2017 National Emissions Inventory: January 2021 Updated Release, Technical Support Document

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U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Assessment Division
Emissions Inventory and Analysis Group
Research Triangle Park, NC

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Acronyms and Chemical Notations

AERR	Air Emissions Reporting Rule
APU	Auxiliary power unit
BEIS	Biogenics Emissions Inventory System
C1	Category 1 (commercial marine vessels)
C2	Category 2 (commercial marine vessels)
C3	Category 3 (commercial marine vessels)
CAMD	Clean Air Markets Division (of EPA Office of Air and Radiation)
CAP	Criteria Air Pollutant
CBM	Coal bed methane
CDL	Cropland Data Layer
CEC	North American Commission for Environmental Cooperation
CEM	Continuous Emissions Monitoring
CENRAP	Central Regional Air Planning Association
CERR	Consolidated Emissions Reporting Rule
CFR	Code of Federal Regulations
CH4	Methane
CMU	Carnegie Mellon University
CMV	Commercial marine vessels
CNG	Compressed natural gas
CO	Carbon monoxide
CO2	Carbon dioxide
CSV	Comma Separated Variable
dNBR	Differenced normalized burned ratio
E10	10% ethanol gasoline
EDMS	Emissions and Dispersion Modeling System
EF	emission factor
EGU	Electric Generating Utility
EIS	Emission Inventory System
EAF	Electric arc furnace
EF	Emission factor
EI	Emissions Inventory
EIA	Energy Information Administration
EMFAC	Emission FACtor (model) – for California
EPA	Environmental Protection Agency
ERG	Eastern Research Group
ERTAC	Eastern Regional Technical Advisory Committee
FAA	Federal Aviation Administration
FACTS	Forest Service Activity Tracking System
FCCS	Fuel Characteristic Classification System
FETS	Fire Emissions Tracking System
FWS	United States Fish and Wildlife Service
FRS	Facility Registry System
GHG	Greenhouse gas
GIS	Geographic information systems
GPA	Geographic phase-in area

GSE	Ground support equipment
HAP	Hazardous Air Pollutant
HCl	Hydrogen chloride (hydrochloric acid)
Hg	Mercury
HMS	Hazard Mapping System
ICR	Information collection request
I/M	Inspection and maintenance
IPM	Integrated Planning Model
KMZ	Keyhole Markup Language, zipped (used for displaying data in Google Earth
LRTAP	Long-range Transboundary Air Pollution
LTO	Landing and takeoff
LPG	Liquified Petroleum Gas
MARAMA	Mid-Atlantic Regional Air Management Association
MATS	Mercury and Air Toxics Standards
MCIP	Meteorology-Chemistry Interface Processor
MMT	Manure management train
MOBILE6	Mobile Source Emission Factor Model, version 6
MODIS	Moderate Resolution Imaging Spectroradiometer
MOVES	Motor Vehicle Emissions Simulator
MW	Megawatts
MWC	Municipal waste combustors
NAA	Nonattainment area
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industry Classification System
NARAP	North American Regional Action Plan
NASF	National Association of State Foresters
NASS	USDA National Agriculture Statistical Service
NATA	National Air Toxics Assessment
NCD	National County Database
NEEDS	National Electric Energy Data System (database)
NEI	National Emissions Inventory
NESCAUM	Northeast States for Coordinated Air Use Management
NFEI	National Fire Emissions Inventory
NG	Natural gas
NH$_3$	Ammonia
NMIM	National Mobile Inventory Model
NO	Nitrous oxide
NO2	Nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrogen oxides
O3	Ozone
OAQPS	Office of Air Quality Standards and Planning (of EPA)
OEI	Office of Environmental Information (of EPA)
ORIS	Office of Regulatory Information Systems
OTAQ	Office of Transportation and Air Quality (of EPA)
PADD	Petroleum Administration for Defense Districts

PAH	Polycyclic aromatic hydrocarbons
Pb	Lead
PCB	Polychlorinated biphenyl
PM	Particulate matter
PM25-CON	Condensable PM2.5
PM25-FIL	Filterable PM2.5
PM25-PRI	Primary PM2.5$_5$ (condensable plus filterable)
PM2.5	Particulate matter 2.5 microns or less in diameter
PM10	Particular matter 10 microns or less in diameter
PM10-FIL	Filterable PM10
PM10-PRI	Primary PM10
POM	Polycyclic organic matter
POTW	Publicly Owned Treatment Works
PSC	Program system code (in EIS)
RFG	Reformulated gasoline
RPD	Rate per distance
RPP	Rate per profile
RPV	Rate per vehicle
RVP	Reid Vapor Pressure
Rx	Prescribed (fire)
SCC	Source classification code
SEDS	State Energy Data System
SFv1	SMARTFIRE version 1
SFv2	SMARTFIRE version 2
S/L/T	State, local, and tribal (agencies)
SMARTFIRE	Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation
SMOKE	Sparse Matrix Operator Kernel Emissions
SO2	Sulfur dioxide
SO4	Sulfate
TAF	Terminal Area Forecasts
TEISS	Tribal Emissions Inventory Software Solution
TRI	Toxics Release Inventory
UNEP	United Nations Environment Programme
USDA	United States Department of Agriculture
VMT	Vehicle miles traveled
VOC	Volatile organic compounds
USFS	United States Forest Service
WebFIRE	Factor Information Retrieval System
WFU	Wildland fire use
WLF	Wildland fire
WRAP	Western Regional Air Partnership
WRF	Weather Research and Forecasting Model

1   Introduction

The Environmental Protection Agency (EPA) has released a revised complete 2017 National Emissions Inventory (NEI). The EPA has released one prior complete release of the 2017 NEI (April 2020) and two prior versions of the 2017 NEI containing some, but not all, data categories. This January 2021 update of the full 2017 NEI release supersedes the initial (complete) April 2020 release and the previous partial releases from February 2020 and August 2019. The 2017 NEI was the first inventory that EPA released incrementally prior to this full release. This updated January 2021 release of the 2017 NEI is available on the web at the 2017 NEI Data page. This is the final public release of the 2017 NEI.

1.1   Why are we releasing a January 2021 update for the 2017 NEI?

The point source inventory is revised from the April 2020 version of the 2017 NEI to reflect a correction to aircraft estimates. A full discussion of the aircraft correction is discussed in Section 3.2.3 "January 2021 correction to aircraft estimates".

In addition, quality assurance efforts by EPA and state agencies continued, resulting in some additional facility and process level changes for several states. These changes are discussed in Section 3.1.1.1.

The EPA recompiled the point inventory in June 2020 in the Emissions Inventory System (EIS), but until now, these data have only been available to state, local, and tribal users via the EIS. This January 2021 updated release simply absorbs this June 2020 EIS update into the full 2017 NEI. All data summaries in this document and on the 2017 NEI Data page reflect this updated point inventory; however, there are no changes to any other data categories from the initial complete release of the 2017 NEI in April 2020.

From the remainder of this document "2017 NEI" is used to represent this updated January 2021 release of the 2017 NEI.

1.2   What data are included in the 2017 NEI release update (January 2021)?

The NEI is a national compilation of air emission estimates of criteria air pollutants (CAPs), the precursors of CAPs, and hazardous air pollutants (HAPs). The hazardous air pollutants that are included in the NEI are based on Section 112(b) of the Clean Air Act. State, local and tribal (S/L/T) air agencies submit emission estimates to EPA and the Agency adds information from EPA emissions programs, such as the emission trading program, Toxics Release Inventory (TRI), and data collected during rule development or compliance testing. The NEI includes estimates of emissions from stationary sources (large and small industries, commercial, institutional and consumer), mobile sources, fires and biogenic emissions. EPA uses the NEI in rule development, non-attainment area designations, and as an input to various reports and assessments. This document discusses all components of the NEI and where useful, highlights differences between the 2017 NEI and the most-recent publicly-available full NEI release, Version 2 of the 2014v2 NEI (2014v2 NEI). The NEI program develops datasets, blends data from these multiple sources, and performs data processing steps that further enhance, quality assure, and augment the compiled data.

The emissions data in the NEI are compiled at different levels of granularity, depending on the data category. For point sources (in general, large facilities), emissions are inventoried at a process-level within a facility. The point data are collected from S/L/T air agencies and the EPA emissions programs including the TRI, the Acid Rain Program, and Maximum Achievable Control Technology (MACT) standards development. For nonpoint sources (typically smaller, yet pervasive sources) and mobile sources (both onroad and nonroad), emissions are given as

county totals. For marine vessel and railroad in-transit sources, emissions are given at the sub-county polygon shape-level. For wildfires and prescribed burning, the data are compiled as day-specific, coordinate-specific (similar to point) events in the "event" portion of the inventory, and these emission estimates are further stratified by smoldering and flaming components.

The pollutants included in the NEI are the pollutants associated with the National Ambient Air Quality Standards (NAAQS), known as CAPs, as well as HAPs associated with EPA's Air Toxics Program. The CAPs have ambient concentration limits or are precursors for pollutants with such limits from the NAAQS program. These pollutants include lead (Pb), carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOCs), sulfur dioxide (SO2), particulate matter 10 microns or less (PM10), particulate matter 2.5 microns or less (PM2.5), and ammonia (NH3), which is technically not a CAP, but an important PM precursor. The HAP pollutants include the 187 remaining HAP pollutants (methyl ethyl ketone was removed) from the original 188 listed in Section 112(b) of the 1990 Clean Air Act Amendments[1]. There are many different types of HAPs. For example, some are acid gases such as hydrochloric acid (HCl); others are heavy metals such as mercury (Hg), nickel and cadmium; and others are organic compounds such as benzene, formaldehyde, and acetaldehyde. Greenhouse gases (GHGs) are included in the NEI for fires, mobiles sources, and point sources where reported.

1.3   What is included in this documentation?

This technical support document (TSD) provides a reference for the 2017 NEI (updated January 2021) release. The primary purpose of this document is to explain the sources of information included in the inventory. This includes showing the sources of data and types of sources that are used for each data category, and then providing more information about the EPA-created components of the data. After the introductory material included in this section, Section 2 provides an overview of the contents of the inventory and some high-level summaries, including comparisons to the 2014v2 NEI. Section 2 also provides a summary on the mercury emissions. Section 3 provides an overview of point sources. Section 4 provides information about nonpoint sources, including descriptions by source category or sector of the EPA emission estimates and tools. Biogenic emissions, which are released with the nonpoint data category, are also discussed in Section 4. Sections 5 and 6 provide information for the nonroad mobile and onroad mobile data categories, respectively. Fires (wild and prescribed burning) are discussed in Section 7.

1.4   Where can I obtain the 2017 NEI data?

The 2017 NEI data are available in several different ways listed below. Data are available to the reporting agencies and EPA staff via the Emission Inventory System (EIS).

1.4.1   Emission Inventory System Gateway

The EIS Gateway is available to all EPA staff, EIS data submitters (i.e., the S/L/T air agency staff), Regional Planning Organization staff that support state, local and tribal agencies, and contractors working for the EPA on emissions related work. The EIS reports functions can be used to obtain raw input datasets and create summary files from these datasets as well as older versions of the NEI such as 2014, 2011, and 2008. The 2017 NEI *dataset* in the EIS is called "2017NEI" ("2017NEI_Apr2020" was the prior full 2017 NEI release). Note that if you run facility-, unit- or process-level reports in the EIS, you will get the 2017 NEI emissions, but the facility inventory, which is dynamic in the EIS, will reflect more current information. For example, if an Agency ID has been changed since the time we ran the reports for the public website (June 2020), then that new Agency ID will be in

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[1] The original of HAPs is available on the EPA Technology Transfer Network – Air Toxics Web Site.

the Facility Inventory or a Facility Configuration report in the EIS but not in the report on the public website nor the Facility Emissions Summary reports run on the "2017NEI" dataset in the EIS.

1.4.2 NEI main webpage

Next, data from the EIS are exported for public release on the 2017 NEI Data webpage. The 2017 NEI Data page includes the most recent **publicly**-available version of the 2017 NEI. The 2017 NEI webpage includes the 2017 NEI plan and schedules, all publicly-available supporting materials by inventory data category (e.g., point, nonpoint, nonroad mobile, onroad mobile, events), and this TSD.

Two types of point data summaries are available on the 2017 NEI Data page, facility summaries and process-level summaries. The source classification codes (SCC) data files section of the webpage provides the process level summaries for all data categories. These detailed CSV files (provided in zip files) contain emissions at the process level. Due to their size, they are broken out into EPA regions. Facility-level by pollutant summaries are also available. These CSV files must be "linked" (as opposed to imported) to open them with Microsoft® Access®. County and tribe-level summaries for events are also provided.

The 2017 NEI Data page also includes a query tool that allows for summaries by EIS Sector (see Section) or the more traditional Tier 1 summary level (for CAPs only) used in the EPA Trends Report. Summaries from the 2017 NEI Data site include national-, state-, and county-level emissions for CAPs, HAPs and GHGs. You can choose which states, EIS Sectors, Tiers, and pollutants to include in custom-generated reports to download Comma Separated Value (CSV) files to import into Microsoft® Excel®, Access®, or other spreadsheet or database tools. Biogenic emissions and tribal data (but not tribal onroad emissions) are also available from this tool. Tribal summaries are also posted under the "Additional Summary Data" section of this page.

The 2017 NEI Documentation page includes links to the NEI TSD and supporting materials referenced in this TSD. This page is a working page, meaning that content is updated as new products are developed.

1.4.3 Modeling files

The modeling files, provided on the Air Emissions Modeling website, are provided in formats that can be read by the Sparse Matrix Operator Kernel Emissions (SMOKE). These files are also CSV formats that can be read by other systems, such as databases. The modeling files provide the process-level emissions apportioned to release points, and the release parameters for the release points. Release parameters include stack height, stack exit diameter, exit temperature, exit velocity and flow rate. The EPA may make changes to the NEI modeling files prior to use. The 2017 modeling platform is based on the 2017 NEI. Any changes between the NEI and modeling platform data will be described in an accompanying TSD for the 2017 Emissions Modeling Platform, which would also be posted at the above website.

The SMOKE flat file for the January 2021 updated version of the 2017 point inventory is called "File:2017NEI_point_full_20200618.zip". This file, and those for all other data categories, are posted on the 2017 NEI Flat Files FTP site.

1.5 Why is the NEI created?

The NEI is created to provide the EPA, federal, state, local and tribal decision makers, and the national and international public the best and most complete estimates of CAP and HAP emissions. While the EPA is not directly obligated to create the NEI, the Clean Air Act authorizes the EPA Administrator to implement data collection efforts needed to properly administer the NAAQS program. Therefore, the Office of Air Quality Planning and Standards (OAQPS) maintains the NEI program in support of the NAAQS. Furthermore, the Clean

Air Act requires States to submit emissions to the EPA as part of their State Implementation Plans (SIPs) that describe how they will attain the NAAQS. The NEI is used as a starting point for many SIP inventory development efforts and for states to obtain emissions from other states needed for their modeled attainment demonstrations.

While the NAAQS program is the basis on which the EPA collects CAP emissions from the S/L/T air agencies, it does not require collection of HAP emissions. For this reason, the HAP reporting requirements are voluntary. Nevertheless, the HAP emissions are an essential part of the NEI program. These emissions estimates allow EPA to assess progress in meeting HAP reduction goals described in the Clean Air Act amendments of 1990. These reductions seek to reduce the negative impacts to people of HAP emissions in the environment, and the NEI allows the EPA to assess how much emissions have been reduced since 1990.

1.6 How is the NEI created?

The Air Emissions Reporting Rule (AERR) is the regulation that requires state and local agencies to submit CAP emissions, and the Emissions Inventory System is the data system used to collect, QA, and compile those submittals as well as EPA augmentation data. Most S/L/T air agencies also provide voluntary submissions of HAP emissions. The 2008 NEI was the first inventory compiled using the AERR, rather than its predecessor, the Consolidated Emissions Reporting Rule (CERR). The 2017 NEI is the fourth AERR-based inventory, and improvements in the 2017 NEI process reflect lessons learned by the S/L/T air agencies and EPA from the prior NEI efforts. The AERR requires agencies to report all sources of emissions, except fires and biogenic sources. Reporting of open fire sources, such as wildfires, is encouraged, but not required. Sources are divided into large groups called "data categories": stationary sources are "point" or "nonpoint" (county totals) and mobile sources are either onroad (cars and trucks driven on roads) or nonroad (locomotives, aircraft, marine, off-road vehicles and nonroad equipment such as lawn and garden equipment).

The AERR has emissions thresholds above which States must report stationary emissions as "point" sources, with the remainder of the stationary emissions reported as "nonpoint" sources.

The AERR changed the way these reporting thresholds work, as compared to the CERR, by changing these thresholds to "potential to emit" thresholds rather than actual emissions thresholds. In both the CERR and the AERR, the emissions that are reported are actual emissions, despite that the criteria for which sources to report is now based on potential emissions. The AERR requires emissions reporting for point sources every year, with additional requirements every third year in the form of lower point source emissions thresholds, and 2017 is one of these third-year inventories.

Table 1-1 provides the potential-to-emit reporting thresholds that applied for the 2017 NEI cycle. "Type B" is the terminology in the rule that represents the lower emissions thresholds required for point sources in the triennial years. The reporting thresholds are sources with potential to emit of 100 tons/year or more for most criteria pollutants, with the exceptions of CO (1000 tons/year), and, updated starting with the 2014 inventory, Pb (0.5 tons/year, actual). As shown in the table, special requirements apply to nonattainment area (NAA) sources, where even lower thresholds apply. The relevant ozone (O3), CO, and PM10 nonattainment areas that applied during the year that the S/L/T agencies submitted their data for the 2017 NEI are available on the Nonattainment Areas for Criteria Pollutants (Green Book) web site.

Table 1-1: Point source reporting thresholds (potential to emit) for CAPs in the AERR

	Triennial reporting thresholds[1]	
Pollutant	Type B Sources	Thresholds within Nonattainment Areas

(1) SO_2	≥100	≥100
(2) VOC	≥100	O_3(moderate) ≥ 100
		O_3 (serious) ≥ 50
		O_3 (severe) ≥ 25
		O_3 (extreme) ≥ 10
(3) NO_x	≥100	≥100
(4) CO	≥1000	O_3 (all areas) ≥ 100
		CO (all areas) ≥ 100
(5) Lead	≥0.5 (actual)	≥0.5 (actual)
(6) Primary PM_{10}	≥100	PM_{10}(moderate) ≥100
		PM_{10}(serious) ≥70
(7) Primary $PM_{2.5}$	≥100	≥100
(8) NH_3	≥100	≥100

[1] Thresholds for point source determination shown in tons per year of potential to emit as defined in 40 CFR part 70, with the exception of lead.

Based on the AERR requirements, S/L/T air agencies submit emissions or model inputs of point, nonpoint, onroad mobile, nonroad mobile, and fires emissions sources. With the exception of California, reporting agencies were required to submit model inputs for onroad and nonroad mobile sources instead of emissions. For the 2017 NEI, all these emissions and inputs were required to be submitted to the EPA per the AERR by December 31, 2018 (with an extension given through January 15, 2019). Once the initial reporting NEI period closed, the EPA provided feedback on data quality such as suspected outliers and missing data by comparing to previously established emissions ranges and past inventories. In addition, the EPA augmented the S/L/T data using various sources of data and augmentation procedures. This documentation provides a detailed account of EPA's quality assurance and augmentation methods.

1.7 Who are the target audiences for the 2017 NEI?

The comprehensive nature of the NEI allows for many uses and, therefore, its target audiences include EPA staff and policy makers, the U.S. public, other federal and S/L/T decision makers, and other countries. Table 1-2 below lists the major current uses of the NEI and the plans for use of the 2017 NEI in those efforts. These uses include those by the EPA in support of the NAAQS, Air Toxics, and other programs as well as uses by other federal and regional agencies and for international needs. In addition to this list, the NEI is used to respond to Congressional inquiries, provide data that supports university research, and allow environmental groups to understand sources of air pollution.

Table 1-2: Examples of major current uses of the NEI

Audience	Purposes
U.S. Public	Learn about sources of air emissions
EPA – NAAQS	Regulatory Impact Analysis – benefits estimates using air quality modeling
	NAAQS Implementations, including State Implementation Plans (SIPs)
	Monitoring Rules
	Final NAAQS designations
	NAAQS Policy Assessments
	Integrated Science Assessments
	Transport Rule air quality modeling (e.g., Clean Air Interstate Rule, Cross-State Air Pollution Rule)
EPA – Air toxics	National Air Toxics Assessment (NATA)
	Mercury and Air Toxics Standard – mercury risk assessment and Regulatory Impact Assessment

Audience	Purposes
	National Monitoring Programs Annual Report
	Toxicity Weighted emission trends for the Government Performance and Reporting Act (GPRA)
	Residual Risk and Technology Review – starting point for inventory development
EPA – other	NEI Reports – analysis of emissions inventory data
	Report on the Environment
	Air Emissions website for providing graphical access to CAP emissions for state maps and Google Earth views of facility total emissions
	Department of Transportation, national transportation sector summaries of CAPs
	Black Carbon Report to Congress
Other federal or regional agencies	Modeling in support of Regional Haze SIPs and other air quality issues
International	United Nations Environment Programme (UNEP) – global and North American Assessments
	The Organization for Economic Co-operation and Development (OECD) - environmental data and indicators report
	UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP) - emission reporting requirements, air quality modeling, and science assessments
	Community Emissions Data System (CEDS) - science network for earth system, climate, and atmospheric modeling
	Commission for Environmental Cooperation (CEC) - North American emissions inventory improvement and reduction policies
	U.S. and Canada Air Quality Reports
	Arctic Contaminants Action Program (ACAP) - national environmental and emission reduction strategy for the Arctic Region
Other outside parties	Researchers and graduate students

1.8   What are appropriate uses of the 2017 NEI and what are the caveats about the data?

As shown in the preceding section, the NEI provides a readily-available comprehensive inventory of both CAP and HAP emissions to meet a variety of user needs. Although the accuracy of individual emissions estimates will vary from facility-to-facility or county-to-county, the NEI largely meets the needs of these users in the aggregate. Some NEI users may wish to evaluate and revise the emission estimates for specific pollutants from specific source types for either the entire U.S. or for smaller geographical areas to meet their needs. Regulatory uses of the NEI by the EPA, such as for interstate transport, always include a public review and comment period. Large-scale assessment uses, such as the NATA study, also provide review periods and can serve as an effective screening tool for identifying potential risks.

One of the primary goals of the NEI is to provide the best assessment of current emissions levels using the data, tools and methods currently available. For significant emissions sectors of key pollutants, the available data, tools and methods typically evolve over time in response to identified deficiencies and the need to understand the costs and benefits of proposed emissions reductions. As these method improvements have been made, there have not been consistent efforts to revise previous NEI year estimates to use the same methods as the current year. Therefore, care must be taken when reviewing different NEI year publications as a time series with the goal of determining the trend or difference in emissions from year to year. An example of such a method change in the 2008 NEI v3 and 2011 NEI is the use of the Motor Vehicle Emissions Simulator (MOVES) model for the onroad data category. Previous NEI years had used the Mobile Source Emission Factor Model, version 6 (MOBILE6) and earlier versions of the MOBILE model for this data category. The 2011 NEI (2011v2) also used an older version of MOVES (2014) that has been updated in the current 2017 NEI (MOVES2014b). The current version of MOVES also calculates nonroad equipment emissions, adding VOCs and toxics, updating the gasoline

fuels used for nonroad equipment to be consistent with those used for onroad vehicles. These changes in MOVES lead to a small increase in nonroad NO_X emissions in some locations, introducing additional uncertainty when comparing 2017 NEI to past inventories.

Other significant emissions sectors have also had improvements and, therefore, trends are also impacted by inconsistent methods. Examples include paved and unpaved road PM emissions, ammonia fertilizer and animal waste emissions, oil and gas production, residential wood combustion, solvents, industrial and commercial/institutional fuel combustion and commercial marine vessel emissions.

Users should take caution in using the emissions data for filterable and condensable components of particulate matter (PM10-FIL, PM2.5-FIL and PM-CON), which is not complete and should not be used at any aggregated level. These data are provided for users who wish to better understand the components of the primary PM species, where they are available, in the disaggregated, process-specific emissions reports. Where not reported by S/L/T agencies, the EPA augments these components (see Section 2.2.4). However, not all sources are covered by this routine, and in mobile source and fire models, only the primary particulate species are estimated. Thus, users interested in PM emissions should use the primary species of particulate matter (PM10-PRI and PM25-PRI), described in this document simply as PM10 and PM2.5.

2   2017 NEI contents overview

2.1   What are EIS sectors?

First used for the 2008 NEI, EIS Sectors continue to be used for all 2017 NEI data categories. The sectors were developed to better group emissions for both CAP and HAP summary purposes. The sectors are based simply on grouping the emissions by the emissions process as indicated by the SCC to an EIS sector. In building this list, we gave consideration not only to the types of emissions sources our data users most frequently ask for, but also to the need to have a relatively concise list in which all sectors have a significant amount of emissions of at least one pollutant. The SCC-EIS Sector cross-walk used for the summaries provided in this document is available for download from the Source Classification Codes (SCCs) website. No changes were made to the SCC-mapping or sectors used for the 2017 NEI except where SCCs were retired, or new SCCs were added.

Some of the sectors include the nomenclature "NEC," which stands for "not elsewhere classified." This simply means that those emissions processes were not appropriate to include in another EIS sector and their emissions were too small individually to include as its own EIS sector.

Since the 2008 NEI, the inventory has been reported and compiled in EIS using five major data categories: point, nonpoint, onroad, nonroad and events. The event category is used to compile day-specific data from prescribed burning and wildfires. While events could be other intermittent releases such as chemical spills and structure fires, prescribed burning and wildfires have been a focus of the NEI creation effort and are the only emission sources contained in the event data category.

Table 2-1 shows the EIS sectors or source category component of the EIS sector in the left most column. EIS data categories -Point, Nonpoint, Onroad, Nonroad, and Events- that have emissions in these sectors/source categories are also reflected.

As Table 2-1 illustrates, many EIS sectors include emissions from more than one EIS data category because the EIS sectors are compiled based on the type of emissions sources rather than the data category. Note that the emissions summary sector "Mobile – Aircraft" is reported partly to the point and partly to the nonpoint data categories and "Mobile – Commercial Marine Vessels" and "Mobile – Locomotives" are reported to the nonpoint data category. We include biogenics emissions, "Biogenics - Vegetation and Soil," in the nonpoint data category in the EIS; however, we document biogenics in its own Section (8). NEI users who aggregate emissions by EIS data category rather than EIS sector should be aware that these changes will give differences from historical summaries of "nonpoint" and "nonroad" data unless care is taken to assign those emissions to the historical grouping.

Table 2-1: EIS sectors/source categories with EIS data category emissions reflected

Component EIS Sector or EIS Sector: Source Category Name	Point	Nonpoint	Onroad	Nonroad	Event
Agriculture - Crops & Livestock Dust		☑			
Agriculture - Fertilizer Application		☑			
Agriculture - Livestock Waste	☑	☑			
Biogenics - Vegetation and Soil		☑			

Component EIS Sector or EIS Sector: Source Category Name	Point	Nonpoint	Onroad	Nonroad	Event
Bulk Gasoline Terminals	☑	☑			
Commercial Cooking		☑			
Dust - Construction Dust	☑	☑			
Dust - Paved Road Dust		☑			
Dust - Unpaved Road Dust		☑			
Fires - Agricultural Field Burning		☑			
Fires - Prescribed Burning					☑
Fires - Wildfires					☑
Fuel Comb - Comm/Institutional - Biomass	☑	☑			
Fuel Comb - Comm/Institutional - Coal	☑	☑			
Fuel Comb - Comm/Institutional - Natural Gas	☑	☑			
Fuel Comb - Comm/Institutional - Oil	☑	☑			
Fuel Comb - Comm/Institutional - Other	☑	☑			
Fuel Comb - Electric Generation - Biomass	☑				
Fuel Comb - Electric Generation - Coal	☑				
Fuel Comb - Electric Generation - Natural Gas	☑				
Fuel Comb - Electric Generation - Oil	☑				
Fuel Comb - Electric Generation - Other	☑				
Fuel Comb - Industrial Boilers, ICEs - Biomass	☑	☑			
Fuel Comb - Industrial Boilers, ICEs - Coal	☑	☑			
Fuel Comb - Industrial Boilers, ICEs - Natural Gas	☑	☑			
Fuel Comb - Industrial Boilers, ICEs - Oil	☑	☑			
Fuel Comb - Industrial Boilers, ICEs - Other	☑	☑			
Fuel Comb - Residential - Natural Gas		☑			
Fuel Comb - Residential - Oil		☑			
Fuel Comb - Residential - Other		☑			
Fuel Comb - Residential - Wood		☑			
Gas Stations	☑	☑	☑		
Industrial Processes - Cement Manufacturing	☑				
Industrial Processes - Chemical Manufacturing	☑	☑			
Industrial Processes - Ferrous Metals	☑				
Industrial Processes - Mining	☑	☑			
Industrial Processes - NEC	☑	☑			
Industrial Processes - Non-ferrous Metals	☑	☑			
Industrial Processes - Oil & Gas Production	☑	☑			
Industrial Processes - Petroleum Refineries	☑	☑			
Industrial Processes - Pulp & Paper	☑				
Industrial Processes - Storage and Transfer	☑	☑			
Miscellaneous Non-Industrial NEC: Residential Charcoal Grilling		☑			

Component EIS Sector or EIS Sector: Source Category Name	Point	Nonpoint	Onroad	Nonroad	Event
Miscellaneous Non-Industrial NEC: Portable Gas Cans		☑			
Miscellaneous Non-Industrial NEC: Nonpoint Hg		☑			
Miscellaneous Non-Industrial NEC (All other)	☑	☑			
Mobile – Aircraft	☑				
Mobile - Commercial Marine Vessels		☑			
Mobile – Locomotives	☑	☑			
Mobile - NonRoad Equipment – Diesel	☑			☑	
Mobile - NonRoad Equipment – Gasoline	☑			☑	
Mobile - NonRoad Equipment – Other	☑			☑	
Mobile - Onroad – Diesel Heavy Duty Vehicles			☑		
Mobile - Onroad – Diesel Light Duty Vehicles			☑		
Mobile - Onroad – Gasoline Heavy Duty Vehicles			☑		
Mobile - Onroad – Gasoline Light Duty Vehicles			☑		
Solvent - Consumer & Commercial Solvent Use: Agricultural Pesticides		☑			
Solvent - Consumer & Commercial Solvent Use: Asphalt Paving		☑			
Solvent - Consumer & Commercial Solvent Use: All Other Solvents		☑			
Solvent - Degreasing	☑	☑			
Solvent - Dry Cleaning	☑	☑			
Solvent - Graphic Arts	☑	☑			
Solvent - Industrial Surface Coating & Solvent Use	☑	☑			
Solvent - Non-Industrial Surface Coating		☑			
Waste Disposal: Open Burning		☑			
Waste Disposal: Nonpoint POTWs		☑			
Waste Disposal: Human Cremation		☑			
Waste Disposal: Nonpoint Hg		☑			
Waste Disposal (all remaining sources)	☑	☑			

2.2 How is the NEI constructed?

Data in the NEI come from a variety of sources. The emissions are predominantly from S/L/T agencies for both CAP and HAP emissions. In addition, the EPA quality assures and augments the data provided by states to assist with data completeness, particularly with the HAP emissions since the S/L/T HAP reporting is voluntary.

The NEI is built by data category for point, nonpoint, nonroad mobile, onroad mobile and events. Each data category contains emissions from various reporters in multiple datasets which are blended to create the final NEI "selection" for that data category. Each data category selection includes S/L/T data and numerous other datasets that are discussed in more detail in each of the following sections in this document. In general, S/L/T data take precedence in the selection hierarchy, which means that it supersedes any other data that may exist for a specific county/tribe/facility/process/pollutant. In other words, the selection hierarchy is built such that the preferred source of data, usually S/L/T, is chosen when multiple sources of data are available. There are

exceptions, to this general rule, which arise based on quality assurance checks and feedback from S/L/Ts that we will discuss in later sections.

The EPA uses augmentation and additional EPA datasets to create the most complete inventory for stakeholders, for use in such applications as NATA, air quality modeling, national rule assessments, international reporting, and other reports and public inquiries. Augmentation to S/L/T data, in addition to EPA datasets, fill in gaps for sources and/or pollutants often not reported by S/L/T agencies. The basic types of augmentation are discussed in the following sections.

2.2.1 Toxics Release Inventory data

The EPA used air emissions data from the 2017 Toxics Release Inventory (TRI) to supplement point source HAP and NH3 emissions provided to EPA by S/L/T agencies. For 2017, all TRI emissions values that could reasonably be matched to an EIS facility with some certainty and with limited risk of double-counting nonpoint emissions were loaded into the EIS for viewing and comparison if desired, but only those pollutants that were not reported anywhere at the EIS facility by the S/L/T agency were included in the 2017 NEI.

The TRI is an EPA database containing data on disposal or other releases including air emissions of over 650 toxic chemicals from approximately 21,000 facilities. One of TRI's primary purposes is to inform communities about toxic chemical releases to the environment. Data are submitted annually by U.S. facilities that meet TRI reporting criteria. Section 3 provides more information on how TRI data was used to supplement the point inventory.

2.2.2 Chromium speciation

The 2017 reporting cycle included 5 valid pollutant codes for chromium, as shown in Table 2-2.

Table 2-2: Valid chromium pollutant codes

Pollutant Code	Description	Pollutant Category Name	Speciated?
1333820	Chromium Trioxide	Chromium Compounds	yes
16065831	Chromium III	Chromium Compounds	yes
18540299	Chromium (VI)	Chromium Compounds	yes
7440473	Chromium	Chromium Compounds	no
7738945	Chromic Acid (VI)	Chromium Compounds	yes

In the above table, all pollutants but "chromium" are considered speciated, and so for clarity, chromium (pollutant 7440473) is referred to as "total chromium" in the remainder of this section. Total chromium could contain a mixture of chromium with different valence states. Since one key inventory use is for risk assessment, and since the valence states of chromium have very different risks, speciated chromium pollutants are the most useful pollutants for the NEI. Therefore, the EPA speciates S/L/T-reported and TRI-based total chromium into hexavalent chromium and non-hexavalent chromium. Hexavalent chromium, or Chromium (VI), is considered high risk and other valence states are not. Most of the non-hexavalent chromium is trivalent chromium (Chromium III); therefore, the EPA characterized all non-hexavalent chromium as trivalent chromium. The 2017 NEI does not contain any total chromium, only the speciated pollutants shown in Table 2-2.

This section describes the procedure we used for speciating chromium emissions from total chromium that was reported by S/L/T agencies.

We used the EIS augmentation feature to speciate S/L/T agency reported total chromium. For point sources, the EIS uses the following priority order for applying the factors:

1) By Process ID
2) By Facility ID
3) By County
4) By State
5) By Emissions Type (for NP only)
6) By SCC
7) By Regulatory Code
8) By NAICS
9) A Default value if none of the others apply

If a particular emissions source of total chromium is not covered by the speciation factors specified by any of the first 8 attributes, a default value of 34 percent hexavalent chromium, 66 percent trivalent chromium is applied.

For the 2017 chromium augmentation, only the "By Facility ID" (2), "By SCC" (6), and "By Default" (9) were used on S/L/T-reported total chromium values. For TRI dataset chromium, the "By NAICS" (8) option was primarily used, although a small number of "By Facility" (2) occurrences were used rather than NAICS. The EIS generates and stores an EPA dataset containing the resultant hexavalent and trivalent chromium species. For all other data categories (e.g., nonpoint, onroad and nonroad), chromium speciation is performed at the SCC level.

This procedure generated hexavalent chromium (Chromium (VI)) and trivalent chromium (Chromium III), and it had no impact on S/L/T agency data that were provided as one of the speciated forms of chromium. The sum of the EPA-computed species (hexavalent and trivalent chromium) equals the mass of the total chromium (i.e., pollutant 7440473) submitted by the S/L/T agencies.

The EPA then used this dataset in the 2017 NEI selection by adding it to the data category-specific selection hierarchy and by excluding the S/L/T agency unspeciated chromium from the selection through a pollutant exception to the hierarchy.

Most of the speciation factors used in the 2017 NEI are SCC-based and are the same as were used in 2011 and 2014, based on data that have long been used by the EPA for NATA and other risk projects. However, some values are updated with every inventory cycle. New data may be developed by OAQPS during rule development or review of NATA data. The speciation factors are accessed in the EIS through the reference data link "Augmentation Profile Information." A chromium speciation "profile" is a set of output multiplication factors for a type of emissions source. The profile data for chromium are stored in the same tables as the HAP augmentation factors described in Section 2.2.3. The speciation factors are a specific case of HAP augmentation whereby the "output pollutants" are always hexavalent chromium and trivalent chromium, and the "input pollutant" is always chromium. There are 3 main tables and a summary table. The summary table excludes the metadata and comments regarding the derivation of the factors and assignment to SCCs; to learn more of the derivation of the factor or assignment of "profile" to a source, the main tables (not summary table) should be consulted.

The three main tables are:

- Augmentation Profile Names and Input Pollutants – general information about the profile and source of the profile names and factors.
- Augmentation Multiplication Factors – provides the output pollutants and multiplication factors associated with a given Augmentation Profile and input pollutant.
- Augmentation Assignments – provides the assignment of the profile to the data source (the list of 9 items above).

The summary table is the Augmentation Multiplication Factors and Assignments, a composite table that provides a view of all the combinations of output pollutants and assignment information associated with a given profile.

For non-EIS users, the data from the main tables were downloaded and provided as described in Section 3 (3.1.4-S/L/T chromium speciation, 3.1.6 – TRI chromium speciation and 3.1.6, HAP augmentation).

2.2.3   HAP augmentation

The EPA supplements missing HAPs in S/L/T agency-reported data. HAP emissions are calculated by multiplying appropriate surrogate CAP emissions by an emissions ratio of HAP to CAP emission factors. For the 2017 NEI, we augmented HAPs for the point and nonpoint data categories. Generally, for point sources, the CAP-to-HAP ratios were computed using uncontrolled emission factors from the WebFIRE database (which contains primarily AP-42 emissions factors). For nonpoint sources, the ratios were computed from the EPA-generated nonpoint data, which contain both CAPs and HAPs where applicable.

HAP augmentation is performed on each emissions source (i.e., specific facility and process for point sources, county and process level for nonpoint sources) using the same EIS augmentation feature as described in chromium speciation. However, unlike chromium speciation, there is no default augmentation factor so that not every process that has S/L/T CAP data will end up with augmented HAP data.

HAP augmentation input pollutants are S/L/T-submitted VOC, PM10-PRI, PM25-PRI, SO2, and PM10-FIL. The resulting output can be a single output pollutant or a full suite of output pollutants. Not every source that has a CAP undergoes HAP augmentation (i.e., livestock NH3 and fugitive dust PM25-PRI). The sum of the HAP augmentation factors does not need to equal 1 (100%); however, we try to ensure, for example, that the sum of HAP-VOC factors is less than 1 for mass balance. HAP augmentation factors are grouped into profiles that contain unique output pollutant factors related to a type of source. Assigning these profiles to the individual sources depends on the source attributes, commonly the SCC.

There are business rules specific to each data category discussed in the point (Section 3.1.6) and nonpoint (4.1.6) sections of the TSD. The ultimate goal is to prevent double-counting of HAP emissions between S/L/T data and the EPA HAP augmentation output, and to prevent, where possible, adding HAP emissions to S/L/T-submitted processes that are not desired. NEI developers use their judgment on how to apply HAP augmentation to the resulting NEI selection.

Caveats

HAP augmentation does have limitations; HAP and CAP emission factors from WebFIRE do not necessarily use the same test methods. In some situations, the VOC emission factor is less than the sum of the VOC HAP emission factors. In those situations, we normalize the HAP ratios so as not to create more VOC HAPs than VOC. We are also aware that there are many similar SCCs that do not always share the same set of emission factors/output pollutants. We do not apply ratios based on emission factors from similar SCCs other than for mercury from combustion SCCs. We would prefer to get HAPs reported from reporting agencies or get the data from other sources (compliance data from rule), but such data are not always available.

Because much of the AP-42 factors are 20+ years old, many incremental edits to these factors have been made over time. We have removed some factors based on results of NATA reviews. For example, we discovered ethylene dichloride was being augmented for SCCs related to gasoline distribution. This pollutant was associated with leaded gasoline which is no longer used. Therefore, we removed it from our HAP augmentation between 2011 NEI v2 and 2014. We also received specific facility and process augmentation factors resulting from the

NATA reviews. More discussion of the underlying data used for the 2017 NEI August2019 point version is discussed in Section 3.1.6.

For point sources, HAPs augmentation data are not used when S/L/T air agency data exists at any process at the facility for the same pollutant. That means that if a S/L/T reports a particular HAP at some processes but misses others, then those other processes will not be augmented with that HAP.

2.2.4 PM augmentation

Particulate matter (PM) emissions species in the NEI are: primary PM10 (called PM10-PRI in the EIS and NEI) and primary PM2.5 (PM25-PRI), filterable PM10 and filterable PM2.5 (PM10-FIL and PM25-FIL) and condensable PM (PM-CON). The EPA needed to augment the S/L/T agency PM components for the point and nonpoint inventories to ensure completeness of the PM components in the final NEI and to ensure that S/L/T agency data did not contain inconsistencies. An example of an inconsistency is if the S/L/T agency submitted a primary PM2.5 value that was greater than a primary PM10 value for the same process. Commonly, the augmentation added condensable PM or PM filterable (PM10-FIL and/or PM25-FIL) where none was provided, or primary PM2.5 where only primary PM2.5 was provided.

In general, emissions for PM species missing from S/L/T agency inventories were calculated by applying factors to the PM emissions data supplied by the S/L/T agencies. These conversion factors were first used in the 1999 NEI's "PM Calculator" as described in an NEI conference paper [ref 1]. The resulting methodology allows the EPA to derive missing PM10-FIL or PM25-FIL emissions from incomplete S/L/T agency submissions based on the SCC and PM controls that describe the emissions process. In cases where condensable emissions are not reported, conversion factors are applied to S/L/T agency reported PM species or species derived from the PM Calculator databases. The PM Calculator has undergone several edits since 1999; now called the "PM Augmentation Tool," this Microsoft ® Access ® database is no longer made available because it should not be run for any purpose other than gap-filling the final NEI selection.

The PM Augmentation Tool is used only for point and nonpoint sources, and the output from the tool is heavily-screened prior to use in the NEI. This screening is done to prevent trivial overwriting of S/L/T data from PM Augmentation Tool calculations, particularly for primary PM submittals by S/L/Ts. More details on the caveats to using the PM Augmentation Tool are discussed in Section 3 on point sources and Section 4 on nonpoint sources.

2.2.5 Other EPA datasets

In addition to TRI, chromium speciation, HAP and PM augmentation, the EPA generates other data to produce a complete inventory. The EPA dataset "2017EPA_PMSpecies" provides speciated PM2.5 emissions for the all sources with PM emissions. This dataset is a result of speciation where the NEI PM25-PRI emissions are split into five PM2.5 species: elemental (also referred to as "black") carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), and the remainder of PM25-PRI (PMFINE). In addition, a copy of PM25-PRI and PM10-PRI from mobile source diesel engines, relabled as DIESEL-PM25 and DIESEL-PM10, respectively, are included in the 2017EPA_PMSpecies dataset.

Examples of other EPA data for point sources, discussed in Section 3, include EPA landfills, electric generating units (EGUs), and aircraft.

2.2.6 Data Tagging

S/L/T agency data generally is used first when creating the NEI selection. When S/L/T data are used, then the NEI would not use other data (primarily EPA data from stand-alone datasets or HAP, PM or TRI augmentation) that

also may exist for the same process/pollutant. Thus, in most cases the S/L/T agency data are used; however, for several reasons, sometimes we need to exclude, or "tag out" S/L/T agency data. Examples of these "S/L/T tags" are when S/L/T agency staff alert the EPA to exclude their data (because of a mistake or outdated value), or when EPA staff find problems with submitted data. Another example is when S/L/T emissions data are significantly less than TRI and are presumed to be incomplete, which can happen for S/L/T that use automated gap-filling procedures for facilities that do not voluntarily provide HAP emissions. These automated procedures gap-fill only for processes that have emission factors and miss processes/pollutants that may have been reported to TRI using other means besides published emission factors.

In previous NEI years data tagging had also been used to avoid double-counting emissions by using emissions from more than one dataset because the two datasets were at different levels of granularity and thus not able to be integrated to the full process level of detail required by the standard selection hierarchy software. The primary example of this is the TRI dataset, which provides facility-total emissions rather than individual process-level emissions. Because the TRI emissions must be stored to a single emission process that is not the same as that used by the S/L/T agency, the standard hierarchy selection software would use both. Thus, tagging was used to "block" any TRI values where the S/L/T had reported the same pollutant at any process(es) within the same facility. For the 2017 NEI, a series of additional rules were added to the selection hierarchy to avoid such tagging. Point source datasets are now identified as being either Process-level, Unit-level, or Facility-level granularity, and the selection software now uses those identifications to avoid double-counting, avoiding the need for those types of tags.

2.2.7   Inventory Selection

Once all S/L/T and EPA data are quality assured in the EIS, and all augmentation and data tagging are complete, then we use the EIS to create a data category-specific inventory selection. To do this, each EIS dataset is assigned a priority ranking prior to running the selection with EIS. The EIS then performs the selection at the most detailed inventory resolution level for each data category. For point sources, this is the process and pollutant level. For nonpoint sources, it is the process (SCC)/shape ID (i.e., ports) and pollutant level. For onroad and nonroad sources, it is process/pollutant, and for events it is day/location/process and pollutant. At these resolutions, the inventory selection process uses data based on highest priority and excludes data where it has been tagged. The EPA then quality assures this final blended inventory to ensure expected processes/pollutants are included or excluded. The EIS uses the inventory selection to also create the SMOKE Flat Files, EIS reports and data that appear on the NEI website.

2.3   What are the sources of data in the 2017 NEI?

This section shows the contributions of S/L/T agency data to total emissions for the point and nonpoint data categories. Figure 2-1 shows the proportion of CAP, select HAPs, and HAP group emissions from various data sources in the NEI for point data category sources. Except for PM2.5, most point emissions come from S/L/T-submitted data. PM augmentation (see Section 2.2.4), which is based off incomplete S/L/T submittals of PM, accounts for a significant portion of PM point emissions. The data sources shown in the figure are described in more detail in Section 3.

Figure 2-1: Relative contributions for various data sources of Point emissions for CAPs and select HAPs
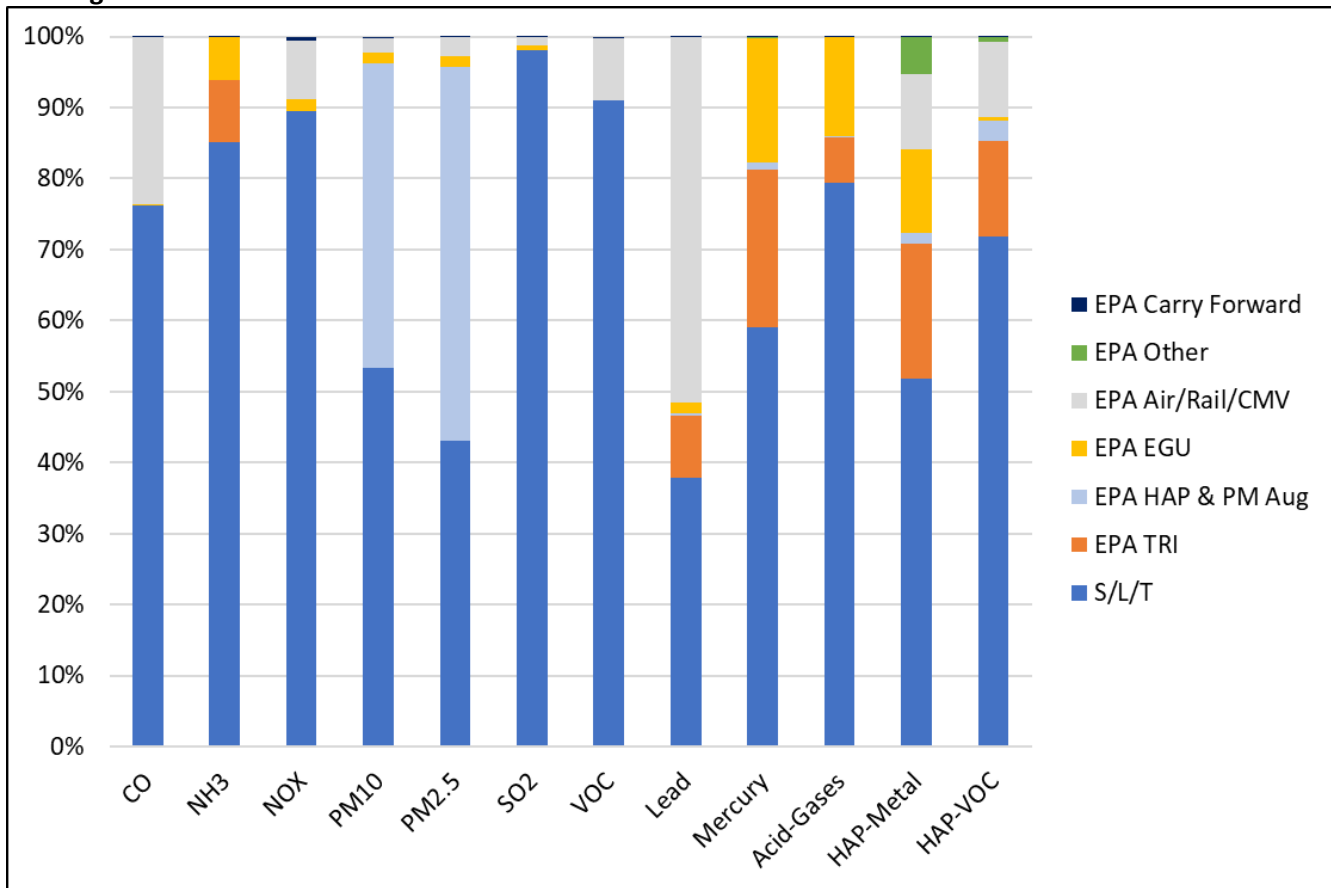
Figure 2-2 shows the proportion of CAP, select HAPs, and HAP group emissions from various data sources in the NEI for nonpoint data category sources. Biogenic sources, all EPA data, are not included in this table. Acid Gases include the following pollutants: hydrogen cyanide, hydrochloric acid, hydrogen fluoride, and chlorine. HAP VOC emissions consist of dozens of VOC HAP species, that in-aggregate, should be less than VOC in our QA checks. HAP metal emissions consist of the following compound groups: Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Manganese, Mercury, Nickel and Selenium. More than 50% of nonpoint pollutant totals come from some type of EPA source; however, as discussed in Section 4.1, S/L/T-submitted nonpoint activity data is absorbed into EPA nonpoint tools and are therefore classified as "EPA" data. The large "EPA Other" bars for PM10 and PM2.5 are predominantly dust sources from unpaved roads, agricultural dust from crop cultivation, and construction dust.

Figure 2-2: Relative contributions for various data sources of Nonpoint emissions for CAPs and select HAPs
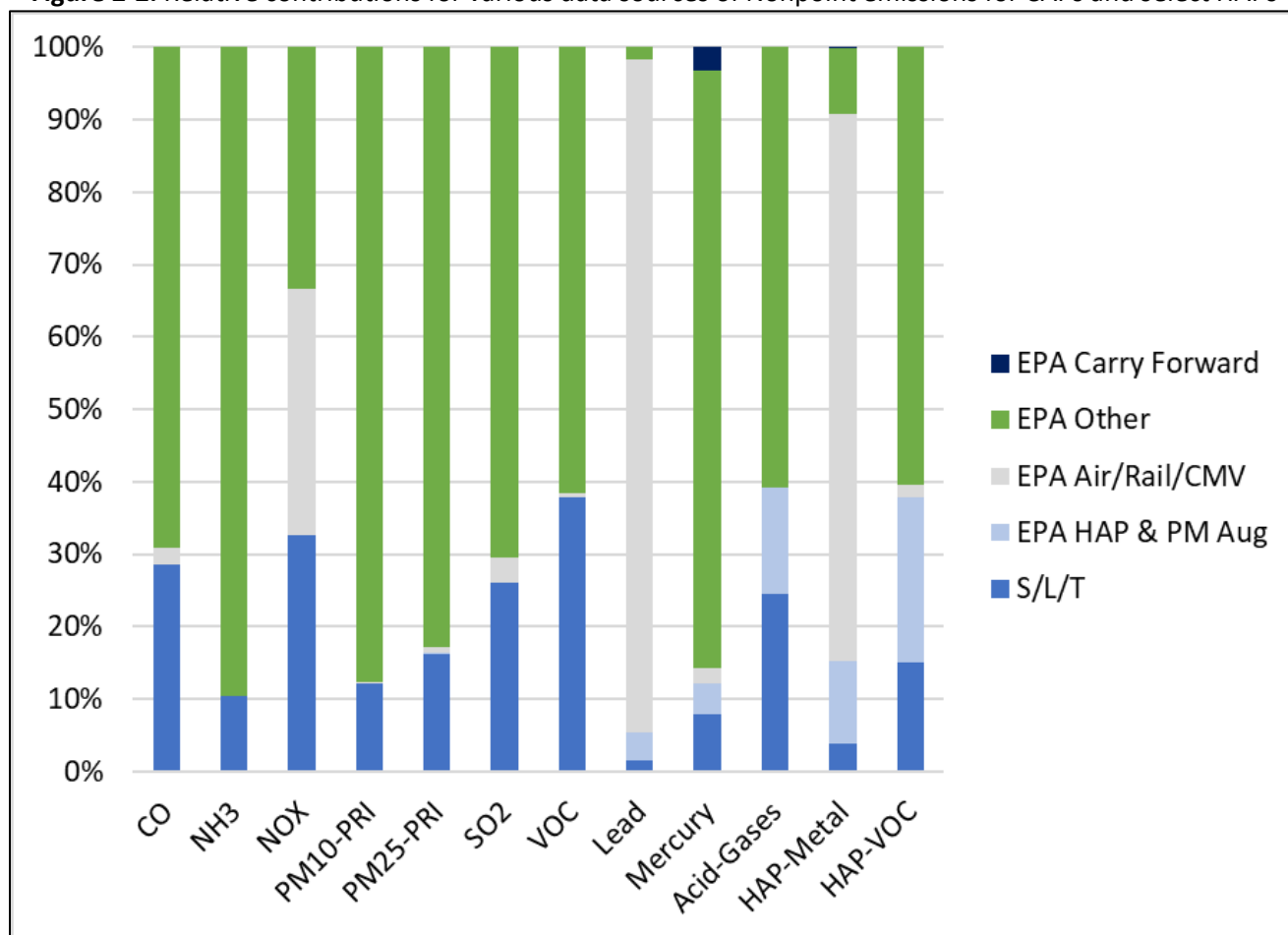
We did not compute relative contributions of emissions from nonroad and onroad data categories because of the nature in how emissions are created for these sources -via a mix of S/L/T and EPA activity data and processed through the MOVES2014 model. California, which uses its own onroad and nonroad mobile models, was the only state that provided emissions rather than inputs for EPA models (this is in accordance with the AERR). All other states were required to provide inputs to the EPA models. Onroad and nonroad mobile data categories use the MOVES emissions model, and the EPA primarily collected model inputs from S/L agencies for these categories and ran the models using these inputs to generate the emissions. The S/L agencies that provided inputs are presented in the nonroad and onroad portions of the document, Section 5 and Section 6, respectively.

2.4 What are the top sources of some key pollutants?

Table 2-3 provides a summary of CAP and total HAP emissions for all EIS sectors, including the biogenic emissions from vegetation and soil. Emissions in federal waters and from vegetation and soils have been split out and totals both with and without these emissions are included. Emissions in federal waters include offshore drilling platforms and commercial marine vessel emissions outside the typical 3-10 nautical mile boundary defining state waters. All emissions values are bounded by the caveats and methods described by this documentation.

Table 2-3: EIS sectors and associated 2017 CAP and total HAP emissions (thousands of tons/year)

Sector	CO	NH3	NOX	PM2.5	PM10	SO2	VOC	Black Carbon	Lead	Total HAPs[1]
Agriculture - Crops & Livestock Dust				794	4,034			11		
Agriculture - Fertilizer Application		926								
Agriculture - Livestock Waste	5.94E-03	2,569	3.57E-03	0.04	0.12	5.60E-05	228	2.20E-03	5.41E-08	25
Bulk Gasoline Terminals	1.07	3.41E-03	0.43	0.05	0.05	9.05E-03	132	3.53E-04	6.42E-04	6.25
Commercial Cooking	46		4.73E-03	118	126	7.28E-04	19	4.05		8.80
Dust - Construction Dust	0.12		0.10	119	1,145	7.52E-03	0.04	9.52E-05	2.26E-03	0.05
Dust - Paved Road Dust				209	885			2.17		
Dust - Unpaved Road Dust				574	5,767			0.56		
Fires - Agricultural Field Burning	301	63	13	31	43	4.24	38	3.35		8.17
Fires - Prescribed Fires	8,870	145	165	805	948	78	2,042	26		416
Fires - Wildfires	19,487	319	231	1,655	1,953	135	4,578	53		978
Fuel Comb - Comm/Institutional - Biomass	20	0.14	9.09	13	15	0.95	0.73	0.47	3.39E-04	0.38
Fuel Comb - Comm/Institutional - Coal	1.21	5.99E-03	3.90	0.45	1.09	13	0.15	0.02	5.04E-04	0.42
Fuel Comb - Comm/Institutional - Natural Gas	119	1.46	144	4.47	4.74	1.46	10.00	0.30	1.83E-03	0.96
Fuel Comb - Comm/Institutional - Oil	14	0.23	36	2.75	2.91	6.27	2.64	0.42	2.64E-03	0.23
Fuel Comb - Comm/Institutional - Other	10	0.05	12	0.58	0.60	1.12	1.16	0.04	3.57E-04	0.19
Fuel Comb - Electric Generation - Biomass	19	0.61	11	1.61	1.87	1.46	0.90	0.06	1.19E-03	1.00
Fuel Comb - Electric Generation - Coal	453	5.77	924	74	97	1,319	17	2.92	8.00E-03	7.77
Fuel Comb - Electric Generation - Natural Gas	78	12	145	24	25	7.50	9.50	1.61	5.85E-04	3.70
Fuel Comb - Electric Generation - Oil	7.71	0.62	55	4.32	5.25	40	1.58	1.31	8.58E-04	0.22
Fuel Comb - Electric Generation - Other	30	0.45	24	2.94	3.08	18	3.20	0.16	5.44E-04	1.90
Fuel Comb - Industrial Boilers, ICEs - Biomass	251	2.29	102	118	137	17	9.46	4.39	5.49E-03	5.31
Fuel Comb - Industrial Boilers, ICEs - Coal	32	0.60	88	12	48	212	0.71	0.49	6.17E-03	5.17
Fuel Comb - Industrial Boilers, ICEs - Natural Gas	293	8.49	558	22	23	16	63	1.45	3.54E-03	27
Fuel Comb - Industrial Boilers, ICEs - Oil	25	0.28	86	6.14	6.94	19	5.51	1.32	8.05E-03	0.52
Fuel Comb - Industrial Boilers, ICEs - Other	78	0.88	47	8.17	9.54	35	7.03	0.62	2.08E-03	1.79
Fuel Comb - Residential - Natural Gas	89	34	205	4.05	4.21	1.37	12	0.27	1.17E-04	0.59
Fuel Comb - Residential - Oil	8.90	1.56	33	3.35	3.84	12	1.06	0.39	2.04E-03	0.08
Fuel Comb - Residential - Other	8.78	0.10	31	0.17	0.19	0.72	1.19	0.01	5.88E-07	0.02
Fuel Comb - Residential - Wood	2,398	17	39	337	339	8.70	333	19	9.66E-07	66
Gas Stations	0.03	1.39E-03	0.02	6.45E-04	6.45E-04	4.80E-05	443	1.96E-05	2.48E-04	52
Industrial Processes - Cement Manuf	102	1.75	105	6.67	11	26	5.30	0.20	2.29E-03	1.87
Industrial Processes - Chemical Manuf	140	24	67	17	22	123	94	0.40	4.37E-03	25
Industrial Processes - Ferrous Metals	328	0.20	59	24	33	22	11	0.48	0.04	1.92
Industrial Processes - Mining	20	0.06	20	61	455	0.95	1.45	0.06	3.58E-03	0.16
Industrial Processes - NEC	163	22	158	78	131	138	183	1.35	0.04	51
Industrial Processes - Non-ferrous Metals	148	0.43	14	10	13	53	11	0.16	0.02	4.51
Industrial Processes - Oil & Gas Production	631	0.27	617	12	13	64	2,455	0.58	1.83E-04	109
Industrial Processes - Petroleum Refineries	58	2.60	68	17	20	60	52	0.95	3.79E-03	9.99
Industrial Processes - Pulp & Paper	90	5.06	74	31	40	24	124	0.93	3.80E-03	50
Industrial Processes - Storage and Transfer	6.31	3.67	2.74	13	37	1.08	195	0.21	5.35E-03	11
Miscellaneous Non-Industrial NEC	108	5.41	3.22	15	18	0.15	80	0.60	7.20E-04	16
Mobile - Aircraft	470		128	8.35	9.61	16	55	3.14	0.47	16
Mobile - Commercial Marine Vessels	43	0.14	314	7.34	7.72	7.75	17	5.51	9.19E-04	1.41
Mobile - Locomotives	116	0.36	600	17	17	0.71	28	13	1.05E-04	12
Mobile - Non-Road Equipment - Diesel	397	1.16	834	60	62	1.18	76	46	7.52E-05	37
Mobile - Non-Road Equipment - Gasoline	10,076	0.74	192	37	40	1.01	1,008	4.47	4.78E-12	325
Mobile - Non-Road Equipment - Other	247	0.01	43	2.12	2.12	0.56	7.85	0.91		1.56
Mobile - On-Road Diesel Heavy Duty Vehicles	455	7.44	1,399	57	90	3.87	100	29		22
Mobile - On-Road Diesel Light Duty Vehicles	360	1.41	147	5.73	8.33	0.40	39	3.69		7.07
Mobile - On-Road non-Diesel Heavy Duty Vehicles	621	1.37	62	1.37	3.71	0.47	30	0.21		8.28
Mobile - On-Road non-Diesel Light Duty Vehicles	18,078	90	1,887	50	138	21	1,507	9.37		418
Solvent - Consumer & Commercial Solvent Use	0.02		6.36E-03	0.02	0.02	4.66E-03	1,610	8.43E-04		174

Sector	CO	NH3	NOX	PM2.5	PM10	SO2	VOC	Black Carbon	Lead	Total HAPs[1]
Solvent - Degreasing	0.03	0.02	0.02	0.07	0.08	6.21E-05	183	5.01E-04	3.32E-04	65
Solvent - Dry Cleaning	4.35E-04		3.75E-04	0.02	0.02	2.10E-06	3.70	2.51E-04		5.50
Solvent - Graphic Arts	0.08	0.07	0.11	0.09	0.09	8.18E-03	346	5.87E-04	2.74E-06	24
Solvent - Industrial Surface Coating & Solvent Use	5.01	0.39	2.42	4.16	4.55	0.35	492	0.06	4.32E-03	56
Solvent - Non-Industrial Surface Coating		0.02					337			48
Waste Disposal	1,304	21	81	203	227	25	172	21	0.01	40
Sub Total (no federal waters)	**66,605**	**4,297**	**9,938**	**5,681**	**17,035**	**2,539**	**17,185**	**279**	**0.66**	**3,158**
Fuel Comb - Industrial Boilers, ICEs - Natural Gas	49	7.55E-03	44	0.41	0.41	0.03	1.16	0.03	1.18E-06	1.18E-06
Fuel Comb - Industrial Boilers, ICEs - Oil	1.15	2.83E-04	4.91	0.21	0.21	0.41	0.24	0.16	2.52E-06	2.52E-06
Fuel Comb - Industrial Boilers, ICEs - Other	4.02E-04	1.51E-05	4.81E-04	2.39E-05	2.39E-05	3.30E-06	4.31E-05	1.62E-06	2.36E-09	2.36E-09
Industrial Processes - Oil & Gas Production	1.50	5.42E-04	0.80	9.13E-03	9.29E-03	0.02	37	2.41E-05	8.46E-08	8.46E-08
Industrial Processes - Storage and Transfer							0.63			
Mobile - Commercial Marine Vessels	55	0.48	531	25	27	175	26	4.85	3.15E-03	2.14
Sub Total (federal waters)	**107**	**0.49**	**581**	**26**	**28**	**175**	**65**	**5.05**	**3.16E-03**	**2.14**
Sub Total (all but vegetation and soil)	**66,711**	**4,298**	**10,419**	**5,707**	**17,063**	**2,715**	**17,250**	**284**	**0.67**	**3,160**
Biogenics - Vegetation and Soil	4,083	22	1,367				25,823			3,028
Total	**70,794**	**4,320**	**11,786**	**5,707**	**17,063**	**2,715**	**43,073**	**284**	**0.67**	**6,188**

1 Total HAP does not include diesel PM, which is not a HAP listed by the Clean Air Act.

2.5 How does this NEI compare to past inventories?

Many similarities exist between the 2017 NEI approaches and past NEI approaches, notably that the data are largely compiled from data submitted by S/L/T agencies for CAPs, and that the HAP emissions are augmented by the EPA to differing degrees depending on geographical jurisdiction because they are a voluntary contribution from the partner agencies. In 2017, S/L/T participation was somewhat more comprehensive than in 2014, though both were good. The NEI program continues with the 2017 NEI to work towards a complete compilation of the nation's CAPs and HAPs. The EPA provided feedback to S/L/T agencies during the compilation of the data on critical issues (such as potential outliers, missing SCCs, missing Hg data and coke oven data) as has been done in the past, collected responses from S/L/T agencies to these issues, and improved the inventory for the release based on S/L/T agency feedback. In addition to these similarities, there are some important differences in how the 2017 NEI has been created and the resulting emissions, which are described in the following two subsections.

2.5.1 Differences in approaches

With any new inventory cycle, changes to approaches are made to improve the process of creating the inventory and the methods for estimating emissions. The key changes for the 2017 cycle are highlighted here.

To improve the process, we learned from the prior three triennial inventories (for 2008, 2011, and 2014) compiled with the EIS. We made changes to pollutant, SCC, and NAICS codes, refined quality assurance checks and features that were used to assist in quality assurance and streamlined the Nonpoint Survey (introduced for the 2014 NEI) to assist with S/L/T and EPA data reconciliation for the nonpoint data. The update to the nonpoint survey helped S/L/Ts and EPA avoid double counting and ensure a complete inventory between the different sources of data.

In addition to process changes, we improved emissions estimation methods for all data categories. We summarize the differences in approaches in the following sections.

2.5.1.1 *Point data category*

For point sources, the only change was our use of EPA-developed HAP emission estimates for the EGUs covered by the Mercury and Air Toxics Standards (MATS) review, rather than the SLT reported values. HAP augmentation improvements are described in Section 3.1.6. More information on point source improvements is available in Section 3.

2.5.1.2 *Nonpoint data category*

We made method improvements for many stationary nonpoint sectors (Section 4). The EPA creates and provides emissions tools to S/L/T agencies for their use, and we use these tools ourselves to fill in emissions values where not provided by S/L/T/ agencies. New for the 2017 NEI development process, was the introduction of "Input Templates" -see Section 4.1.3. EPA provided default Input Templates to S/L/T inventory developers for them to modify and return to EPA. We encouraged S/L/Ts to submit inputs rather than direct emission submittals for many nonpoint categories. We also streamlined the Nonpoint Survey (Section 4.1.2), first introduced for the 2014 NEI development cycle, to simplify the options and improve transparency. By default, all Nonpoint Survey responses were set to "Yes -Supplement my data with EPA Estimates" to ensure complete coverage in the absence of S/L/T feedback.

PM2.5 emissions from agricultural tilling decreased due to assumption change of reducing the number of tilling passes for corn and soybeans. Most states saw a significant increase in PM2.5 and VOC from commercial cooking, a result of using new activity data on the number of restaurants, as opposed to continuing to use a growth rate from 2002 data that was used for recent NEIs. Large decreases in residential fuel combustion for SO2 is a result of a decrease in consumption and more significantly, using a lower default sulfur content for distillate fuel oil: 500ppm in 2017 vs 3% (30,000ppm) in 2014. Large decreases in PM2.5 and NOX for open burning, land clearing debris is due to a new assumption that land clearing debris is limited to only rural parts of counties.

We updated the approach for computing nonpoint Industrial and Commercial/Institutional (ICI) fuel combustion, limiting it state-level subtraction of point inventory throughput (fuel consumption); we no longer compute nonpoint ICI via point emissions subtraction or county-level activity data subtraction. To facilitate this, we provided S/L/Ts with cross-references from point inventory facilities to existing U.S. Energy Information Administration (EIA) ICI sector assignments and fuel mapping. We relied on S/L/Ts to provide EPA with these state-level inputs via 4 different Input Template options.

We updated the activity data for residential wood combustion via a national survey of wood burning in 2018, leading to more robust accounting of outdoor recreational burning and improved characterization of central heaters from both cordwood and pellet-fired hydronic heaters and furnaces. We also obtained local input data for several states. For the livestock waste sector, we updated the animal counts methodology based on what's used in EPA's GHG program, which includes animal sub-types that had been left out in 2014. Using this more robust approach results in increases in the dairy cattle and the broiler category animal counts, and thus increases NH3 emissions from this sector where those animals are more prevalent in the US. For the Ag fertilizer sector, methods were essentially the same as in 2014; however, newer model versions for CMAQ and FEST-C were used. The previous version of CMAQ used for the 2014 NEI fertilizer emission only from vegetated land. This has been corrected in CMAQ 5.3 with the STAGE deposition option and results in higher NH_3 emission rates in agricultural areas before crop germination and in areas with sparse vegetation coverage. Additionally, the updated FEST-C v1.4 module corrected an error in the nitrogen budget form an earlier version of the model used in the 2014 NEI. Also, in the 2017 NEI, annual state and USDA fertilizer data was used to adjust FEST-C fertilizer

rates. The adjusted FEST-C fertilizer rates were correspondingly increased to better match USDA and data submitted by the states.

For road dust, we changed the method used to determine the vehicle miles traveled (VMT) on paved and unpaved roads in each county. Both the methods for the 2014v2 and 2017 NEI used the 2008 NMIM run as the starting point for estimating the state ratio of VMT on paved or unpaved roads. However, in 2014v2, the estimated VMT on paved/unpaved roads were arbitrarily redistributed within Census regions, to smooth out sharp differences in emissions across state lines. This redistribution is not done for the 2017 NEI in order to better preserve the integrity of the original state VMT data submitted to the Federal Highway Administration (FHWA). Also, an additional step was added to update the 2008 NMIM paved/unpaved ratios used for local and rural minor collector road types by using state level 2016 FHWA data on paved vs. unpaved road length for these road types.

We refined emissions calculation approaches for the oil and gas exploration and production sectors to reflect new processes, such as CBM dewatering engines, updated default assumptions, such as the quantity of VOC being captured by control devices at storage tanks, and made use of newly available activity data, including the most recent and appropriate subpart W basin factors available.

For all nonpoint categories, we updated the activity data to use the newest data available, at the time, to represent the 2017 inventory year; in most cases, this is year-2017 activity data. Most emission changes for all nonpoint sources not otherwise discussed in this section resulted from these activity data updates -be they from EPA or new for 2017, provided directly from S/L/Ts.

The Biogenic database incorporated a new version of the Biogenic Emissions Landcover Database (BELD5) and provides updates for all states, including Alaska, Hawaii, Puerto Rico and the U.S. Virgin Islands.

2.5.1.3 *Onroad and nonroad data categories*

For mobile sources, onroad methodology used the same model as in 2014 with updated mobile source activity data such as vehicle miles travelled (VMT). The MOVES model was updated for nonroad estimates. For both, we relied on model inputs provided by S/L/T agencies and other sources, except for California and Tribes, who submitted emissions estimates. Sections 5 and 6 provide more detail on these improvements.

2.5.1.4 *Events data category*

We also made several improvements to approaches for fire sources, as further described in Section 7. For the agricultural fires sector (in nonpoint category), we updated the VOC emissions factors, as well as the HAPs to line up with what's in SPECIATE. Specifically, for the 2017 NEI, we reviewed the crop residue burning VOC speciation profiles in the SPECIATE database, located the original source of this information, and derived new VOC emission factors and new HAP emission factors from the same measurement study. We also brought in some new VOC data for sugarcane burning based on new studies. In addition, we omitted the grass/pasture burning from the agricultural fires sector in and moved it to the Events (as prescribed fires) category for the 2017 NEI. For wildfires and prescribed fires, we improved how VOCs were estimated in areas of the country where duff-fuels are prevalent -primarily in Florida, Louisiana and Minnesota.

2.5.2 Differences in emissions between the 2017 and 2014 NEI

This section presents a comparison from the 2014v2 NEI to the 2017 NEI. Table 2-4 compares CAP emissions for the 2017 minus 2014v2 NEI for seven highly aggregated emission sectors. Table 2-5 compares emissions for select HAPs for the 2017 minus 2014v2 NEI for the same seven highly aggregated emission sectors. Emissions

from the biogenic (natural) sources are excluded, and the wildfire sector is shown separately for CAPs and HAPs. While Pb is a CAP for the purposes of the NAAQS, due to toxic attributes and inclusion in previous national air toxics assessments (NATA), it is reviewed here with the HAPs. The HAPs selected for comparison are based on their national scope of interest as defined by NATA. With a couple notable exceptions, CAP emissions are lower overall in 2017 than in 2014 (v2). Some specific sector/pollutants increased in 2017 from 2014. The increases in fuel combustion CO, benzene, and formaldehyde is primarily from the new residential wood combustion survey-based burn rate and appliance use profiles. The increase in PM10 for industrial processes is mostly from new (more coal mining) activity data for mining and quarrying. The increase in industrial processes NH3, and miscellaneous lead are from state and local agency submittals.

As discussed in Section 7, there were comparatively more wildfires in 2017 than 2014, explaining the significant increases in wildfire emissions for 2017. Year 2014 was a generally quiet year for such fires.

Table 2-4: Emission differences (tons) for CAPs, 2017 minus 2014v2 NEI

Broad Sector	CO	NH3	NOX	PM10	PM2.5	SO2	VOC
Fuel Combustion	10,967	-18,320	-761,536	-118,986	-91,024	-2,088,695	-15,449
Highway Vehicles	-4,923,456	-8,101	-1,384,295	-64,680	-49,023	-2,897	-540,838
Industrial Processes	-221,654	3,081	-118,807	38,644	-16,337	-63,708	-667,938
Miscellaneous	-885,422	602,446	-28,607	-1,862,728	-267,615	-2,098	-17,979
Nonroad Mobile	-1,711,825	-373	-499,897	-46,466	-43,251	-30,873	-534,460
Total Difference, excluding wildfires	**-7,932,388**	**578,733**	**-2,862,540**	**-2,055,530**	**-468,554**	**-2,198,862**	**-1,809,538**
Total % Difference, excluding wildfires	**-14%**	**17%**	**-23%**	**-12%**	**-10%**	**-48%**	**-13%**
Wildfires	9,000,048	147,066	111,394	907,232	768,965	63,904	2,111,711

Table 2-5: Emission differences (tons) for select HAPs, 2017 minus 2014v2 NEI

Broad Sector	Acrolein	Benzene	Ethylene Oxide	Formaldehyde	Hexavalent Chromium	Lead
Fuel Combustion	-83	516	0	5,799	-6	-51
Highway Vehicles	-705	-16,409		-12,102	0	
Industrial Processes	446	-1,864	-25	5,762	1	-21
Miscellaneous	514	-2,624	-17	-4,980	1	0
Nonroad Mobile	-294	-9,550		-6,701	-1	10
Total Difference, excluding wildfires	**-122**	**-29,930**	**-42**	**-12,222**	**-6**	**-64**
Total % Difference, excluding wildfires	**0%**	**-16%**	**-28%**	**-4%**	**-15%**	**-9%**
Wildfires	23,583	24,024		149,000		

2.6   How well are tribal data and regions represented in the 2017 NEI?

Thirteen tribes submitted data to the EIS for 2017 as shown in Table 2-6. In this table, a "CAP, HAP" designation indicates that both criteria and hazardous air pollutants were submitted by the tribe; "GHG" indicates greenhouse gases were submitted. CAP indicates that only criteria pollutants were submitted. Facilities on tribal land were augmented using TRI, HAPs and PM in the same manner as facilities under the state and local jurisdictions, as explained in Section 3.1, therefore, Tribal Nations in Table 2-6 with just a CAP flag will also have

some HAP emissions in most cases. Eight additional tribal agencies, shown in Table 2-7, which did not submit any data, are represented in the point data category of the 2017 NEI due to the emissions added by the EPA. The emissions for these facilities are from the EPA gap fill datasets for airports, EGUs, and TRI data. Furthermore, many nonpoint datasets included in the NEI are presumed to include tribal activity. Most notably, the oil and gas nonpoint emissions have been confirmed to include activity on tribal lands because the underlying database contained data reported by tribes. See Section 4.17 for more information.

Table 2-6: Tribal participation in the 2017 NEI

Tribal Agency	Point	Nonpoint	Onroad	Nonroad
Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation		CAP, HAP		
Coeur d'Alene Tribe	CAP, HAP	CAP, HAP	CAP, HAP	CAP, HAP
Kootenai Tribe of Idaho		CAP, HAP	CAP, HAP	CAP, HAP
Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California			CAP	
Nez Perce Tribe	CAP, HAP	CAP, HAP	CAP, HAP	CAP, HAP
Northern Cheyenne Tribe	CAP	CAP	CAP	CAP
Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation				
Salt River Pima Maricopa Indian Community (SRPMIC) EPNR	CAP, HAP, GHG	CAP		
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	CAP, HAP	CAP, HAP	CAP, HAP	CAP, HAP
Southern Ute Indian Tribe	CAP, HAP, GHG	CAP, HAP		
United Keetoowah Band of Cherokee Indians in Oklahoma				
Ute Mountain Tribe of the Ute Mountain Reservation	CAP, HAP			
Yakama Nation Reservation	CAP, HAP, GHG			

Table 2-7: Facilities on Tribal lands with 2017 NEI emissions from EPA only

Tribal Agency	EPA data used
Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation, Montana	Airports
Fond du Lac Band of Lake Superior Chippewa	Airports
Gila River Indian Community	TRI
Navajo Nation	EGUs
Omaha Tribe of Nebraska	Airports
Southern Ute Indian Tribe	Airports
Tohono O-Odham Nation Reservation	TRI
Ute Indian Tribe of the Uintah & Ouray Reservation, Utah	EGUs

2.7 What does the 2017 NEI tell us about mercury?

The NEI documentation includes this Hg section because of the importance of this pollutant and because the sectors used to categorize Hg are different than the sectors presented for the other pollutants. The Hg sectors primarily focus on regulatory categories and categories of interest to the international community; emissions are summarized by these categories at the end of this section, in Table 2-10.

Mercury emission estimates in the 2017 NEI sum to 32.8 tons, with 32.2 tons from stationary sources and 0.6 tons from mobile sources (including commercial marine vessels and locomotives). Due to large decreases of emissions from sources within the regulated categories, particularly the coal-fired electric generating units (EGU), most of the emissions are from sources other than the categories trended. The "other" includes a large variety of different source types including fluorescent light breakage, landfills, specialty chemical manufacturing, mineral products and other fuel combustion besides boilers and process-heaters. Of the regulatory categories trended, the three with highest emissions in the 2017 NEI are: electric arc furnaces (4.7 tons), coal -fired EGU with units larger than 25 megawatts (MW) (4.4 tons) and boilers and process heaters (2.6 tons). Unlike previous NEIs, coal-fired EGUs no longer comprise the largest portion of the mercury emissions in NEI.

Mercury emissions from the coal fired EGU with units larger than 25 MW are from the database developed for the Residual Risk Assessment for the Coal- and Oil-Fired EGU Source Category in Support of the 2019 Risk and Technology Review Proposed Rule, which is also referred to as the Mercury and Air Toxics Standards (MATS). [ref 2]. Most of the units' emission estimates were from data reported to the Clean Air Markets Division (CAMD), but in some cases emission factors from WebFIRE or the Electric Power Research Institute were used, along with heat input from CAMD. EPA loaded these estimates into EIS as the "2017EPA_MATS" dataset, and they were used in the NEI selection hierarchy ahead of the S/L/T data.

A summary of all data sources used to create the 2017 Hg inventory are shown in Figure 2-3.

Figure 2-3: Data sources of Hg emissions (tons) in the 2017 NEI, by data category
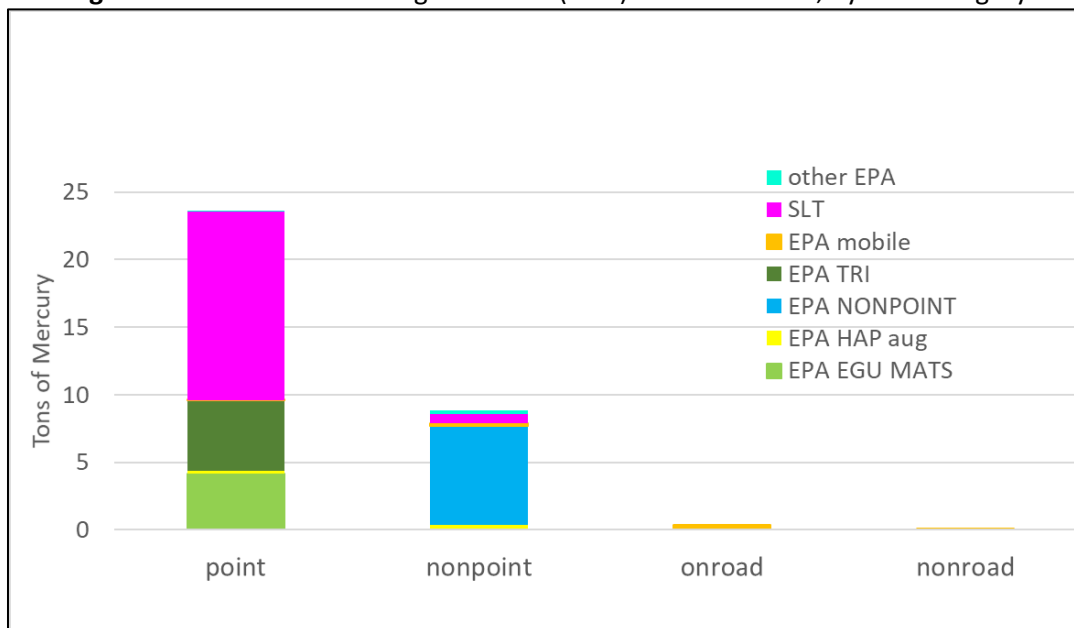
In the above figure the "EPA mobile" accounts for all EPA datasets containing onroad, nonroad, commercial marine vessel and locomotive (also referred to as rail) emissions. The "other EPA" accounts for numerous gap filling datasets in which EPA obtained or estimated mercury emissions (via calling the state, carrying it forward from previous year inventories or estimating with emission factors). The "EPA HAP aug" dataset uses SLT-submitted particulate matter emissions and emission factor ratios (Hg-to-PM) to compute Hg at the process level. The EPA EGU MATS dataset contains data from the MATS rule development described above.

In addition to Figure 2-3, Table 2-8 lists the emissions by data source with the above data sets further broken out. More information on these datasets is available in Section 3.1.2 for point, Section 4.1.1 for nonpoint, Section 5 for nonroad mobile, and Section 6 for onroad mobile sources.

Table 2-8: 2017 NEI Hg emissions (tons) for each dataset type and group

Data Category	Data Set	Brief description	Hg emissions (tons)
Point	S/L/T	State, local, tribal agency-submitted	14
	2017EPA_TRI	Toxics Release Inventory	5.2
	EPA EGU MATS	Mercury and Air Toxics Rule	4.1
	EPA HAP Aug	Computed based on S/L/T CAPs	0.2
	2017EPA_gapfills	Missing data	0.04
	2017EPA_EGU	Non-MATS electric generating units	0.01
	2017EPA_SPPD_PCWP	Plywood and composite wood products rule	0.009
	2017ERTAC_Rail	Locomotives using the ERTAC methodology	0.007
	2017EPA_LF	landfills	0.004
Nonpoint	2017EPA_NONPOINT	All nonpoint categories except mobile sources	7.3
	S/L/T	State, local, tribal agency-submitted	0.7
	EPA HAP Aug	Computed based on S/L/T CAPs	0.4

Data Category	Data Set	Brief description	Hg emissions (tons)
	2017EPA_CarryFwd	Laboratory emissions carried forward from 2014	0.3
	2017ERTAC_Rail	Locomotives using the ERTAC methodology	0.2
	2017EPA_CMV	Commercial Marine Vessels	0.001
Nonroad	2017EPA_MOVES	MOVES model	0.02
	2017EPA_Ca_MOVES	California adjusted by MOVES model for HAPs	0.005
Onroad	2017EPA_MOVES	MOVES model	0.3
	2017EPA_Ca_MOVES	California adjusted by MOVES model for HAPs	0.01

The datasets are described in more detail starting in Sections 3 and 4, and we highlight some key datasets here.

For point sources, we gap-filled Hg that was not reported by S/L/Ts in the same way as other HAPs – including use of the TRI (see Section 3.1.5), EPA HAP Augmentation or "HAP Aug" in the figure (see Section 2.2.3), and other EPA data developed for gap filling. Electric arc furnaces (EAFs) were gap filled using HAP aug and TRI only. The HAP augmentation used facility specific augmentation factors developed so that the resultant emissions would be the same as was used in 2014. This approach was used to provide a more automated approach than to submit the same emissions year after year, that would (via the use of CAPs) account for changes in activity. The 2014 estimates were developed by applying a 34% reduction to 2011 NEI emissions (process level). The 2011 NEI emissions were based on data developed for the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Area Sources: Electric Arc Furnace Steelmaking Facilities (subpart YYYYY). The 34% value was the average reduction from a limited 3 facility test program in 2016 (the range was 11-70%) -based on personal communication with Donna Lee Jones, EPA lead for the NESHAP. The sum of HAP aug mercury for EAFs is about 0.07 tons. We used the same approach as in 2014 for using TRI data associated EAFs in that we excluded S/L/T estimates at non-EAF processes if they were significantly lower than the TRI Hg value. The sum of TRI Hg for EAFs is about 1 ton. The largest contribution to total EAF emissions is S/L/T data which sum to about 3.6 tons.

For municipal waste combustors (MWCs), we gap filled a few facilities by requesting the Hg from specific states that report some pollutants for these facilities but exclude mercury (see section 3.6).

