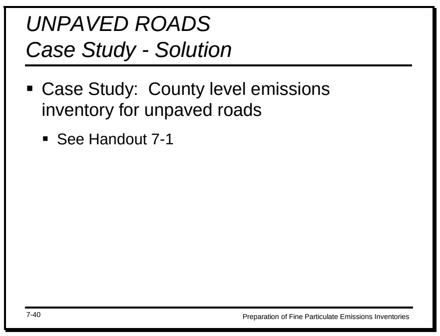
If resources are limited, the focus should be on collecting data that represents local precipitation as well as actual local VMT estimates.

7-39



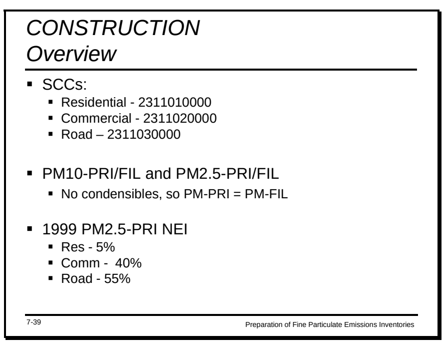
This hypothetical case study involves developing a local inventory using available county level inventory data and filling the data gaps with the NEI default data. Direct student to Case Study Number 7-1 and discuss it with the students.

7-40



Distribute the solutions (Handout 7-1) to the case study. Review each question with the students. Encourage discussion among the class. Ask each group to report on the questions that were assigned to them. Ask the other groups to critique their responses.

7 – 41



The SCCs contained in the National Emissions Inventory for the construction category are shown.

The NEI contains emission estimates for PM_{10} and $PM_{2.5}$ and there are no condensibles, so PM-PRI is equal to PM-FIL.

The relative contribution to the 1999 NEI of three different types of construction is also listed on this slide.

7 – 42

RESIDENTIAL CONSTRUCTION
NEI Method

- Activity Data: Number of acres disturbed per year
- Estimated using housing start data
  - Total no. of regional monthly housing unit starts (HS)
  - National monthly housing unit starts available for:
    - 1-unit housing
    - 2-unit housing
    - 3-4 unit housing
    - 5+ unit housing

7-40 Preparation of Fine Particulate Emissions Inventories

The NEI uses the number of acres disturbed per year as the activity data for residential construction.

Since direct estimates are generally unavailable, the value for this activity is estimated through the use of housing start data that is available from the Bureau of the Census. These data are available as regional monthly housing unit start values.

Data for housing unit starts for various housing classifications are also available at a national level. These classifications include 1-unit houses, 2-unit houses, 3-4 unit houses, and 5+ unit housing.

7 – 43

RESIDENTIAL CONSTRUCTION
NEI Method (cont.)

- Regional housing unit starts by housing category estimated as follows:

$$\text{Reg. HS by Category} = \text{Total Reg. HS} \times \frac{\text{National HS by Category}}{\text{Total National HS}}$$

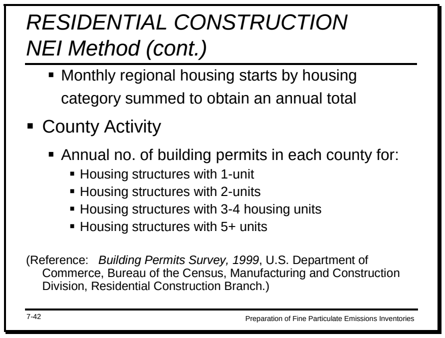
(Reference: *Housing Starts Report, 1999*, U.S. Department of Commerce, Bureau of the Census, Manufacturing and Construction Division, Residential Construction Branch.)

7-41 Preparation of Fine Particulate Emissions Inventories

Housing classifications are important because there are different numbers of acres disturbed for each type of housing.

The regional housing unit starts for each of these categories is estimated using the fraction available at a national level, as shown in the equation.

7 - 44

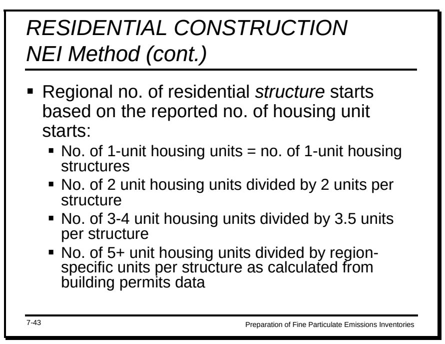


Regional housing starts are provided on a monthly basis, so they are summed to obtain an annual total.

The next step is to allocate these regional housing starts data to the county level. This is done by using data on the annual number of building permits in each county for each housing unit classification.

Note that the building permit data should not be used to estimate housing starts but only to allocate housing starts to the county. At times, a building permit is issued but the dwelling is never constructed. Consequently, the housing start data is a more accurate estimate of what is really being constructed.

7 - 45

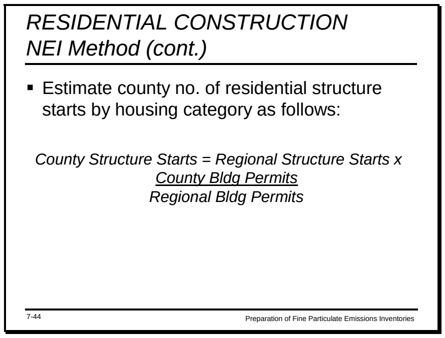


The regional housing start data actually represents the number of units that were started. However, the number of structures is a better activity indicator of the number of acres that are disturbed.

For example, the activity data for an apartment building with multiple units should reflect the structure as a whole (i.e., the number of acres disturbed in the building of the structure and not for each unit).

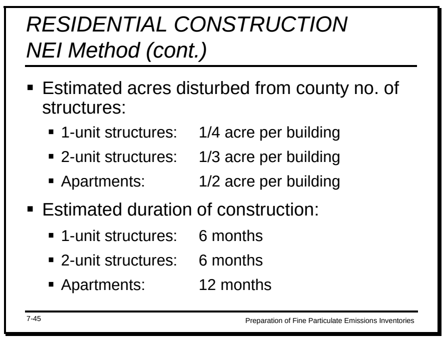
The information here shows the correlation between residential structure starts and housing unit starts.

7 - 46



The equation shown is used to estimate the number of county residential housing structure starts based on the regional number of structure starts.

7 - 47

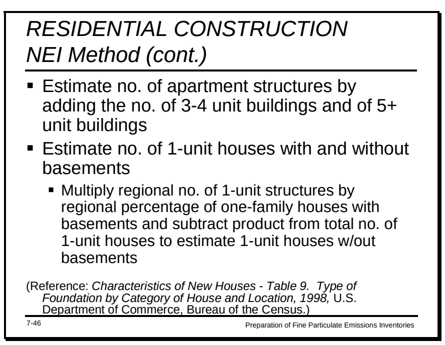


The number of acres disturbed and the duration of the construction activity vary depending on the size and type of the structure.

The assumed values for both acres disturbed and duration are listed here.

The basis for these assumptions can be found in *Estimating Particulate Emissions from Construction Operation*, 1999.

7 - 48



The number of apartment structures is estimated by adding the number of 3-4 unit buildings and the number of 5+ unit buildings.

Also, the number of 1-unit houses should be estimated separately for houses with a basement and those without a basement. This is because building a house with a basement requires the removal of additional dirt. This must be taken into account in the emission factor equation.

The number of 1-unit houses without basements is estimated by multiplying the regional number of 1-unit structures by the regional percentage of one-family houses with basements and subtracting the product from the total number of 1-unit houses.

7 - 49

RESIDENTIAL CONSTRUCTION
NEI Method (cont.)

- For 1-Unit Housing with Basements
  - Estimate cubic yards of dirt moved per house
    - Multiply assumed 2,000 square feet per structure by assumed average basement depth of 8 feet
    - Add-in 10 percent of above cubic yard estimate to account for footings and other backfilled areas adjacent to basement

7-47 Preparation of Fine Particulate Emissions Inventories

Estimate the amount of dirt moved for 1-unit houses with basements by multiplying the assumed average basement depth of 8 feet by the assumed value of 2,000 square feet of dirt moved per structure.

Add 10 percent to this value to account for footings and other back-filled areas adjacent to the basement.

7 - 50

RESIDENTIAL CONSTRUCTION
NEI Method (cont.)

- 1-Unit Housing with Basements
  - PM10-PRI: 0.011 tons/acre/month plus 0.059 tons/1000 cubic yards of on-site cut/fill
- 1-Unit Housing without Basements and all 2-Unit Housing
  - PM10-PRI: 0.032 tons/acre/month
- Apartments
  - PM10-PRI: 0.11 tons/acre/month
- PM2.5-PRI = 0.2 * PM10-PRI

7-48 Preparation of Fine Particulate Emissions Inventories

The emission factor data that the NEI uses to estimate the emissions on an acre-per-month basis is shown. Also, $PM_{2.5}$ is assumed to be 20% of PM_{10}.

7 - 51

RESIDENTIAL CONSTRUCTION
NEI Method (cont.)

- 1-Unit Structures with Basements

$$Emissions = (0.011 \text{ tons } PM_{10}/\text{acre/month}) \times B \times f \times m) + 0.059 \text{ tons } PM_{10}/1000 \text{ yards}^3 \text{ of cut/fill})$$

where: B = no. of housing starts with basements;
f = buildings-to-acres conversion factor (1/4 acre per building);
m = duration of construction activity in months.

7-49 Preparation of Fine Particulate Emissions Inventories

The equation that NEI uses to estimate PM_{10} emissions from 1-unit residential structures with basements is shown.

7 - 52

RESIDENTIAL CONSTRUCTION
NEI Method (cont.)

- 1-Unit Structures without Basements, All 2 Structures, and Apartments

Emissions = (0.032 tons PM_{10}/acre/month) x B x f x m)

where: *B* = no. of housing starts without basements;
f = buildings-to-acres conversion factor; and
m = duration of construction activity in months

7-50 Preparation of Fine Particulate Emissions Inventories

Use this equation for one-unit structures without basements, as well as all two-unit structures.

The same equation is used for apartments with the exception that the emission factor of 0.11 tons/acre/month is used instead of the 0.032 tons/acre/month value.

7 - 53

RESIDENTIAL CONSTRUCTION
NEI Method (cont.)

- Apply a control efficiency of 50 percent for both PM10-PRI and PM25-PRI emissions for PM-10 NAAs; all other areas 0 percent
- Control efficiency represents Best Available Control Method (BACM) controls on fugitive dust construction activities in these counties

7-51 Preparation of Fine Particulate Emissions Inventories

Controls in PM_{10} non-attainment areas are taken into account by applying a control efficiency of 50% for both PM_{10} and $PM_{2.5}$ emissions for all PM_{10} nonattainment areas. There is no adjustment made for attainment areas.

The 50% value represents best available control methods on fugitive dust construction activities in the nonattainment counties.

7 - 54

RESIDENTIAL CONSTRUCTION
NEI Correction Parameters

- Applied to final emissions for all 3 construction categories
- Soil Moisture Level

Moisture Level Corrected Emissions = Base Emissions x (24/PE)

where: PE = Precipitation-Evaporation value for county

- Compiled statewide average Precipitation-Evaporation (PE) values according to Thornthwaite's PE Index

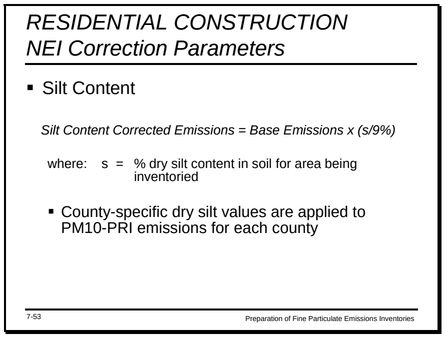
7-52 Preparation of Fine Particulate Emissions Inventories

Additional adjustments for soil moisture content and silt content are applied to the emission estimates for all three construction categories.

Emissions are adjusted for soil moisture content by using average Precipitation Evaporation values according to Thornthwaite's Precipitation Evaporation Index.

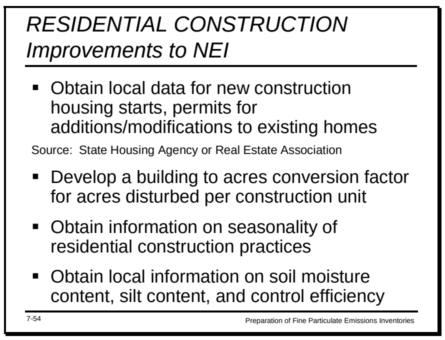
The formula used to make this adjustment is shown. It accounts for precipitation and humidity in a certain area. As shown in the equation, the higher the PE the smaller the adjustment.

7 - 55



Emissions are adjusted for the dry silt content in the soil of the area being inventoried by using the formula shown here.

7 - 56

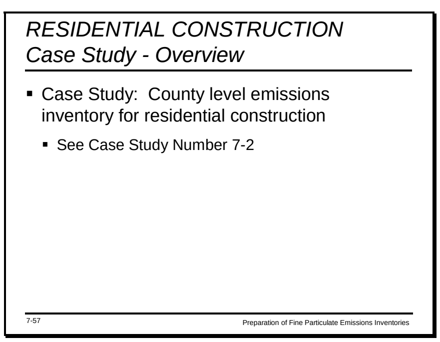


Obtaining local data for new housing starts, or permits for additions or modifications to existing homes would be an improvement over the use of the NEI defaults.

Another improvement is to develop a buildings-to-acres conversion factor for acres disturbed per construction unit. Obtaining data on the seasonality of residential construction practices is a third alternative.

Finally, obtaining local information on soil moisture content, silt content, and control efficiencies would improve the NEI default values.

7 - 57



This case study demonstrates the approach for developing an inventory for residential construction at the county level in a PM nonattainment area.
Direct student to Case Study Number 7-2 and discuss it with the students.

7 - 58

RESIDENTIAL CONSTRUCTION
Case Study - Solution

- Case Study: County level emissions inventory for residential construction
  - See Handout 7-2

7-58 Preparation of Fine Particulate Emissions Inventories

Distribute the solutions (Handout 7-2) to the case study. Review each question with the students. Encourage discussion among the class. Ask each group to report on the questions that were assigned to them. Ask the other groups to critique their responses.

7 - 59

COMMERCIAL CONSTRUCTION
NEI Method

- Activity data: No. of acres disturbed per year
- National-Level Activity
  - Dollar Value of Construction Put in Place, 1999
  - National data allocated to Counties

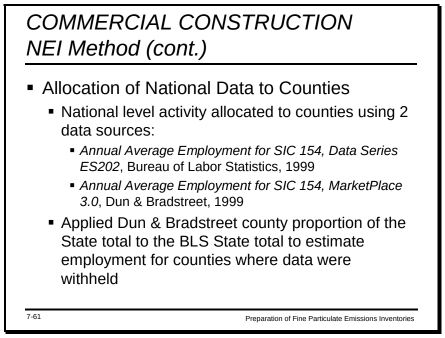
(Reference: *Table 1. Annual Value of Construction Put in Place in the United States for Nonresidential buildings: 1996 - 2000*, Millions of constant dollars, U.S. Department of Commerce, Bureau of the Census.)