The nonpoint non-combustion-related and cremation categories used the same or very similar approaches as were developed for the 2014 NEI, though activity data was updated. For laboratory activities, however, the mercury emissions continue to be carried forward from the 2008 NEI with no activity updates. The methodologies are described in Section 4.2. EPA estimates for these categories are included in the "2017EPA_NONPOINT" (along with other EPA nonpoint category estimates) shown in Figure 2-3 and Table 2-8. Some of these categories have a point contribution, though the specific categories do not exactly line up between the nonpoint and point data categories. They are summarized below:

- switches and relays – emissions from the shredding and crushing of cars containing Hg components at auto crushing yards, SCC = 2650000002: Waste Disposal, Treatment, and Recovery; Scrap and Waste Materials; Scrap and Waste Materials; Shredding (1.26 tons nonpoint; 0.006 tons point)
- landfill "working face" emissions associated with the release of mercury via churning/crushing of new material added to the landfill, SCC= 2620030001: Waste Disposal, Treatment, and Recovery; Landfills;

- Municipal; Dumping/Crushing/Spreading of New Materials (working face) (0.435 tons nonpoint, total point landfill Hg is 0.08 tons)
- thermometers and thermostats – the portion that emit mercury prior to disposal at landfills or incinerators, SCC=2650000000: Waste Disposal, Treatment, and Recovery; Scrap and Waste Materials; Scrap and Waste Materials; Total: All Processes (0.12 tons nonpoint)
- dental amalgam – emissions at dentist offices and from evaporation in teeth, SCC=2850001000: Miscellaneous Area Sources; Health Services; Dental Alloy Production; Overall Process (0.46 tons nonpoint, 0.69 lbs point)
- general laboratory activities, SCC = 2851001000: Miscellaneous Area Sources; Laboratories; Bench Scale Reagents; Total (0.32 tons nonpoint, 4 lbs point)
- fluorescent lamp breakage, SCC= 2861000000: Miscellaneous Area Sources; Fluorescent Lamp Breakage; Non-recycling Related Emissions; Total (0.91 tons nonpoint)
- fluorescent lamp recycling, SCC= 2861000010: Miscellaneous Area Sources; Fluorescent Lamp Breakage; Recycling Related Emissions; Total (less than 1 lb nonpoint, point sum of breakage and recycling = 80 lbs)
- animal cremation, SCC= Miscellaneous Area Sources; Other Combustion; Cremation; Animals (2 lbs nonpoint, 48 lbs point)
- human cremation – emissions primarily due to mercury in dental amalgam, SCC=2810060100: Miscellaneous Area Sources; Other Combustion; Cremation; Humans (1.77 tons nonpoint, 0.18 tons point)

Since mercury is a HAP, it is reported voluntarily by S/L/T agencies. For the point data category of the 2017 NEI, S/L/T agencies reported emissions in 46 states. Two tribal agencies reported point source Hg. Table 2-9 provides the tons of emissions from EPA, the SLT, and the resulting percent of emissions for the point data category.

Table 2-9: Point inventory emissions by reporting agency

State	Agency Type	Agency	From EPA (tons)	From Agency (tons)	Percent from Agency
AK	State	Alaska Department of Environmental Conservation	4.87E-02	0.00E+00	0.00
AL	State	Alabama Department of Environmental Management	2.05E-01	1.15E+00	84.90
AL	Local	Jefferson County (AL) Department of Health	6.97E-02	2.31E-01	76.80
AR	State	Arkansas Department of Environmental Quality	1.12E-01	5.23E-01	82.38
AZ	State	Arizona Department of Environmental Quality	7.45E-02	2.43E-01	76.54
AZ	Local	Maricopa County Air Quality Department	4.93E-02	0.00E+00	0.00
CA	State	California Air Resources Board	3.20E-01	7.15E-01	69.08
CO	State	Colorado Department of Public Health and Environment	1.48E-01	2.23E-01	60.05
CT	State	Connecticut Department of Energy and Environmental Protection	2.15E-03	9.84E-02	97.86
DC	State	DC-District Department of the Environment	3.10E-03	0.00E+00	0.00
DE	State	Delaware Department of Natural Resources and Environmental Control	1.25E-03	1.51E-01	99.18
FL	State	Florida Department of Environmental Protection	1.63E-01	4.39E-01	72.90
GA	State	Georgia Department of Natural Resources	1.85E-01	0.00E+00	0.00
GU	Territory	Guam County	1.39E-04	0.00E+00	0.00

State	Agency Type	Agency	From EPA (tons)	From Agency (tons)	Percent from Agency
HI	State	Hawaii Department of Health Clean Air Branch	1.20E-02	9.69E-03	44.68
IA	State	Iowa Department of Natural Resources	8.58E-02	2.56E-01	74.90
ID	State	Idaho Department of Environmental Quality	6.55E-01	3.04E-03	0.46
IL	State	Illinois Environmental Protection Agency	1.97E-01	5.68E-01	74.26
IN	State	Indiana Department of Environmental Management	1.16E+00	2.05E-01	15.05
KS	State	Kansas Department of Health and Environment	6.58E-02	7.16E-02	52.08
KY	Local	Louisville Metro Air Pollution Control District	1.80E-02	1.09E-01	85.86
KY	State	Kentucky Division for Air Quality	1.87E-01	1.06E-01	36.13
LA	State	Louisiana Department of Environmental Quality	4.04E-01	1.33E-01	24.71
MA	State	Massachusetts Department of Environmental Protection	1.94E-02	5.00E-04	2.51
MD	State	Maryland Department of the Environment	8.83E-02	0.00E+00	0.00
ME	State	Maine Department of Environmental Protection	1.18E-04	4.81E-02	99.75
MI	State	Michigan Department of Environmental Quality	1.47E-01	1.53E-01	50.88
MN	State	Minnesota Pollution Control Agency	7.31E-02	5.18E-01	87.63
MO	State	Missouri Department of Natural Resources	2.61E-01	5.23E-01	66.71
MS	State	Mississippi Dept of Environmental Quality	5.64E-02	2.11E-01	78.90
MT	State	Montana Department of Environmental Quality	1.08E-01	2.00E-04	0.18
NC	Local	Forsyth County Office of Environmental Assistance and Protection	1.57E-05	2.49E-03	99.37
NC	Local	Western North Carolina Regional Air Quality Agency (Buncombe Co.)	3.13E-03	2.59E-03	45.26
NC	State	North Carolina Department of Environmental Quality	7.34E-02	5.39E-01	88.00
ND	State	North Dakota Department of Health	4.62E-01	0.00E+00	0.00
NE	Local	Lincoln/Lancaster County Health Department	4.43E-03	9.61E-05	2.12
NE	State	Nebraska Environmental Quality	1.12E-01	1.31E-01	53.86
NH	State	New Hampshire Department of Environmental Services	2.82E-03	2.32E-02	89.14
NJ	State	New Jersey Department of Environment Protection	6.80E-03	5.98E-02	89.80
NM	Local	City of Albuquerque	8.57E-03	0.00E+00	0.00
NM	State	New Mexico Environment Department Air Quality Bureau	2.75E-02	2.00E-03	6.79
NV	Local	Clark County Department of Air Quality and Environmental Management	2.28E-02	0.00E+00	0.00
NV	Local	Washoe County Health District	1.93E-05	0.00E+00	0.00
NV	State	Nevada Division of Environmental Protection	8.65E-01	3.44E-04	0.04
NY	State	New York State Department of Environmental Conservation	2.28E-03	1.98E-01	98.86
OH	State	Ohio Environmental Protection Agency	7.09E-01	1.01E+00	58.65
OK	State	Oklahoma Department of Environmental Quality	9.77E-02	1.54E-01	61.18
OR	State	Oregon Department of Environmental Quality	7.59E-03	7.14E-02	90.40
PA	Local	Allegheny County Health Department	4.79E-03	4.70E-03	49.54
PA	State	Pennsylvania Department of Environmental Protection	2.73E-01	1.09E+00	79.92
PA	State	Philadelphia Air Management Services	8.57E-04	4.00E-04	31.81
PR	Territory	Puerto Rico	4.47E-02	0.00E+00	0.00
RI	State	Rhode Island Department of Environmental Management	1.13E-04	2.69E-02	99.58

State	Agency Type	Agency	From EPA (tons)	From Agency (tons)	Percent from Agency
SC	State	South Carolina Department of Health and Environmental Control	2.68E-02	7.67E-01	96.63
SD	State	South Dakota Department of Environment and Natural Resources	2.33E-02	0.00E+00	0.00
TN	State	Tennessee Department of Environmental Conservation	1.56E-01	5.78E-02	27.00
TN	Local	Chattanooga Air Pollution Control Bureau (CHCAPCB)	1.19E-02	0.00E+00	0.00
TN	Local	Knox County Department of Air Quality Management	1.02E-01	1.00E-02	8.94
TN	Local	Memphis and Shelby County Health Department - Pollution Control	1.41E-01	4.54E-03	3.13
TN	Local	Metro Public Health of Nashville/Davidson County	8.36E-05	0.00E+00	0.00
TX	State	Texas Commission on Environmental Quality	6.28E-01	1.75E+00	73.63
UT	State	Utah Division of Air Quality	6.28E-02	6.31E-01	90.95
VA	State	Virginia Department of Environmental Quality	1.21E-01	3.09E-01	71.91
VT	State	Vermont Department of Environmental Conservation	4.26E-04	1.20E-04	21.97
WA	State	Washington State Department of Ecology	1.28E-01	8.97E-03	6.55
WA	Local	Olympic Region Clean Air Agency	0.00E+00	5.15E-03	100.00
WA	Local	Southwest Clean Air Agency	3.59E-02	2.94E-03	7.56
WI	State	Wisconsin Department of Natural Resources	1.06E-01	1.02E-01	48.97
WV	State	West Virginia Division of Air Quality	1.88E-01	1.00E-01	34.77
WY	State	Wyoming Department of Environmental Quality	1.85E-01	2.01E-01	52.02
	Tribe	Coeur d'Alene Tribe	1.84E-05	1.71E-03	98.94
	Tribe	Navajo Nation	7.72E-02	0.00E+00	0.00
	Tribe	Nez Perce Tribe	3.83E-05	0.00E+00	0.00
	Tribe	Salt River Pima Maricopa Indian Community (SRPMIC) EPNR	8.60E-07	2.31E-04	99.63
	Tribe	Southern Ute Indian Tribe	2.11E-06	0.00E+00	0.00
	Tribe	Tohono O-Odham Nation Reservation	4.50E-06	0.00E+00	0.00
	Tribe	Ute Indian Tribe of the Uintah & Ouray Reservation, Utah	1.85E-03	0.00E+00	0.00
	Tribe	Yakama Nation Reservation	1.02E-07	0.00E+00	0.00

Eleven states (ID, IL, MD, MN, NC, NY, OR, RI,TX, VA, WV), 4 local agencies (Chattanooga, TN, Knox County, TN, Nashville/Davidson County, TN and Memphis, TN) and 5 tribal agencies reported Hg to the nonpoint data category. The tribal agencies are Coeur d'Alene Tribe; Kootenai Tribe of Idaho; Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho; Nez Perce Tribe; and Southern Ute Indian Tribe.

Table 2-10 and Figure 2-4 show the 2014 NEI mercury emissions for the key categories of interest in comparison to other triennial inventory years and the baseline HAP inventory of 1990. The 2005 data are from the MATS 2005 modeling platform. Two comma-separated values included in the zip file, 2017nei_supdata_mercury.zip, provide the category assignments at the facility-process level for point sources, and the county-SCC level for nonpoint, onroad and nonroad sources. Individual point source processes were matched to categories based on the process-level or unit-level category assignments used in the previous triennial NEI (2014 NEI) as a starting point, and then supplemented with manual assignments considering SCC, NAICS, facility category codes, emission factor information (e.g., fuel combusted) and facility names. For the commercial/Industrial Sold Waste

Incineration (CISWI) category, a set of facilities were provided by the CISWI project lead [ref 3]. Some of these had been categorized as Portland cement but were re-categorized to CISWI.

Table 2-10: Trends in NEI mercury emissions – 1990, 2005, 2008 v3, 2011v2 and 2014v2 NEI and 2017 NEI

Source Category	1990 (tpy) Baseline 11/2005	2005 (tpy) MATS 3/2011	2008 (tpy) 2008v3	2011 (tpy)	2014 (tpy)	2017 (tpy)	Notes
Utility Coal Boilers (Electricity Generation Units – EGUs, combusting coal)	58.8	52.2	29.4	26.8	22.9	4.4	This category includes only units > 25 MW. (smaller units are included in boiler and process heater category) Coal units and integrated gasified coal combustion units. (excludes Hg estimated for startup gas/oil)
Hospital/Medical/ Infectious Waste Incineration	51	0.2	0.1	0.1	0.02	0.003	
Municipal Waste Combustors	57.2	2.3	1.3	1.0	0.6	0.4	
Industrial, Commercial/Institutional Boilers and Process Heaters	14.4	6.4	4.2	3.6	3.2	2.5	includes electricity generating units where less than 25 MW.
Mercury Cell Chlor-Alkali Plants	10	3.1	1.3	0.5	0.1	0.1	
Electric Arc Furnaces	7.5	7.0	4.8	5.4	5.0	4.7	Assumed a 34% reduction from 2011 levels for those units that were gap filled due to lack of S/L/T or TRI data.
Commercial/Industrial Sold Waste Incineration	Not available	1.1	0.02	0.01	0.01	0.06	Possibly an underestimate due to missing sources and overlap in categorization of cement kilns and hazardous waste incineration in facilities that can burn multiple fuels
Hazardous Waste Incineration	6.6	3.2	1.3	0.7	0.8	1.0	
Portland Cement Non-Hazardous Waste	5.0	7.5	4.2	2.9	3.2	1.7	
Gold Mining	4.4	2.5	1.7	0.8	0.6	0.9	includes fugitive emissions at mines such as TRI emissions at fugitive release points that were not reported by S/L/T
Sewage Sludge Incineration	2	0.3	0.3	0.3	0.3	0.4	

Source Category	1990 (tpy) Baseline 11/2005	2005 (tpy) MATS 3/2011	2008 (tpy) 2008v3	2011 (tpy)	2014 (tpy)	2017 (tpy)	Notes
Mobile Sources	Not available	1.2	1.8	1.3	1.0	0.6	Sum of all of onroad, nonroad, locomotives and commercial marine vessels. Decrease mainly due to rail emissions resulting from emission factor changes.
Other Categories	29.5	18	10.7	13	14.0	16.0	Nonpoint increased by a ton due to increases in open burning of household waste and human cremation. Point increased by a ton due to various industries including ferrous and nonferrous metals production (primary and secondary), chemical manufacturing and mineral products such as gypsum.
Total (all categories)	246	105	61	56	52	33	

Figure 2-4: Trends in NEI Mercury emissions (tons)
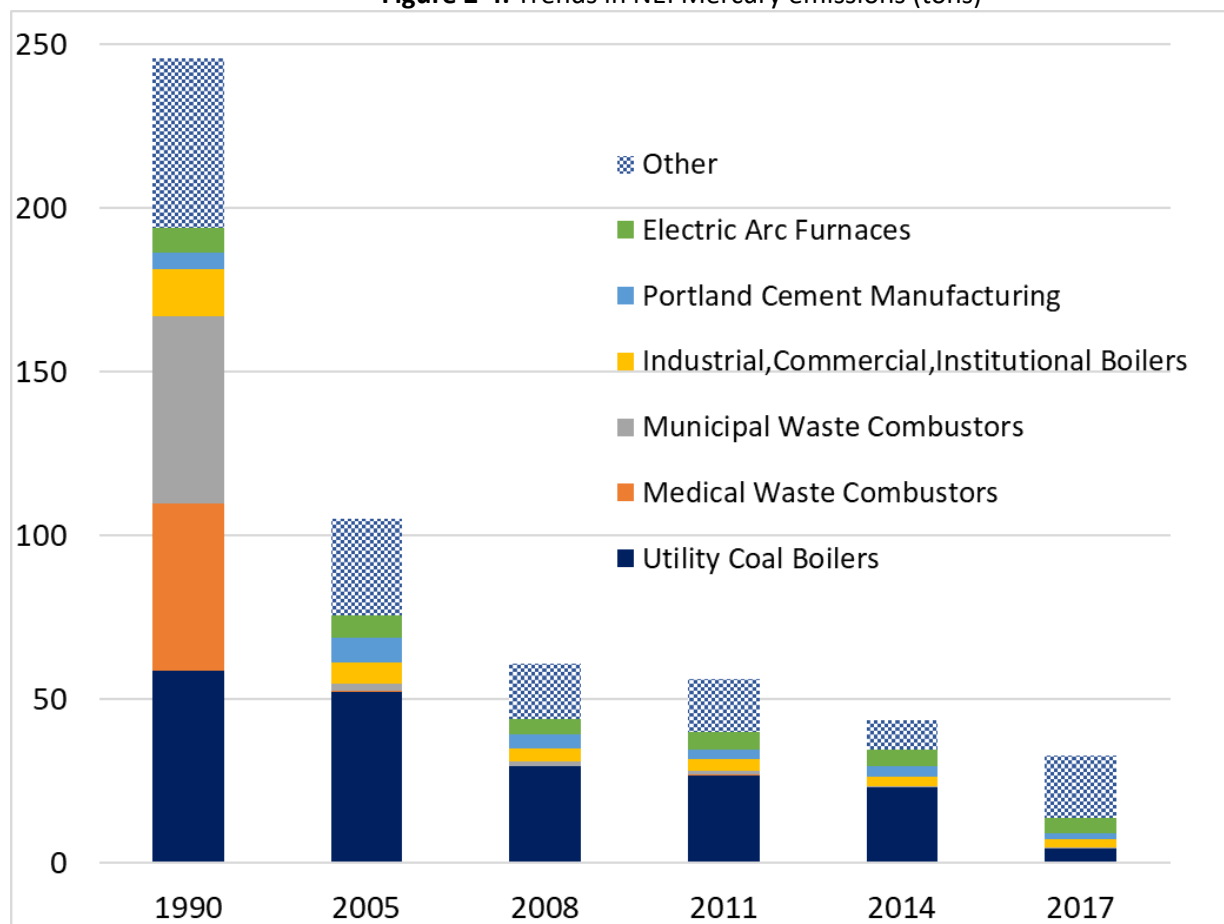
The top emitting 2014 Mercury categories are: electric arc furnaces (rank 1); EGUs (rank 2); industrial, commercial and institutional boilers and process heaters (rank 3); and Portland cement (excluding hazardous waste kilns) (rank 4).

As shown in Table 2-10, 2017 Hg emissions are 19 tons lower than in the 2014. This difference is primarily due to lower Hg emissions from EGUs covered by MATS; two other categories with large decreases are industrial, commercial/institutional boilers and process heaters and Portland cement facilities. For EGUs, the decrease is a combination of fuel switching to natural gas, the installation of Hg controls to comply with state rules and voluntary reductions, early compliance with MATS, and the co-benefits of Hg reductions from control devices installed for the reduction of SO_2 and PM because of state and federal actions, such as New Source Review enforcement actions. For industrial and commercial/institutional boilers, there appears to be fewer boilers using coal. The decrease in the Portland cement category appears to be due to decreases at existing facilities. Some Portland cement facilities have had large decreases in emissions, particularly in CA, FL, MI, TN, IN and PA.

2.8   References for 2017 inventory contents overview

1. Strait, R.; MacKenzie, D.; and Huntley, R., 2003. PM Augmentation Procedures for the 1999 Point and Area Source NEI, 12th International Emission Inventory Conference – "Emission Inventories – Applying New Technologies", San Diego, April 29 – May 1, 2003.
2. U.S. Environmental Protection Agency, 2018. Residual Risk Assessment for the Coal- and Oil-Fired EGU Source Category in Support of the 2019 Risk and Technology Review Proposed Rule, Office of Air Quality Planning and Standards, Docket No. EPA-HQ-OAR-2018-0794-0070, December 2018.

3. Email from Nabanita Modak, EPA, to Janice Godfrey, EPA (cc: Madeleine Strum, EPA and Eric Goehl, EPA) with attached spreadsheet "Facility FRS_NEI IDS For CISWI Units030917.xlsx" emailed 9/6/2019.

3 Point sources

This section provides a description of sources that are in the point data category. Point sources are included in the inventory as individual facilities, usually at specific latitude/longitude coordinates, rather than as county or tribal aggregates. These facilities include large energy and industrial sites, such as electric generating utilities (EGUs), mines and quarries, cement plants, refineries, large gas compressor stations, and facilities that manufacture pulp and paper, automobiles, machinery, chemicals, fertilizers, pharmaceuticals, glass, food products, and other products. Additionally, smaller points sources are included voluntarily by S/L/T agencies, and can include small facilities such as crematoria, dry cleaners, and even gas stations. These smaller sources may appear in one state but not another due to the voluntary nature of providing smaller sources. There are also some portable sources in the point source data category, such as hot mix asphalt facilities, which relocate frequently as a road construction project progress. The point source data category also includes emissions from the landing and take-off portions of aircraft operations, the ground support equipment at airports, and locomotive emissions within railyards. Within a point source facility, emissions are estimated and reported for individual emission units and processes. Those emissions are associated with any number of stack and fugitive release points that each have parameters needed for atmospheric modeling exercises.

The approach used to build the 2017 National Emissions Inventory (NEI) for all point sources is discussed in Section 3.1 through Section 3.8. Some changes to aircraft for the 2017 NEI are also discussed in Section 3.2, and revisions to rail yard estimates for 2017 are included in Section 3.3.

3.1 Point source approach: 2017

The general approach to building the NEI point source inventory is to use state/local/tribal (S/L/T)-submitted emissions, locations, and release point parameters wherever possible. Missing emissions values are gap-filled with EPA data where available. Quality assurance reviews of the emission values, locations, and release point modeling parameters are done by the EPA on the most significant emission sources and where data does not pass quality assurance checks.

3.1.1 QA review of S/L/T data

State/local/tribal agency submittals for the 2017 NEI point sources were accepted through January 15, 2019. We then compared facility-level pollutant sums appearing in either the 2017 NEI S/L/T-submitted values or the 2014v2 NEI. The comparison included all facilities and pollutants, including any missing from the 2017 submittals (i.e., present in 2014 but not 2017) as well as any that were new in the 2017 submittals and all that were common to both years. The comparison table also showed the 2017 emission values from the 2017 Toxics Release Inventory (TRI). We added columns that showed the percent differences between the 2017 S/L/T agency-submitted facility totals and the 2014 NEIv2 and 2017 TRI datasets. To create a more focused review and comparison table, we limited these results to include only cases where the 2017 S/L/T agency-submitted facility total was more than 50 percent different from the 2014 facility total and with an absolute mass value of the difference greater than a pollutant-specific threshold amount[2]. When a facility-pollutant combination was new in 2017 or appeared only in the 2014 NEI v2, we included those values only when they exceeded the absolute

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[2] These thresholds are available on the 2014v1 Supplemental Data FTP site as file "2014_point_pollutant_thresholds_qa_flag1.xlsx"

mass values greater than the pollutant-specific thresholds because the percent differences were undefined. We provided[3] the resulting table of 3,860 records to S/L/T agencies for review.

State/local/tribal edits to address any emissions values were accepted in the Emissions Inventory System (EIS) until July 1, 2019. The S/L/T agencies did not change most of the highlighted values. Where the comparisons were exceptionally suspect, the EPA contacted the agencies by phone or by email if no edits had been made to obtain confirmation of the reported values. For a small number of cases, neither confirmation nor edits were obtained, and the value was tagged to be excluded from selection for the NEI. In some but not all of these instances, a value from TRI or the CAMD data sets was available as a replacement.

Similar to previous NEI years, we quality assured the latitude-longitude coordinates at both the site level and the release point level. In previous NEI cycles, we had reviewed, verified, and locked (in EIS) approximately 5,500 site-level coordinates of the most significant emitting facilities. For the 2017 NEI coordinate review, we compared all other site coordinate pairs to the county boundaries for the FIPS county codes reported for those facilities. We then identified all facilities that met both of the following criteria: (1) more than 50 tons total criteria pollutant emissions or more than 20 pounds total hazardous air pollutants (HAPs) for 2017, (2) the coordinates caused the location of the facility to be more than a half mile outside of its indicated county. For these facilities, we reviewed the location using Google Earth, edited the location as needed in EIS, and locked the location in EIS.

In addition, we compared the release point coordinates of all release points with any 2017 emissions to their site level coordinates, whether protected or not. In cases where we found a difference of more than 0.003 degrees in either latitude plus longitude, we reviewed the release point coordinates in Google Earth and either confirmed that the release point appeared to be on the facility's footprint or we removed the release point's coordinates, which will allow the modeling files to inherit the site coordinates. Site coordinates were edited and locked as needed as part of this release point coordinate review. A new critical QA check was also implemented in EIS, beginning with the 2018 NEI point source submittals, that does not allow the reporting of facility and release point coordinates that differ by more than a facility-specific amount for either latitude or longitude. The tolerance amount was set at 0.003 for most facilities, but that tolerance was increased for facilities where the above review had confirmed that the individual release point coordinates were valid. Some smaller footprint facilities that had to be reviewed due to apparent violations also had the tolerance set lower as part of the above review. As of the release of the 2017 final NEI dated April 2020, approximately 9,900 facilities had verified and locked site coordinates, and all release points used for 2017 emissions were within the facility-specific tolerance of their site coordinates.

3.1.1.1   *January 2021 update to the 2017 point NEI*

After the initial April 2020 release of the 2017 NEI, quality assurance efforts by EPA and by state agencies continued. In some cases, states submitted corrections and additions to their 2017 emissions values. As a result, some additional changes were picked up when we regenerated a point inventory to capture the aircraft corrections (in the June 2020 EIS release). The EPA is now making both sets of updates available in this January 2021 release. See Section 3.2.3 for discussion on the aircraft changes.

The non-aircraft updates are summarized by state and facilities in the tables below. More detailed comparisons are also available by request and state, local, and tribal agency staff can create such comparisons using the EIS at the facility and process levels.

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[3] We emailed the Emission Inventory System data submitters the table and instructions on March 13, 2019.

In addition to the airports, Table 3-1 summarizes the April criteria pollutant and precursor emissions (except Lead) for facilities with emissions changes and Table 3-2 shows the emissions values for these facilities in the June release. Together these tables show that just a select set of states have a few facilities with criteria pollutant emissions changes: Florida (3 facilities), Georgia (8), Iowa (1), Louisiana (1), and Ohio (1).

Table 3-1: 2017 NEI emissions values from April 2020 release for criteria pollutants (airports excluded) and precursors (other than Lead) that changed in the January 2021 release

State	County	EIS Facility ID	Facility Name	Facility Type	CO (Ton)	NOX (Ton)	PM10 (Ton)	PM2.5 (Ton)	VOC (Ton)
FL	Alachua	536811	GAINESVILLE REGIONAL UTILITIES	Electricity Generation via Combustion			15	15	
FL	Martin	751511	FLORIDA POWER & LIGHT (PMR)	Electricity Generation via Combustion	1,105				
FL	Nassau	753711	WESTROCK CP, LLC	Pulp and Paper Plant					627
GA	Bibb	14418411	BROSNAN	Rail Yard		158	4	4	10
GA	Cobb	18338611	AUSTELL	Rail Yard		53			3
GA	DeKalb	18307011	NORTH DORAVILLE	Rail Yard		26			
GA	Floyd	18307111	KRANNERT	Rail Yard		13			
GA	Fulton	14419011	INMAN	Rail Yard		119	3	3	8
GA	Fulton	14419211	INDUSTRY	Rail Yard		26			
GA	Fulton	14478611	HOWELLS	Rail Yard	3	20	1	1	1
GA	Fulton	14479011	TILFORD	Rail Yard	45	290	8	7	19
IA	Muscatine	7741111	GRAIN PROCESSING CORPORATION	Ethanol Biorefineries/Soy Biodiesel					427
LA	Iberville	5504811	Taminco - St Gabriel Plant	Chemical Plant					72
OH	Stark	8521511	Republic Steel (1576050694)	Steel Mill	318	172	144	133	40

Table 3-2: 2017 NEI emissions values that changed in the January 2021 release for criteria pollutants and precursors (other than Lead)

State	County	EIS Facility ID	Facility Name	Facility Type	CO (Ton)	NOX (Ton)	PM10 (Ton)	PM2.5 (Ton)	VOC (Ton)
FL	Alachua	536811	GAINESVILLE REGIONAL UTILITIES	Electricity Generation via Combustion			4	4	
FL	Martin	751511	FLORIDA POWER & LIGHT (PMR)	Electricity Generation via Combustion	1,421				
FL	Nassau	753711	WESTROCK CP, LLC	Pulp and Paper Plant					642
GA	Bibb	14418411	BROSNAN	Rail Yard		98	2	2	6
GA	Cobb	18338611	AUSTELL	Rail Yard		33			2
GA	DeKalb	18307011	NORTH DORAVILLE	Rail Yard		16			
GA	Floyd	18307111	KRANNERT	Rail Yard		5			
GA	Fulton	14419011	INMAN	Rail Yard		73	2	2	5
GA	Fulton	14419211	INDUSTRY	Rail Yard		16			
GA	Fulton	14478611	HOWELLS	Rail Yard	23	145	4	4	9
GA	Fulton	14479011	TILFORD	Rail Yard	25	101	2	2	6
IA	Muscatine	7741111	GRAIN PROCESSING CORPORATION	Ethanol Biorefineries/Soy Biodiesel					600

State	County	EIS Facility ID	Facility Name	Facility Type	CO (Ton)	NOX (Ton)	PM10 (Ton)	PM2.5 (Ton)	VOC (Ton)
LA	Iberville	5504811	Taminco - St Gabriel Plant	Chemical Plant					65
OH	Stark	8521511	Republic Steel (1576050694)	Steel Mill	257	148	258	238	32

In addition, the HAP differences are summarized in Table 3-3 and Table 3-4, but because there are so many pollutants that cannot easily fit in this document, these summaries are provided with aggregated HAP emissions in some cases. Lead and Ethylene Oxide are split out separately, and these are double counted with the "HAP-Metals" and "HAP VOC" emissions totals, respectively. Table 3-3 summarizes the April 2020 HAP emissions for facilities with emissions changes and Table 3-4 shows the emissions values for these facilities in this January 2021 release. Together these tables show that just a select set of states have a few facilities with HAP emissions changes: Florida (3 facilities), Georgia (8), Iowa (1), Louisiana (1), Minnesota (1), Ohio (1), Texas (1), and West Virginia (2).

Table 3-3: 2017 NEI emissions values in April 2020 release for HAPs that changed in the January 2021 release

State	County	EIS Facility ID	Facility Name	Facility Type	Acid-Gases (Lbs)	HAP-Metal (Lbs)	HAP-VOC (Lbs)	Ethylene Oxide (Lbs)	Lead (Lbs)
FL	Duval	3867611	DUVAL ASPHALT PRODUCTS	Hot Mix Asphalt Plant		6			
FL	Martin	751511	FLORIDA POWER & LIGHT (PMR)	Electricity Generation via Combustion			55,559		
FL	Nassau	753711	WESTROCK CP, LLC	Pulp and Paper Plant			21,110		
GA	Bibb	14418411	BROSNAN	Rail Yard		33	9,073		
GA	Cobb	18338611	AUSTELL	Rail Yard		9	3,024		
GA	DeKalb	18307011	NORTH DORAVILLE	Rail Yard		3	1,507		
GA	Floyd	18307111	KRANNERT	Rail Yard		1	754		
GA	Fulton	14419011	INMAN	Rail Yard		24	6,804		
GA	Fulton	14419211	INDUSTRY	Rail Yard		3	1,507		
GA	Fulton	14478611	HOWELLS	Rail Yard		4	1,136		
GA	Fulton	14479011	TILFORD	Rail Yard		60	16,612		
IA	Clinton	12808011	ADM CLINTON CORN PROCESSING	Ethanol Biorefineries/Soy Biodiesel	28		43,960		
LA	Iberville	5504811	Taminco - St Gabriel Plant	Chemical Plant			10,334	1,606	
MN	Itasca	6173211	Minnesota Power Inc - Boswell Energy Ctr	Electricity Generation via Combustion					107
OH	Stark	8521511	Republic Steel (1576050694)	Steel Mill					789
TX	Bexar	4882011	BOEING - SAN ANTONIO	Aircraft, Aerospace, or Related Parts Plant		1,638			
WV	Kanawha	5782311	UNION CARBIDE CORP -SO CHARLESTON FAC.	Chemical Plant			1440	1440	

State	County	EIS Facility ID	Facility Name	Facility Type	Acid-Gases (Lbs)	HAP-Metal (Lbs)	HAP-VOC (Lbs)	Ethylene Oxide (Lbs)	Lead (Lbs)
WV	Kanawha	6884411	UNION CARBIDE CORPORATION-INSTITUTE	Chemical Plant			4,748	4,748	

Table 3-4: 2017 NEI emissions values that changed in the January 2021 for HAPs

State	County	EIS Facility ID	Facility Name	Facility Type	Acid-Gases (Lbs)	HAP-Metal (Lbs)	HAP-VOC (Lbs)	Ethylene Oxide (Lbs)	Lead (Lbs)
FL	Duval	3867611	DUVAL ASPHALT PRODUCTS	Hot Mix Asphalt Plant		1			
FL	Martin	751511	FLORIDA POWER & LIGHT (PMR)	Electricity Generation via Combustion			35,038		
FL	Nassau	753711	WESTROCK CP, LLC	Pulp and Paper Plant			50,330		
GA	Bibb	14418411	BROSNAN	Rail Yard		17	5354		
GA	Cobb	18338611	AUSTELL	Rail Yard		5	1785		
GA	DeKalb	18307011	NORTH DORAVILLE	Rail Yard		2	890		
GA	Floyd	18307111	KRANNERT	Rail Yard		0	269		
GA	Fulton	14419011	INMAN	Rail Yard		13	4,016		
GA	Fulton	14419211	INDUSTRY	Rail Yard		2	890		
GA	Fulton	14478611	HOWELLS	Rail Yard		30	8,304		
GA	Fulton	14479011	TILFORD	Rail Yard		18	5,515		
IA	Clinton	12808011	ADM CLINTON CORN PROCESSING	Ethanol Biorefineries/Soy Biodiesel	132		82,615		
LA	Iberville	5504811	Taminco - St Gabriel Plant	Chemical Plant			7,895	161	
MN	Itasca	6173211	Minnesota Power Inc - Boswell Energy Ctr	Electricity Generation via Combustion					731
OH	Stark	8521511	Republic Steel (1576050694)	Steel Mill					1,621
TX	Bexar	4882011	BOEING - SAN ANTONIO	Aircraft, Aerospace, or Related Parts Plant		146			
WV	Kanawha	5782311	UNION CARBIDE CORP -SO CHARLESTON FAC.	Chemical Plant			202	202	
WV	Kanawha	6884411	UNION CARBIDE CORPORATION-INSTITUTE	Chemical Plant			1,740	1,740	

3.1.2 Sources of EPA data and selection hierarchy

Table 3-5 lists the datasets that we used to compile the 2017 NEI point inventory and the hierarchy used to choose which data value to use for the NEI when multiple data sets are available for the same emissions source (see Section 2.2 for more detail on the EIS selection process).

The EPA developed all datasets other than those containing S/L/T agency data and the dataset containing emissions from offshore oil and gas platforms in federal waters in the Gulf of Mexico. The primary purpose of

the EPA datasets is to add or "gap fill" pollutants or sources not provided by S/L/T agencies, to resolve inconsistencies in S/L/T agency-reported pollutant submissions for particulate matter (PM) (Section 3.1.3) and to speciate S/L/T agency reported total chromium into hexavalent and trivalent forms (Section 3.1.4).

The hierarchy or "order" provided in the tables below defines which data are to be used for situations where multiple datasets provide emissions for the same pollutant and emissions process. The dataset with the lowest order number on the list is preferentially used over other datasets. The table includes the rationale for why each dataset was assigned its position in the hierarchy. In addition to the order of the datasets, the selection also considers whether individual data values have been tagged (see Section 2.2.6). Any data that were tagged by the EPA in any of the datasets were not used. State/local/tribal agency data were tagged only if they were deemed to be likely outliers and were not addressed during the S/L/T agency data reviews. As in earlier NEI years, the 2017 point source selection also excludes dioxins, furans and radionuclides. The EPA has not evaluated the completeness or accuracy of the S/L/T agency dioxin and furan values nor radionuclides and does not have plans to supplement these reported emissions with other data sources to compile a complete and accurate estimate for these pollutants as part of the NEI. The 2017 NEI point source inventory does include greenhouse gas emissions. Facility total values for four GHGs (CO2, CH4, N2O, and SF6) were copied from the U.S. Greenhouse Gas Inventory Report website and matched to EIS facilities.

Table 3-5: Data sets and selection hierarchy used for 2017 NEI August release point source data category

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2017EPA_PMSpecies	Speciated PM2.5 data. A result of offline emissions speciation where the resulting PM25-PRI selection emissions are split into the 5 PM species: elemental (black) carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), and the remainder of PM25-PRI (PMFINE). Diesel engine PM25-PRI and PM10 are also copied as DIESEL-PM pollutants.	1
2017EPA_GHG	Facility-level emissions for four specific GHGs from the USEPA's Greenhouse Gas Reporting Program	2
2017EPA_EGUmats	Emission unit level emissions for 29 HAPs from the Mercury and Air Toxics (MATS) RTR modeling file for electric generating utilities (EGUs)	3
Responsible Agency Data Set	S/L/T agency submitted data through June 2020. These data are selected ahead of lower hierarchy datasets except where individual values in the S/L/T agency emissions were suspected outliers that were not addressed during the draft review and therefore tagged by the EPA.	4
2017EPA_Cr_Aug	Hexavalent and trivalent chromium speciated from S/L/T agency reported chromium. EIS augmentation function creates the dataset by applying multiplication factors by SCC, facility, process or North American Industry Classification System (NAICS) code to S/L/T agency total chromium. See Section 3.1.4.	5
2017EPA_PM-Aug	PM components added to gap fill missing S/L/T agency data or make corrections where S/L/T agency have inconsistent emissions across PM components. Uses ratios of emission factors from the PM Augmentation Tool for covered source classification codes (SCCs). For SCCs without emission factors in the tool, checks/corrects discrepancies or missing PM species using basic relationships such as ensuring that primary PM is greater than or equal to filterable PM (see Section 3.1.3).	6

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2017EPA_EGU	CAP and HAP emission unit level emissions from either the annual sum of CAMD hourly CEM data for SO2 and NOx or from emission factors used in previous NEI year inventories from AP-42 and other sources multiplied by 2017 CAMD heat input data.	7
2017EPA_TRI	TRI data for the year 2017 (see Section 3.1.5). These data are selected for a facility only when the S/L/T agency data do not include emissions for a given pollutant at any process for that facility.	8
2017EPA_TRIcr	TRI data reported as total chromium for the year 2017 speciated into the chromium III and chromium VI valence amounts, usually by use of a NAICs-based speciation profile, but possibly by use of a facility-specific profile.	9
2017EPA_Airports	CAP and HAP emissions for aircraft operations including commercial, general aviation, air taxis and military aircraft, auxiliary power units and ground support equipment computed by the EPA for approximately 20,000 airports. Methods include the use of the Federal Aviation Administration's (FAA's) Aviation Environmental Design Tool (AEDT) and includes data updated in June 2020 (see Section 3.2).	10
2017EPA_BOEM	2017 Gulfwide Emission Inventory CAP emissions from Offshore oil platforms located in Federal Waters in the Gulf of Mexico developed by the U.S. Department of the Interior, Bureau of Ocean and Energy Management (BOEM), Regulation, and Enforcement in the National Inventory Input Format and converted to the CERS format by the EPA. The state code for data from the data set is "DM" (Federal Waters).	11
2017EPA_LF	Landfill emissions developed by EPA using methane data from the EPA's GHG reporting rule program.	12
2017EPA_SPPD_PCWP	Subset of the Plywood and Composite Wood Products Manufacture (PCWP) Risk and Technology Review (RTR) data used for gap filling HAPs at facilities and updating facility configurations. Facilities were initially selected if either formaldehyde or benzene were greater than 0.1 tpy. The PCWP rule information can be found on the Plywood and Composite Wood Products Manufacture NESHAP webpage.	13
2017EPA_HAPAug	HAP data computed from S/L/T agency criteria pollutant data using HAP/CAP EF ratios based on the EPA Factor Information Retrieval System (WebFIRE) database as described in Section 3.1.6. These data are selected below the TRI data because the TRI data are expected to be better.	14
2017EPA_HAPAug-PMaug	This dataset was created in the same fashion as the 2017EPA_HAPAug dataset above and is a supplement to it. This dataset contains HAPs calculated by applying a ratio to PM10-FIL emissions, for those instances where the S/L/T dataset did not contain any PM10-FIL emissions, but the PM augmentation routine was able to calculate a PM10-FIL value from some PM species that was reported by the S/L/T.	15
2017ERTAC_Rail	2017 estimates compiled by the Eastern Regional Technical Advisory Committee (ERTAC) for most rail yards in the US. The ERTAC effort was comprised of a collaborative of state/local agencies, rail companies, and the Federal Rail Administration. Yard emissions are associated with the operation of switcher engines at each yard.	16

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2017EPA_gapfills	2014 emissions values for 212 facilities and 12 pollutants not reported in 2017 S/L/T datasets but appear to still be operating and were above CAP reporting thresholds in 2014. This data set also includes 2017 mercury emissions for 6 municipal waste combustor facilities that were provided (outside of EIS) by Maryland and Massachusetts.	17
2017EPA_2016TRI	2016 TRI ethylene oxide emission estimates for 6 facilities that are still operating but were not reported by S/L/T or are missing from the 2017 TRI.	18

3.1.3 Particulate matter augmentation

Particulate matter emissions components[4] in the NEI are: primary PM10 (called PM10-PRI in the EIS and NEI) and primary PM2.5 (PM25-PRI), filterable PM10 (PM10-FIL) and filterable PM2.5 (PM25-FIL) and condensable PM (PM-CON, which is all within the PM2.5 portion on PM, i.e., PM25-PRI = PM25-FIL + PM-CON). The EPA needed to augment the S/L/T agency PM components to ensure completeness of the PM components in the final NEI and to ensure that S/L/T agency data did not contain inconsistencies. An example of an inconsistency is if the S/L/T agency submitted a primary PM2.5 value that was greater than a primary PM10 value for the same process. Commonly, the augmentation added condensable PM or PM filterable (PM10-FIL and/or PM25-FIL) where no value was provided, or primary PM2.5 where only primary PM10 was provided. Additional information on the procedure is provided in the 2008 NEI PM augmentation documentation [ref 1].

In general, emissions for PM species missing from S/L/T agency inventories were calculated by applying factors to the PM emissions data supplied by the S/L/T agencies. These conversion factors were first used in the 1999 NEI's "PM Calculator" as described in an NEI conference paper [ref 2]. The resulting methodology allows the EPA to derive missing PM10-FIL or PM25-FIL emissions from incomplete S/L/T agency submissions based on the SCC and PM controls that describe the emissions process. In cases where condensable emissions are not reported, conversion factors developed are applied to S/L/T agency reported PM species or species derived from the PM Calculator databases.

3.1.4 Chromium speciation

An overview of chromium speciation, as it impacts both the point and nonpoint data category, is discussed in Section 2.2.2.

The EIS generates and stores an EPA dataset containing the resultant hexavalent and trivalent chromium species. The EPA then used this dataset in the 2017 NEI selection by adding it to the selection hierarchy shown in Table 3-5, excluding the S/L/T agency total chromium from the selection through a pollutant exception to the hierarchy. This EIS feature does not speciate chromium from any of the EPA datasets because the EPA data contains only speciated chromium.

For the 2017 NEI, the EPA named this dataset "2017EPA_Cr_Aug." Most of the speciation factors used in the 2017 NEI are SCC-based and are the same as were used for the 2008, 2011 and 2014 NEIs. There are some facility-specific factors resulting from reviews of previous year (e.g., 2014 and 2011) National Air Toxics Assessment (NATA) data. Facility-specific factors were also provided for several facilities by the state of Indiana. The factors "SLT_based_chromium_speciation.zip", based on data that have long been used by the EPA for NATA and other risk projects, are available on the 2017 Supplemental data FTP site.

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[4] We use the term "components" here rather than "species" to avoid confusion with the PM2.5 "species" that are used for air quality modeling (e.g., organic carbon, elemental carbon, sulfate, nitrate, and other PM).

3.1.5   Use of the 2017 Toxics Release Inventory

The EPA used air emissions data from the 2017 TRI to supplement point source HAP and ammonia emissions provided to the EPA by S/L/T agencies. The resulting augmentation dataset is labeled as "2017EPA_TRI" in the Table 3-5 selection hierarchy shown above. For 2017, all TRI emissions values that could reasonably be matched to an EIS facility were loaded into the EIS for viewing and comparison if desired, but only those pollutants that were not reported anywhere at the EIS facility by the S/L/T agency were included in the 2017 NEI. The October 2018 version of these data were used, however, where emissions changes between this version and the April 2019 version of the 2017 TRI data exceeded 2%, the April 2019 version was used.

The basis of the 2017EPA_TRI dataset is the US EPA's 2017 Toxics Release Inventory (TRI) Program. The TRI is an EPA database containing data on disposal or other releases including air emissions of over 650 toxic chemicals from approximately 21,000 facilities. One of TRI's primary purposes is to inform communities about toxic chemical releases to the environment. Data are submitted annually by U.S. facilities that meet TRI reporting criteria.

The approach used for the 2017 NEI was like that used for the 2014 NEI. The TRI emissions were included in the EIS (and the NEI) as facility-total stack and facility-total fugitive emissions processes, which matches the aggregation detail of the TRI database. For the 2017 NEI Point inventory (PT), a change was made in how we avoid double-counting of TRI and other data sources (primarily the S/L/T data). Rather than tagging each individual TRI facility-based value for wherever the S/L/T had reported that pollutant at any process(es) within the same facility, we enhanced the EIS selection software to not use values from a "Facility" level dataset if a more preferred dataset (the S/L/T datasets) had the pollutant at that facility. (see section 2.2.6). In addition to using this new "facility-based rule" in the selection software, we also implemented a new "pollutant family rule" into the selection software, which prevents pollutants defined as belonging to the same overlapping family of pollutants from being selected for use if a higher preference dataset has already provided a pollutant value for that family. This procedure had also been accomplished using tagging in previous NEI years.

The following steps describe in more detail the development of the 2017EPA_TRI dataset.

1. **Update the TRI_ID to EIS_ID facility-level crosswalk**
    For the 2017 NEI, the same crosswalk list of TRI IDs that was used for the 2014 NEI was used as a starting point. A limited review of the 2017 TRI facilities was conducted to identify new facilities with significant emissions that had not been previously matched to an EIS facility. A total of approximately 50 additional TRI facilities were added to the crosswalk for 2017.

2. **Map TRI pollutant codes to valid EIS pollutant codes and sum where necessary**
    Table 3-6 provides the pollutant mapping from TRI pollutants to EIS pollutants. Many of the 650 TRI pollutants do not have any EIS counterpart, and so are not shown in Table 3-6. In addition, several EIS pollutants may be reported to TRI as either of two TRI pollutants. For example, both Pb and Pb compounds may be reported to TRI, and similarly for several other metal and metal compound TRI pollutants. Table 3-6 shows where such pairs of TRI pollutants both correspond to the same EIS pollutant. In such cases, we summed the two TRI pollutants together as part of the step of assigning the TRI emissions to valid EIS pollutant codes. For the 2017 NEI, a total of 197 TRI pollutant codes were mapped to 185 unique EIS pollutant codes. Similar to the 2011 and 2014 NEIs, we did not use TRI emissions reported for TRI pollutants: "Certain Glycol Ethers," "Dioxin and Dioxin-like Compounds," Dichlorobenzene (mixed isomers)," and "Toluene di-isocyanate (mixed isomers)," because they do not represent the same scope as the EIS pollutants: "Glycol ethers," "Dioxins/Furans as 2,3,7,8-TCDD TEQs," "1,4-Dichlorobenzene," and "2,4-Di-isocyanate," respectively. We maintained TRI stack and fugitive

emissions separately during the summation step and maintained that separation through the storage of the TRI emissions in the EIS.

Table 3-6: Mapping of TRI pollutant codes to EIS pollutant codes

TRI CAS	TRI Pollutant Name	EIS Pollutant Code	EIS Pollutant Name
79345	1,1,2,2-TETRACHLOROETHANE	79345	1,1,2,2-TETRACHLOROETHANE
79005	1,1,2-TRICHLOROETHANE	79005	1,1,2-TRICHLOROETHANE
57147	1,1-DIMETHYL HYDRAZINE	57147	1,1-DIMETHYL HYDRAZINE
120821	1,2,4-TRICHLOROBENZENE	120821	1,2,4-TRICHLOROBENZENE
96128	1,2-DIBROMO-3-CHLOROPROPANE	96128	1,2-DIBROMO-3-CHLOROPROPANE
57147	1,1-DIMETHYL HYDRAZINE	57147	1,1-Dimethyl Hydrazine
106887	1,2-BUTYLENE OXIDE	106887	1,2-EPOXYBUTANE
75558	PROPYLENEIMINE	75558	1,2-PROPYLENIMINE
106990	1,3-BUTADIENE	106990	1,3-BUTADIENE
542756	1,3-DICHLOROPROPYLENE	542756	1,3-DICHLOROPROPENE
1120714	PROPANE SULTONE	1120714	1,3-PROPANESULTONE
106467	1,4-DICHLOROBENZENE	106467	1,4-DICHLOROBENZENE
25321226	DICHLOROBENZENE (MIXED ISOMERS)		NA- pollutant not used
95954	2,4,5-TRICHLOROPHENOL	95954	2,4,5-TRICHLOROPHENOL
88062	2,4,6-TRICHLOROPHENOL	88062	2,4,6-TRICHLOROPHENOL
94757	2,4-DICHLOROPHENOXY ACETIC ACID	94757	2,4-DICHLOROPHENOXY ACETIC ACID
51285	2,4-DINITROPHENOL	51285	2,4-DINITROPHENOL
121142	2,4-DINITROTOLUENE	121142	2,4-DINITROTOLUENE
53963	2-ACETYLAMINOFLUORENE	53963	2-ACETYLAMINOFLUORENE
79469	2-NITROPROPANE	79469	2-NITROPROPANE
91941	3,3'-DICHLOROBENZIDINE	91941	3,3'- DICHLOROBENZIDINE
119904	3,3'-DIMETHOXYBENZIDINE	119904	3,3'- DIMETHOXYBENZIDINE
119937	3,3'-DIMETHYLBENZIDINE	119937	3,3'-DIMETHYLBENZIDINE
101144	4,4'-METHYLENEBIS(2-CHLOROANILINE)	101144	4,4'-METHYLENEBIS(2-CHLORANILINE)
101779	4,4'-METHYLENEDIANILINE	101779	4,4'-METHYLENEDIANILINE
534521	4,6-DINITRO-O-CRESOL	534521	4,6-DINITRO-O-CRESOL
92671	4-AMINOBIPHENYL	92671	4-AMINOBIPHENYL
60117	4-DIMETHYLAMINOAZOBENZENE	60117	4-DIMETHYLAMINOAZOBENZENE
100027	4-NITROPHENOL	100027	4-NITROPHENOL
75070	ACETALDEHYDE	75070	ACETALDEHYDE
60355	ACETAMIDE	60355	ACETAMIDE
75058	ACETONITRILE	75058	ACETONITRILE
98862	ACETOPHENONE	98862	ACETOPHENONE
107028	ACROLEIN	107028	ACROLEIN
79061	ACRYLAMIDE	79061	ACRYLAMIDE
79107	ACRYLIC ACID	79107	ACRYLIC ACID
107131	ACRYLONITRILE	107131	ACRYLONITRILE
107051	ALLYL CHLORIDE	107051	ALLYL CHLORIDE
7664417	AMMONIA	NH3	AMMONIA
62533	ANILINE	62533	ANILINE
7440360	ANTIMONY	7440360	ANTIMONY
N010	ANTIMONY COMPOUNDS	7440360	ANTIMONY
7440382	ARSENIC	7440382	ARSENIC
N020	ARSENIC COMPOUNDS	7440382	ARSENIC
1332214	ASBESTOS (FRIABLE)	1332214	ASBESTOS
71432	BENZENE	71432	BENZENE
92875	BENZIDINE	92875	BENZIDINE
98077	BENZOIC TRICHLORIDE	98077	BENZOTRICHLORIDE
100447	BENZYL CHLORIDE	100447	BENZYL CHLORIDE
7440417	BERYLLIUM	7440417	BERYLLIUM
N050	BERYLLIUM COMPOUNDS	7440417	BERYLLIUM
92524	BIPHENYL	92524	BIPHENYL
117817	DI(2-ETHYLHEXYL) PHTHALATE	117817	BIS(2-ETHYLHEXYL)PHTHALATE
542881	BIS(CHLOROMETHYL) ETHER	542881	BIS(CHLOROMETHYL)ETHER
75252	BROMOFORM	75252	BROMOFORM
7440439	CADMIUM	7440439	CADMIUM
N078	CADMIUM COMPOUNDS	7440439	CADMIUM

TRI CAS	TRI Pollutant Name	EIS Pollutant Code	EIS Pollutant Name
156627	CALCIUM CYANAMIDE	156627	CALCIUM CYANAMIDE
133062	CAPTAN	133062	CAPTAN
63252	CARBARYL	63252	CARBARYL
75150	CARBON DISULFIDE	75150	CARBON DISULFIDE
56235	CARBON TETRACHLORIDE	56235	CARBON TETRACHLORIDE
463581	CARBONYL SULFIDE	463581	CARBONYL SULFIDE
120809	CATECHOL	120809	CATECHOL
57749	CHLORDANE	57749	CHLORDANE
7782505	CHLORINE	7782505	CHLORINE
79118	CHLOROACETIC ACID	79118	CHLOROACETIC ACID
108907	CHLOROBENZENE	108907	CHLOROBENZENE
510156	CHLOROBENZILATE	510156	Chlorobenzilate
67663	CHLOROFORM	67663	CHLOROFORM
107302	CHLOROMETHYL METHYL ETHER	107302	CHLOROMETHYL METHYL ETHER
126998	CHLOROPRENE	126998	CHLOROPRENE
7440473	CHROMIUM	7440473	CHROMIUM
N090	CHROMIUM COMPOUNDS (EXCEPT CHROMITE ORE MINED IN THE TRANSVAAL REGION)	7440473	CHROMIUM
7440484	COBALT	7440484	COBALT
N096	COBALT COMPOUNDS	7440484	COBALT
1319773	CRESOL (MIXED ISOMERS)	1319773	CRESOL/CRESYLIC ACID (MIXED ISOMERS)
108394	M-CRESOL	108394	M-CRESOL
95487	O-CRESOL	95487	O-CRESOL
106445	P-CRESOL	106445	P-CRESOL
98828	CUMENE	98828	CUMENE
N106	CYANIDE COMPOUNDS	57125	CYANIDE
74908	HYDROGEN CYANIDE	57125	CYANIDE
132649	DIBENZOFURAN	132649	DIBENZOFURAN
84742	DIBUTYL PHTHALATE	84742	DIBUTYL PHTHALATE
111444	BIS(2-CHLOROETHYL) ETHER	111444	DICHLOROETHYL ETHER
62737	DICHLORVOS	62737	DICHLORVOS
111422	DIETHANOLAMINE	111422	DIETHANOLAMINE
64675	DIETHYL SULFATE	64675	DIETHYL SULFATE
131113	DIMETHYL PHTHALATE	131113	DIMETHYL PHTHALATE
77781	DIMETHYL SULFATE	77781	DIMETHYL SULFATE
79447	DIMETHYLCARBAMYL CHLORIDE	79447	DIMETHYLCARBAMOYL CHLORIDE
N120	DIISOCYANATES		NA- pollutant not used
26471625	TOLUENE DIISOCYANATE (MIXED ISOMERS)		NA- pollutant not used
584849	TOLUENE-2,4-DIISOCYANATE	584849	2,4-TOLUENE DIISOCYANATE
N150	DIOXIN AND DIOXIN-LIKE COMPOUNDS		NA- pollutant not used
106898	EPICHLOROHYDRIN	106898	EPICHLOROHYDRIN
140885	ETHYL ACRYLATE	140885	ETHYL ACRYLATE
51796	URETHANE	51796	ETHYL CARBAMATE
75003	CHLOROETHANE	75003	ETHYL CHLORIDE
100414	ETHYLBENZENE	100414	ETHYL BENZENE
106934	1,2-DIBROMOETHANE	106934	ETHYLENE DIBROMIDE
107062	1,2-DICHLOROETHANE	107062	ETHYLENE DICHLORIDE
107211	ETHYLENE GLYCOL	107211	ETHYLENE GLYCOL
151564	ETHYLENEIMINE	151564	ETHYLENEIMINE
75218	ETHYLENE OXIDE	75218	ETHYLENE OXIDE
96457	ETHYLENE THIOUREA	96457	ETHYLENE THIOUREA
75343	ETHYLIDENE DICHLORIDE	75343	ETHYLIDENE DICHLORIDE
50000	FORMALDEHYDE	50000	FORMALDEHYDE
N230	CERTAIN GLYCOL ETHERS	171	N/A Pollutant not used
76448	HEPTACHLOR	76448	HEPTACHLOR
118741	HEXACHLOROBENZENE	118741	HEXACHLOROBENZENE
87683	HEXACHLORO-1,3-BUTADIENE	87683	HEXACHLOROBUTADIENE
77474	HEXACHLOROCYCLOPENTADIENE	77474	HEXACHLOROCYCLOPENTADIENE
67721	HEXACHLOROETHANE	67721	HEXACHLOROETHANE
110543	N-HEXANE	110543	HEXANE
302012	HYDRAZINE	302012	HYDRAZINE

TRI CAS	TRI Pollutant Name	EIS Pollutant Code	EIS Pollutant Name
7647010	HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY)	7647010	HYDROCHLORIC ACID
7664393	HYDROGEN FLUORIDE	7664393	HYDROGEN FLUORIDE
123319	HYDROQUINONE	123319	HYDROQUINONE
7439921	LEAD	7439921	LEAD
N420	LEAD COMPOUNDS	7439921	LEAD
58899	LINDANE	58899	1,2,3,4,5,6-HEXACHLOROCYCLOHEXANE
108316	MALEIC ANHYDRIDE	108316	MALEIC ANHYDRIDE
7439965	MANGANESE	7439965	MANGANESE
N450	MANGANESE COMPOUNDS	7439965	MANGANESE
7439976	MERCURY	7439976	MERCURY
N458	MERCURY COMPOUNDS	7439976	MERCURY
67561	METHANOL	67561	METHANOL
72435	METHOXYCHLOR	72435	METHOXYCHLOR
74839	BROMOMETHANE	74839	METHYL BROMIDE
74873	CHLOROMETHANE	74873	METHYL CHLORIDE
71556	1,1,1-TRICHLOROETHANE	71556	METHYL CHLOROFORM
74884	METHYL IODIDE	74884	METHYL IODIDE
108101	METHYL ISOBUTYL KETONE	108101	METHYL ISOBUTYL KETONE
624839	METHYL ISOCYANATE	624839	METHYL ISOCYANATE
80626	METHYL METHACRYLATE	80626	METHYL METHACRYLATE
1634044	METHYL TERT-BUTYL ETHER	1634044	METHYL TERT-BUTYL ETHER
75092	DICHLOROMETHANE	75092	METHYLENE CHLORIDE
60344	METHYL HYDRAZINE	60344	METHYLHYDRAZINE
121697	N,N-DIMETHYLANILINE	121697	N,N-DIMETHYLANILINE
68122	N,N-DIMETHYLFORMAMIDE	68122	N,N-DIMETHYLFORMAMIDE
91203	NAPHTHALENE	91203	NAPHTHALENE
7440020	NICKEL	7440020	NICKEL
N495	NICKEL COMPOUNDS	7440020	NICKEL
98953	NITROBENZENE	98953	NITROBENZENE
684935	N-NITROSO-N-METHYLUREA	684935	N-NITROSO-N-METHYLUREA
90040	O-ANISIDINE	90040	O-ANISIDINE
95534	O-TOLUIDINE	95534	O-TOLUIDINE
123911	1,4-DIOXANE	123911	P-DIOXANE
56382	PARATHION	56382	PARATHION
82688	QUINTOZENE	82688	PENTACHLORONITROBENZENE
87865	PENTACHLOROPHENOL	87865	PENTACHLOROPHENOL
108952	PHENOL	108952	PHENOL
75445	PHOSGENE	75445	PHOSGENE
7803512	PHOSPHINE	7803512	PHOSPHINE
7723140	PHOSPHORUS (YELLOW OR WHITE)	7723140	PHOSPHORUS
85449	PHTHALIC ANHYDRIDE	85449	PHTHALIC ANHYDRIDE
1336363	POLYCHLORINATED BIPHENYLS	1336363	POLYCHLORINATED BIPHENYLS
120127	ANTHRACENE	120127	ANTHRACENE
191242	BENZO(G,H,I)PERYLENE	191242	BENZO[G,H,I,]PERYLENE
85018	PHENANTHRENE	85018	PHENANTHRENE
N590	POLYCYCLIC AROMATIC COMPOUNDS	130498292	PAH, TOTAL
106503	P-PHENYLENEDIAMINE	106503	P-PHENYLENEDIAMINE
123386	PROPIONALDEHYDE	123386	PROPIONALDEHYDE
114261	PROPOXUR	114261	PROPOXUR
78875	1,2-DICHLOROPROPANE	78875	PROPYLENE DICHLORIDE
75569	PROPYLENE OXIDE	75569	PROPYLENE OXIDE
91225	QUINOLINE	91225	QUINOLINE
106514	QUINONE	106514	QUINONE
7782492	SELENIUM	7782492	SELENIUM
N725	SELENIUM COMPOUNDS	7782492	SELENIUM
100425	STYRENE	100425	STYRENE
96093	STYRENE OXIDE	96093	STYRENE OXIDE
127184	TETRACHLOROETHYLENE	127184	TETRACHLOROETHYLENE
7550450	TITANIUM TETRACHLORIDE	7550450	TITANIUM TETRACHLORIDE
108883	TOLUENE	108883	TOLUENE
95807	2,4-DIAMINOTOLUENE	95807	TOLUENE-2,4-DIAMINE

TRI CAS	TRI Pollutant Name	EIS Pollutant Code	EIS Pollutant Name
8001352	TOXAPHENE	8001352	TOXAPHENE
79016	TRICHLOROETHYLENE	79016	TRICHLOROETHYLENE
121448	TRIETHYLAMINE	121448	TRIETHYLAMINE
1582098	TRIFLURALIN	1582098	TRIFLURALIN
108054	VINYL ACETATE	108054	VINYL ACETATE
75014	VINYL CHLORIDE	75014	VINYL CHLORIDE
75354	VINYLIDENE CHLORIDE	75354	VINYLIDENE CHLORIDE
108383	M-XYLENE	108383	M-XYLENE
95476	O-XYLENE	95476	O-XYLENE
106423	P-XYLENE	106423	P-XYLENE
1330207	XYLENE (MIXED ISOMERS)	1330207	XYLENES (MIXED ISOMERS)

An electronic database of the TRI/NEI Pollutant Crosswalk showing NEI and TRI pollutant mappings can be downloaded from the "State/Local/Tribal (S/L/T), National Emission Inventory (NEI), Toxic Release Inventory (TRI) Mapping" portion of the Product Design Team website. It should be noted that while HCN is in the NEI and the electronic mapping shows NEI HCN to TRI HCN, we brought in both TRI HCN and TRI CN emissions as NEI CN. We did this to avoid double counting of S/L/T CN with TRI HCN since some S/L/T include HCN emissions as CN.

3. **Split TRI total chromium emissions into hexavalent and trivalent emissions**

   The TRI allows facilities to report either "Chromium" or "Chromium compounds," but not the hexavalent or trivalent chromium species that are needed for the NEI (see Section 3.1.3). Because the only characterization available for the TRI facilities or their emissions is the facilities' NAICS codes, we created a NAICS-based set of fractions to split the TRI-reported total chromium emissions into the hexavalent and trivalent chromium species. A table of Standard Industrial Classification (SIC)-based chromium split fractions was available from earlier year NEI usage of TRI databases, which had been compiled by SIC rather than NAICS. The earlier SIC-based fractions were used wherever they could be re-assigned to a closely matching NAICS description.

   Unfortunately, not all SIC-based fractions could be assigned this way, so we computed NAICS-based split fractions for any NAICS codes in the 2017 TRI data that did not already have an SIC-to-NAICS assigned split fraction. These factors were used for the remaining TRI-reported chromium. To calculate the NAICS-based factors, we summed by NAICS the total amounts of chromium III and chromium VI for the entire U.S. in the 2014 draft NEI data. These 2017 NEI S/L/T emissions were either reported directly by the S/L/T agencies as chromium III and chromium VI, or they had been split from S/L/T agency-reported total chromium by the EPA using the procedures described in Section 3.1.4. Those procedures largely rely on either SCC-based or Regulatory code-based split factors. The derived NAICS split factors, therefore, represent a weighted average of the SCC and Regulatory code-based split factors, weighted according to the mass of each chromium valence in the 2017 NEI for that NAICS.

   After all TRI facilities with chromium had been assigned a NAICS-based split factor, the factors were applied separately to both the TRI stack and fugitive total chromium emissions. This resulted in speciated chromium emissions for each facility's stack and fugitive emissions that were included in the EIS as part of the 2017EPA_TRI dataset.

   Similar to S/L/T chromium speciation data, the TRI chromium speciation data includes some facility-specific values resulting from 2011 and/or 2014 NATA reviews or provided by S/L/T for use in the 2017

NEI. The TRI-chromium speciation data "TRI_based_chromium_speciation.zip" is available are available on the 2017 Supplemental data FTP site.

4. **Review high TRI emissions values for and exclude any data suspected to be outliers**
   A review and comparison of the largest TRI emissions values was conducted for several key high-risk pollutants. The following pollutants were specifically reviewed, although a few extremely large values for some of the other TRI pollutants were also noticed and treated in the same manner: Hg, Pb, chromium, manganese, nickel, arsenic, 1,3 butadiene, benzene, toluene, ethyl benzene, p-xylene, methanol, acrolein, carbon tetrachloride, tetrachloroethylene, methylene chloride, acrylonitrile, 1,4-dichlorobenzene, ethylene oxide, hydrochloric acid, hydrogen fluoride, chlorine, 2,4-toluene diisocyanate, hexamethylene diisocyanate, and naphthalene. The review included looking at the largest 10 emitting facilities for each of the pollutants in the 2017 TRI dataset itself to identify large differences between facilities and unexpected industry types. Comparisons were then made to the 2014 TRI and the 2017 draft NEI emissions values from S/L/T agencies for any suspect facilities identified by that review (as described above in Section 3.1.1).

5. **Write the 2017 TRI emissions to EIS Process IDs with stack and fugitive release points**
   The total facility stack and total facility fugitive emissions values from the above steps were written to a set of EIS process IDs created to reflect those facility total type emissions. In most cases, the EIS process IDs for a given facility already existed in EIS as a result of earlier NEI.

6. **Revise SCCs on the EIS Processes used for the TRI emissions**
   The 2002 and 2005 NEIs had assigned all the TRI emissions to a default process code SCC of 39999999, which caused a large amount of HAP emissions to be summed to a misleading "miscellaneous" sector. The 2008 NEI approach reduced this problem somewhat because it apportioned all TRI emissions to the multiple processes and SCCs that were used by the S/L/T agencies to report their emissions, but this apportioning created other distortions. The 2011 NEI reverted back to loading the TRI emissions as the single process stack and fugitive values as reported by facilities to the TRI, but we revised the SCCs on those single processes to something other than the default 39999999 wherever possible. The purpose of this is to allow the TRI emissions to map to a more appropriate EIS sector. For the 2017 NEI, we retained the 2011 approach, process IDs, and SCCs.

   On occasion, TRI SCCs are updated where the process is known based on the type of facility or SCCs from processes for which CAPs were reported. However, there has not been a systematic approach to fill in all SCCs and for large industrial facilities, it would not be possible due to the variety of different process operations that can occur at such facilities.

3.1.6   HAP augmentation based on emission factor ratios

The 2017EPA_HAP-augmentation dataset was used for gap filling missing HAPs in the S/L/T agency-reported data. We calculated HAP emissions by multiplying the appropriate surrogate CAP emissions (provided by S/L/T agencies) by an emissions ratio of HAP to CAP EFs. For point sources, these EF ratios were largely the same as were used in the 2008 NEI v3, though additional quality assurance resulted in some changes. The ratios were computed using the EFs from WebFIRE and are based solely on the SCC code. The computation of these point HAP to CAP ratios is described in detail in the 2008 NEI documentation, Section 3.1.5.

For pollutants other than Hg, we computed ratios for only the SCCs in WebFIRE that met specific criteria: 1) the CAP and HAP WebFIRE EFs were both based on uncontrolled emissions and, 2) the units of the EF had to be the same or be able to be converted to the same units. In addition, for Hg, we added ratios for point SCCs that were not in WebFIRE for both PM10-FIL (the CAP surrogate for Hg) and Hg by using Hg or PM10-FIL factors for similar SCCs and computing the resulting ratio. That process is described (and supporting data files provided) in the 2008 NEI documentation (Section 3.1.5.2), since these additional Hg augmentation factors were used in the 2008 NEI v3 as well.

A HAP augmentation feature was built into the EIS for the 2011 cycle, and the HAP EF ratios are available to the EIS users through the reference data link "Augmentation Profile Information." The same tables provide both the HAP augmentation factors and chromium speciation factors and were discussed in Section 2.2.2.

Since the initial set of HAP augmentation factors, factors and/or SCC-assignments were added including facility-specific HAP augmentation factors resulting from NATA reviews. Also new for the 2017 NEI are facility-specific coke oven to SO2 ratios used to compute coke oven emissions for specific facilities with operating coke ovens that were missing coke oven emissions. We have been also exploring using test-based emission factor ratios in place of WebFIRE-based ratios where data are sufficient to do so. Users interested in the few test-based factors that do not have access to EIS can download the full set of HAP augmentation factors from the 2017 Supplemental data FTP site ("HAPaugmentation.zip") and peruse the metadata information (data source and factor comments) to extract them.

A key facet of our approach is that the resulting HAP augmentation dataset does duplicate HAPs from the S/L/T agency data or other EPA datasets. The extra step of data tagging of the HAP augmentation dataset was taken to ensure the NEI would not use the data from the HAP augmentation dataset for facilities where the HAP was reported by an S/L/T agency at any process at the facility or where the HAP was included in the EPA TRI dataset. For example, if a facility reported formaldehyde at process A only, and the WebFIRE emission factor database yields formaldehyde emissions for processes A, B, and C, then we would not use any records from the HAP augmentation dataset containing formaldehyde from any processes at the facility. If that facility had no formaldehyde, but the TRI dataset had formaldehyde for any processes at that facility, then the NEI would still not use formaldehyde from the HAP augmentation dataset for any of the processes (it would use the TRI data). If the EPA EGU dataset contained formaldehyde for that facility, we would use the HAP augmentation set but not for any process at the same unit as EPA EGU dataset. If the EPA EGU dataset contained formaldehyde at process A or any other process within the same unit as process A, then the HAP augmentation dataset would be used for processes B and C, but not process A.

This approach was taken to be conservative in our attempt to prevent double counted emissions, which is necessary because we know that some states aggregate their HAP emissions and assign to fewer or different processes than their CAP emissions. These types of differences are expected since CAPs are required to be submitted at the process level, but HAPs are entirely voluntary for the NEI's reporting rule. We used the EIS new pollutant overlapping business rules (Section 3.3.17) to prevent double counting of pollutants belonging to pollutant groups that may overlap with other pollutants in that group.

One of the changes we made from previous NEI's is that we no longer tag out point source HAP augmentation values where the HAP augmentation value exceeded the maximum emissions reported by any S/L/T agency for the same SCC/pollutant combination, or if no S/L/T agency reported any values for the same SCC/pollutant.

3.1.7   Cross-dataset tagging rules for overlapping pollutants

Several HAPs can be reported as individual chemicals or chemicals that reflect a group which can overlap with individual chemicals, e.g., o-Xylene and Xylenes (mixed isomers). In previous NEI cycles, we tagged out data to prevent double counting of pollutants across datasets that overlap one another. For the 2017 NEI, a software solution that occurs during the blending process was developed so that overlapping pollutants would be excluded from the selection. The business rules were documented as part of the 2017 NEI plan (see Appendix 5). One change to these "Proposed" rules that we implemented for the 2017 NEI is that we allow individual xylene isomers to be reported with Xylenes (mixed isomers) within the same dataset. The cross-data business rules used are the same as documented the plan.

One issue that came up with these rules regards the hexavalent chromium and trivalent chromium in the 2017EPA_CR_Aug dataset. This dataset, which contains S/L/T speciated chromium (i.e., hexavalent and trivalent chromium), is separate from the S/L/T datasets but contains data that could be largely characterized as S/L/T data. While we intended to allow S/L/T to report either unspeciated chromium or hexavalent chromium along with chromic acid VI chromium trioxide at the same process, the software did not allow the hexavalent chromium in the 2017EPA_CR_Aug dataset to be used with S/L/T chromic acid VI. This occurred only in 2 states, NC and KY. For KY, the speciated chromium was less than 0.1 lb and no corrections were made. In NC, there was about 500 lbs hex chromium that would have been dropped so we corrected it. The correction was for NC to incorporate the speciated chromium from2017EPA_CR_Aug into their dataset (instead of unspeciated chromium) so that both pollutants would be used in the 2017 NEI selection. All records where EPA speciated chromium data were used include an emissions comment to that effect.

3.1.8   Additional quality assurance and findings

Prior to the release of the data, we created national summaries of key pollutants and sectors. The list below provides findings and associated follow-up steps:

- We created a preliminary summary of mercury from point source emissions, even in the absence of the other sectors that feed the final mercury summary that will be included in Section 2 of the documentation once the NEI is complete. Such a summary has been included in past documentation for other inventories. This summary revealed a possible underestimation of mercury from the Commercial and Industrial Solid Waste Incineration (CISWI) sector. Since not all sources are reported to NEI as point sources, the NEI may not include all CISWI sources. In addition, the Hg estimates of these sources are highly uncertain, could be underestimated, and the EPA is currently working to get improved mercury and other emissions estimates for these sources.
- We summarized hydrazine emissions and found a significantly larger hydrazine estimate in Arkansas than had been present in past inventories. This makes Hydrazine emissions overall in the NEI increase since 2014. We contacted the air office of the Arkansas Department of Environmental Quality, and the inventory staff there confirmed the accuracy of these emissions.
- We summarized ethylene oxide emissions and found that several facilities did not report ethylene oxide to both the state air agency and to the TRI program in 2017, but those facilities were still operating in 2017. To gap-fill those missing emissions, we used the 2016 TRI data.
- We summarized hexavalent chromium emissions and found a significant increase in emissions since 2014. We identified some missing emissions for sources in NC and worked with NC to include those chromium emissions. We did not find any errors in hexavalent chromium in the 2017 data, which shows an increase in these emissions as compared to the 2014 NEI. This could be due to a more complete inventory or to an actual increase.

3.2 Airports: aircraft-related emissions

The EPA estimated emissions related to aircraft activity for all known U.S. airports, including seaplane ports and heliports, in the 50 states, Puerto Rico, and U.S. Virgin Islands. All of the approximately 20,000 individual airports are geographically located by latitude/longitude and stored in the NEI as point sources. As part of the development process, S/L/T agencies had the opportunity to provide both activity data as well emissions to the NEI. When activity data were provided, the EPA used that data to calculate the EPA's emissions estimates.

3.2.1 Sector Description

The aircraft sector includes all aircraft types used for public, private, and military purposes. This includes four types of aircraft: (1) commercial, (2) air taxis (AT), (3) general aviation (GA), and (4) military. A critical detail about the aircraft is whether each aircraft is turbine- or piston-driven, which allows the emissions estimation model to assign the fuel used, jet fuel or aviation gas, respectively. The fraction of turbine- and piston-driven aircraft is either collected or assumed for all aircraft types.

Commercial aircraft include those used for transporting passengers, freight, or both. Commercial aircraft tend to be larger aircraft powered with jet engines. Air taxis carry passengers, freight, or both, but usually are smaller aircraft and operate on a more limited basis than the commercial aircraft. General aviation includes most other aircraft used for recreational flying and personal transportation. Finally, military aircraft are associated with military purposes, and they sometimes have activity at non-military airports.

The national AT and GA fleets include both jet- and piston-powered aircraft. Most of the AT and GA fleets are made up of larger piston-powered aircraft, though smaller business jets can also be found in these categories. Military aircraft cover a wide range of aircraft types such as training aircraft, fighter jets, helicopters, and jet- and piston-powered planes of varying sizes.

The NEI also includes emission estimates for aircraft auxiliary power units (APUs) and aircraft ground support equipment (GSE) typically found at airports, such as aircraft refueling vehicles, baggage handling vehicles and equipment, aircraft towing vehicles, and passenger buses. These APUs and GSE are located at the airport facilities as point sources along with the aircraft exhaust emissions.

3.2.2 Sources aircraft emissions estimates

Aircraft exhaust, GSE, and APU emissions estimates are associated with aircrafts' landing and takeoff (LTO) cycle. LTO data were available from both S/L/T agencies and FAA databases. For airports where the available LTO included detailed aircraft-specific make and model information (e.g., Boeing 747-200 series), we used the FAA's Aviation Environmental Design Tool (AEDT) to estimate emissions. Note that this is the first NEI to use this model. 2008 and 2011 used the FAA's previous model, Emissions and Dispersion Modeling System (EDMS). Therefore, comparisons of aircraft emissions output may be a function of model revisions, rather than an actual trend in emissions. For airports where FAA databases do not include such detail, the EPA used assumptions regarding the percent of LTOs that were associated with piston-driven (using aviation gas) versus turbine-driven (using jet fuel) aircraft. Then, the EPA estimated emissions based on the percent of each aircraft type, LTOs, and EFs The emissions factors used, as well as the complete methodology for estimating aircraft exhaust from LTOs is in the aircraft documentation available in the document "2017Aircraft_main_19aug2019.pdf" on the 2017 Supplemental data FTP site. Only Texas and California submitted aircraft emissions.

In addition to airport facility point, the EPA also estimated in-flight Pb (from aviation gas) emissions that are allocated to counties in the nonpoint inventory. Details about EPA's estimates

(2017Aircraft_InflightLead_19aug2019.pdf), including a summary of state-level in-flight lead estimates "2017Aircraft_InflightLeadByState_19aug2019.csv" can be found on the 2017 Supplemental data FTP site.

3.2.3 January 2021 correction to aircraft estimates

2017 NEI emissions for aircraft were released as part of the 2017 NEI in April 2020. As mentioned in the previous section, EPA estimated aircraft emissions for the first time in the 2017 NEI using the new FAA AEDT model from the FAA. While emissions were higher than the 2014 NEI that had used a different model (EDMS), these differences seemed to be explained by our use of the different model.

After the 2017 NEI emissions were released, stakeholders who were reviewing the data identified that emissions from AEDT emissions seemed to be unusually high. After additional review, it was apparent that emissions from AEDT were doubled due an additional "track" being incorrectly added in the AEDT input file. Tracks are how emissions are calculated in the model and require two runway points. The original (April release) approach had two tracks (one for each runway point) rather than one track to connect two runway points.

To correct for this error in AEDT estimated emissions, we halved the EPA emissions estimates for all Auxiliary Power Unit, Ground Support Equipment, and any other process with an aircraftenginetypecode other than the generic "9999*". The corrected emissions have been included in this January 2021 release of the 2017 NEI. Airport emissions submitted by Texas and California cover some larger airports and were not changed in the June release.

A county summary of the emissions differences for airport emissions between the April and June releases is available from the Air Emissions Modeling FTP site in the "2017 airports 18jun2020 versus previous.xlsx" Excel file.

3.3 Rail yard-related emissions

The 2017 NEI includes estimates compiled by the Eastern Regional Technical Advisory Committee (ERTAC) for most rail yards in the US. The ERTAC effort was comprised of a collaborative of state/local agencies, rail companies, and the Federal Rail Administration. Yard emissions are associated with the operation of switcher engines at each yard. The project is documented in a report " 2017Rail_main_21aug2019.pdf" on the 2017 Supplemental data FTP site. S/L/Ts submitted point rail yard emissions were given priority over the ERTAC estimates when present.

3.4 EGUs

The EPA developed a single combined dataset of emission estimates for EGUs to be used to fill gaps for pollutants and emission units not reported by S/L/T agencies. For the 2017EPA_EGU dataset, the emissions were estimated at the unit level, because that is the level at which the CAMD heat input activity data and the MATS-based emissions factors and the CAMD CEM data are available. The 2017EPA_EGU dataset was developed from three separate estimation sources. The three sources were the 2010 MATS rule development testing program EFs for 15 HAPs; annual sums of SO_2 and NO_x emissions based on the hourly CEM emissions reported to the EPA's CAMD database; and heat-input based EFs that were built from AP-42 EFs and fuel heat and sulfur contents as part of the 2008 NEI development effort. We used the 2014 annual throughputs in BTUs from the CAMD database with the two EF sets to derive annual emissions for 2017. A small number of the AP-42-based estimates were discarded because the fuels or control configurations were found to be different than what they were during the 2008 development effort that provided the heat-input based EFs that were available.

As shown above in Table 3-5, the selection hierarchy was set such that S/L/T-submitted data was used ahead of the values in the 2017EPA_EGU dataset. In the 2011 NEI, the EPA EGU estimated emissions that were derived from the MATS testing program were used ahead of the S/L/T values, unless the S/L/T submittal indicated that the value was from either a CEM or a recent stack test. For the 2017 NEI, we used the S/L/T-reported values wherever they were reported (unless they were tagged out as an outlier), including where a MATS-based value existed in the 2017EPA EGU dataset. In addition, we made the MATS emission factors available to S/L/T agencies far in advance of the data being submitted so that facilities and/or S/L/T agencies could choose to use that information to compute emissions if it was most applicable.

We assumed that all heat input came from the primary fuel, and the EFs used reflected only that primary fuel. This introduces a small amount of uncertainty as many EGU units use a small amount of alternative fuels. The resultant unit-level estimates had to be loaded into EIS at the process-level to meet the EIS requirement that emissions can only be associated with the most detailed level. To do this for the EGU sectors, we needed to bridge the unit level (i.e., the boiler or gas turbine unit as a whole) to the process level (i.e., the individual fuels burned within the units). So, the EPA emissions were assigned to a single process for the primary fuel that was used by the responsible S/L/T agency for reporting the largest portion of their emissions. The EPA emissions were then "tagged out" wherever the S/L/T agency had reported the same pollutant at any process within the same emission unit. This approach prevented double counting of a portion of the S/L/T-reported emissions in cases where the S/L/T agency may have reported a unit's emissions using two different coal processes and a small oil process, for example.

The matching of the 2017EPA_EGU dataset to the responsible agency facility, unit and process IDs was done largely by using the ORIS plant and CAMD boiler IDs as found in the CAMD heat input activity dataset and linking these to the same two IDs as had been stored in EIS. We also compared the facility names and counties for agreement between the S/L/T-reported values and those in CAMD, and we revised the matches wherever discrepancies were noted. As a final confirmation that the correct emissions unit and a reasonable process ID in EIS had been matched to the EPA data, the magnitudes of the SO2 and NOx emissions for all preliminary matches were compared between the S/L/T agency-reported datasets and the EPA dataset. We identified and resolved several discrepancies from this emissions comparison.

Alternative facility and unit IDs needed for matching with other databases

The 2017 NEI data contains two sets of alternate unit identifiers related to the ORIS plant and CAMD boiler IDs (as found in the CAMD heat input activity dataset) for export to the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling file. The first set is stored in EIS with a Program System Code (PSC) of "EPACAMD." The alternate unit IDs are stored as a concatenation of the ORIS Plant ID and CAMD boiler ID with "CAMDUNIT" between the two IDs. These IDs are exported to the SMOKE file in the fields named ORIS_FACILITY_CODE and ORIS_BOILER_ID. These two fields are used by the SMOKE processing software to replace the annual NEI emissions values with the appropriate hourly CEM values at model run time. The second set of alternate unit IDs are stored in EIS with a PSC of "EPAIPM" and are exported to the SMOKE file as a field named "IPM_YN." The SMOKE processing software uses this field to determine if the unit is one that will have future year projections provided by the integrated planning model (IPM). The storage format of these alternate EPAIPM unit IDs, in both EIS and in the exported SMOKE file, replicates the IDs as found in the National Electric Energy Data System (NEEDS) database used as input to the IPM model. The NEEDS IDs are a concatenation of the ORIS plant ID and the CAMD boiler ID, with either a "_B_" or a "_G_" between the two IDs, indicating "Boiler" or "Generator." The ORIS Plant IDs and CAMD boiler IDs as stored in the CAMD Business System (CAMDBS) dataset and in the NEEDS database are almost always the same, but there are occasional differences for the same unit. The EPACAMD alternate unit IDs available in the 2017 NEI are believed to be a complete set of all those that can

safely be used for the purpose of substituting hourly CEM values without double-counting during SMOKE processing. The EPAIPM alternate unit IDs in the 2017 NEI are not a complete listing of all the NEEDS/IPM units, although most of the larger emitters do have an EPAIPM alternate unit ID. The NEEDS database includes a much larger set of smaller, non-CEM units.

3.5 Landfills

The point source emissions in the EPA's Landfill dataset includes CO and 28 HAPs, as shown in Table 3-7. This set of pollutants was included in the 1999 NEI, and we continue to use the same set of pollutants each year for a consistent time series. To estimate emissions, we used the methane emissions reported by landfill operators in compliance with Subpart HH of the Greenhouse Gas Reporting Program (GHGRP) as a "surrogate" activity indicator. We converted the methane as reported in Mg CO2 equivalent to Mg as actual methane emitted by dividing by 23 (the Global Warming Potential of methane believed to be used in the version of the 2017 GHGRP facility inventory) to get Mg methane emitted, and then multiplied by 1.1023 to get tons methane emitted[5]. We created emission factors for CO and the 28 HAPs on a per ton of methane emitted basis using the default concentrations (ppmv) in AP-42 Section 2.4 (final section dated Jan 1998), Table 2.4-1. The concentrations for toluene and benzene were taken from Table 2.4-2 of AP-42, for the case of "no or unknown" co-disposal history. Per Equation 4 of that AP-42 section, Mp=Qp x MWp x constant (at any given temperature). Writing this equation twice, for the mass of any pollutant "P" and for methane (CH4), and dividing M_p by M_{CH4} yields:

$$M_p / M_{CH4} = (Q_p \text{ x } MW_p \text{ x } k) / Q_{CH4} \text{ x } MW_{CH4} \text{ x } k) = (Q_p/Q_{CH4}) \text{ x } (MW_p/MW_{CH4})$$

in units of pounds pollutant "P" per pound CH4.