7-60 Preparation of Fine Particulate Emissions Inventories

Similar to the residential construction category, the NEI uses the number of acres disturbed each year to represent fugitive dust emissions from commercial construction.

The NEI developed a top-down inventory by using national level activity data on the dollar value of commercial construction. These data were then allocated to the county level.

7 – 60

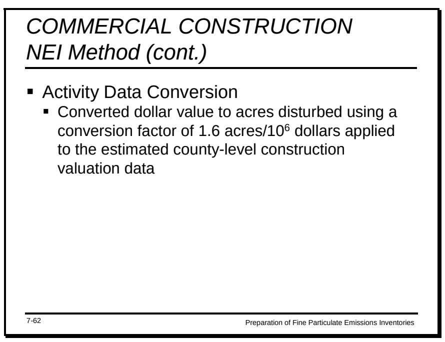


The allocation of the national level expenditure data was performed by using the two data sources shown here.

The Dunn & Bradstreet database was used to fill in the gaps for data missing from the first database.

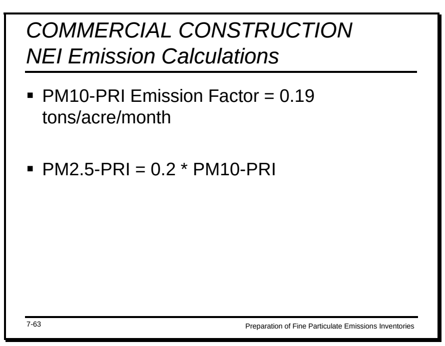
Specifically, the county proportion of the state total from the Dunn & Bradstreet database was applied to the state total from the BLS database to estimate employment for counties where data were missing.

7 - 61



The dollar value activity data were converted to acres disturbed using a conversion factor of 1.6 acres/10^6 dollars. This conversion factor was applied to the estimated county-level construction valuation data.

7 - 62



The PM10-PRI emission factor for commercial construction is 0.19 tons per acre month. The $PM_{2.5}$ is assumed to be 20% of the PM_{10}.

7 – 63

COMMERCIAL CONSTRUCTION
NEI Emission Calculations (cont.)

- Emission formula for calculating the emissions is:

*Emissions = (*0.19 *tons/acre/month) x $ x f x m*

where: $ = dollars spent on nonresidential construction in millions
f = dollars-to-acres conversion factor
m = duration of construction activity in months (assumed 11 months)

7-64 Preparation of Fine Particulate Emissions Inventories

The emission formula used in the NEI to calculate the PM emissions from commercial construction is shown.

The calculated emissions are adjusted to reflect control measures that are in place in PM_{10} non-attainment areas.

In addition to accounting for the control measures, adjustments are applied for soil moisture content and silt content.

7 - 64

COMMERCIAL CONSTRUCTION
Improvements to NEI

- Obtain local information on number of acres disturbed per construction event or per construction dollars spent

Source: Construction Industry Association

- Obtain information on location, average duration, and seasonality of commercial construction practices
- Obtain local information on soil moisture content, silt content, and control efficiency

7-65 Preparation of Fine Particulate Emissions Inventories

The NEI results can be improved by obtaining local information on the number of acres disturbed per construction event or per construction dollar spent.

Also information on location, average duration, and seasonality of commercial construction practices would be an improvement over the NEI default values.

Finally, local information on soil moisture content, silt content, and control efficiency would result in improved emission estimates.

7 – 65

ROAD CONSTRUCTION
NEI Method

- Activity data: Number of acres disturbed
- State-Level Activity
  - Obtained State expenditure data for capital outlay for six classifications
    - Interstate, urban
    - Interstate, rural
    - Other arterial, urban
    - Other arterial, rural
    - Collectors, urban
    - Collectors, rural

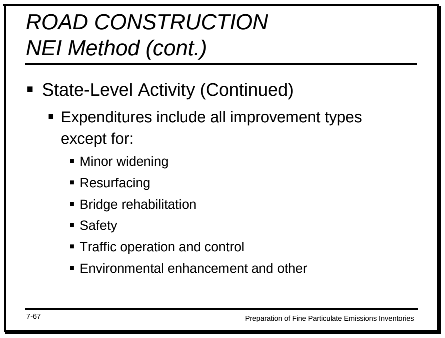
(Reference: Highway Statistics, Section IV - Finance, Table SF-12A, "State Highway Agency Capital Outlay - 1999." Federal Highway Administration.)

7-66 Preparation of Fine Particulate Emissions Inventories

The NEI uses the number of acres disturbed as the activity data indicator for road construction.

State level expenditure data for capital outlay for the six road construction classifications listed are available.

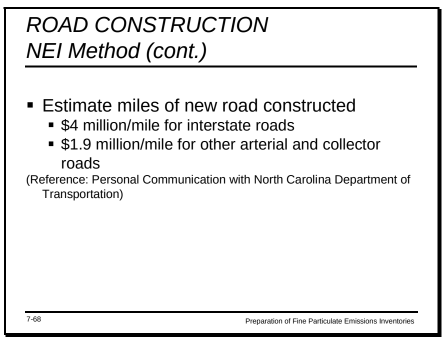
7 – 66



Because some of the activities included in the total state level expenditure data do not contribute to PM emissions, the expenditures for these activities have been removed.

These activities include minor widening, resurfacing, bridge rehabilitation, safety, traffic operation and control, and environmental enhancement and other.

7 - 67

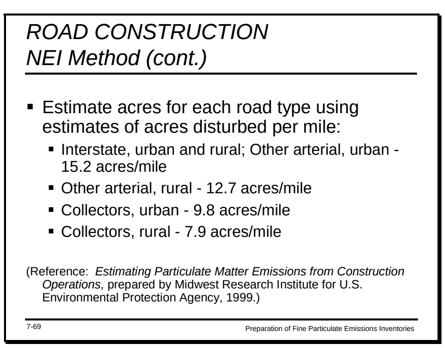


To obtain the activity data in terms of acres disturbed, it was necessary to first convert the expenditure data to mileage and then to acreage.

The NEI estimated the miles of new road constructed by applying conversion factors of $4 million dollars per mile of interstate, and $1.9 million dollars per mile for other arterial and collector roads.

These conversion factors were based on information obtained from the North Carolina Department of Transportation.

7 – 68



The NEI then applied the conversion factors listed on this slide to convert to acres disturbed per mile of road activity level.

7 - 69

ROAD CONSTRUCTION
NEI Method (cont.)

- Sum across road types to yield state total of acres disturbed
- Activity Data Allocation to Counties
  - Distributed state-level estimates of acres disturbed to counties according to housing starts
    - see residential construction for description of development of county-level housing start data

7-70 Preparation of Fine Particulate Emissions Inventories

The estimated acres disturbed are summed across all road types to estimate the total acres disturbed.

The NEI allocates these state-level estimates to the county-level by using housing start data. These are the same data that were developed for the residential construction category. The assumption is that new road development is directly proportional to new housing starts.

7 - 70

ROAD CONSTRUCTION
NEI Emission Calculations

- PM10-PRI Emission Factor = 0.42 tons/acre/month
- PM2.5-PRI = 0.2 * PM10-PRI

7-71 Preparation of Fine Particulate Emissions Inventories

The PM10-PRI emission factor for road construction is 0.42 tons per acre month. The $PM_{2.5}$ is assumed to be 20% of the PM_{10}.

7 - 71

ROAD CONSTRUCTION
NEI Emission Calculations (cont.)

- The formula for calculating emissions is:

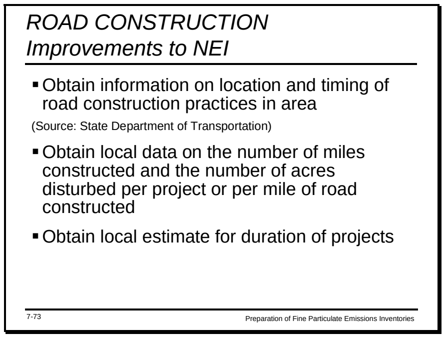
Emissions = (0.42 tons PM10/acre/month) x $ x f1 x f2 x d

where: $ = State expenditures for capital outlay on road construction
f1 = $-to-miles conversion factor
f2 = miles-to-acres conversion factor
d = duration of roadway construction activity in months (assumed 12 months)

7-72 Preparation of Fine Particulate Emissions Inventories

The NEI uses the emission formula shown to calculate the PM emissions from road construction.

7 - 72

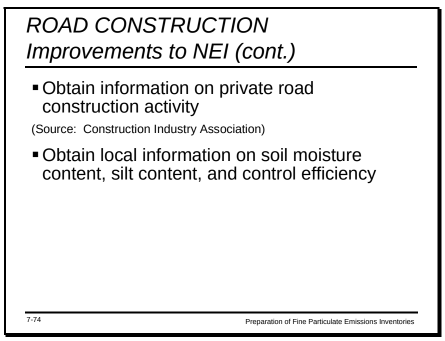


Obtaining information on location and timing of road construction practices in the area is one way to improve NEI results.

Also, obtaining local data on the number of miles constructed and the number of acres disturbed per project or mile of road constructed is better than using the NEI default values based on expenditure data.

Using local data on the duration of the projects would also improve the NEI.

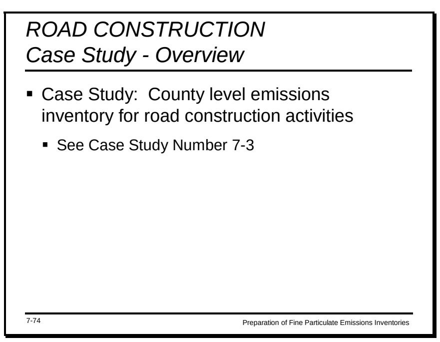
7 - 73



Information on private road construction activity (not included in the NEI) would also serve to improve the NEI.

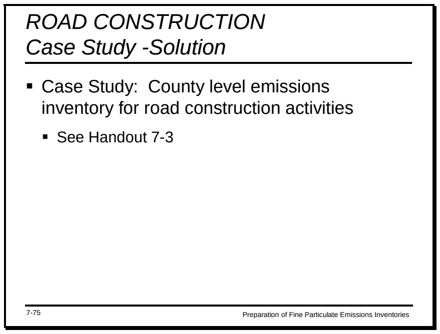
Obtaining information for making adjustments for soil moisture content, silt content, and control efficiency also improve NEI default values.

7 - 74



This hypothetical case study involves developing a local inventory using available county level inventory data and filling the data gaps with the NEI default data. Direct student to Case Study Number 7-3 and discuss it with the students.

7 - 75



Distribute the solutions (Handout 7-3) to the case study. Review each question with the students. Encourage discussion among the class. Ask each group to report on the questions that were assigned to them. Ask the other groups to critique their responses.

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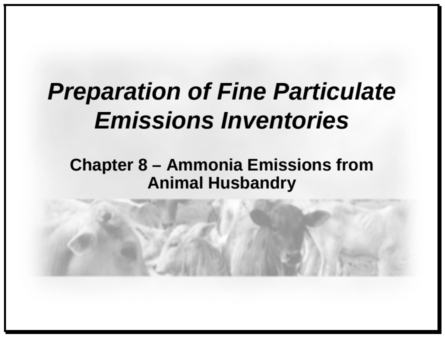
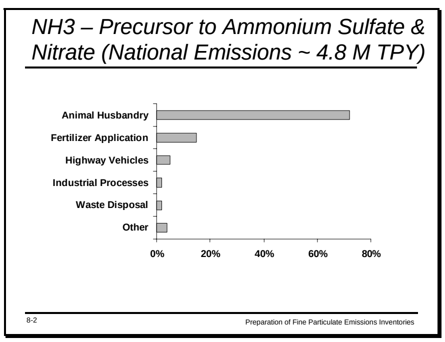
Chapter 8 – Ammonia Emissions from Animal Husbandry

8 - 1



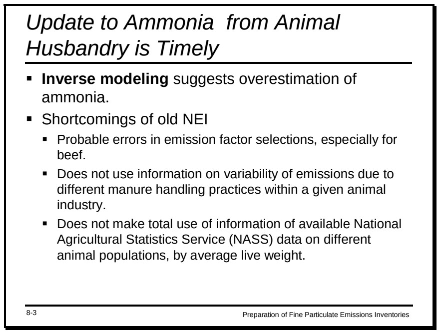
This lesson presents the issues associated with estimating ammonia emissions from animal husbandry operations and some of the efforts that are being undertaken to address these issues.

8 - 2



Almost 5 million tons a year of ammonia are emitted nationally. As the graph demonstrates, animal husbandry is the source of the majority of ammonia emissions nationally.

8 - 3



It is important to address ammonia emissions from animal husbandry because inverse modeling suggests that ammonia emissions may be overestimated.

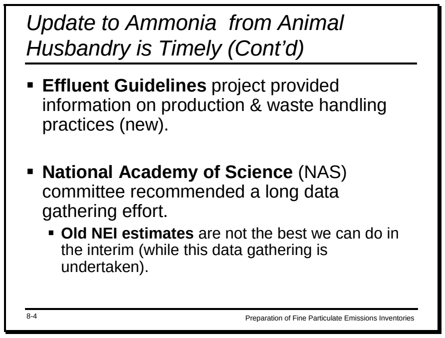
Inverse modeling:

- involves doing a complete chemical transformation and transport modeling of an area
- requires accounting for all of the ammonia through transformation and deposition processes.
- results indicate that ammonia may be overestimated nationally when compared to ammonia in the ambient air

Some problems associated with the old NEI:

- probable errors in the emission factor selections, especially for beef.
- does not use information on variability of emissions due to different manure handling practices within a given animal industry
- does not make total use of the National Agricultural Statistic Service data on different animal populations by weight
- does not take temperature into account, which would greatly increase the temporal variation in ammonia emissions.

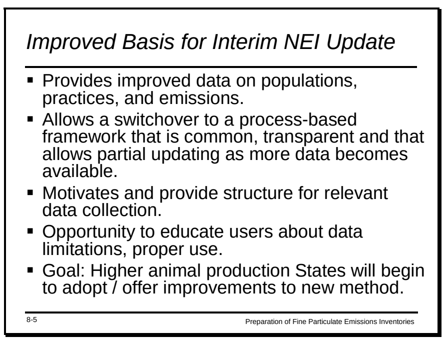
8 - 4



In addition, EPA's water emission effluent guidelines project has provided some new information on animal production and waste handling practices.

Also, the National Academy of Sciences, at the behest of the agricultural community, has reviewed EPA's inventory work, and recommended a long-term data-gathering effort.

8 - 5



A recent EPA report provides a basis for making interim improvements to the NEI through improved data on populations, practices, and emissions.

It is the beginning of a switch-over to a process-based framework that is a consistent and transparent way of estimating emissions.

Advantages:
- will allow for partial updating as better data become available
- provides motivation and a structure for making data-collection improvements
- provides an opportunity to educate users about data limitations and the proper use of the data.

The goal is for the higher animal production states to begin to adopt and offer improvements to the NEI using this new method.

8 - 6

Overview of New Estimation Methodology

- Step 1: Estimate average annual animal populations by animal group, state, and county.
- Step 2: Identify Manure Management Trains (MMT) used by each animal group and then estimate the distribution of the animal population using each MMT.
- Step 3: Estimate the amount of nitrogen excreted from the animals using each type of MMT, using general manure characteristics.

8-6 Preparation of Fine Particulate Emissions Inventories

Let’s review the six steps that comprise this new methodology for estimating ammonia emissions from animal husbandry operations.

8 - 7

Overview of New Estimation Methodology (Cont’d)

- Step 4: Identify or develop emission factors for each component of each MMT.
- Step 5: Estimate ammonia emissions from each animal group by MMT and county for 2002.
- Step 6: Estimate future ammonia emissions for years 2010, 2015, 2020, and 2030.

8-7 Preparation of Fine Particulate Emissions Inventories

8 - 8

Step 1: Population Estimates

- Animals: Dairy, beef, swine, and poultry.
  - Keep weight groups & animal types distinct.
- State-level population: 2002 NASS.
- County apportionment: using 1997 Census of Agriculture.
  - Privacy Issue - Where state and/or county is not disclosed, divide equally.

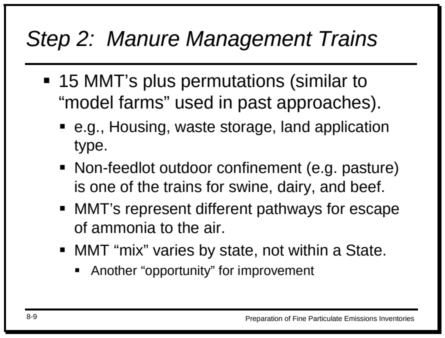
8-8 Preparation of Fine Particulate Emissions Inventories

The first step in this process is estimating average animal populations by animal group, state, and county.

This step uses 2002 NASS data for state-level populations, and the 1997 census of agricultural to apportion the state-level NASS data to the county level. However, there are some privacy issues with regard to animal populations.

For example, a county with only one large facility would create an industrial privacy issue since that facility will not want their competition to know how many animals they are raising.

8 - 9



The second step is using Manure Management Trains (MMTs) for each animal group to estimate the distribution of the animal population.

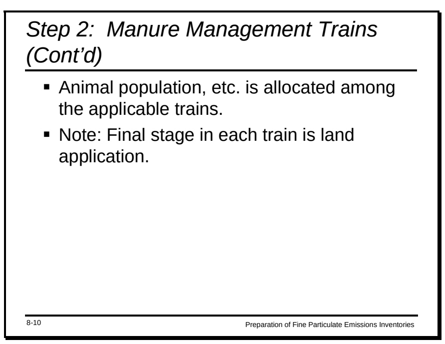
Fifteen MMTs have been identified.
Some of the variables that affect the different trains include:

- the way animals are housed,
- waste storage methods, and
- the land application methods that are used.

For example, the non-feedlot outdoor confinement is one of the trains for swine, dairy, and beef. The MMTs represent different pathways for the escape of ammonia into the air.

In applying the MMT approach to estimate the 2002 ammonia inventory, the mix of MMTs is assumed to vary by state, but not within a state.

8 - 10

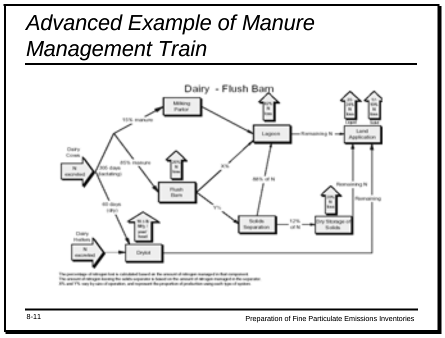


Animal population is allocated among the applicable trains.

For example, in a given state 20% of the hogs may be handled using manure management train 3, another 60% may be using manure management train 7, and the rest of them may be using manure management train 14.

Finally, it should be noted that the final stage on every train is land application.

8 - 11



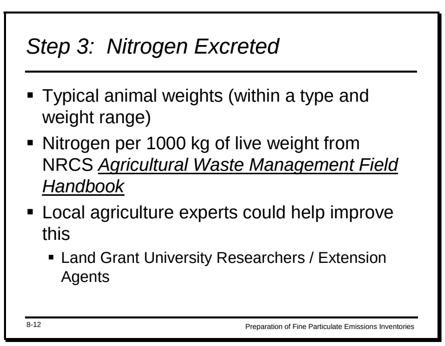
This graphic illustrates an advanced MMT, one of several such trains for the dairy industry.

This MMT begins with the amount of nitrogen excreted by dairy cows.

The train traces the manure through the different handling options and shows how much is handled in different ways. The train also shows the nitrogen and ammonia emissions at the various handling points.

For example, there is nitrogen loss in the flush barn and the lagoon, and ammonia loss in the dry lot. There are other trains that provide similar information for other farm industries. These trains characterize a type of industry, and the general way that manure would be handled in a facility.

8 - 12



The third step involves using each type of MMT to estimate the amount of nitrogen excreted from the animals.

This step involves examining typical animal weights and data on the amount of nitrogen per thousand kilos of live weight. The data on the nitrogen amounts can be obtained from NRCS *Agricultural Waste Management Field Handbook*.

Another useful source of information is land grant university researchers and local agricultural extension agents. It is important to include experts in the agricultural industry in the inventory development efforts.

8 - 13

Step 4: Emission Factors

- Select the emission factor for each stage of each manure management train.
  - Some are lb/animal, some are percent air release of input ammonia.
  - Both kinds also determine ammonia transferred to next stage.
- Air emissions can never be higher than original manure content.
- Using stage-specific emission factors sets the stage for applying temporal profiles and process-related variability later.

8-13 Preparation of Fine Particulate Emissions Inventories

Step four involves identifying or developing the emission factors for each component of each MMT. Some of these factors are in pounds per animal, and some are percent air release of the input ammonia.

These factors are used to determine the amount of ammonia that goes to the next stage of the manure train process.

Under this approach, the air emissions could never be higher than the original manure content. Also, using this approach sets the stage for applying temporal profiles and process-related variables such as moisture and rainfall.

8 - 14

Step 5: Apply for 2002

- Track ammonia release through each manure management train for each animal type, calculating air releases and transfers to next stage.
- Assumes no air emission controls at this time.
  - But can add control assumptions later, and see downstream consequences.
- Emissions are summed up to animal type and county
- Database is preserved with full detail for transparency and later revisions.

8-14 Preparation of Fine Particulate Emissions Inventories

The next step involves applying this methodology to estimate annual ammonia emissions from each animal group by MMT.

This includes:

- tracking the ammonia release through each MMT for each animal type and county, and
- calculating ammonia releases to the air and transfers to the next stage.

This whole process assumes no air emission controls at this time, but control assumptions could be added later. Emissions are summed up to animal type and county, but the database is preserved with full detail for transparency so that changes and improvements can be made.

8 - 15

Step 6: Future Years Projections

- 2010, 2013, 2020, and 2030.
- USDA and Food and Agricultural Policy Research Institute.
- Accounts for past observed cyclical populations.
- State-by-state population pattern.
  - Changes with time for dairy.
  - Fixed for others.

8-15 Preparation of Fine Particulate Emissions Inventories

The last step involves estimating ammonia emissions for future years.

8 - 16

Comparison of 1999 and 2002 Ammonia NEIs

Animal Group0	1999 NEI			2002 NEI		
	Population	**Emission Factor lb/head /yr**	**Emissions Tons/year**	**Population**	**Emission Factor lb/head /yr**	**Emissions Tons/year**
Cattle and Calves Composite	100,126,106	50.5	2,476,333	100,939,728	23.90	1,205,493
Hogs and Pigs Composite	63,095,955	20.3	640,100	59,978,850	14.32	429,468
Poultry and Chickens Composite	1,754,482,225	0.394	345,325	2,201,945,253	0.60	664,238
Total	1,917,704,286	N/A	**3,461,758**	2,362,863,831	N/A	**2,299,199**

8-16 Preparation of Fine Particulate Emissions Inventories

A comparison of the 1999 NEI version 3 with the 2002 NEI version 1 shows significant differences in the ammonia emissions.

As shown on this chart, about half of the emissions from all animals come from calves and cattle.

Also, total ammonia emissions from animal husbandry operations decreased significantly from 3.4 million in 1999 to 2.3 million in 2002.

8 - 17

Ongoing Additional Improvements

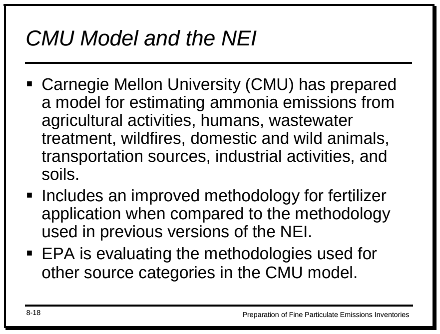
- Plan to incorporate emission estimates for sheep, ducks, goats, and horses.
- Looking at more recent manure production and excretion rates by animal types and weight (may provide lower overall estimates than currently indicated in draft report).
- Looking into ways to better address spatial, seasonal, and regional differences in emissions.

8-17 Preparation of Fine Particulate Emissions Inventories

Other improvements that are being made to the NEI for animal husbandry operations:

- incorporating emission estimates for sheep, ducks, goats, and horses
- examining additional data sources to provide recently data on manure production and excretion rates by animal type and weight.
- examining ways to better address special, seasonal, and regional differences in emissions

8 - 18



Carnegie Mellon University has prepared a model for estimating ammonia emissions from agricultural activities, humans, wastewater treatment, wildfires, domestic and wild animals, transportation sources, industrial activities, and soils.

The Carnegie Mellon model includes an improved methodology for fertilizer application when compared to the methodology used in previous versions of the NEI.

EPA is evaluating the methodologies used for other source categories in the Carnegie Mellon model.

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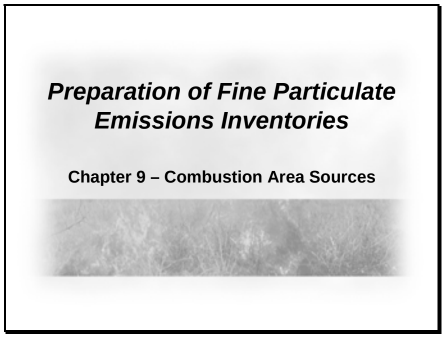
Chapter 9 – Combustion Area Sources

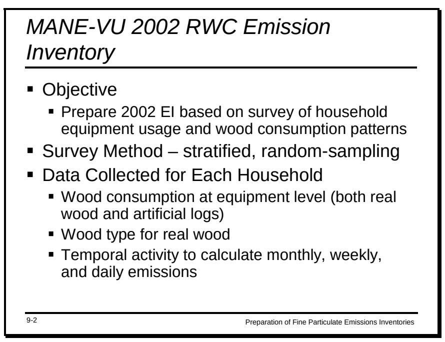
9 - 1



After this lesson, participants will be able to:

- Describe the methodologies for calculating emissions from residential wood combustion, residential and land clearing debris burning, agricultural field burning, and wildland fires.

9 - 2



The MANE-VU View Regional Planning Organization conducted a residential wood combustion survey to develop an emissions inventory for the year 2002.

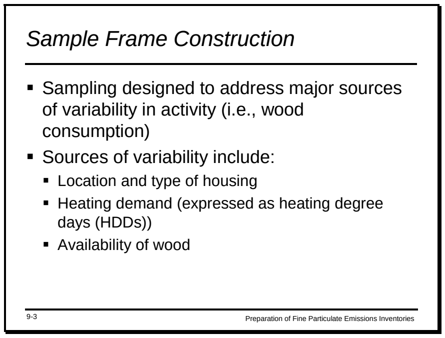
A survey is the EIIP preferred method for this category.

The objective of the MANE-VU project is to prepare a 2002 inventory based on a survey of household equipment usage and wood consumption patterns, using a stratified random sampling approach.

The data collected for each household consists of:

- wood consumption at the equipment level for both real wood and artificial logs;
- the type of real wood; and
- the temporal activity to calculate monthly, weekly, and daily emissions.

9 - 3

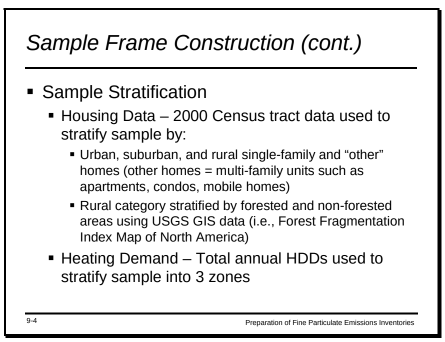


The sampling was designed to address major sources of variability in wood consumption activity.

These sources include:

- the location and type of housing;
- the heating demand expressed as heating degree days; and
- the availability of wood.

9 - 4



Housing data from the 2000 census covers four categories:

- urban
- Suburban
- rural single family
- stratified into forested versus non-forested areas using USGS-GIS data.
- other homes
- includes multi-family units:
- Apartments
- condominiums
- mobile homes

Total annual heating degree days were used to further stratify the sample into three zones:

- low,
- medium and
- high.

9 - 5

Sample Frame

	Rural-Forested		Rural-Non-Forested		Suburban		Urban	
Geographic Zone	Single-Family	Other	Single-Family	Other	Single-Family	Other	Single-Family	Other
High HDD	Cell 1 61 (173)	Cell 2 61 (64)	Cell 3 61 (87)	Cell 4 61 (66)	Cell 5 61 (61)	Cell 6 61 (72)	Cell 7 61 (69)	Cell 8 61 (69)
Low HDD	Cell 9 61 (150)	Cell 10 61 (62)	Cell 11 61 (118)	Cell 12 61 (69)	Cell 13 61 (76)	Cell 14 61 (67)	Cell 15 61 (75)	Cell 16 61 (62)
Med HDD	Cell 17 61 (87)	Cell 18 61 (60)	Cell 19 61 (91)	Cell 20 61 (64)	Cell 21 61 (71)	Cell 22 61 (60)	Cell 23 61 (63)	Cell 24 61 (68)

9-5 Preparation of Fine Particulate Emissions Inventories

This slide shows a sample frame shown in a grid.

61 is the minimum sample size determined based on calculations for the precision desired from the survey

The numbers in parentheses represent the number of surveys that were actually collected or completed.

Surveys for which the respondents did not categorize correctly were removed from the sample.