A rearrangement of Equation 3 of that AP-42 section provides Q_p/ Q_{CH4} = 1.82 x Cp/1000000, where the 1.82 is based upon a default methane concentration of 55 % (550,000 ppm). Plugging this expression for Q_p/ Q_{CH4} into the first expression yields:

$$M_p / M_{CH4} = (1.82 \text{ x } C_p/1000000) \text{ x } (MW_p/ MW_{CH4}) \text{ x } 2000, \text{ units of pounds p/ton CH4}$$

$$M_p / M_{CH4} = (1.82 \text{ x } C_p/1000000) \text{ x } (MW_p/16) \text{ x } 2000 = C_p \text{ x } MW_p / 4395.6$$

Table 3-7: Landfill gas emission factors for 29 EIS pollutants

Pollutant code	Pollutant description	MW	ppmv	MW x ppmv	lbs/Ton CH$_4$
CO	Carbon monoxide	28.01	141	3949.41	0.89849
108883	toluene	92.13	39.3	3620.709	0.82371
1330207	Xylenes	106.16	12.1	1284.536	0.29223
75092	Dichloromethane (methylene chloride)	84.94	14.3	1214.642	0.27633
7783064	Hydrogen sulfide	34.08	35.5	1209.84	0.27524
127184	Perchloroethylene (tetrachloroethylene)	165.83	3.73	618.5459	0.14072
110543	Hexane	86.18	6.57	566.2026	0.12881
100414	Ethylbenzene	106.16	4.61	489.3976	0.11134
75014	Vinyl chloride	62.5	7.34	458.75	0.10437

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[5] For more information on CO2 equivalent and global warming potential, please refer to EPA's page "Understanding Global Warming Potentials".

Pollutant code	Pollutant description	MW	ppmv	MW x ppmv	lbs/Ton CH_4
79016	Trichloroethylene (trichloroethene)	131.4	2.82	370.548	0.08430
107131	Acrylonitrile	53.06	6.33	335.8698	0.07641
75343	1,1-Dichloroethane (ethylidene dichloride)	98.97	2.35	232.5795	0.05291
108101	Methyl isobutyl ketone	100.16	1.87	187.2992	0.04261
79345	1,1,2,2-Tetrachloroethane	167.85	1.11	186.3135	0.04239
71432	benzene	78.11	1.91	149.1901	0.03394
75003	Chloroethane (ethyl chloride)	64.52	1.25	80.65	0.01835
71556	1,1,1-Trichloroethane (methyl chloroform)	133.41	0.48	64.0368	0.01457
74873	Chloromethane	50.49	1.21	61.0929	0.01390
75150	Carbon disulfide	76.13	0.58	44.1554	0.01005
107062	1,2-Dichloroethane (ethylene dichloride)	98.96	0.41	40.5736	0.00923
106467	Dichlorobenzene	147	0.21	30.87	0.00702
463581	Carbonyl sulfide	60.07	0.49	29.4343	0.00670
108907	Chlorobenzene	112.56	0.25	28.14	0.00640
78875	1,2-Dichloropropane (propylene dichloride)	112.99	0.18	20.3382	0.00463
75354	1,1-Dichloroethene (vinylidene chloride)	96.94	0.2	19.388	0.00441
67663	Chloroform	119.39	0.03	3.5817	0.00081
56235	Carbon tetrachloride	153.84	0.004	0.61536	0.00014
106934	Ethylene dibromide	187.88	0.001	0.18788	0.00004
7439976	Mercury (total)	200.61	0.000292	0.05857812	0.00001

3.6   2017EPA_gapfills

This EPA dataset is used to fill in miscellaneous emissions which were not reported by S/L/T agencies for 2017, and for which no EPA dataset has 2017 emissions, but which are believed to exist in 2017. These unreported facilities and pollutants were identified as part of the QA review steps performed on the S/L/T data (see Section 3.1.1). A total of 95 unique facilities across 4 different States and 88 different pollutants are represented in this dataset. Most of the additions were for Indiana (73 facilities), which did not submit emissions for all of their operating facilities for 2017. 2016 NEI emissions were copied into the gapfills dataset for those facilities. Nine facilities in Pinal County, AZ were also added using 2016 NEI emissions. NOx emissions only were added for eleven coal mines in Wyoming which have significant emissions from trucks and other mobile equipment which were not included in WYDEQ's point source dataset, and which are not expected to be adequately covered in EPA's nonroad emission estimates. WYDEQ sent 2017 facility totals for these facilities mobile emissions to be added to the 2017 NEI PT. Lastly, mercury emissions for two municipal waste combustors in Maryland and four municipal waste combustors in Massachusetts were added.

3.7   BOEM

The U.S. Department of the Interior, Bureau of Ocean and Energy Management (BOEM) estimates emissions of CAPs in the Gulf of Mexico from offshore oil platforms in Federal waters, and these data have been previously incorporated into the NEI. More information on the 2017 Outer Continental Shelf (OCS) offshore data is available on the BOEMS OCS Emissions Inventory – 2017 site.

3.8 PM species

For the 2017 NEI PT inventory, the five species (EC, OC, SO4, NO3, and other) of PM2.5-PRI and diesel PM (which are estimated for diesel mobile engines such as locomotives and diesel-fueled ground support equipment) were not included. These species will be generated in full NEI release in the Spring of 2020, similar to earlier NEI years by using the PM speciation ratios as found on the Air Emissions Modeling website.

3.9 References for point sources

1. Dorn, J, 2012. *Memorandum: 2011 NEI Version 2 – PM Augmentation approach.* Memorandum to Roy Huntley, US EPA.
2. Strait et al. (2003). Strait, R.; MacKenzie, D.; and Huntley, R., 2003. PM Augmentation Procedures for the 1999 Point and Area Source NEI, 12th International Emission Inventory Conference – "Emission Inventories – Applying New Technologies", San Diego, April 29 – May 1, 2003.

4 Nonpoint sources

This section includes all sources that are in the nonpoint data category, including biogenics. These sources are reported/generated at the county level, though some sources such as rail lines and shipping lanes and ports are more-finely resolved to the county/shape identifier (ID) (polygon) level. Stationary sources that are inventoried at facilities and stacks (coordinates) are discussed in the previous Point Section 3. This section discusses all sources in the Nonpoint inventory. Some "nonroad" mobile sources such as trains and commercial marine vessels reside and are discussed here in the nonpoint data category, not in the Nonroad Equipment Section 5.

4.1 Nonpoint source approaches

Nonpoint source data are provided by state, local, and tribal (S/L/T) agencies, and for certain sectors and/or pollutants, they are supplemented with data from the EPA. This section describes the various sources of data and the selection priority for each of the datasets to use for building the National Emissions Inventory (NEI) when multiple data sources are available for the same emissions source. Section 2.2 provides more information on the data selection process.

4.1.1 Sources of data overview and selection hierarchies

Table 4-1 describes the datasets comprising most of the nonpoint inventory, and the hierarchy for combining these datasets in construction of the NEI. Commercial marine vessels sector-specific data are provided in the stand-alone dataset "2017EPA_CMV". While the bulk of these datasets are for stationary sources of emissions, some of these datasets contain mobile sources so that emissions from ports, shipping lanes and rail yards could be included as nonpoint sources. The following table includes the rationale for why each dataset was assigned its position in the hierarchy. We excluded certain pollutants from stationary sources in the 2017 NEI: greenhouse gases and pollutants in the pollutant groups "dioxins/furans" and "radionuclides"[††]. The EPA has not evaluated the completeness or accuracy of the S/L/T agency dioxin and furan values nor radionuclides and does not have plans to supplement these reported emissions with other data sources to compile a complete estimate for dioxin and furans nor radionuclides as part of the NEI.

Table 4-1: Data sources and selection hierarchy used for most nonpoint sources

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2017EPA_PMSpecies	Speciated PM2.5 data. A result of offline emissions speciation where the resulting PM25-PRI selection emissions are split into the 5 PM species: elemental (black) carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), and the remainder of PM25-PRI (PMFINE). Diesel engine PM25-PRI and PM10 are also copied as DIESEL-PM pollutants.	1

[††] Dioxins/furans include all pollutants with pollutant category name of: Dioxins/Furans as 2,3,7,8-TCDD TEQs, or Dioxins/Furans as 2,3,7,8-TCDD TEQs – WHO2005, both of which were valid pollutant groups for reporting 2014 emissions. Radionuclides have the pollutant category name of "radionuclides" The specific compounds and codes are in the pollutant code tables in EIS.

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2017PMaug_SLT_NP	PM components added to gap fill missing S/L/T agency data or make corrections where S/L/T agency have inconsistent emissions across PM components. Uses ratios of emission factors from the PM Augmentation Tool for covered source classification codes (SCCs). For SCCs without emission factors in the tool, checks/corrects discrepancies or missing PM species using basic relationships such as ensuring that primary PM is greater than or equal to filterable PM (see Section 4.1.5).	2
Responsible Agency Data Set	S/L/T agency submitted data. These data are selected ahead of other datasets. The only other situation where S/L/T agency emissions are not used is where certain records are tagged in the Emissions Inventory System (EIS) (at the specific source/pollutant level). This occurs: 1) for hierarchy purposes to allow EPA nonpoint emissions to be used ahead of S/L/T agency data where states asked for EPA data to be used in place of their data and 2) where S/L/T agency data were suspected outliers.	3
2017EPA_HAPAug	HAP data computed from S/L/T agency criteria pollutant data using ratios of HAP to CAP emission factors. The emission factors used to create the ratios are the same emission factors as are used in creating the EPA estimates (i.e., in the EPA nonpoint emission tools). This dataset is below the S/L/T agency data so that the S/L/T agency HAP data are used first. HAP augmentation is discussed in Section 4.1.6.	4
2017EPA_HAPAug-PMaug	This dataset was created in the same fashion as the 2017EPA_HAPAug dataset above and is a supplement to it. This dataset contains HAPs calculated by applying a ratio to PM10-FIL emissions, for those instances where the S/L/T dataset did not contain any PM10-FIL emissions, but the PM augmentation routine was able to calculate a PM10-FIL value from some PM species that was reported by the S/L/T.	5
2017EPA_Cr_Aug	Hexavalent and trivalent chromium speciated from S/L/T agency reported chromium. EIS augmentation function creates the dataset by applying multiplication factors by SCC, facility, process or North American Industry Classification System (NAICS) code to S/L/T agency total chromium. See Section 2.2.2.	6
2017ERTAC_Rail	Blend of SLT-submitted and collaboratively generated diesel line and diesel yard locomotive data (referred to as "rail" in this document) emissions estimates. See Section 4.22.	7
2017EPA_NONPOINT	All nonpoint EPA estimates are included in this dataset except those listed elsewhere in this table. This dataset includes sources with and without point source subtraction and outputs from most of the EPA tools, including the "wagon wheel" with (if provided) SLT-submitted Input Templates (see Section 4.1.7). This dataset also includes biogenic emissions. Examples of sources in this dataset include agricultural fertilizer application, most livestock waste, industrial and commercial/institutional fuel combustion, residential wood combustion, solvent utilization, oil and gas exploration and production, open burning, agricultural field burning, road and construction dust, and portable fuel containers.	8
2017EPA_Airports	2017 aircraft in-flight emissions (Lead only)	9
2017EPA_CarryFwd	2014v2 NEI data from 2014 EPA nonpoint estimates that were not updated for 2017: mercury from laboratories; bench scale reagents.	10

The EPA developed all datasets listed above except for the "Responsible Agency Selection," which contains only S/L/T agency data. We used various methods and databases to compile the EPA generated datasets, which are further described in subsequent subsections. The primary purpose of the EPA datasets is to add or "gap fill" pollutants or sources not provided by S/L/T agencies, to resolve inconsistencies in S/L/T agency-reported pollutant submissions for PM (Section 2.2.4) and to speciate S/L/T agency reported total chromium into hexavalent and trivalent forms (Section 2.2.2). The hierarchy or "order" provided in Table 4-1 defines which data are preferentially used when multiple datasets could provide emissions for the same pollutant and emissions process. The dataset with the lowest order on the list is preferentially used over other datasets.

In addition to the order of the datasets, the hierarchy was also influenced by the EIS feature of data tagging (Section 2.2.6). Any data that were tagged by EPA in any of the datasets were not used. S/L/T agency data were tagged for two reasons: 1) S/L/Ts requested that their data not be used, and 2) EPA found unexpected pollutants for a source. Due to improvements in the new nonpoint survey (next section), there was very little need to tag EPA nonpoint data for 2017. If S/L/T agencies report zero emissions, then backfilling with other datasets will not occur. There are two ways that S/L/T agencies can prevent inappropriately backfilled emissions from being included in the NEI: 1) S/L/T agencies can submit zeros for any pollutant they do not want filled in (the EPA data will otherwise fill in for all pollutants that are on the nonpoint expected pollutant list), 2) S/L/T agencies can complete the nonpoint survey and specify "No..." to prevent any EPA estimates from backfilling where S/L/Ts did not submit data, or 3) the EPA can add tags to backfill datasets that prevent the tagged pollutants from being included in the NEI. The first option is most straightforward and takes care of any possible augmentation from the numerous other datasets in the selection hierarchy. The second option was developed as a quick tool for S/L/Ts to essentially prevent the need to "tag out" EPA data yet achieve the same goal.

4.1.2 Revised Nonpoint Survey

The nonpoint survey, first developed for the 2014v1 NEI, then refined for the 2014v2 NEI, was streamlined further for the 2017 NEI. The purpose of the nonpoint survey is to increase the accuracy and transparency in how the nonpoint inventory is built using EPA and S/L/T agency data. The nonpoint inventory includes all nonpoint source categories that EPA generates estimates for.

Because each agency has their own universe of sources and inventory development approaches, each agency reports nonpoint estimates a little differently. The nonpoint survey gathers information specifically for each SLT regarding which source categories are covered by point, nonpoint, or both, and about where point source reconciliation needs to be done to nonpoint activity.

The new nonpoint survey has an "Accept All Emissions Estimates" button on the home page for S/L/Ts that did not submit emissions for any nonpoint sector. Note, acceptable S/L/T activity inputs (next section) provided to EPA were absorbed into EPA tools and therefore became "EPA" estimates. For S/L/Ts that wanted to prevent some EPA data from backfilling, there were options to edit the default responses for each SCC or accept EPA estimates for entire sectors. The optional reasons to select "No" (and this was applied for each SCC that EPA generates estimates) are: 1) I do not have this Source, 2) This source is included in my Point Source contributions, 3) My agency uses different SCCs, and 4) My inventory is complete; it does not need to be supplemented. And additional option to select "Yes -Supplement Only for Missing Pollutants at my reported Counties or Tribe" was provided to allow only missing (expected) pollutants to be added for locations where emissions were submitted for at least one pollutant. More information on the new nonpoint survey is available in Section 5.4.6 of the 2017 NEI Plan.

4.1.3 New for the 2017 NEI: Wagon Wheel and Input Templates

A central database, called the "Wagon Wheel", was developed to house all inputs and calculate emissions for most nonpoint source categories. In past inventories, EPA shared different tools to S/L/Ts, many with the same inputs; this process was very inefficient and prone to human error as many tools shared similar inputs and different versions of these tools were often used by S/L/Ts vs the "final" versions ultimately regarded as "EPA" for the NEI. The Wagon Wheel links each activity input tables to the appropriate sector/module such that refreshing one dataset ensures the next tool iteration captures it for all appropriate sectors. The full list of nonpoint source categories/tools included in the Wagon Wheel is provided in Section 5.4.2 of the 2017 NEI plan.

EPA strongly encouraged S/L/Ts to provide only inputs to the Wagon Wheel because, often late in the inventory development cycle, EPA finds a need for a tool update (e.g., error, or new, improved information, and so if S/L/Ts submitted emissions (rather than inputs) using an old version of the tool, then their submitted data could be out of date or incorrect.

EPA provided blank input templates for all Wagon Wheel source categories. These blank templates included all default activity data, and as these default activity data were updated, the input templates and the wagon wheel were updated to incorporate it. S/L/Ts then provided their completed input templates back to EPA where their updated data, after rudimentary quality assurance, were used to supersede the default data in the template and ultimately the Wagon Wheel. In this process, all S/L/T-submitted input activity data became "EPA" data. Input activity data also included information on controls and emission factors where provided.

With one key exception, S/L/Ts could opt out of submitting input templates as EPA methods did not need S/L/T inputs to compute reasonable nonpoint estimates. EPA used S/L/T-submitted point emissions as default for nonpoint reconciliation for solvents, stage 2 gasoline distribution, and publicly owned treatment works (POTWs); and, little to no overlap with the point inventory would be expected for most other nonpoint source categories in the Wagon Wheel. However, for Industrial and Commercial/Institutional (ICI) nonpoint fuel combustion, we relied on S/L/T-submitted throughput (fuel consumption) data, ideally from their Point inventories. As discussed in Section 4.13.3.6, EPA provided four different options for submitting throughput for the ICI tool. Only three state reporting agencies and two territories did not submit ICI emissions, an input template, or a nonpoint survey indicating there were no nonpoint ICI emissions.

A complete list of all S/L/T-submitted wagon wheel input activity data is provided in Table 4-2. The input templates that are needed for point inventory reconciliation are shaded.

Table 4-2: S/L/T Input Templates submitted for the 2017 NEI

S/L Agency	Central Database	ICI fuel combustion	POTWs	Solvents	Stage 1 Gas Distribution	Ag Tilling	Commercial Cooking	Landfills	Grilling	Road Dust	Residential Heating	Residential Wood Combustion	Mining & Quarrying	Compost	Asphalt Paving	Cremation	Animal Population	Construction Dust
Alabama		X																
Alaska		X										X						
Arizona		X		X		X	X	X	X	X								

S/L Agency	Central Database	ICI fuel combustion	POTWs	Solvents	Stage 1 Gas Distribution	Ag Tilling	Commercial Cooking	Landfills	Grilling	Road Dust	Residential Heating	Residential Wood Combustion	Mining & Quarrying	Compost	Asphalt Paving	Cremation	Animal Population	Construction Dust
Arkansas		X	X	X	X													
Connecticut	X	X	X	X	X						X							
Delaware																		
District of Columbia		X	X	X														
Florida		X																
Georgia		X	X	X	X													
Hawaii		X																
Idaho														X				
Illinois																		
Indiana		X																
Iowa		X	X	X				X						X				
Kansas		X	X	X	X	X		X	X	X				X	X	X		
Jefferson Co, KY		X																
Kentucky																		
Louisiana		X	X	X	X													
Maine		X	X							X				X				
Maryland		X																
Massachusetts		X		X	X													
Michigan		X		X	X					X				X	X			
Mississippi																		
Missouri		X		X														
Montana																		
Nebraska		X																
New Hampshire																		
Clark Co, NV		X																
Nevada																		
New Jersey			X							X								
New Mexico		X																
New York		X		X														
North Carolina	X	X		X	X					X							X	
North Dakota		X																
Ohio		X	X	X	X													
Oklahoma		X		X														
Oregon		X																
Pennsylvania		X																
Rhode Island	X	X	X															
South Carolina		X		X					X							X		
South Dakota																		
Knox Co, TN		X		X														

S/L Agency	Central Database	ICI fuel combustion	POTWs	Solvents	Stage 1 Gas Distribution	Ag Tilling	Commercial Cooking	Landfills	Grilling	Road Dust	Residential Heating	Residential Wood Combustion	Mining & Quarrying	Compost	Asphalt Paving	Cremation	Animal Population	Construction Dust
Nashville, TN		X																
Tennessee		X		X														
Texas																		
Utah												X						
Vermont		X		X					X		X	X		X	X	X		X
Virginia		X																
Washington		X										X						
West Virginia										X								
Wisconsin		X	X	X	X					X	X							
Wyoming																		
Puerto Rico																		
U.S, Virgin Islands																		

4.1.4 New for the 2017 NEI: Cross-dataset tagging

The 2017 nonpoint inventory was compiled in a much different manner than the 2014 NEI beyond the implementation of the Wagon Wheel and associated S/L/T-submitted input templates. For 2017, we also developed and applied the following EIS automated data exclusion rules: Nonpoint Survey Rule, Pollutant Grouping Rule, and the Option Group/Option Set Rule. When applied, these rules greatly minimized the need to "tag" out data that would otherwise be needed to prevent double counting of emissions across pollutant groups, SCCs and from different sources.

4.1.4.1 *Nonpoint Survey Rule*

For the first time, for the2017 NEI, the nonpoint survey responses were directly applied to the nonpoint selection in the EIS. All S/L/Ts that completed the nonpoint surveys (green status button on the home screen for the nonpoint survey), had their responses directly applied in the NEI selection. For each "EPA Tool Estimate Category", nonpoint survey responses were applied if the "Category Complete?" column was saved and submitted as "Yes". By default, all nonpoint survey responses were defaulted to "Yes -Supplement my data with EPA estimates. This simply means that if S/L/T data was not submitted, and EPA data exists (for that process/pollutant), then EPA data will be in the NEI with a caveat to the 2 rules discussed in the next two sections. S/L/Ts were strongly encouraged to leave the SCCs as default (yes) if they were submitting nonpoint inputs, because S/L/T inputs were absorbed into EPA tools and became "EPA" data.

4.1.4.2 *Pollutant Grouping Rules*

In previous NEI cycles, we tagged out data to prevent double counting of pollutants across datasets that overlap one another. For the 2017 NEI, a software solution that occurs during the blending process was developed so that overlapping pollutants would be excluded from the selection. Business rules were developed to select data with overlapping pollutants across datasets, to allow different datasets included in a selection to be blended

together in a way that avoids double counting due to overlapping pollutants. Because there are several HAPs that belong to pollutant groups or represent a pollutant group themselves, these rules are needed to prevent both a group and individual pollutant in that group from being used for the same process or facility. The implementation of these rules is automated in the EIS. These rules are applied at the process level (location and SCC) for nonpoint sources and prevents lower-hierarchy dataset pollutants/pollutant groups from possible double-counts. For example, if an S/L/T reports "Xylenes (Mixed Isomers), then any EPA (lower hierarchy) - generated individual (or mixed) isomers will not make it into the NEI. Rules for the following pollutant groups were applied: xylenes, cresols, polychlorinated biphenyls (PCBs), glycol ethers, chromium, nickel, and PAHs. A complete discussion of the cross dataset tagging proposed rules, applied to the nonpoint inventory selection are available in Appendix 5 of the 2017 NEI Plan. One change to these "Proposed" rules that we implemented for the 2017 NEI is that we allow individual xylene isomers to be reported with Xylenes (mixed isomers) within the same dataset.

4.1.4.3   *Option Group/Option Set Rule*

We applied the EIS Option Group/Option Set (OGOS) feature for the first time in the 2017 nonpoint NEI. In the Source Classification Code table, we can define SCCs that have a hierarchical nature. That is, there may be a "general" group, as well as more specific SCCs within the same group. These relationships are defined by the "Option Group / Option Set" (OGOS) fields in the SCC table. When EPA and SLT datasets are placed in an NEI selection, there is the potential for double counting of data sources (emissions) across these data sources. For example, the EPA may report emissions to a "general" SCC while SLTs report data to detailed SCCs. Without OGOS evaluation, both sets of data would be included in the NEI selection. The current OGOS rules employed in the Selection assumes that if a SLT submits data, they are summitting data for the entire group and no additional data sets are to be used to "back-fill" any SCCs within the same option set. The desired function is for the selection to back-fill any SCCs within the same option set. Refer to "Appendix 6 - Option Group Option Set Enhancement EIS Requirements.pdf" on the 2017 National Emissions Inventory Documentation website for a comprehensive discussion on the OGOS business rules being implemented in EIS for the 2017 nonpoint NEI. A draft list of OGOS assignments for all nonpoint data category SCCs is provided in the "Appendix 4 - 2017 Nonpoint Proposed OptionGroup-OptionSet" workbook on the 2017 National Emissions Inventory Documentation website.

4.1.5   Nonpoint PM augmentation

Section 2.2.4 provides an overview of PM augmentation in the 2017 NEI and explains that we used a PM Augmentation tool. The tool creates two output tables for each data category: Additions and Overwrites. We post-processed these output tables prior to loading the data in the EIS. In this section, we describe the post-processing issues that are specific to the nonpoint inventory. We post-processed these data to prevent inadvertently overriding S/L/T agency primary PM10 and PM2.5 data (i.e., EIS pollutants PM10-PRI and PM2.5-PRI). The PM Augmentation Tool computes the condensable (PM-CON) and filterable PM components (PM10-FIL and PM25-FIL) and re-computes primary PM10 and PM2.5 when the sum of the components differed by more than the slim tolerance assumed by the tool. We decided to remove these "overwrites" for primary PM10 and PM2.5 whenever the summed PM from the components was within 0.01 tons of S/L/T-provided primary PM10 or PM2.5 totals. This tolerance was higher than the one used by the tool, but we wanted the NEI to reflect that the data source for the primary PM10 and PM2.5 was from the S/L/T agency and not the EPA augmentation dataset. We used summed components from the tool to overwrite the S/L/T agency data in the NEI selection when this difference exceeded 0.01 tons and S/L/T agencies reported both primary PM10 and PM2.5; however,

this was a very rare occurrence. Nationally, these overwrites resulted in only a 0.78-ton replacement of primary PM2.5.

4.1.6   Nonpoint HAP augmentation

For nonpoint sources, we derived HAP augmentation ratios from the emission factors used to develop the EPA nonpoint source estimates. The EPA nonpoint HAP emission estimates are computed in EPA nonpoint database "tools" (e.g., previously discussed wagon wheel, oil and gas tool), or stand-alone databases such as that used for agricultural burning and livestock waste. Because we used the same emission factors for these augmentation ratios, the ratios of HAP to CAPs for augmented S/L/T agency data are the same as the HAP to CAP ratios for the EPA-only data. For access by non-EIS users, the zip file called "HAPaugmentation.zip", on the 2017 NEI Supplemental data FTP site, provides the emission ratios that the EPA used for augmenting point and nonpoint data categories. The nonpoint HAP augmentation factors were updated as compared to what was used for the 2014 NEI, particularly for the oil and gas sector. The EPA staff responsible for the nonpoint sectors use their discretion for how to augment HAP emissions and work with the S/L/T agencies to reflect as complete and accurate set of pollutants as possible for the many source types. In general, if a S/L/T agency submitted a partial list of the HAPs that would be augmented for a given category, then we allowed the missing HAPs to be gap-filled with the HAP augmentation data. These missing HAPs are determined by comparing the Expected Pollutant List for Nonpoint SCCs with those that S/L/T agencies submitted. However, this approach has a risk of potentially violating VOC mass balance, whereby the sum of the VOC HAPs exceeds the VOC total. Thus, special cases occur when such problems are identified. In the limited cases where this occurred, we applied the business rules defined in Section 3.3.2 in the 2017 NEI Plan to tag out S/L/T data causing this violation; in this case, S/L/T-submitted HAP-VOCs were replaced with HAP augmentation (generally based on S/L/T-submitted VOC) -based HAP-VOC estimates.

4.1.7   EPA nonpoint data

For the 2017 NEI, the EPA developed emission estimates for many nonpoint sectors in collaboration with a consortium of inventory developers from various state agencies regional planning organizations called the NOnpoint Method Advisory (NOMAD) Committee. The broad NOMAD committee meets approximately monthly to discuss the overall progress on the various sectors for which tools and/or estimates are being developed or refined. More detailed NOMAD subcommittees were established for key nonpoint source categories/sectors including, but not limited to, oil and gas exploration and production, residential wood combustion, agricultural NH3 sources including agricultural fertilizer and livestock, solvents, and industrial and commercial/institutional fuel combustion. These subgroups collaborate on methodologies, emission factors, and SCCs, allowing the EPA to prepare the "default" emission estimates/methodologies and/or input template formats for S/L/T agencies using the group's final approaches. The NOMAD committees were formed in preparation for the 2014 NEI and continued with the 2017 NEI development cycle. The primary focus of the 2017 NEI cycle was on Wagon Wheel and the associated input template development. This shift towards seeking more S/L/T input activity data, rather than emission submittals makes for a more transparent quality assurance process as we now have readily available tracking of the inputs as well as resulting outputs (emissions). We can ensure that the methodology used to estimate the final emissions for all Wagon Wheel sectors is consistent.

During the 2017 NEI inventory development cycle, S/L/T agencies, using the nonpoint survey (Section 4.1.2), could accept the NOMAD/EPA estimates to supplement/fulfill their nonpoint emissions reporting requirements. The EPA encouraged S/L/T agencies that did not use the EPA's estimates or tools to improve upon these "default" methodologies and submit input data directly. Table 4-3 and Table 4-4 describe the sectors for which EPA developed emission estimates. They separately list emissions sectors entirely comprised of data in the

nonpoint (i.e., not point source) data category (Table 4-3), such as residential heating, from sectors that may overlap with the point sources (Table 4-4). For sectors that overlap, some emissions will be submitted as point sources and other emissions in the same state or county are submitted as nonpoint, for example, fuel combustion at commercial or institutional facilities. The EPA attempted to include all EPA-estimated nonpoint emissions that overlap if it was determined that the category was missing from the S/L/T agency data. All EPA methodologies are discussed in the remaining nonpoint sectors that follow; however, some tables (primarily emission factors) were too large to include in this TSD, and we direct the reader to the appropriate name provided in zip files posted on the 2017 NEI Supplemental Nonpoint data FTP site, for these cases. The SCCs associated with the EPA nonpoint data categories can be found on the EPA SCC Search website. The sections following these tables include information on key pollutants submitted by S/L/T agencies for each nonpoint source category or EIS sector.

Table 4-3: EPA-estimated emissions sources expected to be exclusively nonpoint

EPA-estimated emissions source	EIS Sector(s)	TSD Section	Name of supporting documentation
Agricultural Fertilizer Application	Agriculture - Fertilizer Application	4.4	2017_Fertilizer_Application_Supplemental_Data.zip
Agricultural Field Burning	Fires - Agricultural Field Burning	4.12	AgBurning_Emission_Factors_HAPs_2017NEI.xlsx
Agricultural Pesticide Application	Solvent – Consumer & Commercial Solvent Use	4.23	Agricultural Pesticides NEMO 2017 FINAL_4-2 update.docx
Agricultural Tilling	Agriculture - Crops & Livestock Dust	4.3	Agricultural Tilling NEMO 2017 FINAL_4-2 update.docx
Animal Husbandry	Agriculture - Livestock Waste	4.5	Agricultural Livestock NEMO 2017 FINAL.docx
Asphalt Paving	Solvent – Consumer & Commercial Solvent Use	4.24	Asphalt NEMO 2017 FINAL_4-2 update.docx
Aviation Gasoline Distribution Stage 1	Gas Stations	4.7	Aviation Gasoline Distribution Stage 1 NEMO 2017 DRAFT_v2_4-2 update.docx
Aviation Gasoline Distribution Stage 2	Gas Stations	4.7	Aviation Gasoline Distribution Stage 2 NEMO 2017 DRAFT_4-2 update.docx
Commercial Cooking	Commercial Cooking	4.8	Commercial Cooking NEMO FINAL_4-2 update.docx
Composting	Miscellaneous Non-Industrial NEC	4.26	Composting NEMO 2017 FINAL_4-2 update.docx
Dust from Commercial/Institutional Construction	Dust - Construction Dust	4.9	Construction Dust - Nonresidential NEMO 2017 FINAL_4-2 update.docx

EPA-estimated emissions source	EIS Sector(s)	TSD Section	Name of supporting documentation
Dust from Livestock Hooves/Feet	Agriculture - Crops & Livestock Dust	4.3	Dust from Hooves NEMO_FINAL_4-2 update.docx
Dust from Residential Construction	Dust - Construction Dust	4.9	Residential Construction Dust NEMO 2017 FINAL_4-2 update.docx
Dust from Road Construction	Dust - Construction Dust	4.9	Road Construction Dust NEMO 2017 FINAL_4-2 update.docx
Human and Animal Cremation	Waste Disposal	4.18	Cremation NEMO 2017 FINAL_4-2 update.docx
Locomotives, non-Rail Yard	Mobile - Locomotives	4.22	2017Rail_main_21aug2019.pdf (from ../point directory)
Mining and Quarrying	Industrial Processes - Mining & Quarrying	4.16	Mining & quarrying NEMO 2017 FINAL_4-2 update.docx
Nonpoint Mercury from: Dental Amalgam Production, Fluorescent Lamp Breakage, Fluorescent Lamp Recycling, Switches and Relays, Thermometers and Thermostats	Miscellaneous Non-Industrial NEC	4.2	Other Mercury NEMO 2017 FINAL_4-6 update.docx
Open Burning, Land Clearing Debris	Waste Disposal	4.27	Open Burning Land Clearing Debris NEMO 2017 DRAFT_4-2.docx
Open Burning, Yard Waste Debris	Waste Disposal	4.27	Open Burning Yard Waste NEMO 2017 FINAL_4-2 update.docx
Open Burning, Residential Household Waste	Waste Disposal	4.27	Open Burning RHW NEMO 2017 FINAL_4-2 update.docx
Paved and Unpaved Road Dust	Dust - Paved Road Dust, Dust - Unpaved Road Dust	4.10, 4.11	Road Dust NEMO FINAL revised_4_9_2020.docx
Portable Fuel Containers	Miscellaneous Non-Industrial NEC	4.20	Portable Fuel Container Inventory 2017_v1.docx
Residential Charcoal Grilling	Miscellaneous Non-Industrial NEC	4.19	Residential Barbecue Grilling NEMO FINAL_4-2 update.docx

EPA-estimated emissions source	EIS Sector(s)	TSD Section	Name of supporting documentation
Residential Heating, non-wood	Fuel Comb - Residential - Natural Gas, Fuel Comb - Residential - Oil, Fuel Comb - Residential - Other	4.14	Residential Heating NEMO 2017 FINAL_4-2 update.docx
Residential Wood Combustion	Fuel Comb - Residential - Wood	4.15	Residential Wood Combustion_DRAFT.DOCX
Working Face Landfills	Waste Disposal	4.2	Landfills NEMO 2017 FINAL_4-2 update.docx

Table 4-4: Emission sources with potential nonpoint and point contribution

EPA-estimated emissions source	EIS Sector(s)	TSD Section	Name of supporting documentation
Industrial and Commercial/Institutional Fuel Combustion	Fuel Comb - Industrial Boilers, ICEs - All Fuels, Fuel Comb - Commercial/Institutional - All Fuels	4.13	ICI NEMO FINAL_4-2 updated.docx
Nonpoint Gasoline Distribution	Bulk Gasoline Terminals, Gas Stations, Industrial Processes – Storage and Transfer	4.7	Stage I Gasoline Distribution NEMO FINAL_7-18-2019_4-2 updated.docx
Oil and Gas Production and Extraction	Industrial Processes - Oil & Gas Production	4.17	OIL_GAS_TOOL_2017_NEI_PRODUCTION_V1_2.zip, OIL_GAS_TOOL_2017_NEI_EXPLORATION_V1_3.zip, 2017 NEI Oil and Gas Tool Subpart W Analysis_3_14_2019.zip, 2017 Oil and Gas Memos.zip, 2017 Nonpoint Oil and Gas Emission Estimation Tool Revisions_V1 4_11_2019.docx, EPA_2015b_NSPS OOOOa TSD August 2015.pdf, Oil_and_Gas_Tool_Documentation_v1.2_2017.zip, Sept. discussion notes withe EPA and ERG.docx
POTWs	Waste Disposal	4.28	POTWs NEMO FINAL_4-2 updated.docx

EPA-estimated emissions source	EIS Sector(s)	TSD Section	Name of supporting documentation
Solvent Utilization	Solvent - Consumer & Commercial Solvent Use, Solvent - Degreasing, Solvent - Dry Cleaning, Solvent - Graphic Arts, Solvent - Industrial Surface Coating & Solvent Use, Solvent - Non-Industrial Surface Coating	4.25	Solvent NEMO 2017 FINAL_7-8-2019_4-2 updated.docx

4.2 Nonpoint non-combustion-related mercury sources

This category includes the following mercury emission categories: Landfills (working face), Switches and Relays, Fluorescent Lamp Breakage, Dental Amalgam, General Laboratory Activities, Thermostats, Thermometers, Fluorescent Lamp Recycling, and Batteries. Human and animal cremation estimates include CAPs as well as mercury and are discussed later in Section 4.18.

4.2.1 Description of sources

These sources include a mix of EPA-generated and SLT-submitted emissions for the SCCs listed in Table 4-5. EPA updated some of the activity data to year 2017 in the 2017 NEI. Additional descriptions of the individual types of activities are provided in the source-specific sub-sections below.

Table 4-5: SCCs and emissions (lbs) comprising the nonpoint non-combustion Hg sources in the 2017 NEI

Description	SCC	Sector	SCC Description	2014v2	2017
Landfill working face	2620030001	Waste Disposal	Landfills; Municipal; Dumping/Crushing/Spreading of New Materials (working face)	763	871
Scrap waste: Thermostats and Thermometers	2650000000	Waste Disposal	Scrap and Waste Materials; Scrap and Waste Materials; Total: All Processes	241	234
Shredding: Switches and Relays	2650000002	Waste Disposal	Scrap and Waste Materials; Scrap and Waste Materials; Shredding	3,372	2,519
Dental Amalgam Production	2850001000	Miscellaneous Non-Industrial NEC	Miscellaneous Area Sources; Health Services; Dental Alloy Production; Overall Process	923	916
Fluorescent Lamp Breakage	2861000000	Miscellaneous Non-Industrial NEC	Miscellaneous Area Sources; Fluorescent Lamp Breakage;	1,676	1,815

Description	SCC	Sector	SCC Description	2014v2	2017
			Non-recycling Related Emissions; Total		
Fluorescent Lamp Recycling	2861000010	Miscellaneous Non-Industrial NEC	Miscellaneous Area Sources; Fluorescent Lamp Breakage; Recycling Related Emissions; Total	0.6	0.08
General Laboratory Activities	2851001000	Miscellaneous Non-Industrial NEC	Miscellaneous Area Sources; Laboratories; Bench Scale Reagents; Total	635	633
			TOTAL	7,611	6,988

None of these categories are distinct regulatory sectors and are therefore put into the "EPA Other" category in the mercury summary provided in Table 2-8.

4.2.2 Sources of data

The history of these EPA estimates dates to the 2011 NEI. The 2011 NEI nonpoint Hg estimates were developed in collaboration with an Eastern Regional Technical Advisory (ERTAC) workgroup set up for focus on these nonpoint emissions sources. For the 2014v2 NEI, the activity data for all source categories except General Laboratory Activities (2851001000) were updated to year 2014, and these were further updated for select year 2017 activity for the 2017 NEI. These estimates were then merged with S/L/T agency data as part the NEI selection hierarchy defined in Section 4.1.1. The EPA encouraged S/L/T agencies that did not use EPA's estimates or tools to improve upon these "default" 2017 methodologies and submit further improved data. The S/L/T data replaced the EPA estimates in the counties where S/L/T agencies provided data. Table 4-6 lists the agencies and SCCs that were submitted for these nonpoint mercury sources; the S/L/T emissions from these agencies/SCCs replace EPA estimates in 2017 NEI.

Table 4-6: Agencies reporting emissions to non-combustion mercury source categories

Agency	Landfill Working Face	Scrap waste: Thermostats and Thermometers	Shredding: Switches and Relays	Dental Amalgam Production	Fluorescent Lamp Breakage	Fluorescent Lamp Recycling	General Laboratory Activities
Coeur d'Alene Tribe	X	X	X	X	X	X	
Illinois Environmental Protection Agency				X	X	X	X
Kootenai Tribe of Idaho		X		X	X	X	
Maryland Department of the Environment					X	X	X
Memphis and Shelby County Health Department - Pollution Control	X	X	X	X	X	X	

Agency	Landfill Working Face	Scrap waste: Thermostats and Thermometers	Shredding: Switches and Relays	Dental Amalgam Production	Fluorescent Lamp Breakage	Fluorescent Lamp Recycling	General Laboratory Activities
Metro Public Health of Nashville/Davidson County		X	X	X	X	X	
Minnesota Pollution Control Agency				X	X		X
Nez Perce Tribe		X	X	X	X	X	
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	X	X	X	X	X	X	

4.2.3 EPA-developed emissions

Landfills (working face)

The EPA estimated mercury emissions for landfill working face emissions. While the amount of mercury in products placed in landfills has tended to decrease in recent years, there is still a significant amount of mercury in place at landfills across the country. There are three main pathways for mercury emissions at landfills: (1) emissions from landfill gas (LFG) systems, including flare and vented systems; (2) emissions from the working face of landfills where new waste is placed; and (3) emissions from the closed, covered portions of landfills [ref 1]. Emissions from LFG systems are considered point sources and are already included in the NEI as submissions from S/L/T agencies or from the point source dataset that gap fills these landfill emissions (2017EPA_LF). Lindberg et al. (2005) [ref 1] found that emissions from the closed, covered portions of landfills are negligible and are similar to background soil emission rates. Therefore, this methodology focuses on emissions from the working face of landfills.

The calculations for estimating the emissions from landfills involve first estimating the amount of waste each landfill receives in a year. The total amount of waste in place for each landfill in a county is available from the US EPA's Landfill Methane Outreach Program (LMOP) database. The total amount of waste in place for each landfill is divided by the number of years a landfill is operational to estimate the amount of waste a landfill receives each year. The amount of waste that a landfill receives each year is multiplied by an average emissions factor to calculate the total mercury emissions from landfills for each county.

Switches and Relays

Switches and relays make up the largest potential source of mercury from products that intentionally contain mercury. Mercury is an excellent electrical conductor and is liquid at room temperature, making it useful in a variety of products, including switches used to indicate motion or tilt, as the mercury will flow when the switch is in a certain position, completing the circuit.

While mercury switches in cars were phased out as of the 2002 model year, there are still millions of cars on the road that contain them. The switches and relays in these cars are potential emissions sources when the cars are recycled at the end of their useful lives, which involves crushing and shredding of the car. The shredded material is then sent to an arc furnace to recycle the steel. To avoid double counting point source emissions from arc

furnaces, this source category only includes an estimate of nonpoint emissions from crushing/shredding operations.

The calculations for estimating mercury emissions from switches and relays involve first estimating the number of switches unrecovered by the state by taking the difference between the total estimated number of switches available and the total switches recovered in each state. The number of unrecovered switches is then apportioned to each county based on the number of car recycling facilities from the US Census County Business Patterns data for NAICS 423930. The total amount of switches unrecovered by county is multiplied by the emissions factor for mercury to estimate mercury emissions from switches and relays.

Fluorescent Lamp Breakage/Recycling

Fluorescent lights are a potentially significant source of mercury emissions. Although each lamp contains only a small amount of mercury, which has been decreasing in recent years, the increased demand for fluorescent lamps could lead to increases in mercury emissions. Increased demand for fluorescent lamps, particularly compact fluorescents, is driven partly by the phase out of many types of incandescent bulbs from the Energy Independence and Security Act of 2007 (PL 110-140 § 321).

In addition to emissions of mercury from the breakage of fluorescent light bulbs (SCC 2861000000), there is a small amount of emissions from recycling fluorescent bulbs (SCC 2861000010).

The calculations for estimating the emissions from fluorescent lamp breakage and recycling involve first estimating the average life, in hours, of various fluorescent lamp types. Data from a Freedonia Group Industry Study on the U.S. lamp market is used to estimate the total number of lamps that are discarded or recycled. The number of bulbs recycled is calculated using a recycling rate percentage. This number is then subtracted from all bulbs discarded or recycled to determine the number of bulbs discarded. The activity data are allocated to the county-level based on the share of the population present in each county. An emissions factor is calculated using the amount of mercury available in each fluorescent bulb type. The total amount of fluorescent bulbs recycled or discarded is multiplied by the emissions factor for mercury to estimate mercury emissions from fluorescent lamp breakage and recycling.

Dental Amalgam

Dental amalgam is used to fill cavities in teeth, and it is composed of approximately 45% mercury [ref 2]; however, the use of dental amalgam is declining due to the increased popularity of composite fillings for teeth [ref 3]. Nevertheless, there is still a small amount of mercury emissions from dental amalgam in restored teeth. There are two potential sources of mercury emissions from dental amalgam: emissions from the preparation of amalgam in dental offices, and emissions directly from restored teeth.

The calculations for estimating the emissions from dental amalgam include estimating emissions from both dental fillings and dental office preparation. The number of fillings by age group (for dental fillings) and the total mercury sold in dental amalgam (for dental office preparation) are allocated to the county-level based on the share of the population present in each county. The dental filling data by age group are multiplied by the percent of mercury present in dental fillings to determine the amount of mercury from dental fillings. The total amount of mercury from dental fillings and from dental office preparation are multiplied by emissions factors for mercury and summed together to estimate the total mercury emissions from dental amalgam.

General Laboratory Activities

Documentation for previous versions of the NEI have cited personal communications with USGS staff for estimates of the amount of mercury used in general laboratory activities. In discussions with Robert Virta of the USGS (2013), EPA learned that the USGS stopped conducting its survey of the end uses of mercury in the economy in 2002 [ref 4]. However, the Interstate Mercury Education and Reduction Clearinghouse (IMERC) tracks the use of mercury-added chemical products that are sold as a consistent mixture of chemicals [ref 5]. Since this trend indicates that the use of mercury-added chemical products has remained relatively consistent since 2002, the estimate of mercury emissions from general laboratory activities in the 2008 NEI is pulled forward for the 2017 NEI.

Thermostats/Thermometers

Mercury has been used in thermostats to switch on or off a heater or air conditioner based on the temperature of a room. Most of the historic production of mercury thermostats came from three corporations: Honeywell, White-Rogers, and General Electric. In 1998 these corporations formed the Thermostat Recycling Corporation (TRC), a voluntary program that attempts to collect and recycle mercury thermostats as they come out of service [ref 6].

Mercury thermometers have all but been phased out in the United States, with the USEPA and National Institute of Standards and Technology (NIST) working to phase out mercury thermometers in industrial and laboratory settings. NIST issued notice in 2011 that it would no longer calibrate mercury-in-glass thermometers for traceability purposes. EPA issued a rule in 2012 that provides flexibility to use alternatives to mercury thermometers when complying with certain regulations pertaining to petroleum refining, power generation, and PCB waste disposal. Furthermore, thirteen states have laws that limit the manufacture, sale, and/or distribution of mercury-containing fever thermometers [ref 7]. Nevertheless, given the historical prevalence of mercury thermometers, it is likely that a significant amount of mercury remains in thermometers in homes in the United States

The calculations for estimating the emissions from thermostats and thermometers involve first estimating the total number of thermostats disposed and the amount of mercury in thermometers available for release. The number of thermostats disposed and the amount of mercury in thermometers available for release are allocated to the county-level based on the share of the population present in each county. The total number of thermostats disposed and the amount of mercury in thermometers available for release are multiplied by the emissions factor for mercury and summed together to estimate mercury emissions from thermostats and thermometers.

4.2.3.1 *Activity data*

Landfills (working face)

The U.S. EPA's Landfill Methane Outreach Program (LMOP) maintains a database of the landfills in the United States with information on the total amount of waste in place, as well as the opening and closing years of the landfill and the county where the landfill is located [ref 8]. The average number of tons of waste each landfill receives is estimated by dividing the total waste in place by the number of years the landfill has been operating. Only landfills that were open in 2014 are included in the analysis.

To determine the number of years each landfill has been active, the year the landfill opened is subtracted from 2017. Only landfills that are open in 2017 are included in the analysis.

$$OP_l = 2017 - O_l \qquad\qquad (1)$$

Where:

      OP_l =   Total number of years of operation for each landfill *l*
      O_l =   Year landfill *l* opened

The average number of tons of waste each landfill receives is estimated by dividing the total waste in place by the number of years the landfill has been operating.

$$W_l = \frac{WP_l}{OP_l}$$ (2)

Where:

      W_l =   Average tons of waste that landfill *l* receives per year
      WP_l =   Total waste in place in landfill *l*, in tons
      OP_l =   Total number of years of operation for landfill *l*

Some counties have multiple landfills, so emissions within the county are summed in these instances.

$$W_c = \sum_{l=1}^{n} W_l$$ (3)

Where:

      W_c =   Average tons of waste from *n* landfills in county *c*
      W_l =   Average tons of waste that landfill *l* receives per year

Switches and Relays

The End of Life Vehicle Solutions Corporation (ELVS) provides information on the estimated number of switches available for recovery in each state and the amount of switches actually recovered in 2017 [ref 9, ref 10]. There were 1.8 million mercury-containing automobile switches available nationwide in 2017 and 217,634 switches collected for recycling, for a collection rate of 11.7%. Therefore, there were approximately 1.6 million unrecycled automotive switches in 2017 in the United States. The state level number of switches unrecovered is calculated by taking the difference between the total estimated number of switches available and the total switches recovered in each state.

$$UnS_s = TotS_s - RecS_s$$ (1)

Where:

      UnS_s =   Total switches unrecovered by state *s*
      $TotS_s$ =   Total switches available in state *s*
      $RecS_s$ =   Total switches recovered by state *s*

Fluorescent Lamp Breakage/Recycling

Data from a Freedonia Group Industry Study on the U.S. lamp market were used to estimate that approximately 1.485 billion mercury containing lamps, including compact fluorescents (CFLs), linear, and high impact discharge

(HID) lamps, were discarded or recycled in 2017 [ref 11]. Bulb sales for 2002, 2007, 2012 and projections for 2017 were obtained from Freedonia; sales for all other years were calculated by extrapolating data. Average rated life (hours) of lamp types is used to calculate lifetimes (years), assuming that CFLs are on for 4 hours per day and all other fluorescents and HIDs are on for 8 hours per day [ref 12, ref 13]. Table 4-7 includes the lifetime data assumed for each bulb type. The lifetime data are used to estimate the year in which bulbs that are discarded or recycled in 2017 would have been purchased.

Table 4-7: Lifetime in hours and years for each bulb type

Bulb Type	Life (hrs)	Life (yr)	Purchase Year*	Number of bulbs (million)
CFL	9,000	6	2011	722
Linear	25,000	9	2008	583
HID	17,000	6	2011	180
Total	--	--	--	*1,485*

*If bulbs are discarded or recycled in 2017

$$TotB = \sum_b PB_b \qquad \text{(FL1)}$$

Where:

    TotB   =   Total number of bulbs discarded and recycled, in million units (see Table 4-7)
    PB_b =   Total number of bulb *type b* purchased

According to a 2010 study by Silveira and Chang, the recycling rate for mercury containing lamps in the U.S. is 23% [ref 14]. Taking into account recycling, this suggests that there were approximately 1,143 million mercury-containing lamps discarded at landfills and approximately 341 million mercury-containing lamps recycled in 2017.

For fluorescent bulbs recycled:

$$RecB = TotB \times RR \qquad \text{(FL2)}$$

Where:

    RecB   =   Total number of bulbs recycled, in million units
    TotB   =   Total number of bulbs discarded and recycled, in million units
    RR   =   Recycling rate for mercury containing lamps in the US

For fluorescent bulbs discarded:

$$DiscB = TotB - RecB \qquad \text{(FL3)}$$

Where:

    RecB   =   Total number of bulbs recycled, in million units
    TotB   =   Total number of bulbs discarded and recycled, in million units
    RR   =   Recycling rate for mercury containing lamps in the US

Dental Amalgam

According to a NEWMOA's IMERC factsheet (2015) [ref 15], the amount of mercury in dental amalgam was estimated to be 15.97 tons (31,940 lbs.) in 2013.

The amount of mercury emissions from restored teeth is estimated using data from the National Institutes of Health's National Institute of Dental and Craniofacial Research, which provides estimates of the average number of filled teeth per person, from the CDC National Health and Nutrition Examination Survey (NHANES), in nine different age brackets: 2-5 years, 6-11 years, 12-15 years, 16-19 years, 20-34 years, 35-49 years, 50-64 years, 65-74 years, and 75 and up [ref 16]. The filling data for the age groups 6-11 years, 12-15 years, and 16-19 years are averaged together as are the filling data for the age groups 65-74 years and 75 and up to match the U.S. Census age category, 5-19 and 65 and up. Table 4-8 lists the average number of filled teeth per person by age group.

Table 4-8: Average number of filled teeth per person and percentage of fillings containing mercury by age group

Age Group	Average Number of Filled Teeth Per Person	Percentage of Fillings Containing Mercury
0–4	0.47	15.8%
5–19	1.756	31.6%
20–34	4.61	40.8%
35–49	7.78	50%
50–64	9.20	62.5%
65+	8.69	75.0%

According to the American Dental Association (ADA 1998) more than 75% of restorations before the 1970s used amalgam, which declined to 50% by 1991 [ref 17]. Using these numbers, it is assumed that 40.8% of the filled teeth for 20-34 age group contain amalgam, 50% of filled teeth in the 35-49 age group, 62.5% of filled teeth in the 50-64 age group, and 75% of filled teeth for people over 65. The BAAQMD memorandum is used to estimate that 31.6% of filled teeth in the 1-19 age group contain amalgam. The Food and Drug Administration has discouraged the use of dental amalgam in children under 6 [ref 18]. While EPA does not have data on the percent of fillings containing dental amalgam for the 0-4 age group, it is assumed that the percentage of fillings containing mercury in this age group is approximately half that of the overall under 20 age group.

Thermostats/Thermometers

A 2002 EPA report estimated that 2-3 million thermostats came out of service in 1994 [ref 19]. A 2013 report from a consortium of environmental groups, which assumed that the estimate from the 2002 EPA report remained viable, estimated that the TRC collects at most 8% of the retired thermostats each year [ref 20]. A literature search revealed no new data that could be used to estimate the number of thermostats coming out of service. Therefore, using this estimate, there are approximately 2.3 million thermostats that are not recycled each year.

$$DispTs = RemTs \times (1 - 0.08) \qquad\qquad (T1)$$

Where:

    DispTs = Total thermostats disposed
    RemTs = Total thermostats removed from service

Data from a NEWMOA's IMERC factsheet suggests that there were 546 lbs. of mercury used in thermometers in 2013 [ref 21]. Using past NEWMOA IMERC thermometer data we forecasted the values for mercury in 2014-2017. See Table 4-9 for the amount of mercury used in thermometers each year from 2013-2017.

Table 4-9: Total mercury in thermometers sold and mercury available from thermometers, annually

Year	Total Mercury in Thermometers Sold (lbs.)	Mercury Available from Thermometers each year (lbs.)
2013	546	519
2014	532	1,024
2015	523	1,496
2016	514	1,936
2017	506	2,345

The US EPA assumes that the average lifespan of a glass thermometer is 5 years, and that 5% of glass thermometers are broken each year [ref 19]. Therefore, using the pounds of mercury available in thermometers each year (shown in Table 4-9 above) there would be an estimated 2,345 pounds of mercury remaining in thermometers in 2017 (accounting for the breakage rate each year). The following equation calculates the total amount of mercury remaining in thermometers for each year during the lifespan of the thermometer. To calculate the value at the 5 year lifespan mark, the following equation (equation T2) needs to be used to calculate the value for years 2 through 5, with each year building upon the previous year (i.e., the calculation needs to be conducted for all years to find the final year 5 data). See Table 4-9 for the final values of mercury available from thermometers in 2017, and Section 4.2.3.5 for detailed calculations on how to arrive at the final number.

$$HgTm_n = (HgTm_{n-1} \times 95\%) + HgTmSold_n \tag{T2}$$

Where:

$HgTm_n$ = Amount of mercury remaining in thermometers in year n, in pounds
$HgTm_{n-1}$ = Amount of mercury remaining in thermometers in the year prior to year n, in pounds
$HgTmSold_n$ = Amount of mercury in thermometers in year 1, in pounds
n = Year

King et al. (2008) [ref 22] estimate that during the period 2000-2006 there were 350 lbs. of mercury from thermometers collected in recycling programs.

Subtracting the amount of mercury removed due to thermometers being collected in recycling programs from the total amount of mercury remaining in thermometers in 2017 estimates the total amount of mercury in thermometer available for release, in tons. Therefore, there were 1,995 lbs. (0.99 tons) of mercury available for release in 2017.

$$HgTRl = (HgTm_5 - HgTRm) \times \frac{1\ ton}{2,000\ lbs.} \tag{T3}$$

Where:

$HgTRl$ = Amount of mercury in thermometers available for release, in tons
$HgTm_5$ = Amount of mercury remaining in thermometers in year 5, the lifespan of a thermometer, in pounds

$HgTRm$ =   Amount of mercury removed in thermometer collections, in pounds

4.2.3.2   Allocation procedure

Landfills (working face)

The EPA LMOP database provides data at the county level; therefore, no allocation procedure is needed for this source.

Switches and Relays

The number of unrecovered switches is apportioned to each county based on the number of car recycling facilities. The number of car recycling facilities is estimated using establishment data for recyclable material merchant wholesalers (NAICS 423930) from the U.S. Census Bureau's 2016 County Business Patterns (CBP) [ref 23].

The number of car recycling facilities by county from the US Census County Business Patterns data is first summed to the state level.

$$F_s = \sum_c F_c \qquad\qquad (SR2)$$

Where:

F_s =   Total car recycling facilities in state s
F_c =   Total car recycling facilities in county c

The share of state car recycling facilities by county is calculated by taking the total number of car recycling facilities in a given county by the total number of car recycling facilities in the state.

$$FracF_c = \frac{F_c}{F_s} \qquad\qquad (SR3)$$

Where:

$FracF_c$ =   Total fraction of state car recycling facilities in county c
F_c =   Total car recycling facilities in county c
F_s =   Total car recycling facilities in state s

The share of unrecovered switches by county is calculated using the state number of unrecovered switches and the total share of state car recycling facilities by county, calculated above.

$$UnS_c = UnS_s \times FracF_c \qquad\qquad (SR4)$$

Where:

UnS_c = Total switches unrecovered in county c
UnS_s = Total switches unrecovered in state s
$FracF_c$ = Total share of state car recycling facilities in county c

<u>Fluorescent Lamp Breakage/Recycling</u>

The national-level mercury emissions from fluorescent lamp breakage are allocated to each county based on population.

$$FracP_c = \frac{P_c}{P_{US}}$$ (FL4)

Where:

Frac$P_{c,}$ = Fraction of total US population in county c
P_c = Population in county c
P_{US} = Population in the US

The fraction of total US population in a county is multiplied by the national data for fluorescent bulbs recycled or discarded to calculate the number of fluorescent bulbs recycled or discarded at the county-level.

For fluorescent bulbs discarded:

$$DiscB_c = FracP_c \times DiscB$$ (FL5)

Where:

$DiscB_c$ = Total number of bulbs discarded in county c, in million units
FracP_c = Fraction of total US population in county c
$DiscB$ = Total number of bulbs discarded in the US, in million units

For fluorescent bulbs recycled:

$$RecB_c = FracP_c \times RecB$$ (FL6)

Where:

$RecB_c$ = Total number of bulbs recycled in county c, in million units
FracP_c = Fraction of total US population in county c
$RecB$ = Total number of bulbs recycled in the US, in million units

<u>Dental Amalgam</u>

The amount of mercury from dental office preparations, based on the amount of mercury in dental amalgam from NEWMOA's IMERC factsheet [ref 15], are allocated to the county level based on population.

$$FracP_c = \frac{P_c}{P_{US}}$$ (DA1)

Where:

FracP_c = Fraction of total US population in county c
P_c = Total population in county c

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$$P_{US} \quad = \quad \text{Total population for the United States}$$

The county-level population fraction is multiplied by the amount of mercury sold for dental amalgam to calculate the total mercury from dental office preparations by county.

$$HgO_c = FracP_c \times HgDA \tag{DA2}$$

Where:

HgO_c = Total mercury from dental office preparations in county c, in pounds
$FracP_c$ = Fraction of total US population in county c
$HgDA$ = Total mercury sold for dental amalgam in the US, in pounds

The emissions from filled teeth are allocated to each county by multiplying the county population by the proportion of the national population in each age group, the average number of filled teeth per person, and the fraction of fillings containing mercury (Table 4-10; fraction = percentage/100). The age groups listed in Table 4-10, hereafter referred to as filling groups, are different than official US census bureau age groups; therefore national fractions of each US census bureau age group were calculated, summed, and multiplied by county level population to estimate the county level population for each filling group. Table 4-10 shows how the US Census age groups correspond to each filling group.

Table 4-10: US Census age groups and filling groups

US Census Age Group	Corresponding Filling Age Group
Under 5	0–4
5–9	5–19
10–14	
15–19	
20–24	20–34
25–29	
30–34	
35–39	35–49
40–44	
45–49	
50–54	50–64
55–59	
60–64	
65–69	65+
70–74	
75–79	
80–84	
85 and up	

First, the share of total population each US Census age group represents to the entire US population is calculated.

$$FracP_a = \frac{P_a}{P_{US}} \tag{DA3}$$

Where:

$FracP_a$ = Fraction of the total US population in Census Bureau age group a
P_a = Total population in Census Bureau age group a
P_{US} = Total population for the United States

The fraction of the population for each US Census age group is then summed to match the filling groups.

$$FracP_{fg} = \sum_a FracP_a \qquad \text{(DA4)}$$

Where:

$FracP_{fg}$ = Fraction of the total US population in filling group fg
$FracP_{a,}$ = Fraction of the total US population in census bureau age group a, where age group a falls within filling group fg

The fraction of population for each filling group is multiplied by the county-level population data to get the total population for each filling group.

$$P_{fg,c} = FracP_{fg} \times P_c \qquad \text{(DA5)}$$

Where:

$P_{fg,c}$ = Total population in filling group fg in county c
$FracP_{fg}$ = Fraction of the total US population in filling group fg
P_c = Total population in county c

The filling group county-level population is multiplied by the average number of fillings per person in each filling group to determine the total number of fillings in each filling group in each county.

$$F_{fg,c} = P_{fg,c} \times F_{fg} \qquad \text{(DA6)}$$

Where:

$F_{fg,c}$ = Total fillings in filling group fg in county c
$P_{fg,c}$ = Total population in filling group fg in county c
F_{fg} = Average number of fillings per person in filling group fg

The total fillings in each filling group is then multiplied by the fraction of fillings that contain mercury in each filling group to determine the total number of fillings by filling group in each county.

$$HgF_{fg,c} = F_{fg,c} \times FracHgF_{fg} \qquad \text{(DA7)}$$

Where:

$HgF_{fg,c}$ = Total fillings containing mercury in filling group fg in county c
$F_{fg,c}$ = Total fillings in filling group fg in county c
$FracHgF_{fg}$ = Fraction of fillings containing mercury in filling group fg

<u>Thermostats/Thermometers</u>

The national-level mercury emissions from thermostats and thermometers are allocated to the county level based on population.

$$FracP_c = \frac{P_c}{P_{US}}$$ (T1)

Where:

$FracP_c$ = Fraction of total US population in county c
P_c = Total population in county c
P_{US} = Total population for the United States

The fraction of the US population in the county is multiplied by the national data for thermostats and thermometers to calculate the number of thermostats disposed and the amount of mercury in thermometers available for release at the county-level.

For thermostats:

$$DispTs_c = FracP_c \times DispTs$$ (T2)

Where:

$DispTs_c$ = Total thermostats disposed of in county c
$FracP_c$ = Fraction of total US population in county c
$DispTs$ = Total thermostats disposed of in the US

For thermometers:

$$HgTm_c = FracP_c \times HgTmRl$$ (T3)

Where:

$HgTm_c$ = Amount of mercury in thermometers available for release in county c, in pounds
$FracP_c$ = Fraction of total US population in county c
$HgTmRl$ = Amount of mercury in thermometers available for release in the US, in tons

4.2.3.3 *Emission factors*

<u>Landfills (working face)</u>

The emissions factor for mercury from landfills was developed using an average of mercury emissions factors for the working face of landfills from two different studies [ref 1, ref 24].

Lindberg et al. (2005) [ref 1] measured mercury emissions from the working face of four landfills in Florida and determined an average emissions factor of 2.5 mg/ton of waste, or 5.51×10^{-6} lbs./ton of waste placed in a landfill annually. Babineau et al. (2016) [ref 24] determined that the average mercury content of municipal solid waste (MSW) in Minnesota is 0.00175 lbs./ton[‡‡]. It is assumed that 0.1% of mercury from MSW in landfills is volatized to the air, so the emissions factor from Babineau et al. [ref 24] is estimated to be 1.75×10^{-6} lbs./ton of waste. These emissions factors, presented in Table 4-11, are averaged together to yield an average emissions factor of 3.63×10^{-6} lbs./ton of waste.

Table 4-11: Emissions Factors for mercury from landfills working face

Pollutant	Pollutant Code	Emissions Factor	Emissions Factor Units	Emissions Factor Reference
Mercury	7439976	5.51E-06	lbs./ton	1
Mercury	7439976	1.75E-06	lbs./ton	24
Mercury	7439976	3.63E-06	lbs./ton	Average of above

Switches and Relays

The response to comments for the 2007 EPA Significant New Use Rule on Mercury Switches (72 Fed. Reg. 56903), suggests that the weighted average amount of mercury in switches is 1.2 grams (0.0026 lbs.) [ref 25]. A report by Griffith et al. (2001) [ref 26] shows that 60% of mercury in switches is released at the shredding operation, while 40% is sent to arc furnaces for smelting. Therefore, the emissions factor for switches is 60% of the emissions factor reported in the 2007 EPA Significant New Use Rule on Mercury Switches response to comment document, 0.00156 lbs. per switch.

Fluorescent Lamp Breakage/Recycling

The average amount of mercury in a CFL has been studied extensively, with the amount of mercury in each CFL commonly reported as 1.27–4.0 mg (2.63 mg average, Table 4-12). Linear fluorescent bulbs contain more mercury than CFLs, with a range of 8.3 to 12 mg per bulb (10.15 average, Table 4-13). Data from the USGS suggests that there is an average of 17 mg of mercury per HID bulb [ref 27].

Table 4-12: Mercury used in CFLs (mg/bulb) as determined by three different studies

Study	Average Amount of Mercury per CFL (mg)	Source
Li and Jin (2011)	1.27	[ref 28]
Arendt and Katers (2013)	4.00[*]	[ref 29]
Singhvi et al. (2011)	2.63	[ref 30]
Average	**2.63**	--

[‡‡] The average Hg content of MSW in Minnesota listed in the reference document as 0.87 parts per million (ppm). A conversion factor of 0.002 is used to convert from ppm to lbs./ton – resulting in an average Hg content of 0.00175 lbs./ton.

*Adjusted from 4.5 mg to 4 mg due to increased market penetration of Energy Star
CFLs with a lower Hg content.

Table 4-13: Mercury used in linear fluorescent bulbs (mg/bulb) as determined by two different studies

Study	Average Amount of Mercury per Linear Fluorescent Bulb (mg)	Source
Aucott et al. (2004)	12.0	[ref 31]
NEMA (2005)	8.3	[ref 32]
Average	**10.2**	--

Cain et. al (2007) [ref 33] provides the most comprehensive materials flow analysis of mercury intentionally used in products. Their analysis estimates that 10% of all mercury used in fluorescent light bulbs is eventually released to the atmosphere after production and before disposal, with the majority being released during transport to the disposal facility.

The emissions factor for CFL, linear, and HID bulbs are calculated by multiplying the average amount of mercury per bulb discussed above by 10%.

$$EF_{b,p} = Hg_b \times 0.10 \qquad \text{(FL4)}$$

Where:

$EF_{b,p}$ = Emissions factor by bulb b for pollutant p, in mg/bulb
Hg_b = Average mercury content per bulb b, in mg

The emissions factors for all three bulb types can be found in Table 4-14.

Table 4-14: Mercury emissions factors for CFLs, linear fluorescents and HIDs

Bulb type	Pollutant	Pollutant Code	Emissions Factor	Emissions Factor Units
CFL	Mercury	7439976	0.263	mg/bulb
Linear	Mercury	7439976	1.015	mg/bulb
HID	Mercury	7439976	1.7	mg/bulb

A weighted average of all three emissions factors in Table 4-14 is calculated to estimate total emissions from all fluorescent lamp breakage. The first step estimates the fraction each bulb represents of the total amount of bulbs discarded and recycled.

$$FracTotB_b = \frac{PB_b}{TotB} \qquad \text{(FL5)}$$

Where:

$FracTotB_b$ = Fraction of bulb type b discarded and recycled
PB_b = Total number of bulb type b discarded and recycled, in million bulbs
$TotB$ = Total number of bulbs discarded and recycled in the US, in million bulbs

A weighted emissions factor for fluorescent lamp breakage is then calculated by multiplying the fraction the bulb type represents of the total number of bulbs by the bulb type-specific emissions factor.

$$EF_{br,p} = \left(\sum_b EF_{b,p} \times FracTotB_b\right) \times \left(2.2 \times 10^{-6}\frac{lbs.}{mg}\right) \qquad \text{(FL6)}$$

Where:

$EF_{br,p}$	=	Weighted emissions factor for pollutant p for fluorescent bulb breakage, br, in lbs./bulb
$EF_{b,p}$	=	Emissions factor for bulb type b and pollutant p, in mg/bulb (see Table 4-14)
$FracTotB_b$	=	Fraction of the number of bulb type b discarded and recycled

For mercury-containing bulb recycling, the US EPA has estimated an emissions factor of 0.00088 mg/bulb (1.9 × 10^{-9} lbs./bulb) [ref 34].

Dental Amalgam

US EPA (1997) estimates that 2% of mercury used in dental offices is emitted to the air [ref 34].

Richardson et al. (2011) [ref 35] estimate emissions from filled teeth of approximately 0.3 µg/day of mercury per filled tooth, or 2.4 × 10^{-7} lbs. per year per filled tooth. The emissions factors used for estimating mercury emissions from dental amalgam are shown in Table 4-15.

Table 4-15: Mercury emissions factors for dental amalgam

Activity	Pollutant	Pollutant Code	Emissions Factor	Emissions Factor Units	Source
Released from dental offices	Mercury	7439976	0.02	Lbs./Lb.	34
Filled teeth	Mercury	7439976	2.4x10^{-7}	Lbs./tooth filled	35

Thermostats/Thermometers

The 2002 EPA report estimates that there are 3 grams of mercury per thermostat [ref 19]. Cain et al. (2007) [ref 33] estimate that 1.5% of mercury in "control devices," including thermostats, is emitted to the air before it is disposed of at a landfill or incinerator. Therefore, the amount of mercury emitted is 0.045 grams per thermostat, or 9.92× 10^{-5} lbs. per thermostat [ref 28].

Leopold (2002) [ref 19] estimates that 5% of thermometers are broken each year. EPA assumes that the remaining 95% of thermometers that are not broken are still in use and therefore do not contribute to emissions. Cain et al. (2007) [ref 33] estimate that 10% of mercury from thermometers is emitted to the air before disposal in a landfill Therefore the emissions factor is estimated to be 10 lbs. of mercury emissions per ton of mercury in thermometers.

The emissions factors used for estimating mercury emissions from thermostats and thermometers are shown in Table 4-16.

Table 4-16: Mercury emissions factors for thermostats and thermometers

Type	Pollutant	Pollutant Code	Emissions Factor	Emissions Factor Units	Source
Thermostats	Mercury	7439976	9.92 x 10^{-5}	Lbs./Thermostat	28, 33

Type	Pollutant	Pollutant Code	Emissions Factor	Emissions Factor Units	Source
Thermometers	Mercury	7439976	10	Lbs./Ton	19, 33

4.2.3.4 *Controls*

There are no controls assumed for these sources.

4.2.3.5 *Emissions*

Landfills (working face)

The total mercury emissions from landfills, in pounds, is estimated by multiplying the average tons of waste that each landfill receives per year by the average emissions factor in Table 4-11. The emissions are reported at the county level for the county that the landfill is located in.

$$E_{p,c} = W_c \times EF_p \tag{1}$$

Where:

$E_{p,c}$ = Annual emissions of pollutant p in county c, in lbs.
W_c = Average tons of waste from all landfills in county c
EF_p = Average emissions factor for pollutant p, in lbs./ton

Switches and Relays

The total county-level mercury emissions from switches and relays, in pounds, is estimated by multiplying the total switches unrecovered for each county by the emissions factor.

$$E_{s,p,c} = UnS_c \times EF_{s,p} \tag{SR5}$$

Where:

$E_{s,p,c}$ = Annual emissions of pollutant p in county c from switches and relays, s, in lbs.
UnS_c = Total switches unrecovered by county c
$EF_{s,p}$ = Emissions factor for pollutant p for switches and relays, s, in lbs./switch

Fluorescent Lamp Breakage/Recycling

The total county-level mercury emissions for fluorescent lamp breakage and recycling, in pounds, is estimated by multiplying the total fluorescent lamps broken or recycled for each county by the emissions factor.

For fluorescent lamp breakage:

$$E_{br,p,c} = (DiscB_c \times 1{,}000 \; units) \times EF_{br,p} \tag{FL4}$$

Where:

$E_{br,p,c}$ = Annual emissions of pollutant p from fluorescent bulb breakage, br, by county c, in lbs.
$DiscB_c$ = Total number of bulbs discarded for county c, in million units

$EF_{br,p}$ = Weighted emissions factor for pollutant p for fluorescent bulb breakage, br, in lbs./bulb

For fluorescent lamp recycling:

$$E_{r,p,c} = (RecB_c \times 1,000 \ units) \times EF_{r,p} \qquad \text{(FL5)}$$

Where:

$E_{r,p,c}$ = Annual emissions of pollutant p from fluorescent lamp recycling, r, by county c, in lbs.
$RecB_c$ = Total number of bulbs recycled for county c, in million bulbs
$EF_{r,p}$ = Weighted emissions factor for pollutant p for fluorescent bulb recycling, r, in lbs./bulb

<u>Dental Amalgam</u>

The total county-level mercury emissions for dental amalgam from fillings, in pounds, is estimated by multiplying the total number of fillings containing mercury for each county by the emissions factor.

$$E_{f,p,c} = \sum_{fg} HgF_{fg,c} \times EF_{f,p} \qquad \text{(DA7)}$$

Where:

$E_{f,p,c}$ = Annual emissions of pollutant p from dental fillings, f, by county c, in lbs.
$HgF_{fg,c}$ = Total fillings containing mercury in filling group fg in county c
$Ef_{f,p}$ = Emissions factor for pollutant p from dental fillings, f, in lbs./tooth filled

The total county-level mercury emissions for dental office preparation, in pounds, is estimated by multiplying the total pounds mercury from dental office preparations for each county by the emissions factor.

$$E_{o,p,c} = HgO_c \times EF_{o,p} \qquad \text{(DA8)}$$

Where:

$E_{o,p,c}$ = Annual emissions of pollutant p from dental office preparations, o, by county c, in lbs.
HgO_c = Total mercury from dental office preparations by county c, by pounds
$EF_{o,p}$ = Emissions factor for pollutant p for dental office preparations, o, by lbs./lb.

The emissions from dental fillings and dental office preparations are summed to get the total mercury emissions from dental amalgam.

$$E_{da,p,c} = E_{f,p,c} + E_{o,p,c} \qquad \text{(DA9)}$$

Where:

$E_{da,p,c}$ = Annual emissions of pollutant p from total dental amalgam, da, by county c, in lbs.
$E_{f,p,c}$ = Annual emissions of pollutant p from dental fillings, f, by county c, in lbs.
$E_{OP,p,c}$ = Annual emissions of pollutant p from dental office preparations , o, by county c, in lbs.

Thermostats/Thermometers

The total county-level mercury emissions for thermostats, in pounds, is estimated by multiplying the total number of thermostats disposed in each county by the emissions factor.

$$E_{ts,p,c} = DispTs_c \times EF_{ts,p}$$ (T1)

Where:

$E_{ts,p,c}$ =   Annual emissions of pollutant p for thermostats in county c, in lbs.
$DispTs_c$ =   Total thermostats disposed in county c
$Ef_{ts,p}$ =   Emissions factor for pollutant p for thermostats, ts, in lbs./thermostat

The total county-level mercury emissions for thermometers, in pounds, is estimated by multiplying the total amount of mercury remaining in thermometers over their lifespan for each county by the emissions factor.

$$E_{t,p,c} = HgTm_c \times EF_{t,p}$$ (T2)

Where:

$E_{t,p,c}$ =   Annual emissions of pollutant p for thermometers in county c, in lbs.
$HgTm_c$ =   Amount of mercury remaining in thermometers over their lifespan in county c, in lbs.
$EF_{t,p}$ =   Emissions factor for pollutant p for thermometers, in lbs./ton

The emissions from thermostats and thermometers are summed to get the total mercury emissions.

$$E_{tt,p.c} = E_{ts,p,c} + E_{t,p,c}$$ (T3)

Where:

$E_{tt,p,c}$ =   Annual emissions of pollutant p for thermostats and thermometers in county c, in lbs.
$E_{ts,p,c}$ =   Annual emissions of pollutant p for thermostats in county c, in lbs.
$E_{tm,p,c}$ =   Annual emissions of pollutant p for thermometers in county c, in lbs.

4.2.3.6 *Example calculations*

Landfills (working face)

Table 4-17 lists sample calculations to determine the mercury emissions from landfills in New Hanover County, North Carolina. The landfill used in this calculation is the New Hanover County Secure Landfill in New Hanover County, NC. New Hanover County, NC only has one landfill, so equation 3 is only including this one value.

Table 4-17: Sample calculations for mercury emissions from landfills in New Hanover County, NC

Eq. #	Equation	Values for New Hanover County, North Carolina	Result
1	$OP_l = 2017 - O_l$	$2017 - 1979$	38 years that New Hanover County Secure Landfill will be open
2	$W_l = \dfrac{WP_l}{OP_l}$	$\dfrac{4{,}845{,}027\ tons}{38\ years}$	127,501 average tons of waste per year for the New Hanover County Secure Landfill
3	$W_c = \sum_c W_l$	N/A; there is only one landfill in Hanover County, NC	111,191 average tons of waste per year for the New Hanover County, NC
4	$E_{p,c} = W_c \times EF_{p,}$	$127{,}501\ tons\ \times (3.63 \times 10^{-6})\ \dfrac{lbs.}{tons}$	0.46 pounds of mercury for New Hanover County, NC

Switches and Relays

Table 4-18 lists sample calculations to estimate the mercury emissions from switches and relays in Hartford County, Connecticut.

Table 4-18: Sample calculations for mercury emissions from switches and relays for Hartford County, CT

Eq. #	Equation	Values for Hartford County, Connecticut	Result
1	$UnS_s = TotS_s - RecS_s$	$22{,}000\ switches\ available - 618\ switches\ recovered$	21,382 unrecovered switches in Connecticut
2	$F_s = \sum_{cs} F_c$	$\sum All\ facilities\ in\ Connecticut$	85 car recycling facilities in Connecticut
3	$FracF_c = \dfrac{F_c}{F_s}$	$\dfrac{18\ facilities\ in\ Hartford\ County, CT}{85\ facilities\ in\ CT}$	0.2118 share of state car recycling facilities in Hartford County, CT

Eq. #	Equation	Values for Hartford County, Connecticut	Result
4	$UnS_c = UnS_s \times FracF_c$	$21,382 \ unrecovered \ switches$ $\times 0.2118 \ share \ of \ state \ facilities$	4,528 unrecovered switches in Hartford County, CT
5	$E_{s,p,c} = UnS_c \times EF_{s,p}$	$4,528 \ switches \ \times \ 0.00156 \ \dfrac{lbs.}{switch}$	7.06 pounds of mercury from switches and relays in Hartford County, CT

Fluorescent Lamp Breakage/Recycling

Table 4-19 lists sample calculations to estimate the mercury emissions from fluorescent lamp breakage in Hartford County, Connecticut.

Table 4-19: Sample calculations for mercury emissions from fluorescent lamp breakage for Hartford County, CT

Eq. #	Equation	Values for Hartford County, Connecticut	Result
1	$TotB = \sum_b PB_b$	$\sum all \ bulbs \ recycled \ or \ discarded$	1,485 million bulbs discarded and recycled in the US in 2014
2	$RecB = TotB \times RR$	$1,485 \ million \ recycled \ and \ discarded$ $bulbs \ \times 23\% \ recycling \ rate$	341 million bulbs recycled in the US in 2014
3	$DiscB = TotB - RecB$	$1,485 \ million \ recycled \ and \ discarded$ $bulbs - 341 \ million \ recycled \ bulbs$	1,143 million bulbs discarded in the US in 2014
4	$FracP_c = \dfrac{P_c}{P_{US}}$	$\dfrac{895,388 \ people \ in \ Hartford \ County,}{318,857,056 \ people \ in \ the \ US}$	0.272% of total US population is in Hartford County, CT
5	$DiscB_c = FracP_c \times DiscB$	$0.00272 \times 1,143 \ million \ bulbs$	3.109 million fluorescent bulbs discarded in Hartford County, CT
6	$RecB_c = FracP_c \times RecB$	$0.00272 \ \times 341 \ million \ bulbs$	0.928 million fluorescent bulbs recycled in Hartford County, CT
7	$EF_{b,p} = Hg_b \times 0.10$	$CFL: 2.63 \ mg \ Hg \ \times 10\%$ $Linear: 10.2 \ mg \ Hg \ x \ 10\%$ $HID: 17 \ mg \ Hg \ x \ 10\%$	0.263 mg Hg/CFL bulb 1.02 mg Hg/linear bulb 1.7 mg Hg/HID bulb

Eq. #	Equation	Values for Hartford County, Connecticut	Result
8	$FracTotB_b = \dfrac{PB_b}{TotB}$	$CFL: \dfrac{722 \text{ million CFL bulbs}}{1{,}485 \text{ million bulbs total}}$ $Linear: \dfrac{583 \text{ million Linear bulbs}}{1{,}485 \text{ million bulbs total}}$ $HID: \dfrac{180 \text{ million HID bulbs}}{1{,}485 \text{ million bulbs total}}$	48.6% of total for CFL 39.2% of total for Linear 12.1% of total for HID
9	$EF_{br,p} = \left(\sum_b EF_{b,p} \times FracTotB_b\right) \times \left(2.2 \times 10^{-6} \frac{lbs.}{mg}\right)$	$\left(\left(0.263 \frac{mg}{bulb} \times 48.6\%\right) + \left(1.02 \frac{mg}{bulb} \times 39.2\%\right) + \left(1.7 \frac{mg}{bulb} \times 12.1\%\right)\right) \times \left(2.2 \times 10^{-6} \frac{lbs.}{mg}\right)$	1.61×10^{-6} lbs. Hg/bulb weighted emissions factor for mercury for fluorescent lamp breakage
10	$E_{br,p,c} = (DiscB_c) \times EF_{br,p}$	$3{,}109{,}617 \text{ bulbs} \times \left(1.61 \times 10^{-6} \frac{lbs.Hg}{bulb}\right)$	5.0 lbs. of mercury from fluorescent lamp breakage in Hartford County, CT
11	$E_{r,p,c} = (RecB_c) \times EF_{r,p}$	$928{,}846 \text{ bulbs} \times \left(1.94 \times 10^{-9} \frac{lbs.Hg}{bulb}\right)$	1.8×10^{-4} lbs. of mercury from fluorescent lamp recycling in Hartford County, CT

Dental Amalgam

Table 4-20 lists sample calculations to determine the mercury emissions from dental amalgam in Hartford County, Connecticut. The example will show the process for the 5-19 age group, with the total sum of emissions in the final step.

Table 4-20: Sample calculations for mercury emissions from dental amalgam for Hartford County, CT

Eq. #	Equation	Values for Hartford County, Connecticut	Result
1	$FracP_c = \dfrac{P_c}{P_{US}}$	$\dfrac{895{,}338 \text{ people in Hartford County, CT}}{329{,}164{,}967 \text{ people in the US}}$	0.272% of total US population is in Hartford County, CT
2	$HgO_c = FracP_c \times HgDA$	$0.272\% \times 31{,}940 \text{ lbs.}$	86.88 lbs. total mercury from dental office preparations in Hartford County, CT

Eq. #	Equation	Values for Hartford County, Connecticut	Result
3	$FracP_a = \dfrac{P_a}{P_{US}}$	$5\ to\ 9:\ \dfrac{20,304,238\ people,5\ to\ 9\ age\ group}{325,719,178\ people\ in\ the\ US}$ $10\ to\ 14:\ \dfrac{20,778,454\ people,10\ to\ 14\ age\ g}{325,719,178\ people\ in\ the\ U.}$ $15\ to\ 19:\ \dfrac{21,131,660\ people,14\ to\ 19\ age\ g}{325,719,178\ people\ in\ the\ U.}$	6.23% of total US population for 5-9 age group 6.38% of total US population for 10-14 age group 6.49% of total US population for 14-19 age group
4	$FracP_{fg} = \displaystyle\sum_a FracP_a$	$\displaystyle\sum 6.23\% + 6.38\% + 6.49\%$	19.1006% of total US population for 5-19 age group
5	$P_{fg,c} = FracP_{fg} \times P_c$	$19.1006\% \times$ $895,338\ people\ in\ Hartford\ County, CT$	171,025 people in the 5-19 age group in Hartford County, CT
6	$F_{fg,c} = P_{fg,c} \times F_{fg}$	$171,025\ people\ 5 -$ $19\ in\ Hartford\ County, CT \times$ $1.756\ fillings, 5 - 19\ age\ group$	300,433 fillings in the 5-19 age group in Hartford County, CT
7	$HgF_{fg,c} = F_{fg,c} \times FracHgF_{fg}$	$300,433\ fillings, 5$ $- 19\ age\ group \times 31.6\%$	94,936 total fillings containing mercury in the 5-19 age group in Hartford County, CT
8	$E_{f,p,c} = \displaystyle\sum_{fg} HgF_{fg,c} \times EF_{f,p}$	$94,936 fillings\ with\ mercury, 5 -$ $19\ age\ group \times \left(2.4 \times 10^{-7}\ \dfrac{lbs.}{tooth\ filled}\right)$	0.023 pounds of mercury emissions from fillings in the 5-19 age group (0.722 pounds of mercury in all age groups) in Hartford County, CT
9	$E_{o,p,c} = HgO_c \times EF_{o,p}$	$86.88\ lbs. \times 0.02\ \dfrac{lbs.}{lb.}$	1.74 pounds of mercury emissions from dental office preparations in Hartford County, CT
10	$E_{da,p,c} = E_{f,p,c} + E_{o,p,c}$	$0.722\ pounds + 1.74\ pounds$	2.46 pounds of mercury from dental amalgam in Hartford County, CT

Thermostats/Thermometers

Table 4-21 lists sample calculations to determine the mercury emissions from thermostats and thermometers in Hartford County, Connecticut.