9 - 6

Survey Instrument

- Questionnaire developed to gather activity data for:
  - Indoor equipment (fireplaces, woodstoves, pellet stoves, furnaces, and boilers)
  - Outdoor equipment (fire pits, barbeques, fireplaces, and chimineas)
- Pilot survey performed to test the instrument
- Survey conducted using computer-assisted telephone interviewing
  - Completed 1,904 surveys across all 24 cells

9-6 Preparation of Fine Particulate Emissions Inventories

The survey instrument is a questionnaire developed to gather the activity data on indoor equipment and outdoor equipment.

A pilot survey was conducted to test the questionnaire.

Questions were rephrased in order to collect the information that was needed to characterize the activity.

The final survey was conducted using computer-assisted telephone interviewing.

Completed over 1,900 surveys across all 24 cells

9 - 7

Survey Data Reduction/Analysis

- QA reviewed each survey
- Calculated/summarized for each cell:
  - User fraction (fraction of total household population that burns wood in indoor and outdoor equipment)
  - Annual activity (cords of wood by equipment and wood types)
  - Temporal data
- Conducted statistical analyses to identify significant differences between cells for:
  - User fraction
  - Annual Activity

9-7 Preparation of Fine Particulate Emissions Inventories

Surveys were quality assured to make sure that the data collected made sense.

Cell summaries included:

- the user fraction,
- the annual activity, and
- temporal data.

Statistical analyses identified significant differences between cells:

- the user fraction
- annual activity

9 - 8

Indoor Wood-Burning Equipment Preliminary Survey Results (% Burners)

Geographic Zone	Rural-Forested		Rural-Non-Forested		Suburban		Urban	
	Single-Family	Other	Single-Family	Other	Single-Family	Other	Single-Family	Other
High HDD	Cell 1 FP= 34 WS= 67 F/B= 21 PS= ***4***	Cell 2 FP= 75 WS= 75 F/B= 0 PS= 0	Cell 3 FP= 43 WS= 76 F/B= 7 PS= 0	Cell 4 FP= 33 WS= 67 F/B= 0 PS= 0	Cell 5 FP= 36 WS= 64 F/B= ***18*** PS= 0	Cell 6 FP= 0 WS= 0 F/B= 0 PS= 0	Cell 7 FP= 80 WS= 30 F/B= 0 PS= 0	Cell 8 FP= 100 WS= 0 F/B= ***50*** PS= 0
Low HDD	Cell 9 FP= 60 WS= 65 F/B= 5 PS= ***2***	Cell 10 FP= 100 WS= 0 F/B= 0 PS= 0	Cell 11 FP= 61 WS= 54 F/B= ***4*** PS= 4	Cell 12 FP= 50 WS= 50 F/B= 0 PS= 0	Cell 13 FP= 70 WS= 35 F/B= 0 PS= 5	Cell 14 FP= 67 WS= 0 F/B= 0 PS= 33	Cell 15 FP= 90 WS= 10 F/B= 0 PS= 0	Cell 16 FP= 100 WS= 0 F/B= 0 PS= ***20***
Med HDD	Cell 17 FP= 55 WS= 66 F/B= 7 PS= 7	Cell 18 FP= 60 WS= 60 F/B= 0 PS= 0	Cell 19 FP= 59 WS= 45 F/B= 0 PS= 9	Cell 20 FP= 100 WS= 0 F/B= 0 PS= ***25***	Cell 21 FP= 81 WS= 27 F/B= ***8*** PS= 4	Cell 22 FP= 50 WS= 50 F/B= 0 PS= 0	Cell 23 FP= 100 WS= 0 F/B= 0 PS= 0	Cell 24 FP= 0 WS= 0 F/B= 0 PS= 0

FP = fireplace; WS = woodstove; F/B = furnace/boiler; PS = pellet stove; Totals do not always add to 100 since some respondents use more than one type of equipment. Values in ***bold italics*** are derived from responses that were identified as wood consumption outliers (equipment could be miss-categorized by the respondent).

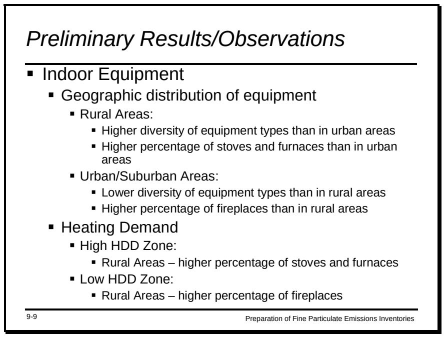
9-8 Preparation of Fine Particulate Emissions Inventories

This table is the same table that was shown on an earlier slide with the exception that the grid cells have the fraction of indoor wood burning equipment on a percentage basis.

Observations:

- In some cases the fractions add up to more than 100% because some houses were using more than one piece of equipment.
- Rural forested areas within a high heating demand zone have a higher diversity of equipment.
- More rural households are using wood burning equipment than the urban areas.

9 - 9



Rural areas have a higher percentage of stoves and furnaces and boilers than urban areas.

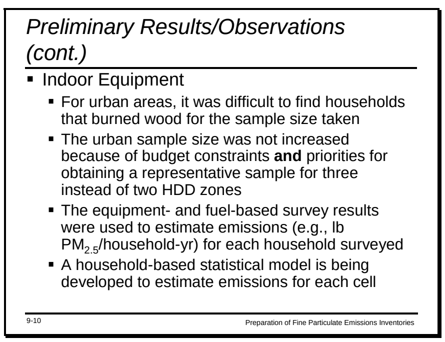
Urban and suburban areas:

- lower diversity of equipment types
- higher percentage of fireplaces

Rural areas:

- higher percentage of stoves and furnaces in the higher HDD zone
- higher percentage of fireplaces in the lower HDD zone

9 - 10



For indoor equipment, because of the sample size of the survey, it was hard to find households that burned wood in urban areas.

Urban sample size was not increased for two reasons:

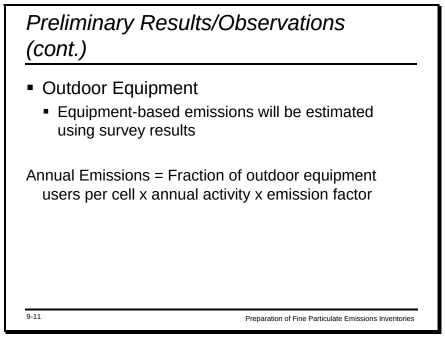
- Budget, and
- Priorities.

As a result, emissions were not calculated for each piece of indoor equipment in urban areas.

Equipment and fuel-based survey results were used to estimate average emissions.

Household-based statistical model was used to estimate emissions for each cell for indoor equipment.

9 - 11



Emissions were estimated for outdoor equipment using the survey results.

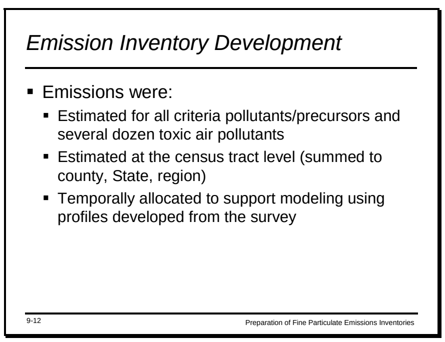
The emissions are the product of:

- the fraction of outdoor equipment users per cell,
- the annual activity, and
- the emission factor.

This is the first attempt to estimate emissions from outdoor wood burning equipment at the household level.

NEI only includes indoor equipment.

9 - 12



Emissions were estimated for:

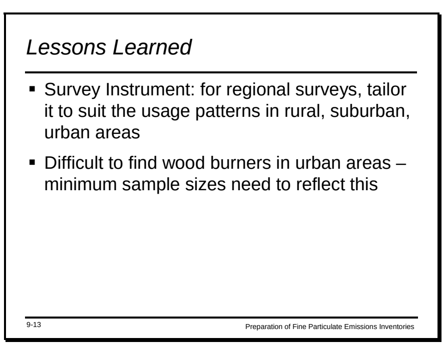
- criteria pollutants and precursors, and
- several dozen toxic air pollutants.

They were estimated at census track level

Summed to the county, state and region.

Emissions were temporally allocated to support modeling using profiles that were developed from the survey.

9 - 13

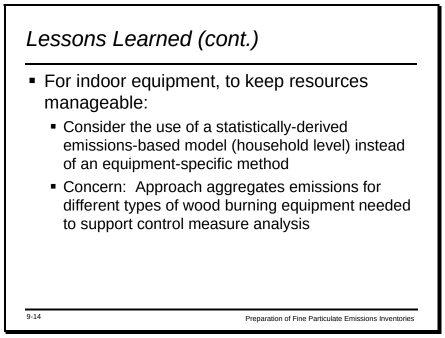


A number of lessons were learned from the MANE-VU study:

Survey instrument for regional surveys should be tailored to suit the usage patterns on rural and suburban and urban areas.

It is difficult to find wood burners in the urban areas, and the sample size may need to be increased to locate these sources.

9 - 14



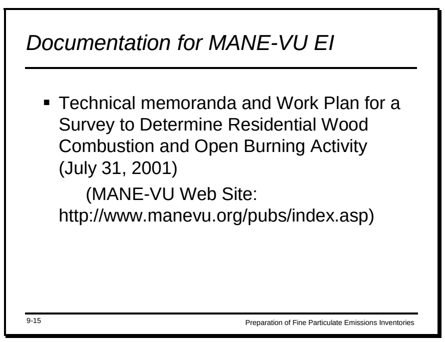
For indoor equipment, keep resources manageable.

Consider the use of statistically derived emissions based model (household level) instead of an equipment specific method.

The concern with this MANE-VU approach is that it aggregates emissions for different types of wood burning equipment.

Should be disaggregated in order to conduct a control strategy analysis.

9 - 15

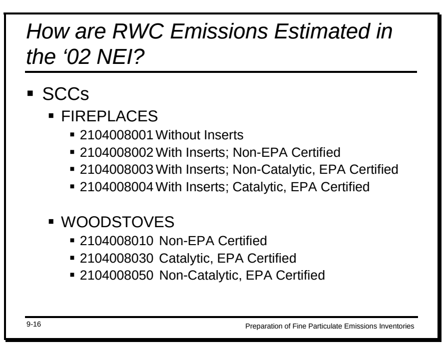


Documentation for the MANE-VU project can be obtained at the web address listed here.

Technical memoranda

Work plan including equations for calculating the sampling precision

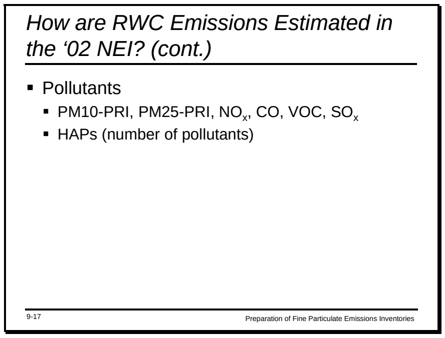
9 - 16



NEI categorization:

- Fireplaces - Four SCCs
- Woodstoves - Three SCCs

9 - 17



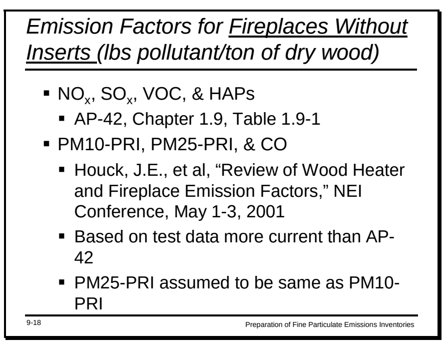
NEI pollutants for residential wood combustion:

- PM_{10} primary
- $PM_{2.5}$ primary
- NO_X
- CO
- SO_X
- HAPs.

The emission factors that are used for residential wood combustion represent primary emissions.

There is no breakout of the filterable and condensable portions of the emission factor.

9 - 18

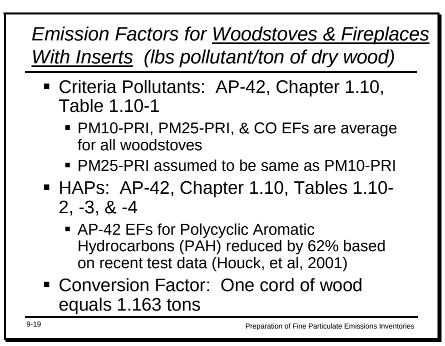


The emission factors for fireplaces without inserts obtained from AP-42 except:

- PM and CO obtained from the reference listed on this slide.
- The $PM_{2.5}$ emission factor assumed to be the same as PM_{10} primary emission factor.

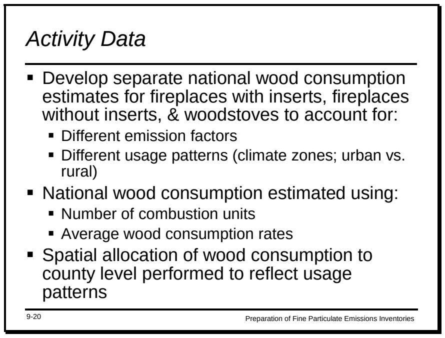
Emission factors for all pollutants from woodstoves and fireplaces without inserts are obtained from AP-42.

9 - 19



This slide shows the information for emission factors for woodstoves and fireplaces with inserts.

9 - 20

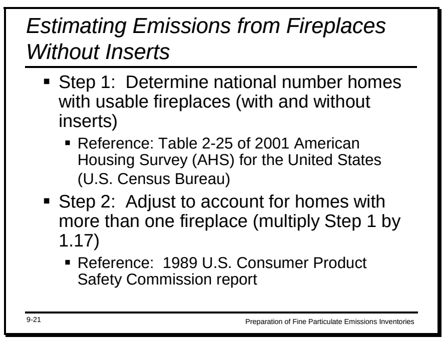


To account for the different emission factors and different usage patterns, the NEI developed separate national wood consumption estimates and emission estimates for:

- fireplaces with inserts,
- fireplaces without inserts,
- and woodstoves.

The methodology is different for fireplaces without inserts than it is for fireplaces with inserts and woodstoves.

9 - 21

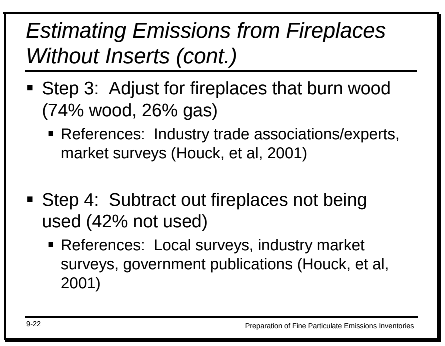


Estimating emissions from fireplaces without inserts

Step 1: determine the number of homes with fireplaces in the United States using data obtained from the US Department of Census.

Step 2: adjust to account for the fact that some homes have more than one fireplace.

9 - 22



Estimating emissions from fireplaces without inserts

Step 3: adjust to account for the fact that not every home burns wood.

Step 4: subtract the number of fireplaces not being used.

9 - 23

Estimating Emissions from Fireplaces Without Inserts (cont.)

- Step 5: Determine number of homes with usable fireplaces with inserts used for heating
  - Used to determine the number of homes with usable fireplaces without inserts
  - Reference: Table 2-4 of 2001 AHS
- Step 6: Adjust to account for homes with more than one fireplace (multiply Step 5 by 1.10)
  - Reference: 1989 U.S. Consumer Product Safety Commission report

9-23 Preparation of Fine Particulate Emissions Inventories

Estimating emissions from fireplaces without inserts

Step 5: subtract number of fireplaces with inserts.

Step 6: adjust for homes with more than one fireplace.

9 - 24

Estimating Emissions from Fireplaces Without Inserts (cont.)

- Step 7: Determine number of fireplaces without inserts used for heating and aesthetic purposes
- The amount of wood burned in each device is determined by assuming wood consumption rates
  - 0.656 cords burned /unit/year for fireplaces used for heating
  - 0.069 cords/unit/year for fireplaces used for aesthetics

9-24 Preparation of Fine Particulate Emissions Inventories

Estimating emissions from fireplaces without inserts

Step 7: Separated fireplaces without inserts into 2 categories: those used for heating and those used for aesthetics.

The amount of wood burned in each device is determined by assuming wood consumption rates:

- 0.656 cords burned /unit/year for fireplaces used for heating and
- 0.069 cords/unit/year for fireplaces used for aesthetics.

9 - 25

Estimating Emissions from Fireplaces Without Inserts (cont.)

- In 1997, EPA estimated that 2.94 million cords of wood were burned in the former and 0.483 million cords of wood were burned in the latter

9-25 Preparation of Fine Particulate Emissions Inventories

In 1997, EPA estimated:

- 2.94 million cords of wood were burned for heating
- 0.483 million cords of wood were burned for aesthetics

9 - 26

Spatial Allocation of National Residential Wood Consumption to Counties

- National activity is allocated to counties using:
  - Climate zone (i.e., temperature)
  - Demographics/population (i.e., number of single-family homes)
  - Usage patterns for each device (i.e., urban versus rural)

9-26 Preparation of Fine Particulate Emissions Inventories

Calculated consumption is allocated to counties based on:

- 1 of 5 climate zones,
- demographics/population, and
- usage patterns.

9 - 27

Spatial Allocation of National Residential Wood Consumption to Counties (cont.)

Climate Zone	Percent of Wood Consumed
1 (>7000 HDD)	36
2 (5500-7000 HDD)	19
3 (4000-5499 HDD)	21
4 (<4000 HDD and <2000 CDD)	15
5 (<4000 HDD and >2000 CDD)	9

9-27 Preparation of Fine Particulate Emissions Inventories

Climate zones defined by:

- ranges of heating degree day and cooling degree day values
- amount of national consumption allocated to each zone

9 - 28

Spatial Allocation of National Residential Wood Consumption to Counties (cont.)

- Urban/Rural Apportionment
  - Designate each county as either urban or rural, sum activity for climate zone, and adjust county activity so climate zone total matches the following proportions :

	Rural	Urban
Woodstoves	65%	35%
Fireplaces with inserts	43%	57%
Fireplaces without inserts	27%	73%

9-28 Preparation of Fine Particulate Emissions Inventories

The census data classifies counties as either urban or rural.

Urban = 50 percent of the county's population located in cities and towns

Rural = less than 50 percent of the population located in cities and towns

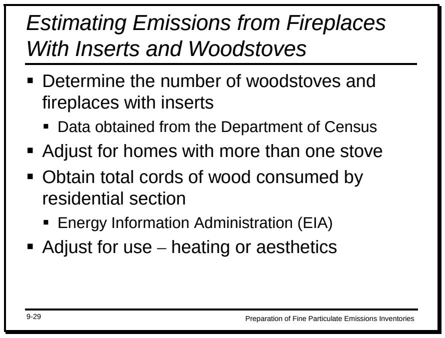
The total wood consumption for all the urban counties are summed for each climate zone, and the same is done for the rural counties.

The data is adjusted if the percentage proportion between urban and rural areas does not match the percentage in the number of units that are reported in the 2001 census.

For example, if the total wood consumption for woodstoves in climate zone 1 is 60 percent for rural and 40 percent for urban, then each urban and rural county within zone 1 receives a percent increase or decrease in cordwood consumption to obtain the correct percent split to reach the 65 percent rural and 35 percent urban split for zone 1.

Finally, AP-42 factors are used to determine county emissions from fireplaces without inserts.

9 - 29



Estimating emissions from fireplaces with inserts and woodstoves

Determine the number of woodstoves and inserts in the United States.

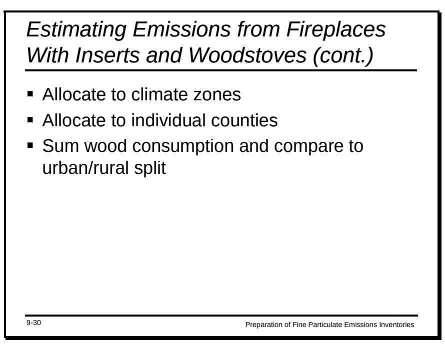
These data are obtained from the DOC. Adjust for the fact that some homes have more than one stove.

The total cords of wood consumed by the residential section for 1997 are obtained from the Energy Information Administration.

Subtract the cords of wood used in fireplaces for aesthetic purposes.

Units used for main heating purposes are considered different from units that are used for other heating purposes.

9 - 30



Allocate consumption to 1 of 5 climate zones.

Within each climate zone, allocate consumption to the individual counties using the relative percent of detached single family homes in the county to the total number of detached single family homes in the entire climate zone.

After allocating to the climate zones, the wood consumption in each zone is summed and compared the urban and rural split.

The total is adjusted until the desired split is achieved.

The split is 65 percent rural and 35 percent urban.

For inserts, the split is 43/57.

9 - 31

Estimating Emissions from Fireplaces With Inserts and Woodstoves (cont.)

- Wood consumption for woodstoves and fireplaces with inserts were apportioned as follows:

Type of Device	Percent of Total Wood Consumption
Non-certified	92
Certified non-catalytic	5.7
Certified catalytic	2.3

9-31 Preparation of Fine Particulate Emissions Inventories

Wood consumption for woodstoves and fireplaces with inserts are allocated to one of the three SCCs.

Fireplaces without inserts are recorded on one SCC.

Once the amount of wood consumed per residential wood combustion type is obtained, AP-42 emission factors are used to calculate emission estimates.

9 - 32

Temporal Allocation of Residential Wood Consumption Emissions

- Default temporal allocation profiles by climate zone
  - S/L/T agencies should adjust allocations to better fit seasonal usage patterns
- Seasonal throughput percentages assigned to each climate zone are:

Climate Zone	Winter	Spring	Summer	Fall
5	100	0	0	0
4	70	15	0	15
3	50	25	0	25
2	40	30	0	30
1	33.33	33.33	0	33.33

9-32 Preparation of Fine Particulate Emissions Inventories

NEI seasonal activity is allocated by climate zone.

The seasonal throughput percentages assigned to each climate zone are listed on this slide.

Zone five is the warmest zone, so all the activity was placed into the winter category.

Summer has no activity with the NEI default method.

The activity is distributed across the seasons for zones two, three and four.

9 - 33

How Can You Improve the NEI for Your Area?

- Preferred Method: Residential Wood Survey
  - Obtain locally representative information on the amount of wood fuel use specifically for woodstoves & fireplaces (with and without inserts)
  - This will require a local survey, or activity data generated by State & local governments
  - Reduces uncertainties in estimates associated with allocating national activity to counties
- Alternative Method: Census Bureau and EIA Data Method
  - Use if resources are limited or emphasis is on preparing summer season inventory

9-33 Preparation of Fine Particulate Emissions Inventories

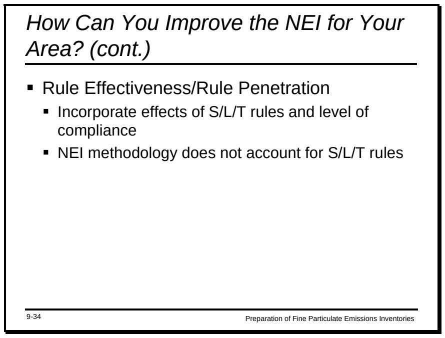
Improving on the NEI method can be accomplished by:

- Conducting a local survey
- Allocating emissions within the seasons.

It is preferable to use local data and the preferred collection method is to do a local or statewide survey.

The EIIP provides an alternative method using census bureau data and the EIA data method.

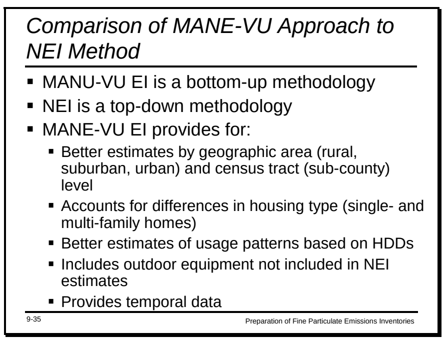
9 - 34



Any assumptions other than 100% for rule effectiveness and rule penetration should be incorporated into the emissions estimation methodology

NEI method does not account for the effect of state and local rules.

9 - 35



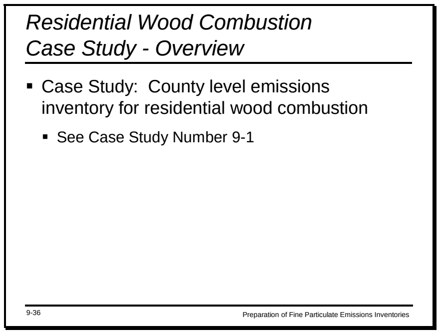
The MANE-VU inventory is a bottom-up methodology.

NEI is top down.

MANE-VU:
- Provides better estimates by geographic area and census.
- Accounts for differences in housing type
- Provides better estimates of usage patterns based on heating demand.
- Includes outdoor equipment not included in the NEI estimates.
- Provides some temporal data that can be used to allocate emissions.

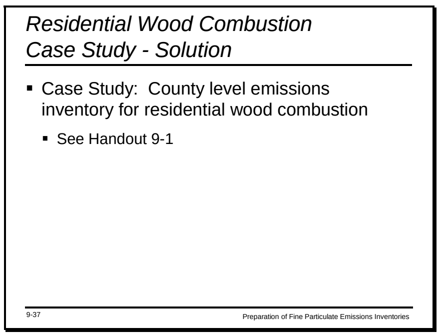
NEI emission estimates for residential wood combustion are generally within the ballpark of, but on the low end of the range of, emissions estimated for the MANE-VU inventory.

9-36



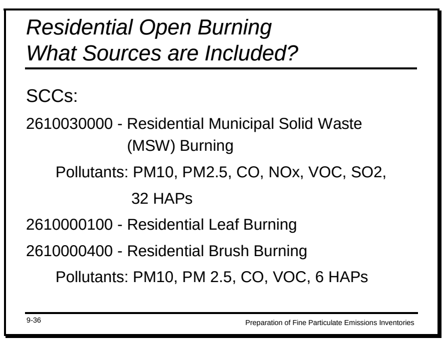
This hypothetical case study involves developing a local inventory using survey data and filling the data gaps with the NEI default data.
Direct student to Case Study 9-1 and discuss it with the students.

9-37



Distribute the solutions (Handout 9-1) to the case study. Review each question with the students. Encourage discussion among the class. Ask each group to report on the questions that were assigned to them. Ask the other groups to critique their responses.

9 - 38

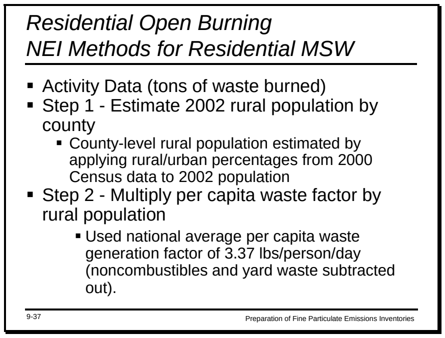


Residential open burning includes:

- household waste burning
- yard waste burning (includes brush waste and leaf waste).

This slide lists the SCCs and the pollutants for residential open burning that are included in the NEI.

9 - 39

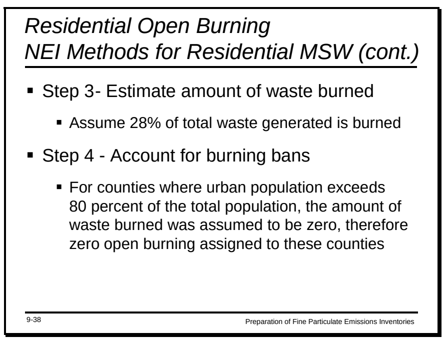


Developing activity data for residential municipal solid waste:

Step 1: estimate the rural population by county by applying percentages of rural and urban population from the census data.

Step 2: multiply the rural population by a per capita household waste factor of 3.37 pounds per person per day.

9 - 40



Developing activity data for residential municipal solid waste:

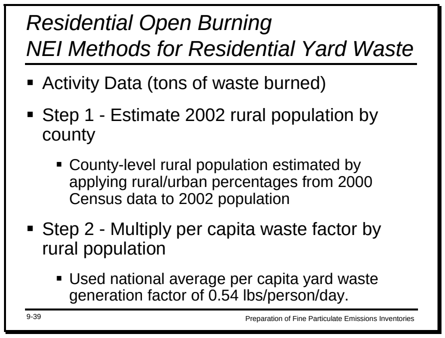
Step 3: estimate the amount of waste burned

Assume that 28% of the household waste generated is burned.

Step 4: account for burning bans.
Ideally this is done by knowing exactly which areas have instituted a burning ban and the time period over which the ban applies.

The NEI assumes that if a county has an urban population that exceeds 80% of the total population the amount of waste burned is zero.

9 - 41

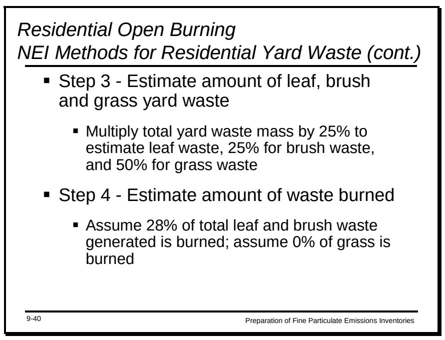


Developing activity data for residential yard waste:

Step 1: estimate the rural population by county by applying percentages of rural and urban population from the census data.

Step 2: multiply the rural population by a per capita household waste factor of 0.54 pounds per person per day.

9 - 42



Developing activity data for residential yard waste:

Step 3: estimate the percentage of total yard waste that corresponds to leaf, brush, and grass waste.