Table 4-21: Sample calculations for mercury emissions from thermostats and thermometers for Hartford County, CT

Eq. #	Equation	Values for Hartford County, Connecticut	Result
1	$DispTs = RemTs \times (1 - 8\%)$	2,500,000 *thermostats removed from ser* $\times 92\%$	2,300,000 thermostats disposed of in the United States in 2017
2	$HgTm_n = (HgTm_{n-1} \times 95\%) + HgTm_1$	$y = 1: 546\ lbs \times 95\%$ $y = 2: (518.7\ lbs. \times 95\%) + 532\ lbs.$ $y = 3: (1,024\ lbs. \times 95\%) + 523\ lbs.$ $y = 4: (1,496\ lbs. \times 95\%) + 514\ lbs.$ $y = 5: (1,935\ lbs. \times 95\%) + 506\ lbs.$	2,345 pounds of mercury available for release in thermometers in year 2017
3	$HgTRl = (HgTm_5 - HgTRm) \times \frac{1\ ton}{2,000\ lbs.}$	$2,345\ lbs. - 350\ lbs. \times \frac{1\ ton}{2,000\ lbs.}$	0.99 tons of total mercury in thermometers available for release
4	$FracP_c = \frac{P_c}{P_{US}}$	$\frac{895,388 people\ in\ Hartford\ County, CT}{329,164,967\ people\ in\ the\ US}$	0.272% of total US population is in Hartford County, CT
5	$DispTs_c = FracP_c \times DispTs$	$0.272\% \times 2,300,000\ thermostats$	6,256 thermostats disposed in Hartford County, CT
6	$HgTm_c = FracP_c \times HgTmRl$	$0.272\% \times 0.99\ tons$	0.0027 tons of mercury from thermometers available for release in Hartford County, CT
7	$E_{ts,p,c} = DispTs_c \times EF_{ts,p}$	$6,256\ thermostats \times \left(9.92 \times 10^{-5} \frac{lbs.}{thermostat}\right)$	0.62 pounds of mercury emissions from thermostats in Hartford County, CT
8	$E_{t,p,c} = HgTm_c \times EF_{t,p}$	$0.0027\ tons \times 10 \frac{lbs.}{ton}$	0.027 pounds of mercury emissions from thermometers in Hartford County, CT

Eq. #	Equation	Values for Hartford County, Connecticut	Result
9	$E_{tt,p.c} = E_{ts,p,c} + E_{t,p,c}$	$0.62\ lbs. + 0.027\ lbs.$	0.647 pounds of mercury emissions from thermostats and thermometers in Hartford County, CT

4.2.3.7 *Changes from the 2014 methodology*

There are no methodology changes from the 2014 NEI development. However, activity information has been updated to year 2017 for state-level data on the number of recyclers, number of switches recovered, and the amount of mercury recovered, as well as the number of switches available for recovery.

4.2.3.8 *Puerto Rico and U.S. Virgin Islands*

For landfills, Puerto Rico and the U.S. Virgin Islands use the same methodology as the rest of the U.S. However, for all other sources, because insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in pounds for these two Florida counties are divided by their respective populations creating a pound per capita emission factor. For each Puerto Rico and US Virgin Island county, the pound per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which serves as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.2.4 References

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4.3 Agriculture – Crops and Livestock Dust

This sector includes fugitive dust estimates from both agricultural tilling and dust kicked up by livestock animal hooves and feet. These sources are significant contributors of atmospheric dust, both fine and coarse particulate matter (PM2.5 and PM10, respectively).

4.3.1 Sector description

Agricultural Tilling

Fugitive dust emissions from agricultural tilling (SCC=2801000003) include the airborne soil particulate emissions produced during the preparation of agricultural lands for planting. Fugitive dust emissions from agricultural tilling were estimated for PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there is no condensable PM (PM-CON) emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL. Particulate emissions from agricultural tilling were computed by multiplying a crop-specific emissions factor by an activity factor, as described below.

Dust kicked up by animals

The SCCs that belong to this sector are provided in Table 4-22. The level 1 and level 2 SCC description for these SCCs is "Miscellaneous Area Sources; Agricultural Production – Livestock". Hoof emissions were estimated for beef and dairy cattle, swine, and dust emissions from poultry feet were also examined. Fugitive dust emissions from hooves/feet were estimated for primary and filterable PM: PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there are no condensable PM (PM-CON) emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL.

Table 4-22: EPA-generated Dust from animal hooves and feet SCCs with level 3 and 4 descriptions

SCC	SCC Level 3	SCC Level 4
2805001000	Beef cattle	Dust Kicked-up by Hooves
2805001010	Dairy Cattle	Dust Kicked-up by Hooves
2805001020	Broilers	Dust Kicked-up by Feet
2805001030	Layers	Dust Kicked-up by Feet
2805001040	Swine	Dust Kicked-up by Hooves
2805001050	Turkeys	Dust Kicked-up by Feet

4.3.2 Sources of data

Several S/L/T agencies submitted data for agricultural tilling and/or other agriculture production -crops-sources and for dust from hooves/feet. These agencies and SCCs-submitted are listed in Table 4-23.

Table 4-23: Agencies reporting emissions to the dust from crops and animal feet/hooves.

SCC	SCC Level 3 and 4	S/L/Ts reporting emissions
2801000000	Agriculture - Crops; Total	Maricopa County Air Quality Department

SCC	SCC Level 3 and 4	S/L/Ts reporting emissions
2801000003	Agriculture - Crops; Tilling	California Air Resources Board Clark County Department of Air Quality and Environmental Management Coeur d'Alene Tribe Delaware Department of Natural Resources and Environmental Control Idaho Department of Environmental Quality Illinois Environmental Protection Agency Kootenai Tribe of Idaho Maricopa County Air Quality Department Maryland Department of the Environment Memphis and Shelby County Health Department - Pollution Control Metro Public Health of Nashville/Davidson County New Hampshire Department of Environmental Services Nez Perce Tribe Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho Utah Division of Air Quality
2801000005	Agriculture - Crops; Harvesting	Coeur d'Alene Tribe Delaware Department of Natural Resources and Environmental Control Idaho Department of Environmental Quality Kootenai Tribe of Idaho Maricopa County Air Quality Department Nez Perce Tribe Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho Washington State Department of Ecology
2801000008	Agriculture - Crops; Transport	Maricopa County Air Quality Department
2801600000	Country Grain Elevators; Total	Coeur d'Alene Tribe Idaho Department of Environmental Quality Kootenai Tribe of Idaho Maricopa County Air Quality Department Nez Perce Tribe Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho
2805001000	Livestock; Beef cattle - finishing operations on feedlots (drylots); Dust Kicked-up by Hooves	Coeur d'Alene Tribe Idaho Department of Environmental Quality Kootenai Tribe of Idaho Memphis and Shelby County Health Department - Pollution Control Metro Public Health of Nashville/Davidson County Nez Perce Tribe Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho
2805001010	Livestock; Dairy Cattle; Dust Kicked-up by Hooves	Coeur d'Alene Tribe Idaho Department of Environmental Quality Kootenai Tribe of Idaho Nez Perce Tribe Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho
2805001020	Livestock; Broilers; Dust Kicked-up by Feet	

SCC	SCC Level 3 and 4	S/L/Ts reporting emissions
2805001030	Livestock; Layers; Dust Kicked-up by Feet	
2805001040	Livestock; Swine; Dust Kicked-up by Hooves	
2805001050	Livestock; Turkeys; Dust Kicked-up by Feet	

4.3.3   EPA-developed methodology

<u>Ag Tilling overview</u>

The calculations for estimating emissions from agricultural tilling involves distributing state-level tilling data by tilling type (conservation, no-till, and conventional) to the county level and calculating a ratio of conservation, no-till, and conventional tilling for each county. That ratio is used to estimate the type of tillage for each crop type for each tilling type in each county. The type of tillage is used to develop a county-level emissions factor for each crop type and tilling type, which is used to calculate county-level PM10-FIL, PM10-PRI, PM25-FIL, and PM25-PRI emissions

<u>Dust kicked up by feet and hooves overview</u>

The calculations for estimating emissions from animal hooves and feet are performed for each animal type using emission factors for each animal unit (e.g., pigs under 55 pounds, pigs 55 pounds to market, sows, boars), multiplied by state animal counts and allocated to counties using available data discussed in the following sections.

4.3.3.1   *Emission factor equation*

<u>Agricultural Tilling</u>

The county-level emission factors for agricultural tilling (in lbs per acre) are specific to the crop type and tilling method (e.g., conventional tillage corn, no-till soybean, etc.) and were calculated using the following equation [ref 1, ref 2]:

$$EF_{p,t,x,c} = c \times k \times s_c^{0.6} \times p_t \tag{2}$$

Where:

$EF_{p,t,x,c}$ = Emissions factor for pollutant p, crop tilling type t, and crop type x in county c, in lbs./acre
c = Constant 4.8 lbs./acre-pass
k = Dimensionless particle size multiplier (PM10-FIL and PM10-PRI = 0.21; PM25-FIL and PM25-PRI = 0.042)
s_c = Percent silt content of surface soil (%) in county c, defined as the mass fraction of particles smaller than 50 µm diameter found in surface soil
p_t = Number of passes or tillings in a year by crop tilling type, t

The U.S. Department of Agriculture and the National Cooperative Soil Survey define silt content of surface soil as the percentage of particles (mass basis) of diameter smaller than 50 micrometers (µm) found in the surface

soil.[§§] The soil sample data used to estimate county-level, average silt content values are from the National Cooperative Soil Survey Microsoft Access Soil Characterization Database [ref 3]. This database contains the most commonly requested data from the National Cooperative Soil Survey Laboratories including data from the Kellogg Soil Survey Laboratory and cooperating universities.

EPA applied specific selection criteria to the database to ensure that all samples are comparable and relevant to this analysis. The selection criteria included selecting only samples taken inside the United States with a preparation code of S and a horizon top of zero centimeters or a master horizon of A or O. A preparation code of S signifies that the sample is the air-dried whole soil passing through a 3-inch sieve and a horizon top of zero or master horizon of A or O ensures that the sample is taken at the surface.

In some cases, the sample metadata did not indicate a county, but included latitude and longitude coordinates. In these cases, the state and county information are determined based on the latitude and longitude coordinates and added to the sample entry in the database.

The average silt content for a county is calculated by summing the total silt content of all the samples in the county and dividing by the number of samples in the county. For counties without samples, the average silt content is calculated by summing the total silt content of soil samples in neighboring counties and dividing by the number of samples in the neighboring counties. If neighboring counties also lacked sample data, then the county is assigned the average silt value of soil samples within the state.

Table 4-24 shows the number of passes or tillings in a year for each crop for conservation use, no-till and conventional use [ref 4]. These values are used as p_t in equation 1 to estimate the county-level emissions factors. Mulch till and ridge till tillage systems are classified as conservation use, while 0 to 15 percent residue and 15 to 30 percent residue tillage systems are classified as conventional use.

Table 4-24: Number of passes or tillings per year

Crop	Conservation Use	No-Till	Conventional Use
Barley	3	3	5
Beans	3	3	3
Canola	3	3	3
Corn	1	0	2
Cotton	5	5	8
Cover	1	1	1
Fallow	1	1	1
Fall-seeded/Winter Wheat	3	3	5
Forage	3	3	3
Hay	3	3	3
Oats	3	3	5
Peanuts	3	3	3
Peas	3	3	3
Permanent Pasture	0	0	1
Potatoes	3	3	3
Rice	5	5	5
Rye	3	3	5
Sorghum	1	1	6
Soybeans	1	0	2
Spring Wheat	1	1	4
Sugarbeets	3	3	3

[§§] Note that this definition is different than the U.S. Environmental Protection Agency's definition that includes all particles (mass basis) of diameter smaller than 75 micrometers.

Crop	Conservation Use	No-Till	Conventional Use
Sugarcane	3	3	3
Sunflowers	3	3	3
Tobacco	3	3	3

<u>Dust Kicked up by Hooves</u>

Dust emission factors were obtained from a variety of different literature articles [ref 5 through ref 24] for each livestock type. From the literature, calculations were done to obtain the emission factor for each pollutant in the desired form. No references for $PM_{2.5}$ emission factors were found in the extensive literature search for Beef Cattle. To complete $PM_{2.5}$ for this tool, the Dairy Cattle PM_{10} to $PM_{2.5}$ ratio of 4.81118266481148 from this tool was used and is based on ratios ultimately derived from AP-42 [ref 1]. The general methodology for computing emission factors is provided below:

1. Determine if study calculated emission factors (EF) for pollutants
2. If the study did calculate EFs, then convert (if necessary) to ton/year/1000 head
3. If the study did not calculate EF, calculate EF if possible
4. To calculate the EF, the following equation* is used:

EF (ton/year/1000 head) = Emission rate (ton/year) / Animal Units

   *Adapted from Equation 2-1 from the NRC's Scientific Basis for Estimating Air Emissions from Animal Feeding Operations: Interim Report (2002)

5. Make sure the emission rate (typically given) is in the correct units (ton/year)
6. Calculate the animal units using the following equation from the Wisconsin Department of Natural Resources:

AU = Equivalent Factor * Number of Animals

   Where the equivalent factor is obtained from Table 4-25 and the number of animals is obtained from the study.
   Note: In some cases, the weight of the animals is also necessary to obtain the equivalent factor.
7. Convert the AU to number of animals, assuming 1 AU = 500 kg
8. Calculate the emission factor in tons/year/head

Multiply calculated emission factor by 1000 to get the tons/year/1000 head

Table 4-25: Animal units equivalent factors

Animal type	Specification	AU Equivalent Factor
Cattle	Dairy/Beef Calves (under 400lbs)	0.20
Dairy Cattle	Milking & Dry Cows	1.40
Dairy Cattle	Heifers (800-1200 lbs)	1.10
Dairy Cattle	Heifers (400 – 800 lbs)	0.60
Beef Cattle	Steers or Cows (400 lbs to market)	1.00
Beef Cattle	Bulls	1.40
Cattle	Veal Calves	0.50
Swine	Pigs (up to 55 lbs)	0.10
Swine	Pigs (55 lbs to market)	0.40
Swine	Sows	0.40
Swine	Boars	0.50

Animal type	Specification	AU Equivalent Factor
Chicken	Layers – non-liquid manure system	0.01
Chicken	Broilers/pullets – non-liquid manure system	0.005
Chicken	Bird – liquid manure system	0.033
Turkeys	Turkey	0.018

4.3.3.2 *Activity data*

<u>Agricultural Tilling</u>

The basis of agricultural tilling emission estimates is the number of acres of crops tilled in each county by crop type and tillage type. These data were estimated based on data from the USDA *2012 Census of Agriculture* [ref 25]. The USDA Census of Agriculture reports acres harvested for a given crop at the county level but does not provide tilling data for each crop type at the county level. To calculate acres harvested per tilling type for each crop, the breakdown of tilling types (conservation, no-till, and conventional) at the county-level was applied to the acres harvested for each crop type at the county level.

The USDA Census of Agriculture redacts some county-level data to avoid disclosing data for individual farms. Missing county-level data for acres harvested by crop type and tilling type were calculated using the difference between the state and national level reported data and the sum of the county-level data by state.

When county level tilling data are unavailable, the total state level tilling data by tilling type, conservation, no-till, and conventional are distributed to the county level for each crop. The difference between the county-level data for acres harvested by crop tilling type and the state-level data for acres harvested by crop tilling are equally distributed to the counties without data.

$$a_{m,t} = \frac{a_{s,t} - \sum a_{c,t}}{C_{m,t}} \qquad (1)$$

Where:

$a_{m,t}$ = County-level land tilled by crop tilling type, t, for counties missing tilling data, m, in acres
$a_{s,t}$ = Land tilled by crop tilling type t in state s, in acres
$a_{c,t}$ = Sum of county-level land tilled by crop tilling type, t, in acres
$C_{m,t}$ = Number of counties missing county-level land tilled data by crop tilling type, t

USDA provides data on the number of acres tilled by tillage type (conservation, no-till, and conventional) in each county [ref 26], but not by tillage type and crop type in each county. To estimate tillage by crop type in each county, a ratio is determined based on the number of acres in each county tilled by each tillage type to the total acres tilled by all tillage types. This calculation uses either the data directly reported by USDA or the data gap-filled by equation 1.

$$r_{c,t} = \frac{a_{c,t} \ (or \ a_{m,t})}{\sum a_{c,t} \ (or \ a_{m,t})} \qquad (2)$$

Where:

$r_{c,t}$ = Ratio of crop tilling type t to total all crop tilling types in county c
$a_{c,t}$ = Land tilled by crop tilling type t in county c, in acres
$a_{m,t}$ = Land tilled by crop tilling type t for counties missing data, m, in acres

The ratio is then used to estimate the county-level acres harvested by crop type from the *2012 Census of Agriculture* to the tilling type (conservation, no-till, and conventional) at the county-level.

$$a_{t,c,x} = r_{c,t} \times a_{c,x} \qquad (3)$$

Where:

$a_{t,c,x}$ = Land tilled by crop tilling type t and crop type x in county c, in acres
$r_{c,t}$ = Ratio of crop tilling type t to total all crop tilling types in county c
$a_{c,x}$ = Acres harvested of crop type x in county c, in acres

Tilling data for permanent pasture followed a different methodology. Conventional tilling data are available for the state of Utah [ref 27]. For Utah, a ratio of the conventional tilling acres to the total acres of permanent pasture is developed (0.0023) and applied to the total acreage data for permanent pasture from the *2012 Census of Agriculture* to determine the number of conventional tilled permanent pasture acres by county in other states. It is assumed that the remainder of the permanent pasture acres is not tilled, so the remaining distribution of permanent pasture acres is then distributed to no till acres and conservation tilling acres are left as zero.

A summary of national-level acres tilled in 2012 for each tilling type are presented in Table 4-26 [ref 3].

Table 4-26: Acres (millions) tilled by tillage type, in 2012

Tillage system	National acres tilled
No-Till	658.07
Conservation	162.19
Conventional	273.16
Total	**1,093.42**

Dust kicked up by hooves and feet

The activity data for this source category is based on livestock counts (average annual number of standing head) and population information by state and county used to develop U.S. EPA's Greenhouse Gas Inventory [ref 28]. This data set is derived from multiple data sets from the United States Department of Agriculture (USDA), particularly the National Agricultural Statistics Service (NASS) survey and census [ref 29]. The USDA NASS survey dataset, which represents latest available, 2017 national livestock data, was used to obtain the livestock counts for as many counties as possible across the United States. For a full description of the GHG livestock population estimation methodology, refer to the above referenced citation for the EPA's GHG inventory document.

Generally, counties not specifically included in the NASS survey data set (e.g., due to business confidentially reasons) were gap-filled based on the difference in the reported state total animal counts and the sum of all county-level reported animal counts from the NASS survey dataset. State-level data on animal counts for all the non-reported NASS survey counties from the GHG population dataset were distributed to individual counties based on the proportion of animal counts in those counties from the 2012 NASS census (the 2012 census data is generally more complete in terms of county coverage).

$$P_{a,c,2017} = P_{a,s,2017} \times r_{a,c,2012} \qquad (4)$$

Where:
$P_{a,c,2017}$ = Estimated 2017 population of animal type a in county c
$P_{a,s,2017}$ = NASS survey reported 2017 state-level population of animal type a in state s

$r_{a,c,2012}$ = Ratio of animal county- to state-level animal counts from the 2012 NASS census for animal type a in county c

4.3.3.3 *Example calculations*

<u>Agricultural Tilling</u>

Particulate matter emissions from agricultural tilling are computed by multiplying crop- and county-specific emissions factors by crop- and county-specific data on tilling activity. The emissions are then summed across all tilling types and crop types.

$$E_{p,c} = \sum_{t=1}^{T} \sum_{x=1}^{X} EF_{p,t,x,c} \times a_{t,c} \times \frac{1\ ton}{2000\ lb} \tag{5}$$

Where:

$E_{p,c}$ = Annual total agricultural tilling county level emissions of pollutant p in county c from all crop tilling types, in tons

$EF_{p,t,x,c}$ = Emissions factor for pollutant p, crop tilling type t, and crop type x in county c, in lbs./acre

$a_{t,x,c}$ = Land tilled by crop tilling type t, and crop type x in county c, in acres

Table 4-27 provides a sample calculation for PM10-FIL emissions for conservation tilling from corn in Clay County, Alabama. For total PM10-FIL emissions, the calculations below would need to be repeated for all crop types for all three tilling types, and then summed in equation 5 for total emissions.

Table 4-27: Sample calculations for PM10-FIL emissions from conservation tilling from corn in Clay County, AL

Eq. #	Equation	Values for Clay County, AL	Result
1	$a_{m,t} = \dfrac{a_{s,t} - \sum a_{c,t}}{C_{m,t}}$	$\dfrac{311,942\ acres - 298,042\ acres}{13\ missing\ counties}$	1,069.23 acres for conservation tilling in Clay County, AL
2	$r_{c,t} = \dfrac{a_{c,t}\ (or\ a_{m,t})}{\sum a_{c,t}\ (or\ a_{m,t})}$	$\dfrac{1,069.23\ acres}{1,489.23\ acres}$	0.718 ratio of conservation tilling to all tilling for Clay County, AL
3	$a_{t,c,x} = r_{c,t} \times a_{c,x}$	$0.718 \times 89\ acres$	63.9 acres corn harvested using conservation tilling in Clay County, AL
4	$EF_{p,t,x,c} = c \times k \times s_c^{0.6} \times p_t$	$4.8 \frac{pounds}{acre-pass} \times 0.21 \times 28.93^{0.6} \times 1\ pass$	7.59 pounds per acre for conservation tilling from corn in Clay County, AL
5	$E_{p,c} = \sum_{t=1}^{T} \sum_{x=1}^{X} EF_{p,t,x,c} \times a_{t,c} \times \frac{1\ ton}{2000\ lb}$	$7.59 \frac{pounds}{acre} \times 63.9\ acres \times \frac{1\ ton}{2000\ lb}$	0.24 tons PM10-FIL emissions from conservation tilling for corn in Clay County, AL*

<u>Dust kicked up by hooves and feet</u>

A general method to calculate the emissions per county for a given pollutant can be calculated by multiplying the emission factor for the given livestock type by the animal activity in each county. However, some manipulation is necessary to obtain the desired result.

To calculate the dust emissions due to hooves, the first step is to divide the emission factor (ton per year per 1000 head) by 1000. The resulting emission factor is then multiplied by the number of animals (head) in the region to get the emission (tons per year).

If the emission factor of PM2.5 emitted by beef cattle is approximately 10 ton per year per 1000 head and the farm is known to have 100 beef cattle, then the emission of this pollutant by the farm can be calculated using the following procedure:

1.   Convert the emission factor from tons per year per 1000 head to tons per year per head

   10 tons per year per 1000 head / 1000   = 10/1000 tons per year per head
                                            = .01 tons per year per head

2.   Calculate the emissions (tons/year):

   Emissions = Emission Factor*Number of head
   Emissions = 0.01 tons per year per head*100 head = 1 ton per year

4.3.3.4   *Controls*

There are no controls assumed for ag tilling and dust kicked up by hooves and feet.

4.3.3.5   *Changes from 2014 methodology*

There are no significant changes in methodology from that in the 2014 NEI for agricultural tilling. For dust kicked up by animals, activity data has been updated to year 2017, and new SCCs for animal types have been created.

4.3.3.6   *Puerto Rico and Virgin Islands emissions calculations: Agricultural Tilling*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emissions factor. For each Puerto Rico and US Virgin Island county, the tons per capita emissions factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.3.4   References

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4.4   Agriculture – Fertilizer Application

4.4.1   Sector description

Fertilizer in this category refers to any nitrogen-based compound, or mixture containing such a compound, that is applied to land to improve plant fitness. The SCCs that compose this sector in the 2017 NEI are provided in Table 4-28. The SCC level 1, 2 and 3 description is "Miscellaneous Area Sources; Agriculture Production – Crops; Fertilizer Application" for both SCCs. EPA-estimated emissions are for SCC 2801700099 and discussed further below.

Table 4-28: SCCs in the Agricultural Fertilizer Application sector

SCC	SCC Level 4 Description	EPA	S/L/T
2801700000	Total Fertilizers		X
2801700099	Miscellaneous Fertilizers	X	X

4.4.2   Sources of data

The agricultural fertilizer application sector includes data from the S/L/T agencies and the default EPA-generated agricultural fertilizer emissions. The agencies listed in Table 4-29 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. It should be noted that Delaware was the only state to also submit NO2 emissions (to the same counties as NH3 was reported) for this sector.

Table 4-29: Agencies that submitted fertilizer application NH$_3$ emissions in the 2017 NEI

Region	Agency	S/L/T
3	Delaware Department of Natural Resources and Environmental Control	State
5	Illinois Environmental Protection Agency	State
9	California Air Resources Board	State
9	Maricopa County Air Quality Department	Local
10	Coeur d'Alene Tribe	Tribe
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.4.3   EPA-developed emissions

4.4.3.1   *2017 methodology*

Direct flux measurements of ammonia (NH$_3$) over agricultural fields and natural vegetation over the past few decades have demonstrated that vegetation and soil can either be a source or a sink of atmospheric NH$_3$. The direction and magnitude of the exchange depends on the concentration gradient between the canopy and the atmosphere. The bidirectional approach taken here accounts, in the most comprehensive way possible, for estimated NH$_3$ emissions from this complex process. The NH$_3$ emissions estimated here are for fertilizer that has been applied to the soil. Emissions from the application processes are estimated in the manure management portion of livestock emissions. The approach to calculating emissions from this sector in 2017 is consistent with the methodology used for the 2014 NEI. The bidirectional version of CMAQ (v5.3) [ref 1] and the Fertilizer Emissions Scenario Tool for CMAQ FEST-C (v1.3) [ref 2] were used to estimate ammonia (NH$_3$) emissions from agricultural soils. These estimates were then loaded into EIS for use in the 2017 NEI. The approach to estimate 2017 fertilizer emissions consists of these steps:

- Run FEST-C to produce nitrate (NO$_3$), Ammonium (NH4+, including Urea), and organic (manure) nitrogen (N) fertilizer usage estimates
- Use USDA Economic Research Services crop specific fertilizer use data and state submitted data to adjust the FEST-C fertilizer totals to match the USDA and State submitted.
- CMAQ model with bidirectional ("bidi") NH$_3$ exchange to generate gaseous ammonia NH3 emission estimates.
- Calculate county-level emission factors as the ratio of bidirectional CMAQ NH$_3$ fertilizer emissions to FEST-C total N fertilizer application.
- Assign the NH3 emissions to one SCC: "…Miscellaneous Fertilizers" (2801700099).

An iterative calculation will be applied to estimate fertilizer emissions for the 2017 NEI. We first estimate fertilizer application by crop type for 2017 using FEST-C modeled data. After receipt and addressing of comments to the extent possible, we then adjusted the 2017 fertilizer application estimates using state submitted data, currently only Iowa, and USDA Economic Research Service state and crop specific survey data. The USDA and state submitted annual fertilizer data was used to estimate the ratio of UDSA/state fertilizer use to FEST-C annual total fertilizer estimates for each state and crop with USDA or state data. This ratio is then applied to the FEST-C fertilizer application rates for each state and crop with data. A maximum annual fertilization rate was set in the FEST-C simulation and annual adjusted totals were limited to this rate to prevent unrealistically higher fertilization rates. The we ran the CMAQ v5.3 model with the Surface Tiled Aerosol and

Gaseous Exchange (STAGE) deposition option with bidirectional exchange to estimate fertilizer and biogenic NH$_3$ emissions for 2017. We use this approach for three reasons: (1) FEST-C estimates fertilizer applications based on crop nutrient needs which is typically lower than real world fertilization rates; (2) FEST-C fertilizer timing and application methods are assumed to be correct; and (3) This CMAQ model option allows us to incorporate state submitted and USDA reported data into the final fertilization emission estimates.

FEST-C is the software program that processes land use and agricultural activity data to develop inputs for the CMAQ model when run with bidirectional exchange. FEST-C reads land use data from the Biogenic Emissions Landuse Dataset (BELD), meteorological variables from the Weather Research and Forecasting model [ref 3], and nitrogen deposition data from a previous or historical average CMAQ simulation. FEST-C, then uses the USDA's Environmental Policy Integrated Climate (EPIC) modeling system [ref 4] to simulate the agricultural practices and soil biogeochemistry and provides information regarding fertilizer timing, composition, application method and amount. Figure 4-1 below provides a comprehensive flowchart if the complete EPIC/FEST-C/WRF "bidi" modeling system.

Figure 4-1: "Bidi" modeling system used to compute 2017 Fertilizer Application emissions
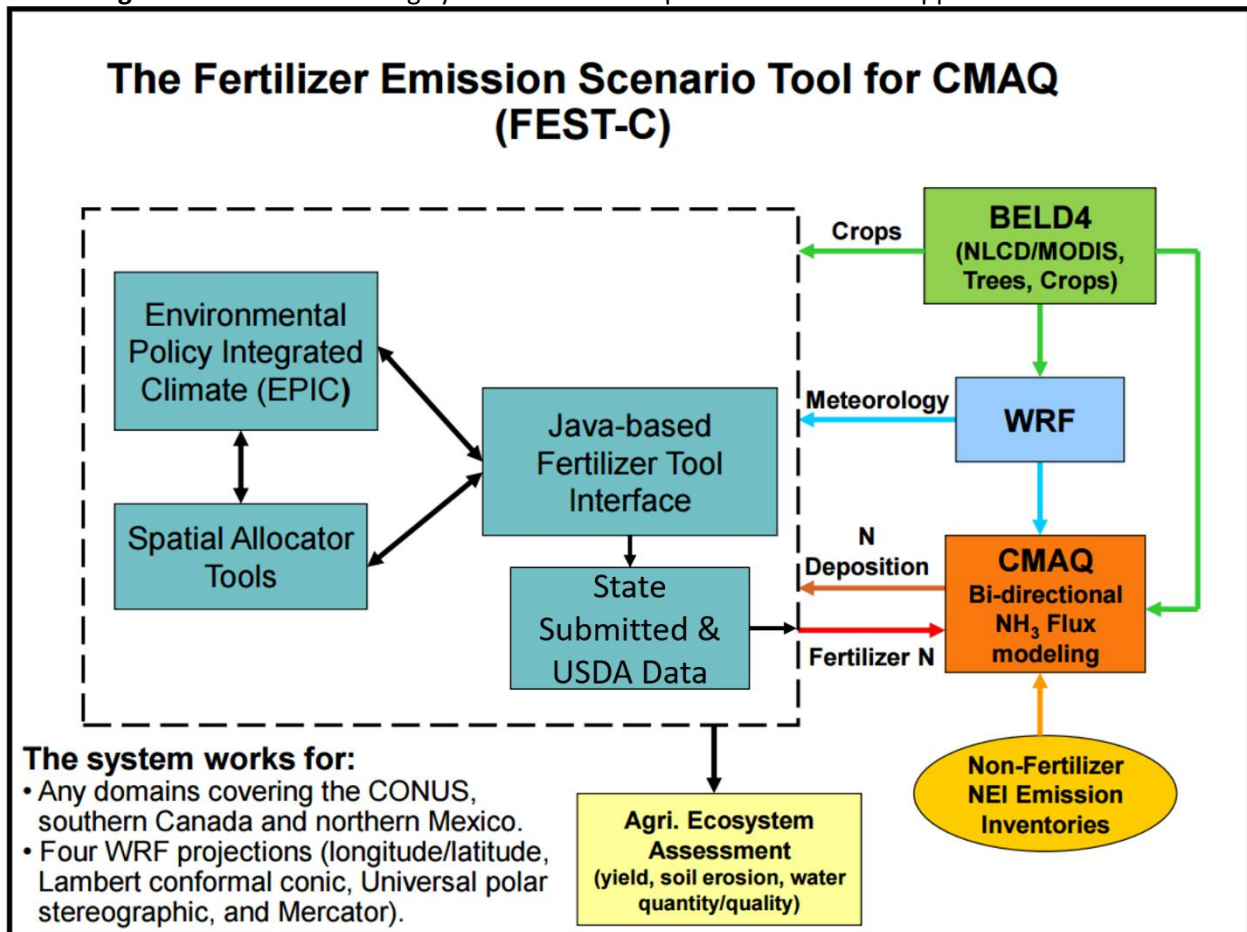
The following activity parameters were input into the EPIC model:

- Grid cell meteorological variables from WRF
- Initial soil profiles/soil selection

- Presence of 21 major crops: irrigated and rain fed hay, alfalfa, grass, barley, beans, grain corn, silage corn, cotton, oats, peanuts, potatoes, rice, rye, grain sorghum, silage sorghum, soybeans, spring wheat, winter wheat, canola, and other crops (e.g. lettuce, tomatoes, etc.)
- Fertilizer sales to establish the type/composition of nutrients applied
- Management scenarios for the 10 USDA production regions (Figure 4-2) [ref 5]. These include irrigation, tile drainage, intervals between forage harvest, fertilizer application method (injected versus surface applied), and equipment commonly used in these production regions.

Figure 4-2: USDA farm production regions used in FT-C simulations
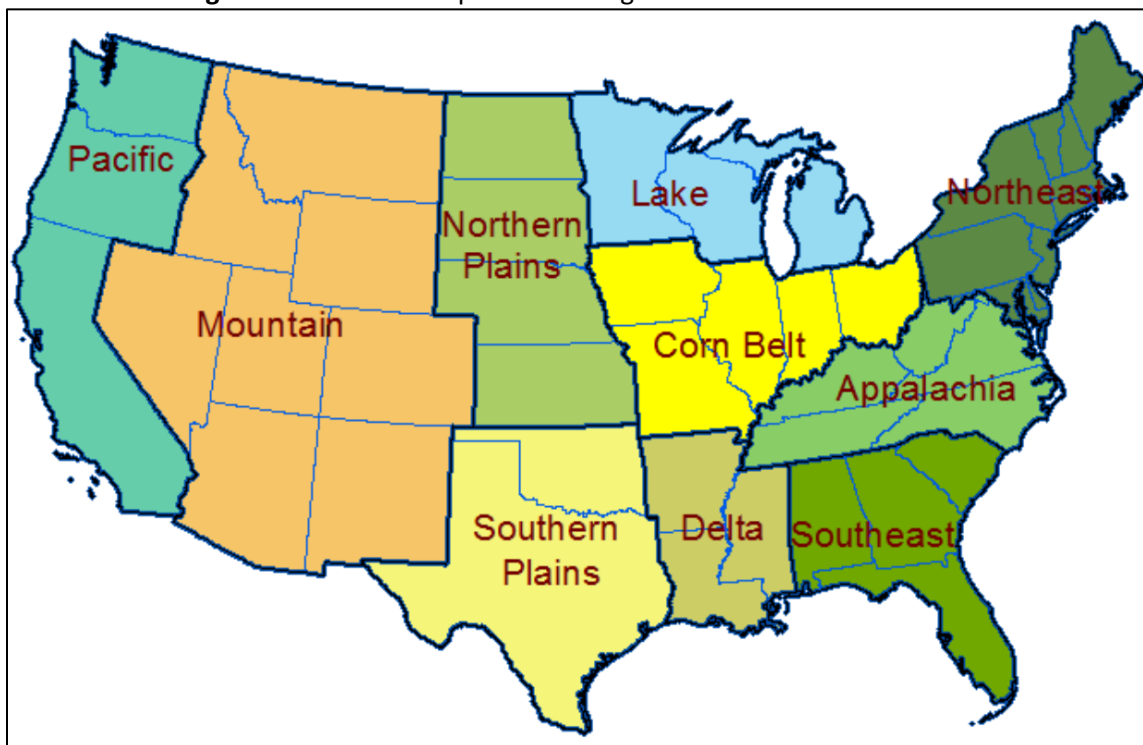
We used the WRF meteorological model to provide grid cell meteorological parameters for 2016 using a national 12-km rectangular grid covering the continental U.S. The meteorological parameters in Table 4-30 below were used as EPIC model inputs.

Table 4-30: Environmental variables needed for an EPIC simulation

EPIC input variable	Variable Source
Daily Total Radiation (MJ m^2)	WRF
Daily Maximum 2-m Temperature (C)	WRF
Daily minimum 2-m temperature (C)	WRF
Daily Total Precipitation (mm)	WRF
Daily Average Relative Humidity (unitless)	WRF
Daily Average 10-m Wind Speed (m s^{-1})	WRF
Daily Total Wet Deposition Oxidized N (g/ha)	CMAQ
Daily Total Wet Deposition Reduced N (g/ha)	CMAQ
Daily Total Dry Deposition Oxidized N (g/ha)	CMAQ
Daily Total Dry Deposition Reduced N (g/ha)	CMAQ

EPIC input variable	Variable Source
Daily Total Wet Deposition Organic N (g/ha)	CMAQ

Initial soil nutrient and pH conditions in EPIC are based on the 1992 USDA Soil Conservation Service (CSC) Soils-5 survey. The EPIC model then is run for 25 years using current fertilization and agricultural cropping techniques to estimate soil nutrient content and pH for the 2017 EPIC/WRF/CMAQ simulation.

The presence of crops in each model grid cell was determined through the use of USDA Census of Agriculture data (2006) and USGS National Land Cover data (2011). These two data sources were used to compute the fraction of agricultural land in a model grid cell and the mix of crops grown on that land.

Fertilizer sales data and the 6-month period in which they were sold were extracted from the 2014 Association of American Plant Food Control Officials (AAPFCO). AAPFCO data are used to identify the composition (e.g. urea, nitrate, organic) of the fertilizer used, and the amount applied is estimated using the modeled crop demand. These data are useful in making a reasonable assignment of what kind of fertilizer is being applied to which crops.

Management activity data refers to data used to estimate representative crop management schemes. We used the USDA Agricultural Resource Management Survey (ARMS) to provide management activity data. These data cover 10 USDA production regions and provide management schemes for irrigated and rain fed hay, alfalfa, grass, barley, beans, grain corn, silage corn, cotton, oats, peanuts, potatoes, rice, rye, grain sorghum, silage sorghum, soybeans, spring wheat, winter wheat, canola, and other crops (e.g. lettuce, tomatoes, etc.).

The variables shown below are provided in the "*2017_Fertilizer_Application_Supplemental_Data.zip*" file (on the 2017 NEI Supplemental Data FTP site) for purposes of assessing crop data:

- Fertilizer application timing
- Plant/harvest dates
- Fertilizer application rates by crop and county
- Area planted
- Crop yields

4.4.3.2 *Emision factors*

The emission factors were derived from the 2017 CMAQ FEST-C outputs. Total fertilizer emission factors for each month and county were computed by taking the ratio of total fertilizer NH_3 emissions (short tons) to total nitrogen fertilizer application (short tons).

12 km by 12 km gridded NH_3 emissions were mapped to a county shape file polygon. The cell was assigned to a county if the grid centroid fell within the county boundary. An example calculation adjustment of FEST-C fertilizer rates using state or USDA data is provided here:

$$Fert_{ajusted,crop} = max\left(\frac{Fert_{submitted,crop}}{\frac{1}{n_{crop}}\sum Fert_{FEST-C,crop}} Fert_{FEST-C,crop}, Fert_{max,crop}\right) \qquad (1)$$

Where:

$Fert_{adjusted,crop}$ = The FEST-C 12km grid cell adjusted fertilization rate,

Fert$_{Submitted,i}$ = The USDA or State submitted state mean annual application data for the specified crop, in kg ha^{-1},

FERT$_{FEST-C,I}$ = The initial FEST-C 12km grid cell fertilization rate for the state being considered,

n$_{crop}$ = The number of grid cells with fertilization use for the specified crop in the state,

Fert$_{max,crop}$ = The maximum fertilization rate estimated from EPIC for the crop.

County-level fertilizer emissions (NH3) for 2017 are derived from the diagnostic emission output from a 2017 CMAQ FEST-C model simulation (for details see Bash et al. 2013). With this modeling system, it would be difficult to perform a sample calculation; this is not something that could be demonstrated in a spreadsheet. These emissions are computed via the full chemical transport model, as illustrated in Figure 4-3.

Figure 4-3: Simplified FEST-C system flow of operations in estimating NH_3 emissions
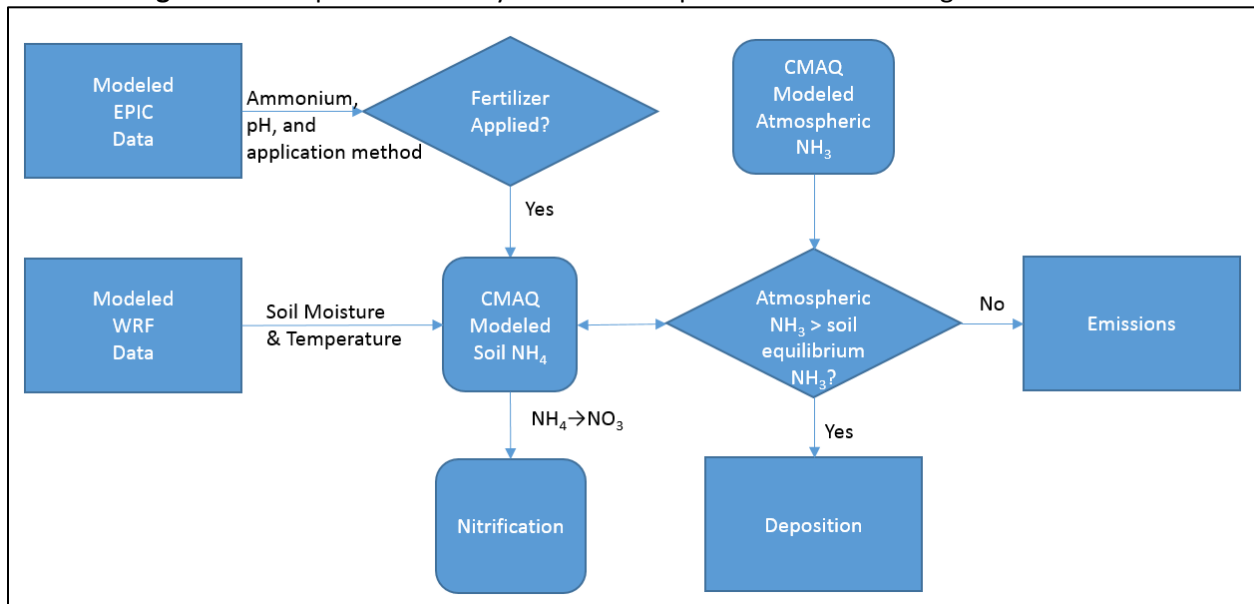
4.4.3.3 *Comparison to 2014 methodology*

The 2017 fertilizer estimates are based on the CMAQ FEST-C "bidirectional" approach outlined in Figure 4-3 that couples meteorological inputs, CMAQ and the EPIC modeling system through the FEST-C interface. This approach used for deriving ammonia emissions for the 2017 NEI is substantially the same as the approach used for the 2014 NEI fertilizer estimates, section 4.4; however, newer model versions for CMAQ and FEST-C were used. These estimates used FEST-C v1.4 simulations with CMAQ 5.3 beta using the land use specific deposition option, Surface Tiled Aerosol and Gaseous Exchange (STAGE), and bidirectional NH_3 exchange. The previous version of CMAQ used for the 2014 NEI fertilizer emission only from vegetated land. This has been corrected in CMAQ 5.3 with the STAGE deposition option and results in higher NH_3 emission rates in agricultural areas before crop germination and in areas with sparse vegetation coverage. Additionally, FEST-C v1.4 corrected an error in the nitrogen budget form an earlier version of the model used in the 2014 NEI. This results in approximately 38% lower fertilization estimates than used in the 2014 NEI, see Table 4-31, and thus lower emission estimates in much of the US in Figure 4-6. This emission reduction was largely offset when annual state and USDA fertilizer data was used at adjust FEST-C rates. The adjusted FEST-C fertilizer rates were increased by approximately 20% with the exceptions of wheat (50% increase) and cotton (60% increase) to better match USDA and data submitted by the states. Crops without state or USDA fertilizer data were adjusted by the mean adjustment

factor from all the crops with state or USDA submitted data, approximately a 20% increase. Large increase in fertilizer rates for cotton and wheat resulted in a large increase in NH_3 emissions from fertilizer due to the typically alkali soils and warm climate where these crops are grown. Emission maps for the 2014 NEI, these 2017 NEI estimates, and a difference map are provided below in Figure 4-4, Figure 4-5, and Figure 4-6, respectively.

Figure 4-4: NEI 2014 "bidi" Fertilizer Application NH3 Emissions
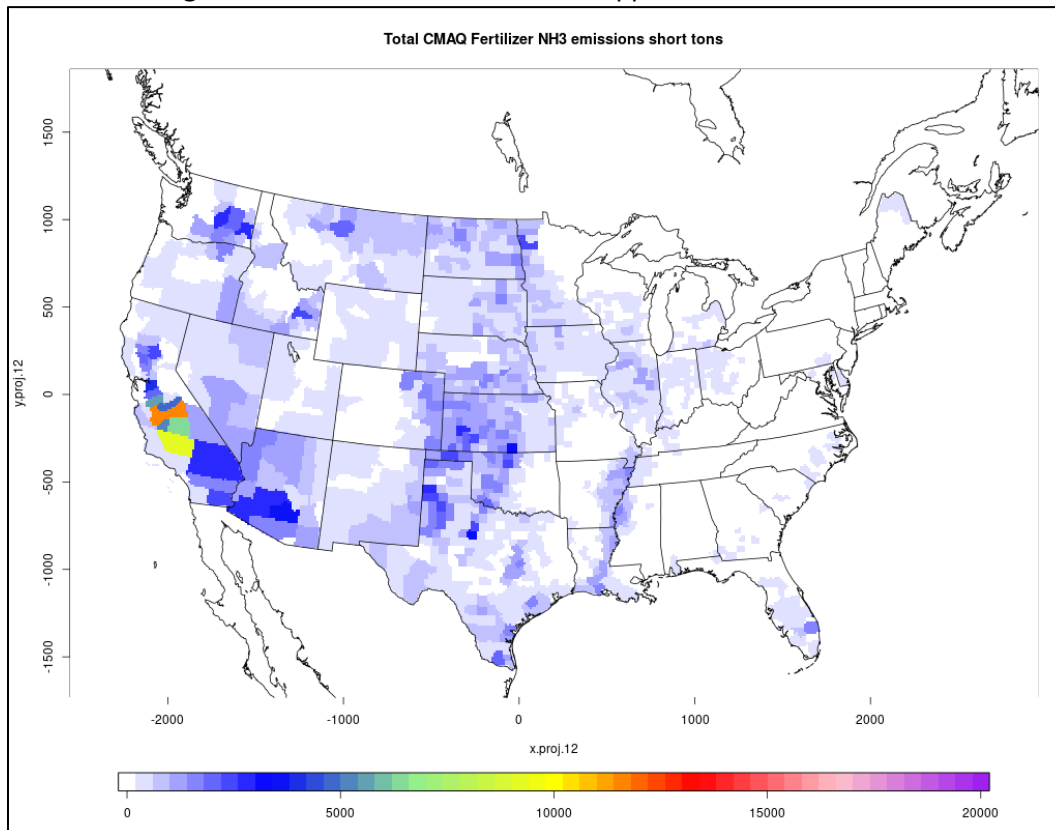
Figure 4-5: 2017 NEI "bidi" Fertilizer Application NH3 Emissions

Total CMAQ Fertilizer NH3 emissions short tons
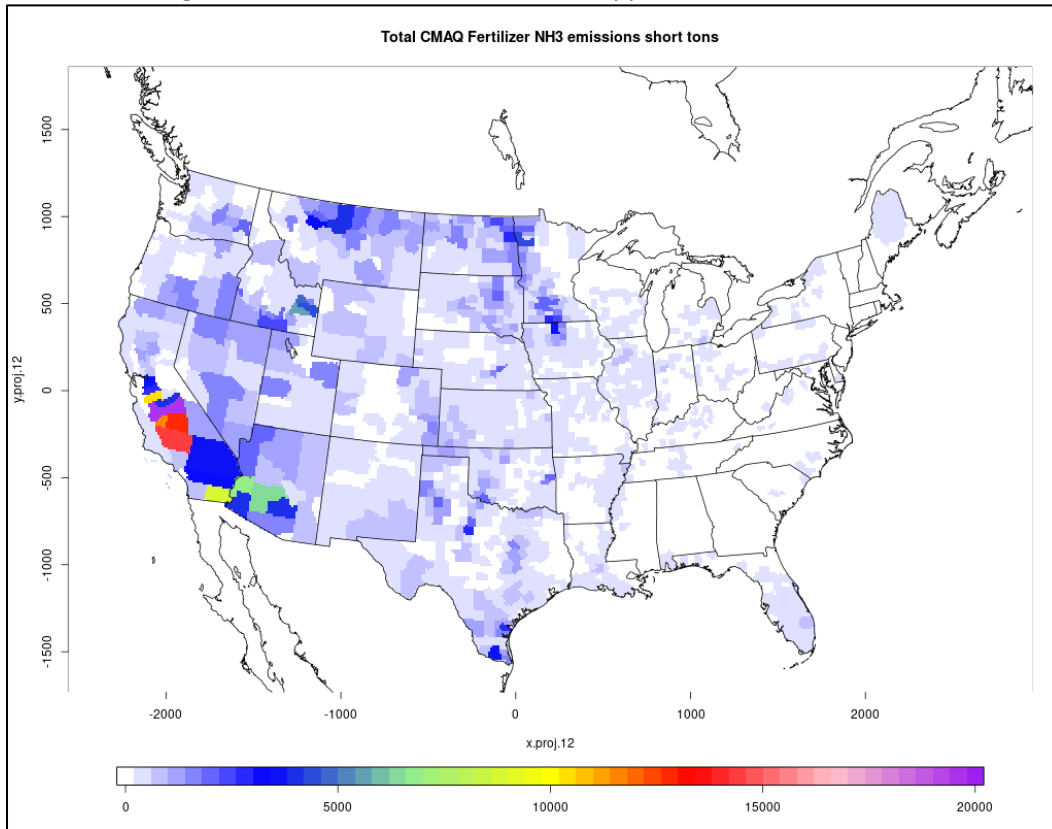
Figure 4-6: 2017 -2014 NEI "bidi" Fertilizer Application Emissions in tons NH3

2017-2014 Fertilizer Emissions (short tons)
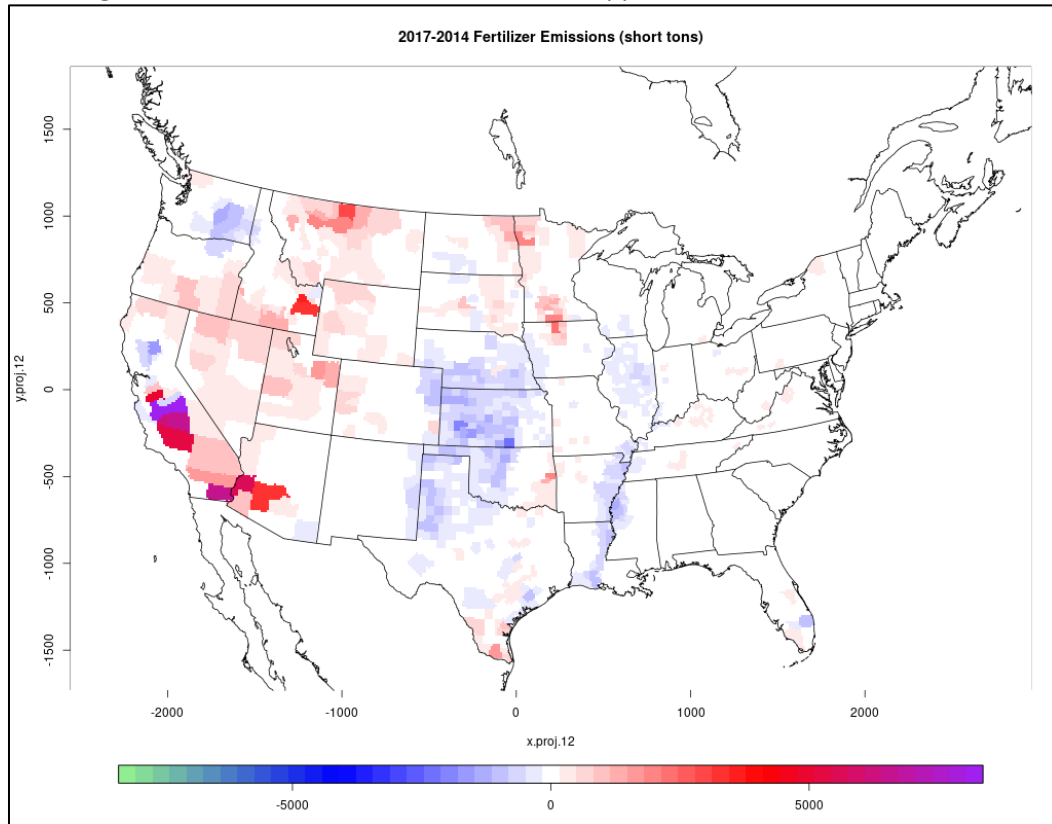
Table 4-31: Contiguous US fertilizer totals and emissions for the 2017 NEI and 2014 NEI

	2017 FINAL	2017 DRAFT	2014 V2	2014 V1
EPIC FERTILIZER APPLICATION (TONS N)	13,604,640	11,451,713	18,851,866	20,314,303
CMAQ EMISSIONS (TONS N)	986,509	592,218	883,526	948,616
MEAN ANNUAL EMISSIONS FACTOR*	7.3% total, 12.5% of urea/NH_4	4.8% total, 8.9% of urea/NH_4	4.7% total, 9.8% of urea/NH_4	4.7% total, 9.1% of urea/NH_4
FERTILIZER USE** (TONS N)	Not Available	Not Available	13,295,000	12,814,000

* Defined as the annual emissions divided by the annual fertilizer application

** USDA Economic Research Service, Fertilizer Use and Price

Additional Information regarding the 2014 methodology and the development of the 2017 methodology can be found in the Air Emissions Inventory Training site, 2014 NEI training, search for "Key Ammonia sectors".

4.4.4   References

1. Community Multiscale Air Quality (CMAQ v5.3) model.
2. Fertilizer Emission Scenario Tool for CMAQ (FEST-C) system.
3. Weather Research Forecast (WRF) model.
4. Environmental Policy Integrated Climate (EPIC) model.
5. Cooter, E.J., Bash, J.O., Benson V., Ran, L.-M.; Linking agricultural crop management and air-quality models for regional to national-scale nitrogen deposition assessments, Biogeosciences, 9, 4023-4035, 2012.

4.5   Agriculture – Livestock Waste

4.5.1   Sector description

The emissions from this category are primarily from domesticated animals intentionally reared for the production of food, fiber, or other goods or for the use of their labor. The livestock included in the EPA–estimated emissions include beef cattle, dairy cattle, goats, horses, poultry, sheep, turkeys and swine. A few S/L/T agencies reported data from a few other categories in this sector such as domestic and wild animal waste, though these emissions are small compared to the livestock listed above. The domestic and wild animal waste emissions are not included for every state and not estimated by the EPA. The pollutants that EPA reports using its methods for this sector are NH3 and VOC (VOC is always just 8% of NH3), and some VOC-HAPs that vary by animal type as described below.

4.5.2   Sources of data

Table 4-32 shows the nonpoint SCCs covered by the EPA estimates and by the S/L/T agencies that submitted data. The SCC level 2, 3 and 4 descriptions are also provided. The SCC level 1 description is "Miscellaneous Area Sources" for all SCCs.

Table 4-32: Nonpoint SCCs with 2017 NEI emissions in the Livestock Waste sector

SCC	Description	EPA	S/L/T
2805001100	Agriculture Production - Livestock; Beef cattle - finishing operations on feedlots (drylots); Confinement		X

SCC	Description	EPA	S/L/T
2805001200	Agriculture Production - Livestock; Beef cattle - finishing operations on feedlots (drylots); Manure handling and storage		X
2805001300	Agriculture Production - Livestock; Beef cattle - finishing operations on feedlots (drylots); Land application of manure		X
2805002000	Agriculture Production - Livestock; Beef cattle production composite; Not Elsewhere Classified	X	X
2805003100	Agriculture Production - Livestock; Beef cattle - finishing operations on pasture/range; Confinement		X
2805007100	Agriculture Production - Livestock; Poultry production - layers with dry manure management systems; Confinement	X	X
2805007300	Agriculture Production - Livestock; Poultry production - layers with dry manure management systems; Land application of manure		X
2805008100	Agriculture Production - Livestock; Poultry production - layers with wet manure management systems; Confinement		X
2805008200	Agriculture Production - Livestock; Poultry production - layers with wet manure management systems; Manure handling and storage		X
2805008300	Agriculture Production - Livestock; Poultry production - layers with wet manure management systems; Land application of manure		X
2805009100	Agriculture Production - Livestock; Poultry production - broilers; Confinement	X	X
2805009200	Agriculture Production - Livestock; Poultry production - broilers; Manure handling and storage		X
2805009300	Agriculture Production - Livestock; Poultry production - broilers; Land application of manure		X
2805010100	Agriculture Production - Livestock; Poultry production - turkeys; Confinement	X	X
2805010200	Agriculture Production - Livestock; Poultry production - turkeys; Manure handling and storage		X
2805010300	Agriculture Production - Livestock; Poultry production - turkeys; Land application of manure		X
2805018000	Agriculture Production - Livestock; Dairy cattle composite; Not Elsewhere Classified	X	X
2805019100	Agriculture Production - Livestock; Dairy cattle - flush dairy; Confinement		X
2805019200	Agriculture Production - Livestock; Dairy cattle - flush dairy; Manure handling and storage		X
2805019300	Agriculture Production - Livestock; Dairy cattle - flush dairy; Land application of manure		X
2805020002	Agriculture Production - Livestock; Cattle and Calves Waste Emissions; Beef Cows		X
2805021100	Agriculture Production - Livestock; Dairy cattle - scrape dairy; Confinement		X
2805021200	Agriculture Production - Livestock; Dairy cattle - scrape dairy; Manure handling and storage		X
2805021300	Agriculture Production - Livestock; Dairy cattle - scrape dairy; Land application of manure		X
2805022100	Agriculture Production - Livestock; Dairy cattle - deep pit dairy; Confinement		X

SCC	Description	EPA	S/L/T
2805022200	Agriculture Production - Livestock; Dairy cattle - deep pit dairy; Manure handling and storage		X
2805022300	Agriculture Production - Livestock; Dairy cattle - deep pit dairy; Land application of manure		X
2805023100	Agriculture Production - Livestock; Dairy cattle - drylot/pasture dairy; Confinement		X
2805023200	Agriculture Production - Livestock; Dairy cattle - drylot/pasture dairy; Manure handling and storage		X
2805023300	Agriculture Production - Livestock; Dairy cattle - drylot/pasture dairy; Land application of manure		X
2805025000	Agriculture Production - Livestock; Swine production composite; Not Elsewhere Classified (see also 28-05-039, -047, -053)	X	X
2805030000	Agriculture Production - Livestock; Poultry Waste Emissions; Not Elsewhere Classified (see also 28-05-007, -008, -009)		X
2805030007	Agriculture Production - Livestock; Poultry Waste Emissions; Ducks		X
2805030008	Agriculture Production - Livestock; Poultry Waste Emissions; Geese		X
2805035000	Agriculture Production - Livestock; Horses and Ponies Waste Emissions; Not Elsewhere Classified	X	X
2805039100	Agriculture Production - Livestock; Swine production - operations with lagoons (unspecified animal age); Confinement		X
2805039200	Agriculture Production - Livestock; Swine production - operations with lagoons (unspecified animal age); Manure handling and storage		X
2805039300	Agriculture Production - Livestock; Swine production - operations with lagoons (unspecified animal age); Land application of manure		X
2805040000	Agriculture Production - Livestock; Sheep and Lambs Waste Emissions; Total	X	X
2805045000	Agriculture Production - Livestock; Goats Waste Emissions; Not Elsewhere Classified	X	X
2805047100	Agriculture Production - Livestock; Swine production - deep-pit house operations (unspecified animal age); Confinement		X
2805047300	Agriculture Production - Livestock; Swine production - deep-pit house operations (unspecified animal age); Land application of manure		X
2805053100	Agriculture Production - Livestock; Swine production - outdoor operations (unspecified animal age); Confinement		X
2806010000	Domestic Animals Waste Emissions; Cats; Total		X
2806015000	Domestic Animals Waste Emissions; Dogs; Total		X
2807025000	Wild Animals Waste Emissions; Elk; Total		X
2807030000	Wild Animals Waste Emissions; Deer; Total		X

Table 4-33 presents the three "Industrial Processes" point SCCs reported by 2 states for NH3 emissions: California and Delaware. Point source emissions from this sector are negligible, particularly for NH_3, compared to the nonpoint emissions (many orders of magnitude lower). The SCC level 1 and 2 descriptions is "Industrial Processes; Food and Agriculture" for all SCCs. Generally, these emissions are ignored in the Nonpoint NH3 emissions accounting process. Some other states have reported some PM, PM species, and some HAPs using point source SCCs, however, most of those emission totals are small (we do not report PM or components for this sector in our methods), and will be ignored in all subsequent discussions here, and will not be included in

the totals in other parts of this document for this sector. No point source subtraction is deemed necessary for this sector.

Table 4-33: Point SCCs with 2014 NEI emissions in the Livestock Waste sector – reported only by States

SCC	SCC Level Three	SCC Level Four	CA	DE
30202120	Broilers	Enteric, Confinement, Manure Handling, Storage, Land Application		X
30202001	Beef Cattle Feedlots	Feedlots: General	X	

The agencies listed in Table 4-34 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%). In cases where a full submittal was not made, EPA data was used to backfill according to the information provided in the nonpoint survey for this sector.

Table 4-34: Agencies that submitted Ag Livestock Waste emissions in the 2017 NEI

Region	Agency	S/L/T
1	Massachusetts Department of Environmental Protection	State
3	Delaware Department of Natural Resources and Environmental Control	State
5	Illinois Environmental Protection Agency	State
8	Utah Division of Air Quality	State
9	California Air Resources Board	State
9	Maricopa Air Quality Department (county in AZ)	State
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.5.3   EPA-developed emissions

Animal waste from livestock results in emissions of both NH3 (ammonia) and, Volatile Organic Compounds (VOCs), as introduced in the 2014 NEI for this sector. VOCs emitted by livestock can be defined as any compound of carbon (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate) that may participate in atmospheric photochemical reactions and is emitted by livestock. Livestock are domesticated farm animals raised in an agricultural setting for home use or profit. Following the model-development work of Carnegie Mellon University (CMU) [ref 102], the following livestock were evaluated: dairy cattle, beef cattle, swine, and poultry (layers and broilers) as part of the model. These animals make up over 90% of NH3 emissions from this sector. For the 2017 NEI, EPA also estimated NH3 (and VOC) emissions for goats, sheep, turkeys, and horses. For these animals, emissions were estimated using a nationwide emission factor multiplied by the appropriate animal count as described below.

The general approach to calculating NH3 emissions due to livestock is to multiply the emission factor (in kg per year per animal) by the number of animals in the county. VOC emissions were estimated by multiplying a national VOC/NH3 emissions ratio (VOC = 8% of NH3 emissions) by the county NH3 emissions.

In the 2017 NEI, the EPA methodology for ammonia emissions that results from the use of the CMU model, includes all processes from the housing/grazing, storage and application of manure from beef cattle, dairy cattle,

swine, broiler chicken, and layer chicken production, and these are assigned to the "EPA" SCCs listed in Table 4-32. It is assumed the EFs used also take into account, on average, all the management practices that are used in waste treatment for each of those animals.

4.5.3.1 *Overview of calculations*

The general approach to calculating NH_3 emissions due to livestock is to multiply the emission factor (in kg per year per animal) by the number of animals in the county. The state-level NH_3 emissions factors are generated using the CMU Ammonia Model [ref 18, ref 102] for dairy cattle, beef cattle, poultry layers, poultry broilers, and swine. EFs for the other animals comes from a naitonwide average, which is coupled with the number of animals in the county. VOC emissions were estimated by multiplying a national VOC/NH_3 (0.08) emissions ratio by the county-level NH_3 emissions. HAP emissions were estimated by multiplying the county-level VOC emissions by HAP/VOC ratios.

4.5.3.2 *Activity data*

The activity data for this source category is based on livestock counts (average annual number of standing head) and population information by state and county used to develop U.S. EPA's Greenhouse Gas (GHG) Inventory [ref 99]. This data set is derived from multiple data sets from the United States Department of Agriculture (USDA), particularly the National Agricultural Statistics Service (NASS) survey and census [ref 100]. The USDA NASS survey dataset, which represents latest available, 2017 national livestock data, is used to obtain the livestock counts for as many counties as possible across the United States. This is a new and more robust method that has been introduced into the 2017 NEI for this category for estimating population counts. There are several improvements in this animal counting procedure, including better accounting of the dairy and beef cattle counts by relying on the EPA's Office of Atmospheric Programs (OAP) Cattle Enteric Fermentation Model (CEFM) that is used in developing EPA's official GHG inventory livestock population dataset for cattle; the official EPA GHG inventory is developed by EPA/OAP. The CEFM uses a cattle transition matrix to simulate the population of cattle from birth to slaughter, using starting point USDA populations, calving rates, weight gain, and death rates over the course of the year to produce an annual average standing population. A description of the CEFM is provided in many of the references cited in this document.

To give an idea of changes from 2014v2NEI to 2017 NEI counts based on these improved procedures a summary Table 4-35 is shown below for the major animals that the CMU model estimates emissions for. These data do not include state inputs to population counts, but most of the count data for the entire US is based on EPA information, so it gives an accurate depiction of the changes in animal population counts going from the 2014 NEI to the 2017 NEI.

Table 4-35: National-level animal population data trend from 2014 NEI to draft 2017 NEI

Livestock Category	2014 NEIv2	2017 Draft NEI	% Increase in 2017 Draft NEI
Beef	79,367,367	81,559,685	3%
Dairy	9,035,195	18,893,022	109%
Swine	67,766,007	72,151,500	6%
Poultry - Layers	362,319,588	497,677,000	37%
Poultry - Broilers	1,506,271,264	1,621,052,369	8%

The change in beef, swine and poultry-broilers shown in the above summary table is due mainly to normal operational and production growth in those livestock categories; however, note that the 2014 NEIv2 populations

originated primarily from 2012 NASS data, so it has a 5-yr growth term since the last population dataset used. The significant change in the dairy and poultry-layers categories are due to the inclusion of new sub-categories within those livestock groups that were not previously included in the 2014 NEI populations. For the dairy cattle category, heifers and calves are now included in population totals in addition to mature dairy cows. For poultry-layers, pullets (young hens) are now included in the population total for this category. These additions may account for some of the discrepancy noticed in the 2014 NEIv2 NH3 estimates where EPA estimates were low (around half for dairy cattle) compared to state estimates for these two livestock categories

Generally, counties not specifically included in the NASS survey data set (e.g., due to business confidentially reasons) were gap-filled based on the difference in the reported state total animal counts and the sum of all county-level reported animal counts. State-level data on animal counts from the GHG inventory were distributed to counties based on the proportion of animal counts in those counties from the 2012 NASS census.

$$P_{a,c,2017} = P_{a,s,2017} \times r_{a,c,2012} \tag{1}$$

Where:

$P_{a,c,2017}$	=	Estimated population of animal type a in county c
$P_{a,s,2017}$	=	NASS survey reported state-level population of animal type a in state s
$r_{a,c,2012}$	=	Ratio of animal county- to state-level animal counts from the 2012 NASS census for animal type a in county c

4.5.3.3 *Allocation procedure*

The USDA survey reports the livestock counts at the county level for many counties, so no allocation is necessary. The procedure for gap-filling missing county-level data using state-level data is described in the previous section.

4.5.3.4 *Emission factor development*

CMU developed a model to estimate NH_3 emissions from livestock [ref 18, ref 102]. This model produces daily-resolved, climate level emissions factors for a particular distribution of management practices for each county and animal type (for dairy cows, beef cattle, swine, poultry layers, and poultry broilers only), as expressed as emissions/animal. These county level emissions factors are then combined together to create a state level emissions factor for each animal type. For the 2014 NEI v2, these state level emissions factors were back calculated from the CMU model using statewide emissions divided by statewide animal totals. Thus, the CMU model provides a state specific emission factor for each animal type (NH_3 emissions/head). For the non-CMU model animals that EPA estimates emissions for, we are reliant on use of population counts that come from the same source as described above combined with one national EF for each animal type (horses, goats, turkeys, and sheep) [ref 104].

To develop emissions factors for the 2017 NEI for the CMU-based animals, the CMU model was modified to use hourly meteorological data and two runs were performed using 2014 and 2017 meteorological data. The ratio of the 2017 to 2014 CMU model values were then applied to the 2014 back calculated state-level emissions factors to develop emissions factors for the 2017 NEI. As discussed in the 2014 NEI TSD, VOC emissions were estimated as 8% of NH3 across the board. The 8% was simply derived from where states had reported both NH3 and VOC in the previous inventory: there were 106 counties which provided emissions for both pollutants, and the average ratio was 0.08 tons of VOC for every ton of NH_3. This ratio is multiplied by all county level NH_3 emissions in NEI 2017 to estimate VOC emissions for each county. This ratio does not vary by state or animal type.

HAP emissions were estimated by multiplying county-specific VOC emissions by speciation factors that are animal-specific as shown in Table 4-36 below. All of the HAP VOC fractions were obtained from EPA's SPECIATE database [ref 101]. As per the availability in SPECIATE, there are total of 6 VOC HAPs estimated for beef cattle, 5 VOC HAPs for dairy cattle, 4 VOC HAPs for swine, and 14 (same) VOC HAPs for layers and broilers (poultry).

Table 4-36: VOC speciation fractions used to estimate HAP Emissions for Livestock Waste

SCC	Animal Type	HAP	Fraction of VOC	SPECIATE Profile Number
2805002000	Beef Cattle	1,4-Dichlorobenzene	0.0013	95240
2805002000	Beef Cattle	Methyl isobutyl Ketone	0.0008	
2805002000	Beef Cattle	Toluene	0.0110	
2805002000	Beef Cattle	Chlorobenzene	0.0001	
2805002000	Beef Cattle	Phenol	0.0006	
2805002000	Beef Cattle	Benzene	0.0001	
2805007100	Poultry---Layers	Methyl isobutyl ketone	0.0169	95223
2805007100	Poultry---Layers	Toluene	0.0018	
2805007100	Poultry---Layers	Phenol	0.0024	
2805007100	Poultry---Layers	N-hexane	0.0111	
2805007100	Poultry---Layers	Chloroform	0.0025	
2805007100	Poultry---Layers	Cresol/Cresylic Acid (mixed isomers)	0.0048	
2805007100	Poultry---Layers	Acetamide	0.0075	
2805007100	Poultry---Layers	Methanol	0.0608	
2805007100	Poultry---Layers	Benzene	0.0052	
2805007100	Poultry---Layers	Ethyl Chloride	0.0031	
2805007100	Poultry---Layers	Acetonitrile	0.0088	
2805007100	Poultry---Layers	Dichloromethane	0.0002	
2805007100	Poultry---Layers	Carbon Disulfide	0.0034	
2805007100	Poultry---Layers	2-Methyl Napthalene	0.0006	
2805009100	Poultry-Broilers	Methyl isobutyl ketone	0.0169	95223
2805009100	Poultry-Broilers	Toluene	0.0018	
2805009100	Poultry-Broilers	Phenol	0.0024	
2805009100	Poultry-Broilers	N-hexane	0.0111	
2805009100	Poultry-Broilers	Chloroform	0.0025	

SCC	Animal Type	HAP	Fraction of VOC	SPECIATE Profile Number
2805009100	Poultry-Broilers	Cresol/Cresylic Acid (mixed isomers)	0.0048	
2805009100	Poultry-Broilers	Acetamide	0.0075	
2805009100	Poultry-Broilers	Methanol	0.0608	
2805009100	Poultry-Broilers	Benzene	0.0052	
2805009100	Poultry-Broilers	Ethyl Chloride	0.0031	
2805009100	Poultry-Broilers	Acetonitrile	0.0088	
2805009100	Poultry-Broilers	Dichloromethane	0.0002	
2805009100	Poultry-Broilers	Carbon Disulfide	0.0034	
2805009100	Poultry-Broilers	2-Methyl Napthalene	0.0006	
2805018000	Dairy Cattle	Toluene	0.0018	
2805018000	Dairy Cattle	Cresol/Cresylic Acid (mixed isomers)	0.0276	
2805018000	Dairy Cattle	Xylenes (mixed isomers)	0.0046	8897
2805018000	Dairy Cattle	Methanol	0.3542	
2805018000	Dairy Cattle	Acetaldehyde	0.0141	
2805025000	Swine	Toluene	0.0047	
2805025000	Swine	Phenol (Carbolic Acid)	0.0179	
2805025000	Swine	Benzene	0.0035	95241
2805025000	Swine	Acetaldehyde	0.0155	

For the non-CMU animals (goats, sheep, horses, and turkeys), animal-specific HAP speciation profiles were not available in the literature, so the following assignments were made:

- Sheep and Goats: Same HAP fractions as Dairy Cattle
- Turkeys Same: HAP fractions as Chicken-Broilers
- Horses: Same HAP fractions as Beef Cattle

Meteorological Data Used in Adjusting FEM Emission Factors

The source code provided for FEM model contained weather data for 2014. It did not use standard identifiers (WBAN ID) and was limited to a small number of observations with an unknown source. The FEM weather data used a single monthly value for wind, temperature, and precipitation. FEM interpolated this data to hourly using different techniques. For temperature, a standard deviation was used to raise and lower the mean temperature in the month. For wind speed, the average monthly value was used for all hours. For precipitation, monthly amounts were divided into days (an hours) based upon a parameter defining the frequency of rain in a month.

The source code was modified to accommodate a true hourly processing of the met data. For the years 2014 and 2017, ISD (Integrated Surface Database) files from NOAA were processed into a yearly-hourly data file. Individual weather station files were retrieved from NOAA for all stations in the US.

This is an automated process whereby a year and certain inclusion criteria are set (country codes, missing value limits, etc.) and a direct indexed file is created of all passing stations. In the case of FEM, all stations in the US were included with a maximum of 4000 missing hours for temperature and wind speed and a maximum of 40 consecutive hours without temperature or wind speed. The system automatically fills in missing values using linear interpolation between missing hours.

To determine the weather characteristics for the year, the county centroid is matched to the nearest weather station in the yearly-hourly file. Emissions factors are calculated using every hour of the year for the county location and the model farm types located within the county.

Animal Practice Documentation

The animal practice documentation summarizes the information provided in A. McQulling's dissertation entitled, "Ammonia emissions from livestock in the United States: from farm-level models to a new national inventory" [ref 102]. This work was funded by EPA grant number RD834549 [ref 103].

Ammonia emissions from livestock depend on two major factors—the management practices employed by the producers (i.e. what housing, storage and application methods are used) and the environmental conditions of location where the farm is situated (i.e. temperatures, wind speeds, precipitation). All of these factors have significant impacts on the conditions of the manure and waste (e.g. water content, total ammoniacal nitrogen concentration) and as a result can enhance or reduce the emissions of ammonia from these sources.

The CMU model requires farm-type inputs which describe the type of animal housing, manure storage and application methods used for a particular location. Each location is expected to have some combination of practices; for example, in a single county, some of the swine farms may use deep-pit housing, lagoon storage, and irrigation application while other farms use shallow-pit housing with lagoon storage and injection application. In order to understand the differences in regional preferences for particular manure management strategies, information was extracted from the most recent National Animal Health Monitoring Surveys done by the USDA. The beef cattle NAHMS was completed in 2007 and feedlot beef in 2011; dairy cattle data was from 2002 and 2007; swine data were collected for 2006 and 2012, and the most recent poultry NAHMS was completed for 2010. The most recent data available had limited spatial resolution (compared to previous work [ref 1, ref 2]), and so the model is only able to resolve large-scale regional differences in practices. For beef cow-calf systems, the United States was divided into four regions, but only two regions for beef housed on feedlots. For swine, the country was divided into three regions—Midwest, East, and South, and for layers, there were four regions—Northeast, Southeast, Central and West. An additional limitation in the data available for the characterization of the farm practices was that for some of the questions asked by the study, results were only reported in terms of percent of operations which used a particular practice. This may give too much weight to the practices used on smaller farms which have a relatively small contribution to the overall level of ammonia emissions from a particular livestock type or practice. Thus, some uncertainty is expected as a result of the limited quantity of data available regarding manure management practices throughout the country.

As was previously discussed by Pinder et al. [ref 3], one of the factors most limiting to the FEM's skill is the lack of information about manure managment practices throughout the country. It is unclear whether these uncertainties result in the overprediction or underprediction of total ammonia emissions from livestock in the United States.

Beef

Information regarding beef manure management practices was provided through the USDA National Animal Health Monitoring Study (NAHMS) with a regional distribution of practices. Beef data were provided for beef housed on feedlots as well as those that are a part of cow-calf systems. Cow-calf systems are those in which cattle are left on pasture or rangeland and the cows are kept with their calves, often until the calves are 1-2 years old and ready for sale. Feedlots are a much denser style of production in which large numbers of cattle are housed on concrete or packed earth lots and fed a mixture of corn and grains. Using the information from NAHMS and the animal numbers in the USDA 2012 agriculture census, the fraction of cattle in each state that were housed on feedlots as opposed those raised in a pasture-based farm system was discerned.

The distribution of manure management practices for the states included in the National Animal Health Monitoring System (NAHMS) (as split between feedlots and cow-calf systems) is based on liteature [ref 4 – ref 8]. The regional distribution of cattle on feed can be seen in the Figure 4-7. States in the West include: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. The states in the Central region are: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin. Texas and Oklahoma are in the South Central region. The remaining states are in the East. There have been relatively few studies that have characterized the emissions from cow-calf or pasture-based systems in the United States, especially compared to the emissions characterization that has been done at a variety of Texas and Oklahoma feedlots. The grazing portion of the beef farm emission model is therefore less constrained and may result in the underprediction of emissions of ammonia from beef not housed on feedlots.

Figure 4-7: Regional distribution of beef cattle on feed
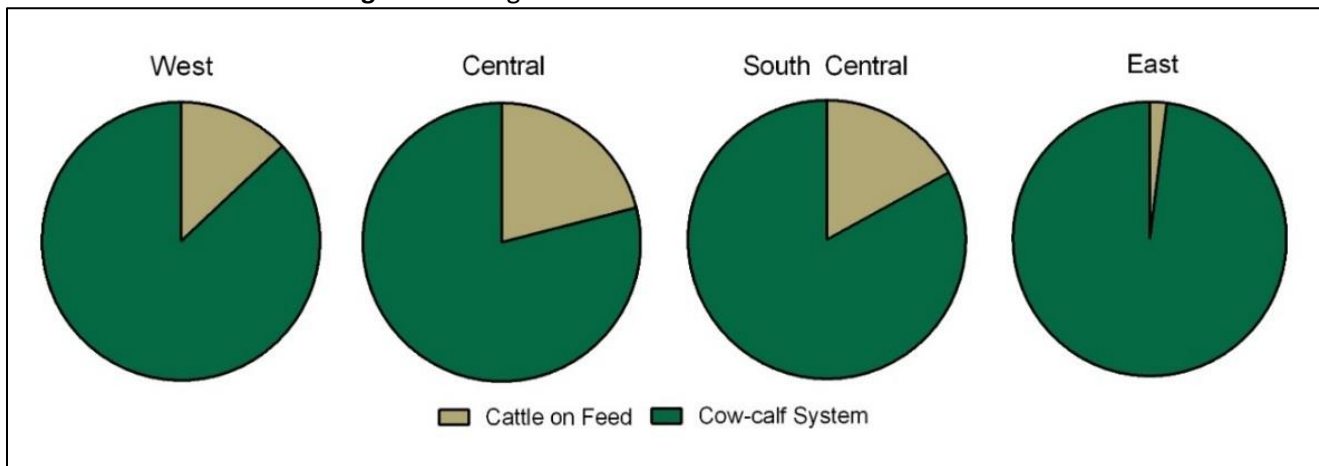
Based on the information provided by NAHMS and the USDA Agricultural census, two manure managment trains (MMTs) are considered. The first is an all grazing system where emissions are affected by the rate of manure infiltration and directly exposed to the elements (temperature, windspeed, precipitation). The alternative is a feedlot system with solid manure storage and broadcast application.

Dairy

The distribution of practices used in dairy cattle is unlikely to have changed substantially in the years following the work of Pinder et al. [ref 1, ref 2], as seen when comparing the two most recent NAHMS results (from 2002 and 2007) to the 1996 NAHMS data used in the cited work. However, the data available for the 2002 and 2007 NAHMS was less regionally specific than was used in the previous work [ref 9 – ref 13]. The manure

management practice information received at that time included state-specific data, something not available for the current study years. Addtionally, storage and application data for 2002 and 2007 was only available by fraction of surveyed operations rather than by population which may give too much weight to practices employed primarily at smaller dairy farms. Manure management practices can be described regionally as either in the West or East; the distribution of practices is shown below in Figure 4-8 and Figure 4-9. Eastern States include Minnesota, Iowa, Missouri, Arkansas, Louisiana and eastward. Western states are the rest of the continental US. Regionally separated data was not available from the 2007 NAHMS, and results are presented in terms of percent of farming operations rather than percent of animal population, which may lead to over representation of minor practices.

Figure 4-8: Regional distribution of dairy housing practices from 2007 NAHMS for Eastern and Western U.S.
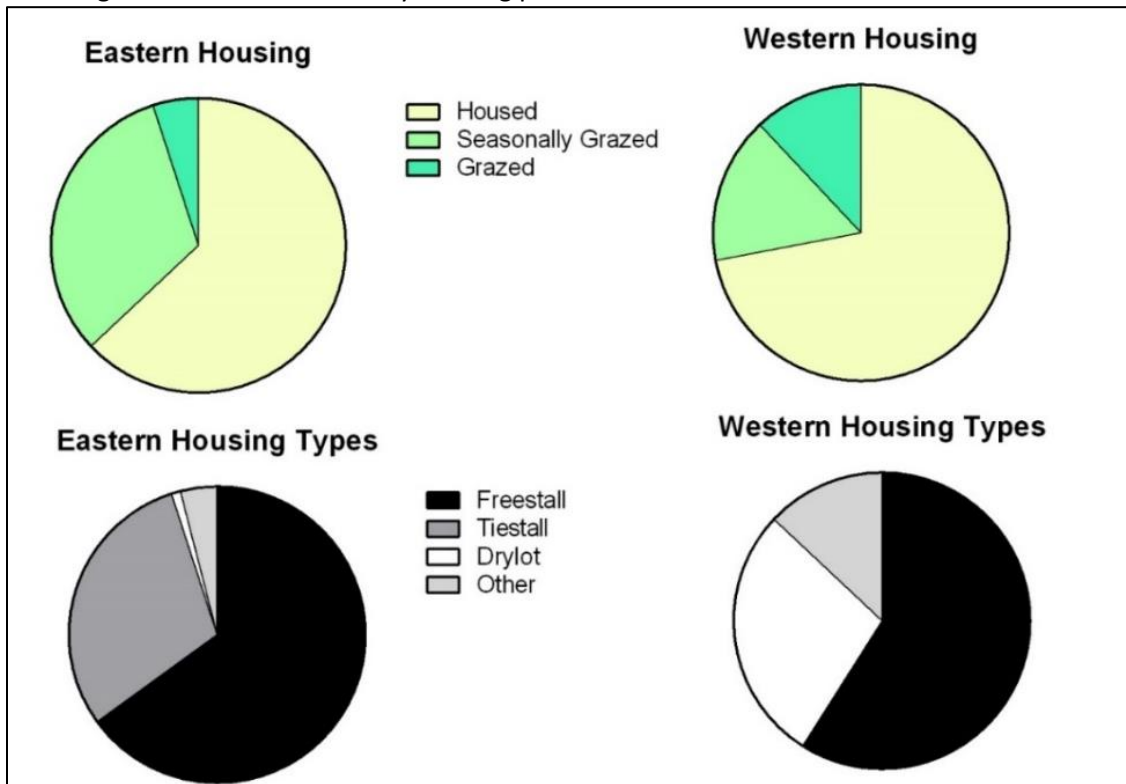
Figure 4-9: Distribution of storage and application practices across the U.S.
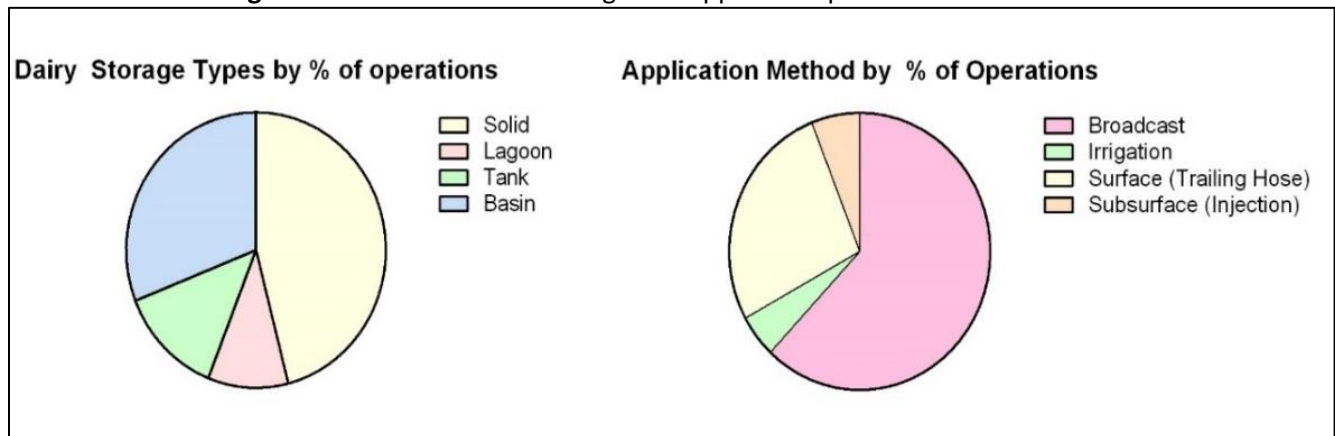
Swine

There is significant regional variability in the housing types and manure management practices (in terms of storage and application) for swine production in the United States. Some of the management choices made are the result of meteorological limitations (i.e. deep-pit versus shallow-pit housing) while others are chosen for economic reasons (less expensive to use irrigation application rather than injection).

Using the information provided by NAHMS, regional distributions of management practices can be described [ref 14 – ref 17]. The United States can be broken into three regions based on this data: the South, the Midwest, and the East. Each of these groups of states has a unique distribution of housing, storage, and application practices, seen in Figure 4-10. The Midwest includes: Idaho, Iowa, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin and Wyoming. The Eastern states include Connecticut, Delaware, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and Vermont. The remainder of the states are included in the Southern region.