The NEI assumed:

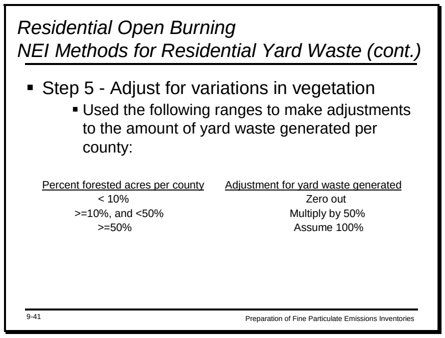
- 25% was leaf waste
- 25% was brush waste
- 50% was grass waste.

Step 4: estimate amount of waste burned.

Assume that 28% of the total leaf and brush waste is burned.

Assume that 0% of the grass waste is burned.

9 - 43



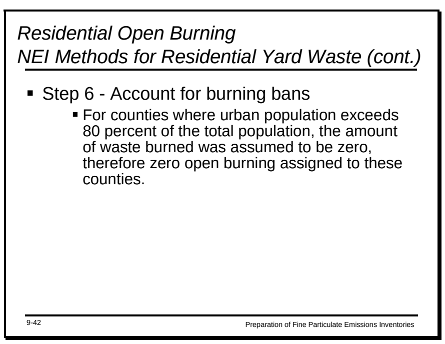
Developing activity data for residential yard waste:

Step 5: adjust to account for the variation in vegetation among the counties.

Use an estimate of the percent of the forested acres per county that was obtained from the biogenic emissions land cover database from the Biogenic Emission Inventory System.

For example, if the BEIS data indicates that a county has less than 10% forested acres, the NEI assumes that there is no yard waste generated.

9 - 44



Developing activity data for residential yard waste:

Step 6: account for burning bans in the same manner that was used for household waste.

9 - 45

Residential Open Burning
NEI Methods for Residential MSW and Yard Waste

E = A * EF * (1 – CE * RP * RE)

where: E = Controlled Emissions, lbs pollutant per year
A = Activity, tons of MSW or leaves/brush burned per year
EF = Emission Factor, lbs per ton burned
CE = % Control Efficiency/100
RP = % Rule Penetration/100
RE = % Rule Effectiveness/100

- 100% CE assumed for counties where urban population exceeds 80% of the total population
- Assumed 100% RE and RP
- All other counties, assumed 0% CE, RE, and RP

9-43 Preparation of Fine Particulate Emissions Inventories

Once the activity data is estimated for both solid waste and yard waste, emissions are calculated by the use of the equation shown here.

A 100% CE is assumed for counties that have an urban population greater than 80% of the total population.

The NEI also assumes that RE and RP are 100% for these areas.

The NEI assumes that all other counties are uncontrolled.

9 - 46

Residential Open Burning
EIIP Alternative for Yard Waste

- Identify records of burning permits or violations, coupled with data (or assumptions) on typical volumes and material composition

9-44 Preparation of Fine Particulate Emissions Inventories

The EIIP document for open burning contains an alternative approach for estimating emissions for yard waste.

This approach involves:

- obtaining records of burning permits or violations, and
- data on typical volumes and material composition.

9 - 47

Residential Open Burning
Improvements to NEI Methods

- Review EIIP Volume III, Ch. 16 Open Burning
- Obtain State/local estimates of per-capita waste generation
- Use State/local estimates for amount or percentage of waste burned
- Obtain State/local estimates of months when yard wastes are burned

9-45 Preparation of Fine Particulate Emissions Inventories

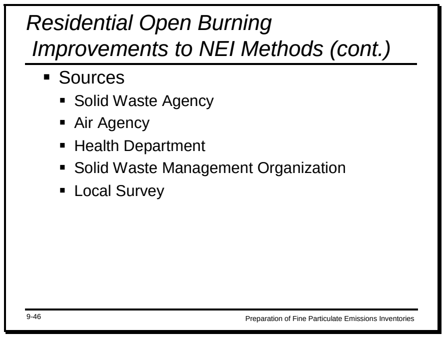
The open burning EIIP contains alternative methods for estimating activity data for this category.

Another approach is to use the NEI methodology coupled with state or local estimates of the per capita waste generation and the amount or percentage of waste burned.

Also, state/local data on the months when yard waste is burned would be an improvement.

The NEI does not make any temporal adjustment for yard waste burning.

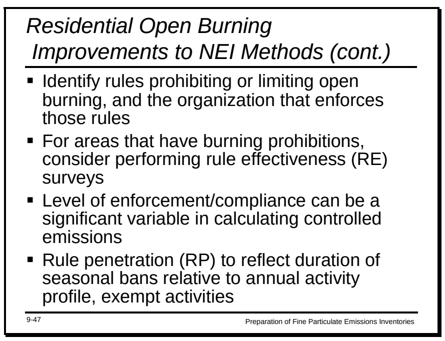
9 - 48



Some of the sources for this type of information include:

- the Solid Waste agency;
- the Air Agency;
- the Health Department;
- the Solid Waste Management agency; and
- the use of local surveys.

9 - 49



The NEI can also be improved by obtaining better estimates of control measures that are applied to open burning.

This involves identifying the rules that limit or prohibit open burning and the organization that enforces those rules (e.g., fire marshal, health department).

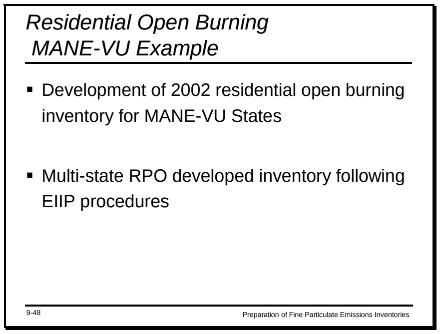
For areas that have burning prohibitions, a rule effectiveness survey can be performed to estimate the compliance rate with the rule.

This is critical in rural areas where there are few complaints about open burning.

Also, rule penetration is critical since many open burning rules have exemptions that are listed (e.g., firefighting training activities, recreational campfires).

Rule penetration is also important for seasonal bans.

9 - 50

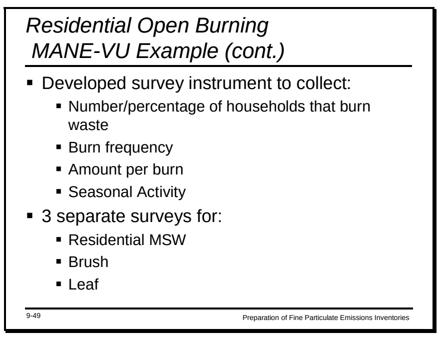


This example examines the development of a 2002 residential open burning inventory for the MANE-VU states.

Developed by a multi-state Regional Planning Organization

Followed the procedures in the EIIP document (i.e., conducting a survey) to obtain activity data

9 - 51



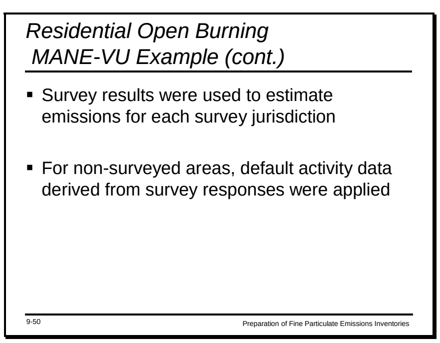
A survey instrument was developed to collect data on:

- the number of households burn waste,
- the burn frequency,
- the amount burned, and
- the seasonal nature of the burning.

Three separate surveys were performed:

- residential municipal solid waste,
- brush waste, and
- leaf waste.

9 - 52



The data collected from these surveys were used to estimate:

- emissions for each survey area, and
- default activity data for those areas not included in the surveyed areas.

9 - 53

Residential Open Burning MANE-VU Example (cont.)

- To estimate the mass of waste burned for residential MSW and yard waste, the following equation was used:

$$Wt = HH * Bt * M$$

where: Wt = Mass of waste burned per time period
HH = Number of households that burn
Bt = Number of burns per time period
M = Mass of waste per burn

9-51 Preparation of Fine Particulate Emissions Inventories

This is the equation that was used to estimate the amount of waste burned based on the data collected from the surveys.

9 - 54

Residential Open Burning MANE-VU Example (cont.)

- Developed control database to establish area-specific control efficiency (CE), rule effectiveness (RE), and rule penetration (RP)
- Performed rule effectiveness (RE) survey to determine level of compliance with state or local open burning prohibitions
- To estimate default RE values, the survey data was statistically analyzed resulting in one value for all non-surveyed areas

9-52 Preparation of Fine Particulate Emissions Inventories

A control database was developed that established area-specific control efficiency, rule effectiveness, and rule penetration.

Rule effectiveness and rule penetration can vary significantly depending on enforcement and the rule applicability.

A rule effectiveness survey was conducted to determine the level of compliance with the state or local open burning prohibitions.

This data was also used to estimate default RE values for use in the non-surveyed areas.

9 - 55

Residential Open Burning MANE-VU Example (cont.)

- Emissions estimated for all criteria pollutants/precursors and several toxic air pollutants
- Emissions estimated at the census tract level (summed to county, State, region)
- Emissions temporally allocated to support modeling using profiles developed from the survey

9-53 Preparation of Fine Particulate Emissions Inventories

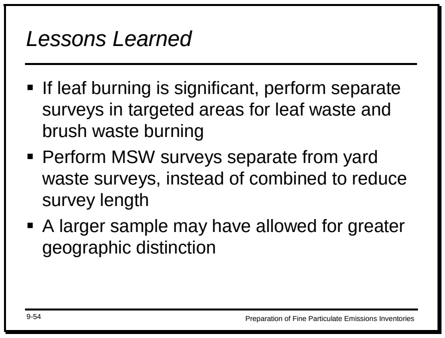
Using the activity data and the control information, emissions were estimated for:

- all criteria pollutants and precursors, and
- several HAPs.

The emissions were estimated at the census track level and summed to the county, state, and regional level.

Finally, the data on the occurrence of the burning activities were used to temporally allocate the emissions to support modeling using profiles that were developed from the survey.

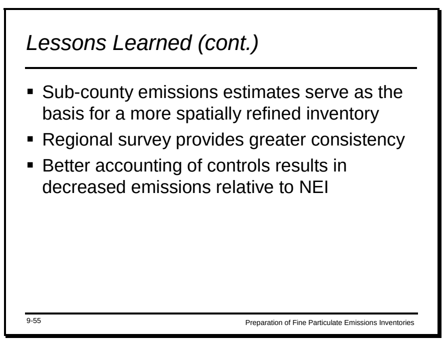
9 - 56



A number of lessons were learned from conducting the survey:

- Separate surveys should be performed in targeted areas where leaf burning is significant.
- Household waste and yard waste surveys should be performed separately simply to reduce the length of the survey.
- A larger sample may have allowed for greater geographic distinction.

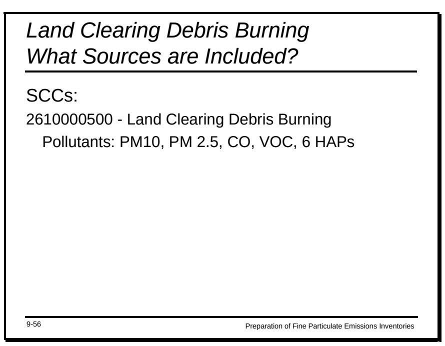
9 - 57



A number of lessons were learned from conducting the survey:

- Sub-county emissions estimates serve as the basis for a more spatially refined inventory.
- A regional survey provides greater consistency that allows for easier comparison of emission estimates from different areas.
- Better accounting of controls results in a decrease of the NEI emissions.

9 - 58



Land clearing debris burning is covered under SCC 2610000500.

The NEI contains emission estimates for PM_{10}, $PM_{2.5}$, CO, VOC, and 6 HAPs from this category.

9 - 59

Land Clearing Debris Burning
NEI Method

- Activity Data
- Estimate the county-level total number of acres disturbed by residential, non-residential and roadway construction
  - Used number of acres disturbed from fugitive dust construction emissions activity calculations
- Apply loading factor to number of acres to estimate the amount of material or fuel subject to burning

9-57 Preparation of Fine Particulate Emissions Inventories

The activity data for this category is the number of acres disturbed for the different types of construction categories.

Step 1: estimate of the county-level total number of acres disturbed.

Step 2: Apply loading factor to the number of acres disturbed to estimate the amount of material burned.

9 - 60

Land Clearing Debris Burning
NEI Method (cont.)

- Weighted, county-specific loading factors developed based on acres of hardwoods, softwoods, and grasses (BELD2 data base in BEIS)
- Multiplied average loading factors by percent contribution of each type of vegetation class to the total county land area

9-58 Preparation of Fine Particulate Emissions Inventories

Step 3: develop weighted county-specific loading factors based on the acres of hardwood, softwoods, and grasses.

Step 4: Multiply average loading factors by the percent contribution of each type of vegetation class to the total county land area.

9 - 61

Land Clearing Debris Burning
NEI Method (cont.)

- Average loading factors for hardwood and softwood further adjusted by 1.5 to account for mass of tree below the surface

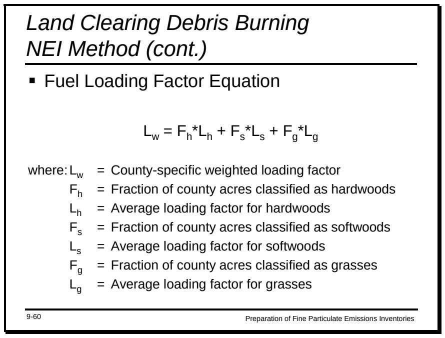
Fuel Type	Fuel Loading (tons/acre)
Hardwood	99
Softwood	57
Grass	4.5

9-59 Preparation of Fine Particulate Emissions Inventories

Step 5: adjust average loading factors for hardwood and softwoods by an additional 1.5 to account for the mass of tree below the surface.

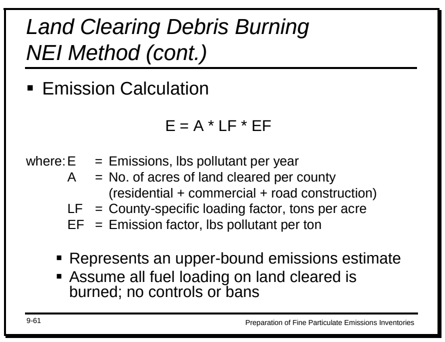
The emission factors presented in the table reflect this adjustment.

9 - 62



This slide shows the equation for developing the loading factors.

9 - 63



Emissions are estimated from the activity data as shown by this equation.

This formula multiplies:

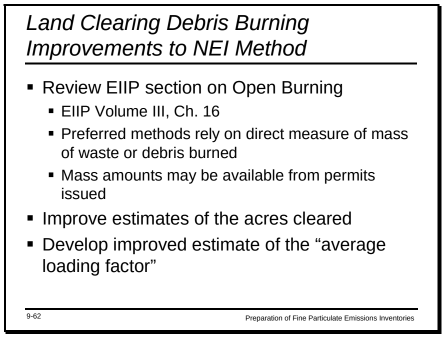
- the activity data,
- the number of acres of land, and
- the county-specific loading factor.