Figure 4-10: Regional distribution of swine manure management practices
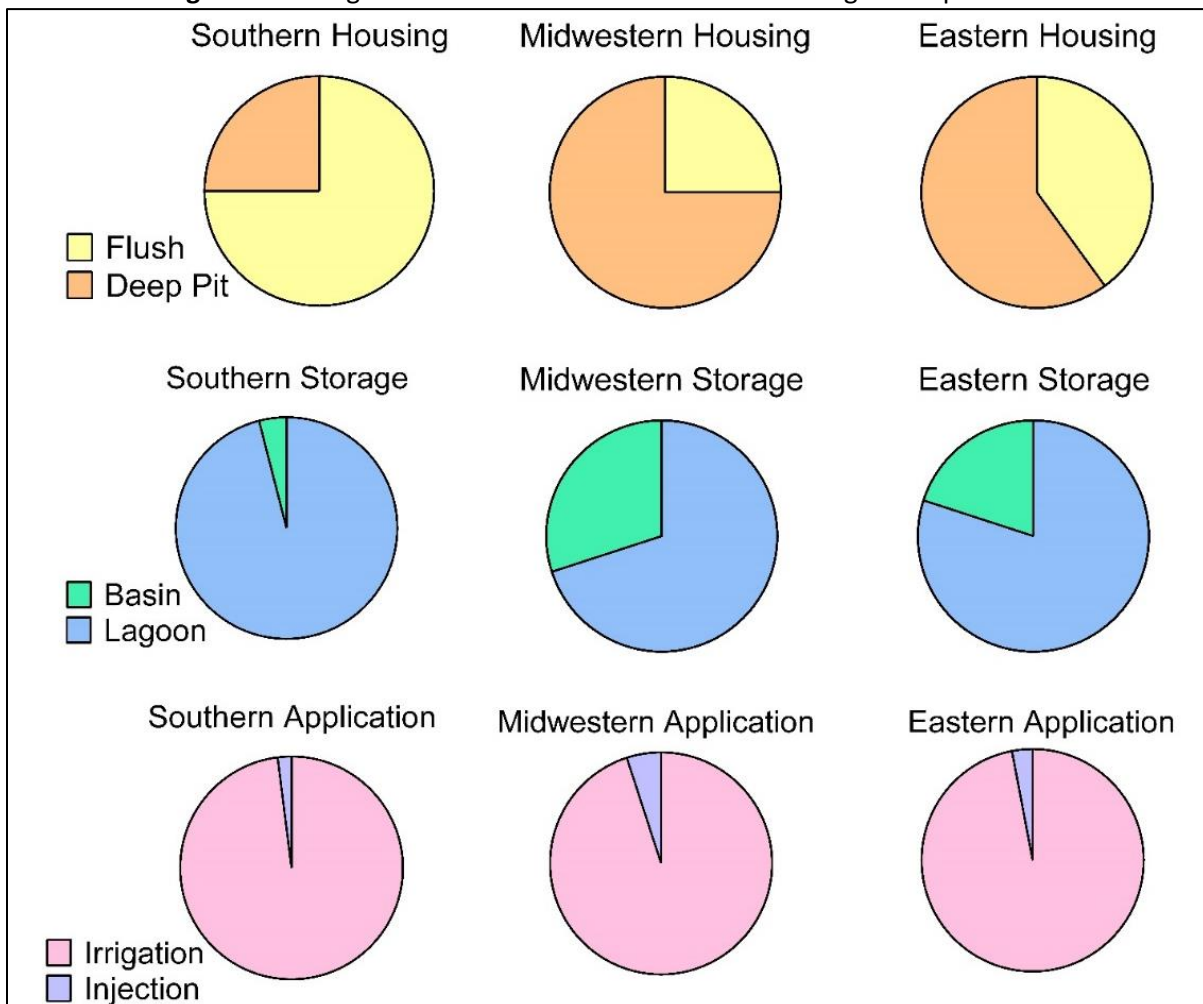
Poultry

Broilers

The major differences in broiler chicken production occur not in terms of farm type, but in the frequency with which barns are entirely cleaned out of their litter material; literature suggests that barns that are cleaned out more frequently have lower emissions than those in which litter material is built up and reused [ref 19 – ref 22]. Additional factors that may alter the emissions from these facilities include what the bedding or litter material is made up of as well as how long each barn stays empty between flocks. There is not sufficient data to include either bedding material or the time between flocks within the emissions inventory. In fact, much of the variability that might be caused by these factors on a single farm will likely be averaged out as a result of short lifecycle of these birds, which take less than two months to reach market size. Additionally, pasture-raised or organic practices are not included as they make up a very small fraction of total bird population and the emissions from these farms has not been characterized in the literature.   The limited data available regarding manure storage and application from broiler housing may result in the underestimation of ammonia emissions from this animal type.

Layers

There are two major housing types used in the production of layer chickens in the United States. These are high-rise layer houses and manure-belt layer houses. The primary difference between these two housing types is the frequency with which manure is removed; in high-rise barns, manure is removed 1-2 times each year, while manure is removed on a daily or weekly basis from manure-belt barns, which results in lower housing emissions and ammonia concentrations but leaves greater quantities in the manure that is headed toward storage and application or processing. High-rise housing operations are more prevalent than manure-belt houses throughout the United States (Figure 4-11), but manure-belt are somewhat more common in the western and central portions of the United States. The majority of ammonia emissions from poultry are expected to be from housing (particularly for high-rise facilities). The West includes: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oklahoma, Oregon, Texas, Utah, Washington, and Wyoming. The Central states are: Arkansas, Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. Southeastern states are: Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia. The remaining states are considered to be in the Northeast. There are some limitations on the abiility of the FEM for both the storage and application of poultry manure as there have been few studies to characterize these emissions.

Figure 4-11: Regional distribution of layer housing types
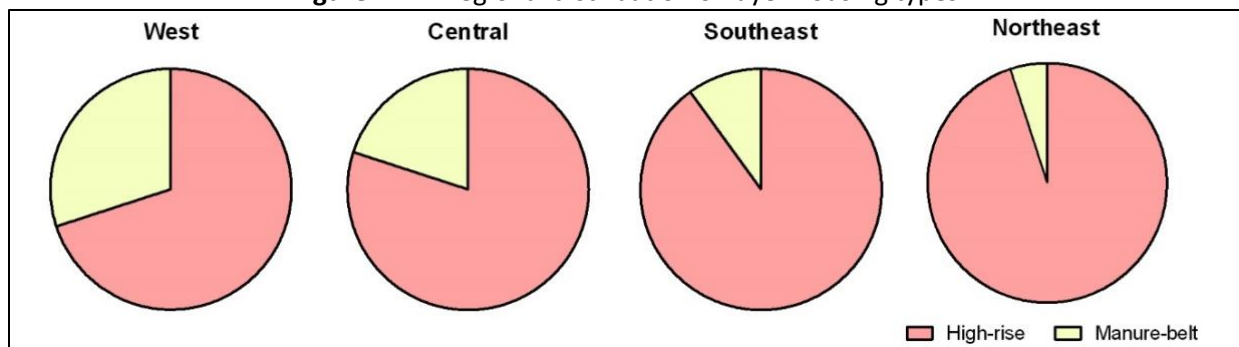
Additionally, the most recent NAHMS information does not capture the more recent trend towards cage-free housing or pasture-raised layer chickens [ref 23 – ref 25]. Cage-free housing is a relatively minor housing

practice currently (<10% of all layer chickens are raised on cage free farms, but state-specific data is unavailable so this may vary significantly by state, and this may not represent a similar fraction of total eggs produced), but is poised to grow as a result of concerns about animal health and welfare and the demand for cage-free eggs increases. According to the most recently completed NAHMS, cage-free production occurs at approximately 3% of large layer operations (more than 100,000 layers), and approximately one-quarter of smaller farms. The data provided by NAHMS does not specify the fractions of total layer populations raised at particular farm sizes, but large farms have become increasingly common and it is expected that most eggs are produced from larger farms [ref 25]. Cage-free and organic products are more likely to come from smaller farms whose emissions have not been well-characterized in the literature. Cage-free production is more common in Europe than the United States, so emissions studies from Europe could be used to better characterize cage-free housing emissions [ref 26 – ref 28].

Model Parameters

The FEM is a tuned model that applies adjustments to approximate observed data. However, the model evaluation does not reflect the ability of the FEM to predict completely independent measurements but the ability of a relatively simple process-based model, with a single set of mass transfer parameters for each manure management practice, to describe the full range of observed variability.

The National Air Emissions Monitoring Study (NAEMS) data and literature data are displayed in Figure 4-12. Results in Figure 4-12 are displayed by animal type and management stage as follows: a) free-stall dairy housing emissions, b) dairy lagoon storage emissions, c) deep-pit and flush-type swine housing emissions, d) swine lagoon and basin storage emissions, e) litter-based broiler housing emissions, and f) manure-belt (MB) and high-rise (HR) layer housing emissions. (1 AU = animal unit = 500 kg live animal weight). The range of temperatures studied is most extended for layer hens. With the additional NAEMS data, an apparent inverse relationship between temperature and ammonia emissions is observed, something that was not clear in the prior literature. It has been suggested that this inverse relationship (higher emissions factors for lower temperatures) is related to the drying out of manure in hot barns with high ventilation rates [ref 30]. At lower temperatures, barn ventilation is reduced (to conserve heat) and manure dries slowly, and, therefore more manure urea can be broken down into ammonia, which is then available for volatilization. Additionally, for some practices, particularly for swine storage, emissions factors from NAEMS were uniformly higher than those previously reported in the literature, for both high and low temperatures. As a result of these differences, the FEM's tuned parameters were adjusted so that model emission factors fell between NAEMS and literature data, weighting the literature studies equally with the NAEMS observations so as not to over-tune to only the literature or NAEMS data. There is significant value in both previously published studies as well as in the values reported by NAEMS, so the re-tuning done is to ensure that this work takes advantage of all available data.

Figure 4-12: Emission factors as a function of temperature reported in the prior literature and from the NAEMS
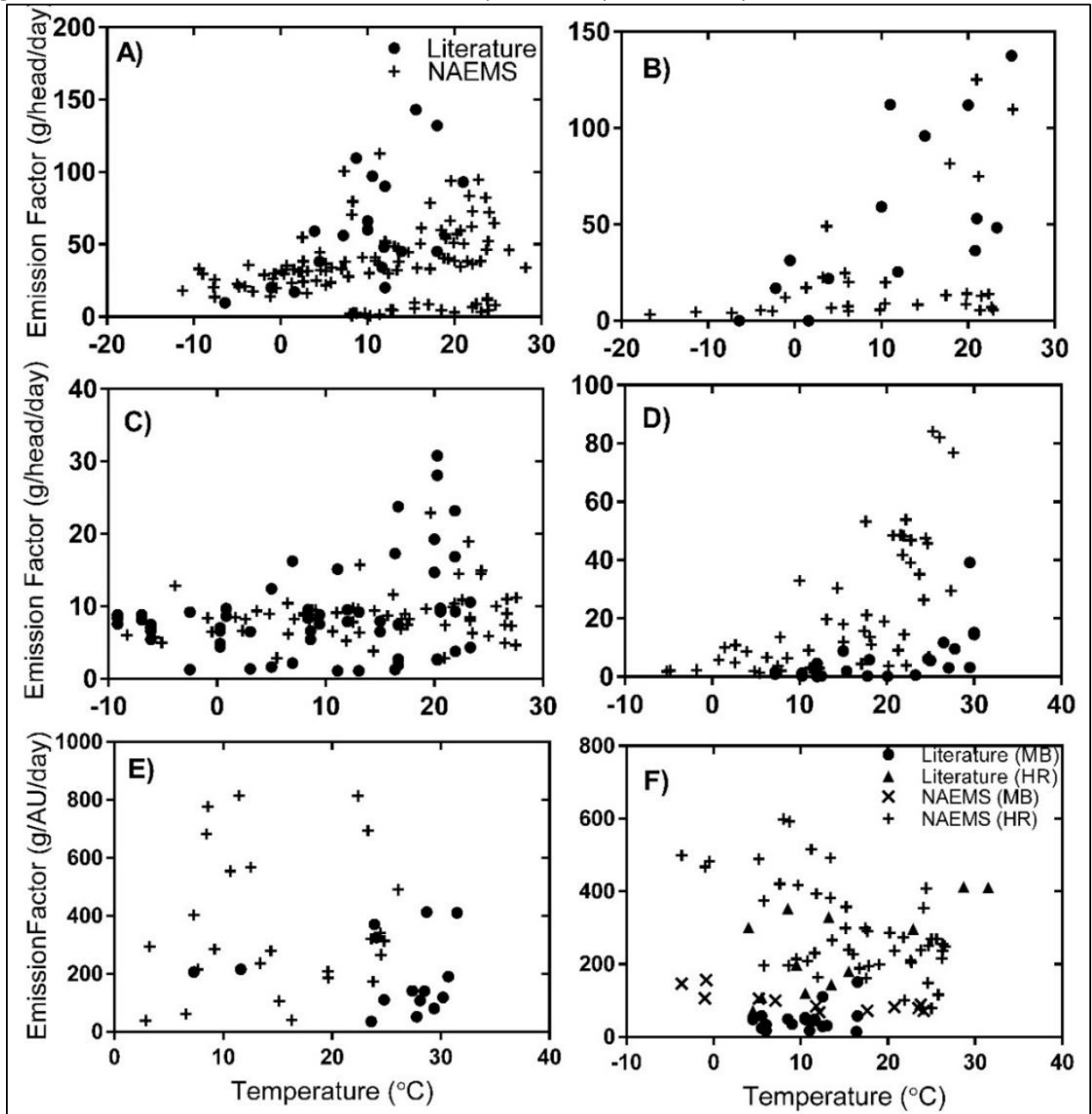
Manure characteristics

Manure characteristics are important input parameters to the model because they govern the amount of nitrogen available for emission, whether or not the nitrogen present is likely to be volatilized, and how well the waste can infiltrate into the soil during manure application. These parameters have been selected based on information extracted from published literature as well as reports from the National Air Emissions Monitoring study. Table 4-37 describes the types of parameters and inputs critical to the model and Table 4-38 presents information about manure volume, nitrogen concentration and pH levels in the waste from each type of animal included in the model.

Table 4-37: Description and sources of model inputs and parameters

Data Type	Description	Source of input or parameter	Input or Tuned Parameter?
Meteorology	Temperature (°C) Wind speed (m/s) Precipitation	From National Climate Data Center, based on farm location	Input value (monthly average for seasonal emissions, daily values for daily model run)
Manure Management Practice	Type of housing, storage, or application	Unique to each farm type; farm types have a unique set of inputs	Input value
Resistance Parameters	Surface mass transfer resistance from manure to atmosphere	Tuned based on literature and NAEMS observations to agree with previous work; constant for a particular management practice (for a particular animal type)	Tuned Parameters

Table 4-38: Model Input parameters related to manure characteristics

Parameter Name	Animal Type	Range of Values	Value Used in Model	Units	Source
Manure Volume	Beef	12-17	15	l animal^{-1} day^{-1}	2, 31
	Dairy			l animal^{-1} day^{-1}	2
	Swine	4-10	6	l animal^{-1} day^{-1}	32
	Poultry-Layer	0.088	0.088	l animal^{-1} day^{-1}	33, 34
	Poultry-Broiler	4.9	4.9	l finished animal^{-1}	33
Manure Urea Concentration	Beef	47-70		kg N animal^{-1} year^{-1}	33
	Dairy			kg N animal^{-1} year^{-1}	2
	Swine	11-35		kg N animal^{-1} year^{-1}	34, 35
	Poultry-Layer	0.5-0.6	0.55	kg N animal^{-1} year^{-1}	33
	Poultry-Broiler	0.05-0.06	0.055	kg N finished animal^{-1}	33
Housing pH	Beef	7.7	7.7		36
	Dairy	7.5-8.3	7.7		2
	Swine	6.5-7.5	7		37
	Poultry-Layer	7.1-7.6 (MB); 8.4-8.7	7.3		38, 39
	Poultry-Broiler	8	8		40
Storage pH	Dairy	7.0-8.0	7.5		1
	Swine	7.5-8	7.7		35
Application pH	Beef	7.5	7.5		41
	Dairy	7.0-7.7	7.3		2
	Swine	7.8-8.2	8		42
	Poultry-Layer	7.2	7.2		43
	Poultry-Broiler	8.8	8.8		44
Storage pH	Beef	7.7	7.7		2
	Dairy	7.5-8.3	7.7		2

There are a limited number of studies which describe the manure nitrogen and manure pH for each animal type. As a result, there is considerable uncertainty in these input values which can result in significant uncertainty in predicted emissions from the model.

<u>**Tunable parameters**</u>

The FEM is a balance between an empirical approach and first-principles process-based model. A nitrogen mass balance and a process description of ammonia losses are used, but the FEM model parameters are tuned to reproduce measured emissions factors. Model complexity is limited to the most important emissions processes and to inputs that are typically available. The strategy pursued for developing process-based models is guided by the need to build emissions inventories, and the requirements and data limitations associated with this application. Previous measurement campaigns also often sampled emissions from a single part of the production process. This means that information about the emissions process from the start to end of production might be lacking, making nitrogen mass balance in the system difficult. The lack of whole-farm measurements is one gap in much of the literature available and a benefit of the estimates of ammonia emissions produced by the FEM.

There are 2-3 tunable parameters associated with each sub-model in the farm emissions model. These tunable parameters allow adjustment of model-predicted emissions and to correct for the unknowns and uncertainties of the input parameters and to ensure that the model-predicted values are consistent with those that have been reported in the literature and in the National Air Emissions monitoring study; they are constant for a particular farm type—tuning is not done for a particular farm—and as a result, there can be significant disagreement between model predictions and the measured emissions for a single farm. The goal of the FEM is not necessarily to capture the emissions of single farms perfectly, but rather to capture the effects of various parameters on emissions on a farm typical of a certain set of practices.

In the FEM, as previously described [ref 29, ref 45, ref 46], ammonia emissions are estimated as a function of the nitrogen present in the waste and the mass transfer resistance. This resistance is made up of the following three parts: the aerodynamic (r_a), quasi-laminar (r_b), and surface resistances (r_s) [ref 47]. Aerodynamic and quasi-laminar resistances are used to describe the resistance to transport in the gaseous layer above the animal wastes [ref 45, ref 48, ref 49]. These parameters are based on widely used theoretical formulas and are not tuned. The third part of the resistance is the surface resistance from diffusion closest to the gas-liquid (manure) interface. Here, the surface resistance is a function of tuned parameters as well as temperature which ensures the modeled ammonia emission factors are consistent with observations; Table 4-39 lists which tunable parameters are used for each animal and each sub-model.

These values are specific to a particular practice for a particular animal type. This means that a free stall dairy with lagoon storage and injection application would employ the same tuned parameters whether it was located in New York or California. Conversely, two farms in the same location but utilizing different manure management practices would have different tuned parameters in their sub-models. The values that have been used for each of these parameters can be found in Table 4-40.

Table 4-39: Tuned model parameters for beef, swine, and poultry

Sub-model	Animal Type	Description	Tuning/Evaluation Sources
Housing	Cattle: Beef & Dairy Swine Poultry: Broiler & Layer	Resistance parameters H_1, H_2	50-67, 68-72, 73-78, 79-84
Storage	Dairy Cattle Swine	Resistance parameters S_1, S_2	85-90
Application	Cattle: Beef & Dairy Swine Poultry: Broiler & Layer	Resistance parameters A_1, A_2, A_3	91, 92, 93-95, 96-97

Sub-model	Animal Type	Description	Tuning/Evaluation Sources
Grazing	Cattle: Dairy & Beef	Resistance parameters G_1, G_2	98

Table 4-40: Tuned Parameter Values by practice and animal type

Sub-model	Animal Type	Description	Parameter Values
Housing	Beef cattle	Beef Feedlot	$H_1=0.1$ (s•m^{-1}•°C^{-1}), $H_2=-0.01$ (s^{2}m^{-2})
	Swine	Swine—shallow pit	$H_1=0.08$(s•m^{-1}), $H_2=-0.004$(s•m^{-1}•°C^{-1})
	Swine	Swine—deep pit	$H_1=0.1$(s•m^{-1}), $H_2=-0.008$(s•m^{-1}•°C^{-1})
	Poultry-Layer	Layer—Manure belt	$H_1=0.3$(s•m^{-1}), $H_2=-0.015$(s•m^{-1}•°C^{-1})
	Poultry-Layer	Layer—High Rise	$H_1=0.22$(s•m^{-1}), $H_2=-0.02$(s•m^{-1}•°C^{-1})
	Poultry-Broiler	Broiler	$H_1=0.15$(s•m^{-1}), $H_2=-0.035$(s•m^{-1}•°C^{-1})
Storage	Swine	Swine lagoon	$S_1=0.20$(s•m^{-1}), $S_2=4.00$(s•m^{-1}•°C^{-1})
	Swine	Swine basin	$S_1=0.11$(s•m^{-1}), $S_2=2.24$(s•m^{-1}•°C^{-1})
Application	Beef cattle	Beef—broadcast	$A_1=0.0004$, (s•m^{-1})$A_2=0.88$, $A_3=-1.4$
	Swine	Swine—irrigation	$A_1=0.001$(s•m^{-1}), $A_2=-10$, $A_3=20$
	Swine	Swine—injection	$A_1=0.01$(s•m^{-1}), $A_2=-15$, $A_3=40$
Grazing	Beef Cattle	Beef Pasture	$G_1=0.12$(s•m^{-1}), $G_2=5.4$

4.5.3.5 Controls

There are no controls assumed for this category.

4.5.3.6 Emissions calculation procedure

Back Calculating the 2014 NH_3 Emissions Factors from the CMU Model

Because we could not get the model to reproduce results properly using 2014 inputs, EPA had to use a scaling approach to estimate emissions from the CMU FEM model for the 2017 NEI. This is described in this section.

The emissions estimates in NEI 2014 v1 came from the CMU model. These emissions were then divided by the model's animal population figures to estimate the statewide NH_3 emission factor.

$$EF_{s,a,2014} = E_{s,a,2014} \div A_{s,a,2014} \tag{2}$$

Where:
$EF_{s,a,2014}$ = 2014 NH_3 emissions factor from the CMU model for animal type a and state s (kg/head)
$E_{s,a,2014}$ = 2014 NH3 emissions from the CMU model for animal type a and state s (kg)
$A_{s,a2014}$ = 2014 animal count for animal type a and state s (head)

Calculating the 2017 NH_3 Emissions Factors

The 2017 NH_3 emissions factors are estimated by multiplying the NH_3 emissions factors from the 2014 NEI CMU model run with the ratio of the 2017 to 2014 CMU model runs performed with the updated hourly metrological data.

$$EF_{s,a,2017} = EF_{s,a,2014} \times EF_{CMU,s,a,2017} \div EF_{CMU,s,a,2014} \tag{3}$$

Where:

       $EF_{s,a,2017}$ = 2017 NH_3 emissions factor for animal type a and state s (kg/head)

       $EF_{s,a,2014}$ = 2014 NH_3 emissions factor from the 2014 NEI CMU model run for animal type a and state s (kg/head)

       $E_{CMU,s,a,2017}$ = 2017 NH_3 emissions factor from the 2017 CMU model run for animal type a and state s (kg/head)

       $E_{CMU,s,a,2014}$ = 2014 NH_3 emissions factor from the updated 2014 CMU model run for animal type a and state s (kg/head)

Calculating 2017 NH_3 Emissions due to Livestock

Emissions are calculated by multiplying the state specific NH_3 emission factor (in NH_3/head) by the number of animals in a given county in that state.

$$E_{c,a,2017} = EF_{s,a,2017} \times A_{c,a,2017} \times 2.2/2000 \tag{4}$$

Where:

       $E_{c,a,2017}$ = 2017 NH_3 emissions for animal type a and county c (ton)

       $EF_{s,a,2017}$ = 2017 NH_3 emissions factor for animal type a and state s in which the county is located (kg/head)

       $A_{c,a,2017}$ = 2017 animal count for animal type a and state s (head)

       2.2/2000 = conversion factor from kg to tons

Calculating 2017 VOC Emissions due to Livestock

VOC emissions are calculated using the ratio of VOC to NH_3 emissions from livestock. That ratio is 0.08 kg of VOC for every kg of NH_3.

$$E_{VOC,c,a,2017} = VOC/NH_3 \times E_{c,a,2017} \tag{5}$$

Where:

       $E_{VOC,c,a,2017}$ = 2017 VOC emissions for animal type a and county c (ton)

       VOC/NH_3 = 0.08

       $E_{c,a,2017}$ = 2017 NH_3 emissions for animal type a and county c (ton)

Calculating 2017 HAP Emissions due to Livestock

HAP emissions are calculated using the ratio of HAP to VOC emissions from livestock. These ratios are derived from the SPECIATE database as discussed above in Section 4.5.3.4.

$$E_{HAP,c,a,2017} = \frac{HAP}{VOC} \times E_{VOC,c,a,2017} \times 2000 \tag{6}$$

Where:

       $E_{HAP,c,a,2017}$ = 2017 HAP emissions for animal type a and county c (lb)

       HAP/VOC = speciation factor derived from the SPECIATE database and listed in Table 2

       $E_{VOC,c,a,2017}$ = 2017 VOC emissions for animal type a and county c (ton)

       2000 = Conversion factor from tons to pounds

<u>Alaska and Hawaii</u>

The CMU model does not cover Alaska or Hawaii (only the lower 48 states); however, the animal counts database does have values for Alaska and Hawaii. To estimate NH_3 (and other pollutant) emissions for Alaska and Hawaii, the state-level emissions factors from Idaho were used as a surrogate for Alaska and state-level emissions factors from Florida were used as a surrogate for Hawaii.

4.5.3.7 *Point source subtraction*

Point source subtraction was not performed for this category.

4.5.3.8 *Example calculations*

Table 4-41 lists sample calculations to determine NH3, VOC and Toluene emissions from swine production in Cochise County, Arizona.

Table 4-41: Sample Calculations for NH3, VOC and Toluene emissions from swine in Cochise County, AZ

Eq. #	Equation	Values for Cochise County, AZ	Result
2	$EF_{s,a,2014}$ $= E_{s,a,2014}$ $\div A_{s,a,2014}$	$= 9,370\ kg\ NH_3 \div 925$ swine	10.13 kg NH_3 per head of swine in Cochise County in 2014
3	$EF_{s,a,2017}$ $= EF_{s,a,2014}$ $\times EF_{CMU,s,a,2017}$ $\div EF_{CMU,s,a,2014}$	$= 10.13\ kg\ NH_3\ per\ swine \times 1.019159$	10.32 kg NH_3 per head of swine in Cochise County in 2017
4	$E_{c,a,2017}$ $= EF_{s,a,2017}$ $\times A_{c,a,2017}$ $\times 2.2/2000$	$= 10.32\ kg\ NH_3 \times 30,693\ swine \times 2.2\ /2000$	348.6 tons of NH_3 emissions from swine in Cochise County in 2017
5	$E_{VOC,c,a,2017}$ $= VOC/NH_3$ $\times E_{c,a,2017}$	$= 0.08 \times 348.6$ tons of NH_3	27.89 tons of VOC emissions from swine in Cochise County in 2017

Eq. #	Equation	Values for Cochise County, AZ	Result
6	$E_{HAP,c,a,2017}$ $= \dfrac{HAP}{VOC}$ $\times E_{VOC,c,a,2017}$ $\times 2000$	$= 0.0047 \times 27.89 \; tons \; VOC \times 2000$	262.1 lb of toluene from swine in Cochise County in 2017

4.5.3.9   *Changes from the 2014 methodology*

The methodology for estimating county-level animal counts is based on the U.S. EPA's Greenhouse Gas Inventory. This data set is derived from multiple data sets from the United States Department of Agriculture (USDA), particularly the National Agricultural Statistics Service (NASS) survey and census. In addition, the NH_3 emissions factors were updated to 2017 by growing 2014 emissions factors based on the ratio of 2017 to 2014 emission rates from CMU model runs with updated 2014 and 2017 hourly meteorological data from NOAA. The basic CMU model structure stays the same as that used in the 2014 NEI process via assistance from CMU.

4.5.3.10 *Puerto Rico and U.S. Virgin Islands*

Due to the lack of animal counts in Puerto Rico and the U.S. Virgin Islands, emissions are not estimated for these territories.

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4.6 Biogenics – Vegetation and Soil

Biogenic emissions are emissions that come from natural sources. They need to be accounted for in photochemical grid models, as most types are widespread and ubiquitous contributors to background air chemistry. In the NEI, only the emissions from vegetation and soils are included. Other relevant sources not included in the NEI are volcanic emissions (geogenic), lightning oxides of nitrogen (NOx), and sea salt. Biogenic emissions from vegetation and soils are computed using a model that utilizes spatial information on vegetation, land use and environmental conditions of temperature and solar radiation. The model inputs are typically horizontally allocated (gridded) data, and the outputs are gridded biogenic emissions, which can then be speciated and utilized as input to photochemical grid models.

4.6.1 Sector description

In the 2017 NEI, biogenic emissions are included in the nonpoint data category, in the EIS sector "Biogenics – Vegetation and Soil." Table 4-42 lists the two source classification codes (SCCs) used in the 2017 NEI that comprise this sector. The level 1 and 2 SCC description for both SCCs is "Natural Sources; Biogenic" and the full Tier 3 description for both SCCs is "Natural Resources; Biogenic; Vegetation". These two SCCs have distinct pollutants: SCC 2701220000 has only NOX emissions, and SCC 2701200000 has emissions for carbon monoxide (CO), volatile organic compounds (VOC) and three VOC hazardous air pollutants (HAPs): formaldehyde, acetaldehyde and methanol.

Table 4-42: SCCs for biogenic sources

SCC	SCC Level 3	SCC Level 4
2701200000	Vegetation	Total
2701220000	Vegetation/Agriculture	Total

4.6.2   Sources of data

The biogenics sector includes data from the S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-43 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector.

Table 4-43: Agencies that submitted biogenics emissions

Region	Agency	S/L/T
9	California Air Resources Board	State
9	Maricopa County Air Quality Department	Local
10	Coeur d'Alene Tribe	Tribe
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.6.3   EPA-developed emissions

4.6.3.1   *Continental U.S.*

The biogenic emissions for the 2017 National Emissions Inventory (NEI) were computed based on 2017 meteorology data from the Weather Research and Forecasting (WRF) model version 3.8 (WRFv3.8) and using the Biogenic Emission Inventory System, version 3.61 (BEIS3.61) model within the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system version 4.7. The BEIS3.61 model creates gridded, hourly, model-species emissions from vegetation and soils at 12-kilometer horizontal resolution. The 12-kilometer gridded hourly data are summed to monthly and annual level (see Figure 4-13) and are mapped from 12-kilometer grid cells to counties using a standard mapping file.

Figure 4-13: Annual VOC emissions for year 2017 for 12km modeling domain
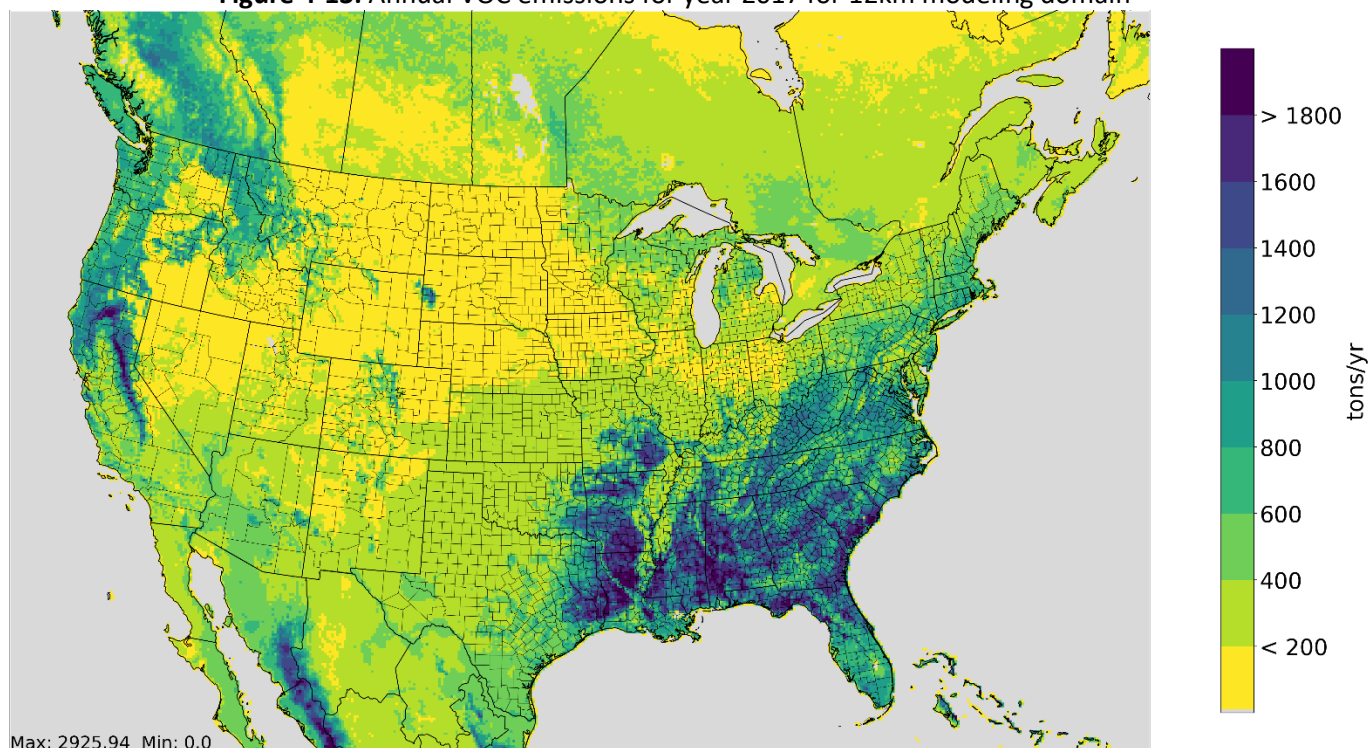
BEIS produces biogenic emissions for a modeling domain which includes the contiguous 48 states in the U.S., parts of Mexico, and Canada. The NEI uses the biogenic emissions from counties from the contiguous 48 states and Washington, DC. The model-species are those associated with the Carbon Bond mechanism version 6 (CB6). The NEI pollutants produced are: CO, VOC, NOx, methanol, formaldehyde and acetaldehyde. VOC is the sum of all biogenic species except CO and nitrogen oxide (NO). Mapping of BEIS species to NEI pollutants is as follows:

- NO maps to NOx
- FORM maps to formaldehyde
- ALD2 maps to acetaldehyde
- MEOH maps to methanol
- VOC is the sum of all biogenic species except CO and NO

BEIS3.61 includes a two-layer canopy model. Layer structure varies with light intensity and solar zenith angle [ref 2]. Both layers of the canopy model include estimates of sunlit and shaded leaf area based on solar zenith angle and light intensity, direct and diffuse solar radiation, and leaf temperature [ref 1, ref 2]. The canopy model requires additional meteorological inputs as compared to previous versions of BEIS, and these meteorology inputs must be in a data file format that is output from the Meteorology-Chemistry Interface Processor (MCIP). MCIP is also used to convert WRF outputs to inputs for the Community Multi-scale Air Quality (CMAQ) model. The meteorology input data fields used by BEIS are shown in Table 4-44.

Table 4-44: Meteorological variables required by BEIS 3.61

Variable	Description
LAI	leaf-area index
PRSFC	surface pressure
Q2	mixing ratio at 2 m

Variable	Description
RC	convective precipitation per meteorological time step
RGRND	solar rad reaching surface
RN	non-convective precipitation per meteorological time step
RSTOMI	inverse of bulk stomatal resistance
SLYTP	soil texture type by USDA category
SOIM1	volumetric soil moisture in top cm
SOIT1	soil temperature in top cm
TEMPG	skin temperature at ground
USTAR	cell averaged friction velocity
RADYNI	inverse of aerodynamic resistance
TEMP2	temperature at 2 m

Important updates were made to two other input datasets used in the BEIS3.61 modeling system for the 2017NEI. The Biogenic Emissions Landcover Database version 5 (BELD5) was used as the input gridded land use information in generating 2017NEI estimates. BELD version 4.1 (BELD4.1) was used to generate 2014NEI estimates. The other input dataset change involved updating the dry leaf biomass (grams/m2) values for various vegetation types. The BELD5 includes the following datasets:

- Newer version of the Forest Inventory and Analysis, FIA version 8.0
- Agricultural land use from the 2017 US Department of Agriculture (USDA) crop data layer
- Global Moderate Resolution Imaging Spectroradiometer (MODIS) 20 category data with enhanced lakes and Fraction of Photosynthetically Active Radiation (FPAR) for vegetation coverage from National Center for Atmospheric Research (NCAR)
  - Note BELD4.1 used 2011 USGS National Land Cover Data (NLCD) limited to the USA and MODIS 20 category land use for the rest of the world.
- Canadian BELD land use, Updates to Version 4 of the Biogenic Emissions Landuse Database (BELD4) for Canada and Impacts on Biogenic VOC Emissions.

The FIA database reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. The FIA database version 8.0 includes recent updates of these data through the year 2017 (from 2001). Earlier versions of BELD used an older version of the FIA database that had included data only through the year 2014. Canopy coverage is based on the MODIS 20 category data. The FIA includes approximately 250,000 representative plots of species fraction data that are within approximately 75 km of one another in areas identified as forest by the MODIS canopy coverage. For all land areas in the United States, 500-meter grid spacing land cover data from the MODIS is used.

The processing of the BELD5 data follows the spatial allocation methods [ref 2] like BELD 4. However, MODIS land use categories and FPAR are used in the place of NLCD land use and forest coverage. MODIS land use has the additional broadleaf evergreen and deciduous needleleaf land use types and only one developed land use type.

BELD4.1 used lookup tables for species leaf biomass. In BELD5, allometric relationships from the FIA v8.0 database were utilized to estimate foliage biomass per species. This resulted in better agreement with measured foliage biomass. BVOC emissions are understood to originate from foliage thus these biomass changes directly impacted the BEIS emission factors.

4.6.3.2 *Alaska, Hawaii, Puerto Rico and Virgin Islands*

The 2017NEI also include biogenic emissions estimates for counties in the states of Alaska and Hawaii, and for the territories of Puerto Rico and Virgin Islands. The BEIS3.61 modeling system and WRFv3.8 meteorology data for year 2017 were used to produce gridded biogenic emissions for 3 separate modeling domains at 9-km horizontal resolution. The modeling domain for Alaska is shown in Figure 4-14. The land use data used for generating input data for BEIS3.61 included the MODIS 20 category dataset and the FIA version 8.0 used for estimating biomass input information.

Figure 4-14: Alaska 9-km modeling domain
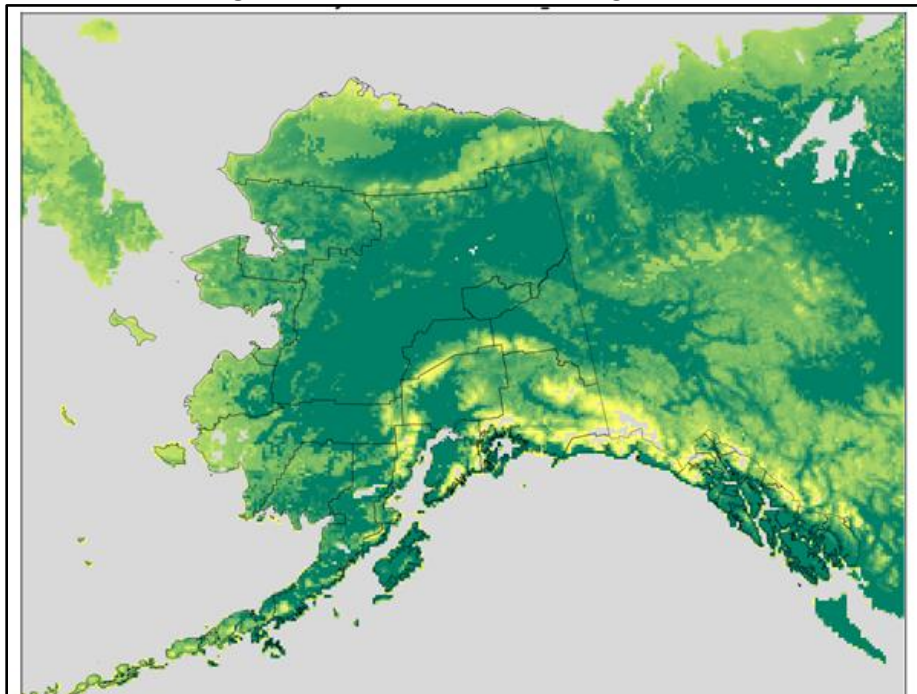
The modeling domains for Hawaii, Puerto Rico and Virgin Islands are shown in Figure 4-15 and Figure 4-16, respectively. Both Puerto Rico and Virgin Islands territories are in the same 9-km modeling domain. The MODIS 20 category land use dataset was the only dataset used for land use/vegetation input into BEIS3.61.

Figure 4-15: Hawaii 9-km modeling domain
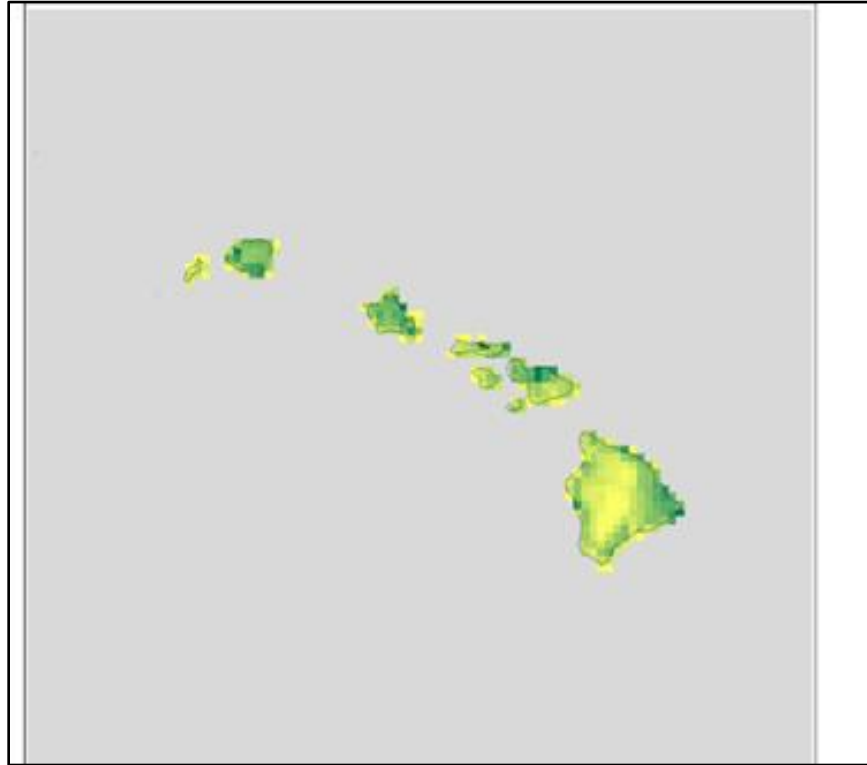
Figure 4-16: Puerto Rico and Virgin Islands 9-km modeling domain
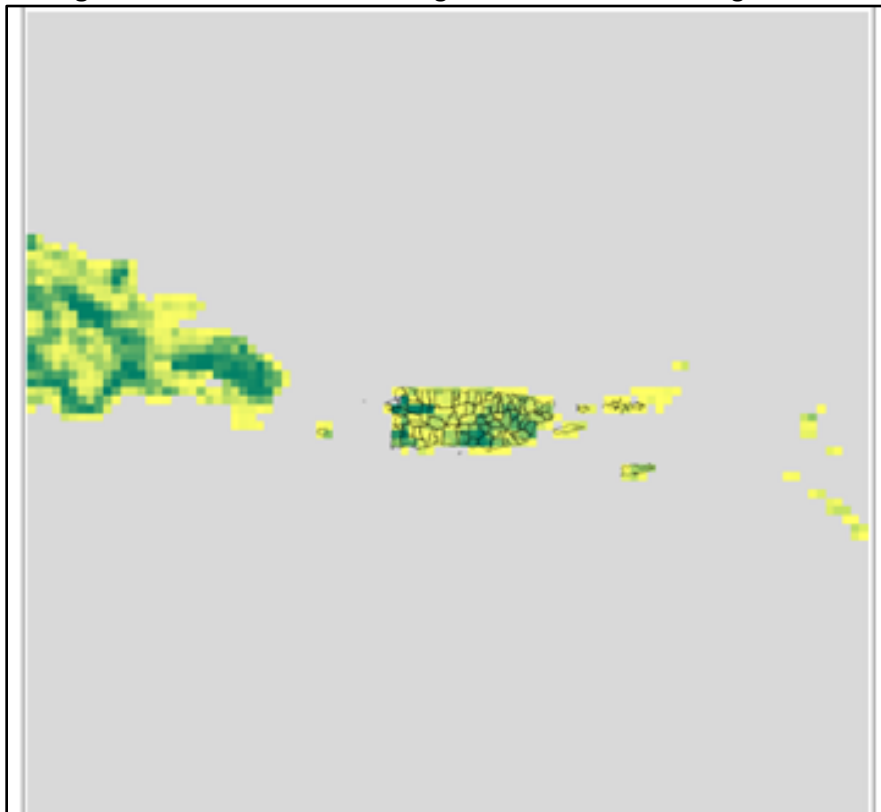
The 9-kilometer gridded hourly data from these modeling domains are summed to monthly and annual level and are mapped from 9-kilometer grid cells to counties using a standard mapping file in a similar manner as was done for the contiguous 48 states. The mapping of BEIS species to NEI pollutants for these states and territories was also done in the same manner as the contiguous 48 states.

4.6.4 References

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4.7 Nonpoint Gasoline Distribution

This section includes discussion of all nonpoint sources in three EIS sectors: Bulk Gasoline Terminals, Gas Stations, and Industrial Processes – Storage and Transfer. Many of the sources in these sectors include sources reported to the point inventory as well; therefore, the EPA nonpoint survey is useful to avoid double-counting S/L/T-reported point emissions with EPA-estimated nonpoint emissions.

4.7.1 Description of sources

This section is broken into two categories: those sources related to stage 1 gasoline distribution and those related to aviation gasoline.

4.7.1.1 *Stage 1 gasoline distribution*

Stage 1 gasoline distribution is covered by the 2017 NEI in both the point and nonpoint data categories. In general terms, Stage 1 gasoline distribution is the emissions associated with gasoline handling excluding emissions from refueling activities. Stage I gasoline distribution includes the following gasoline emission points: 1) bulk terminals; 2) pipeline facilities; 3) bulk plants; 4) tank trucks; and 5) unloading at service stations. Emissions from Stage I gasoline distribution occur as gasoline vapors are released into the atmosphere. These Stage I processes are subject to EPA's maximum available control technology (MACT) standards for gasoline distribution [ref 1].

Emissions from gasoline distribution at bulk terminals and bulk plants take place when gasoline is loaded into a storage tank or tank truck, from working losses (for fixed roof tanks), and from working losses and roof seals (for floating roof tanks). Working losses consist of both breathing and emptying losses. Breathing losses are the expulsion of vapor from a tank vapor space that has expanded or contracted because of daily changes in temperature and barometric pressure; these emissions occur in the absence of any liquid level change in the tank. Emptying losses occur when the air that is drawn into the tank during liquid removal saturates with hydrocarbon vapor and expands, thus exceeding the fixed capacity of the vapor space and overflowing through the pressure vacuum valve [ref 2].

Emissions from tank trucks in transit occur when gasoline vapor evaporates from (1) loaded tank trucks during transportation of gasoline from bulk terminals/plants to service stations, and (2) empty tank trucks returning from service stations to bulk terminals/plants [ref 3]. Pipeline emissions result from the valves and pumps found at pipeline pumping stations and from the valves, pumps, and storage tanks at pipeline breakout stations. Stage I gasoline distribution emissions also occur when gasoline vapors are displaced from storage tanks during unloading of gasoline from tank trucks at service stations (Gasoline Service Station Unloading) and from gasoline

vapors evaporating from service station storage tanks and from the lines going to the pumps (Underground Storage Tank Breathing and Emptying).

4.7.1.2   *Aviation gasoline distribution, stage 1 and 2*

Aviation gasoline (also called "AvGas") is the only aviation fuel that contains lead as a knock-out component for small reciprocating, piston-engine crafts in civil aviation [ref 4]. Commercial and military aviation rarely use this fuel. AvGas is shipped to airports and is filled into bulk terminals, and then into tanker trucks. These processes fall under the definition of stage 1, displacement vapors during the transfer of gasoline from tank trucks to storage tanks, and vice versa. Stage 2 involves the transfer of fuel from the tanker trucks into general aviation aircraft.

4.7.2   Sources of data

Sources in the EIS sectors for Bulk Gasoline Terminals, Gas Stations, and Industrial Processes – Storage and Transfer do not focus solely on gasoline; however, for the purposes of developing the NEI, these SCCs are the only ones that EPA estimates in these sectors. EPA does not develop calculation tools that estimate emissions from transfer of naphtha, distillate oil, inorganic chemicals, kerosene, residual oil, or crude oil. Therefore, sector level emissions for these three EIS sectors will include sources not related to gasoline distribution, some from the point inventory.

Table 4-45 shows all non-Aviation Gasoline SCCs in the nonpoint data category for EIS sectors Bulk Gasoline Terminals, Gas Stations, and Industrial Processes – Storage and Transfer. For Stage 1 Gasoline Distribution, the nonpoint SCCs covered by the EPA estimates are also noted. Table 4-46 shows, for Aviation Gasoline, the nonpoint SCCs covered by the EPA estimates and by the S/L/T agencies that submitted data. The SCC level 2, 3 and 4 SCC descriptions are also provided. The SCC level 1 description is "Storage and Transport" for all SCCs in both tables.

Table 4-45: Nonpoint bulk gasoline terminals, gas stations, and storage and transfer SCCs in the 2017 NEI

SCC	Description	Sector	EPA	S/L/T
2501050120	Petroleum and Petroleum Product Storage; Bulk Terminals: All Evaporative Losses; Gasoline	Bulk Gasoline Terminals	X	X
2501055120	Petroleum and Petroleum Product Storage; Bulk Plants: All Evaporative Losses; Gasoline	Bulk Gasoline Terminals	X	X
2501060051	Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Submerged Filling	Gas Stations	X	X
2501060052	Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Splash Filling	Gas Stations	X	X
2501060053	Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Balanced Submerged Filling	Gas Stations	X	X
2501060201	Petroleum and Petroleum Product Storage; Gasoline Service Stations; Underground Tank: Breathing and Emptying	Gas Stations	X	X
2501070053	Petroleum and Petroleum Product Storage; Diesel Service Stations; Stage 1: Balanced Submerged Filling	Gas Stations		X

SCC	Description	Sector	EPA	S/L/T
2501995120	Petroleum and Petroleum Product Storage; All Storage Types: Working Loss; Gasoline	Industrial Processes - Storage and Transfer		X
2505010000	Petroleum and Petroleum Product Transport; Rail Tank Car; Total: All Products	Industrial Processes - Storage and Transfer		X
2505020000	Petroleum and Petroleum Product Transport; Marine Vessel; Total: All Products	Industrial Processes - Storage and Transfer		X
2505020030	Petroleum and Petroleum Product Transport; Marine Vessel; Crude Oil	Industrial Processes - Storage and Transfer		X
2505020060	Petroleum and Petroleum Product Transport; Marine Vessel; Residual Oil	Industrial Processes - Storage and Transfer		X
2505020090	Petroleum and Petroleum Product Transport; Marine Vessel; Distillate Oil	Industrial Processes - Storage and Transfer		X
2505020120	Petroleum and Petroleum Product Transport; Marine Vessel; Gasoline	Industrial Processes - Storage and Transfer		X
2505020150	Petroleum and Petroleum Product Transport; Marine Vessel; Jet Naphtha	Industrial Processes - Storage and Transfer		X
2505020180	Petroleum and Petroleum Product Transport; Marine Vessel; Kerosene	Industrial Processes - Storage and Transfer		X
2505030120	Petroleum and Petroleum Product Transport; Truck; Gasoline	Industrial Processes - Storage and Transfer	X	X
2505040120	Petroleum and Petroleum Product Transport; Pipeline; Gasoline	Industrial Processes - Storage and Transfer	X	X
2510000000	Organic Chemical Storage; All Storage Types: Breathing Loss; Total: All Products	Industrial Processes - Storage and Transfer		X
2520010000	Inorganic Chemical Storage; Commercial/Industrial: Breathing Loss; Total: All Products	Industrial Processes - Storage and Transfer		X

Table 4-46: Nonpoint aviation gasoline distribution SCCs in the 2017 NEI

SCC	Description	Sector	EPA	S/L/T
2501080050	Petroleum and Petroleum Product Storage; Airports: Aviation Gasoline; Stage 1: Total	Gas Stations	X	X
2501080100	Petroleum and Petroleum Product Storage; Airports: Aviation Gasoline; Stage 2: Total	Gas Stations	X	X
2501080201	Petroleum and Petroleum Product Storage; Airports: Aviation Gasoline; Underground Tank: Breathing and Emptying	Gas Stations		X

The agencies listed in Table 4-47 submitted emissions for these sectors. Agencies not listed used EPA estimates for the entire sector.

Table 4-47: Agencies reporting emissions to gasoline distribution source categories

Agency	Bulk Gasoline Terminals	Gas Stations	Industrial Processes – Storage and Transfer
Alaska Department of Environmental Conservation	X		
California Air Resources Board	X	X	X
Coeur d'Alene Tribe	X	X	X
Connecticut Department of Energy and Environmental Protection	X		
Delaware Department of Natural Resources and Environmental Control		X	X
Idaho Department of Environmental Quality		X	X
Illinois Environmental Protection Agency	X	X	X
Knox County Department of Air Quality Management	X		
Kootenai Tribe of Idaho		X	X
Maricopa County Air Quality Department	X	X	X
Maryland Department of the Environment		X	X
Massachusetts Department of Environmental Protection		X	X
Memphis and Shelby County Health Department - Pollution Control	X	X	X
Metro Public Health of Nashville/Davidson County	X	X	X
New Hampshire Department of Environmental Services		X	X
New Jersey Department of Environment Protection	X	X	X
New York State Department of Environmental Conservation	X	X	X
Nez Perce Tribe	X	X	X
Salt River Pima Maricopa Indian Community (SRPMIC) EPNR		X	
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	X	X	X
Southern Ute Indian Tribe		X	
Texas Commission on Environmental Quality	X		
Utah Division of Air Quality	X	X	X
Virginia Department of Environmental Quality		X	X
Washoe County Health District		X	X

4.7.3   EPA-developed emissions

<u>Bulk Terminals</u>

The calculations for estimating VOC and HAP emissions from bulk terminals involve first multiplying the 1998 national VOC emissions developed in support of the Gasoline Distribution MACT standard by the ratio of the national volume of wholesale gasoline supplied between 1998 and 2017. Emissions from HAPs are calculated by multiplying VOC emissions by a national average speciation profile. National VOC and HAP emissions are allocated to states using data on refinery, bulk terminal, and natural gas plant stocks of motor gasoline in each state. State-level VOC and HAP emissions are then allocated to each county based on employment at petroleum

bulk stations and terminals from the US Census County Business Patterns data for NAICS 42471 (Petroleum Bulk Stations and Terminals).

Pipelines

The calculations for estimating VOC and HAP emissions from pipelines involve first multiplying the 1998 national VOC emissions developed in support of the Gasoline Distribution MACT standard by the 2017 to 1998 ratio of national volume of wholesale gasoline supplied. Emissions from HAPs are calculated by multiplying VOC emissions by a national average speciation profile. National VOC and HAP emissions are allocated to Petroleum Administration for Defense (PAD) District using data on the movement of finished motor gasoline in PAD District. PAD District-level VOC and HAP emissions are then allocated to each county based on employment at petroleum bulk stations and terminals from the US Census County Business Patterns data for NAICS 42471 (Petroleum Bulk Stations and Terminals).

Bulk Plants

The calculations for estimating VOC and HAP emissions from bulk plants involve first calculating bulk plant gasoline throughput in the US based on data from the U.S. Energy Information Administration (EIA). National bulk plant gasoline throughput is then allocated to each county based on the number of petroleum bulk stations and terminals from the US Census County Business Patterns data for NAICS 42471. The number of petroleum bulk stations and terminals by county is multiplied by the emissions factor for VOC to estimate VOC emissions from bulk plants. County-level benzene speciation profiles are multiplied by VOC emissions to estimate benzene emissions from bulk plants. National average speciation profiles for all other HAPs are multiplied by VOC emissions to estimate HAP emissions from bulk plants.

Tank Trucks in Transit

The calculations for estimating VOC and HAP emissions from tank trucks in transit involve first calculating county-level total gasoline consumption by summing onroad gasoline consumption and nonroad gasoline consumption in each county. County-level gasoline consumption is multiplied by the emissions factor for VOC to estimate VOC emissions from tank trucks in transit. County-level benzene speciation profiles are multiplied by VOC emissions to estimate benzene emissions from tank trucks in transit. National average speciation profiles for all other HAPs are multiplied by VOC emissions to estimate HAP emissions from tank trucks in transit.

Underground Storage Tank (UST) Breathing and Storing

The calculations for estimating VOC and HAP emissions from UST breathing and storing involve first calculating county-level gasoline consumption by summing onroad gasoline consumption and nonroad gasoline consumption in each county. County-level gasoline consumption is multiplied by the emissions factor for VOC to estimate VOC emissions from UST breathing and storing. County-level benzene speciation profiles are multiplied by VOC emissions to estimate benzene emissions from UST breathing and storing. National average speciation profiles for all other HAPs are multiplied by VOC emissions to estimate HAP emissions from UST breathing and storing.

Gasoline Service Station Unloading

The calculations for estimating VOC and HAP emissions from gasoline service station unloading involve first calculating county-level total gasoline consumption by summing monthly onroad gasoline consumption and nonroad gasoline consumption in each county by fuel subtype. Monthly county-level gasoline consumption is then allocated to submerged, splash, and balanced filling technologies based on assumptions about the

percentage of each filling technology used in each county. True vapor pressure is calculated for each county, month, and fuel subtype. Uncontrolled loading loss of liquid is calculated using true vapor pressure, temperature, molecular weight, and a saturation factor for the filling technology. Uncontrolled loading loss of liquid loaded is multiplied by monthly county-level gasoline consumption by fuel type to estimate VOC emissions from loading loss. Controlled VOC emissions are calculated by multiplying VOC emissions from loading loss by a control efficiency value. Controlled VOC emissions are subtracted from VOC emissions from loading loss to estimate monthly county-level VOC emissions by fuel subtype. Total county-level VOC emissions are calculated by summing monthly county-level VOC emissions by fuel subtype. County-level benzene speciation profiles are multiplied by VOC emissions to estimate benzene emissions from gasoline service station unloading. National average speciation profiles for all other HAPs are multiplied by VOC emissions to estimate HAP emissions from gasoline service station unloading.

Aviation Gasoline Stage 1

The calculations for estimating emissions from stage 1 aviation gasoline distribution involve first estimating the amount of aviation gasoline consumed in each county, based on state-level aviation gasoline consumption data from the Energy Information Administration (EIA). State-level aviation gasoline consumption is distributed to the counties based on the proportion of Landing-Take Offs (LTOs). The total amount of gasoline consumed is used to estimate non-fugitive and fugitive VOC emissions, as well as hazardous air pollutant (HAP) emissions.

Aviation Gasoline Stage 2

The calculations for estimating emissions from stage 2 aviation gasoline distribution involve first estimating the amount of aviation gasoline consumed in each county based on state-level aviation gasoline consumption data from the Energy Information Administration (EIA). State-level aviation gasoline consumption is distributed to the counties based on the proportion of Landing-Take Offs (LTOs). The total amount of gasoline consumed is used to estimate VOC and hazardous air pollutant (HAP) emissions.

4.7.3.1 *Activity data*

Bulk Terminals and Pipelines

Emissions from bulk terminals and pipelines are calculated by growing the 1998 emissions estimates developed in support of the Gasoline MACT standard. Therefore, there is no activity data for this source category.

Bulk Plants

The activity data for estimating emissions from bulk plants are national volume of bulk plant gasoline throughput. The EIA's Petroleum Navigator reports the volume of finished motor gasoline supplied in the U.S [ref 5]. The volume of finished motor gasoline is assumed to be the same as total gasoline consumption, and the volume of bulk plant gasoline throughput is assumed to be 9 percent of total gasoline consumption [ref 6].

$$GT_{US,bp} = V_{US} \times 0.09 \qquad\qquad (1)$$

Where:

$GT_{US, bp}$ = Bulk plant gasoline throughput in the U.S., in thousand barrels
V_{US} = Volume of finished motor gasoline in the U.S., in thousand barrels

Tank Trucks in Transit

The activity data for tank trucks in transit is county-level total gasoline consumption. County-level nonroad gasoline consumption is estimated by allocating MOVES derived state/SCC-level nonroad gasoline consumption to the county-level based on nonroad county/SCC-level CO_2 emissions [ref 7]. County-level onroad consumption was estimated by subtracting the NMIM-derived national nonroad consumption from the EIA's estimate of finished motor gasoline supplied and then allocating to counties using NMIM-derived onroad county-level CO_2 emissions [ref 7]. County-level onroad consumption and county-level nonroad consumption are estimated by summing county-level monthly consumption estimates.

$$GC_{OR,c} = \sum GC_{OR,m} \tag{2}$$

Where:

$GC_{OR,c}$ = Onroad gasoline consumption in county c, in gallons
$GC_{OR,m}$ = Onroad gasoline consumption in county c for month m, in gallons

$$GC_{NR,c} = \sum GC_{NR,m} \tag{3}$$

Where:

$GC_{NR,c}$ = Nonroad gasoline consumption in county c, in gallons
$GC_{NR,m}$ = Nonroad gasoline consumption in county c for month m, in gallons

County-level tank truck gasoline throughput is estimated by summing county-level onroad and nonroad estimates, and multiplying the sum by 1.09 to account for gasoline that is transported more than once in a given area (i.e., transported from bulk terminal to bulk plant and then from bulk plant to service station) [ref 6].

$$GC_{c,t} = (GC_{OR,c} + GC_{NR,c}) \times 1.09 \tag{4}$$

Where:

$GC_{c,t}$ = Total gasoline consumption in county c, in gallons
$GC_{OR,c}$ = Onroad gasoline consumption in county c, in gallons
$GC_{NR,c}$ = Nonroad gasoline consumption in county c, in gallons

Underground Storage Tank (UST) Breathing and Storing

The activity data for underground storage tank breathing and storing is county-level gasoline consumption, calculated as described above in the tank trucks in transit section.

Gasoline Service Station Unloading

The activity data for gasoline service station unloading is county-level total gasoline consumption for each month and fuel subtype from MOVES [ref 7].

County-level gasoline consumption is estimated by summing onroad gasoline consumption and nonroad gasoline consumption and multiplying the sum by 1.09 to account for gasoline that is transported more than once in a given area (i.e., transported from bulk terminal to bulk plant and then from bulk plant to service station) [ref 6].

$$GC_{c,t,m,f} = (GC_{c,OR,m,f} + GC_{c,NR,m,f}) \times 1.09 \qquad\qquad (5)$$

Where:

$GC_{c,t,m,f}$ = Total gasoline consumption in county c for month m for fuel subtype f, in gallons
$GC_{c,OR,m,f}$ = Onroad gasoline consumption in county c for month m for fuel subtype f, in gallons
$GC_{c,NR,m,f}$ = Nonroad gasoline consumption in county c for month m for fuel subtype f, in gallons

The county-level gasoline consumption is allocated to submerged, splash, and balanced filling technologies. Percentages of each filling technology are derived from the EIIP study [ref 8]. State, local, and tribal (SLT) agencies may submit input templates to update theses default assumptions about the percentage of delivered fuel by filling technology.

$$GC_{c,ft,m,f} = GC_{c,t,m,f} \times Perc_{ft,c} \qquad\qquad (6)$$

Where:

$GC_{c,ft,m,f}$ = Total gasoline consumption in county c for filling technology ft for month m for fuel subtype f, in gallons
$GC_{c,t,m,f}$ = Total gasoline consumption in county c for month m for fuel subtype f, in gallons
$Perc_{ft,c}$ = Percentage of filling technology ft in county c

Aviation Gasoline Stage 1 and 2

The activity data for this source category is the amount of aviation gasoline consumed, which is estimated using data from the EIA's State Energy Data System (SEDS) [ref 9]. The SEDS MSN Code AVTCP is used to identify the total consumption of aviation gasoline in units of thousand barrels. Data are then converted to units of gallons.

$$AG_s = AGB_s \times 42 \, ^{gallons}/_{barrel} \qquad\qquad (7)$$

Where:

AG_s = Annual consumption of AvGas for state s, in gallons
AGB_s = Annual consumption of AvGas for state s, in barrels

4.7.3.2 *Allocation procedure*

Bulk Terminals

Emissions from bulk terminals are calculated by growing the 1998 emissions estimates developed in support of the Gasoline MACT standard. The national-level emissions are allocated to the states based on the fraction of refinery, bulk terminal, and natural gas plant stocks in each state. The state-level emissions are distributed to the counties based on employment in NAICS 42471.

Pipelines

Emissions from pipelines are calculated by growing the 1998 emissions estimates developed in support of the Gasoline MACT standard. The national-level emissions are allocated to the PAD Districts based on data on the

movement of finished motor gasoline by pipeline between PAD Districts from the EIA. The emissions in each PAD District are distributed to the counties based on employment in NAICS 42471.

Bulk Plants

The national volume of bulk plant gasoline throughput is allocated to counties using County Business Patterns employment data for NAICS code 42471 (Petroleum Bulk Stations and Terminals) [ref 10]. The number of petroleum bulk stations and terminals is first summed to the national level.

$$Emp_{US} = \sum Emp_c \qquad (8)$$

Where:

Emp_{US}	=	Number of petroleum bulk stations and terminals in the U.S.
Emp_c	=	Number of petroleum bulk stations and terminals in county c

The fraction of petroleum bulk stations and terminals by county is calculated by dividing the total number of petroleum bulk stations and terminals in each county by the total number of petroleum bulk stations and terminals in the U.S.

$$EmpFrac_c = \frac{Emp_c}{Emp_{US}} \qquad (9)$$

Where:

$EmpFrac_c$	=	Total fraction of petroleum bulk stations and terminals in county c
Emp_c	=	Number of petroleum bulk stations and terminals in county c
Emp_{US}	=	Number of petroleum bulk stations and terminals in the U.S.

The county-level volume of bulk plant gasoline throughput is calculated by multiplying the fraction of petroleum bulk stations and terminals in each county by the national volume of bulk plant gasoline throughput.

$$GT_{c.bp} = GT_{US,bp} \times EmpFrac_c \qquad (10)$$

Where:

$GT_{c,bp}$	=	Bulk plant gasoline throughput in county c, in thousand barrels
$GT_{US,bp}$	=	Bulk plant gasoline throughput in the U.S., in thousand barrels, from equation 1
$EmpFrac_c$	=	Total fraction of petroleum bulk stations and terminals in county c

Due to concerns with releasing confidential business information, the CBP does not release exact numbers for a given NAICS code if the data can be traced to an individual business. Instead, a series of range codes is used. Many counties and some smaller states have only one petroleum bulk station and terminal facility, leading to withheld data in the county and/or state business pattern data. To estimate employment in counties and states with withheld data, the following procedure is used for NAICS code 42471.

To gap-fill withheld state-level employment data:

   a. State-level data for states with known employment in NAICS 42471 are summed to the national level.
   b. The total sum of state-level known employment from step a is subtracted from the national total

reported employment for NAICS 42471 in the national-level CBP to determine the employment total for the withheld states.

c. Each of the withheld states is assigned the midpoint of the range code reported for that state. Table 4-48 lists the range codes and midpoints.
d. The midpoints for the states with withheld data are summed to the national level.
e. An adjustment factor is created by dividing the number of withheld employees (calculated in step b of this section) by the sum of the midpoints (step d).
f. For the states with withheld employment data, the midpoint of the range for that state (step c) is multiplied by the adjustment factor (step e) to calculate the adjusted state-level employment for landfills.

These same steps are then followed to fill in withheld data in the county-level business patterns.

g. County-level data for counties with known employment are summed by state.
h. County-level known employment is subtracted from the state total reported in state-level CBP (or, if the state-level data are withheld, from the state total estimated using the procedure discussed above).
i. Each of the withheld counties is assigned the midpoint of the range code (Table 4-48).
j. The midpoints for the counties with withheld data are summed to the state level.
k. An adjustment factor is created by dividing the number of withheld employees (step h) by the sum of the midpoints (step j).
l. For counties with withheld employment data, the midpoints (step i) are multiplied by the adjustment factor (step k) to calculate the adjusted county-level employment for landfills.

Table 4-48: Ranges and midpoints for data withheld from state and county business patterns

Employment Code	Ranges	Midpoint
A	0-19	10
B	20-99	60
C	100-249	175
E	250-499	375
F	500-999	750
G	1,000-2,499	1,750
H	2,500-4,999	3,750
I	5,000-9,999	7,500
J	10,000-24,999	17,500
K	25,000-49,999	37,500
L	50,000-99,999	75,000
M	100,000+	

Tank Trucks in Transit, Underground Storage Tank (UST) Breathing and Storing, and Gasoline Service Station Unloading

The activity data for these sources is available at the county-level; therefore, county allocation is not needed.

Aviation Gasoline Distribution Stage 1 and 2

State-level gasoline consumption (from equation 7) is allocated to the county-level using the ratio of county-to-state-level LTOs. State and county LTO data for 2017 were compiled by the U.S. EPA's Office of Air Quality,

Planning and Standards (OAQPS) [ref 11].

$$RLTO_c = \frac{LTO_c}{LTO_s} \qquad (11)$$

Where:

RLTOc = The ratio of landing-take offs (LTOs) in county *c*
LTOc = The number of LTOs in county *c*
LTOs = The number of LTOs in state *s*

LTO data for turbine-powered airplanes were excluded because turbine-powered planes do not use aviation gasoline. Additionally, LTOs at airports that do not have aviation gasoline refueling, according to data from FAA Form 5010, were also excluded [ref 12].

The state-level gasoline consumption values from equation 7 are multiplied by the proportion of LTOs in each county to estimate the county-level amount of aviation gasoline consumed.

$$AG_c = AG_s \times RLTO_c \qquad (12)$$

Where:

AG$_c$ = Annual consumption of AvGas in county *c*, in gallons
RLTOc = The ratio of landing-take offs (LTOs) in county *c*

4.7.3.3   *Emission factors*

Bulk Terminals

Emissions from bulk terminals are calculated by growing the 1998 emissions estimates developed in support of the Gasoline MACT standard. Therefore, there are no activity-based emissions factors for bulk terminals.

HAP emissions are estimated using speciation profiles shown in Table 4-49. Note that the values shown in Table 4-49 are percentages and should be divided by 100 before being multiplied by the VOC emissions.

Table 4-49: HAP speciation factors for stage I gasoline distribution.

HAP	Pollutant Code	Percentage of VOC Emissions	Reference
Benzene	71432	0.27	13
2,2,4-Trimethylpentane	540841	0.75	13
Cumene	98828	0.012	13
Ethyl Benzene	100414	0.053	13
n-Hexane	110543	1.8	13
Naphthalene	91203	0.00027	13
Toluene	108883	1.4	13
Xylenes	1330207	0.56	13

Pipelines

Emissions from pipelines are calculated by growing the 1998 emissions estimates developed in support of the

Gasoline MACT standard. Therefore, there are no activity-based emissions factors for pipelines. HAP emissions are estimated using speciation profiles shown in Table 4-49.

Bulk Plants

The VOC emissions factor for bulk plants is 8.62 pounds of VOC per 1,000 gallons of gasoline [ref 13]. HAP emissions are calculated using speciation profiles from Table 4-49, with the exception of benzene. Speciation profiles for benzene emissions from bulk plants are based on county-specific refueling emissions data from MOVES [ref 14].

Tank Trucks in Transit

The VOC emissions factor for tank trucks in transit is 0.06 pounds of VOC per 1,000 gallons of gasoline. As shown in Table 4-50, the VOC emission factor is the sum of the individual emission factors reported in the Gasoline Distribution EIIP guidance document for gasoline-filled trucks (traveling to service station/bulk plant for delivery) and vapor-filled trucks (traveling to bulk terminal/plant for reloading) [ref 3].

Table 4-50: Tank trucks in transit VOC emission factors

Transit Type	VOC Emission Factor	Reference
Vapor-Filled Trucks	0.055 lb/1,000 gallons	7
Gasoline Filled Trucks	0.005 lb/1,000 gallons	7
Total	**0.06 lb/1,000 gallons**	

HAP emissions are calculated using speciation profiles from Table 4-49, except for benzene. Speciation profiles for benzene emissions from bulk plants are based on county-specific refueling emissions data from MOVES.

Underground Storage Tank (UST) Breathing and Storing

The VOC emissions factor for underground storage tank breathing and storing is 1 pound per 1,000 gallons. The VOC emissions factor for underground storage tank breathing and storing is recommended by the Gasoline Distribution EIIP guidance document [ref 3].

HAP emissions are calculated using speciation profiles from Table 4-49, except for benzene. Speciation profiles for benzene emissions from bulk plants are based on county-specific refueling emissions data from MOVES.

Gasoline Service Station Unloading

To calculate the VOC emissions factor for gasoline service station unloading, first calculate the true vapor pressure for each county and month using the following equation and data from MOVES [ref 7]: Geographic-specific information on the temperature of gasoline and the method of loading were obtained from a Stage I and II gasoline emission inventory study prepared for the EIIP.

The true vapor pressure is calculated using the following equation:

$$P_{c,m,f} = \left\{ \left[0.7553 - \left(\frac{413}{T_{c.m} + 459.6} \right) \right] S^{0.5} \log_{10}(RVP_{c,m,f}) - \left[1.854 - \left(\frac{1042}{T_{c.m} + 459.6} \right) \right] S^{0.5} \right. \tag{13}$$
$$\left. + \left[\left(\frac{2416}{T_{c.m} + 459.6} \right) - 2.013 \right] \log_{10}(RVP_{c,m,f}) - \left(\frac{8742}{T_{c.m} + 459.6} \right) + 15.64 \right\}$$

Where:

$P_{c,m,f}$ = Stock true vapor pressure for county c in month m for fuel subtype f, in pounds per square inch absolute

$T_{c,m}$ = Stock temperature for county c in month m, in degrees Fahrenheit

$RVP_{c,m,f}$ = Reid vapor pressure for county c in month m for fuel subtype f, in pounds per square inch

S = Slope of the ASTM distillation curve at 10 percent evaporated, in degrees Fahrenheit per percent (assumed that S=3.0 for gasoline per Figure 7.1-14a of AP-42) [ref 13]

The following equation is used to calculate the VOC emissions factor for gasoline service station unloading:

$$L_{c,m,f} = 12.46 \times S_{ft} \times P_{c,m,f} \times M/T \tag{14}$$

Where:

$L_{c,m,f}$ = Uncontrolled loading loss of liquid loaded, in pounds per thousand gallons

S_{ft} = Saturation factor for filling technology ft

$P_{c,m,f}$ = True vapor pressure of liquid loaded, in pounds per square inch absolute

M = Molecular weight of vapors, in pounds per pound per mole

T = Temperature of liquid loaded (Rankine) [ref 8]

HAP emissions are calculated using speciation profiles from Table 4-49, except for benzene. Speciation profiles for benzene emissions from bulk plants are based on county-specific refueling emissions data from MOVES.

Aviation Gasoline Distribution Stage 1

Emission factors for stage 1 aviation gasoline distribution are reported in Table 4-51 and Table 4-52. The emissions factors for fugitive and non-fugitive VOC are taken from the TRC report *Estimation of Alkylated Lead Emissions, Final Report* [ref 4]. The emissions factors for the HAPs are taken from multiple sources: the TRC report; the EPA report *Locating and Estimating Air Emissions from Source of Ethylene Dichloride* [ref 14]; a memorandum to EPA/OAQPS [ref 15], and a personal email between EPA/OAQPS employees [ref 16]. The tables list the emission factors as reported in the original references, and the emission factors that have been converted (if necessary) for use in the NEI emissions calculations.

Table 4-51: VOC Emissions Factors for Aviation Gasoline Distribution-Stage 1 (2501080050)

Pollutant	Emission Source	Emission Factor (original)	Emission Factor Units (original)	Emission Factor (converted)	Emission Factor Units (converted)	Factor Reference
VOC	Aviation Gas Unloading/ Tank Filling - tank fill	1,081	mg/l gasoline*	9.02E-3	LB/GAL AvGas	Table 7 in Reference 4
	Aviation Gas Unloading/ Tank Filling - Storage tank working	432		3.61E-3		
	Aviation Gas Tank Truck Filling - Composite	1,235		1.03E-2		
	Aviation Gas Storage Tank - Breathing losses	203		1.69E-3		
	Aviation Gas - Fugitive from valves	0.26	kg/valve/day	5.73E-1	LB/valve/day	
	Aviation Gas - Fugitive from pumps	2.7	kg/seal/day	5.95E0	LB/seal/day	

* Converted from mg/l to LB/GAL using conversion factors of 3.785 liters per gallon and 453,592 mg per pound.

Table 4-52: HAP Emissions Factors for Aviation Gasoline Distribution-Stage 1 (2501080050)

Pollutant	Pollutant Code	Emission Factor (original)	Emission Factor Units (original)	Emission Factor (converted)	Emission Factor Units (converted)	Factor Reference
Ethylene Dichloride	107062	0.26	mg/l gasoline*	2.17E-6	LB/GAL AvGas	14
Lead**	7439921			6.27E-6	LB/ LB VOC	4
2,2,4-Trimethylpentane	540841			8.00E-3		15
Benzene	71432			9.00E-3		
Cumene	98828			1.00E-4		16
Ethylbenzene	100414			1.00E-3		15
Hexane	110543			1.60E-2		
Naphthalene	91203			5.00E-4		
Toluene	108883			1.30E-2		
Xylene	1330207			5.00E-3		

* Converted from mg/l to LB/GAL using conversion factors of 3.785 liters per gallon and 453,592 mg per pound.

** The 2011 NEI included tetraethyl lead (TEL) with an emission factor of 9.78E-6 lbs./lb. VOC. In 2017, EPA only accounts for the emissions of elemental lead. The TEL emission factor was modified by multiplying by the ratio of the atomic mass of lead to the atomic mass of TEL, or 64.06%.

Aviation Gasoline Distribution Stage 2

Emission factors for stage 2 of aviation gasoline distribution are reported in Table 4-53 and Table 4-54. The emissions factors for VOC are taken from the TRC report *Estimation of Alkylated Lead Emissions, Final Report* [ref 4]. The emissions factors for the HAPs are taken from multiple sources: the TRC report; the EPA report

Locating and Estimating Air Emissions from Source of Ethylene Dichloride [ref 14]; a memorandum to EPA/OAQPS [ref 15]; and a personal email between OAQPS employees [ref 16]. The tables list the emission factors as reported in the original references, and the emission factors that have been converted (if necessary) for use in the NEI emissions calculations.

Table 4-53: VOC Emissions Factors for Aviation Gasoline Distribution-Stage 2 (2501080100)

Pollutant	Emission Source	Emission Factor (original)	Emission Factor Units (original)	Emission Factor	Emission Factor Units	Factor Reference
VOC	Fuel Transfer from Tanker Trucks to General Aviation Aircraft	1,420*	mg/l gasoline**	8.27E-4	LB/GAL AvGas	4

* This emission factor represents the sum of the emission factor for uncontrolled displacement losses (1,340 mg/l) and spillage (80 mg/l).

** Converted from mg/l to LB/GAL using conversion factors of 3.785 liters per gallon and 453,592 mg per pound.

Table 4-54: HAP Emissions Factors for Aviation Gasoline Distribution-Stage 2 (2501080100)

Pollutant	Pollutant Code	Emission Source	Emission Factor (original)	Emission Factor Units (original)	Emission Factor (converted)	Emission Factor Units (converted)	Factor Reference
Ethylene Dichloride	107062	All processes	0.226*	mg/l gasoline**	1.88 E-6	LB/GAL AvGas	14
Lead***	7439921	All processes			8.50 E-8		4
2,2,4-Trimethylpentane	540841	All processes			8.00E-3		15
Benzene	71432	All processes			9.00E-3		
Cumene	98828	All processes			1.00E-4		16
Ethylbenzene	100414	All processes			1.00E-3	LB/ LB VOC	
Hexane	110543	All processes			1.60E-2		
Naphthalene	91203	All processes			5.00E-4		15
Toluene	108883	All processes			1.30E-2		
Xylene	1330207	All processes			5.00E-3		

 * This emission factor represents the sum of the emission factor for uncontrolled displacement losses (0.21 mg/l) and spillage (0.016 mg/l).

** Converted from mg/l to LB/GAL using conversion factors of 3.785 liters per gallon and 453,592 mg per pound.

*** The 2011 NEI included tetraethyl lead (TEL) with an emission factor of 9.78E-6 LB/GAL AvGas. In 2017, EPA only accounts for the emissions of elemental lead. The TEL emission factor was modified by multiplying by the ratio of the atomic mass of lead to the atomic mass of TEL, or 64.06%.

4.7.3.4 Controls

There are county-level control efficiencies for service station unloading, including assumptions about the percentage of gasoline unloaded under different filling technologies: splash, submerged, or balanced. There are no controls assumed for all other sources.

4.7.3.5 Emissions

Bulk Terminals

Emissions of VOCs for bulk terminals and pipelines are calculated by multiplying 1998 national emissions estimates developed in support of the Gasoline Distribution MACT standard (Table 4-55) by the 2017 to 1998 ratio of the national volume of wholesale gasoline supplied [ref 17, ref 18]. Emissions are converted from megagrams (Mg) to tons.

$$E_{VOC,US,bt} = E_{MACT,US,bt} \times \frac{G_{2017}}{G_{1998}} \times 1.1023 \; ton \; per \; Mg \tag{15}$$

Where:

$E_{VOC,US,bt}$	=	Annual national-level emissions of VOC from bulk terminals, in tons
$E_{MACT,US,bt}$	=	1998 national VOC emission estimates developed for Gasoline Distribution MACT standard from bulk terminals, in Mg
G_{2017}	=	National volume of wholesale gasoline supplied in 2017, in thousand barrels per day
G_{1998}	=	National volume of wholesale gasoline supplied in 1998, in thousand barrels per day

Table 4-55: 1998 Post-MACT Control Emissions

Emission Point	1998 Post-MACT Control Emissions (Mg)	Reference
Pipelines	79,830	5
Bulk Terminals	137,555	5

National VOC emissions are allocated to states using the fraction of refinery, bulk terminal, and natural gas plant stocks of motor gasoline in each state (see Table 4-56) [ref 19].

$$GasFrac_s = \frac{M_s}{M_{US}} \tag{16}$$

Where:

$GasFrac_s$	=	Fraction of motor gasoline in state s
M_s	=	Amount of motor gasoline in state s
M_{US}	=	Amount of motor gasoline in the U.S.

Table 4-56: Refinery, Bulk Terminal, and Natural Gas Plant Stocks of Motor Gasoline, 2017

State	Motor Gasoline (Thousand Barrels)	State	Motor Gasoline (Thousand Barrels)
Alabama	205	Montana	357
Alaska	793	Nebraska	92
Arizona	87	Nevada	146
Arkansas	175	New Hampshire	*
California	286	New Jersey	376
Colorado	190	New Mexico	108
Connecticut	*	New York	17
Delaware	*	North Carolina	200
District of Columbia	*	North Dakota	48
Florida	732	Ohio	970
Georgia	268	Oklahoma	348
Hawaii	1	Oregon	68
Idaho	276	Pennsylvania	25
Illinois	410	Rhode Island	*
Indiana	352	South Carolina	228
Iowa	183	South Dakota	77
Kansas	325	Tennessee	195
Kentucky	378	Texas	3,855
Louisiana	1,662	Utah	127
Maine	*	Vermont	30
Maryland	*	Virginia	150
Massachusetts	7	Washington	383
Michigan	266	West Virginia	36
Minnesota	363	Wisconsin	133
Mississippi	1,213	Wyoming	455
Missouri	202	**Total**	16,798

* No Data Reported

The fraction of stocks of motor gasoline in each state is then used to distribute the VOC and HAP emissions.

$$E_{VOC,bt,s} = GasFrac_s \times E_{VOC,US,bt} \tag{17}$$

Where:

$E_{VOC,bt,s}$ = Annual VOC emissions in state *s* from bulk terminals, in tons
$GasFrac_s$ = Fraction of motor gasoline in state *s*
$E_{VOC,US,bt}$ = Annual national-level VOC emissions from bulk terminals, in tons

State-level VOC emissions are allocated to counties using the fraction of petroleum bulk stations and terminals facilities employees in each county from the US Census County Business patterns data for NAICS code 42471 [ref 10].

$$EmpFrac_c = \frac{Emp_c}{Emp_s} \tag{18}$$

Where:

$EmpFrac_c$ = Fraction of petroleum bulk stations and terminals facilities employees in county c
Emp_c = Number of petroleum bulk stations and terminals facilities employees in county c
Emp_s = Number of petroleum bulk stations and terminals facilities employees in state s

Due to concerns with releasing confidential business information, the CBP does not release exact numbers for a given NAICS code if the data can be traced to an individual business. Instead, a series of range codes is used. Many counties and some smaller states have only one petroleum bulk station and terminal facility, leading to withheld data in the county and/or state business pattern data. To estimate employment in counties and states with withheld data, the procedure discussed in Section 4.7.3.2 is used for NAICS code 42471.

The fraction of petroleum bulk stations and terminals facilities employees in each county is then used to distribute the VOC emissions.

$$E_{VOC,bt,c} = EmpFrac_c \times E_{VOC,bt,s} \tag{19}$$

Where:

$E_{VOC,bt,c}$ = Annual VOC emissions from bulk terminals in county c, in tons
$EmpFrac_c$ = Fraction of petroleum bulk stations and terminals facilities employees in county c
$E_{VOC,bt,s}$ = Annual VOC emissions from bulk terminals in state s, in tons

Emissions of HAPs are calculated by multiplying emissions of VOCs by a national average speciation profile (Table 4-49) [ref 20].

$$E_{p,c,bt} = E_{VOC,c,bt} \times S_p \tag{20}$$

Where:

$E_{p,bt}$ = Annual emissions of pollutant p in county c from bulk terminal, in tons
$E_{VOC,bt}$ = Annual VOC emissions in county c from bulk terminals, in tons
S_p = Speciation profile of pollutant p, as a fraction of VOC emissions

Pipelines

Emissions of VOCs for pipelines are calculated by multiplying 1998 national estimates developed in support of the Gasoline Distribution MACT standard (Table 4-55) by the 2017 to 1998 ratio of the national volume of wholesale gasoline supplied [ref 17, ref 18]. Emissions are converted to tons.

$$E_{VOC,US,pl} = E_{MACT,US.,pl} \times \frac{G_{2017}}{G_{1998}} \times 1.1023 \ ton \ per \ Mg \tag{21}$$

Where:

$E_{VOC,US,pl}$ = Annual national-level emissions of VOC from pipelines, in tons
$E_{MACT,US,pl}$ = 1998 national VOC emission estimates developed for Gasoline Distribution MACT standard from pipelines, in Mg
G_{2017} = National volume of wholesale gasoline supplied in 2017, in thousand barrels per day
G_{1998} = National volume of wholesale gasoline supplied in 1998, in thousand barrels per day

National VOC and HAP emissions are allocated to PAD Districts using the fraction of the total amount of finished motor gasoline that originated in each PAD District in 2017. There are five PAD Districts across the United States. PAD District 1 comprises seventeen states plus the District of Columbia along the Atlantic Coast; PAD District 2 comprises fifteen states in the Midwest; PAD District 3 comprises six states in South Central U.S.; PAD District 4 comprises five states in the Rocky Mountains; and PAD District 5 comprises seven states along the West Coast. These data, which are displayed below in Table 4-57, are reported in Table 37 of Volume 1 of Petroleum Supply Annual 2017 [ref 21]. States in each PAD District are shown in Table 4-58.

$$PADDFrac_{PD} = \frac{M_{PD}}{M_{US}} \tag{22}$$

Where:

$PADDFrac_{PD}$ = Fraction of motor gasoline in PAD District PD
M_{PD} = Amount of finished motor gasoline in PAD District PD, in thousand barrels
M_{US} = Amount of finished motor gasoline in the U.S., in thousand barrels

$$E_{VOC,PD,pl} = PADDFrac_{PD} \times E_{VOC,US,pl} \tag{23}$$

Where:

$E_{VOC,PD,pl}$ = Annual VOC emissions from pipelines in PAD District PD, in tons
$PADDFrac_{PD}$ = Fraction of motor gasoline in PAD District PD
$E_{VOC,US,pl}$ = Annual national-level VOC emissions of from pipelines, in tons

Pipeline emissions in each PAD District are allocated to counties based on County Business Patterns employment data. Because employment data for NAICS code 48691 (Pipeline Transportation of Refined Petroleum Products) are often withheld due to confidentiality reasons, the number of employees in NAICS code 42471 (Petroleum Bulk Stations and Terminals) are used for this allocation. To better account for the location of refined petroleum pipelines, however, no activity is allocated to States which had employees in this NAICS code but did not have employees in NAICS code 48691 (i.e., District of Columbia, Idaho, Maine, New Hampshire, Vermont, and West Virginia). To allocate pipeline emissions in each PAD District to counties, first the county level employment data for NAICS code 42471 is summed to the PAD District.

$$Emp_{PD} = \sum Emp_c \tag{24}$$

Where:

Emp_{PD} = Number of petroleum bulk stations and terminals facilities employees in PAD District PD
Emp_c = Number of petroleum bulk stations and terminals facilities employees in county c

The fraction of petroleum bulk stations and terminals employees in each county is used to allocate the emissions from the PAD District to counties.

$$EmpFrac_c = \frac{Emp_c}{Emp_{PD}} \tag{25}$$

Where:

$EmpFrac_c$ = Fraction of petroleum bulk stations and terminals facilities employees in county c

Emp_c = Number of petroleum bulk stations and terminals facilities employees in county c

Emp_{PD} = Number of petroleum bulk stations and terminals facilities employees in PAD District PD

Due to concerns with releasing confidential business information, the CBP does not release exact numbers for a given NAICS code if the data can be traced to an individual business. Instead, a series of range codes is used. Many counties and some smaller states have only one petroleum bulk station and terminal facility, leading to withheld data in the county and/or state business pattern data. To estimate employment in counties and states with withheld data, the procedure discussed in Section 4.7.3.2 is used for NAICS code 42471.

The fraction of petroleum bulk stations and terminals facilities employees in each county is then used to distribute the VOC emissions.

$$E_{VOC,c,pl} = EmpFrac_c \times E_{VOC,PD,pl} \tag{26}$$

Where:

$E_{VOC,c,pl}$ = Annual VOC emissions from pipelines in county c, in tons

$EmpFrac_c$ = Fraction of petroleum bulk stations and terminals facilities employees in county c

$E_{VOC,PD,pl}$ = Annual VOC emissions from pipelines in PAD District PD, in tons

Emissions of HAPs are calculated by multiplying emissions of VOCs by a national average speciation profile [ref 13]. Table 4-49 includes these speciation profiles. Total VOC emission estimates are used so emissions represent total emissions.

$$E_{p,c,pl} = E_{VOC,c,pl} \times S_p \tag{27}$$

Where:

$E_{p,c,pl}$ = Annual emissions of pollutant p from pipelines in county c, in tons

$E_{VOC,c,pl}$ = Annual VOC emissions from pipelines in county c, in tons

S_p = Speciation profile of pollutant p, as a fraction of VOC emissions

Table 4-57: Movement of Finished Motor Gasoline (thousand barrels) by Pipeline in PAD Districts, 2017

PADD	Gasoline Moved (thousand barrels)	PADD Fraction
1	40,770	0.34
2	20,438	0.17
3	44,536	0.37
4	10,034	0.08
5	3,856	0.03

Table 4-58: States by PAD District

PAD District 1	PAD District 2	PAD District 3	PAD District 4	PAD District 5
Connecticut	Illinois	Alabama	Colorado	Alaska
Delaware	Indiana	Arkansas	Idaho	Arizona
Florida	Iowa	Louisiana	Montana	California
Georgia	Kansas	Mississippi	Utah	Hawaii

PAD District 1	PAD District 2	PAD District 3	PAD District 4	PAD District 5
Maine	Kentucky	New Mexico	Wyoming	Nevada
Maryland	Michigan	Texas		Oregon
Massachusetts	Minnesota			Washington
New Hampshire	Missouri			
New Jersey	Nebraska			
New York	North Dakota			
North Carolina	Ohio			
Pennsylvania	Oklahoma			
Rhode Island	South Dakota			
South Carolina	Tennessee			
Vermont	Wisconsin			
Virginia				
West Virginia				

Bulk Plants

VOC emissions from bulk plants are estimated by multiplying the VOC emission factor by county-level volume of bulk plant gasoline throughput.

$$E_{VOC,c,bp} = EF_{VOC,bp}/1000 \; gallons \times GT_{c,bp} \times 42 \; gallons \; per \; barrel \qquad (28)$$

Where:

$E_{VOC,c,bp}$ = Annual emissions of VOC from bulk plants in county c, in pounds
$EF_{VOC,bp}$ = Emissions factor for VOC from bulk plants, in pounds per 1,000 gallons
$GT_{c,bp}$ = Gasoline throughput for bulk plants in county c, in thousand barrels

Benzene emissions are estimated by multiplying VOC emissions by county-level speciation profiles from MOVES [ref 7].

$$E_{BZ,c,bp} = E_{VOC,c,bp} \times S_{BZ,c} \qquad (29)$$

Where:

$E_{BZ,c,bp}$ = Annual emissions of benzene from bulk plants in county c, in pounds
$E_{VOC,c,bp}$ = Annual emissions of VOC from bulk plants in county c, in pounds
$S_{BZ,c}$ = Speciation profile for benzene for bulk plants in county c, as a fraction of VOC

All other HAPs emissions are estimated by multiplying VOC emissions by the national average speciation profiles displayed in Table 4-49.

$$E_{p,c,bp} = E_{VOC,c,bp} \times S_{p,c} \qquad (30)$$

Where:

$E_{p,c,bp}$ =   Annual emissions of pollutant p from bulk plants in county c, in pounds
$E_{VOC,c,bp}$ =   Annual emissions of VOC from bulk plants in county c, in pounds
$S_{p,c}$ =   Speciation profile for pollutant p for bulk plants in county c, as a fraction of VOC

Tank Trucks in Transit

VOC emissions from tank trucks in transit are calculated by multiplying county-level total gasoline consumption by the VOC emission factor for tank trucks in transit.

$$E_{VOC,c,tt} = EF_{VOC,tt} \times \frac{GC_{c,t}}{1000 \; gallons} \tag{31}$$

Where:

$E_{VOC,c,tt}$ =   Annual emissions of VOC from tank trucks in transit in county c, in pounds
$EF_{VOC,tt}$ =   Emissions factor for VOC from tank trucks in transit, in pounds per 1,000 gallons
$GC_{c,t}$ =   Gasoline consumption for tank trucks in transit in county c, gallons

Benzene emissions are estimated by multiplying VOC emissions by county-level speciation profiles from MOVES.

$$E_{BZ,c,tt} = E_{VOC,c,tt} \times S_{BZ,c} \tag{32}$$

Where:

$E_{BZ,c,tt}$ =   Annual emissions of benzene from tank trucks in transit in county c, in pounds
$E_{VOC,c,tt}$ =   Annual emissions of VOC from tank trucks in transit in county c, in pounds
$S_{BZ,c}$ =   Speciation profile for benzene for tank trucks in transit in county c, as a fraction of VOC

All other HAPs emissions are estimated by multiplying VOC emissions by the national average speciation profiles in Table 4-49.

$$E_{p,c,tt} = E_{VOC,c,tt} \times S_{p,c} \tag{33}$$

Where:

$E_{p,c,tt}$ = Annual emissions of pollutant p from tank trucks in transit in county c, in pounds
$E_{VOC,c,tt}$ = Annual emissions of VOC from tank trucks in transit in county c, in pounds
$S_{p,c}$ = Speciation profile for pollutant p for tank trucks in transit in county c, as a fraction of VOC

Underground Storage Tank (UST) Breathing and Storing

VOC emissions from UST breathing and storing are calculated by multiplying county-level total gasoline consumption by the VOC emission factor for UST breathing and storing.

$$E_{VOC,c,ust} = EF_{VOC,ust} \times \frac{GC_{c,t}}{1000 \; gallons} \tag{34}$$

Where:

$E_{VOC,c,ust}$ = Annual emissions of VOC from UST breathing and storing in county c, in pounds
$EF_{VOC,ust}$ = Emissions factor for VOC from UST breathing and storing, in pounds per 1,000 gallons
$GC_{c,t}$ = Gasoline consumption for UST breathing and storing in county c, in gallons

Benzene emissions are estimated by multiplying VOC emissions by county-level speciation profiles from MOVES.

$$E_{BZ,c,ust} = E_{VOC,c,ust} \times S_{BZ,c} \tag{35}$$

Where:

$E_{BZ,c,ust}$ = Annual emissions of benzene from UST breathing and storing in county c, in pounds
$E_{VOC,c,ust}$ = Annual emissions of VOC from UST breathing and storing in county c, in pounds
$S_{BZ,c}$ = Speciation profile for benzene for UST breathing and storing in county c, as a fraction of VOC

All other HAPs emissions are estimated by multiplying VOC emissions by the national average speciation profiles displayed in Table 4-49.

$$E_{p,c,ust} = E_{VOC,c,ust} \times S_{p,c} \tag{36}$$

Where:

$E_{p,c,ust}$ = Annual emissions of pollutant p from UST breathing and storing in county c, in pounds
$E_{VOC,c,ust}$ = Annual emissions of VOC from UST breathing and storing in county c, in pounds
$S_{p,c}$ = Speciation profile for pollutant p for UST breathing and storing in county c, as a fraction of VOC

Gasoline Service Station Unloading

County-level uncontrolled loading loss of liquid loaded VOC emissions are calculated by multiplying the loading loss calculated in equation 9 by the total gasoline consumption in each county for each filling technology.

$$E_{VOC,c,m,f,ft,ll} = \frac{GC_{c,ft,m,f}}{1000 \ gallons} \times L_{c,m,f} \tag{37}$$

Where:

$E_{VOC,c,m,f,ft,ll}$ = VOC emissions from loading loss in county c for month m for filling technology ft and fuel subtype f, in pounds
$GC_{c,ft,m,f}$ = Total gasoline consumption in county c for month m for filling technology ft and fuel subtype f, in gallons
$L_{c,m,f}$ = Uncontrolled loading loss of liquid loaded for county c for month m and fuel subtype f, in pounds per thousand gallons

County-level controlled VOC emissions are calculated by multiplying loading loss VOC emissions by a county-level control efficiency [ref 8]. Emissions are divided by 100 to convert the control efficiency from a percentage.

$$E_{VOC,c,m.f,ft,ct} = E_{VOC,c,m,f,ft,ll} \times CE_c/100 \qquad (38)$$

Where:

$E_{VOC,c,m,f,ft,ct}$ = Controlled VOC emissions in county c for month m for filling technology ft and fuel subtype f, in pounds

$E_{VOC,c,m,f,ft,ll}$ = VOC emissions from loading loss in county c month m for filling technology ft and fuel subtype f, in pounds

CE_c = Control efficiency value for county c, as a percentage

County-level monthly VOC emissions by fuel subtype and filling technology are calculated by subtracting controlled VOC emissions from VOC emissions from loading loss.

$$E_{VOC,c,m,f,ft} = E_{VOC,c,m,f,ft,ll} - E_{VOC,c,m.f,ft,ct} \qquad (39)$$

Where:

$E_{VOC,c,m,f,ft}$ = VOC emissions in from gasoline service station unloading county c for month m for filling technology ft and fuel subtype f, in pounds

$E_{VOC,c,m,f,ft,ct}$ = Controlled VOC emissions in county c for month m for filling technology ft and fuel subtype f, in pounds

$E_{VOC,c,m,f,ft,ll}$ = VOC emissions from loading loss in county c month m for filling technology ft and fuel subtype f, in pounds

County-level total VOC emissions by filling technology are calculated by summing VOC emissions for each month and fuel subtype.

$$E_{VOC,c,ft} = \sum E_{VOC,c,m,f,ft} \qquad (40)$$

Where:

$E_{VOC,c,ft}$ = Annual VOC emissions in from filling type ft for gasoline service station unloading for county c, in pounds

$E_{VOC,c,m,f,ft}$ = VOC emissions in from gasoline service station unloading county c for month m for filling technology ft and fuel subtype f, in pounds

Benzene emissions are estimated by multiplying VOC emissions by county-level speciation profiles from MOVES.

$$E_{BZ,c,ssu} = E_{VOC,c,ssu} \times S_{BZ,c} \qquad (41)$$

Where:

$E_{BZ,c,ssu}$ = Annual emissions of benzene from gasoline service station unloading in county c, in pounds

$E_{VOC,c,ssu}$ = Annual emissions of VOC from gasoline service station unloading in county c, in pounds

$S_{BZ,c}$ = Speciation profile for benzene for gasoline service station unloading in county c, as a fraction of VOC

All other HAPs emissions are estimated by multiplying VOC emissions by the national average speciation profiles displayed in Table 4-49.

$$E_{p,c,ust} = E_{VOC,c,ust} \times S_{p,c} \qquad (42)$$

Where:

$E_{p,c,ssu}$ =   Annual emissions of pollutant p from gasoline service station unloading in county c, in pounds
$E_{VOC,c,ssu}$ =   Annual emissions of VOC from gasoline service station unloading in county c, in pounds
$S_{p,c}$ =   Speciation profile for pollutant p for gasoline service station unloading in county c, as a fraction of VOC

<u>Aviation Gasoline Distribution Stage 1</u>

The annual aviation gasoline consumed in each county is used with the emissions factors in Table 4-51 and Table 4-52 to estimate emissions. Emissions of non-fugitive VOC from multiple sources, including tank truck filling and storage tank breathing, are estimated by multiplying gasoline consumed by the emissions factor in Table 4-51. For VOC, emissions are multiplied by a conversion factor to convert from tons to pounds.

$$NFE_{r,c} = AG_c \times EF_{VOC,r} \div 2000\,{}^{lbs}\!/_{ton} \qquad (43)$$

Where:

$NFE_{r,c}$ =   Annual non-fugitive VOC emissions for source r in county c, in tons per year
$EF_{VOC,r}$ =   VOC emission factor for source r, units vary based on pollutant.

Fugitive VOC emissions from valves and pumps are estimated by multiplying gasoline consumed by the emissions factor in Table 4-51. Assumptions concerning bulk terminals used in these calculations can be found in Table 4-59.

Table 4-59: Assumptions for Bulk Terminals Using Aviation Gasoline

Parameter	Data	Reference
Number of Bulk Plant Equivalents (U.S.)	2,442 plants	4, Table 2-8
Number of valves per bulk plant	50 valves/plant	
Number of pumps per bulk plant	2 pumps/plant	
Number of seals per bulk plant	4 seals/pump	
Number of days per year used	300 days	

$$VFE_c = BPE \times V \times EF_{VOC,r} \times D \times {}^{LTO_c}\!/_{LTO_{US}} \div 2000\,{}^{lbs}\!/_{ton} \qquad (44)$$

$$PFE_c = BPE \times P \times S \times EF_{VOC,r} \times D \times {}^{LTO_c}\!/_{LTO_{US}} \div 2000\,{}^{lbs}\!/_{ton} \qquad (45)$$

Where:

PFE_c =   Annual fugitive VOC emissions from valves in county c, in tons
VFE_c =   Annual fugitive VOC emissions from pumps in county c, in tons
BPE =   Number of bulk plant equivalents in the U.S.
V =   Number of valves per plant in the U.S.
P =   Number of pumps per plant in the U.S.

S   =   Number of seals per plant in the U.S.
D   =   Number of days used per year
LTO_c =   The number of LTOs in county c
LTO_{US} =   The number of LTOs in the United States

Total Annual VOC emissions in each county are estimated by summing the fugitive emissions (from equations 35 and 36) and all sources of non-fugitive emissions (from equation 34).

$$E_{VOC,c} = \sum_r NFE_c + PFE_c + VFE_c \tag{46}$$

Where:

$E_{VOC,c}$ =   Annual VOC emissions in county c, in tons

Emissions of all HAPs, except ethylene dichloride, are estimated by applying speciation factors found in Table 4-52 to the annual VOC emissions. For HAPs, no conversion factor is needed, and the emissions are reported in tons.

$$E_{h,c} = E_{VOC,c} \times SF_h \tag{47}$$

Where:

$E_{h,c}$ =   Annual emissions of HAP h in county c, in tons per year
SF_h =   Speciation factor for HAP h, in tons of HAP emissions per ton of VOC emissions

Ethylene dichloride emissions are calculated by multiplying the gasoline consumed in each county (from equation 33) by the emission factor from Table 4-49. For ethylene dichloride, emissions are multiplied by a conversion factor to convert from to pounds tons.

$$E_{e,c} = AG_c \times EF_e \times 0.0005 \, ^{tons}/_{lb} \tag{48}$$

Where:

$E_{e,c}$ =   Annual emissions of ethylene dichloride in county c, in tons
EF_e =   Emission factor for ethylene dichloride, in lbs. of ethylene dichloride per gallon of AvGas

Aviation Gasoline Distribution Stage 2

The annual aviation gasoline consumed in each county is used with the emissions factors in Table 4-53 and Table 4-54 to estimate emissions. Emissions of VOC are estimated by multiplying gasoline consumed by the emissions factor in Table 4-53. For VOC, emissions are multiplied by a conversion factor to convert from tons to pounds.

$$E_{VOC.c} = AG_c \times EF_{VOC} \times 0.0005 \, ^{tons}/_{lb} \tag{49}$$

Where:

$E_{VOC,c}$ =   Annual VOC emissions in county c, in tons
AG_c =   Annual consumption of AvGas in county c, in gallons
EF_{VOC} =   VOC emission factor, in tons of VOC per gallon of AvGas

Emissions of all HAPs, except ethylene dichloride and lead, are estimated by applying speciation factors found in Table 4-54 to the annual VOC emissions. For HAPs, no conversion factor is needed, and the emissions are reported in tons.

$$E_{h,c} = E_{VOC,c} \times SF_h \tag{50}$$

Where:

$E_{h,c}$ = Annual emissions of HAP h in county c, in tons per year
$E_{VOC,c}$ = Annual VOC emissions in county c, in tons
SF_h = Speciation factor for HAP h, in tons of HAP emissions per ton of VOC emissions

Ethylene dichloride and lead emissions are calculated by multiplying the gasoline consumed (from equation 12) by the emission factor from Table 4-54. For lead and ethylene dichloride, emissions are multiplied by a conversion factor to convert from pounds to tons.

$$E_{p,c} = AG_c \times EF_p \times 0.0005 \, ^{tons}/_{lb} \tag{51}$$

Where:

$E_{p,c}$ = Annual emissions of pollutant p in county c, in tons
EF_p = Emission factor for pollutant p, in lbs. of pollutant per gallon of AvGas

4.7.3.6   Point Source Subtraction

There are no point source-specific SCCs for stage 1 and stage 2 aviation gasoline distribution; therefore, point source subtraction is not performed for these sources. However, some stage I gasoline emissions are reported in the point source inventory. To avoid double counting of emissions, point source emissions are subtracted from the total emissions from each source category to estimate the nonpoint emissions from each source category. Point source emissions are mapped to nonpoint source SCCs using the crosswalk shown in Table 14 of the document "Stage I Gasoline Distribution NEMO FINAL_7-18-2019_4-2 updated.docx" on the 2017 NEI Supplemental data FTP site. The point source emissions table is also provided in an Excel input template. Point source emissions are submitted by SLT agencies.

$$NPE_{p,c,scc} = E_{p,c,scc} - PE_{p,c,scc} \tag{52}$$

Where:

$NPE_{p,c,scc}$ = Annual nonpoint source emissions of pollutant p from each SCC in county c
$E_{p,c,scc}$ = Annual total emissions of pollutant p from each SCC in county c
$PE_{p,c,scc}$ = Annual total point source emissions of pollutant p from each SCC in county c

4.7.3.7   Example calculations

The tables below show sample calculations for estimating VOC and benzene emissions for stage I gasoline distribution. Each SCC relies on a speciation factor to estimate the benzene emissions from the VOC emissions. Note that bulk terminals and pipelines have a different benzene speciation factor than the other SCCs. The speciation factor for bulk terminals and pipelines in 0.0027. All other SCCs use a county-specific benzene speciation factor. See section 4.7.3.3 for more information.

Bulk Terminals

Table 4-60: Sample calculations for benzene emissions for Apache County, AZ in 2017 from Stage I Gasoline Distribution

Eq. #	Equation	Values for Apache County, AZ	Result
15	$E_{VOC,US,bt}$ $= E_{MACT,US,bt} \times \dfrac{G_{2017}}{G_{1998}}$ $\times 1.1023 \, ton \, per \, Mg$	$137555 \, Mg$ $\times \dfrac{9327 \, thousand \, barrels \, per \, day}{8253 \, thousand \, barrels \, per \, day}$ $\times 1.1023 \, ton \, per \, Mg$	171359 tons VOC emissions in the US
16	$GasFrac_s = \dfrac{M_s}{M_{US}}$	$\dfrac{205 \, thousand \, barrels}{16798 \, thousand \, barrels}$	.0052
17	$E_{VOC,bt,s} = GasFrac_s$ $\times E_{VOC,US,bt}$	$.0052 \times 171359 \, tons$	891.1 tons VOC emissions in Arizona
18	$EmpFrac_c = \dfrac{Emp_c}{Emp_s}$	$\dfrac{6.54 \, employees}{732 \, employees}$	.0089
19	$E_{VOC,bt,c} = EmpFrac_c$ $\times E_{VOC,bt,s}$	$.0089 \times 891.1 \, tons$	7.93 tons VOC emissions in Apache County, AZ
20	$E_{p,c,bt} = E_{VOC,c,bt} \times S_p$	$7.93 \, tons \times 0.0027 \, speciation \, factor$	.0214 tons benzene emissions in Apache County, AZ

Pipelines

Table 4-61: Sample calculations for benzene emissions for Apache County, AZ in 2017 from Stage I Gasoline Distribution

Eq. #	Equation	Values for Apache County, AZ	Result
21	$E_{VOC,US,pl}$ $= E_{MACT,US.,pl} \times \dfrac{G_{2017}}{G_{1998}}$ $\times 1.1023 \, ton \, per \, Mg$	$137555 \, Mg$ $\times \dfrac{9327 \, thousand \, barrels \, per \, day}{8253 \, thousand \, barrels \, per \, day}$ $\times 1.1023 \, ton \, per \, Mg$	171359 tons VOC emissions in the US
22	$PADDFrac_{PD} = \dfrac{M_{PD}}{M_{US}}$	$\dfrac{3,856 \, thousand \, barrels \, in \, PAD \, District \, 5}{119,634 \, gasoline \, in \, US}$	0.32
23	$E_{VOC,PD,pl}$ $= PADDFrac_{PD}$ $\times E_{VOC,US,pl}$	$0.32 \times 171359 \, tons$	5,523 tons VOC emissions in PAD District 5
24	$Emp_{PD} = \sum Emp_c$	$\sum Emp_c$	10641 employees in PAD District 5
25	$EmpFrac_c = \dfrac{Emp_c}{Emp_{PD}}$	$\dfrac{6.54 \, employees}{10641 \, employees}$	.00061

Eq. #	Equation	Values for Apache County, AZ	Result
26	$E_{VOC,c,pl}$ $= EmpFrac_c \times E_{VOC,PD,pl}$	$.00061 \times 5{,}523\ tons$	3.37 tons VOC emissions in Apache County, AZ
27	$E_{p,c,pl} = E_{VOC,c,pl} \times S_p$	$3.37 \times 0.0027\ speciation\ factor$	0.9 tons benzene emissions in Apache County, AZ

Bulk Plants

Table 4-62: Sample calculations for benzene emissions for Apache County, AZ in 2017 from Stage I Gasoline Distribution

Eq. #	Equation	Values for Apache County, AZ	Result
1	$GT_{US,bp} = V_{US} \times 0.09$	$3404186\ thousand\ barrels \times 0.09$	306377 thousand barrels
8	$Emp_{US} = \sum Emp_c$	$\sum Emp_c$	73908 employees in the US
9	$EmpFrac_c = \dfrac{Emp_c}{Emp_{US}}$	$\dfrac{6.54\ employees}{73908\ employees}$	.000089
10	$GT_c = GT_{US} \times EmpFrac_c$	$306377\ thousand\ barrels \times .000089$	27.11 thousand barrels in Apache County
28	$E_{VOC,c,bp}$ $= \dfrac{EF_{VOC,bp}}{1000\ gallon} \times GT_{c,bp}$ $\times 42\ gallons\ per\ Mbbl$	$8.62\ pounds\ per\ 1{,}000\ gallons$ $\div 1000\ gallons$ $\times 27.11\ thousand\ barrels$ $\times 42\ gallons\ per\ Mbbl$	9.8 pounds VOC emissions in Apache Count, AZ
29	$E_{BZ,c,bp} = E_{VOC,c,bp} \times S_{BZ,c}$	$9.8\ pounds$ $\times 0.0061\ speciation\ factor$	.06 pounds benzene emissions in Apache County, AZ

Tank Trucks in Transit

Table 4-63: Sample calculations for benzene emissions for Apache County, AZ in 2017 from Stage I Gasoline Distribution

Eq. #	Equation	Values for Apache County, AZ	Result
2	$GC_{OR,c} = \sum GC_{OR,m}$	$\sum GC_{OR,m}$	44,007,116.5 gallons of onroad gasoline consumed in Apache County, AZ

Eq. #	Equation	Values for Apache County, AZ	Result
3	$GC_{NR,c} = \sum GC_{NR,m}$	$\sum GC_{NR,m}$	913,078.6 gallons of nonroad gasoline consumed in Apache County, AZ
4	$GC_{c,t} = (GC_{OR,c} + GC_{NR,c}) \times 1.09$	$(44,007,116.5\ gallons + 913,078.6\ gallons) \times 1.09$	48,963,012.6 gallons of gasoline consumed in Apache County, AZ
31	$E_{VOC,c,tt} = (EF_{VOC,tt} \times GC_{c,t}) /1000\ gallons$	$(.06\ pounds\ per\ 1000\ gallons \times 48,963,012.6\ gallons) /1000\ gallons$	2937.7 pounds VOC emissions in Apache County, AZ
32	$E_{BZ,c,tt} = E_{VOC,c,tt} \times S_{BZ,c}$	$2937.7\ pounds \times 0.0061\ speciation\ factor$	17.9 pounds benzene emissions Apache County, AZ

Underground Storage Tank (UST) Breathing and Storing

Table 4-64: Sample calculations for benzene emissions for Apache County, AZ in 2017 from Stage I Gasoline Distribution

Eq. #	Equation	Values for Apache County, AZ	Result
2	$GC_{OR,c} = \sum GC_{OR,m}$	$\sum GC_{OR,m}$	44,007,116.5 gallons of onroad gasoline consumed in Apache County, AZ
3	$GC_{NR,c} = \sum GC_{NR,m}$	$\sum GC_{NR,m}$	913,078.6 gallons of nonroad gasoline consumed in Apache County, AZ
4	$GC_{c,t} = (GC_{OR,c} + GC_{NR,c}) \times 1.09$	$(4,4007,116.5\ gallons + 913,078.6\ gallons) \times 1.09$	48,963,012.6 gallons of gasoline consumed in Apache County, AZ
34	$E_{VOC,c,ust} = (EF_{VOC,ust} \times GC_{c,t}) /1000\ gallons$	$(1\ pound\ per\ 1000\ gallons \times 48,963,012.62\ gallons) /1000\ gallons$	48,963 pounds VOC emissions in Apache County, AZ
35	$E_{BZ,c,ust} = E_{VOC,c,ust} \times S_{BZ,c}$	$48,963\ pounds \times 0.0061\ speciation\ factor$	298.7 pounds benzene emissions in Apache County, AZ

Gasoline Service Station Unloading

These sample calculations use splash filling as an example, and the equations use fuel subtype 10 and January as

an example. These calculations would need to be repeated using every month and both fuel subtypes to calculate values for each filling technology (splash, submerged, and balance).

Table 4-65: Sample calculations for benzene emissions for Apache County, AZ in 2017 from Stage I Gasoline Distribution

Eq. #	Equation	Values for Apache County, AZ	Result
5	$GC_{c,t,m,f} = (GC_{c,OR,m,f} + GC_{c,NR,m,f}) \times 1.09$	$(1{,}650{,}266.8 \ gallons + 11{,}985.2 \ gallons) \times 1.09$	18,111,854.7 gallons
6	$GC_{c,ft,m,f} = GC_{c,t,m,f} \times Perc_{ft,c}$	$18{,}111{,}854.7 \ gallons \times 0 \ \% \ splash \ filling$	0 gallons splash filling in Apache County, AZ
13	$\begin{aligned} P_{c,m,f} &= \Bigg\{ \bigg[0.7553 \\ &- \left(\frac{413}{T_{c.m} + 459.6} \right) \bigg] S^{0.5} \log_{10}(RVP_{c,m,f}) - \bigg[1.8 \\ &- \left(\frac{1042}{T_{c.m} + 459.6} \right) \bigg] S^{0.5} \\ &+ \bigg[\left(\frac{2416}{T_{c.m} + 459.6} \right) \\ &- 2.013 \bigg] \log_{10}(RVP_{c,m,f}) - \left(\frac{8742}{T_{c.m} + 459.6} \right) \\ &+ 15.64 \Bigg\} \end{aligned}$	$\begin{aligned} &\Bigg\{ \bigg[0.7553 \\ &- \left(\frac{413}{60 + 459.6} \right) \bigg] 3^{0.5} \log_{10}(10.61) - \bigg[1.8\!\\ &- \left(\frac{1042}{60 + 459.6} \right) \bigg] 3^{0.5} \\ &+ \bigg[\left(\frac{2416}{60 + 459.6} \right) \\ &- 2.013 \bigg] \log_{10}(10.61) - \left(\frac{8742}{60 + 459.6} \right) \\ &+ 15.64 \Bigg\} \end{aligned}$	5.54 pounds per square inch absolute
14	$L_{c,m,f} = 12.46 \times S_{ft} \times P_{c,m,f} \times M/T$	$12.46 \times 1.45 \ saturation \ factor \times 5.54 \ pounds \ per \ square \ inch \ absolute \times \frac{65.5 \ pounds \ per \ pound \ per \ mole}{520 \ Rankine}$	12.61 pounds per 1000 gallons
35	$E_{VOC,c,m,f,ft,ll} = \frac{GC_{c,ft,m,f}}{1000 \ gallons} \times L_{c,m,f}$	$\frac{0 \ gallons \ splash \ filling}{1000 \ gallons} \times 12.61 \ pounds \ per \ 1000 \ gallons$	0 pounds VOC emissions from uncontrolled loading loss in Apache County, AZ in January for fueling subtype 10 for splash filling

Eq. #	Equation	Values for Apache County, AZ	Result
36	$E_{VOC,c,m,f,ft,ct} = E_{VOC,c,m,f,ft,ll} \times CE_c/100$	$0\ pounds \times 0\ control\ efficiency/100$	0 pounds controlled VOC emissions in Apache County, AZ in January for fueling subtype 10 for splash filling
37	$E_{VOC,c,m,f,ft} = E_{VOC,c,m,f,ft,ll} - E_{VOC,c,m,f,ft,ct}$	$0\ pounds - 0\ pounds$	0 pounds total VOC emissions in Apache County, AZ in January for fueling subtype 10 for splash filling
38	$E_{VOC,c,ft} = \sum E_{VOC,c,m,f,ft}$	$\sum E_{VOC,c,m,f,ft}$	0 pounds total VOC emissions in Apache County, AZ for splash filling
39	$E_{BZ,c,ft} = E_{VOC,c,ft} \times S_{BZ,c}$	$0\ pounds \times 0.0061\ speciation\ factor$	0 pounds benzene emissions in Apache County, AZ for splash filling

Aviation Gasoline Distribution Stage 1

Table 4-66 lists sample calculations to determine the VOC emissions from stage 1 aviation gasoline distribution in Autauga County, Alabama.

Table 4-66: Sample Calculations for Emissions from Aviation Gasoline-Stage 1 in Autauga County, AL

Eq. #	Equation	Values for Autauga, AL	Result
7	$AG_s = AGB_s \times 42\,{}^{gallons}/_{barrel}$	$57,000\ barrels \times 42\,{}^{gallons}/_{barrel}$	2,394,000 gallons of AvGas consumed in AL
11	$RLTO_c = \dfrac{LTO_c}{LTO_s}$	$\dfrac{3,064\ LTOs\ in\ Autauga}{689,947\ LTOs\ in\ AL}$	0.00444 fraction of LTOs in Autauga County, AL
12	$AG_c = AG_s \times RLTO_c$	$2,394,000\ gal\ AvGas\ in\ Al \times 4.44 \times 10^{-3} fraction$	10,633 gallons of AvGas consumed in Autauga County, AL
43	$NFE_{r,c} = AG_c \times EF_{VOC,r} \div 2000\,{}^{lbs}/_{ton}$	$10,633\ gal\ AvGas\ in\ Autauga \times 9.02 \times 10^{-3} lbs.VOC\ per\ gal\ AvGas \div 2000\,{}^{lbs}/_{ton}$	0.048 tons VOC emissions from tank filling in Autauga County, AL
		$10,633\ gal\ AvGas\ in\ Autauga \times 3.61 \times 10^{-3} lbs.VOC\ per\ gal\ AvGas \div 2000\,{}^{lbs}/_{ton}$	0.0192 tons VOC emissions from storage tank working in Autauga County, AL
		$10,633\ gal\ AvGas\ in\ Autauga \times 1.03 \times 10^{-2} lbs.VOC\ per\ gal\ AvGas \div 2000\,{}^{lbs}/_{ton}$	0.0548 tons VOC emissions from composite in Autauga County, AL
		$10,633\ gal\ AvGas\ in\ Autauga \times 1.69 \times 10^{-3} lbs.VOC\ per\ gal\ AvGas \div 2000\,{}^{lbs}/_{ton}$	0.00901 tons VOC emissions from breathing losses in Autauga County, AL
44	$VFE_c = BPE \times V \times EF_{VOC,r} \times D \times {}^{LTO_c}/_{LTO_{US}} \div 2000\,{}^{lbs}/_{ton}$	$2,442\ plants\ in\ US \times 50\,{}^{valves}/_{plant} \times 0.573\ lbs.per\ valve\ per\ day \times 300\ days \times {}^{3,064}/_{28,353,661} \div 2000\,{}^{lbs}/_{ton}$	1.13 tons fugitive VOC emissions from valves in Autauga County, AL
45	$PFE_c = BPE \times P \times S \times EF_{VOC,r} \times D \times {}^{LTO_c}/_{LTO_{US}} \div 2000\,{}^{lbs}/_{ton}$	$2,442\ plants\ in\ US \times 2\,{}^{pumps}/_{plant} \times 4\,{}^{seals}/_{pump} \times 5.95\ lbs.per\ seal\ per\ day \times 300\ days \times {}^{3.064}/_{28,353,661} \div 2000\,{}^{lbs}/_{ton}$	1.89 tons fugitive VOC emissions from pumps in Autauga County, AL
46	$E_{VOC,c} = \sum_r NFE_c + PFE_c + VFE_c$	$0.131\ tons + 1.13\ tons + 1.89\ tons$	3.15 total annual tons VOC emissions from AvGas distribution in Autauga County, AL

Aviation Gasoline Distribution Stage 2

Table 4-67 lists sample calculations to determine the VOC, lead, and ethylene dichloride emissions from stage 2 aviation gasoline distribution in Autauga County, Alabama.

Table 4-67: Sample Calculations for Emissions from Aviation Gasoline-Stage 1 in Autauga County, AL

Eq. #	Equation	Values for Apache County, AZ	Result
7	$AG_s = AGB_s \times 42\ ^{gallons}/_{barrel}$	$57{,}000\ barrels \times 42\ ^{gallons}/_{barrel}$	2,394,000 gallons of AvGas consumed in AL
11	$RLTO_c = \dfrac{LTO_c}{LTO_s}$	$\dfrac{3{,}064\ LTOs\ in\ Autauga}{689{,}947\ LTOs\ in\ AL}$	0.00444 fraction of LTOs in Autauga County, AL
12	$AG_c = AG_s \times RLTO_c$	$2{,}394{,}000\ gal\ AvGas\ in\ Al \times 4.44 \times 10^{-3} fraction$	10,633 gallons of AvGas consumed in Autauga County, AL
49	$E_{VOC.c} = AG_c \times EF_{VOC} \times 0.0005\ ^{tons}/_{lb}$	$10{,}633\ gal\ of\ AvGas\ in\ Autauga \times 0.0136\ lbs.VOC\ per\ gal \times 0.0005\ ^{tons}/_{lb}$	0.0723 tons VOC emissions from AvGas distribution in Autauga County, AL
51	$E_{p,c} = AG_c \times EF_p \times 0.0005\ ^{tons}/_{lb}$	$10{,}633\ gal\ of\ AvGas\ in\ Autauga \times 1.88 \times 10^{-6}\ lbs.of\ ethylene\ dichloride\ per\ gal \times 0.0005\ ^{tons}/_{lb}$	1.0E-5 tons ethylene dichloride emissions from AvGas distribution in Autauga County, AL
	$E_{p,c} = AG_c \times EF_p \times 0.0005\ ^{tons}/_{lb}$	$10{,}633\ gal\ of\ AvGas\ in\ Autauga \times 8.50 \times 10^{-8}\ lbs.of\ lead\ per\ gal \times 0.0005\ ^{tons}/_{lb}$	4.52E-7 tons of lead emissions from AvGas distribution in Autauga County, AL

4.7.3.8   *Changes for the 2014 methodology*

For every source except Aviation Gasoline Distribution Stage 2, there are no significant changes from the methodology used to calculate the 2014 v2 NEI emissions. For Aviation Gasoline Distribution Stage 2, the only change from the methodology used to estimate the 2014 v2 NEI emissions is that the VOC emission factor for fuel transfer from tanker trucks to aircraft was decreased from 1.36E-2 lbs. VOC/gallon AvGas to 8.27E-4 lbs. VOC/gallon AvGas after reviewing the emission factor reference more carefully.

4.7.3.9   *Puerto Rico and U.S. Virgin Islands*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in pounds for these two Florida counties are divided by their respective populations creating a pound per capita emission factor. For each Puerto Rico and US Virgin Island county, the pound per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which serves as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.7.4   References

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4.8   Commercial Cooking

4.8.1   Sector description

Commercial cooking refers to the cooking of meat, including steak, hamburger, poultry, pork, and seafood, and french fries on five different cooking devices: chain-driven (conveyorized) charbroilers, underfired charbroilers, deep-fat fryers, flat griddles and clamshell griddles. Table 4-68 lists the SCCs in the commercial cooking sector; EPA estimates emissions for all SCCs in this sector. The SCC level 1 and 2 descriptions are "Industrial Processes; Food and Kindred Products: SIC 20" for all SCCs.

Table 4-68: Source Classification Codes used in the Commercial Cooking sector

SCC	SCC Description, level 3	SCC Descriptions, level 4
2302002100	Commercial Cooking – Charbroiling	Conveyorized Charbroiling
2302002200	Commercial Cooking – Charbroiling	Under-fired Charbroiling
2302003000	Commercial Cooking – Frying	Deep Fat Frying
2302003100	Commercial Cooking – Frying	Flat Griddle Frying
2302003200	Commercial Cooking – Frying	Clamshell Griddle Frying

4.8.2   Sources of data

The commercial cooking sector includes data from the S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-88 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector.

Table 4-69: Agencies that submitted Commercial Cooking emissions

Region	Agency	S/L/T
3	Maryland Department of the Environment	State
4	Memphis and Shelby County Health Department - Pollution Control	Local
4	Metro Public Health of Nashville/Davidson County	Local
5	Illinois Environmental Protection Agency	State
6	Texas Commission on Environmental Quality	State
8	Utah Division of Air Quality	State
9	California Air Resources Board	State
9	Maricopa County Air Quality Department	Local
9	Washoe County Health District	Local
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.8.3   EPA-developed emissions

The calculations for estimating the emissions from commercial cooking involve first estimating the amount of meat and french fries cooked on various cooking devices in each county. These data are estimated using the number of restaurants, by specific restaurant type, from the Dun & Bradstreet (D&B) Hoovers Database [ref 1] and assumptions concerning the percent of those restaurants with specific cooking devices, the number of devices per restaurant, and the amount of meat cooked per device from a California Air Resources Board (CARB) sponsored survey [ref 2]. The amount of french fries cooked by the foodservice industry is from a report prepared for Potatoes USA [ref 3]. The total amount of meat or french fries cooked on each device is multiplied by emissions factors for CAPS including, VOC, CO, PM10 and PM25, and various HAPs to estimate emissions of these pollutants from commercial cooking.

4.8.3.1   *Activity data*

The activity data for this source category is the amount of meat and potatoes cooked on each type of cooking device in each county. These amounts are estimated based on the number of restaurants in a county that use commercial cooking equipment, the percent of restaurants with each type of cooking device, the average number of cooking devices per restaurant, and the average amount of meat or potatoes cooked on each device.

Data concerning the number of restaurants in each county are from the Dun & Bradstreet (D&B) Hoovers Database [ref 1]. Hoovers data are proprietary and were purchased by EPA for use in the NEI; EPA provides users with aggregated data on county level restaurants by type. The relevant restaurants pulled from the Hoovers Database and their primary SIC codes are listed in Table 4-70.

Table 4-70: Hoovers database restaurant types

Restaurant Type	Primary SIC Code
Ethnic Food	5812-01
Fast Food	5812-03
Family	5812-05
Seafood	5812-07
Steak & BBQ	5812-08

The number of restaurants by type in each county, pulled from the Hoovers database, is then multiplied by the percentage of restaurants by type with commercial cooking equipment in order to calculate the number of restaurants with the specific cooking devices in each county; these percentages are shown in Table 4-71. The data on cooking devices and meat cooked are from a survey on charbroiling activity in the state of California [ref 2].

Table 4-71: Percent of restaurants with each type of cooking device

Restaurant Type	Conveyorized Char-broilers	Underfired Char-broilers	Deep-Fat Fryers	Flat Griddles	Clamshell Griddles
Ethnic	3.5	47.5	81.9	62.7	4.0
Fast Food	18.6	30.8	96.8	51.9	14.7
Family	10.1	60.9	91.4	82.9	1.4
Seafood	0.0	52.6	100.0	36.8	10.5
Steak & BBQ	6.9	55.2	82.8	89.7	0.0

Source: Reference 2, Table 4

$$R_{t,c,d} = R_{t,c} \times Frac_{t,d} \tag{1}$$

Where:

$R_{t,c,e}$ = Number of type t restaurants in county c with cooking device d
$R_{t,c}$ = Number of type t restaurants in county c
$Frac_{t,e}$ = Fraction of type t restaurants with cooking device d

The number of restaurants in each county with cooking devices are then multiplied by the average number of cooking devices by restaurant type shown Table 4-72, from the same California Survey dataset, to calculate the total number of cooking devices.

Table 4-72: Average number of devices by restaurant type*

Restaurant Type	Conveyorized Char-broilers	Underfired Char-broilers	Deep-Fat Fryers	Flat Griddles	Clamshell Griddles
Ethnic	1.62	1.54	1.63	1.88	1.80
Fast Food	1.07	1.58	3.10	1.43	2.09
Family	1.71	1.29	2.34	2.03	-
Seafood	-	1.10	2.47	1.11	1.50
Steak & BBQ	-	1.63	2.42	1.35	-

*Only includes restaurants with at least one piece of the equipment. Source: Reference 2, Table 5.

$$D_{t,c,d} = R_{t,c,d} \times E_{t,d} \tag{2}$$

Where:

$D_{t,c,d}$ = Total number of cooking device d in county c from type t restaurants
$R_{t,c,d}$ = Number of type t restaurants in county c with cooking device d
$E_{t,d}$ = Average number of cooking device d at type t restaurants

The number of cooking devices in each restaurant type from equation 2 are summed across restaurant types to estimate the total number of cooking devices in each county.

$$D_{c,d} = \sum_t D_{t,c,d} \tag{3}$$

Where:

$D_{c,d}$ = Total number of cooking devices d from all restaurants in county c
$D_{t,c,d}$ = Total number of cooking device d in restaurant type t in county c

The total number of cooking devices in each county is used to determine the amount of meat cooked in that county. The average amount of meat cooked on each cooking device is listed in Table 4-73.

Table 4-73: Average amount of meat cooked per year on each cooking device (tons)

Meat Type	Conveyorized Char-broilers	Underfired Char-broilers	Deep-Fat Fryers	Flat Griddles	Clamshell Griddles
Steak	6.1	4.7	4.7	4.3	2.4
Hamburger	20.7	7.0	7.1	9.4	34.2
Poultry	10.7	8.4	14.9	5.2	5.7

Meat Type	Conveyorized Char-broilers	Underfired Char-broilers	Deep-Fat Fryers	Flat Griddles	Clamshell Griddles
Pork	1.5	3.8	1.5	2.9	3.1
Seafood	3.1	3.7	4.1	2.4	16.4
Other	-	1.1	7.1	1.5	-

Source: Reference 2, Table 13

$$M_{i,d,c} = D_{c,d} \times m_{i,d} \tag{4}$$

Where:

$M_{i,d,c}$ = Total amount of meat type i cooked on device d in county c, in tons
$D_{c,d}$ = Total number of cooking device d from all restaurants in county c
$m_{i,d}$ = Average amount of meat type i cooked on device d, in tons

The amount of french fries cooked in each county is calculated based on the amount of frozen potatoes used in the foodservice industry. According to a report prepared for Potatoes USA, 5,977 million pounds of frozen potatoes were used in the food service industry in 2017 [ref 1]. Frozen potatoes used in limited service restaurants account for approximately 74% of the total, and those used in full-service restaurants account for the remaining 26%. The process used to distribute the national amount of french fries cooked to the county-level is discussed in the next section.

4.8.3.2 *Allocation procedure*

In 2017, 5,977 million pounds of frozen potatoes were used in limited and full-service restaurants in the U.S [ref 3]. In order to allocate this value to the county-level, fractions of the number of limited and full-service restaurants in each county are used. To create these fractions, it is assumed that limited service restaurants are D&B classified fast food restaurants and full services restaurants are represented by all other D&B restaurant codes. County-level fast food and other restaurants are summed, and then divided by the national number of fast food or other restaurants in order to develop the county-level fractions.

$$RFrac_{lim,c} = \frac{R_{lim,c}}{R_{lim,US}} \tag{5}$$

$$RFrac_{full,c} = \frac{R_{full,c}}{R_{full,US}} \tag{6}$$

Where:

$RFrac_{lim,c}$ = Fraction of limited service restaurants in county c
$RFrac_{full,c}$ = Fraction of full service restaurants in county c
$R_{lim,c}$ = The number of limited service restaurants in county c
$R_{full,c}$ = The number of full service restaurants in county c
$R_{lim,US}$ = The number of limited service restaurants in the U.S.
$R_{full,US}$ = The number of full service restaurants in the U.S.

The fraction of limited and full-service restaurants in each county is then used to distribute the amount of frozen potatoes cooked. Approximately 4,414 million pounds of frozen potatoes were used in limited service restaurants in the US in 2017 and 1,563 million pounds were used in full-service restaurants [ref 3].

$$F_{lim,c} = RFrac_{lim,c} \times f_{lim,US} \div 2000 \; lbs \; per \; ton \qquad (7)$$

$$F_{full,c} = RFrac_{full,c} \times f_{full,US} \div 2000 \; lbs \; per \; ton \qquad (8)$$

Where:

$F_{lim,c}$	=	Amount of french fries cooked in limited service restaurants in county c, in tons
$F_{full,c}$	=	Amount of french fries cooked in full service restaurants in county c, in ton
$RFrac_{lim,c}$	=	Fraction of limited service restaurants in county c
$RFrac_{full,c}$	=	Fraction of full service restaurants in county c
$f_{lim,US}$	=	Amount of french fries cooked in limited service restaurants in the U.S., in lbs.
$f_{full,US}$	=	Amount of french fries cooked in full service restaurants in the U.S., in lbs.

The amount of french fries cooked in limited and full-service restaurants are then summed to the county level.

$$F_{all,c} = F_{lim,c} + F_{full,c} \qquad (9)$$

Where:

$F_{all,c}$	=	Amount of french fries cooked in county c, in tons
$F_{lim,c}$	=	Amount of french fries cooked in limited service restaurants in county c, in tons
$F_{full,c}$	=	Amount of french fries cooked in full service restaurants in county c, in tons

4.8.3.3 Emission factors

Emissions factors for CAPs from commercial cooking are reported in Table 6 in the Commercial Cooking NEMO FINAL document on the 2017 NEI Supplemental data FTP site. CAP emissions factors are taken from the article *Emissions from Charbroiling and Grilling of Chicken and Beef* [ref 4], and a South Coast Air Quality Management District Report (SCAQMD) [ref 5]. According to the most recent PM Augmentation tool, Primary PM is equal to Filterable PM and there are assumed to be no condensible PM emissions from commercial cooking. Emissions factors for HAPs from commercial cooking are reported in Table 7 in the Commercial Cooking NEMO FINAL document. HAP emissions factors are also from *Emissions from Charbroiling and Grilling of Chicken and Beef* [ref 4], and an EPA report on emissions from street vendor cooking devices [ref 6].

4.8.3.4 Controls

There are no controls assumed for this category.

4.8.3.5 Emissions

To calculate emissions of CAPs, the total amount of meat and potatoes cooked on each cooking device in each county is multiplied by the appropriate emissions factor (listed in Table 6 in the Commercial Cooking NEMO FINAL document). The amount of french fries cooked is converted from pounds to tons, and all emissions are converted to tons.

$$E_{p,i,d,c} = M_{i,d,c} \times EF_{p,i,d} \div 2000 \; lbs \; per \; ton \qquad (10)$$

$$E_{p,f,d,c} = F_{all,c} \times EF_{p,f,d} \div 2000 \; lbs \; per \; ton \qquad (11)$$

Where:

$E_{p,i,d,c}$	=	Annual emissions of pollutant p from cooking meat type i on device d in county c, in tons

$E_{p,f,d,c}$ = Annual emissions of pollutant p from cooking french fries, f, on device d in county c, in tons
$M_{i,d,c}$ = Total amount of meat type i cooked on device d in county c, in tons
$F_{all,c}$ = Total amount of french fries cooked in county c, in tons
$EF_{p,i,d}$ = Emissions factor for pollutant p, in lbs. of pollutant per ton of meat type i cooked on device d
$EF_{p,f,d}$ = Emissions factor for pollutant p, in lbs. of pollutant per ton of french fries cooked on device d

Emissions of HAPs are also calculated by multiplying an emissions factor (Table 7 in the [Commercial Cooking NEMO FINAL](#) document) by the amount of meat cooked on each cooking device. Note that cooking of french fries does not result in HAP emissions. For HAPs, no conversion factor is needed, and emissions are reported in pounds.

$$E_{p,i,d,c} = M_{i,d,c} \times EF_{p,i,d} \qquad (12)$$

Where:

$E_{p,i,d,c}$ = Annual emissions of pollutant p from cooking meat type i on device d in county c, in pounds
$M_{i,d,c}$ = Total amount of meat type i cooked on device d in county c, in tons
$EF_{p,i,d}$ = Emissions factor for pollutant p, in lbs. of pollutant per ton of meat type i cooked on device d

The emissions are summed for all types of meat and french fries to estimate the total emissions from each cooking device type in each county.

$$E_{p,d,c} = \sum_i E_{p,i,d,c} + E_{p,f,d,c} \qquad (13)$$

Where:

$E_{p,d,c}$ = Total annual emissions of pollutant p from cooking device d in county c
$E_{p,i,d,c}$ = Annual emissions of pollutant p from cooking meat type i on device d in county c
$E_{p,f,d,c}$ = Annual emissions of pollutant p from cooking french fries, f, on device d in county c

4.8.3.6 Example calculations

Table 4-74 lists sample calculations to determine the VOC emissions from commercial cooking on flat griddles in Apache County, Arizona. The first two equations use fast food restaurants as an example, and equations 4 and 10 use hamburgers as an example. However, these calculations would need to be repeated to calculate values for all restaurant and meat types.

Table 4-74: Sample VOC emissions calculations from commercial cooking on flat griddles in Apache county, AZ

Eq. #	Equation	Values for Apache County, AZ	Result
1	$R_{t,c,d} = R_{t,c} \times Frac_{t,d}$	$6 \ fast \ food \ rest.$ $\times 51.9\% \ with \ flat \ griddles$	3.114 fast food restaurants in Apache County, AZ with flat griddles
2	$D_{t,c,d} = R_{t,c,d} \times E_{t,d}$	$3.114 \ fast \ food \ rest. with \ flat \ griddles$ $\times 1.43 \ flat \ griddles \ per \ rest.$	4.45 flat griddles in fast food restaurants in Apache County, AZ

Eq. #	Equation	Values for Apache County, AZ	Result
3	$D_{c,d} = \sum_t D_{t,c,d}$	$\sum$ Flat griddles in Apache County, AZ	9.5 flat griddles in all restaurants in Apache County, AZ
4	$M_{i,d,c} = D_{c,d} \times m_{i,d}$	9.5 flat griddles in Apache $\times$ 9.4 tons of hamburger cooked on flat griddles	89.3 tons of hamburger cooked on flat griddles in Apache County, AZ
5	$RFrac_{lim,c} = \dfrac{R_{lim,c}}{R_{lim,US}}$	N/A	Equation is for deep-fat fryers; example is for flat griddles
6	$RFrac_{full,c} = \dfrac{R_{full,c}}{R_{full,US}}$	N/A	Equation is for deep-fat fryers; example is for flat griddles
7	$F_{lim,c} = RFrac_{lim,c} \times f_{lim,US} \div 2000\ lbs\ per\ ton$	N/A	Equation is for deep-fat fryers; example is for flat griddles
8	$F_{full,c} = RFrac_{full,c} \times f_{full,US} \div 2000\ lbs\ per\ ton$	N/A	Equation is for deep-fat fryers; example is for flat griddles
9	$F_{all,c} = F_{lim,c} + F_{full,c}$	N/A	Equation is for deep-fat fryers; example is for flat griddles
10	$E_{p,i,d,c} = M_{i,d,c} \times EF_{p,i,d} \div 2000\ lbs\ per\ ton$	89.3 tons of hamburger cooked $\times$ 0.14 lbs. VOC per ton hamburger $\div$ 2000 lbs. per ton	0.00625 tons VOC emissions from cooking hamburgers on flat griddles in Apache County, AZ
11	$E_{p,f,d,c} = F_{all,c} \times EF_{p,f,d} \div 2000\ lbs\ per\ ton$	N/A	Equation is for deep-fat fryers; example is for flat griddles
12	$E_{p,i,d,c} = M_{i,d,c} \times EF_{p,i,d}$	NA	Equation is for HAPs; example is for VOC
13	$E_{p,d,c} = \sum_i E_{p,i,d,c} + E_{p,f,d,c}$	$\sum$ VOC emissions in Apache County	0.04 tons VOC emissions from flat griddles in Apache County, AZ

4.8.3.7 Changes for the 2014 NEI methodology

The methodology used to calculate commercial cooking emissions for the 2014 v2 NEI used data on the number of restaurants in each county, according to US NAICS codes, to grow emissions data from the 2002 NEI commercial cooking category. This was completed as EPA did not have access to the more specific D&B data on

restaurants in each county. For the 2017 NEI, EPA has access to the D&B data and is therefore using the 2002 NEI methodology (which is also used by the state of California).

4.8.4   References

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4.9   Dust – Construction Dust

4.9.1   Sector description

Construction dust refers to residential and non-residential construction activity, which are functions of acreage disturbed for construction. This sector will be divided below when describing the calculation of EPA's emissions. Table 4-75 lists the nonpoint SCCs associated with this sector in the 2017 NEI. The SCC level 1 and 2 descriptions is "Industrial Processes; Construction: SIC 15 - 17" for all SCCs.

Table 4-75: SCCs in the Construction Dust sector

SCC	SCC Level Three	SCC Level Four
2311010000	Residential	Total
2311020000	Industrial/Commercial/Institutional	Total
2311030000	Road Construction	Total

4.9.2   Sources of data

The construction dust sector includes data from the S/L/T agency submitted data and the default EPA generated construction dust emissions. The agencies listed in Table 4-76 submitted Residential (Res), Industrial and Commercial/Institutional (ICI), and/or Road construction emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector, while others submitted only a portion of the sector.

Table 4-76: S/L/Ts that submitted Construction Dust emissions

Region	Agency	Res	ICI	Road
1	New Hampshire Department of Environmental Services	✓		
2	New Jersey Department of Environment Protection	✓	✓	✓
3	Delaware Department of Natural Resources and Environmental Control	✓	✓	✓
3	Maryland Department of the Environment	✓	✓	✓
4	Memphis and Shelby County Health Department - Pollution Control	✓	✓	✓
4	Metro Public Health of Nashville/Davidson County	✓	✓	✓

Region	Agency	Res	ICI	Road
5	Illinois Environmental Protection Agency	✓	✓	✓
8	Utah Division of Air Quality	✓	✓	✓
9	California Air Resources Board	✓		✓
9	Clark County Department of Air Quality and Environmental Management	✓	✓	✓
9	Maricopa County Air Quality Department	✓	✓	✓
9	Washoe County Health District	✓	✓	✓
10	Coeur d'Alene Tribe	✓	✓	✓
10	Idaho Department of Environmental Quality	✓	✓	✓
10	Kootenai Tribe of Idaho	✓	✓	✓
10	Nez Perce Tribe	✓	✓	✓
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	✓	✓	✓
10	Washington State Department of Ecology	✓	✓	✓

4.9.3 EPA-developed emissions for residential construction

Emissions from residential construction activity are a function of the acreage disturbed and volume of soil excavated for residential construction. Residential construction activity is developed from data obtained from the U.S. Department of Commerce (DOC)'s Bureau of the Census.

4.9.3.1 *Activity data*

There are two activity calculations performed for residential construction: acres of soil disturbed, and volume of soil removed for basements.

Determine the Number of Housing Starts in Each County

The US Census Bureau has 2017 data for *New Privately Owned Housing Units Started by Purpose and Design* [ref 1] which provides data on housing starts based on the groupings of 1 unit, 2-4 units, and 5 or more units. Regional-level results are also provided for quarterly totals and 1-unit structures in Table 4-77 [ref 1]. In order to breakdown the 2 to 4-unit category, data from a consultation with the Census Bureau in 2002 are used; approximately 1/3 of the housing starts are for 2-unit structures, and 2/3 are for 3- and 4-unit structures.

The 2017 US Census Bureau *New Privately Owned Housing Units Started by Purpose and Design* [ref 1] data for 2-4 units are distributed to two categories, 2 and 3-4 units, based on a ratio for 2 and 3-4 units calculated from the 2000 US Census Bureau *National Housing Starts* data [ref 2], for each quarter in 2017. Note that 2000 is the last full year when Census housing starts data are available separately for 2-unit and 3-4-unit homes. Table 4-78 shows a breakdown of the 2 unit and 3-4-unit structures based on the following calculation.

$$S_{Q,n} = \left(\frac{U_n}{U_t}\right) \times S_{Q,2-4} \tag{1}$$

Where:

$S_{Q,n}$ = Housing starts, by quarter, Q, and number of units, n (2 units or 3-4 units), in thousand units

U_n = Number of housing starts by number of units, n, from the 2000 *National Housing Starts* data, in thousand housing starts

U_t = Total number of housing starts for both 2 units and 3-4 units from the 2000 *National Housing Starts* data, in thousand housing starts

$S_{Q,2\text{-}4}$ = Number of 2-4 units by quarter, Q, from the 2017 *New Privately Owned Housing Units Started by Purpose and Design* data, in thousand units

Table 4-77: Housing Start Data for 2017

Quarter	Total	1 unit	Structure 2 to 4 units	Structure 5 units or more	Region NE	Region MW	Region S	Region W	Regional Starts of Structures with 1 unit NE	Regional Starts of Structures with 1 unit MW	Regional Starts of Structures with 1 unit S	Regional Starts of Structures with 1 unit W
Q1-14	206.0	134.0	2.0	70.0	23.0	21.0	113.0	49.0	9.0	14.0	79.0	32.0
Q2-14	275.0	183.0	3.0	89.0	28.0	53.0	130.0	62.0	15.0	34.0	91.0	42.0
Q3-14	282.0	178.0	4.0	100.0	32.0	49.0	134.0	65.0	14.0	32.0	92.0	39.0
Q4-14	241.0	154.0	4.0	84.0	26.0	39.0	118.0	58.0	13.0	25.0	83.0	32.0

Table 4-78: Breakdown of 2 to 4-unit structures

Quarter	2 to 4 units	2 units	3-4 units
Q1-14	2.0	0.74	1.26
Q2-14	3.0	1.11	1.89
Q3-14	4.0	1.47	2.53
Q4-14	4.0	1.47	2.53

Ratios of the number of 2, 3-4, and 5 or more-unit structures are then used to estimate the number of structures of each type in each region. The ratios are calculated by dividing the housing starts by quarter for each unit type by the total housing starts for buildings with 2 or more units.

$$r_{Q,n} = \frac{S_{Q,n}}{S_{Q.t}} \tag{2}$$

Where:

$r_{Q,n}$ = Ratio of structures with number of units, n, to total number of units by quarter, Q

$S_{Q,n}$ = Housing starts, by quarter, Q, and number of units, n, from distributed calculation in Step 1 for the 2-unit or 3-4 unit categories or directly from the 2017 *New Privately Owned Housing Units Started by Purpose and Design* data for the 5 units or more category, in thousand housing starts

$S_{Q,t}$ = Housing starts, by quarter, Q, for total number of buildings with 2 or more units, t (excludes 1-unit category), in thousand housing starts

The ratio is then used to distribute the 2017 *New Privately Owned Housing Units Started by Purpose and Design* regional data for all unit types to the 2, 3-4, or 5 or more-unit categories within each Census region – Northeast, Midwest, South, and West.

$$A_{Q,n,rgn} = r_{Q,n} \times (RS_{t,rgn} - RS_{1,rgn}) \tag{3}$$

Where:

$A_{Q,n,rgn}$ = Number of housing units started in quarter Q, by number of units, n, and region of the country, rgn, in thousand units

$r_{Q,n}$ = Ratio of structures with number of units, *n*, to total number of units by quarter, *Q*

$RS_{t,rgn}$ = Total regional starts from the 2017 *New Privately Owned Housing Units Started by Purpose and Design* data, in thousand housing starts

$RS_{1,rgn}$ = Regional starts of structures with 1 unit from the 2017 *New Privately Owned Housing Units Started by Purpose and Design* data, in thousand housing starts

Data from the Census report *New Privately Owned Housing Units Authorized Unadjusted Units* [ref 3] is used to calculate a conversion factor to determine the ratio of structures to units in the 5 or more-unit category. The conversion factor is calculated by dividing the total number of units in structures with 5 or more units by region [ref 2] by the total number of buildings with 5 or more units by region [ref 3].

$$CF_{5,rgn} = \frac{U_{5,rgn}}{B_{5,rgn}}$$ (4)

Where:

$CF_{5,rgn}$ = Ratio of 5 units or more to the number of buildings with 5 units or more by region, *rgn*

$U_{5,rgn}$ = Total number of 5 or more units by region, *rgn*

$B_{5,rgn}$ = Total number of buildings with 5 or more units by region, *rgn*

Structures started by category are then calculated at a regional level by summing the number of housing unit starts across all four quarters and dividing by the number of units in each building type. For the 3-4-unit type, the number of units per building is 3.5. The value is multiplied by 1,000 because the Census data are in units of thousand building starts.

For buildings with 1, 2, or 3-4 units:

$$B_{n,rgn} = \frac{(\sum_{Q1}^{Q4} A_{Q.n.rgn}) \times 1{,}000}{n}$$ (5)

Where:

$B_{n,rgn}$ = Number of building starts by the unit number category, *n*, and by region, *rgn*

$A_{Q,n,rgn}$ = Number of housing units started in quarter *Q,* by number of units, *n*, and region of the country, *rgn*, in thousand units

n = Number of units per building

For buildings with 5 or more units:

$$B_{n,rgn} = \frac{(\sum_{Q1}^{Q4} A_{Q.n.rgn}) \times 1{,}000}{CF_5}$$ (6)

Where:

$B_{n,rgn}$ = Number of building starts by the unit number category, *n*, and by region, *rgn*

$A_{Q,n,rgn}$ = Number of housing units started in quarter *Q,* by number of units, *n*, and region of the country, *rgn*, in thousand units

CF_5 = Ratio of 5 units or more to the number of buildings with 5 units or more

Annual county-level building permit data were purchased from the US Census Bureau for 2017 [ref 4]. The 2017 County Level Residential Building Permit dataset has 2017 data to allocate regional housing starts to the county level. This results in county-level housing starts by number of units.

The number of building permits for each unit number category by region is calculated by summing the county-level Census data to the Census region level.

$$BP_{n,rgn} = \sum BP_{n,c}$$

(7)

Where:

$BP_{n,rgn}$ = Number of building permits by the unit number category, n, and by region, rgn
$BP_{n,c}$ = Number of building permits by the unit number category, n, and by county, c

The ratio of the number of building permits by county to the total number of building permits by region in which the county is located, for each unit number category, is then calculated.

$$R_{BP,c} = \frac{BP_{n,c}}{BP_{n,rgn}}$$

(8)

Where:

$R_{BP,c}$ = Ratio of building permits, BP, to total regional building permits in county c
$BP_{n,c}$ = Number of building permits by the unit number category, n, and by county, c
$BP_{n,rgn}$ = Number of building permits by the unit number category, n, and by region, rgn

The final number of building starts for each unit type category is then calculated at the county-level by multiplying the number of structures started at the regional level and the building permit ratio.

$$B_{n,c} = B_{n,rgn} \times R_{BP,c}$$

(9)

Where:

$B_{n,c}$ = Number of building starts by the unit number category, n, and by county, c
$B_{n,rgn}$ = Number of building starts by the unit number category, n, and by region, rgn
$R_{BP,c}$ = Ratio of building permits, BP, to total regional building permits in county c

Determine Amount of Soil Removed for Basements

To calculate basement soil removal, the 2017 *Characteristics of New Single-Family Houses Completed, Foundation table* [ref 5] is used to estimate the percentage of 1-unit structures that have a basement at the regional level. The data indicate whether the structure has a full/partial basement, slab or other type, or crawl space. However, only structures with full/partial basements are used in this calculation.

$$BM_{rgn} = \frac{BM_{fp,rgn}}{BM_{t,rgn}}$$

(10)

Where:

BM_{rgn} = Fraction of basements for buildings in the region
$BM_{fp,rgn}$ = Number of full or partial basements, fp, by region, rgn

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$BM_{t,rgn}$ = Total number of houses regardless of basement type (full/partial, slab/other, crawl space by region, rgn

To estimate the number of building starts with and without basements in each county, the county level estimate of the number of 1-unit starts (from equation 9) is multiplied by the percent of 1-unit houses in the region that have a basement.

$$B_{c,BM} = B_{n.c} \times BM_{rgn} \tag{11}$$

$$B_{c,nBM} = B_{n.c} \times (1 - BM_{rgn}) \tag{11a}$$

Where:

$B_{c,BM}$ = Number of building starts by county, c, with a basement, BM
$B_{c,nBM}$ = Number of building starts by county, c, without a basement, BM
$B_{n,c}$ = Number of building starts by the unit number category, n, and by county, c
BM_{rgn} = Fraction of basements for buildings in the region

Basement volume is calculated by assuming a house with a 2000 square foot footprint has a basement dug to a depth of 8 feet (making 16,000 ft^3 per basement). An additional 10% is added for peripheral dirt bringing the total to 17,600 ft^3 (651.85 yd^3) per basement.

Determine Amount of Soil Disturbed by Unit Type

The number of acres of soil disturbed by the construction of residential buildings is calculated for apartment buildings, buildings with 2 units, and buildings with 1 unit. Table 4-79 below shows the assumptions used for the surface area disturbed for each unit type. Buildings with unit types of 3-4 and 5 or more are grouped together as apartments in this step.

Table 4-79: Surface soil removed per unit type

Structure Type	Acres disturbed
1-Unit	1/4 acre per structure
2-Unit	1/3 acre per structure
Apartment	1/2 acre per structure

For apartment buildings (sum of 3-4 and 5 or more units) and buildings with 2 units:

$$S_{n,c} = B_{n.c} \times a_n \tag{12}$$

Where:

$S_{n,c}$ = Surface soil disturbed by building construction by county, c, and unit type category, n, in acres
$B_{n,c}$ = Number of building starts by the unit type category, n, and by county, c
a_n = Acres of surface soil disturbed by each unit type category, n. See Table 4-79 for values for each type.

For buildings with 1 unit, with or without a basement:

$$S_{n,c} = B_{c,BM} \times a_n \tag{13}$$

Where:

$S_{n,c}$ = Surface soil disturbed by building construction by county, *c*, and unit type category, *n*, in acres

$B_{c,BM}$ = Number of buildings by county, *c*, with or without a basement, *BM*

a_n = Acres of surface soil disturbed by each unit type category, *n*. See Table 4-79 for values for each type.

4.9.3.2 *Allocation procedure*

Annual county building permit data were purchased from the US Census Bureau for 2017 [ref 4]. The 2017 County Level Residential Building Permit dataset is used to allocate regional housing starts to the county level.

4.9.3.3 *Emission factors*

Initial PM10 emissions from construction of single family, 2-unit, and apartments structures are calculated using the emissions factors given in Table 4-80 [ref 5]. These emissions factors describe average "unit operations," such as "loading and unloading of earth and aggregate materials, land clearing and general vehicle traffic" [ref 6]. They therefore take into account the entire duration of construction, and not simply the duration of active excavation. The duration of construction activity for houses is assumed to be 6 months and the duration of construction for apartments is assumed to be 12 months.

Table 4-80: Emissions factors for residential construction

Type of Structure	Emissions Factor	Duration of Construction
Apartments	0.11 tons PM10/acre-month	12 months
2-Unit Structures	0.032 tons PM10/acre-month	6 months
1-unit Structures with Basements	0.011 tons PM10/acre-month	6 months
	0.059 tons PM10/1000 cubic yards	
1-Unit Structures w/o Basements	0.032 tons PM10/acre-month	6 months

To account for the soil moisture level, the PM10 emissions are weighted using the 30-year average precipitation-evaporation (PE) values from Thornthwaite's PE Index. Average precipitation evaporation values for each state are estimated based on PE values for specific climatic divisions within a state. The average PE value for the test sites from which the PM10 emissions factor was developed is 24 [ref 6]. Equation 14 is used to adjust the county-level emissions factor based on this PE value.

To account for the silt content, the PM10-PRI emissions are weighted using average silt content for each county. EPA used the National Cooperative Soil Survey Microsoft Access Soil Characterization Database to develop county-level, average silt content values for surface soil [ref 7]. The U.S. Department of Agriculture and the National Cooperative Soil Survey define silt content of surface soil as the percentage of particles (mass basis) of diameter smaller than 50 micrometers (μm) found in the surface soil [ref 8]. Note that this definition is different than the U.S. Environmental Protection Agency's definition [ref 9] that includes all particles (mass basis) of diameter smaller than 75 micrometers. This database contains the most commonly requested data from the National Cooperative Soil Survey Laboratories including data from the Kellogg Soil Survey Laboratory and cooperating universities. The average silt content for the test sites from which the PM10 emissions factor was developed is 9% [ref 6]. Equation 7 is used to adjust the county-level emissions factor based on this silt content value.

$$AF_{PM10} = \frac{24}{PE} \times \frac{s}{9\%} \qquad (14)$$

Where:

AF_{PM10} = PM10-PRI adjustment factor
PE = precipitation-evaporation value for each State
s = % dry silt content, by county, in soil for area being inventoried

This adjustment factor is used to adjust the PM10-PRI emissions factor for each unit type category – apartment, 2-unit, 1-unit with basement, and 1-unit without basement.

$$EF_{p,n,c} = AF_{PM10} \times D_n \times EF_{orig} \tag{15}$$

Where:

$EF_{p,n,c}$ = Adjusted county-level, c, PM10-PRI emissions factor, p, for each unit type category, n, in tons/acre
AF_{PM10} = PM10-PRI adjustment factor
D_n = Duration of construction by unit type category, n, in months. See Table 4-80 for duration values.
EF_{orig} = Original unadjusted PM10 emissions factor, in tons/acre. See Table 4-80 for original emissions factors

4.9.3.4 *Controls*

There are no controls assumed for this category.

4.9.3.5 *Emissions*

The PM10-PRI emissions are calculated by taking the sum of the surface soil disturbed by county and unit type category and multiplying it by the corresponding adjusted PM10-PRI emissions factor. Once PM10-PRI adjustments have been made, PM25-PRI emissions are estimated by applying a particle size multiplier of 0.10 to PM10-PRI emissions [ref 8]. Primary PM emissions are equal to filterable emissions since there are no condensible emissions from residential construction.

The PM10-PRI emissions are calculated at the county-level by multiplying the surface soil disturbed from construction for each unit type by the corresponding emissions factor for that unit type, and then summed across unit types.

$$E_{PM10,c} = \sum_{n=1}^{N} S_{n,c} \times EF_{PM10,n,c} \tag{1}$$

Where:

$E_{PM10,c}$ = Total PM10-PRI emissions in county c, in tons
$S_{n,c}$ = Surface soil disturbed by building construction by county, c, and unit type category, n
$EF_{p,n,c}$ = Adjusted county-level, c, PM$_{10}$ emissions factor, p, for each unit type category, n, in tons/acre

The PM25-PRI emissions are calculated based on the assumption that they are 10% of the PM10-PRI emissions.

$$E_{PM2.5,c} = E_{PM10,c} \times 0.1 \tag{2}$$

Where:

$E_{PM2.5,c}$ = Total county-level, c, PM25-PRI emissions
$E_{PM10,c}$ = Total county-level, c, PM10-PRI emissions
0.1 = Particle size multiplier

4.9.3.6 *Sample calculations*

Table 4-81 shows sample calculations for PM10-PRI and PM25-PRI emissions from residential construction for a 2-unit structure in Suffolk County, Massachusetts. The first 3 equations use the first quarter (Q1) of 2017 for 2-unit structures as an example. However, these calculations would need to be repeated to calculate values for all 4 quarters for all 3-unit sizes. Note that structures with 5 or more units and structures with 1 unit with or without a basement have additional steps not shown in the sample calculations here.

Table 4-81: Sample calculations for PM-10 PRI and PM25-PRI emissions from residential construction of 2-unit structures in Suffolk County, MA.

Eq. #	Equation	Values for Suffolk County, MA	Result
1	$S_{Q,n} = \left(\dfrac{U_n}{U_t}\right) \times S_{Q,2-4}$	$\left(\dfrac{14\ two\ unit\ housing\ starts\ in\ 2002}{38\ total\ housing\ starts\ in\ 2002}\right)$ $\times$ $2\ two\ to\ four\ unit\ housing\ starts\ in\ Q1\ 2017$	0.74 thousand housing starts for 2-unit structures in Q1 2017, nationally
2	$r_{Q,n} = \dfrac{S_{Q,n}}{S_{Q.t}}$	$\dfrac{0.74\ two\ unit\ housing\ starts}{72\ two\ or\ more\ unit\ housing\ starts}$	0.01 ratio of buildings with 2 units to all 2 or more-unit housing starts for Q1 2017, nationally
3	$A_{Q,n,rgn} = r_{Q,n} \times (RS_t - RS_1)$	0.01 $\times (23\ total\ Q1\ housing\ starts\ in\ Northeast$ $- 9\ one\ unit\ housing\ starts\ in\ Northeast)$	0.14 thousand housing starts for 2-unit structures for Q1 2017 in the Northeast
4	$CF_5 = \dfrac{U_{5,rgn}}{B_{5,r}}$	N/A	Equation is for 5 or more-unit buildings; example is for 2-unit buildings
5	$B_{n,rgn}$ $= \dfrac{(\sum_{Q1}^{Q4} A_{Q.n.rgn}) \times 1{,}000}{n}$	$\dfrac{0.772\ two\ unit\ structures\ \times 1{,}000}{2\ units\ per\ building}$	386 2-unit structures constructed in the Northeast

Eq. #	Equation	Values for Suffolk County, MA	Result
6	$B_{n,rgn} = \dfrac{(\sum_{Q1}^{Q4} A_{Q.n.rgn}) \times 1{,}000}{CF_5}$	N/A	Equation is for 5 or more-unit buildings; example is for 2-unit buildings
7	$BP_{n,rgn} = \sum BP_{n,c}$	$\sum Northeast\ two\ unit\ building\ permits$	1,545 2-unit structure building permits in the Northeast
8	$R_{BP,c} = \dfrac{BP_{n,c}}{BP_{n,rgn}}$	$\dfrac{49\ Suffolk\ county\ building\ permits}{1{,}545\ Northeast\ building\ permits}$	0.03172 ratio of county-level building permits to regional-level building permits in Suffolk County, MA
9	$B_{n,c} = B_{n,rgn} \times R_{BP,c}$	386×0.03172	12.25 total 2-unit structure building starts for Suffolk County, MA
10	$BM_{rgn} = \dfrac{BM_{fp,rgn}}{BM_{t,rgn}}$	N/A	Equation is for 1-unit buildings; example is for 2-unit buildings
11	$B_{c,BM} = B_{n.c} \times BM_{rgn}$	N/A	Equation is for 1-unit buildings; example is for 2-unit buildings
12	$S_{n,c} = B_{n.c} \times a_n$	$12.25\ two\ unit\ structures \times 0.33\ acres\ per\ structure$	4.08 acres surface soil disturbed by 2-unit structures in Suffolk County, MA
13	$S_{n,c} = B_{c,BM} \times a_n$	N/A	Equation is for 1-unit buildings; example is for 2-unit buildings
14	$AF_{PM10} = \dfrac{24}{PE} \times \dfrac{s}{9\%}$	$\dfrac{24}{119.7\ PE\ value\ for\ Massachusetts} \times \dfrac{27.07\%\ silt\ content}{9\%}$	0.603 PM10-PRI adjustment factor for 2-unit structures in Suffolk County, MA

Eq. #	Equation	Values for Suffolk County, MA	Result
15	$EF_{p,n,c} = AF_{PM10} \times D_{m,n} \times EF_{orig}$	$0.603 \times 6\ months \times 0.032\ tons\ per\ acre$	0.1158 tons/acre PM10-PRI emissions factor for 2-unit structures in Suffolk County, MA
16	$E_{PM10,c} = \sum S_{n,c} \times EF_{p,n,c}$	$4.08\ acres \times 0.1158\ tons\ per\ acre$	0.47 tons PM10-PRI emissions for 2-unit structures in Suffolk County, MA
17	$E_{PM2.5,c} = E_{PM10,c} \times 0.1$	$0.47\ tons\ \times 0.1$	0.047 tons PM25-PRI emissions for 2-unit structures in Suffolk County, MA

4.9.3.7 *Updates in 2017 methodology*

Except for activity data updates, there are no significant changes from the methodology used in the 2014 NEI.

4.9.3.8 *Puerto Rico and Virgin Islands*

Since insufficient data exist to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emissions factor. For each Puerto Rico and US Virgin Island county, the tons per capita emissions factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.9.3.9 *References for residential construction*

1. U.S. Census Bureau, New Privately Owned Housing Units Started by Purpose and Design in 2017, accessed March 2019.
2. U.S. Census Bureau, 2001. Housing Starts, Table 1. New Privately-Owned Housing Units Started.
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4. U.S. Census Bureau, Annual Housing Units Authorized by Building Permits CO2017A, purchased March 2019.
5. U.S. Census Bureau, 2017 Characteristics of New Housing. Characteristics of New Single-Family Houses Completed, Annual 2017, Foundation Table.
6. Midwest Research Institute. 1996. Improvement of Specific Emission Factors (BACM Project No. 1). Prepared for South Coast Air Quality Management District.

7. U.S. Department of Agriculture, National Cooperative Soil Survey, NCSS Microsoft Access Soil Characterization Database.
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9. Midwest Research Institute. 1999. Estimating Particulate Matter Emissions from Construction Operations. Prepared for Emission Factor and Inventory Group, Office of Air Quality Planning and Standards US EPA.

4.9.4   EPA-developed emissions for non-residential construction

The calculations for estimating the emissions from non-residential construction involve first estimating the acres disturbed from non-residential construction in each county. The value of national-level non-residential construction spending is available from the U.S. Census Bureau and is converted to acreage disturbed using a conversion factor from a report by the Midwest Research Institute (MRI). The national-level acres disturbed are distributed to counties based on the proportion of non-residential construction employment in each county. Emissions factors for PM10 and PM25 are calculated based on precipitation-evaporation values and dry silt content in each county. The total amount of acres disturbed is multiplied by these emissions factors to estimate emissions of PM from non-residential construction.

4.9.4.1   *Activity data*

The activity data for this source category is the acreage disturbed from non-residential construction, which is estimated using data from the U.S. Census Bureau's *Annual Value of Construction Put in Place in the U.S* [ref 1]. and a conversion factor from MRI's *Estimating Particulate Matter Emissions from Construction Operations, Final Report* [ref 2]. The national-level non-residential construction spending data are allocated to the county-level based on the proportion of non-residential construction employees (NAICS 2362) in each county. Employment data are taken from the U.S. Census Bureau's 2017 County Business Patterns (CBP), and gaps in employment data are filled using a process described in detail in the next section.

$$EmpFr_c = \frac{Emp_c}{Emp_{US}} \qquad (1)$$

$$CS_c = EmpFr_c \times CS_{US} \qquad (2)$$

Where:

$EmpFr_c$	=	The fraction of non-residential construction employees in county c
Emp_c	=	The number of non-residential construction employees in county c
Emp_{US}	=	The number of non-residential construction employees in the US
CS_c	=	Non-residential construction spending in county c
CS_{US}	=	Non-residential construction spending in the US

Non-residential construction spending is converted to acres disturbed using a conversion factor from MRI's report. For the average acres disturbed per million dollars of non-residential construction, MRI reported a conversion factor of 2 acres/$1 million (in 1992 constant dollars). The 1992 conversion factor is adjusted to 2017 using the *Price Deflator (Fisher) Index of New Single-Family Houses under Construction* [ref 3]. In 2017 the conversion factor was 1.009 acres per million dollars spent on non-residential construction activities.

$$Apd_{2017} = \frac{2\ acres}{\$1\ million} \times \frac{PD_{1992}}{PD_{2017}} \tag{3}$$

Where:

Apd_{2017} = Acres disturbed per million dollars in 2017
PD_{1992} = Price Deflator (Fisher) Index value in 1992
PD_{2017} = Price Deflator (Fisher) Index value in 2017

County-level non-residential construction spending (from equation 2) is then multiplied by this conversion factor to estimate county-level acreage disturbed from non-residential construction activities.

$$A_c = CS_c \times Apd_{2017} \tag{4}$$

Where:

A_c = Acres disturbed from non-residential construction in county c
CS_c = Non-residential construction spending in county c
Apd_{2017} = Acres disturbed per million dollars in 2017

4.9.4.2   *Allocation procedure*

Employment data are obtained from the U.S. Census Bureau's 2017 County Business Patterns (CBP) [ref 4]. Due to concerns with releasing confidential business information, the *CBP* does not release exact numbers for a given NAICS code if the data can be traced to an individual business. Instead, a series of range codes is used. To estimate employment in counties and states with withheld data, the following procedure is used for NAICS code 2362 (non-residential construction).

To gap-fill withheld state-level employment data:
1. State-level data for states with known employment are summed to the national level.
2. State-level known employment is subtracted from the national total reported in the national-level CBP.
3. Each of the withheld states is assigned the midpoint of the range code. Table 4-82 lists the range codes and midpoints.
4. The midpoints for the states with withheld data are summed to the national level.
5. An adjustment factor is created by dividing the number of withheld employees (calculated in step 2 of this section) by the sum of the midpoints (step 4)
6. For the states with withheld employment data, the midpoint of the range for that state (step 3) is multiplied by the adjustment factor (step 5) to calculate the adjusted state-level employment for non-residential construction.

These same steps are then followed to fill in withheld data in the county-level business patterns.
1. County-level data for counties with known employment are summed by state.
2. County-level known employment is subtracted from the state total reported in state-level CBP (or, if the state-level data are withheld, from the state total estimated using the procedure discussed above).
3. Each of the withheld counties is assigned the midpoint of the range code (Table 4-82).
4. The midpoints for the counties with withheld data are summed to the state level.
5. An adjustment factor is created by dividing the number of withheld employees (step 2) by the sum of the midpoints (step 4).
6. For counties with withheld employment data, the midpoints (step 3) are multiplied by the adjustment factor (step 5) to calculate the adjusted county-level employment for non-residential construction.