Since the loading factor does not vary by the types of construction, the number of acres cleared for all three types of activities are summed before the loading factor is applied.

The NEI assumes that all the fuel loading on the land cleared is burned and that no controls or bans are in place.

For estimating these emissions, the NEI takes a similar approach as to that used for Residential Yard Waste (see Slide 42), in that it removes emissions from counties that are considered mostly urban.

9 - 64



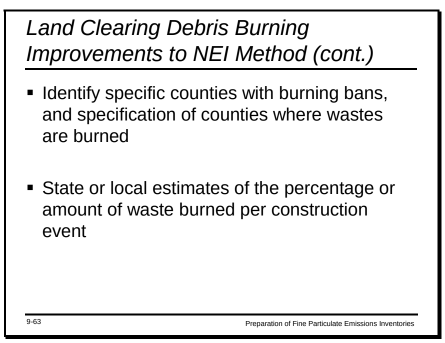
A good place to begin is to Review the EIIP section on open burning.

The EIIP methods rely on a direct measure of mass of waste or debris burned, which may be obtainable from local officials that track this activity for permitting purposes.

Also, obtaining a better estimate of the acres cleared for the fugitive dust construction category would improve the inventory for the land clearing debris burning category.

Other approaches for improving the NEI include developing an improved loading factor.

9 - 65



Other ways to improve on the NEI include:

- Identifying specific counties with burning bans and specifying counties where wastes are burned.
- Obtaining state or local estimates of the percentage or amount of waste burned per construction event (The NEI assumes that the fuel loading associated with the land that is cleared is being burned).

9 - 66

Land Clearing Debris Burning
Northern Virginia Example

- Performed RE survey to determine the level of compliance with rules for:
  - Land clearing debris burning
  - Residential waste burning
- Developed RE to apply to ozone season open burning emission estimates for the Virginia portion of the Washington DC-MD-VA Ozone Nonattainment Area

9-64 Preparation of Fine Particulate Emissions Inventories

This Northern Virginia area study involved a RE survey to determine the level of compliance with rules for land clearing debris burning and residential waste burning.

The objective of the study was to develop a defensible RE value for use in the State Implementation Plan.

Current EPA guidelines requires the application of an 80% rule effectiveness.

9 - 67

Land Clearing Debris Burning
Northern Virginia Example (cont.)

- Reviewed conditions of existing open burning rules
  - Time period of ban
  - Exemptions and special provisions
- Surveyed local open burning officials responsible for tracking and enforcing open burning rules

9-65 Preparation of Fine Particulate Emissions Inventories

The study reviewed the existing conditions of the open burning rules to determine:

- the time period of the ban, and
- the exemptions that apply.

A survey of local open burning officials responsible for tracking and enforcing open burning rules was conducted.

9 - 68

Land Clearing Debris Burning
Northern Virginia Example (cont.)

- Started with EPA questionnaire from RE guidance, modified for open burning
- Responses to questions are assigned specific point values that add up to a maximum of 100 points, considered equivalent to a RE percentage value

9-66 Preparation of Fine Particulate Emissions Inventories

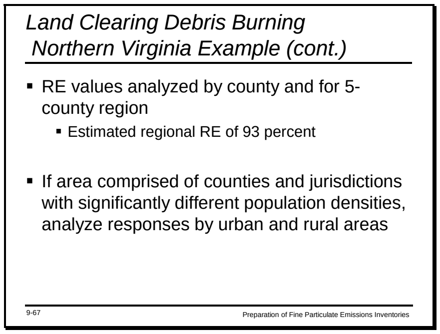
The survey form was derived from an EPA questionnaire that is available from the rule effectiveness guidance.

Responses to the questions on the survey were assigned a specific point value that adds up to a maximum of 100 points.

This point value is considered equivalent to the RE percentage value.

If all the questions were answered with the highest rating, an RE value of 100% was assigned.

9 - 69

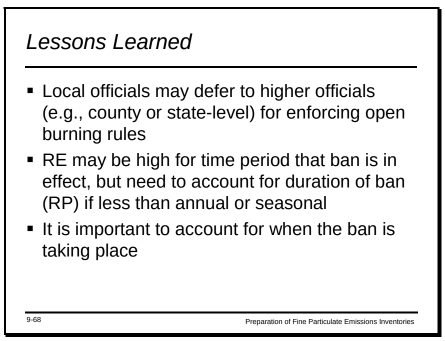


The RE values were analyzed by county as well as for the five-county region.

A regional RE value of 93% was estimated.

Although not done in this case study, separate RE values could be developed for urban and rural area in cases where there are significantly different population densities.

9 - 70



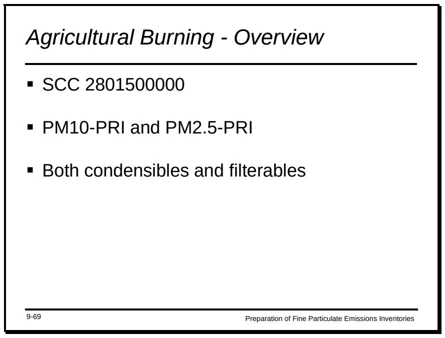
Some of the lessons learned from this study are:

- Local officials tend to defer to the county or state level officials for enforcing the open burning rules.
- In developing an annual emissions inventory, it is important to note that RE may be high only for the time period that the ban is in effect.
- The duration of the ban needs to be taken into account if it is less than annual or seasonal.

Account for when the ban is taking place and if it overlaps with when the activity occurs.

For example, a ban in place for the summer months for brush waste burning will have minimal impact if the majority of the brush burning occurs in the fall.

9 - 71



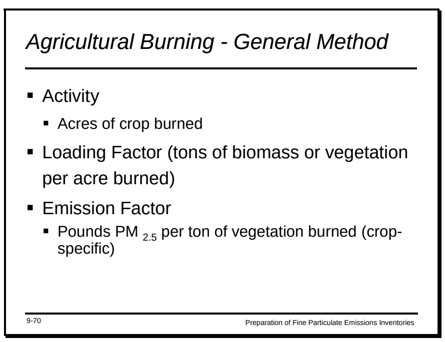
Agricultural burns create particulate matter pollution and their inventory is important to the overall particulate matter air quality analysis.

The SCC for agricultural burning is 2801500000.

EPA encourages States to inventory both PM10 and PM2.5-PRI.

Since agricultural burning is a combustion process, both condensibles and filterables are included in the PM-PRI estimate.

9 - 72



EPA develops emission estimates for most source categories in the NEI and States submit any improved information that they have for those particular categories.

EPA does not at this time prepare an estimate of emissions from agricultural burning.

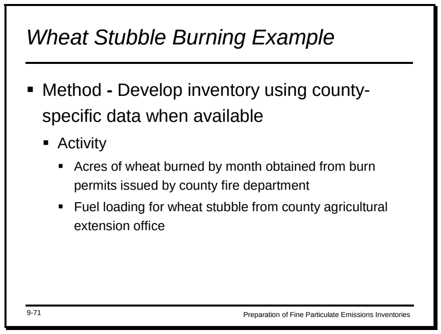
EPA encourages each State to develop their own inventories and submit them.

In 1999 ten States (Alabama, California, Delaware, Georgia, Idaho, Kansas, Maine, Oregon, Texas, and Utah) developed their own agricultural burning inventory.

In general, these States developed the inventories by:

- characterizing the activity or acres of the crop burned,
- the loading factor, and
- the emission factor.

9 - 73



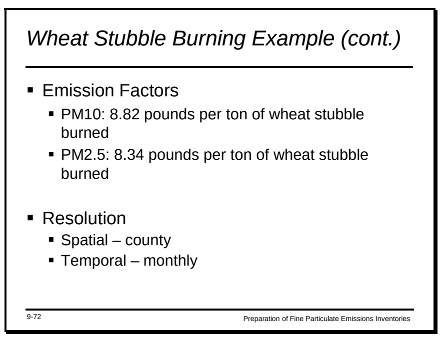
This study involves wheat stubble burning and uses county-specific data.

The activity data that was obtained are the acres of wheat burned by month.

This was obtained from burn permits that are usually issued by the county fire department.

The fuel loading for wheat stubble was obtained from the county agricultural extension office.

9 - 74



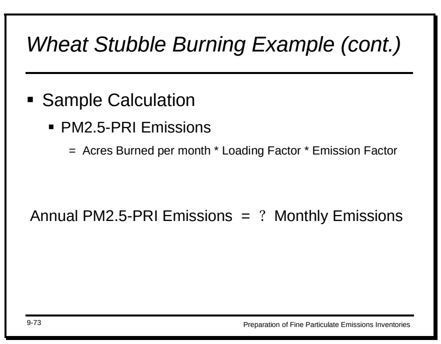
The emission factors are from a study done by CARB

(Jenkins, B.M. et al., *Atmospheric Pollutant Emission Factors from Open Burning of Agricultural and Forest Biomass by Wind Tunnel Simulations*, Volume 2, Results, Cereal Crop Residues, California Air Resources Board Project Number A932-126).

The spatial resolution = county

The temporal resolution = monthly.

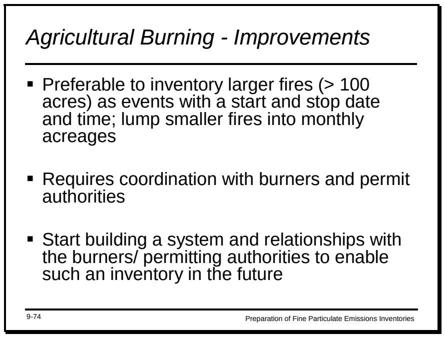
9 - 75



This slide shows the formula for calculating PM2.5-PRI emissions.

This calculation would be repeated for each month during the burning season and summed to give an annual emissions estimate.

9 - 76



EPA encourages all states to develop their own agricultural burning inventory.

For fires larger than 100 acres, EPA suggests:

- locate at a specific latitude and longitude, and
- record stop and start date and time of the fire.

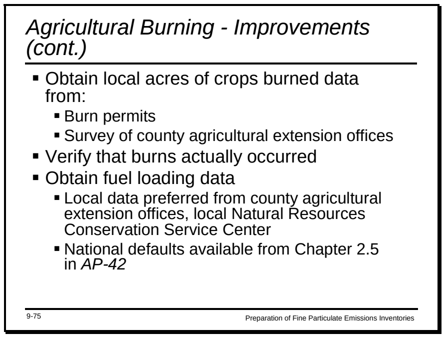
Smaller fires should be lumped into overall monthly acreage like in the previous case study example.

Obtaining information on agricultural burning requires coordination with the burners and the permitting authorities.

In order to develop an agricultural burning inventory, states needs to build a system and a relationship with the burners and permitting authorities.

Chances are pretty good that the first time a State tries to obtain this information they will find that records are not kept or are not kept in a way that can easily be understood.

9 - 77



The local acres of crops burned are obtained from:

- burn permits,
- a survey of county agricultural extension offices, or
- a combination of both.

It is important that States verify that the burns actually occurred.

Often a burner will get a permit to burn a lot more acreage than they actually are able to burn in a particular day.

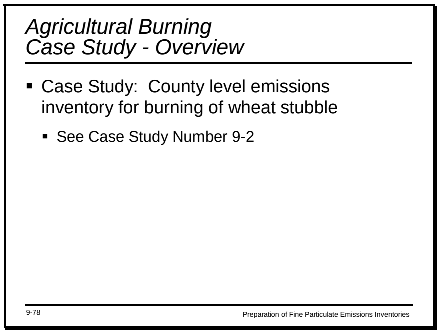
In many cases a burner is limited by the weather or other factors that keep them from burning the acreage that they are permitted to burn.

States need to obtain local fuel loading data.

Obtainable from the local county agricultural extension office or the local Natural Resources Conservation Service Center.

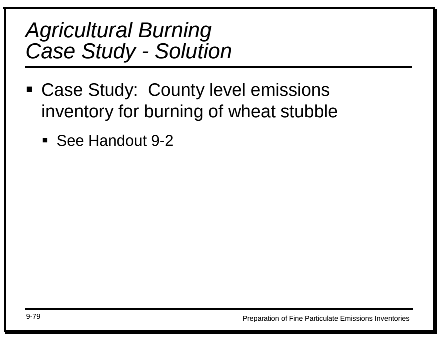
Preferable to using the national defaults that are available in Chapter 2.5 of AP-42.

9-78



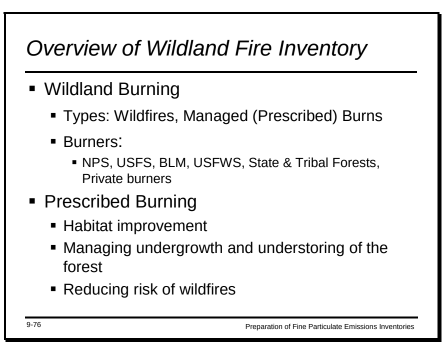
This hypothetical case study involves developing a local inventory using survey data and filling the data gaps with the NEI default data.
Direct student to Case Study 9-2 and discuss it with the students.

9-79



Distribute the solutions (Handout 9-2) to the case study. Review each question with the students. Encourage discussion among the class. Ask each group to report on the questions that were assigned to them. Ask the other groups to critique their responses.

9 - 80



Fires have become a major issue in:

- visibility impairment
- creation of high concentrations of $PM_{2.5}$ that could result in health problems.

The problems have been mainly in the West, but also wildfires from the Southeast, the Central States, Canada, and Mexico have become a concern.

EPA's wildland burning inventory includes both wild and managed burns.

The typical agencies that burn are:

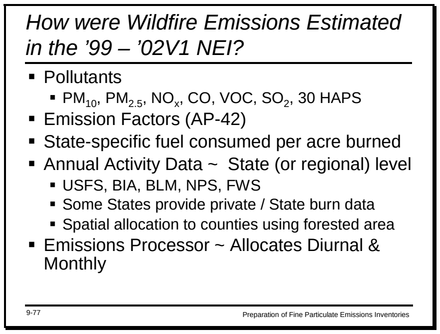
- the National Park Service,
- the United States Forest Service,

- the Bureau of Land Management,
- the United States Fish and Wildlife Service,
- State & Tribal Forests, and
- private burners.

Prescribed burns are those burns that are ignited intentionally:

- for habitat improvement of the wildlife;
- for managing the overall under growth and understoring of the forest; and
- to reduce the risk of wildfires later on by removing the fuels from the forested area.

9 - 81



The approach used to estimate wildfire emissions in the NEI is a very rudimentary approach.

It should be noted that this discussion focuses on the technique for estimating emissions from wildfires; however, emissions from prescribed or managed fires are estimated in a similar fashion.

The pollutants that are included in the NEI inventory for wildland fire emissions are:

- PM_{10},
- $PM_{2.5}$,
- NOx,
- CO,
- VOC,
- SO_2, and
- about 30 HAPS.