Note that step 5 adjusts all counties within each state with withheld employment data by the same state-based proportion. It is unlikely that actual employment corresponds exactly with this smoothed adjustment method, but this method is the best option given the availability of the data.

Table 4-82: Ranges and midpoints for data withheld from State and County Business Patterns

Range Letter	Ranges	Midpoint
A	0-19	10
B	20-99	60
C	100-249	175
E	250-499	375
F	500-999	750
G	1,000-2,499	1,750
H	2,500-4,999	3,750
I	5,000-9,999	7,500
J	10,000-24,999	17,500
K	25,000-49,999	37,500
L	50,000-99,999	75,000
M	100,000+	

For example, take the 2017 CBP data for NAICS 2362 (non-residential construction) in Arizona provided in Table 4-83.

Table 4-83: 2017 CBP for NAICS 2361 in Arizona

FIPS state	FIPS county	NAICS	empflag	emp
04	001	2362	A	withheld
04	003	2362	B	withheld
04	005	2362		177
04	007	2362		11
04	009	2362	A	withheld
04	011	2362	H	withheld
04	012	2362	A	withheld
04	013	2362		7,945
04	015	2362		47
04	017	2362		79
04	019	2362		2,220
04	021	2362		112
04	023	2362	A	withheld
04	025	2362		171
04	027	2362		359

1. The total of employees not including withheld counties is 11,121.
2. The state-level *CBP* reports 13,952 employees for NAICS 2362. The difference is 2,831.
3. County 001 is given a midpoint of 10 (since range code A is 0-19) and County 011 is given a midpoint of 3,750.
4. State total for these all withheld counties is 3,850.
5. 2,831/3,850 = 0.74.
6. The adjusted employment for county 001 is 10 × 0.74 = 7.35. County 011 has an adjusted employment

of 3,750 × 0.74 = 2,757.47.

The county-level employment data are used to allocate the national-level non-residential construction spending data to the county-level (see equations 1 and 2).

4.9.4.3   *Emission factors*

Due to regional variances in soil moisture and silt content, emissions factors for PM10 and PM25 are calculated for each county. The initial PM10 emissions factor from non-residential construction is 0.19 tons/acre-month [ref 5]. The duration of construction activity for non-residential construction is assumed to be 11 months.

To account for the soil moisture level, the PM10 emissions are weighted using the 30-year average precipitation-evaporation (PE) values from Thornthwaite's PE Index. Average precipitation evaporation values for each state are estimated based on PE values for specific climatic divisions within a state [ref 5]. The average PE value for the test sites from which the PM10 emissions factor was developed is 24. Equation 5 adjusts the county-level emissions factor based on this PE value.

To account for the silt content, the PM10 emissions are weighted using average silt content for each county. EPA uses the National Cooperative Soil Survey Microsoft Access Soil Characterization Database to develop county-level, average silt content values for surface soil [ref 6]. The U.S. Department of Agriculture and the National Cooperative Soil Survey define silt content of surface soil as the percentage of particles (mass basis) of diameter smaller than 50 micrometers (μm) found in the surface soil. Note that this definition is different than the U.S. Environmental Protection Agency's definition that includes all particles (mass basis) of diameter smaller than 75 micrometers. This database contains the most commonly requested data from the National Cooperative Soil Survey Laboratories including data from the Kellogg Soil Survey Laboratory and cooperating universities. The average silt content for the test sites from which the PM10 emissions factor was developed is 9%. Equation 5 adjusts the county-level emissions factor based on this silt content value.

$$EF_{PM10,c} = ef_{PM10} \times \frac{24}{PE_s} \times \frac{S_c}{9\%} \tag{5}$$

Where:

$EF_{PM10,c}$ = PM$_{10}$ emission factor corrected for soil moisture and silt content in state s and county c, in tons/acre-month

ef_{PM10} = Initial PM$_{10}$ emissions factor for non-residential construction, 0.19 tons/acre-month

PE_s = Precipitation-evaporation value for state s

S_c = Percent dry silt content in soil for county c

Once PM$_{10}$ adjustments have been made, PM$_{2.5}$ emissions are set to 10% of PM$_{10}$.[ref 7]

$$EF_{PM25,c} = 0.10 \times EF_{PM10,c} \tag{6}$$

Where:

$EF_{PM10,c}$ = PM$_{10}$ emission factor corrected for soil moisture and silt content in state s and county c, in tons/acre-month

$EF_{PM25,c}$ = PM$_{2.5}$ emission factor corrected for soil moisture and silt content in county c, in tons/acre-month

Primary PM emissions are equal to filterable emissions as there are no condensible emissions from dust from non-residential construction.

4.9.4.4   *Controls*

There are no controls assumed for this category.

4.9.4.5   *Emissions*

The total annual PM emissions from non-residential construction in each county are calculated by multiplying the acres disturbed by the emissions factors calculated in equations 5 and 6 and by the duration of construction activity.

$$E_{p,c} = A_c \times EF_{p,c} \times M \tag{7}$$

Where:

$E_{p,c}$	=	Annual emissions of pollutant p in county c
A_c	=	Acres disturbed from non-residential construction in county c
$EF_{PM10,c}$	=	PM_{10} emission factor corrected for soil moisture and silt content in state s and county c, in tons/acre-month
$EF_{PM25,c}$	=	$PM_{2.5}$ emission factor corrected for soil moisture and silt content in county c, in tons/acre-month
M	=	Duration of construction activity in months, assumed to be 11 months

4.9.4.6   *Sample calculations*

Table 4-84 lists sample calculations to determine the dust emissions from non-residential construction in Grand Traverse County, Michigan.

Table 4-84. Sample calculations for non-residential construction in Grand Traverse County, Michigan

Eq. #	Equation	Values for Grand Traverse County, MI	Result
1	$EmpFr_c = \dfrac{Emp_c}{Emp_{US}}$	$\dfrac{120 \; nonres \; construction \; employees}{582,574 \; nonres \; construction \; employees}$	0.000206 fraction of non-residential construction employees in Grand Traverse County, MI
2	$CS_c = EmpFrac_c \times CS_{US}$	$0.000206 \; fraction \; of \; employees \; in \; Grand \; Traverse \times$ $\$ 347,666 \; million \; in \; nonres \; construction \; spending \; in \; the \; US$	$71.61 million in non-residential construction spending in Grand Traverse County, MI

Eq. #	Equation	Values for Grand Traverse County, MI	Result
3	$Apd_y = \dfrac{2\ acres}{\$1\ million} \times \dfrac{PD_{1992}}{PD_y}$	$\dfrac{2\ acres\ disturbed}{\$1\ million} \times \dfrac{57\ in\ 1992}{113\ in\ 2017}$	1.009 acres disturbed per million dollars spent on non-residential construction spending
4	$A_c = CS_c \times Apd_y$	$\$\ 71.61\ million \times 1.009\ \dfrac{acres\ disturbed}{million\ \$}$	72.25 acres disturbed from non-residential construction in Grand Traverse County, MI
5	$EF_{PM10,c} = ef_{PM10} \times \dfrac{24}{PE_s} \times \dfrac{S_c}{9\%}$	$0.19\ tons\ per\ acre\ month \times \dfrac{24}{103.6} \times \dfrac{21.95\%}{9\%}$	0.1073 tons PM10 per acre-month of non-residential construction in Grand Traverse County, MI
6	$EF_{PM25,c} = 0.10 \times EF_{PM10,c}$	$0.10 \times 0.1073\ tons\ per\ acre\ month$	0.0107 tons PM25 per acre month on non-residential construction in Grand Traverse County, MI
7	$E_{p,c} = A_c \times EF_{p,c} \times M$	$72.25\ acres \times 0.1073\ \dfrac{tons}{acre-month} \times 11\ months$	85.3 tons PM10 emissions from non-residential construction in Grand Traverse County, MI

Eq. #	Equation	Values for Grand Traverse County, MI	Result
	$$72.25\ acres \times 0.0107\ \frac{tons}{acre-month} \times 11\ months$$		8.5 tons PM25 emissions from non-residential construction in Grand Traverse County, MI

4.9.4.7 *Updates in 2017 methodology*

Except for activity data updates, there are no significant changes from the methodology used in the 2014 NEI.

4.9.4.8 *Puerto Rico and Virgin Islands*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island counties, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which serve as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.9.4.9 *References for non-residential construction*

1. U.S. Census Bureau, 2017. Value of Construction Put in Place.
2. Midwest Research Institute. 1999. *Estimating Particulate Matter Emissions from Construction Operations, Final Report,* prepared for the Emission Factor and Inventory Group, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency. Table 5-2.
3. U.S. Census Bureau. 2017. *Price Deflator (Fisher) Index of New Single-Family Houses Under Construction*
4. U.S. Census Bureau, County Business Patterns. 2017. *Complete County File* [14.4mb zip]
5. Midwest Research Institute. 1996. Improvement of Specific Emission Factors (BACM Project No. 1). Prepared for South Coast Air Quality Management District.
6. U.S. Department of Agriculture, National Cooperative Soil Survey, NCSS Microsoft Access Soil Characterization Database.
7. Midwest Research Institute. 2006. Background Document for Revisions to Find Fraction Ratios Used for AP-42 Fugitive Dust Emissions Factors. Prepared for Wester Governors 'Association.

4.9.5 EPA-developed emissions for road construction

The calculations for estimating the emissions from road construction involve first estimating the acres disturbed from new road constructed in each county. The amount of state-level road construction spending by road type is available from the Federal Highway Administration (FHWA) and is converted to acreage disturbed using conversion factors from the Florida Department of Transportation (FLDOT). The state-level acreage disturbed by road type is summed together and distributed to the counties based on the proportion of building starts in each county. Emissions factors for PM10 and PM25 are calculated based on precipitation-evaporation values and dry

silt content in each county. The total amount of acres disturbed is multiplied by these emissions factors to estimate emissions of PM from road construction.

4.9.5.1   *Activity data*

The activity data for this source category is the acreage disturbed from new road construction, which is estimated using data from FHWA's *Highway Statistics, State Highway Agency Capital Outlay 2014, Table SF-12A* [ref 1] and FLDOT's *Generic Cost per Mile Models* [ref 2]. From the FHWA table, the following construction types are used: New Construction, Relocation, Added Capacity, Major Widening, and Minor Widening. Each of the following road types have spending broken out for each construction type:

1. Interstate, urban
2. Interstate, rural
3. Other arterial, urban
4. Other arterial, rural
5. Collectors, urban
6. Collectors, rural

Construction spending for each road type is summed across all construction types to determine the total annual highway spending for each road type.

$$HS_{s,r} = \sum_{ct} S_{s,r} \tag{1}$$

Where:

$HS_{s,r}$	=	Annual highway spending for road type r in state s, in dollars
ct	=	Construction type
$S_{s,r}$	=	Annual spending per construction type in state s for road type r, in dollars

State expenditure data are converted to miles of new road and acres disturbed per mile of new road by applying conversions based on data obtained from FLDOT. The conversions are shown in Table 4-85, and the acres disturbed per mile conversions are calculated by multiplying the FLDOT's total affected roadway width (including all lanes, shoulders, and areas affected beyond the road width) in feet by the number of feet in a mile and converting the resulting land area from ft^2 to acres [ref 2]. Total affected roadway with is the sum of the numbers of lanes (assumed at 12 feet each), number of shoulders, and area affected beyond the road width (25 feet). There are 5,280 feet in a mile, and 43,560 ft^2 in an acre.

$$RC_{m,s,r} = \frac{HS_{s,r}}{TDM} \tag{2}$$

$$RC_{a,s,r} = RC_{m,s,r} \times ADM \tag{3}$$

Where:

$RC_{m,s,r}$	=	Miles of FHWA road type r constructed in state s
$RC_{a,s,r}$	=	Acres of land disturbed for construction of FHWA road type r in state s
$HS_{s,r}$	=	Annual highway spending for road type r in state s
TDM	=	Conversion of dollars spent to road miles constructed, in thousand dollars per mile

ADM   =   Conversion of road miles constructed to acres disturbed, in acres per mile

Table 4-85: Spending per mile and acres disturbed per mile by highway type

Road Type	Thousand Dollars per mile	Total Affected Roadway Width (ft)*	Acres Disturbed per mile
Urban Areas, Interstate	6,895	94	11.4
Rural Areas, Interstate	3,810	89	10.8
Urban Areas, Other Arterials	4,112	63	7.6
Rural Areas, Other Arterials	2,076	55	6.6
Urban Areas, Collectors	4,112	63	7.6
Rural Areas, Collectors	2,076	55	6.6

The acres of land disturbed by road type can then be summed across all road types in a state to calculate the total state-level acreage disturbed due to new road construction.

$$A_s = \sum_r RC_{a,s} \tag{4}$$

Where:

A_s =   Acres of land disturbed for all road construction in state s
$RC_{a,s}$ =   Acres of land disturbed for construction of FHWA road type r in state s

The process used to distribute the state-level amount of acreage disturbed to the counties is discussed in the next section.

4.9.5.2   Allocation procedure

Building permits data, used as a surrogate for road construction activity, from the U.S. Census Bureau are used to allocate the state-level acres disturbed by road construction to the county-level [ref 3]. Specifically, the ratio of the county-to state-level number of building starts is calculated and multiplied by the state-level acreage disturbed (from equation 4) to estimate the county-level acreage disturbed by road construction.

$$BFrac_c = \frac{Build_c}{Build_s} \tag{5}$$

$$A_c = A_s \times BFrac_c \tag{6}$$

Where:
$BFrac_c$ =   The fraction of building starts in county c
$Build_c$ =   The number of building starts in county c
$Build_s$ =   The number of building starts in state s
A_c =   Acres of land disturbed for road construction in county c
A_s =   Acres of land disturbed for all road construction in state s

4.9.5.3   Emission factors

Due to regional variances in soil moisture and silt content, uncontrolled emissions factors for PM10 and PM25 are adjusted for each county. The initial uncontrolled PM10 emissions factor from construction of roads is 0.42 tons/acre-month [ref 4]. This emission factor represents the large amount of dirt moved during the construction of roadways, reflecting the high level of cut and fill activity that occurs at road construction sites.

To account for the soil moisture level, the uncontrolled PM10 emissions are weighted using the 30-year average precipitation-evaporation (PE) values from Thornthwaite's PE Index. Average precipitation evaporation values for each state are estimated based on PE values for specific climatic divisions within a state [ref 4]. The average PE value for the test sites from which the PM10 emissions factor was developed is 24. Equation 7 adjusts the county-level uncontrolled emissions factor based on this PE value.

To account for the silt content, the uncontrolled PM10 emissions are weighted using average silt content for each county. EPA uses the National Cooperative Soil Survey Microsoft Access Soil Characterization Database to develop county-level, average silt content values for surface soil [ref 5]. The U.S. Department of Agriculture and the National Cooperative Soil Survey define silt content of surface soil as the percentage of particles (mass basis) of diameter smaller than 50 micrometers (μm) found in the surface soil. Note that this definition is different than the U.S. Environmental Protection Agency's definition that includes all particles (mass basis) of diameter smaller than 75 micrometers. This database contains the most commonly requested data from the National Cooperative Soil Survey Laboratories including data from the Kellogg Soil Survey Laboratory and cooperating universities. The average silt content for the test sites from which the PM10 emissions factor was developed is 9%. Equation 7 adjusts the county-level uncontrolled emissions factor based on this silt content value.

$$UEF_{PM10,c} = EF_{PM10} \times \frac{24}{PE_s} \times \frac{S_c}{9\%} \tag{7}$$

Where:

$UEF_{PM10,c}$ = Uncontrolled PM$_{10}$ emission factor corrected for soil moisture and silt content in state s and county c, in tons/acre-month

EF_{PM10} = Initial PM$_{10}$ emissions for road construction, 0.42 tons/acre-month

PE_s = Precipitation-evaporation value for state s

S_c = Percent dry silt content in soil for county c

Once uncontrolled PM$_{10}$ adjustments have been made, uncontrolled PM$_{2.5}$ emissions are set to 10% of PM$_{10}$.

$$UEF_{PM25,c} = 0.10 \times UEF_{PM10,c} \tag{8}$$

Where:

$UEF_{PM10,c}$ = Uncontrolled PM$_{10}$ emission factor corrected for soil moisture and silt content in state s and county c, in tons/acre-month

$UEF_{PM25,c}$ = Uncontrolled PM$_{2.5}$ emission factor corrected for soil moisture and silt content in county c, in tons/acre-month

Primary PM emissions are equal to filterable emissions as there are no condensible dust emissions from road construction.

4.9.5.4 Controls

Dust emissions from road construction are generally controlled by watering the construction site. The Midwest Research Institute recommends using a control efficiency of 50% for PM10 and PM25 emissions from road construction [ref 6].

$$EF_{P,c} = 0.50 \times UEF_{p,c} \tag{9}$$

Where:

$EF_{p,c}$ = Controlled emissions factor of pollutant p in county c

$UEF_{p,c}$ = Uncontrolled emissions factor of pollutant p in county c

4.9.5.5 Emissions

The total annual dust emissions from road construction in each county are multiplied by the emissions factors calculated in equation 9. The duration of construction activity for road construction is assumed to be 12 months.

$$E_{p,c} = A_c \times EF_{p,c} \times M \tag{10}$$

Where:

$E_{p,c}$ = Annual emissions of pollutant p in county c
A_c = Acres of land disturbed for road construction in county c
$EF_{PM10,c}$ = Controlled PM_{10} emission factor corrected for soil moisture and silt content in state s and county c, in tons/acre-month
$EF_{PM25,c}$ = Controlled $PM_{2.5}$ emission factor corrected for soil moisture and silt content in county c, in tons/acre-month
M = Duration of construction activity in months

4.9.5.6 Sample calculations

Table 4-86 Lists sample calculations to determine the dust emissions from road construction in Newport County, Rhode Island.

Table 4-86: Sample calculations for urban interstate, urban other arterial, and urban collector road construction in Newport County, RI

Eq. #	Equation	Values for Newport County, RI	Result
1	$HS_{s,r} = \sum_{ct} S_{s,r}$	$\$1{,}000 + \$9{,}155{,}000$	\$9,156,000 spent on urban interstate construction in RI
		$\$1{,}276{,}000 + \$2{,}471{,}000$	\$3,747,000 spent on urban other arterial construction in RI
		$\$2{,}583{,}000$	\$2,583,000 spent on urban collector construction in RI
2	$RC_{m,s,r} = \dfrac{HS_{s,r}}{TDM}$	$\dfrac{\$9{,}156{,}000}{6{,}895{,}000\ \$\,per\,mile}$	1.328 miles of urban interstate constructed in RI
		$\dfrac{\$3{,}747{,}000}{4{,}112{,}000\ \$\,per\,mile}$	0.911 miles of urban other arterial constructed in RI
		$\dfrac{\$2{,}683{,}000}{4{,}112{,}000\ \$\,per\,mile}$	0.628 miles of urban collector constructed in RI

Eq. #	Equation	Values for Newport County, RI	Result
3	$RC_{a,s,r} = RC_{m,s,r} \times ADM$	$1.328\ miles \times 11.4\ acres\ per\ mile =$	15.1 acres disturbed from urban interstate construction in RI
		$0.911\ miles \times 7.6\ acres\ per\ mile$	6.9 acres disturbed from urban other arterial construction in RI
		$0.628\ miles \times 7.6\ acres\ per\ mile$	4.8 acres disturbed from urban collector construction in RI
4	$A_s = \sum_r RC_{a,s}$	$15.1\ acres + 6.9\ acres + 4.8\ acres$	26.78 acres disturbed from urban road construction in RI
5	$BFrac_c = \dfrac{Build_c}{Build_s}$	$\dfrac{185\ building\ starts\ in\ Newport\ County}{952\ building\ starts\ in\ RI}$	0.194 fraction of building starts in Newport County, RI
6	$A_c = A_s \times BFrac_c$	$26.78\ acres \times 0.194$	5.20 acres disturbed from urban road construction in Newport County, RI
7	$UEF_{PM10,c} = EF_{PM10} \times \dfrac{24}{PE_s} \times \dfrac{S_c}{9\%}$	$0.42\ tons/acre - month \times \dfrac{24}{132} \times \dfrac{41,45\%}{9\%}$	0.3517 tons per acre-month uncontrolled PM10 emissions from road construction in Newport County, RI
8	$UEF_{PM25,c} = 0.10 \times UEF_{PM10,c}$	$0.10 \times 0.3517\ tons/acre - month$	0.0352 tons per acre-month PM25 emissions from road construction in Newport County, RI
9	$EF_{P,c} = 0.50 \times UEF_{p,c}$	$0.50 \times 0.3514\ tons\ per\ acre - month$	0.1758 tons per care-month controlled PM10 emissions from new road construction in Newport County, RI

Eq. #	Equation	Values for Newport County, RI	Result
		$0.50 \times 0.0352 \; tons\; per\; acre - month$	0.0176 tons per care-month controlled PM25 emissions from new road construction in Newport County, RI
10	$E_{p,c} = A_c \times EF_{p,c} \times M$	$5.2\; acres \times 0.1758\; tons/acre - month \times 12$	10.98 tons PM10 from urban road construction in Newport County, RI
		$5.2\; acres \times 0.0176\; tons/acre - month \times 12$	1.98 tons PM25 from urban road construction in Newport County, RI

4.9.5.7 Updates in 2017 methodology

The only methodology change from that used to calculate the 2014 NEI emissions is the addition of a 50% control due to watering of construction sites.

4.9.5.8 Puerto Rico and Virgin Islands

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.9.5.9 References for road construction

1. Federal Highway Administration. Table SF-12A, State Highway Agency Capital Outlay -2014.
2. Florida Department of Transportation. Generic Cost per Mile Models for 2018
3. U.S. Census Bureau. 2015. Annual Housing Units Authorized by Building Permits CO2017A, purchased March 2019.
4. Midwest Research Institute. 1996. Improvement of Specific Emission Factors (BACM Project No. 1). Prepared for South Coast Air Quality Management District.
5. U.S. Department of Agriculture, National Cooperative Soil Survey, NCSS Microsoft Access Soil Characterization Database.
6. Midwest Research Institute. 1999. Estimating Particulate Matter Emissions from Construction Operations, Final Report, Section 5.7.1. prepared for the Emission Factor and Inventory Group, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency.

4.10 Dust – Paved Road Dust

4.10.1 Sector description

The paved road dust sector reflects emissions of particulate matter from vehicles driving over paved roads. The SCCs that belong in this sector are provided in Table 4-87. EPA estimates emissions for total fugitives only. Fugitive dust emissions from paved road traffic were estimated for PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there are no PM-CON emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL emissions.

Table 4-87: SCCs in the paved road dust sector

SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
2294000000	Mobile Sources	Paved Roads	All Paved Roads	Total: Fugitives
2294000002	Mobile Sources	Paved Roads	All Paved Roads	Total: Sanding/Salting - Fugitives

4.10.2 Sources of data

The paved road dust sector includes data from the S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-88 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector.

Table 4-88: Agencies that submitted paved road dust emissions

Region	Agency	S/L/T
1	New Hampshire Department of Environmental Services	State
3	Delaware Department of Natural Resources and Environmental Control	State
3	Maryland Department of the Environment	State
4	Metro Public Health of Nashville/Davidson County	Local
4	Memphis and Shelby County Health Department - Pollution Control	Local
8	Northern Cheyenne Tribe	Tribe
9	California Air Resources Board	State
9	Maricopa County Air Quality Department	Local
9	Washoe County Health District	Local
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe
10	Washington State Department of Ecology	State

4.10.3 EPA-developed emissions

Uncontrolled paved road emissions were calculated at the county level by roadway type for the year 2017. This was done by multiplying the county/roadway class paved road vehicle miles traveled (VMT) by the appropriate paved road emission factor. Next, control factors were applied to the paved road emissions in PM$_{10}$ nonattainment and maintenance status counties. Emissions by roadway class were then totaled to the county level for reporting in the NEI. The following provides further details on the emission factor equation, determination of paved road VMT, and controls.

4.10.3.1 *Emission factors*

Re-entrained road dust emissions for paved roads were estimated using paved road VMT and the emission factor equation from AP-42 [ref 1]:

$$E = [k \times (sL)^{0.91} \times (W)^{1.02}]$$

Where:

E = paved road dust emission factor (g/VMT)
k = particle size multiplier (g/VMT)
sL = road surface silt loading (g/ m^2) (dimensionless in eq.)
W = average weight (tons) of all vehicles traveling the road (dimensionless in eq.)

The particle size multipliers for both PM10-PRI/-FIL and PM25-PRI/-FIL for paved roads came from AP-42. Paved road silt loadings were assigned to each of the fourteen functional roadway classes (seven urban and seven rural) based on the average annual daily traffic volume (ADTV) of each functional system by county [ref 2]. The silt loading values per average daily traffic volume come from the ubiquitous baseline values from Section 13.2.1 of AP-42 and are provided in Table 4-89.

Table 4-89: Assumed paved roads silt loading by road type (gm2) based on ADTV range

FHWA road type	0 -499	500-4,999	5,000-9,999	10,000+
Rural Interstate	0.015	0.015	0.015	0.015
Rural Other Freeways and Expressways	0.015	0.015	0.015	0.015
Rural Other Principal Arterial	0.6	0.2	0.06	0.03
Rural Minor Arterial	0.6	0.2	0.06	0.03
Rural Major Collector	0.6	0.2	0.06	0.03
Rural Minor Collector	0.6	0.2	0.06	0.03
Rural Local	0.6	0.2	0.06	0.03
Urban Interstate	0.015	0.015	0.015	0.015
Urban Other Freeways and Expressways	0.015	0.015	0.015	0.015
Urban Other Principal Arterial	0.6	0.2	0.06	0.03
Urban Minor Arterial	0.6	0.2	0.06	0.03
Urban Major Collector	0.6	0.2	0.06	0.03
Urban Minor Collector	0.6	0.2	0.06	0.03
Urban Local	0.6	0.2	0.06	0.03

Average daily traffic volume (ADTV) was calculated by dividing an estimate of VMT by functional road length and then by 365. State FHWA road length by functional road type data was broken down to the county level by multiplying by the ratio of county VMT to state VMT for each FHWA road type.

To better estimate paved road fugitive dust emissions, the average vehicle weight was estimated by road type for each county in the U.S. based on the 2017 VMT by vehicle type. The VMT for each vehicle type (per MOVES road type and county) was divided by the sum of the VMT of all vehicle types for the given road type in each county. This ratio was multiplied by the vehicle type mass (see Table 4-90) and summed to road type for each county to calculate a VMT-weighted average vehicle weight for each county/road type combination in the database. The VMT-weighted average vehicle weight by MOVES vehicle type was converted to FWHA vehicle type using the crosswalk in Table 4-91 to be used in the emission factor equation above.

Table 4-90: Average vehicle weights by FWHA vehicle class

MOVES Vehicle Type	Source Mass (tons)
Motorcycle	0.285
Passenger Car	1.479
Passenger Truck	1.867
Light Commercial Truck	2.0598
Intercity Bus	19.594
Transit Bus	16.556
School Bus	9.070
Refuse Truck	23.114
Single Unit Short-haul Truck	8.539
Single Unit Long-haul Truck	6.984
Motor Home	7.526
Combination Short-haul Truck	22.975
Combination Long-haul Truck	24.601

Table 4-91: MOVES and FWHA vehicle type crosswalk

MOVES Road Type Description	FWHA Road Type
Rural Restricted Access	Rural Interstate
Rural Unrestricted Access	Rural Principal Arterial
Rural Unrestricted Access	Rural Minor Arterial
Rural Unrestricted Access	Rural Collector
Rural Unrestricted Access	Rural Local
Urban Restricted Access	Urban Interstate
Urban Unrestricted Access	Urban Principal Arterial
Urban Unrestricted Access	Urban Minor Arterial
Urban Unrestricted Access	Urban Collector
Urban Unrestricted Access	Urban Local

Note: Other Freeways and Expressways were not included in the crosswalk, and so were assumed to be restricted access like Interstates.

4.10.3.2 *Activity data*

Generally, VMT on US roads can be obtained from the Federal Highway Administration (FHWA). Total VMT in each county in 2017 is provided by FHWA to EPA for use in EPA's MOtor Vehicle Emission Simulator (MOVES) model to calculate emissions for the mobile sector. The road dust methodology uses these same county-level VMT data from FHWA. FHWA categorizes roads into 14 different types based on road function and access; these road types can be found in Table 4-92.

Table 4-92: FHWA road types

FHWA Road Type
Rural Interstate
Rural Other Freeways and Expressways
Rural Other Principal Arterial
Rural Minor Arterial

Rural Major Collector
Rural Minor Collector
Rural Local
Urban Interstate
Urban Other Freeways and Expressways
Urban Other Principal Arterial
Urban Major Collector
Urban Minor Collector
Urban Local
Urban Minor Arterial

To estimate the portion of the total VMT occurring on paved roads, first the VMT on unpaved roads were estimated using a procedure to estimate proportion of unpaved vs. paved VMT (see the full description for VMT development in the "Activity Data" subsection under the *Unpaved Road Dust* section below). The estimated VMT on unpaved roads was then subtracted from the total VMT from MOVES to estimate the VMT on paved roads for each road type category where applicable.

4.10.3.3 *Allocation*

County level emissions were calculated by multiplying the county unpaved VMT (by road type) by the emission factors calculated according to Section 4.10.3.1 above and aggregating based on county and urban/rural classification.

4.10.3.4 *Controls*

Paved road dust controls were applied by county to urban and rural roads in serious PM_{10} nonattainment areas and to urban roads in moderate PM_{10} nonattainment areas. The assumed control measure is vacuum sweeping of paved roads twice per month. A control efficiency of 79% was assumed for this control measure [ref 3]. The assumed rule penetration varies by roadway class and PM_{10} nonattainment area classification (serious or moderate). The rule penetration rates are shown in Table 4-93. Rule effectiveness was assumed to be 100% for all counties where this control was applied.

Table 4-93: Penetration rate of Paved Road vacuum sweeping

PM_{10} Nonattainment Status	Roadway Class	Vacuum Sweeping Penetration Rate
Moderate	Urban Freeway & Expressway	0.67
Moderate	Urban Minor Arterial	0.67
Moderate	Urban Collector	0.64
Moderate	Urban Local	0.88
Serious	Rural Minor Arterial	0.71
Serious	Rural Major Collector	0.83
Serious	Rural Minor Collector	0.59
Serious	Rural Local	0.35
Serious	Urban Freeway & Expressway	0.67
Serious	Urban Minor Arterial	0.67
Serious	Urban Collector	0.64

PM$_{10}$ Nonattainment Status	Roadway Class	Vacuum Sweeping Penetration Rate
Serious	Urban Local	0.88

Note that the controls were applied at the county/roadway class level, and the controls differ by roadway class. No controls were applied to interstate or principal arterial roadways because these road surfaces typically do not have vacuum sweeping. In the excel spreadsheet, the total emissions for all roadway classes were summed to the county level. Therefore, the emissions at the county level can represent several different control efficiency and rule penetration levels and may include both controlled and uncontrolled emissions in the composite value.

4.10.3.5 *Meteorological adjustment*

After controls were applied, emissions were summed to the county level and converted to tons prior to applying the meteorological adjustment. The meteorological adjustment accounts for the reduction in fugitive dust emissions via the impact of precipitation and other meteorological factors over each hour of the year and then averaged to an annual meteorological adjustment factor for each grid cell in each county, aggregated to a single county-level factor. The county-level meteorological adjustment factors were developed by EPA based on the ratio of the unadjusted to meteorology-adjusted 2017 county-level emissions from the SMOKE Flat Files. The county-level meteorological adjustment is a scalar between 0 and 1 that is multiplied by the estimated emissions, where lower-values/greater-reductions are typically found in areas with more frequent precipitation.

4.10.3.6 *Changes from the 2014 NEI methodology*

The largest change from the methodology used to calculate the 2014v2 NEI emissions from road dust is the method used to determine the VMT on paved and unpaved roads in each county. Both the methods for the 2014v2 and 2017 NEI used the 2008 National Mobile Inventory Model (NMIM) run as the starting point for estimating the ratio of VMT on paved vs. unpaved roads. However, in 2014v2, the estimated VMT on unpaved roads were redistributed within Census regions as an additional step, to smooth out sharp differences in emissions across state lines. This redistribution is not done for the 2017 NEI in order to better preserve the integrity of the original SLT VMT data submitted to FHWA. An additional step was, however, added to update the 2008 NMIM paved/unpaved ratios used for local and rural minor collector road types by using state level 2017 FHWA data on paved vs. unpaved road *length* for these road types.

4.10.3.7 *Puerto Rico and Virgin Islands*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and Monroe (state-county FIPS=12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.10.4 References

1. United States Environmental Protection Agency, Office of Air Quality Planning and Standards. "Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.2.1, Paved Roads." Research Triangle Park, NC. January 2011.

2. U.S. Department of Transportation, Federal Highway Administration. [Highway Statistics 2016](). Table HM-51. Office of Highway Policy Information. Washington, DC. September 2018.
3. E.H. Pechan & Associates, Inc. "Phase II Regional Particulate Strategies; Task 4: Particulate Control Technology Characterization," draft report prepared for U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation. Washington, DC. June 1995.

4.11 Dust – Unpaved Road Dust

4.11.1 Sector description

The unpaved road dust sector reflects emissions of particulate matter from vehicles driving over unpaved roads. The SCCs that belong in this sector are provided in Table 4-94.Fugitive dust emissions from unpaved road traffic were estimated for PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there are no PM-CON emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL emissions.

Table 4-94: SCC in the unpaved road dust sector

SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
2296000000	Mobile Sources	Unpaved Roads	All Unpaved Roads	Total: Fugitives

4.11.2 Sources of data

The paved road dust sector includes data from the S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-95 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector.

Table 4-95: Agencies that submitted unpaved road dust emissions

Region	Agency	S/L/T
1	New Hampshire Department of Environmental Services	State
3	Maryland Department of the Environment	State
4	Metro Public Health of Nashville/Davidson County	Local
4	Memphis and Shelby County Health Department - Pollution Control	Local
8	Northern Cheyenne Tribe	Tribe
9	California Air Resources Board	State
9	Maricopa County Air Quality Department	Local
9	Washoe County Health District	Local
10	Alaska Department of Environmental Conservation	State
10	Coeur d'Alene Tribe	Tribe
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe
10	Washington State Department of Ecology	State

4.11.3 EPA-developed emissions

Uncontrolled unpaved road emissions were calculated at the county level by roadway type for the year 2017. This was done by multiplying the county/roadway class unpaved road vehicle miles traveled (VMT) by the

appropriate unpaved road emission factor. Next, control factors were applied to the unpaved road emissions in PM_{10} nonattainment and maintenance area counties. Emissions by roadway class were then totaled to the county level and adjusted for meteorological conditions. The following provides further details on the emission factor equation, determination of unpaved road VMT, and controls.

4.11.3.1 *Emission factors*

Re-entrained road dust emissions for unpaved roads were estimated using paved road VMT and the emission factor equation from AP-42 [ref 1]:

$$E = [k \times (s/12)^1 \times (SPD/30)^{0.5}] / (M/0.5)^{0.2} - C$$

Where k and C are empirical constants given in Table 4-96, with:

E = unpaved road dust emission factor (lb/VMT)
k = particle size multiplier (lb/VMT)
s = surface material silt content (%)
SPD = mean vehicle speed (mph)
M = surface material moisture content (%)
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)

Values used for the particle size multiplier and the 1980's vehicle fleet exhaust, brake wear, and tire wear are provided in Table 4-96, and come from AP-42 defaults.

Table 4-96: Constants for unpaved roads re-entrained dust emission factor equation

Constant	PM25-PRI/PM25-FIL	PM_{10}-PRI/PM_{10}-FIL
k (lb/VMT)	0.18	1.8
C	0.00036	0.00047

Average State-level unpaved road silt content values, developed as part of the 1985 NAPAP Inventory, were obtained from the Illinois State Water Survey [ref 2]. Silt contents of over 200 unpaved roads from over 30 States were obtained. Average silt contents of unpaved roads were calculated for each sate that had three or more samples for that State. For States that did not have three or more samples, the average for all samples from all States was used as a default value. The silt content values are reported by State in Table 4-97.

Table 4-97: Surface material silt content values (%) for unpaved roads by state

States	Surface material silt content (%)
OR	7.2
WY	7.1
MT	6.6
MO	6.5
TX	5.6
NC	5.1
NY	4.7
OK	4.4
NM	4.3

States	Surface material silt content (%)
NE, WI	4.2
AL, AR, AZ, CT, DE, DC, FL, GA, ID, KS, KY, LA, ME, MD, MA, MS, NH, NJ, ND, RI, SC, UT, VT, WA, WV	3.9
AK, HI	3.8
PA	3.3
VA	3.2
OH, SD	3.1
AZ	3.0
MN	2.7
CA, IL, IN, MI	2.6
IA	2.5
TN	2.0
NV	1.7
CO	1.5

Table 4-98 lists the speeds modeled on the unpaved roads by roadway class. These speeds were determined based on the average speeds modeled for onroad emission calculations and weighted to determine a single average speed for each of the roadway classes [ref 3]. The roadway class "Urban collector" with an average speed of 20 mph was split into two sub-categories, "Urban major collector" and "Urban minor collector", to correspond to the roadway types found in the 2017 VMT data.

Table 4-98: Speeds modeled by roadway type on unpaved roads

Unpaved Roadway Type	Speed (mph)
Rural Minor Arterial	39
Rural Major Collector	34
Rural Minor Collector	30
Rural Local	30
Urban Other Principal Arterial	20
Urban Minor Arterial	20
Urban Major Collector	20
Urban Minor Collector	20
Urban Local	20

A report by Cowherd et al. [ref 4] estimates a range of 0.3% to 1.1% for surface material moisture content (M) from different road samples across regions of the country. EPA used expert judgment to assign surface material moisture content values from this range to counties based on 2017 regional patterns of soil moisture and precipitation.

4.11.3.2 *Activity data*

Generally, VMT on US roads can be obtained from the Federal Highway Administration (FHWA). FHWA categorizes roads into 14 different types based on road function and access; these road types can be found in Table 4-99.

Table 4-99: FHWA road types

FHWA Road Type
Rural Interstate
Rural Other Freeways and Expressways
Rural Other Principal Arterial
Rural Minor Arterial
Rural Major Collector
Rural Minor Collector
Rural Local
Urban Interstate
Urban Other Freeways and Expressways
Urban Other Principal Arterial
Urban Major Collector
Urban Minor Collector
Urban Local
Urban Minor Arterial

Total VMT in each county in 2017 is provided by FHWA to EPA for use in EPA's MOtor Vehicle Emission Simulator (MOVES) model to calculate emissions for the mobile sector. The road dust methodology uses these county-level VMT data from FHWA.

The county-level VMT from FHWA includes total VMT, but it does not provide data how much of that VMT is on paved or unpaved roads. FHWA provides state-level data on the amount of VMT on paved and unpaved roads in 2017 for most road types, except for three: Rural Local, Urban Local, and Rural Minor Collector [ref 5]. To determine how much of the total VMT is on paved or unpaved roads, the total VMT in each county is multiplied by the ratio of state-level VMT on paved or unpaved roads to total state-level VMT on each road type.

$$VMT_{p/u,c,r} = VMT_{t,c,r} \times \frac{VMT_{p/u,s,r}}{VMT_{t,s,r}} \tag{1}$$

Where:

$VMT_{p/u,c,r}$ = Paved or unpaved vehicle miles traveled in county c on FHWA road type r

$VMT_{t,c,r}$ = Total vehicle miles traveled in county c on FHWA road type r, from equation 1

$VMT_{p/u,s,r}$ = Paved or unpaved vehicle miles traveled in state s on FHWA road type r

Because paved and unpaved VMT data were unavailable from FHWA for 2017 for the Rural Local, Urban Local, and Rural Minor Collector road types, ratios for those road types were developed using state-level results from a 2008 model run from the National Mobile Inventory Model (NMIM), a precursor to MOVES. To account for the fact that some states have paved many of their unpaved roads since 2008, an adjustment factor was developed based on the change in unpaved road length. While FHWA does not provide 2017 data on paved or unpaved VMT for those three road types, it does provide 2016 data on paved and unpaved road *length* for these road types [ref 6]. The adjustment factor is based on the change in the ratio of paved or unpaved road *length* 2016 to the ratio in 2008.

$$AF_{p/u,r,s} = \frac{\dfrac{Length_{p/u,s,r,2016}}{Length_{t,s,r,2016}}}{\dfrac{Length_{p/u,s,r,2008}}{Length_{t,s,r,2008}}} \tag{1a}$$

Where:

$AF_{p/u,s,r}$ = Adjustment factor for paved or unpaved vehicle miles traveled in state s on FHWA road type r

$Length_{p/u,s,r,2016}$ = Paved or unpaved road length in state s for FHWA road type r in 2016

$Length_{t,s,r,2016}$ = Total road length in state s for FHWA road type r in 2016

$Length_{p/u,s,r,2008}$ = Paved or unpaved road length in state s for FHWA road type r in 2008

$Length_{p/u,s,r,2008}$ = Total road length in state s for FHWA road type r in 2008

This adjustment factor is multiplied by the paved or unpaved VMT ratio from NMIM for Rural Local, Urban Local, and Rural Minor Collector roads.

$$VMT_{p/u,c,r} = VMT_{t,c,r} \times \frac{VMT_{p/u,s,r}}{VMT_{t,s,r}} \times AF_{p/u,s,r} \tag{21b}$$

Where:

$VMT_{p/u,c,r}$ = Paved or unpaved vehicle miles traveled in county c on FHWA road type r

$VMT_{t,c,r}$ = Total vehicle miles traveled in county c on FHWA road type r, from equation 1

$VMT_{p/u,s,r}$ = Paved or unpaved vehicle miles traveled in state s on FHWA road type r (from NMIM)

$VMT_{t,s,r}$ = Total vehicle miles traveled in state s on FHWA road type r

$AF_{p/u,s,r}$ = Adjustment factor for paved or unpaved vehicle miles traveled in state s on FHWA road (from equation 2a)

As an example, if a state paved many of its unpaved roads between 2008 and 2016, then the adjustment factor for unpaved roads would be less than 1, reducing the estimated ratio of unpaved VMT to total VMT (and, therefore, increasing the ratio of paved VMT to total VMT).

In addition, it is assumed that there is no VMT on unpaved roads for urban road types or in counties with a population density greater than 3,000 people per square mile. For these cases, all VMT is assumed to be on paved roads.

4.11.3.3 *Allocation*

The total VMT used to estimate emissions from road dust is available at the county level. The amount of paved and unpaved VMT in each county is estimated using state-level ratios, as described in the previous "Activity data" section. County level emissions were calculated by multiplying the county unpaved VMT (by road type) by the emission factors calculated in 4.11.3.1.

4.11.3.4 *Controls*

The controls assumed for unpaved roads varied by PM_{10} nonattainment area classification and by urban and rural areas. On urban unpaved roads in moderate PM_{10} nonattainment areas, paving of the unpaved road was assumed and a control efficiency of 96 percent and a rule penetration of 50 percent were applied. Controls were not applied to rural unpaved roads in moderate nonattainment areas. Chemical stabilization, with a control efficiency of 75 percent and a rule penetration of 50 percent, was assumed for rural areas in serious PM_{10} nonattainment areas. A combination of paving and chemical stabilization, with a control efficiency of 90 percent and a rule penetration of 75 percent, was assumed for urban unpaved roads in serious PM_{10} nonattainment areas. In counties currently at maintenance status, controls were assumed based on the severity (moderate or serious) of their prior nonattainment status. Some counties had multiple partial areas with differing levels of nonattainment. In these cases, controls were assumed to be applied based on the most serious level of nonattainment found within a given county.

Note that the controls were applied at the county level, and the controls differ by urban vs. rural roadway class. In the final emissions table, the emissions for all roadway classes were summed to the county level. Therefore, the emissions at the county level can represent several different control effectiveness and rule penetration levels. However, the control efficiency and rule penetration values were reported in the Controlled Emissions worksheet at the county level for urban and rural roadways separately.

4.11.3.5 *Meteorological adjustment*

After controls were applied, emissions were summed to the county level and converted to tons prior to applying the meteorological adjustment. The meteorological adjustment accounts for the reduction on fugitive dust emissions via the impact of precipitation and other meteorological factors over each hour of the year and then averaged to an annual meteorological adjustment factor for each grid cell in each county, aggregated to a single county-level factor. For example, wet roads will result in significantly lower dust emissions. The county-level meteorological adjustment factors were developed by EPA based on the ratio of the unadjusted to meteorology-adjusted 2017 county-level emissions from the SMOKE Flat Files. The county-level meteorological adjustment is a scalar between 0 and 1 that is multiplied by the estimated emissions, where lower-values/greater-reductions are typically found in areas with more frequent precipitation.

4.11.3.6 *Changes from the 2014 NEI methodology*

The methodology described above contains several adjustments from the methodology used to compose the 2014v2 version. The largest change from the methodology used to calculate the 2014v2 NEI emissions from road dust is the method used to determine the VMT on paved and unpaved roads in each county. Both the methods for the 2014v2 and 2017 NEI used the 2008 National Mobile Inventory Model (NMIM) run as the starting point for estimating the ratio of VMT on paved or unpaved roads. However, in 2014v2, the estimated VMT on unpaved roads were redistributed within Census regions, to smooth out sharp differences in emissions across state lines. This redistribution is not done for the 2017 NEI in order to preserve the integrity of the original SLT VMT data submitted to FHWA. An additional step was added to update the 2008 NMIM paved/unpaved ratios used for local and rural minor collector road types by using state level 2016 FHWA data on paved vs. unpaved road length for these road types.

In the 2014v2 NEI, emissions from unpaved roads were also redistributed within states based on proportion of rural population. The goal of this redistribution was to move emissions from unpaved roads out of cities into rural areas where unpaved roads are more likely to occur; however, upon review, this redistribution was considered too arbitrary in nature, sacrificing the spatial integrity of the FHWA source data, and was not done for the 2017 NEI. As an alternative to address anomalies of unexplained unpaved VMT occurring on urban roads, for the 2017 NEI, it is assumed that urban road types do not have emissions from unpaved roads. This assumption was not made for the 2014v2 NEI.

A change was made to the value used for surface material moisture content, "M", in the AP-42 emission factor equation. Previously, a single national default value of 0.5% was used for all counties. For 2017 NEI, values of 0.3% or 1.1% were used to assign surface material moisture content values to counties based on regional patterns of soil moisture and precipitation. Previously, a value of 0.5 percent for M was chosen as the national default as sufficient resources were not available at the time the emissions were calculated to determine more representative values.

4.11.3.7 *Puerto Rico and Virgin Islands*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and Monroe (state-county FIPS=12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.11.4 References

1. United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.2.2, Unpaved Roads. Research Triangle Park, NC. November 2006.
2. W. Barnard, G. Stensland, and D. Gatz, Illinois State Water Survey, "Evaluation of Potential Improvements in the Estimation of Unpaved Road Fugitive Emission Inventories," paper 87-58.1, presented at the 80th Annual Meeting of the APCA. New York, New York. June 21-26, 1987
3. United States Environmental Protection Agency, 2011 National Emissions Inventory, version 2 Technical Support Document. Research Triangle Park, NC. August 2015.
4. Cowherd, C., M.A. Grelinger, C. Kies, and T.G. Pace. 2002. Improved Activity Levels for National Emission Inventories of Fugitive Dust from Paved and Unpaved Roads. Presentation at 11th International Emission Inventory Conference. Atlanta, Georgia, April 15-18, 2002.
5. Data provided to Abt Associates by Robert Rozycki, FHWA.
6. Federal Highway Administration, "Highway Statistics, 2016." Table HM-51.

4.12 Fires – Agricultural Field Burning

4.12.1 Sector description

Agricultural burning refers to fires that occur over lands used for cultivating crops and agriculture. Another term for this sector is crop residue burning. In past NEIs for this sector, it was exclusively limited to emissions resulting in the burning of crops. However, in the 2014 NEI, we included grass/pasture burning SCCs into this sector. However, for technical reasons, we have moved the grass/pasture burning to the Events data category for the 2017 NEI, thereby causing this sector to once again only house emissions resulting from burning of crops.

4.12.2 Sources of data

Table 4-100 shows, the agricultural field burning SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The leading SCC description is "Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire;" for all SCCs in the table.

The basic SCC structure introduced in the 2014 NEI is retained here, with the exception of moving the grassland/pastures/rangeland emissions to the Events data category. For example, the SCCs that were added in 2014 to better describe the specific crops being burned, including fields in which two or more crops are burned, are retained here.

Note that many general crops are included in the SCC 2801500000, and it also is the SCC to report into for "crops unknown." Note that EPA reported emissions into all of the "double crops" SCCs, as in 2014.

Table 4-100: Nonpoint Agricultural Field Burning SCCs in the 2017 NEI

SCC	Description	EPA	S/L/T
2801500000	Unspecified crop type and Burn Method	X	X
2801500112	Field Crop is Alfalfa: Backfire Burning		X
2801500130	Field Crop is Barley: Burning Techniques Not Significant		X
2801500141	Field Crop is Bean (red): Headfire Burning	X	X
2801500142	Field Crop is Bean (red): Backfire Burning		X
2801500150	Field Crop is Corn: Burning Techniques Not Important	X	X
2801500151	Double Crop Winter Wheat and Corn	X	
2801500152	Double Crop Corn and Soybeans	X	
2801500160	Field Crop is Cotton: Burning Techniques Not Important	X	
2801500170	Field Crop is Grasses: Burning Techniques Not Important		X
2801500171	Fallow	X	X
2801500182	Field Crop is Hay (wild): Backfire Burning		X
2801500192	Field Crop is Oats: Backfire Burning		X
2801500202	Field Crop is Pea: Backfire Burning		X
2801500220	Field Crop is Rice: Burning Techniques Not Significant	X	
2801500250	Field Crop is Sugar Cane: Burning Techniques Not Significant	X	
2801500262	Field Crop is Wheat: Backfire Burning	X	X
2801500263	Double Crop Winter Wheat and Cotton	X	
2801500264	Double Crop Winter Wheat and Soybeans	X	X
2801500300	Orchard Crop Unspecified		X
2801500320	Orchard Crop is Apple		X
2801500330	Orchard Crop is Apricot		X
2801500350	Orchard Crop is Cherry		X
2801500390	Orchard Crop is Nectarine		X
2801500410	Orchard Crop is Peach		X
2801500420	Orchard Crop is Pear		X
2801500430	Orchard Crop is Prune		X
2801500500	Vine Crop Unspecified		X
2801500600	Forest Residues Unspecified		X

As an example of what agencies submitted, the agencies listed in Table 4-101 submitted PM2.5 emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector while others submitted only a portion of the sector. When an agency submits less than 100%, their Nonpoint Survey responses, along with other general business rules for building the NEI, are used to backfill with EPA estimates as appropriate.

Table 4-101: PM2.5 emissions submitted by reporting agency

Region	Agency	S/L/T
2	New Jersey Department of Environment Protection	State
4	Georgia Department of Natural Resources	State
5	Illinois Environmental Protection Agency	State
9	California Air Resources Board	State

Region	Agency	S/L/T
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe
10	Washington State Department of Ecology	State

4.12.3 EPA-developed emissions for agricultural field burning

By way of history for this sector, in the 2008 NEI, crop residue emission estimates were developed using satellite detects occurring over land types classified as "agricultural" and uncertain field sizes or were sporadically reported by a handful of states. In the 2011 NEI, the method described in McCarty et al. 2009 [ref 1] and McCarty 2011 [ref 2] was employed to estimate the emissions from this sector with the exception that states could submit their own estimates. However, this produced significant state to state variability between states that submitted their own data and states that did not. In addition, we received comments that many false detects (EPA emission estimates were too high) occurred using this method (due to dark fields resulting from irrigation) Therefore, a consistent methodology across multiple years for the CONUS has not yet been developed for this sector. To address these issues, in the 2014 NEI, a simple and efficient method was been developed to estimate emissions from crop residue that can easily be applied across multiple years over the CONUS at minimal cost. The method was developed by EPA Office of Research and Development and the reader is directed to a paper in press for details on the methods described below [ref 3]. This is the basic method used for the 2017 NEI, with the changes/improvements made as noted below.

The approach developed for use in the 2014 NEI, and used again for the 2017 NEI, already improves on previous estimates [ref 1, ref 2] as follows:

- Multiple satellite detections are used to locate fires using an operational product
- Field Size estimates are based on field work studies in multiple states (rather than a one size fits all approach)
- This method allows for intra-annual as well as annual changes in crop land use
- This method incorporates comments on this sector from past NEI efforts to improve the method and remove some of the false detects that occurred in the 2011 NEI
- Additional processing of the HMS data was done to remove 2 types of duplicates
- This method uses USDA NASS Cropland Data Layer (CDL) (USDA, 2015a) [ref 4] information to separate grass/pasture lands, which include Pasture/Grass, Grassland Herbaceous, and Pasture/Hay lands from all other agricultural burning and to identify the crop type
- Removal of agricultural fires from the Hazard Mapping System (HMS) dataset before the application of the SMARTFIRE2 system for wildfires and prescribed fires to eliminate double counting in the NEI and the use of state information to further identify fires as crop residue burning rather than another type of fire
- To further identify fires as crop residue burning rather than some type of wildfire. Our 2014 NEI approach complements the method used to estimate emissions from wildfires and prescribed fires because we use crop level land use information to identify crop residue fires and grassland ('rangeland') fires. The remaining fire detections are used in SMARTFIRE to estimate emissions in forested areas where fuel loadings are available from the National Forest Service.

4.12.3.1 *Improvements/Changes in the 2017 NEI*

For the 2017 NEI, we have made a few revisions to the method used to estimate this sector compared to the 2014 NEI and will summarize them here. As discussed previously, all details on 2014 methods (and thus, the starting point for our 2017 methodology) can be found in our published article "Development of the crop residue and rangeland burning in the 2014 National Emissions Inventory using information from multiple sources" [ref 3] as well as in Section 7 of our 2014 NEI Technical Support Document.

- In all prior NEIs for this sector, the VOC and HAP emission factors were inconsistent. The HAP emission factors were copied from the HAP emission factors for wildfires while the VOC emission factors were scaled from the CO emission factors. Therefore, the VOC emission factors had no consistency with the HAP emission factors. For the 2017 NEI, we reviewed the crop residue burning VOC speciation profiles in the SPECIATE database, located the original source of this information, and derived new VOC emission factors and new HAP emission factors from the same measurement study. The measurement study was focused on wheat straw and rice straw burning. We averaged these two emission factors for the remaining crop types, excluding sugarcane. For sugarcane, we located a new reference for sugarcane HAP emission factors and incorporated these into the dataset. Since the total mass was not reported in this paper, we used another reference for the total VOC for sugarcane. Sugarcane is unique because it is the only crop type that is burned pre-harvest and has different VOC emission factors compared to other crop types. In this database, we have revised all the VOC and HAP emission factors so that the HAP estimates are consistent with the VOC speciation derived from the SPECIATE profiles. The new VOC EFs are shown in the Tables that follow in this section. All non-VOC EFs used in the 2017 NEI remain the same as that used in the 2014 NEI as shown in the TSD for the 2014 NEI. For the new VOC and HAP EFs used in the 2017 NEI, readers are referred to SPECIATE5.0 data and its documentation.
- A second new feature of the 2017 database is that we have calculated, on a per fire basis, the heat release of each fire. This information is needed for a plume rise calculation within a chemical transport modeling system. In prior NEIs, we put all the emissions into layer 1. While this is not critical for the NEI (this sector in in the nonpoint category, where heat values are not required), for emissions processing for air quality modeling, this is a key improvement, and is thus noted here.
- A third feature of the database is that we have filtered out the satellite detections for 2017 to exclude areas covered by snow during the winter months. Certain crop types (corn and soybeans) have been excluded from these midwestern states: Iowa, Kansas, Indiana, Illinois, Michigan, Missouri, Minnesota, Wisconsin, Ohio. This update is partially based on comments we received from some of these states in the 2014 NEI development cycle.
- Finally, to avoid double counting with the wildfire inventory, all grassland detections of fires outside of the Flint Hills in Kansas and Oklahoma have been incorporated into the wildfire and prescribed fire inventory process and are not part of this database. These fires are included as appropriate in our wildland fire inventory, which is part of the "EVENTS" data category (see Section 7). While EPA did not report grassland fires to this sector in 2017, a few tribes did. Their emissions were miniscule compared to other totals, and while described in the above tables, they were too small to consider including in emission summaries.

4.12.3.2 *Activity Data*

As with the 2014 process, the HMS satellite product is the main system used for the 2017 NEI. The HMS satellite product is an operational satellite product showing hot spots and smoke plumes indicative of fire locations. It is a blended product using algorithms for the Geostationary Operational Environmental Satellite (GOES) Imager, the Polar Operational Environmental Satellite (POES) Advanced Very High Resolution Radiometer (AVHRR), Moderate Resolution Imaging Spectroradiometer (MODIS) and more recently the Visible Infrared Imaging

Radiometer Suite (VIIRS). These satellite detections are provided at 0.001 degrees latitude or longitude, but they are derived from active fire satellite products ranging in spatial accuracy from 375 m to 4km. To identify the crop type and to distinguish agricultural fires from all other fires in the HMS product, the USDA Cropland Data Layer (CDL) (USDA, 2015a) [ref 4] was employed. This dataset is produced annually by the USDA National Agricultural Statistics Service and provides high resolution (30 meter) detailed crop information to accurately identify crop types for agricultural fires. Based on field reconnaissance of McCarty (2013) [ref 5], a "typical" field size was assumed for each burn location, which varied by region of the country. The assumed field sizes can be found on the file "draft_2014_ag_grasspasture_emissions_nei_may62015.xlsx" on the 2014v1 Supplemental Data FTP site.

4.12.3.3 *Emission Factors*

Emission Factors for CO, NOx, SO$_2$, PM$_{2.5}$ and PM$_{10}$ were based on Table 1 from McCarty (2011) [ref 3]. The emission factors in McCarty (2011) were based on mean values from all available literature at the time. Emission Factors for NH$_3$ were derived from the 2002 NEI crop residue emission estimates using the ratio of NH$_3$/NOx and the NOx emission factor in Table 1 from McCarty (2011). These emission factors are shown in the 2014 NEI TSD. As discussed above the VOC EFs were improved for the 2017 NEI, as shown below in Table 4-107.

A subset of the HAP emission factors is shown in Table 4-103. These are based on updated VOC work mentioned above. The full set of HAP emission factors, available on the 2017 NEI Supplemental data FTP site, also includes the following HAPs: isopropylbenzene, n-hexane, o-xylene, propionaldehyde, styrene, toluene, 2,2,4-trimethylpentane, and m, p-xylenes.

Table 4-102: Revised Ag Burning Emission factors (lbs/ton) for VOC

Crop Type	Emission Factor
Corn	18.47
Wheat	18.69
Soybean	18.47
Cotton	18.47
Fallow	18.47
Rice	18.26
Sugarcane	3.68
All Other crops/Default	18.47
Double Crop Wheat/Soybeans	18.58
Double Crop Corn/Soybeans	18.47
Double Crop Wheat/Cotton	18.58

Table 4-103: Select HAP Emission factors (lb/ton) used in EPA Methods by crop type for entire US

Crop Type	SCC	Acetaldehyde	Benzene	1,3-butadiene	Ethylbenzene	Formaldehyde
Unspecified/General/Default	2801500000	1.521677	0.227658	0.161739	0.026645	1.025634
Red Bean	2801500141	1.521677	0.227658	0.161739	0.026645	1.025634
Red Bean	2801500142	1.521677	0.227658	0.161739	0.026645	1.025634
Corn	2801500150	1.521677	0.227658	0.161739	0.026645	1.025634
Wheat and Corn	2801500151	1.311003	0.224041	0.144669	0.020768	1.19077

Corn and Soybeans	2801500152	1.521677	0.227658	0.161739	0.026645	1.025634
Cotton	2801500160	1.521677	0.227658	0.161739	0.026645	1.025634
Fallow	2801500171	1.521677	0.227658	0.161739	0.026645	1.025634
Rice	2801500220	1.943024	0.234892	0.195879	0.038401	0.695364
Sugarcane	2801500250	0.0896	0.033	0	0.00162	0.3
Wheat	2801500262	1.10033	0.220424	0.127599	0.01489	1.355905
Wheat and Cotton	2801500263	1.311003	0.224041	0.144669	0.020768	1.19077
Wheat and Soybeans	2801500264	1.311003	0.224041	0.144669	0.020768	1.19077

4.12.3.4 *Emission Estimates for 2017*

Figure 4-17 summarizes 2017 NEI PM2.5 emission estimates by state, sorted from largest to smallest, based on the 2017 NEI. Florida, Washington, California, Georgia, and North Dakota are the top emitters. Some of these emissions come from S/L/T submissions, and some from EPA estimates. Tribal emissions are not shown here. A total of about 30,000 tons of PM2.5 are estimated to be emitted by this sector. Note that in the 2014 NEI, this sector total is significantly higher due to the additional inclusion of grassland/pasture burning. Shown in Table 4-104 are comparisons of PM2.5 emissions for those states that submitted PM2.5 vs EPA estimates. Only a few states submitted. Of those states that submitted to EIS, only 3 states (GA, ID, IL) and tribes included HAPS in their ag burning emission submittals. Only Idaho indicated to supplement their data with EPA estimates via the Nonpoint Survey. A total of about 33,000 tons of PM2.5 are estimated to be emitted for this sector using EPA methods alone, compared to about 30,000 when these SLT emissions are also factored into the final NEI.

Figure 4-17: Total 2017 NEI Agricultural Burning PM2.5 Emissions by state
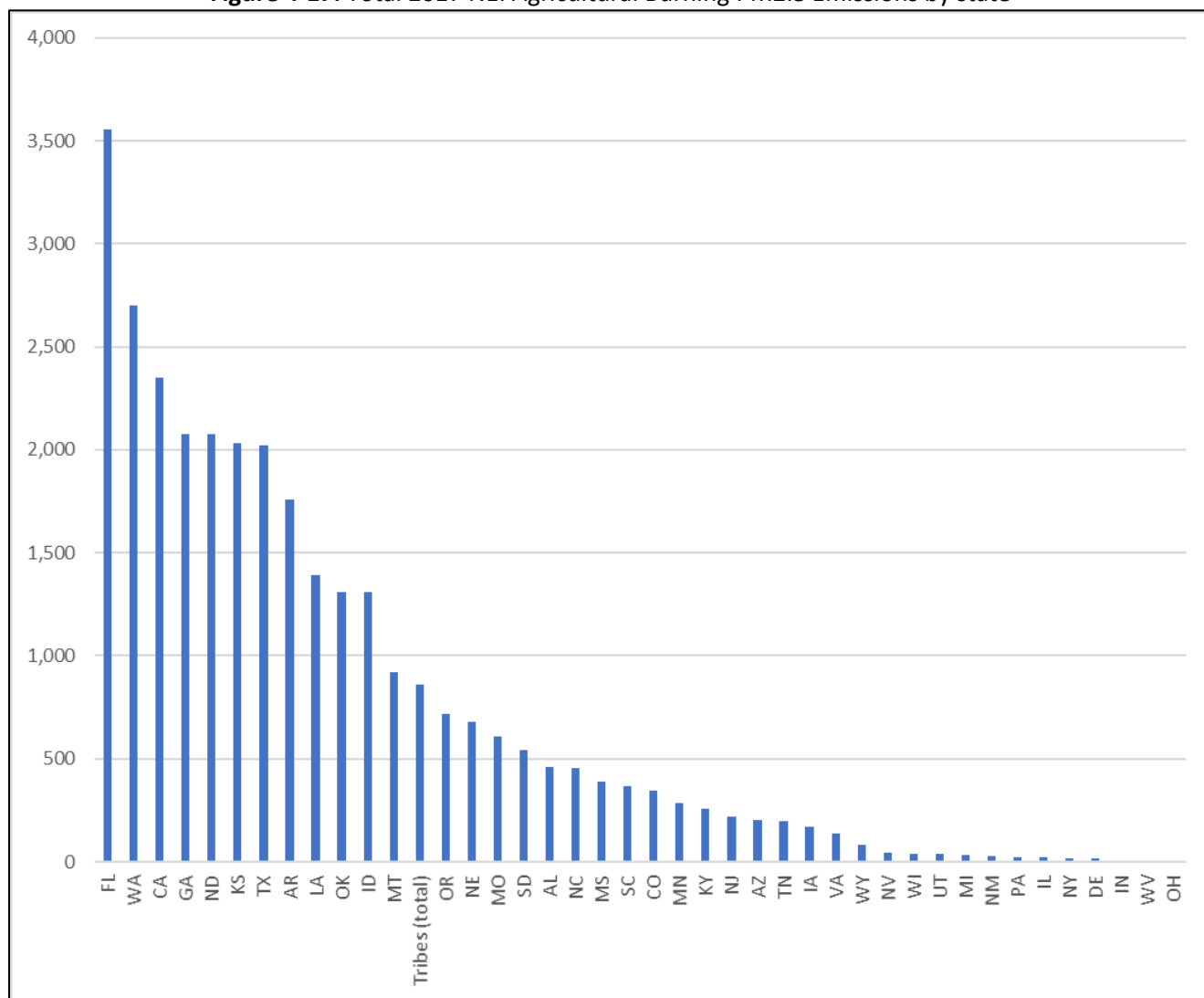
Table 4-104: Comparison of State vs EPA 2017 PM2.5 emissions (tons) for agencies that submitted

State/Tribe	S/L/T-submitted	EPA-generated
California	2,348	6,600
Georgia	2,077	1,577
Idaho	1,310	557
Illinois	23	44
New Jersey	221	0
Washington	2,703	1,148
Tribes Total	859	0

4.12.3.5 *Quality assurance of final estimates*

Some of the QA was implemented as part of the new methodology (discussed in Section 4.12.3.1 above) was applied for this sector. Additional review of the quality of EPA's data included addressing of S/L/T comments as we received them during the 2017 NEI process. In addition, the following checks were done on EPA data:

- Comparison to past NEI estimates, and explaining differences noted

- Check of diurnal profile using day specific data generated by EPA methods with existing profiles used for air quality modeling
- Using past comments received from S/L/Ts for this sector to ground truth estimates
- Ensuring HAPs and VOC speciation line up as expected

The QA of S/L/T-submitted data included checking with EPA estimates, working with S/L/Ts to understand why differences exist, and making sure pollutant coverage is complete.

We do not expect to make any major changes or improvements (e.g., methodology, pollutants expected) to this sector for the 2020 NEI. We will respond to specific comments we do receive for this sector.

4.12.3.6 *Known issue with the 2017 NEI*

Further analysis of the fire sectors including agricultural burning, wildland fires, and prescribed burns for the 2017 NEI revealed some double counting of acres burned and emissions in a few select regions and days in 2017.   The agriculture fire emissions estimation process is conducted separately from the development of the wildland fires inventory (see Section 7). The agricultural fire emissions estimation process has fires identified using the USDA Cropland Dataset and the Hazard Mapping System (HMS) satellite detects. The current process does not necessarily identify if an agricultural fire is a wildland fire, defined as a controlled (prescribed) burn or part of a wildfire. The separate NEI process for wildland fires uses fire activity data including shapefiles for major fires. These shapefiles define the area burned for major wildland fires and the NEI process assumes that **all fuels will burn within the area defined by the shape which can include croplands**. For 2017, we found that a major wildfire named Starbuck Complex in western Oklahoma and Kansas included the burning of 50,000+ acres of agricultural lands during the March 4-8 time period. Therefore, the same 50,000+ acres of agricultural fuels were treated as being burned in both the agricultural burn and wildland fires sectors using 2017NEI processes. The double counting of acres burned results in about 800-1,000 tons of PM2.5 emissions overestimation in western OK and KS during this time period. There are a few other smaller instances of double counting like this Starbuck Complex wildfire event that occur in the 2017 NEI in Texas, Washington and California. The EPA plans to change the 2020 NEI process to avert double counting emissions for agricultural lands in major wildfire events.

4.12.4 References for agricultural field burning

1. McCarty, J.L., S. Korontzi, C. O. Justice, and T. Loboda. 2009. *The spatial and temporal distribution of crop residue burning in the contiguous United States*. Science of the Total Environment 407 (21), 5701-5712.
2. McCarty, J. L. 2011. *Remote Sensing-Based Estimates of Annual and Seasonal Emissions from Crop Residue Burning in the Contiguous United States*. Journal of the Air & Waste Management Association 61 (1), 22-34.
3. Pouliot, G., Rao, V., McCarty, J. L., and A. Soja. 2017. *Development of the crop residue and rangeland burning in the 2014 National Emissions Inventory using information from multiple sources*. Journal of the Air & Waste Management Association Vol. 67, Issue 5.
4. United States Department of Agriculture. 2015a. USDA National Agricultural Statistics Service Cropland Data Layer *for 2015.*
5. Personal communication with Dr J. McCarty, 2013, Michigan Technological Institute.

4.13 Fuel Combustion – Industrial and Commercial/Institutional Boilers and ICEs

Industrial, Commercial, and Institutional (ICI) fuel combustion sources are a significant portion of the total emissions inventory for many areas and include emissions from boilers, engines, and other combustion sources

from the industrial, commercial, and institutional sectors that are not reported as point sources. This source category includes emissions from combustion of coal, distillate fuel oil, residual fuel oil, kerosene, liquefied petroleum gas (LPG), natural gas, and wood. Unless all ICI combustion emission sources are provided in an S/L/T point inventory submittal, it is necessary for inventory preparers to estimate ICI combustion nonpoint source emissions.

4.13.1 Sector description

The EIS sectors documented in this section include these nonpoint emissions from ICI fuel combustion:

- Fuel Comb - Industrial Boilers, ICEs - Biomass
- Fuel Comb - Industrial Boilers, ICEs - Coal
- Fuel Comb - Industrial Boilers, ICEs - Natural Gas
- Fuel Comb - Industrial Boilers, ICEs - Oil
- Fuel Comb - Industrial Boilers, ICEs - Other
- Fuel Comb - Comm/Institutional - Biomass
- Fuel Comb - Comm/Institutional - Coal
- Fuel Comb - Comm/Institutional - Natural Gas
- Fuel Comb - Comm/Institutional - Oil
- Fuel Comb - Comm/Institutional - Other

We document all these sectors in this section because EPA generates all the nonpoint emissions from these EIS sectors via the "ICI Tool" module. S/L/Ts were encouraged to submit Point inventory activity data -via many options reflecting sector and fuel type- in order to compute the "remaining" nonpoint emissions component to these sectors.

4.13.2 Sources of data

Table 4-105 shows, for ICI fuel combustion, the nonpoint SCCs covered by the EPA ICI Tool as well emissions directly submitted by State/Local and Tribal agencies. The SCC level 2, 3 and 4 descriptions are also provided except for the last SCC (2801520000), where the full SCC description is provided. The SCC level 1 description is "Stationary Source Fuel Combustion" for all SCCs except the last one. The leading sector description is "Fuel Comb" for all SCCs.

Table 4-105: Nonpoint ICI SCCs in the 2017 NEI

SCC	Description	Sector	EPA	SLT
2102001000	Industrial; Anthracite Coal; Total: All Boiler Types	Fuel Comb - Industrial Boilers, ICEs - Coal	X	X
2102002000	Industrial; Bituminous/Subbituminous Coal; Total: All Boiler Types	Fuel Comb - Industrial Boilers, ICEs - Coal	X	X
2102004000	Industrial; Distillate Oil; Total: Boilers and IC Engines	Fuel Comb - Industrial Boilers, ICEs - Oil	X	
2102004001	Industrial; Distillate Oil; All Boiler Types	Fuel Comb - Industrial Boilers, ICEs - Oil	X	X
2102004002	Industrial; Distillate Oil; All IC Engine Types	Fuel Comb - Industrial Boilers, ICEs - Oil	X	X

SCC	Description	Sector	EPA	SLT
2102005000	Industrial; Residual Oil; Total: All Boiler Types	Fuel Comb - Industrial Boilers, ICEs - Oil	X	X
2102006000	Industrial; Natural Gas; Total: Boilers and IC Engines	Fuel Comb - Industrial Boilers, ICEs - Natural Gas	X	X
2102007000	Industrial; Liquified Petroleum Gas (LPG); Total: All Boiler Types	Fuel Comb - Industrial Boilers, ICEs - Other	X	X
2102008000	Industrial; Wood; Total: All Boiler Types	Fuel Comb - Industrial Boilers, ICEs - Biomass	X	X
2102010000	Industrial; Process Gas; Total: All Boiler Types	Fuel Comb - Industrial Boilers, ICEs - Other	X	
2102011000	Industrial; Kerosene; Total: All Boiler Types	Fuel Comb - Industrial Boilers, ICEs - Oil	X	X
2103001000	Commercial/Institutional; Anthracite Coal; Total: All Boiler Types	Fuel Comb - Comm/Institutional - Coal	X	X
2103002000	Commercial/Institutional; Bituminous/Subbituminous Coal; Total: All Boiler Types	Fuel Comb - Comm/Institutional - Coal	X	X
2103004000	Commercial/Institutional; Distillate Oil; Total: Boilers and IC Engines	Fuel Comb - Comm/Institutional - Oil	X	
2103004001	Commercial/Institutional; Distillate Oil; Boilers	Fuel Comb - Comm/Institutional - Oil	X	X
2103004002	Commercial/Institutional; Distillate Oil; IC Engines	Fuel Comb - Comm/Institutional - Oil	X	X
2103005000	Commercial/Institutional; Residual Oil; Total: All Boiler Types	Fuel Comb - Comm/Institutional - Oil	X	X
2103006000	Commercial/Institutional; Natural Gas; Total: Boilers and IC Engines	Fuel Comb - Comm/Institutional - Natural Gas	X	X
2103007000	Commercial/Institutional; Liquified Petroleum Gas (LPG); Total: All Combustor Types	Fuel Comb - Comm/Institutional - Other	X	X
2103008000	Commercial/Institutional; Wood; Total: All Boiler Types	Fuel Comb - Comm/Institutional - Biomass	X	X
2103011000	Commercial/Institutional; Kerosene; Total: All Combustor Types	Fuel Comb - Comm/Institutional - Oil	X	X
2801520000	Miscellaneous Area Sources; Agriculture Production - Crops; Orchard Heaters; Total, all fuels	Fuel Comb - Industrial Boilers, ICEs - Other	X	

The agencies listed in Table 4-106 submitted emissions for these sectors. Agencies not listed used EPA estimates for all ICI sectors; most of the agencies not listed provided input activity data used to subtract point throughput data for subtraction.

Table 4-106: Agencies reporting nonpoint ICI sector emissions

Agency	Industrial: Biomass	Industrial: Coal	Industrial: Natural Gas	Industrial: Oil	Industrial: Other	Comm/Inst: Biomass	Comm/Inst: Coal	Comm/Inst: Natural Gas	Comm/Inst: Oil	Comm/Inst: Other
Alaska Department of Environmental Conservation			X	X				X	X	X
California Air Resources Board			X	X	X		X	X	X	X
Chattanooga Air Pollution Control Bureau (CHCAPCB)	X	X	X	X	X	X		X	X	X
Coeur d'Alene Tribe	X		X	X	X	X	X	X	X	X
Delaware Department of Natural Resources and Environmental Control			X	X	X			X	X	X
Idaho Department of Environmental Quality	X	X	X	X	X	X	X	X	X	X
Illinois Environmental Protection Agency	X	X	X	X	X	X	X	X	X	X
Kootenai Tribe of Idaho	X		X	X	X	X	X	X	X	X
Maricopa County Air Quality Department	X		X	X	X	X		X	X	
Memphis and Shelby County Health Department - Pollution Control			X	X	X			X	X	X
Metro Public Health of Nashville/Davidson County	X	X	X	X	X	X		X	X	X
Minnesota Pollution Control Agency	X	X	X	X	X	X	X	X	X	X
New Hampshire Department of Environmental Services			X	X	X	X		X	X	X
New Jersey Department of Environment Protection			X	X	X			X	X	X
Nez Perce Tribe	X		X	X	X	X	X	X	X	X
Northern Cheyenne Tribe						X	X		X	X
Oregon Department of Environmental Quality	X	X	X	X	X	X		X	X	X
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	X		X	X	X	X	X	X	X	X
Southern Ute Indian Tribe					X					
Texas Commission on Environmental Quality	X		X	X	X	X		X	X	X
Utah Division of Air Quality	X		X	X	X	X		X	X	X
Washoe County Health District			X	X	X			X	X	X

New for the 2017 NEI and discussed in Section 5.4.3 of the 2017 NEI Plan, was a request for States and Locals to submit total fuel consumption data if they were not submitting their own emission estimates. As discussed later in section 4.13.3.6, we developed several options for reporting agencies to submit this fuel consumption input data. Most states submitted emissions, input activity data, or both depending on the specific SCC. A couple of states completed the Nonpoint Survey (see Section 4.1.2) and indicated that all their ICI emissions were included

in their Point inventory submittal (Colorado and Kentucky); and nonpoint ICI emissions are therefore zero for these states. Conversely, a couple states (Nevada outside of Clark and Washoe counties, Mississippi, Montana, and South Dakota) did not submit emissions or inputs and therefore ICI nonpoint estimates are entirely based on state-total fuel consumption data, which is likely an overestimate as it would double-count any point inventory ICI emissions.

Table 4-107: Comprehensive State/Local agency submittal status for ICI estimates in the 2017 NEI

State/Local Agency	Data Submitted?	Nonpoint Survey Response (if no data provided)
Alabama	Input data	
Alaska	Input data & Emissions	
Arizona	Input data	
Arizona - Phoenix/Maricopa County	Emissions	
Arkansas	Input data	
California	Emissions	
Colorado	Survey	No - This source is included in my Point Source contributions
Connecticut	Input data	
District of Columbia	Input data	
Delaware	Emissions	
Florida	Input data	
Georgia	Input data	
Hawaii	Input data	
Idaho	Emissions	
Illinois	Emissions	
Indiana	Input data	
Iowa	Input data	
Kansas	Input data	
Kentucky		No - This source is included in my Point Source contributions
Kentucky -Louisville/Jefferson County	Input data	
Louisiana	Input data	
Maine	Input data	
Maryland	Input data	
Massachusetts	Input data	
Michigan	Input data	
Minnesota	Emissions	
Mississippi		Yes - Supplement My Data with EPA Estimates
Missouri	Input data	
Montana		
Nebraska	Input data	
Nevada		Supplement Only At Reported Location - SCCs

State/Local Agency	Data Submitted?	Nonpoint Survey Response (if no data provided)
Nevada -Clark County	Input data	
Nevada - Washoe County	Emissions	
New Hampshire	Emissions	
New Jersey	Emissions	
New Mexico	Input data	
New York	Input data	
North Carolina	Input data	
North Dakota	Input data	
Ohio	Input data	
Oklahoma	Input data	
Oregon	Input data & Emissions	
Pennsylvania	Input data	
Rhode Island	Input data	
South Carolina	Input data	
South Dakota		Yes - Supplement My Data with EPA Estimates
Tennessee	Input data	
Tennessee - Chattanooga	Emissions	
Tennessee - Knoxville/Knox County	Input data	
Tennessee - Memphis/Shelby County	Emissions	
Tennessee - Nashville/Davidson County	Input data & Emissions	
Texas	Emissions	
Utah	Emissions	
Vermont	Input data	
Virginia	Input data	
Washington	Input data	
West Virginia	Input data	
Wisconsin	Input data	
Wyoming	Input data	
Puerto Rico		Yes - Supplement My Data with EPA Estimates
U.S. Virgin Islands		

4.13.3 EPA-developed emissions

The calculations for estimating emissions from the ICI sectors include estimating the total fuel consumption by sector in each state, using data from the Energy Information Administration (EIA) State Energy Data System (SEDS) [ref 1]. Total fuel consumption is adjusted to account for fuel consumed by mobile sources in each sector and fuel used as an input to industrial processes but is not combusted. Fuel consumption from nonpoint sources in each state is determined by subtracting fuel consumption from point sources from total fuel consumption.

Estimated nonpoint source fuel consumption in each state is distributed to the county level based on the proportion of employment in the industrial and commercial sectors.

4.13.3.1 *Activity data*

The activity data for this source category is total fuel consumption in the industrial and commercial/institutional sectors. The default data for this category are obtained from the total 2017 state-level fuel consumption in each sector from EIA SEDS [ref 1] for all fuel types except distillate. Distillate fuel consumption is taken from EIA's Form 821 data, which reports distillate sales by state and sector for 2016 [ref 2]. State, local, and tribal (SLT) agencies are expected to submit state-level fuel consumption data from point sources in these sectors. The state-level point source fuel consumption is subtracted from the total fuel consumption to estimate the fuel consumption from nonpoint sources. The point source subtraction method is described in more detail in section 4.13.3.6.

Total fuel consumption is adjusted to account for the fraction of fuel consumed by nonroad mobile sources, whose emissions are included in the nonroad inventory. This fraction is based on results from the National Mobile Inventory Model (NMIM), a precursor to EPA's Motor Vehicle Emission Simulator (MOVES). This adjustment is particularly important for distillate fuel oil consumption. The ICI tool uses distillate consumption data from Form 821 rather than SEDS because Form 821 reports more detailed data by sector, and the ICI tool uses different stationary source fuel consumption assumptions by sector, including the industrial, commercial, farm, off-highway, and oil company sectors. Note that fuel consumption in the farm, off-highway, and oil company sectors are mapped to the industrial sector in the ICI tool. Assumptions about the fraction of fuel consumed by stationary sources are shown in an appendix.

The total fuel consumption is also adjusted to account for fuel used as an input to industrial processes where it is not combusted. These assumptions are based on the EIA Manufacturing Energy Consumption Survey (MECS) [ref 3], which reports both total fuel consumption and non-combustion use of fuel by Census region. Assumptions about non-combustion use of fuel are shown in Table 4-108. In some cases, EIA withholds the regional-level data on non-combustion use of fuel because it is less than 0.5 million barrels. In these cases, a value of 0.25 million barrels is used as the amount of regional-level non-combustion use of fuels.

Note that the stationary source adjustment is performed for fuel consumption from both the industrial and commercial/institutional sectors, while the non-combustion use of fuel adjustment is performed only for fuel consumption in the industrial sector.

$$AF_{f,s,x} = TF_{f,s,x} \times SS_{f,s,x} \times (1 - nc_{f,s,industrial}) \tag{1}$$

Where:

$AF_{f,s,x}$	=	Consumption of fuel f by stationary sources in state s in sector x
$TF_{f,s,x}$	=	Total consumption of fuel f in state s in sector x, from EIA SEDS
$SS_{f,s,x}$	=	Fraction of fuel f consumed by stationary sources in state s in sector x
$nc_{f,s,x}$	=	Fraction of fuel f used as an industrial input and is not combusted in state s in the industrial sector, from Table 4-108

Table 4-108: Assumptions about non-combustion use of fuel by fuel type and state

State	Coal	Distillate	LPG	Natural Gas	Residual Oil	Kerosene
AK	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
AL	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%

State	Coal	Distillate	LPG	Natural Gas	Residual Oil	Kerosene
AR	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
AZ	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
CA	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
CO	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
CT	75.0%	8.3%	91.3%	1.0%	0.0%	0.0%
DC	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
DE	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
FL	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
GA	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
HI	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
IA	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
ID	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
IL	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
IN	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
KS	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
KY	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
LA	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
MA	75.0%	8.3%	91.3%	1.0%	0.0%	0.0%
MD	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
ME	75.0%	8.3%	91.3%	1.0%	0.0%	0.0%
MI	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
MN	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
MO	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
MS	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
MT	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
NC	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
ND	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
NE	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
NH	75.0%	8.3%	91.3%	1.0%	0.0%	0.0%
NJ	75.0%	8.3%	91.3%	1.0%	0.0%	0.0%
NM	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
NV	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
NY	75.0%	8.3%	91.3%	1.0%	0.0%	0.0%
OH	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
OK	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
OR	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
PA	75.0%	8.3%	91.3%	1.0%	0.0%	0.0%
RI	75.0%	8.3%	91.3%	1.0%	0.0%	0.0%
SC	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
SD	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
TN	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
TX	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%

State	Coal	Distillate	LPG	Natural Gas	Residual Oil	Kerosene
UT	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
VA	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
VT	75.0%	8.3%	91.3%	1.0%	0.0%	0.0%
WA	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%
WI	44.0%	6.3%	80.0%	4.3%	100.0%	0.0%
WV	29.4%	11.1%	98.9%	13.3%	81.8%	0.0%
WY	0.0%	8.3%	6.3%	1.6%	0.0%	0.0%

The SEDS data do not distinguish between anthracite and bituminous/subbituminous coal consumption estimates. The EIA table "Domestic Distribution of U.S. Coal by Destination State, Consumer, Origin and Method of Transportation" [ref 4] provides state-level coal distribution data for 2006 that is used to estimate the fraction of coal consumption that is anthracite and bituminous/subbituminous. Table 4-109 presents these anthracite and bituminous coal ratios for each state.

Table 4-109: Anthracite and Bituminous Coal Distribution for the Residential and Commercial Sectors

State	Ratio of Bituminous	Ratio of Anthracite	State	Ratio of Bituminous	Ratio of Anthracite
Alabama	1.000	0.000	Montana	1.000	0.000
Alaska	1.000	0.000	Nebraska	1.000	0.000
Arizona	0.814	0.186	Nevada	1.000	0.000
Arkansas	0.814	0.186	New Hampshire	0.000	1.000
California	1.000	0.000	New Jersey	0.000	1.000
Colorado	0.996	0.004	New Mexico	1.000	0.000
Connecticut	0.000	1.000	New York	0.600	0.400
Delaware	0.814	0.186	North Carolina	1.000	0.000
Dist. Columbia	1.000	0.000	North Dakota	1.000	0.000
Florida	0.814	0.186	Ohio	0.873	0.127
Georgia	1.000	0.000	Oklahoma	0.917	0.083
Hawaii	1.000	0.000	Oregon	1.000	0.000
Idaho	0.979	0.021	Pennsylvania	0.194	0.806
Illinois	0.998	0.002	Rhode Island	0.000	1.000
Indiana	0.947	0.053	South Carolina	0.997	0.003
Iowa	0.999	0.001	South Dakota	1.000	0.000
Kansas	1.000	0.000	Tennessee	0.994	0.006
Kentucky	0.998	0.002	Texas	0.814	0.186
Louisiana	1.000	0.000	Utah	1.000	0.000
Maine	0.000	1.000	Vermont	0.000	1.000
Maryland	0.929	0.071	Virginia	0.963	0.037
Massachusetts	0.500	0.500	Washington	1.000	0.000
Michigan	0.667	0.333	West Virginia	0.905	0.095
Minnesota	0.997	0.003	Wisconsin	0.991	0.009
Mississippi	1.000	0.000	Wyoming	1.000	0.000
Missouri	1.000	0.000			

The SEDS data on industrial and commercial coal consumption are split into consumption of anthracite and bituminous/subbituminous coal based on the ratios in Table 4-109.

$$AF_{ant/bit,s,x} = AF_{coal,s,x} \times R_{ant/bit,s} \tag{2}$$

Where:

$AF_{ant/bit,s,x}$ = Adjusted anthracite or bituminous coal consumption in state *s* in sector *x*
$AF_{coal,s,x}$ = Total adjusted coal consumption in state *s* in sector *x*, from equation 1
$R_{ant/bit,s}$ = Ratio of anthracite or bituminous coal to total coal in state *s*, from Table 4-109

The EIA Form 821 data report total distillate consumption, but the NEI requires data separately on consumption by boilers and engines, because there are substantially different emissions factors for distillate boilers and engines. The ICI tool uses assumptions based on the EIA MECS [ref 3] and the EIA Commercial Building Energy Consumption Survey (CBECS) [ref 5]. These data sources suggest that in the industrial sector, 60 percent of distillate consumption is by boilers and 40 percent by engines, and in the commercial sector, 95 percent is by boilers and 5 percent is by engines.

$$AF_{boiler/engine,s,x} = AF_{distillate,s,x} \times R_{boiler/engine,s,x} \tag{3}$$

Where:

$AF_{boiler/engine,s,x}$ = Adjusted distillate consumption in boilers or engines state *s* in sector *x*
$AF_{distillates,x}$ = Total adjusted distillate consumption in state *s* in sector *x*, from equation 1
$R_{boiler/engine,s,x}$ = Ratio of distillate consumption by boilers or engines in state *s* in sector *x*

Following the adjustments to the total fuel consumption, the total fuel consumption data is also adjusted to subtract fuel consumption from point sources, which is accounted for in the point source inventory. Point source fuel consumption data by fuel type and sector is submitted by SLT agencies. This point source subtraction procedure is described in more detail in section 4.13.3.6. The point source subtraction step is performed at the state level, and it is done before the allocation procedure discussed in section 4.13.3.2 and before the emissions calculations discussed in section 4.13.3.5.