The emissions factors for estimating fire emissions and the state-specific fuel consumed per acre burned are found in the NEI documentation.

The technique is to merge the factor and fuel consumption information with annual activity data obtained at either the state or regional level from the main burning agencies.

Most of the federal burners keep fairly good records of the burns that they conduct mostly because these fires end up being watched and/or fought by personnel.

Some states also provide burn data as do some private burners

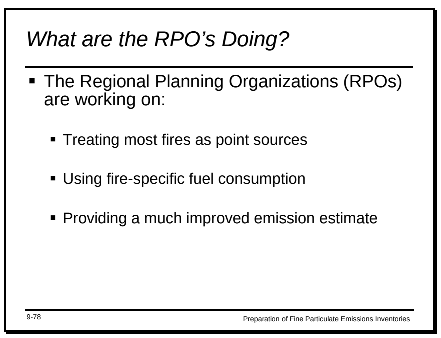
The data obtained from the burners is at the state level or regional level and it is allocated to the state or county level using the amount of forested area in a state.

The amount of acreage that was burned during a year in a particular state is allocated across the state to the forested lands

The NEI allocates the emissions annually and the emissions processor allocates the emissions diurnally and monthly.

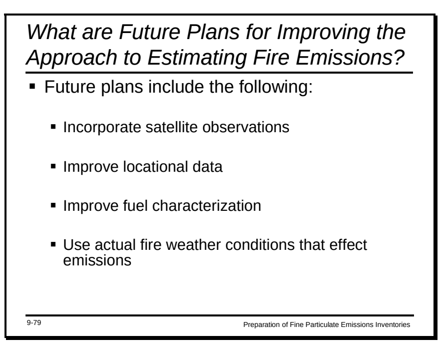
This allocation is important because certain areas of the country have different fire seasons and fire seasons are different for prescribed burns and managed burns.

9-82



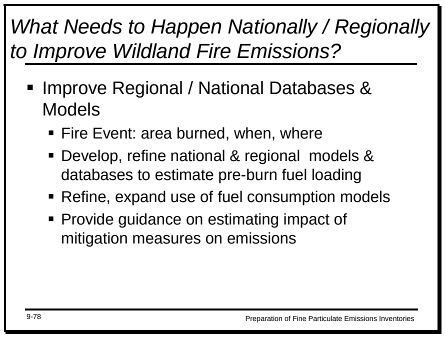
RPOs are working on treating most fires as point sources, using fire-specific fuel consumption, and providing a much improved emission estimate.

9-83



Future plans include incorporating satellite observations, improving locational data, improving fuel characterization, and using actual fire weather conditions that effect emissions.

9 – 84



In order to improve wild land fire emissions, national and regional databases and models must be improved.

Fires need to be treated as events.

Large fires need to be entered into the databases as point sources, including:

- particular location,
- start date,
- end date, and
- the time of day.

National regional models and databases need to be developed and refined to improve the pre-burn fuel loading information.

The information in AP-42 is very general, very dated, and averaged over large regions of the country.

Use of fuel consumption models needs to be to refined and expanded.

Guidance on estimating the impact of mitigation measures on emissions needs to be provided.

9 – 85

Fire Events Database Development

There is a Memorandum of Understanding in effect between the EPA, Department of Interior, and the United States Department of Agriculture to develop a fire events database.

It is a broad scope MOU that covers fire management activities including ways to improve the national databases.

There is a similar effort called nice guy, being conducted at Washington University in St. Louis.

There currently exists a database for recording fire events in the Pacific NW called the B-RAINS system.

Although these types of projects are moving toward real time data collection, quality assurance and data sharing, there is much more work needed in these areas.

9 – 86

EPA is also investigating the potential use of satellites to improve wildland fire inventories.

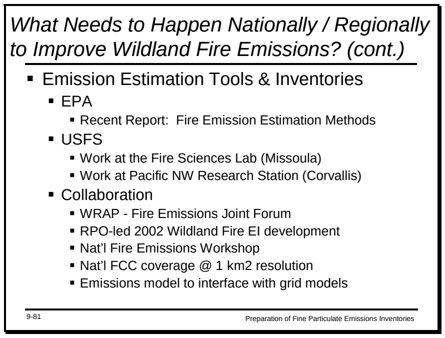
EPA has funded a report entitled *Overview of Using Satellites in AQ Management*.

There is also collaboration going on with NASA to take advantage of their skills in aerial surveillance with satellites.

There are several interagency groups working on the use of satellites including the National Interagency Fire Center (a jointly funded effort of all the Federal burners) in Boise, Idaho, the Missoula Fire Research Center, and Salt Lake City.

Another project includes CAMFER, which is a project underway at University of California Berkeley.

9 - 87



EPA recently published a report entitled *Fire Emission Estimation Methods* that is available on the CHIEF web site that contains a lot of good background information on wildland fire emission estimation.

In addition, there is a lot of ongoing work to improve emission estimation tools for wildland fires.

The US Forest Service has ongoing work on the development of fuel consumption and fire behavior models at the Fire Sciences Lab in Missoula and also at the Pacific NW Research Station in Corvallis.

Also, there is also a lot of emission factor testing occurring in the Fire Sciences Lab in Missoula.

There is also collaboration going on between all the different burn agencies, EPA, and the Regional Planning Organizations.

The Western Regional Air Partnership conducts a fire emissions joint forum and EPA and the burn agencies participate in that forum.

There is a RPO project to refine the 2002 wildland fire emissions inventory.

There was a national fire emissions workshop held in May of 2004 that focused on the latest ideas and methodologies for estimating fire emissions.

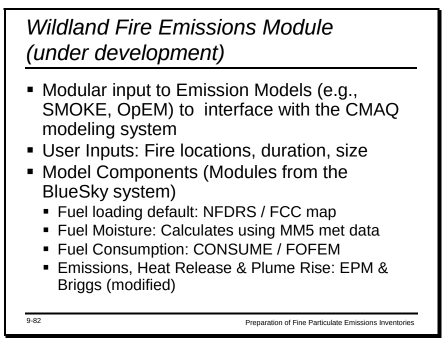
Also, the US Forest Service with assistance and funding from EPA is developing a geographic coverage of the fuel types and fuel conditions for burning at a 1km resolution.

A map of the country that will be useful in GIS systems will be developed out of this project.

Finally there will be further work on developing an emissions model that will estimate fire emissions in real time using real time meteorological data.

Output from this model will be fed directly into the grid models for estimating ambient air concentrations associated with fire emissions.

9 - 88



The emissions model that is under development is the Wildlands Fire Emissions Model.

It will interface with SMOKE and OpEMs, and the CMAQ modeling system.

The user will need to input:

- fire locations,
- durations, and
- size of the fire.

The model components, which will be drawn from the Blue Sky system being developed in the Pacific NW, are:

1) A fuel loading default that will use either the national fire danger rating system or, as it becomes available, the FCC map.
2) Fuel moisture will be calculated using actual metrological data for the period during, and immediately before the fire.

This is a significant improvement over the past and an important improvement since fuel moisture is critical in determining the amount of fuel that will burn and the emissions from that fuel.

3) Fuel consumption models are being built into the model.

Both the CONSUME / FOFEM are such models that have recently been improved significantly.

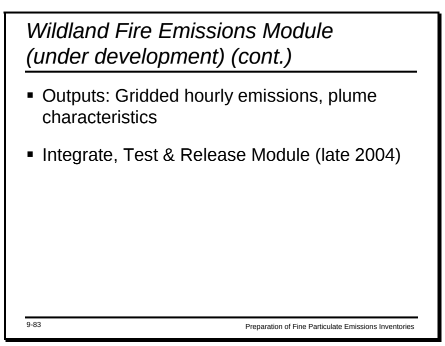
The CONSUME model is developed in the Corvallis lab and the FOFEM has been developed by the Missoula Fire Lab.

These models compliment each other and have strengths and weakness that, when used together properly, give a pretty good handle on fuel consumption.

4) The emission heat release and plume rise is being handled through the EPM model and the modified Briggs plume rise equation.

There is an improvement to the EPM model called FAR, which is about to be released in beta test form.

9 – 89



The output of the model will be:

- a gridded hourly emission estimate, and
- plume characteristics.

The output will be able to be interfaced with grid models to provide a regional scale estimate of the effects of fires.

For instance, this new wildland fire model will be able to estimate the NOx plume from a wildland fire and the effects of that increased NOx on ozone formation.

The integration, testing, and release of the model are anticipated for late 2004.

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Preparation of Fine Particulate Emission Inventories

Final Exam

1. __________ are composed mostly of carbonaceous particles, but will also contain crustal materials and a few other materials.
   a. Primary particles
   b. Secondary particles
   c. VOCs
   d. Sulfates

2. Twenty-five percent of total ____ emissions are associated with electric utilities, the second largest contributor.
   a. VOC
   b. SOx
   c. NOx
   d. PM

3. ____________ are currently under development for estimating emissions from ammonia sources, fugitive dust and wildland fires.
   a. Emission processors
   b. Process-based emission models
   c. Receptor Models
   d. FIRE databases

4. The ___________ includes data on 52,000-point sources and about 400 categories of highway and nonroad mobile sources and 300 categories of area sources.
   a. National Acidic Precipitation Assessment Program
   b. National Particle Inventory
   c. National Emissions Trends Inventory
   d. National Emissions Inventory

5. In calculating emissions from onroad sources, _______ data needs to be matched to a corresponding MOBILE 6.2 emission factor and mapped according to speed, roadway, and vehicle type.
   a. VMT
   b. FHA
   c. LTO
   d. RMS

6. Which of the following pollutants do **not** have an emission factor included in the NONROAD model?
   a. CO
   b. CO2
   c. VOC
   d. None of the above

7. Which of the following is a measure of equipment activity that is used by the NONROAD model to estimate exhaust emissions?
   a. Load factor
   b. Horsepower
   c. Equipment population
   d. All of the above

8. Which of the following statements about primary PM is true?
   a. It is emitted directly from a stack.
   b. It is formed downwind of the source.
   c. It consists of filterable PM only.
   d. It is almost always $PM_{2.5}$ or less.

9. Secondary PM precursors should ________
   a. not be reported in a particulate matter emission inventory.
   b. always be reported in a particulate matter emission inventory.
   c. be reported in a particulate matter emission inventory for nonattainment areas.
   d. be totaled with primary PM in a particulate matter emission inventory.

10. Which of the following is **not** a source for obtaining information for identifying area sources for inclusion in an emissions inventory?
   a. EIIP Area Source Guidance
   b. AP-42
   c. SCC Handbook
   d. Toxics Release Inventory

11. Which type of emissions are reported for PM in the NEI?
   a. Actual
   b. Allowable
   c. Potential
   d. All of the above

12. Which of the following variables is **not** included in the NEI emissions methodology for estimating emissions from agricultural tilling operations?
   a. silt content of soil
   b. acres of land tilled
   c. control measures
   d. number of passes

13. In the unpaved roads category, the NEI contains emission estimates for _____________.
    a. PM_{10}
    b. $PM_{2.5}$
    c. Condensable PM
    d. A and B

14. True or False - A smaller Precipitation Evaporation value represents low precipitation and humidity and results in larger adjustment to the base emissions estimate for fugitive emissions from construction activities.
    a. True
    b. False

15. Which of the following statements about ammonia emissions from animal husbandry operations is **false**?
    a. Animal husbandry operations are the largest emitter of ammonia nationally.
    b. There are probable errors in some of the ammonia emission factors in the NEI.
    c. The NEI does not take temperature into account in estimating ammonia emissions.
    d. All of these statements are false.

16. For which of the following categories did the NEI **not** develop a methodology?
    a. agricultural field burning
    b. agricultural tilling
    c. wood stoves
    d. land clearing debris burning

17. The NEI methodology for residential municipal solid waste burning assumes that if a county has an urban population that exceeds 80% of the total population, the amount of waste burned is ______ percent.
    a. 0
    b. 25
    c. 50
    d. 75

18. The activity data for land clearing debris burning is the same that is used for the _______ category.
    a. agricultural burning
    b. unpaved roads
    c. agricultural tilling
    d. construction

19. How many manure management trains have been identified for estimating ammonia emissions from animal husbandry operations?
    a. one
    b. one for each type of animal
    c. six
    d. fifteen

20. Developing VMT data for use in conjunction with MOBILE 6.2 can be done by using _______ distributions of VMT.
    a. roadway type
    b. time-weighted
    c. speed
    d. population-weighted

Name: ___________________________

PREPARATION OF FINE PARTICULATE EMISSION INVENTORIES
FINAL EXAM ANSWER SHEET

Instructions: Circle the appropriate answer on this Answer Sheet

1.	A	B	C	D
2.	A	B	C	D
3.	A	B	C	D
4.	A	B	C	D
5.	A	B	C	D
6.	A	B	C	D
7.	A	B	C	D
8.	A	B	C	D
9.	A	B	C	D
10.	A	B	C	D
11.	A	B	C	D
12.	A	B	C	D
13.	A	B	C	D
14.	A	B	C	D
15.	A	B	C	D
16.	A	B	C	D
17.	A	B	C	D
18.	A	B	C	D
19.	A	B	C	D
20.	A	B	C	D

Preparation of Fine Particulate Emission Inventories

Final Exam- Instructor's Version

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    b. agricultural tilling
    c. wood stoves
    d. land clearing debris burning

17. The NEI methodology for residential municipal solid waste burning assumes that if a county has an urban population that exceeds 80% of the total population, the amount of waste burned is ______ percent.
    a. 0
    b. 25
    c. 50
    d. 75

18. The activity data for land clearing debris burning is the same that is used for the _______ category.
    a. agricultural burning
    b. unpaved roads
    c. agricultural tilling
    d. construction

19. How many manure management trains have been identified for estimating ammonia emissions from animal husbandry operations?
    a. one
    b. one for each type of animal
    c. six
    d. fifteen

20. Developing VMT data for use in conjunction with MOBILE 6.2 can be done by using ________ distributions of VMT.
    a. roadway type
    b. time-weighted
    c. speed
    d. population-weighted

Name: ____________________________

PREPARATION OF FINE PARTICULATE EMISSION INVENTORIES
FINAL EXAM ANSWER SHEET – INSTRUCTOR VERSION

Instructions: Circle the appropriate answer on this Answer Sheet

1.	**A**	B	C	D
2.	A	B	**C**	D
3.	A	**B**	C	D
4.	A	B	C	**D**
5.	**A**	B	C	D
6.	A	B	C	**D**
7.	A	B	C	**D**
8.	**A**	B	C	D
9.	**A**	B	C	D
10.	A	B	**C**	D
11.	**A**	B	C	D
12.	A	B	**C**	D
13.	A	B	C	**D**
14.	**A**	B	C	D
15.	A	B	C	**D**
16.	**A**	B	C	D
17.	**A**	B	C	D
18.	A	B	C	**D**
19.	A	B	C	**D**
20.	**A**	B	C	D