4.13.3.2 *Allocation procedure*

SEDS data are reported at the state level. Following the adjustments to the state level fuel consumption discussed in section 4.13.3.1 and the point source subtraction discussed below in section 4.13.3.6, the estimated state-level nonpoint source activity data in each state is distributed to the county level based on employment in the industrial or commercial sector from the Census Bureau's County Business Patterns [ref 6]. The adjusted nonpoint fuel consumption in each state is distributed to the county based on the proportion of employment in each county in each sector to the total employment at the state level in each sector.

$$NPF_{f,c,x} = NPF_{f,s,x} \times \frac{emp_{c,x}}{emp_{s,x}} \tag{4}$$

Where:

$NPF_{f,c,x}$ = Adjusted nonpoint consumption of fuel *f* in county *c* in sector *x*
$NPF_{f,s,x}$ = Adjusted nonpoint consumption of fuel *f* in state *s* in sector *x,* from equation 6
$emp_{c,x}$ = Employment in county *c* in sector *x*

$emp_{s,x}$ =   Employment in state s in sector x

Employment in each sector is determined based on the crosswalk between North American Industrial Classification System (NAICS) codes in the Point inventory and sectors, as shown in Table 4-110, where "Commercial" is interchangeable with the EIS "Commercial/Institutional" sector definition.

Table 4-110: Mapping of NAICS codes to ICI sectors

NAICS	Sector
11	Industrial
21	Industrial
2212	Commercial
2213	Commercial
23	Industrial
31	Industrial
32	Industrial
33	Industrial
42	Commercial
44	Commercial
45	Commercial
48 (except 4862)	Commercial
49	Commercial
51	Commercial
52	Commercial
53	Commercial
54	Commercial
55	Commercial
56	Commercial
61	Commercial
62	Commercial
71	Commercial
72	Commercial
81	Commercial
92	Commercial

4.13.3.3 *Emission factors*

The emissions factors for ICI sectors are from AP-42 [ref 7] and a spreadsheet developed in 2010 by EPA and the Eastern Regional Technical Advisory Committee [ref 8]. The emissions factors for ammonia are taken from one of two reports from EPA on ammonia emissions in the ICI sectors [ref 9, ref 10]. The emissions factors for hazardous air pollutants from wood combustion in the ICI sectors are taken from EPA's SPECIATE database [ref 11]. These emission factors are provided in Table 5 of the Appendix to the "ICI NEMO FINAL_4-2 updated.docx" document on the 2017 NEI Supplemental data FTP site.

4.13.3.4 *Controls*

There are no controls assumed for this category. However, the ICI tool includes options for SLT agencies to submit pollutant-, SCC-, and county-specific control factors if needed. These control factors are a number

between 0 and 1 that is multiplied by the emissions for that pollutant, SCC, and county. These factors allow SLT agencies to "fine tune" emissions estimates based on their understanding of how specific national and local rules combined with their penetration/effectiveness could lead to "composite-rule" emission factors for specific counties and pollutants. The relative difference between these "composite-rule" and default ICI tool emission factors can then be used to compute SCC-, county-, and pollutant-specific "controls."

Alternatively, SLT agencies can adjust the emissions factors; however, this would affect the calculation of emissions for all counties in the state.

4.13.3.5 *Emissions*

Emissions in each ICI sector are estimated by multiplying the county-level nonpoint source fuel consumption by the emission factors from Table 5 of the Appendix to the "ICI NEMO FINAL_4-2 updated.docx" document on the 2017 NEI Supplemental data FTP site.

$$E_{p,f,c,x} = NPF_{f,c,x} \times EF_{p,f,x} \tag{5}$$

Where:

$E_{p,f,c,x}$	=	Annual emissions of pollutant p from fuel type f in county c in sector x
$NPF_{f,c,x}$	=	Nonpoint source consumption of fuel type f in county c in sector x
$EF_{p,f,x}$	=	Emissions factor for pollutant p, fuel type f, and sector x

4.13.3.6 *Point Source subtraction*

The adjusted fuel consumption discussed in section 4.13.3.1 is an estimate of the state-level total fuel combusted for all sources, including point and nonpoint sources. To estimate the fuel consumption from only nonpoint sources, the fuel consumption from point sources is subtracted from the total adjusted fuel consumption. The fuel consumption from point sources is provided to EPA by SLT agencies.

The starting point for computing state-level point fuel consumption ($PF_{f,s,x}$) begins by matching NEI (EIS/state) facility identifier codes with EIA facilities in EIA-923 data [ref 12] to identify facilities that are in the industrial, commercial, or electric utility sectors. NEI facilities that match EIA-923 facilities with EIA sector assignments of 4 (Commercial NAICS Non-Co-gen) or 5 (Commercial NAICS Cogen) are assigned as "Commercial/Institutional" whose point source throughput activity data (consumption) are subject to Point subtraction from EIA SEDS. Similarly, NEI facilities that match EIA-923 facilities with EIA sector assignments of 6 (Industrial NAICS Non-Co-gen) or 7 (Industrial NAICS Cogen) are assigned as "Commercial/Institutional" whose point source throughput activity data (consumption) are subject to Point subtraction from EIA SEDS. NEI facilities that match EIA-923 facilities with EIA sector assignments of 1, 2 or 3 (Electric Utility, NAICS-22 Non-Cogen, and NAICS-22 Cogen, respectively) are assigned as "EGU" and thus not subject to Point "ICI" subtraction. An existing EIA 923 to NEI (EIS/state) facility ID cross-reference to EIA ICI sectors is available for each state "Proposed_facility_to_ICI_sector_assignments_2016NEI_14dec18_<state>.csv" on the 2017 NEI Supplemental data FTP site.

The remaining facilities that are not matched to EIA-923 facilities are then assigned to "Industrial", "Commercial/Institutional" or "N/A" based on facility NAICS codes provided in Table 4-110.

Once all point facilities have been mapped to the appropriate sector via either the EIA-923 or the NAICS assignments, the point inventory fuel consumption data are then aggregated by fuels using one of four different options to identify the fuel:

- **Option A: By NAICS and SCC**. In this option, SLT agencies submit state-level point source data aggregated by NAICS code and SCC. NAICS codes are used to map the point source fuel consumption to the appropriate ICI sector according to the mapping in Table 4-110. SCCs are used to identify the type of fuel consumed, according to the mapping in Table 7 of the Appendix to the "ICI NEMO FINAL_4-2 updated.docx" document on the 2017 NEI Supplemental data FTP site.
- **Option B: By NAICS and Fuel Type.** If the SLT agency knows the type of fuel consumed at each facility, the agency can submit fuel consumption by fuel type and NAICS. As with option A, the NAICS code will be used to map the fuel consumption to the appropriate sector.
- **Option C: Point Source Fuel Consumption By Sector and Fuel Type.** If the SLT agency has an alternative approach for determining the state-level fuel consumption by point sources in the industrial and commercial/institutional sectors by fuel type, the agency can submit this data directly.
- **Option D: Nonpoint Source Fuel Consumption By Sector and Fuel Type.** If the SLT agency has an alternative approach for determining the state-level fuel consumption by nonpoint sources in the industrial and commercial/institutional sectors by fuel type, the agency can submit this data directly. If the SLT agency chooses this option, point source subtraction is not needed, and the nonpoint source fuel consumption will be used directly to estimate emissions without further adjustment.

$$NPF_{f,s,x} = AF_{f,s,x} - PF_{f,s,x}$$
(6)

Where:

$NPF_{f,s,x}$ = Adjusted nonpoint consumption of fuel f in state s in sector x

$AF_{f,s,x}$ = Total consumption of fuel f in state s in sector x, adjusted as discussed in section 4.13.3.1

$PF_{f,s,x}$ = Consumption of fuel f by points sources in state s in sector x

Following point source subtraction at the state level, the estimated state-level nonpoint source fuel consumption is distributed to the states based on employment in the industrial and commercial sectors. This allocation procedure is discussed in section 4.13.3.2.

4.13.3.7 *Example calculations*

Table 4-111 lists sample calculations to determine PM25-PRI emissions from nonpoint source bituminous/subbituminous coal combustion in the industrial sector in Alamance County, North Carolina. Note that the equations in the table are listed in the order of the calculations, not in the order in which they are presented in this NEMO. Note also that the point source fuel consumption used in in equation 6 is just shown as an example and is not actual point source fuel consumption data submitted by an SLT agency.

Table 4-111: Sample calculations for PM25-PRI emissions from nonpoint industrial sector source bituminous/subbituminous coal combustion in Alamance County, NC

Eq. #	Equation	Values for Alamance County, NC	Result
1	$AF_{f,s,x}$ $= TF_{f,s,x}$ $\times SS_{f,s,x} \times (1$ $- nc_{f,s,industrial})$	$454\ thousand\ tons\ coal\ consumption\ in\ the\ industrial\ sector\ in$ $1\ [fraction\ of\ coal\ used\ by\ stationary\ sources] \times (1 -$ $0.2632\ [fraction\ of\ coal\ in\ NC\ used\ as\ input\ to\ industrial\ proc$	334.5 thousand tons adjusted industrial coal consumption in NC
2	$AF_{ant/bit,s,x}$ $= AF_{coal,s,x}$ $\times R_{ant/bit,s}$	$334.5\ thousand\ tons\ coal$ $\times 1\ [fraction\ of\ bit/subbit\ coal\ consumption]$	334.5 thousand tons industrial bituminous/ subbituminou s coal consumption in NC
3	$AF_{boiler/engine,s,x}$ $= AF_{distillate,s,x}$ $\times R_{boiler/engine,s,}$	*N/A*	Not needed for coal consumption
6	$NPF_{f,s,x}$ $= AF_{f,s,x}$ $- PF_{f,s,x}$	$334.5\ thousand\ tons\ bit/subbit\ coal$ $- 300\ tons\ point\ source\ bit$ $/subbit\ coal\ consumption$	34.5 thousand tons industrial nonpoint source bituminous/ subbituminou s coal consumption
4	$NPF_{f,c,x}$ $= NPF_{f,s,x}$ $\times \dfrac{emp_{c,x}}{emp_{s,x}}$	$34.5\ thousand\ tons$ $\times \dfrac{17,733\ industrial\ employees\ in\ Alamance}{861,292\ industrial\ employees\ in\ NC}$	0.71 thousand tons industrial nonpoint source bituminous/ subbituminou s coal consumption in Alamance County, NC

Eq. #	Equation	Values for Alamance County, NC	Result
5	$E_{p,f,c,x} = NPF_{f,c,x} \times EF_{p,f,x}$	$0.71\ thousand\ tons\ \times 2.44\ lbs\ PM25-PRI/ton$	1,732 lbs. (0.866 tons) PM25-PRI emissions from industrial nonpoint source bituminous/ subbituminous coal consumption in Alamance County

4.13.3.8 *Changes from the 2014 methodology*

The current method uses a different approach to point source subtraction compared to the 2014 method. The 2014 method used point source SCCs to identify both the sector and fuel type for fuel consumption by point sources. In the current method, the EIA-923 data is first used to assign point inventory facilities as Industrial, Commercial/Institutional, or neither; then, facilities' NAICS codes are used to determine which of the remaining facilities are either Industrial or Commercial/Institutional. The current method also now allows four different options for submitting state-level fuel consumption data.

In addition, in the current method, point source subtraction is conducted at the state level, rather than the county level. In the 2014 method, total fuel consumption was distributed to the county level before point source subtraction, and then point source subtraction was conducted using county-level point source data.

Finally, the 2014 method allowed point source subtraction using either point source emissions or point source fuel consumption. In the current method, point source subtraction is conducted using only point source fuel consumption; point source subtraction using emissions is no longer allowed.

4.13.3.9 *Puerto Rico and U.S. Virgin Islands*

Since insufficient data exists to calculate emissions from the ICI sectors for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emissions factor. For each Puerto Rico and US Virgin Island county, the tons per capita emissions factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.13.4 References

1. Energy Information Administration, 2018. State Energy Data System, 2017 data.
2. Energy Information Administration. 2018. Form 821: Sales of Distillate Fuel Oil by End Use, 2016 data.
3. Energy Information Administration. 2018. Manufacturing Energy Consumption Survey, 2014 data.

4. Energy Information Administration. 2008. "Domestic Distribution of U.S. Coal by Destination State, Consumer, Origin and Method of Transportation"

5. Energy Information Administration. 2015. Commercial Building Energy Consumption Survey, 2012 data.

6. U.S. Census Bureau. 2018. 2016 County Business Patterns.

7. U.S. Environmental Protection Agency. 1996. Compilation of Air Pollutant Emission Factors, 5th Edition, AP-42, Volume I: Stationary Point and Area Sources. Research Triangle Park, North Carolina.

8. EPA and Eastern Regional Technical Advisory Committee. 2010. Excel file: state_comparison_ERTAC_SS_version7_5_Mar 16 2010.xls

9. Battye, W. Battye, C. Overcash, and S. Fudge. 1994. Development and Selection of Ammonia Emission Factors: Final Report. Durham, NC: EC/R Incorporated. Prepared for USEPA Office of Research and Development.

10. E.H. Pechan and Associates, Inc. 2003. Estimating Ammonia Emissions from Anthropogenic Sources, Draft Report. Durham, NC. Prepared for USEPA Emission Factor and Inventory Group.

11. EPA. 2016. SPECIATE v4.5. Fireplace wood combustion – pine wood.

12. Energy Information Administration. 2018. Form 923 Electricity Sector Data, 2017 data.

4.14 Fuel Combustion – Residential – Natural Gas, Oil, and Other

Residential heating includes the combustion of fuel, including coal, distillate oil, kerosene, natural gas, and liquefied propane gas (LPG) to heat homes. Common uses of energy associated with this category include space heating, water heating, and cooking. This category does not include the combustion of wood, which is estimated separately in Section 4.15.

4.14.1 Sector description

The EIS sectors documented in this section include these emissions from residential fuel combustion:

- Fuel Comb - Residential - Natural Gas. Includes fuel natural gas only. Residential natural gas combustion is natural gas that is burned to heat residential housing as well as in grills, hot water heaters, and dryers.
- Fuel Comb - Residential – Oil. Includes the fuels: distillate oil, kerosene, and residual oil. Residual oil is not an EPA-estimated category, and no agencies submitted data for it in 2017. Residential distillate oil combustion is oil that is burned in residential housing. Residential kerosene combustion is kerosene that is burned in residential housing. Common uses of energy associated with this sector include space heating, water heating, cooking, and running a wide variety of other equipment.
- Fuel Comb - Residential – Other: Includes the fuels: coal, liquid petroleum gas (LPG), and "biomass; all except wood". Note that "biomass; all except wood" is not an EPA-estimated category and no agency submitted data for it in 2017. Residential coal combustion is coal that is burned in residential housing. Residential LPG combustion is liquefied propane gas that is burned in residential housing. Common uses of energy associated with this sector include space heating, water heating, and cooking.

4.14.2 Sources of data

Table 4-112 shows, for non-wood Residential heating, the nonpoint SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The SCC level 3 and 4 SCC descriptions are also provided. The SCC level 1 and 2 descriptions is "Stationary Source Fuel Combustion; Residential" for all SCCs. According to the State Energy Data System (SEDS) 2017 Consumption tables published by the Energy Information Administration (EIA) [ref 1], there was no residential coal combustion in 2017. However, the old

methodology is retained here and provided in an EPA workbook, and as seen in Table 4-112, with zero emissions, in case a state would like to use their own coal consumption data

Table 4-112: Non-wood residential fuel combustion SCCs in the 2017 NEI

SCC	Description	Sector	EPA	SLT
2104002000	Bituminous/Subbituminous Coal; Total: All Combustor Types	Fuel Comb - Residential - Other	0	X
2104004000	Distillate Oil; Total: All Combustor Types	Fuel Comb - Residential - Oil	X	X
2104006000	Natural Gas; Total: All Combustor Types	Fuel Comb - Residential - Natural Gas	X	X
2104007000	Liquified Petroleum Gas (LPG); Total: All Combustor Types	Fuel Comb - Residential - Other	X	X
2104011000	Kerosene; Total: All Heater Types	Fuel Comb - Residential - Oil	X	X

The agencies listed in Table 4-113 submitted emissions for these sectors. Agencies not listed uses EPA estimates for the entire sector.

Table 4-113: Agencies reporting non-wood residential fuel combustion emissions

Agency	Oil	Other	Natural Gas
Alaska Department of Environmental Conservation	X	X	
California Air Resources Board	X	X	X
Coeur d'Alene Tribe	X	X	X
Delaware Department of Natural Resources and Environmental Control	X	X	X
Idaho Department of Environmental Quality	X	X	X
Illinois Environmental Protection Agency	X	X	X
Kootenai Tribe of Idaho	X	X	X
Maricopa County Air Quality Department	X	X	X
Maryland Department of the Environment	X	X	X
Massachusetts Department of Environmental Protection	X	X	X
Memphis and Shelby County Health Department - Pollution Control	X	X	X
Metro Public Health of Nashville/Davidson County	X	X	X
New Hampshire Department of Environmental Services	X	X	X
New Jersey Department of Environment Protection	X	X	X
New York State Department of Environmental Conservation	X	X	X
Nez Perce Tribe	X	X	X
Northern Cheyenne Tribe		X	X
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	X	X	X
Southern Ute Indian Tribe		X	X
Texas Commission on Environmental Quality	X	X	X
Utah Division of Air Quality		X	X
Washoe County Health District	X	X	X

4.14.3 EPA-developed emissions

The general approach to calculating emissions for these SCCs is to take state-level fuel consumption from the EIA State Energy Data System (SEDS) [ref 1] and allocate it to the county level based on data from the Census

Bureau on the number of homes in each county that use each fuel type [ref 2]. County-level fuel consumption is multiplied by emissions factors to calculate emissions.

Note that SEDS no longer includes data on residential coal consumption, as it is assumed to be near zero, and therefore emissions will be nonexistent for residential coal consumption. However, the methodology for estimating emissions from coal has been retained if states have additional data on residential coal consumption that they would like to use.

The calculations for estimating emissions from residential heating involve distributing state-level energy consumption data from SEDS to each county based on the proportion of houses in that county that use each fuel type as a primary fuel source. Additional calculations are necessary to distribute coal consumption to anthracite or bituminous coal consumption and to distribute fuel oil consumption to distillate fuel oil and kerosene consumption. County-level consumption of each fuel is multiplied by an emissions factor to estimate emissions of criteria air pollutants (CAPs) and hazardous air pollutants (HAPs).

4.14.3.1 *Activity data*

The amount of fuel consumed by residential sector in the United States from SEDS [ref 1] is used to estimate emissions for this source category. The relevant fuel codes from SEDS are shown in Table 4-114.

Table 4-114: EIA State Energy Data System Fuel Codes

Fuel	SEDS Fuel Code
Coal	CLRCP
Distillate fuel oil	DFRCP
Kerosene	KSRCP
Natural Gas	NGRCP
LPG	LGRCP

The SEDS data do not distinguish between anthracite and bituminous/subbituminous coal consumption estimates. The EIA table "Domestic Distribution of U.S. Coal by Destination State, Consumer, Origin and Method of Transportation" [ref 3] provides state-level residential coal distribution data for 2006 that is used to estimate the fraction of coal consumption that is anthracite and bituminous/subbituminous. The amount of anthracite distributed to each state and the total coal delivered to each state is used to estimate the proportion of anthracite and bituminous coal consumption. Table 4-115 presents the anthracite and bituminous coal ratios for each state.

Table 4-115: Anthracite and Bituminous Coal Distribution for the Residential and Commercial Sectors

State	Ratio of Bituminous	Ratio of Anthracite	State	Ratio of Bituminous	Ratio of Anthracite
Alabama	1.000	0.000	Montana	1.000	0.000
Alaska	1.000	0.000	Nebraska	1.000	0.000
Arizona	0.814	0.186	Nevada	1.000	0.000
Arkansas	0.814	0.186	New Hampshire	0.000	1.000
California	1.000	0.000	New Jersey	0.000	1.000
Colorado	0.996	0.004	New Mexico	1.000	0.000
Connecticut	0.000	1.000	New York	0.600	0.400
Delaware	0.814	0.186	North Carolina	1.000	0.000
Dist. Columbia	1.000	0.000	North Dakota	1.000	0.000
Florida	0.814	0.186	Ohio	0.873	0.127

State	Ratio of Bituminous	Ratio of Anthracite	State	Ratio of Bituminous	Ratio of Anthracite
Georgia	1.000	0.000	Oklahoma	0.917	0.083
Hawaii	1.000	0.000	Oregon	1.000	0.000
Idaho	0.979	0.021	Pennsylvania	0.194	0.806
Illinois	0.998	0.002	Rhode Island	0.000	1.000
Indiana	0.947	0.053	South Carolina	0.997	0.003
Iowa	0.999	0.001	South Dakota	1.000	0.000
Kansas	1.000	0.000	Tennessee	0.994	0.006
Kentucky	0.998	0.002	Texas	0.814	0.186
Louisiana	1.000	0.000	Utah	1.000	0.000
Maine	0.000	1.000	Vermont	0.000	1.000
Maryland	0.929	0.071	Virginia	0.963	0.037
Massachusetts	0.500	0.500	Washington	1.000	0.000
Michigan	0.667	0.333	West Virginia	0.905	0.095
Minnesota	0.997	0.003	Wisconsin	0.991	0.009
Mississippi	1.000	0.000	Wyoming	1.000	0.000
Missouri	1.000	0.000			

The SEDS data on residential coal consumption are split into consumption of anthracite and bituminous/subbituminous coal based on the ratios in Table 4-115.

$$FC_{ant/bit,s} = FC_{coal,s} \times R_{ant/bit} \tag{1}$$

Where:

$FC_{ant/bit,s}$ = anthracite or bituminous coal consumption in state s, in tons
$FC_{coal,s}$ = total fuel consumption of coal in state s from SEDS, in tons
$R_{ant/bit}$ = ratio of anthracite or bituminous coal to total coal, as found in Table 4-115

4.14.3.2 *Allocation procedure*

State-level fuel consumption is allocated to each county using the US Census Bureau's 5-year estimate Census Detailed Housing Information [ref 2], which includes the number of housing units using a specific type of fuel for their primary fuel source. State fuel consumption is allocated to each county using the ratio of the number of houses using each fuel in each county to the total number of houses using each fuel in the state.

For most fuels, the fuel type in SEDS matches well to the fuel type used in the Census data. However, the Census data report only for total fuel oil, which does not distinguish between distillate fuel oil and kerosene. Therefore, the ratio of distillate fuel oil versus kerosene in the heating fuel oil mix, which is used to determine the fraction of homes in each county that use distillate and those that use kerosene, is calculated.

$$R_{dfo/ker,s} = \frac{FC_{dfo/ker,s}}{FC_{dfo,s} + FC_{ker,s}} \tag{2}$$

Where:

$R_{dfo/ker,s}$ = ratio of residential distillate fuel oil or kerosene to total distillate fuel oil and kerosene in state s

$A_{dfo/ker,s}$ = fuel consumption of distillate fuel oil or kerosene in state s from SEDS, in thousand barrels

Then, the ratio of distillate fuel oil or kerosene to total fuel oil is used to determine how many housing units in each county use distillate fuel oil or kerosene.

$$HU_{dfo/ker,c} = HU_{fo,c} \times R_{dfo/ker,s}$$ (3)

Where:

$HU_{dfo/ker,c}$ = housing units in county c using distillate fuel oil or kerosene as the primary heating fuel
$HU_{fo,c}$ = housing units in county c using any fuel oil as primary heating fuel

To distribute the state-level energy consumption data for all fuel types, the ratio of county-level housing units using each fuel type as primary heating fuel to state-level housing units using that fuel type is calculated. This ratio is used to distribute state-level fuel consumption to the county level. The county-level values for housing units using distillate oil and kerosene as primary fuel are calculated in equations 2 and 3 above.

$$R_{f,c} = \frac{HU_{f,c}}{HU_{f,s}}$$ (4)

Where:

$R_{f,c}$ = ratio of homes in county c to homes in state s that use fuel f as primary heating fuel
$HU_{f,c}$ = housing units in county c using fuel type f as primary heating fuel
$HU_{f,s}$ = housing units in state s using fuel type f as primary heating fuel

The state-level fuel consumption of each fuel type from SEDS is multiplied by the county-level ratio of homes using each fuel type. State-level fuel consumption of anthracite and bituminous/subbituminous coal is calculated in equation 1 in Section 4.14.3.1.

$$FC_{f,c} = FC_{f,s} \times R_{f,c}$$ (5)

Where:

$FC_{f,c}$ = fuel consumption of fuel type f in county c, in tons, thousand barrels, or thousand cubic feet
$FC_{f,s}$ = fuel consumption of fuel type f in state s, in tons, thousand barrels, or thousand cubic feet, from SEDS
$R_{f,c}$ = ratio of homes in county c to homes in state s that use fuel f as primary heating fuel

Fuel consumption of distillate fuel oil is converted from barrels to gallons using a conversion factor of 42 gallons per barrel.

4.14.3.3 Emission factors

All emissions factors for CAPs, except ammonia, are from AP-42 [ref 4]. The ammonia emissions factor is from EPA's Estimating Ammonia Emissions from Anthropogenic Sources, Draft Final Report [ref 5]. In some cases, HAP emissions factors are from a memorandum to EPA called "Baseline Emission Inventory of HAP Emissions from MACT Sources – Interim Final Report" [ref 6].

For many residential heating fuels, the emissions factors for SO2 and PM species are adjusted using sulfur or ash content data for the fuel at the county level. Note that for coal emissions, this step need only be done if a state supplies data on residential coal consumption, because SEDS currently assumes zero residential coal consumption.

$$EF_{f,s,p} = SAC_{f,s} \times EF_{unadj,f}$$ (6)

Where:

$EF_{x,p}$ = emissions factor of pollutant p for fuel type f in state s
SAC_x = sulfur or ash content for fuel type f in state s
$EF_{unadj,f}$ = unadjusted emissions factor for fuel type f, from EPA AP-42

A summary of the emissions factors for all fuel types for residential heating: anthracite coal, bituminous/subbituminous coal, distillate fuel oil, kerosene, LPG, and natural gas is provided in Table 5 of the "Residential Heating NEMO 2017 FINAL_4-2 update.docx" document on the 2017 NEI Supplemental data FTP site.

For coal combustion, the SO2 emission factors are based on the sulfur content of the coal burned, and some of the PM emission factors for anthracite coal require information on the ash content of the coal. State-specific coal sulfur contents for bituminous coal are obtained from the EIA's Coal Data Browser and applied at the county level [ref 7]. Bituminous sulfur content data can be found in the Coal Consumption and Quality Data Set, filtered to only account for commercial and institutional sources. For anthracite coal, an ash content value of 13.38% and a sulfur content of 0.89% are applied to all counties except those in New Mexico (ash content 16.61%, sulfur content 0.77%), Washington (ash content 12%, sulfur content 0.9%), and Virginia (ash content 13.38%, sulfur content 0.43%). Table 4-116 shows the coal SO2 and PM emissions factors. Table 4-117 presents the bituminous coal sulfur content values used for each state.

Table 4-116: SO2 and PM Emissions Factors for Residential Anthracite and Bituminous Coal Combustion

Pollutant	Emissions Factor (lb/ton)	Data Source, AP-42 Table No.
Anthracite Emissions Factors (SCC 2104001000)		
PM-CON	0.08 * % Ash	1.2-3 (stoker)
PM10-FIL	10	1.2-3 (hand-fired)
PM25-FIL	4.6	Fig. 1.2-1 (ratio of PM25/PM10=1.25/2.70=0.46) 0.46*10=4.6
PM10-PRI	10 + 0.08 * % Ash	1.2-3
PM25-PRI	4.6 + 0.08 * % Ash	1.2-3 and Fig 1.2-1
Sulfur Dioxide	39 * % Sulfur	1.2-1 (residential space heater)
Bituminous Emissions Factors (SCC 2104002000)		
PM-CON	1.04+	1.1-5 (stoker)
PM10-FIL	6.2	1.1-4 (hand-fed)
PM25-FIL	3.8	1.1-11 (underfeed stoker)
PM10-PRI	7.24	Sum of FIL and CON
PM25-PRI	4.84	Sum of FIL and CON
Sulfur Dioxide	31 * % Sulfur	1.1-3 (hand-fed)

Pollutant	Emissions Factor (lb/ton)	Data Source, AP-42 Table No.
+Emissions factor provided in AP-42 is 0.04 lb/MMBtu. This is multiplied by the conversion factor of 26 MMBtu/ton provided in AP-42 for bituminous coal.		

Table 4-117: State-Specific Sulfur Content for Bituminous Coal (SCC 2104002000)

State	Percent Sulfur Content	State	Percent Sulfur Content
Alabama	0.00	Montana	0.46
Alaska	0.15	Nebraska	0.00
Arizona	0.00	Nevada	0.00
Arkansas	0.00	New Hampshire	0.00
California	0.00	New Jersey	0.00
Colorado	0.31	New Mexico	0.00
Connecticut	0.00	New York	0.00
Delaware	0.00	North Carolina	1.63
District of Columbia	0.51	North Dakota	0.64
Florida	0.00	Ohio	0.88
Georgia	0.00	Oklahoma	0.00
Hawaii	0.00	Oregon	0.00
Idaho	0.00	Pennsylvania	0.83
Illinois	3.21	Rhode Island	0.00
Indiana	2.95	South Carolina	0.00
Iowa	2.60	South Dakota	0.00
Kansas	0.00	Tennessee	0.00
Kentucky	0.71	Texas	0.00
Louisiana	0.00	Utah	0.00
Maine	0.00	Vermont	0.00
Maryland	0.00	Virginia	1.08
Massachusetts	0.00	Washington	0.00
Michigan	0.00	West Virginia	0.00
Minnesota	0.22	Wisconsin	0.78
Mississippi	0.00	Wyoming	0.44
Missouri	3.03		

The emissions factors for CO, VOC, and some HAPs for anthracite coal are the emissions factors provided in AP-42 for bituminous coal. See Table 5 of the "Residential Heating NEMO 2017 FINAL_4-2 update.docx" document on the 2017 NEI Supplemental data FTP site for the reference for each emissions factor. Emission rates for these pollutants are dependent upon combustion efficiency, with the mass of emissions per unit of heat input generally increasing with decreasing unit size. No anthracite emission rates are provided for residential heaters for these pollutants. Therefore, it was felt that it the AP-42 emission rates from bituminous coal that are derived for smaller hand-fed units, are more appropriate to use than applying anthracite emissions factors derived for much larger boilers.

Note that while AP-42 provides emissions factors for emissions of some metals from coal combustion, these factors are based on tests at controlled and/or pulverized coal boilers. These test conditions are not expected to be a good representation of emission rates for metals from residential heaters, so these pollutants are not included.

For all counties in the United States, the distillate oil consumed by residential combustion is assumed to be No. 2 fuel oil with a heating value of 140,000 Btu per gallon. The SO2 emissions factor for distillate oil assumes a sulfur content of 500 parts per million (ppm) and is calculated at the county level [ref 8].

Emissions factors for kerosene are based on the emissions factors for distillate oil, which are multiplied by a factor of 135/140 to convert them for this use. This factor is based on the ratio of the heat content of kerosene (135,000 Btu/gallon) to the heat content of distillate oil (140,000 Btu/gallon) [ref 4]. Criteria pollutant and HAP emissions factors are from the same sources discussed above for distillate fuel oil. The distillate sulfur content (500 ppm) is used for kerosene as well [ref 8].

Pollutant emissions factors for residential LPG are based on the residential natural gas emissions factors. The natural gas emissions factors [ref 9] are converted to LPG emissions factors by multiplying by 96,750 Btu/gallon.

4.14.3.4 *Controls*

There are no controls assumed for this category.

4.14.3.5 *Emissions*

The criteria pollutant and HAP emissions from residential heating are calculated by multiplying the distributed county-level residential fuel consumption by the corresponding emissions factor for each pollutant. The adjusted emissions factors for SO2 and PM for anthracite and bituminous/subbituminous coal are calculated above in equation 6 in Section 4.14.3.3.

$$E_{f,c,p} = FC_{f,c} \times EF_{f,p} \times \frac{1 \ ton}{2000 \ lb} \tag{7}$$

Where:

$E_{f,c,p}$ = annual emissions of pollutant p from combustion of fuel type f in county c, in tons
$FC_{f,c}$ = fuel consumption of fuel type f in county c, in tons, thousand barrels, or thousand cubic feet, from equation 5
$EF_{f,p}$ = emissions factor pollutant p and fuel type f, in pounds of emissions per unit (tons, thousand barrels, or thousand cubic feet) of fuel consumption, from Table 5 of the "Residential Heating NEMO 2017 FINAL_4-2 update.docx" document on the 2017 NEI Supplemental data FTP site.

4.14.3.6 *Example calculations*

Table 4-118 provides sample calculations for CO emissions from residential heating from distillate fuel oil in Allegheny County, PA.

Table 4-118: Sample calculations for CO emissions from residential heating from distillate fuel oil in Allegheny County, PA

Eq. #	Equation	Values for Allegheny County, PA	Result
1	$FC_{anth/bit,s} = FC_{coal,s} \times R_{anth/bit}$	N/A	This example is for distillate. Equation 1 is for coal.

Eq. #	Equation	Values for Allegheny County, PA	Result
2	$R_{dfo/ker,s}$ $= \dfrac{FC_{dfo/ker,s}}{FC_{dfo,s} + FC_{ker,s}}$	$\dfrac{15{,}062\ thousand\ barrels}{(15{,}062\ thousand\ barrels + 238\ thousand\ barrels)}$	0.9844 ratio of DFO to total fuel oil
3	$HU_{dfo/ker,c}$ $= HU_{fo,c} \times R_{dfo/ker,s}$	$8{,}081\ houses \times\ 0.9844$	7,955.30 houses using DFO in Allegheny County, PA
4	$R_{f,c} = \dfrac{HU_{f,c}}{HU_{f,s}}$	$\dfrac{7{,}955.30\ houses}{916{,}301.2\ houses}$	0.0086 county housing allocation ratio for Allegheny County, PA
5	$FC_{f,c}$ $= FC_{f,s} \times R_{f,c}$ $\times 42\ gal.\,per\ barrel$	$15{,}062\ thous.\,barrels \times 0.0086 \times 42\ gal.\,per\ barrel$	5,492.25 thousand gallons DFO consumed in Allegheny County, PA
6	$EF_{anth/bit,s,p}$ $= SAC_{f,s} \times EF_{unadj,f}$	N/A	This example is for distillate. Equation 6 is for coal.
7	$E_{f,c,p}$ $= FC_{f,c} \times EF_{f,p}$ $\times \dfrac{1\ ton}{2000\ lb}$	$5{,}492.25\ thous.\,gal. \times 5\ lbs.\,per\ thous.\,gal \times \dfrac{1\ ton}{2000\ lb}$	13.7 tons CO from DFO in Allegheny County, PA

4.14.3.7 *Changes from the 2014 methodology*

The 2017 methodology used a lower sulfur content value of 500 ppm for distillate fuel oil and kerosene compared to the value of 3% used in the 2014 methodology.

4.14.3.8 *Puerto Rico and U.S. Virgin Islands*

Since insufficient data exist to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emissions factor. For each Puerto Rico and US Virgin Island county, the tons per capita emissions factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.14.4 References

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4.15 Fuel Combustion – Residential – Wood

4.15.1 Sector description

Residential wood combustion (RWC) appliances, such as fireplaces, fireplace inserts, woodstoves, central heaters (indoor furnaces and hydronic heaters), and other outdoor wood-burning devices, are significant sources of air pollution in the United States—especially during winter months. RWC emits large amounts of fine particulate matter (PM25-PRI), volatile organic compounds (VOCs), and hazardous air pollutants (HAPs) that are known to contribute to poor human health, air quality, and visibility. We further differentiate freestanding woodstoves and inserts into three categories: conventional (not EPA-certified), EPA certified catalytic, and EPA-certified non-catalytic. Generally, the conventional units were produced before 1988. Units constructed after 1988 had to meet EPA emission standards. In addition, characterize central heaters by fuel type (cordwood vs pellet-fired) and location (indoor vs outdoor for hydronic heaters). For shorthand, we refer to the Residential Wood Combustion sector as "RWC" in the remaining documentation.

4.15.2 Sources of data

Table 4-119 shows, for RWC, the SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The SCC level 3 and 4 SCC descriptions are also provided. The SCC level 1 and 2 descriptions is "Stationary Source Fuel Combustion; Residential" for all SCCs.

Table 4-119 : RWC sector SCCs in the 2017 NEI

SCC	Description	EPA	S/L/T
2104008100	Wood; Fireplace: general	X	X
2104008210	Wood; Woodstove: fireplace inserts; non-EPA certified	X	X

SCC	Description	EPA	S/L/T
2104008220	Wood; Woodstove: fireplace inserts; EPA certified; non-catalytic	X	X
2104008230	Wood; Woodstove: fireplace inserts; EPA certified; catalytic	X	X
2104008300	Wood; Woodstove: freestanding, general		X
2104008310	Wood; Woodstove: freestanding, non-EPA certified	X	X
2104008320	Wood; Woodstove: freestanding, EPA certified, non-catalytic	X	X
2104008330	Wood; Woodstove: freestanding, EPA certified, catalytic	X	X
2104008400	Wood; Woodstove: pellet-fired, general (freestanding or FP insert)	X	X
2104008510	Wood; Furnace: Indoor, cordwood-fired, non-EPA certified	X	X
2104008530	Wood; Furnace: Indoor, pellet-fired, general	X	X
2104008610	Wood; Hydronic heater: outdoor	X	X
2104008620	Wood; Hydronic heater: indoor	X	X
2104008630	Wood; Hydronic heater: pellet-fired	X	X
2104008700	Wood; Outdoor wood burning device, NEC (fire-pits, chimeneas, etc)	X	X
2104009000	Firelog; Total: All Combustor Types	X	X

The agencies listed in Table 4-120 submitted emissions for RWC. Agencies not listed uses EPA estimates for the entire sector.

Table 4-120: Agencies reporting RWC emissions

Region	Agency	S/L/T
4	Metro Public Health of Nashville/Davidson County	Local
5	Illinois Environmental Protection Agency	State
5	Minnesota Pollution Control Agency	State
6	Texas Commission on Environmental Quality	State
8	Southern Ute Indian Tribe	Tribe
9	California Air Resources Board	State
9	Maricopa County Air Quality Department	Local
9	Washoe County Health District	Local
10	Alaska Department of Environmental Conservation	State
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Northern Cheyenne Tribe	Tribe
10	Oregon Department of Environmental Quality	State
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.15.3 EPA-developed emissions

To improve estimates in this sector, the EPA, along with the Commission on Environmental Cooperation (CEC), the Northeast States for Coordinated Air Use Management (NESCAUM), and Abt Associates, conducted a national survey of wood-burning activity in 2018. The results of this survey were used to estimate county-level burning activity, as discussed in more detail below.

The activity data for this category is the amount of wood burned in each county, which is based on data from the CEC survey on the fraction of homes in each county that use each wood-burning appliance and the average amount of wood burned in each appliance [ref 1]. These assumptions are used with the number of occupied homes in each county to estimate the total amount of wood burned in each county, in cords for cordwood appliances and tons for pellet appliances. Cords of wood are converted to tons using county-level density factors from the U.S. Forest Service [ref 2]. Emissions are calculated by multiplying the tons of wood burned by emissions factors.

4.15.3.1 *Activity data*

The activity data for RWC relies on assumptions developed from the CEC survey. The survey received 2,984 responses, and it asked questions about whether and how often the respondent used the different wood burning appliances and how much wood they burned annually. It also asked demographic questions about the respondents. EPA used statistical regression approaches to develop appliance fractions and burn rates for each county, based on predictor variables from the survey responses. These predictor variables include:

- The number of heating degree days in 2017 associated with the climate zone where the respondent lives, from NOAA [ref 3].
- The population density in 2017 of the county the respondent lives in, from the Census Bureau [ref 4].
- Whether the zip code where the respondent lives is considered urban or rural, according to data from the Census Bureau [ref 5].
- The percentage of forest cover in the county wherer the respondent lives, according to the Biogenic Emissions Landuse Database (BELD, v4.1) [ref 6].
- The fraction of homes that use natural gas as a primary heat source in 2017 in the county where the respondent lives, according to data from the American Community Survey [ref 7].
- The type of home the respondent lives in (single family detached, single family attached, multifamily, mobile), based on responses in the CEC survey.

The regression analysis compared all respondents who said they used a given appliance, such as a woodstove, to develop an equation based on each of these predictor variables. For example, survey respondents who lived in areas with more heating degree days (i.e. colder climates) or areas where few homes used natural gas as a primary heat sources (i.e. they might not have much natural gas service) tended to be more likely to say that they used a given wood-burning appliance.

The regression equation estimates the probability that a home in each county, with a given set of predictor variables, will use each wood-burning appliance. Therefore, when values of the predictor variables from each county are plugged into the equation, the result is a county-specific appliance fraction, which represents the fraction of homes in that county that use each wood-burning appliance. For example, urban counties with a low number of heating degree days, high population density, low forest cover, and many homes using natural gas tend to have a low appliance fraction for most appliances. County-specific appliance fractions are calculated separately for six appliance types: fireplaces, fireplace inserts, woodstoves, pellet stoves, central heaters (e.g. wood boilers or furnaces), and outdoor recreational equipment (such as fire pits). The process for splitting these appliance types into each of the 15 SCCs is discussed below.

Burn rates, which represent the average amount of wood burned in each appliance, are also calculated using regression analysis and the same predictor variables listed above. When county-level values of the predictor variables are plugged into the burn rate regression equation, the result is county-specific burn rates for each appliance type. The burn rates include the same appliance types as the appliance fractions.

The appliance fractions and burn rates are multiplied by the number of occupied homes in each county from the American Community Survey [ref 7] to estimate the amount of wood burned in each county, in cords or tons, depending on whether the appliance burns cordwood or pellets. For devices that burn cordwood, the estimated number of cords burned in each county is multiplied by a county-level wood density factor from the U.S. Forest Service [ref 2].

$$W_{c,a} = H_c \times AF_{c,a} \times BR_{c,a} \times D_c \tag{1}$$

Where:

$W_{c,a}$ = Amount of wood burned in appliance type a in county c, in tons per year
H_c = Number of occupied homes in county c
$AF_{c,a}$ = Appliance fraction for appliance type a in county c, determined from the CEC survey
$BR_{c,a}$ = Burn rate for appliance type a in county c, determined from the CEC survey, in cords or tons burned per appliance
D_c = Wood density factor for county c, in tons per cord of wood (used only for cordwood appliance types)

As discussed above, the appliance fractions and burn rates are used to estimate wood-burning activity at the appliance level in each county. This activity for certain appliance types must be distributed from the appliance level to the specific SCC level. For example, wood burned in "woodstoves" must be apportioned to three SCCs: non-EPA certified stoves, EPA certified non-catalytic stoves, and EPA certified catalytic stoves. For woodstoves and fireplace inserts, EPA used distribution profiles based on a combination of data from the 2015 EIA Residential Energy Consumption Survey (RECS) and the state of Minnesota's 2014/2015 residential wood survey.

Data from RECS is used to determine whether woodstoves or fireplace inserts are EPA certified. Although RECS does not specifically ask whether the woodstove is EPA certified, it does ask the age of the appliance. It is assumed that any appliance in the oldest age bin in RECS (20 years or older) is uncertified.[***] All appliances less than 20 years old are assumed to be EPA certified. The split between EPA certified non-catalytic and catalytic stoves is based on data provided by Minnesota from their 2014/2015 residential wood survey, which suggests that certified stoves are 60 percent non-catalytic and 40 percent catalytic. The distribution profiles for woodstoves and fireplace inserts are shown in Table 4-121.

The CEC survey data were seen to be more reliable for developing distribution profiles for central heaters, including wood boilers and furnaces. Survey respondents listed whether they owned a furnace or a boiler, whether it was located inside or outside the home, and whether it burned cordwood or pellets. These responses were used to develop distribution profiles for the central heaters. The distribution profiles for central heaters are shown in Table 4-122.

The default distribution profiles are estimated at the Census Region level for woodstoves and fireplace inserts and nationally for central heaters, but the RWC tool allows the profiles to be adjusted for each county. Not all appliance types need to be distributed. Appliance populations of fireplaces, pellet stoves, and outdoor recreational equipment are estimated directly from the regression equations and are not multiplied distribution fractions.

[***] A 20-year-old appliance in the 2015 RECS would have been manufactured in 1995, which is after the 1988 NSPS for wood stoves. However, this is the oldest age bin in RECS. EPA lacks data on the fraction of appliances in this age bin that were manufacturer before or after 1988. Therefore EPA assumed that all appliances in this age bin were uncertified.

The amount of wood-burning activity in each SCC in each county is determined by multiplying the county-level wood-burning activity by appliance type by the distribution profile for each SCC.

$$W_{c,SCC} = W_{c,a} \times DP_{SCC} \tag{2}$$

Where:

$W_{c,SCC}$ = Amount of wood burned in each SCC in county *c*, in tons per year

$W_{c,a}$ = Amount of wood burned in appliance type *a* in county *c*, in cords or tons per year, from equation 1

DP_{SCC} = Distribution profile for each SCC from Table 4-121 or Table 4-122, depending on the appliance type

Table 4-121: Distribution profiles for woodstoves and fireplace inserts by Census Region

Woodstove or Fireplace Insert Type	Census Region			
	NE	MW	S	W
Uncertified	0.16	0.12	0.31	0.31
Certified Catalytic	0.34	0.35	0.28	0.28
Certified Non-catalytic	0.50	0.53	0.41	0.41

Table 4-122: Distribution profiles for central heaters

Type of Central Heater	SCC	Distribution Profile
Indoor pellet boiler	2104008630	0.01
Indoor pellet furnace	2104008530	0.03
Indoor cordwood boiler	2104008620	0.23
Indoor cordwood furnace	2104008510	0.37
Outdoor cordwood boiler	2104008610	0.36

After an initial review of the wood-burning activity predicted by the appliance fractions and burn rates develop from the CEC survey data, EPA decided to make two adjustments to the estimates. The first adjustment corrects the total wood-burning activity in each state. The amount of residential wood-burning activity initially predicted by the appliance fractions and burn rates was significantly higher than the state-level totals reported by EIA's State Energy Data System (SEDS) [ref 8] for most states. As a result, EPA developed an adjustment factor to normalize the state-level residential wood-burning activity predicted by the tool to the amount predicted by SEDS. The SEDS adjustment factor is developed by summing the predicted amount of wood-burning activity (in cords) to the state level in each state and dividing it by the state-level amount of residential wood consumption reported by SEDS. SEDS reports wood consumption in Btu, rather than cords; therefore, the wood-burning activity predicted by the RWC tool is converted from cords to Btu using a conversion factor of 20 million Btu per cord, from the SEDS documentation. In addition, SEDS only includes wood consumption for residential heating; therefore, predicted wood consumption from outdoor recreational wood-burning (2104008700) and wax firelogs (2104009000) are not summed to calculate the SEDS adjustment.

$$SAF_s = \frac{\sum W_{c,SCC}}{W_{s,SEDS}} \tag{3}$$

Where:

SAF_s = SEDS adjustment factor for state *s*

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$W_{c,SCC}$ = Amount of wood burned in each SCC in county c, in tons per year

$W_{s,SEDS}$ = Amount of wood consumption in state s reported by SEDS

The second adjustment EPA made to the predicted wood consumption relates to central heaters and outdoor recreational equipment. After an initial review of predicted wood-burning activity, EPA felt that the estimated amount of wood burned in these appliances in dense urban areas was unreasonably high. Therefore, EPA developed a second adjustment factor based on the housing density (homes/mi^2) in each county, based on the equation for a sigmoid curve. The housing density adjustment factor is calibrated such that it approaches 0 when county-level housing density approaches 1,000 homes/mi^2. The housing density adjustment factor is multiplied by the predicted wood-burning activity only for central heating appliances (wood boilers and furnaces) and outdoor recreational wood-burning appliances.

$$HAF_c = -\frac{1}{1 + e^{-0.01\,(HD_c - 500)}} + 1 \qquad (4)$$

Where:

HAF_s = Housing density adjustment factor for county c

HD_c = Housing density in county c, in homes/mi^2

The SEDS and housing density adjustment factors are multiplied by the county-level predicted wood-burning activity to develop the adjusted wood-burning activity in each county.

$$AW_{c,SCC} = W_{c,SCC} \times SAF_s \times HAF_c \qquad (5)$$

Where:

$AW_{c,SCC}$ = Adjusted amount of wood burned in each SCC in county c, in tons per year

SAF_s = SEDS adjustment factor for state s

HAF_s = Housing density adjustment factor for county c

Note that the appliance fractions and burn rates provided in the input templates already take into account the housing density and SEDS adjustments. Therefore, the input templates for RWC do not ask SLT agencies to submit values for the housing density or SEDS adjustments. Rather, SLT agencies need only to submit revisions to the appliance fractions and burn rates themselves. Equations 4 and 5 are included here only to provide more information about how the appliance fractions and burn rates were adjusted.

4.15.3.2 *Allocation procedure*

Appliance fractions and burn rates are calculated at the county-level. There is no need to allocate data to the county level for this category.

4.15.3.3 *Emission factors*

Emissions factors for RWC come primarily from AP-42 [ref 9] and Houck and Eagle (2006) [ref 10], but also from Houck et al. (2001) [ref 11]. Many of the HAP emissions factors are from Hays et al. (2003) [ref 12]. Emissions factors for wax firelogs are from Li and Rosenthal (2006) [ref 13]. Additional emission factors are taken from Houck et al. (2001) [ref 11] and Aurell et al. (2012) [ref 14]. Emission factors for all SCCs are provided in Table 3 of the appendix in the "Residential Wood Combustion_DRAFT.DOCX" document on the 2017 NEI Supplemental data FTP site.

For certified woodstoves and fireplace inserts, EPA is using the emissions factors from the Regulatory Impact Analysis (RIA) for the 2015 New Source Performance Standards (NSPS) [ref 15], which is based on the woodstove emissions standards from the state of Washington in 1995. The RIA notes that the emissions factors for woodstove, fireplace inserts, and pellet stoves will not decrease from that level until the Step 2 standards become effective in 2020. Therefore, EPA used the Washington state emissions factors to estimate 2017 emissions for these categories.

While the NSPS was expected to decrease emissions for hydronic heaters and furnaces in 2015, EPA lacks data on the fraction of these appliances in use that were manufactured after the 2015 NSPS went into effect. Therefore, EPA made no changes to the emissions factors for hydronic heaters or furnaces.

4.15.3.4 *Controls*

There are no controls assumed for this category. However, SLT agencies may submit state- or county-level control factors that will adjust the emissions by SCC.

4.15.3.5 *Emissions*

Emissions from RWC are calculated by multiplying the adjusted amount of wood burned in each SCC in each county by SCC- and pollutant-specific emissions factors.

$$E_{c,SCC,p} = AW_{c,SCC} \times EF_{SCC,p} \tag{6}$$

Where:
$E_{c,SCC,p}$ = Emissions of pollutant p from each SCC in county c
$AW_{c,SCC}$ = Adjusted amount of wood burned in each SCC in county c, in tons per year
$EF_{SCC,p}$ = Emissions factor for pollutant p for each SCC, from Table 3 of the appendix in the "Residential Wood Combustion_DRAFT.DOCX" document on the 2017 NEI Supplemental data FTP site.

4.15.3.6 *Example calculations*

Table 4-123 lists sample calculations for the estimation of emissions of PM25-PRI from non-EPA certified wood stoves in Delaware County, OH.

Note that the appliance fractions and burn rates provided in the input templates already take into account the housing density and SEDS adjustments. Therefore, the input templates for RWC do not ask SLT agencies to submit values for the housing density or SEDS adjustments. Rather, SLT agencies need only to submit revisions to the appliance fractions and burn rates themselves. Equations 4 and 5 are included here only to provide more information about how the appliance fractions and burn rates were adjusted.

Table 4-123: Sample calculations for PM25-PRI emissions from non-EPA certified woodstoves in Delaware County, OH

Eq. #	Equation	Values for Delaware County, OH	Result
1	$W_{c,a} = H_c \times AF_{c,a} \times BR_{c,a} \times D_c$	67,701 homes × 0.0751 × 1.9304 × 1.3341 tons/cord	13,094 tons of wood burned in woodstoves

Eq. #	Equation	Values for Delaware County, OH	Result
2	$W_{c,SCC} = W_{c,a} \times DP_{SCC}$	$13{,}094 \times 0.12$	1,571 tons of wood burned in non-EPA certified woodstoves
3	$SAF_s = \dfrac{W_{s,SEDS}}{\sum W_{c,SCC}}$	$\dfrac{14{,}714\ BBtu}{28{,}369\ BBtu}$	0.52 SEDS adjustment factor
4	$HAF_c = -\dfrac{1}{1+e^{-0.01\,(HD_c-500)}} + 1$	$-\dfrac{1}{1+e^{-0.01\,(153\,-500)}} + 1$	0.97 housing adjustment factor
5	$AW_{c,SCC} = W_{c,SCC} \times SAF_s \times HAF_c$	$1{,}571 \times 0.52 \times 0.97$	792 adjusted tons of wood burned in non-EPA certified woodstoves
6	$E_{c,SCC,p} = AW_{c,SCC} \times EF_{SCC,p}$	792×30.6 lb/ton	24,235 lbs. (12.12 tons) PM25-PRI from non-EPA certified woodstoves in Delaware County, OH

4.15.3.7 *Changes from the 2014 methodology*

The largest changes from the 2014 methodology are the source of the data used to develop the appliance fractions and burn rates. In 2014, the appliance fractions and burn rates were calculated based on survey data from the 2009 EIA RECS, while in 2017 the appliance fractions and burn rates are calculated based on the CEC survey data. In addition, while EPA lacked data in 2014 to estimate county-level appliance fractions and burn rates for outdoor recreational wood-burning equipment and wax firelogs, EPA was able to estimate appliance fractions and burn rates for these categories for 2017 using data from the CEC survey. The general approach for using regression analysis to develop county level appliance fractions and burn rates is unchanged from 2014.

Another change involves the estimation of emissions for three additional SCCs: indoor pellet boilers, indoor pellet furnaces, and indoor hydronic heaters.

4.15.3.8 *Puerto Rico and U.S. Virgin Islands*

Insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, so emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island County, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.15.3.9 *Known issue with the 2017 NEI*

A minor error was discovered in the EPA RWC Wagon Wheel tool for pellet-fired indoor furnaces. An incorrect overallocation of central heaters to indoor pellet-fired indoor furnaces resulted in an approximately 1,700 ton national overestimate in PM2.5 from this appliance type. This is a small component of the overall RWC sector total of approximately 337,000 tons of PM2.5 and the EPA plans to correct this for the 2020 NEI.

4.15.4 References

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4.16 Industrial Processes – Mining and Quarrying

4.16.1 Sector description

Mining and quarrying activities produce particulate matter (PM) emissions due to the variety of processes used to extract the ore and associated overburden, including drilling and blasting, loading and unloading, and overburden replacement. Fugitive dust emissions for mining and quarrying operations are the sum of emissions from the mining of metallic and nonmetallic ores and coal. Each of these mining operations has specific emissions factors accounting for the different means by which the resources are extracted.

4.16.2 Sources of data

Table 4-124 shows, for mining and quarrying, the SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The SCC level 3 and 4 SCC descriptions are also provided. The SCC level 1 and leading level 2 descriptions is "Industrial Processes; Mining and Quarrying:" for all SCCs.

Table 4-124: Mining and Quarrying sector SCCs in the 2017 NEI

SCC	Description	EPA	S/L/T
2325000000	SIC 14; All Processes; Total	X	X

SCC	Description	EPA	S/L/T
2325020000	SIC 14; Crushed and Broken Stone; Total		X
2325030000	SIC 14; Sand and Gravel; Total		X
2325060000	SIC 10; Lead Ore Mining and Milling; Total		X

The agencies listed in Table 4-125 submitted emissions for mining and quarrying. Agencies not listed use EPA estimates for the entire sector.

Table 4-125: Agencies reporting Mining and Quarrying emissions

Region	Agency	S/L/T
1	Rhode Island Department of Environmental Management	State
2	New Jersey Department of Environment Protection	State
3	Maryland Department of the Environment	State
4	Knox County Department of Air Quality Management	Local
4	Memphis and Shelby County Health Department - Pollution Control	Local
4	Metro Public Health of Nashville/Davidson County	Local
5	Illinois Environmental Protection Agency	State
6	Texas Commission on Environmental Quality	State
7	Missouri Department of Natural Resources	State
8	Utah Division of Air Quality	State
9	California Air Resources Board	State
9	Clark County Department of Air Quality and Environmental Management	Local
9	Maricopa County Air Quality Department	Local
9	Washoe County Health District	Local
10	Alaska Department of Environmental Conservation	State
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.16.3   EPA-developed emissions

Four specific activities are included in the emissions estimate for mining and quarrying operations: overburden removal, drilling and blasting, loading and unloading, and overburden replacement. Not included are the transfer and conveyance operations, crushing and screening operations, and storage since the dust emissions from these activities are assumed to be well controlled. Fugitive dust emissions for mining and quarrying operations are the sum of emissions from the mining of metallic and nonmetallic ores and coal. Emissions for each activity are calculated by multiplying the emissions factors by the activity data.

4.16.3.1   *Activity data*

Activity data for this source category include state-level metallic and non-metallic (a.k.a. mineral) crude ore handled at surface mines from the U.S. Geologic Survey (USGS) [ref 1] and mine-specific coal production data for surface mines from the Energy Information Administration (EIA) [ref 2]. Emissions are not estimated for underground mining given that emissions factors are calculated exclusively for surface activity.

In some cases, the amount of mining waste is withheld for some states to avoid disclosing company proprietary

data. To estimate state-level withheld waste data the fraction of crude ore production in the state is multiplied by the amount of waste data withheld at the national level. The national-level amount of waste withheld is calculated by subtracting all known state-level waste values (i.e. those that are *not* withheld) from the national-level waste value. Note that this calculation only needs to be completed for states where state-level mining waste data are withheld.

$$W_s = \frac{O_s}{O_{US}} \times W_{US} \tag{1}$$

Where:

W_s	=	Amount of metallic and non-metallic mining waste for state *s*, in metric tons
W_{US}	=	Amount of metallic and non-metallic mining waste withheld at the national level, in metric tons
O_s	=	Amount of crude ore produced in state *s*, in metric tons
O_{US}	=	Amount of crude ore produced at the national level, in metric tons

The data on state-level mining production and waste is split into production and waste for metallic and non-metallic ores using the fraction of national-level metallic and non-metallic ore production. Values are also converted from metric tons to short tons. Throughout the remainder of this document references to "ton(s)" refer to short tons, while metric tons will be explicitly labeled.

$$MP_{t,s} = (W_s + O_s) \times \frac{MP_{t,US}}{MP_{US}} \times 1.1023 \, {}^{ton}\!/_{metric \ ton} \tag{2}$$

Where:

MPt,s	=	Amount of mining material type *t* (i.e. either metallic or non-metallic ore) produced in state *s*, in tons
W_s	=	Amount of total metallic and non-metallic mining waste for state *s*, in metric tons
O_s	=	Amount of crude ore produced in state *s*, in metric tons
$MP_{t,US}$	=	Amount of mining material type *t* produced at the national-level, in metric tons
MP_{US}	=	Total metallic and non-metallic ore production at the national level, in metric tons

4.16.3.2 *Allocation procedure*

The state-level data on metallic and non-metallic mining materials (from equation 2) is distributed to the county level based on the proportion of employees in the metallic and non-metallic ore sectors (see Table 4-126 for a list of NAICS codes), from the U.S. Census Bureau County Business Patterns [ref 3]. Separate fractions are determined for metallic ore mining employees and non-metallic ore mining employees in each county.

$$EmpFrac_{t,c} = \frac{Emp_{t,c}}{Emp_{t,s}} \tag{3}$$

Where:

$EmpFrac_{t,c}$	= The fraction of mining employees for material type *t* in county *c*
$Emp_{t,c}$	= The number of mining employees for material type *t* in county *c*
$Emp_{t,s}$	= The number of mining employees for material type *t* in state *s*

Table 4-126: NAICS Codes for Metallic and Non-Metallic Mining

NAICS Code	Description
2122	Metal Ore Mining
212210	Iron Ore Mining
21222	Gold Ore and Silver Ore Mining
212221	Gold Ore Mining
212222	Silver Ore Mining
21223	Copper, Nickel, Lead, and Zinc Mining
212231	Lead Ore and Zinc Ore Mining
212234	Copper Ore and Nickel Ore Mining
21229	Other Metal Ore Mining
212291	Uranium-Radium-Vanadium Ore Mining
212299	All Other Metal Ore Mining
2123	Nonmetallic Mineral Mining and Quarrying
21231	Stone Mining and Quarrying
212311	Dimension Stone Mining and Quarrying
212312	Crushed and Broken Limestone Mining and Quarrying
212313	Crushed and Broken Granite Mining and Quarrying
212319	Other Crushed and Broken Stone Mining and Quarrying
21232	Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying
212321	Construction Sand and Gravel Mining
212322	Industrial Sand Mining
212324	Kaolin and Ball Clay Mining
212325	Clay and Ceramic and Refractory Minerals Mining
21239	Other Nonmetallic Mineral Mining and Quarrying
212391	Potash, Soda, and Borate Mineral Mining
212392	Phosphate Rock Mining
212393	Other Chemical and Fertilizer Mineral Mining
212399	All Other Nonmetallic Mineral Mining

Due to concerns with releasing confidential business information, the CBP does not release exact numbers for a given NAICS code if the data can be traced to an individual business. Instead, a series of range codes is used. To estimate employment in counties and states with withheld data, the following procedure is used for NAICS code being computed.

To gap-fill withheld state-level employment data:

m. State-level data for states with known employment in each NAICS are summed to the national level.
n. The total sum of state-level known employment from step a is subtracted from the national total reported employment for each NAICS in the national-level CBP to determine the employment total for the withheld states.
o. Each of the withheld states is assigned the midpoint of the range code reported for that state. Table 4-127 lists the range codes and midpoints.
p. The midpoints for the states with withheld data are summed to the national level.
q. An adjustment factor is created by dividing the number of withheld employees (calculated in step b of this section) by the sum of the midpoints (step d).
r. For the states with withheld employment data, the midpoint of the range for that state (step c) is multiplied by the adjustment factor (step e) to calculate the adjusted state-level employment for

landfills.

These same steps are then followed to fill in withheld data in the county-level business patterns.

s. County-level data for counties with known employment are summed by state.
t. County-level known employment is subtracted from the state total reported in state-level CBP (or, if the state-level data are withheld, from the state total estimated using the procedure discussed above).
u. Each of the withheld counties is assigned the midpoint of the range code (Table 4-127).
v. The midpoints for the counties with withheld data are summed to the state level.
w. An adjustment factor is created by dividing the number of withheld employees (step h) by the sum of the midpoints (step j).
x. For counties with withheld employment data, the midpoints (step i) are multiplied by the adjustment factor (step k) to calculate the adjusted county-level employment for landfills.

Table 4-127: Withheld data ranges and midpoints

Employment Code	Employment Range	Midpoint
A	0-19	10
B	20-99	60
C	100-249	175
E	250-499	375
F	500-999	750
G	1,000-2,499	1,750
H	2,500-4,999	3,750
I	5,000-9,999	7,500
J	10,000-24,999	17,500
K	25,000-49,999	37,500
L	50,000-99,999	75,000
M	100,000+	

For example, take the 2016 CBP data for NAICS 2123 (Nonmetallic Mineral Mining and Quarrying) in Arizona provided in Table 4-128.

Table 4-128: 2016 County Business Pattern for NAICS 2123 in Arizona

State FIPS	County FIPS	County Name	NAICS	Employment Code	Employment
04	001	Apache	2123	B	withheld
04	003	Cochise	2123		16
04	005	Coconino	2123	A	withheld
04	007	Gila	2123		10
04	009	Graham	2123	B	withheld
04	012	La Paz	2123	A	withheld
04	013	Maricopa	2123		563
04	015	Mohave	2123		69
04	017	Navajo	2123		65
04	019	Pima	2123		121
04	021	Pinal	2123		201
04	023	Santa Cruz	2123	A	withheld
04	025	Yavapai	2123		133

State FIPS	County FIPS	County Name	NAICS	Employment Code	Employment
04	027	Yuma	2123		51

Note: Counties in Arizona that do not have employment in mining and quarrying are excluded from this table.

7. The total number of employees reported at the county level is 1,229.
8. The state-level CBP reports 1,363 employees for NAICS 2123. This means that there are 134 employees withheld at the county level.
9. The counties with withheld data are assigned midpoints according to the employment codes in Table 4-127. For example, County 001 is given a midpoint of 60 employees (since employment code B is 20-99).
10. The sum of the midpoints for all withheld counties is 150 employees.
11. The adjustment factor is 134/150 = 0.8933.
12. The adjusted employment for county 001 is 60 × 0.8933 = 54 employees.

Once county- and state-level metal and non-metal employment are known for each county, the ratio of county to state employees (from equation 3) is multiplied by the state-level metal and non-metal production (from equation 2) to calculate county-level production.

$$MP_{t,c} = MP_{t,s} \times EmpFrac_{t,c}$$ (4)

Where:

$MP_{t,c}$ = Amount of mining material type t produced in county c, in tons

$MPt_{,s}$ = Amount of mining material type t (i.e. either metallic or non-metallic ore) produced in state s, in tons

$EmpFrac_{t,c}$ = The fraction of mining employees for material type t in county c

4.16.3.3 *Emission factors*

Emissions factors are calculated separately for metallic ore mining, non-metallic ore mining, and coal mining. This section describes those calculations and the relevant data sources.

Metallic Ore Mining

The emissions factor for metallic ore mining includes emissions from overburden removal, drilling and blasting, and loading and unloading activities, and are taken from emissions factors for copper ore mining from EPA's *National Air Pollutant Emission Trends Procedures Document for 1900-1996* [ref 4]*.* The emissions factors are applied to all three activities with PM10/TSP ratios of 0.35 for overburden removal [ref 5], 0.81 for drilling and blasting [ref 6], and 0.43 for loading and unloading operations [ref 6].

$$EF_{PM10,m} = EF_o + (B \times EF_b) + EF_l + EF_d$$ (5)

Where:

$EF_{PM10,m}$ = PM10-PRI metallic ore mining emissions factor, in lbs./ton

EF_o = PM10-PRI open pit overburden removal emissions factor for copper ore, in lbs./ton

B = Fraction of total ore production that is obtained by blasting at metallic ore mines

EF_b = PM10-PRI drilling/blasting emissions factor for copper ore, in lbs./ton
EF_l = PM10-PRI loading emissions factor for copper ore, in lbs./ton
EF_d = PM10-PRI truck dumping emissions factor for copper ore, in lbs./ton

Using values from the *National Air Pollutant Emission Trends Procedures Document for 1900-1996, Table 3.1-3,* the PM10-PRI emissions factor is calculated as:

$$0.0548 \; lbs/ton = 0.0003 + (0.57625 \times 0.0008) + 0.022 + 0.032 \tag{5a}$$

The PM25-PRI emissions factor is assumed to be 12.5% of the PM10-PRI emissions factor.

$$EF_{PM25,m} = EF_{PM10,m} \times 0.125 \tag{6}$$

$$0.0069 = 0.0548 \times 0.125 \tag{6a}$$

Where:
$EF_{PM25,m}$ = PM25-PRI metallic ore mining emissions factor, in lbs./ton
$EF_{PM10,m}$ = PM10-PRI metallic ore mining emissions factor, in lbs./ton

Non-Metallic Ore Mining

The emissions factor for non-metallic ore mining includes overburden removal, drilling and blasting, and loading and unloading activities. The emissions factor is based on western surface coal mining operations from AP-42 [ref 7] and a PM10/TSP ratio.

$$EF_{PM10,nm} = EF_v + (D \times EF_r) + EF_a + (0.5 \times (EF_e + EF_t)) \tag{7}$$

Where:

$EF_{PM10,nm}$ = PM10-PRI non-metallic ore mining emissions factor, in lbs./ton
EF_v = PM10-PRI open pit overburden removal emissions factor at western surface coal mining operations, in lbs./ton
D = fraction of total ore production that is obtained by blasting at non-metallic ore mines
EF_r = PM10-PRI drilling/blasting emissions factor at western surface coal mining operations, in lbs./ton
EF_a = PM10-PRI loading emissions factor at western surface coal mining operations, in lbs./ton
EF_e = PM10-PRI truck unloading: end dump-coal emissions factor at western surface coal mining operations, in lbs./ton
EF_t = PM10-PRI truck unloading: bottom dump-coal emissions factor at western surface coal mining operations, in lbs./ton

Applying the TSP emissions factors developed for western surface coal mining operations from AP-42 [ref 7] and a PM10/TSP ratio of 0.4 [ref 8] yields the following non-metallic ore mining emissions factor:

$$0.293 \; lbs./ton = 0.225 + (0.61542 \times 0.00005) + 0.05 + 0.5 \, (0.0035 + 0.033) \tag{7a}$$

The PM25-PRI emissions factor is assumed to be 12.5% of the PM10-PRI emissions factor.

$$EF_{PM25,nm} = EF_{10,nm} \times 0.125 \tag{8}$$
$$0.037 \; lbs/ton = 0.293 \times 0.125 \tag{8a}$$

Where:

$EF_{PM25,nm}$ = PM25-PRI non-metallic ore mining emissions factor, in lbs./ton
$EF_{PM10,nm}$ = PM10-PRI non-metallic ore mining emissions factor, in lbs./ton

Coal Mining

The emissions factor for coal mining includes overburden removal, drilling and blasting, loading and unloading and overburden replacement activities. The amount of overburden material handled is assumed to equal ten times the quantity of coal mined, and coal unloading is assumed to split evenly between end-dump and bottom-dump operations. The emissions factor is based on the PM_{10} emissions factors developed for western surface coal mining operations from AP-42 [ref 7].

$$EF_{PM10,co} = \left(10 \times (EF_{to} + EF_{or} + EF_{dt})\right) + EF_v + EF_r + EF_a + (0.5 \times (EF_e + EF_t)) \tag{9}$$

Where:

$EF_{PM10,co}$= PM10-PRI coal mining emissions factor, in lbs./ton
EF_{to} = PM10-PRI emissions factor for truck loading overburden at western surface coal mining operations, in lbs./ton of overburden
EF_{or} = PM10-PRI emissions factor for overburden replacement at western surface coal mining operations, in lbs./ton of overburden
EF_{dt} = PM10-PRI emissions factors for truck unloading: bottom dump-overburden at western surface coal mining operations, in lbs./ton of overburden
EF_v = PM10-PRI open pit overburden removal emissions factor at western surface coal mining operations, in lbs./ton
EF_r = PM10-PRI drilling/blasting emissions factor at western surface coal mining operations, in lbs./ton
EF_a = PM10-PRI loading emissions factor at western surface coal mining operations, in lbs./ton
EF_e = PM10-PRI truck unloading: end dump-coal emissions factor at western surface coal mining operations, in lbs./ton
EF_t = PM10-PRI truck unloading: bottom dump-coal emissions factor at western surface coal mining operations, in lbs./ton

Applying the PM10-PRI emissions factors developed for western surface coal mining operations [ref 7] yields the following coal mining emissions factor:

$$0.513 \; lbs/ton = (10 \times (0.015 + 0.001 + 0.006)) + 0.225 + 0.00005 + 0.05 + (0.5 \times (0.0035 + 0.033)) \tag{9a}$$

The PM25-PRI emissions factor is assumed to be 12.5% of the PM10-PRI emissions factor.

$$EF_{PM25,co} = EF_{10,co} \times 0.125 \tag{10}$$

Where:

$EF_{PM25,co}$ = PM25-PRI coal mining emissions factor, in lbs./ton
$EF_{PM10,co}$ = PM10-PRI coal mining emissions factor, in lbs./ton

PM-FIL and PM2.5-PRI Emissions Factors

PM-FIL emissions factors are assumed to be the same as PM-PRI emissions factors. In reality, there is a small amount of PM-CON emissions included in the PM-PRI emissions, but insufficient data exists to estimate the PM-CON portion. In 2006, the EPA adopted new PM2.5/PM10 ratios for several fugitive dust categories and concluded that the PM2.5/PM10 ratios for fugitive dust categories should be in the range of 0.1 to 0.15 [ref 9]. Consequently, a ratio of 0.125 was applied to the PM10 emissions factors to estimate PM2.5 emissions factors for mining and quarrying. A summary of emissions factors is presented in Table 4-129.

Table 4-129: Emissions factors for Mining and Quarrying (2325000000)

Mining Type	Pollutant	Emissions Factor	Emissions Factor Units	Emissions Factor Reference
Metallic	PM10-PRI	0.0548	lbs./ton	4
Metallic	PM10-FIL	0.0548	lbs./ton	4
Metallic	PM25-PRI	0.0069	lbs./ton	PM10 × 0.125
Metallic	PM25-FIL	0.0069	lbs./ton	PM10 × 0.125
Non-Metallic	PM10-PRI	0.293	lbs./ton	7, 8
Non-Metallic	PM10-FIL	0.293	lbs./ton	7, 8
Non-Metallic	PM25-PRI	0.037	lbs./ton	PM10 × 0.125
Non-Metallic	PM25-FIL	0.037	lbs./ton	PM10 × 0.125
Coal	PM10-PRI	0.513	lbs./ton	7
Coal	PM10-FIL	0.513	lbs./ton	7
Coal	PM25-PRI	0.064	lbs./ton	PM10 × 0.125
Coal	PM25-FIL	0.064	lbs./ton	PM10 × 0.125

4.16.3.4 *Controls*

There are no controls assumed for this category.

4.16.3.5 *Emissions*

Emissions from mining and quarrying are calculated by multiplying the amount of mining material produced (from equation 4 for metallic and non-metallic mining, and from the EIA [ref 2] for coal) by an emissions factor (from Table 4-129).

$$E_{p,t,c} = EF_{t,p} \times MP_{t,c} \tag{11}$$

Where:

$E_{t,p,c}$ = Annual emissions of pollutant p from mining material type t in county c, in lbs.
$EF_{t,p}$ = Emissions factor for pollutant p from mining material type t, in lbs./ton of material produced
$MP_{t,c}$ = Amount of mining material type t produced in county c, in tons

The final step of the process is to sum the mining emissions estimates for each pollutant in each county. Emissions estimates are then converted from pounds to tons.

$$AE_{p,c} = \sum_t E_{p,t,c} \times 0.0005\ {ton}/{lb.}\qquad(12)$$

Where:

$AE_{p,c}$ =   Annual emissions of pollutant p in county c, in tons

$E_{t,p,c}$ =   Annual emissions of pollutant p from mining material type t in county c, in lbs.

4.16.3.6 *Example calculations*

The steps below provide sample calculations to determine the PM25-PRI emissions from mining and quarrying operations in Barbour County, Alabama. Constant emissions factor calculations that are used in all counties are not repeated here.

Table 4-130 provides a summary of these calculations. Note that equations 5-10 produce constant emissions factors that are used in all counties. Those calculations are not repeated here.

Table 4-130: Sample calculations for estimating PM25-PRI emissions from mining and quarrying in Barbour County, Alabama

Eq. #	Equation	Values for Barbour County, AL	Result
1	$W_s = \dfrac{O_s}{O_{US}} \times W_{US}$	N/A	Waste data is not withheld for Alabama.
2	$MP_{t,s} = (W_s + O_s) \times \dfrac{MP_{t,US}}{MP_{US}}$ $\times 1.1023\ {short\ ton}/{metric\ ton}$	$(3,720 + 42,900)$ $\times (2,660,000 \div 5,060,000)$ $\times 1.1023\ {ton}/{metric\ ton}$	27,015 thousand tons metallic ore in Alabama
		$(3,720 + 42,900)$ $\times (2,400,000 \div 5,060,000)$ $\times 1.1023\ {ton}/{metric\ ton}$	24,375 thousand tons non-metallic ore in Alabama
3	$EmpFrac_{t,c} = \dfrac{Emp_{t,c}}{Emp_{t,s}}$	$\dfrac{67\ metallic\ mining\ employess\ in\ Barbour}{67\ metallic\ mining\ employees\ in\ Alabama}$	Metallic employee fraction of 1 for Barbour County, AL
		$\dfrac{8\ nonmetallic\ mining\ employess\ in\ Barbo}{1,778\ nonmetallic\ mining\ employess\ in\ A}$	Nonmetallic employee fraction of 4.5 × 10⁻³ for Barbour County, AL
4	$MP_{t,c} = MP_{t,s} \times EmpFrac_{t,c}$	$27,015\ tons \times 1$	27,015 thousand tons metallic ore in Barbour County, AL

Eq. #	Equation	Values for Barbour County, AL	Result
		$24,375\ tons \times 4.5 \times 10^{-3}$	112 thousand tons non-metallic ore in Barbour County, AL
11	$E_{p,t,c} = EF_{t,p} \times MP_{t,c}$	$0.0068\ {}^{lbs.}\!/_{ton} \times 27,015,167\ tons$	184,922.19 lbs. PM25-PRI emissions from metallic ore in Barbour County, AL
		$0.037\ {}^{lbs.}\!/_{ton} \times 112,039\ tons$	4,107.38 lbs. PM25-PRI emissions from non-metallic ore in Barbour County, AL
		$0.064\ {}^{lbs}\!/_{ton} \times 0\ tons$	0 lbs. PM25-PRI from coal mining in Barbour County, AL
12	$AE_{p,c} = \sum_t E_{p,c} \times 0.0005\ {}^{short\ ton}\!/_{lb.}$	$184,922.19\ lbs. + 4,107.38\ lbs. + 0\ lbs.$ $\times 0.0005\ {}^{ton}\!/_{lb.}$	95 tons PM25-PRI from mining and quarrying in Barbour County, AL

4.16.3.7 *Changes from the 2014 methodology*

There are no significant changes for this methodology from the methodology used for the 2014 NEI.

4.16.3.8 *Puerto Rico and U.S. Virgin Islands*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emissions factor. For each Puerto Rico and US Virgin Island county, the tons per capita emissions factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.16.4 References

1. U.S. Geologic Survey. Minerals Yearbook 2012.
2. U.S. Department of Energy, Energy Information Administration. "Detailed data from the EIA-7A and the U.S. Mine Safety and Health Administration", data pulled for year 2017.
3. U.S. Census Bureau. 2016 County Business Patterns.

4. U.S. Environmental Protection Agency. 1998. *National Air Pollutant Emission Trends Procedure Document for 1900-1996*, EPA-454/R-98-008.
5. U.S. Environmental Protection Agency, AP-42, Fifth Edition, Volume 1, Chapter 13: Miscellaneous Sources, Section 13.2.4: Aggregate Handling and Storage Piles.
6. U.S. Environmental Protection Agency. 1986. *Generalized Particle Size Distributions for Use in Preparing Size-Specific Particulate Emissions Inventories*, EPA-450/4-86-013.
7. U.S. Environmental Protection Agency, AP-42, Fifth Edition, Volume 1, Chapter 11: Mineral Products Industry, Section 11.9: Western Surface Coal Mining.
8. United States Environmental Protection Agency, *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*, EPA-450/4-90-003, March 1990.
9. Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors*, MRI Project No. 110397.

4.17 Industrial Processes – Oil and Gas Production

4.17.1 Sector description

This sector includes processes associated with the exploration and drilling at oil, gas, and coal bed methane (CBM) wells and the equipment used at the well sites to extract the product from the well and deliver it to a central collection point or processing facility.

4.17.2 Sources of data

Table 4-131 lists the processes below with their corresponding SCCs; the SCCs used by EPA to estimate nonpoint emissions are marked in second column. SCCS with asterisks (*) denote new SCCs and created for the 2017 inventory. The set of asterisked SCCs that EPA does not use (denoted by * with no Y) were created for the 2017 inventory based on a request by the state of Utah. Note also that the SCCs in this list are only the SCCs that either the EPA used or the submitting State agencies used in the 2017 NEI. All of the SCCs that the EPA oil and gas tool uses are nonpoint SCCs.

Table 4-131: Point and Nonpoint SCCs used for the Oil and Gas Production Sector

Data Category	EPA uses	SCC	SCC Description (Abbreviated)
Nonpoint		2310000000	Total: All Processes (doesn't distinguish oil or gas)
Nonpoint	Y	2310000220	Drill Rigs
Nonpoint		2310000230	Workover Rigs
Nonpoint	(no, was used in 2014)[†††]	2310000330	Artificial Lift
Nonpoint	(no, was used in 2014)[‡‡‡]	2310000550	Produced Water
Nonpoint	Y*	2310000551	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Produced Water from CBM Wells

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[†††] This SCC was replaced with the code 2310011600, new for the tool in 2017.
[‡‡‡] The single SCC previously used to categorize emissions from produced water has been disaggregated into 3 new SCCs, one each for CBM, gas, and oil wells: 2310000551, 2310000552, 2310000553.

Data Category	EPA uses	SCC	SCC Description (Abbreviated)
Nonpoint	Y*	2310000552	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Produced Water from Gas Wells
Nonpoint	Y*	2310000553	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Produced Water from Oil Wells
Nonpoint	Y	2310000660	Hydraulic Fracturing Engines
Nonpoint		2310001000	On-Shore, Total: All Processes
Nonpoint		2310002000 through 2310002421	Off-Shore Oil & Gas Production; Total: All Processes, Flares: Continuous Pilot Light, Flares: Flaring Operations, Pneumatic Pumps: Gas And Oil Wells, Pressure/Level Controllers, Cold Vents
Nonpoint		2310010000	Industrial Processes; Oil and Gas Exploration and Production; Crude Petroleum; Total: All Processes
Nonpoint	Y	2310010100	Crude Petroleum; Oil Well Heaters
Nonpoint	Y	2310010200	Crude Petroleum; Oil Well Tanks - Flashing & Standing/Working/Breathing
Nonpoint	Y	2310010300	Crude Petroleum; Oil Well Pneumatic Devices
Nonpoint		2310010700	Crude Petroleum; Oil Well Fugitives
Nonpoint		2310010800	Crude Petroleum; Oil Well Truck Loading
Nonpoint	(no, was used in 2014)§§§	2310011000	On-shore oil production; Total: All Processes
Nonpoint	Y *	2310011001	On-Shore Oil Production; Associated Gas Venting
Nonpoint		2310011020	On-shore oil production; Storage Tanks: Crude Oil
Nonpoint		2310011100	On-shore oil production; Heater Treater
Nonpoint	Y	2310011201	On-shore oil production; Tank Truck/Railcar Loading: Crude Oil
Nonpoint		2310011450	On-shore oil production; Wellhead
Nonpoint		2310011500	On-shore oil production; Fugitives: All Processes
Nonpoint	Y	2310011501	On-shore oil production; Fugitives: Connectors
Nonpoint	Y	2310011502	On-shore oil production; Fugitives: Flanges
Nonpoint	Y	2310011503	On-shore oil production; Fugitives: Open Ended Lines
Nonpoint		2310011504	On-shore oil production; Fugitives: Pumps
Nonpoint	Y	2310011505	On-shore oil production; Fugitives: Valves
Nonpoint		2310011506	On-shore oil production; Fugitives: Other
Nonpoint	Y *	2310011600	On-shore oil production; Artificial Lift Engines
Nonpoint		2310012000 through 2310012526	Off-Shore Oil Production; Total: All Processes, Storage Tanks: Crude Oil, Fugitives, Connectors: Oil Streams, Fugitives, Flanges: Oil, Fugitives, Valves: Oil, Fugitives, Other: Oil, Fugitives, Connectors: Oil/Water Streams, Fugitives, Flanges: Oil/Water, Fugitives, Other: Oil/Water
Nonpoint		2310020000	Natural Gas; Total: All Processes
Nonpoint	Y, PA only	2310020600	Natural Gas; Compressor Engines

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§§§This SCC was replaced with the more accurately descriptive 2310011001, associated gas venting.

Data Category	EPA uses	SCC	SCC Description (Abbreviated)
Nonpoint		2310020700 2310020800	Natural Gas; Gas Well Fugitives, Gas Well Truck Loading
Nonpoint	Y	2310021010	On-Shore Gas Production; Storage Tanks: Condensate
Nonpoint		2310021011	On-Shore Gas Production; Condensate Tank Flaring
Nonpoint	Y	2310021030	On-Shore Gas Production; Tank Truck/Railcar Loading: Condensate
Nonpoint	Y	2310021100	On-Shore Gas Production; Gas Well Heaters
Nonpoint		2310021101	Natural Gas Fired 2Cycle Lean Burn Compressor Engines < 50 HP
Nonpoint	Y	2310021102	Natural Gas Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP
Nonpoint		2310021103	Natural Gas Fired 2Cycle Lean Burn Compressor Engines 500+ HP
Nonpoint		2310021109	On-Shore Gas Production; Total: All Natural Gas Fired 2Cycle Lean Burn Compressor Engines
Nonpoint		2310021201	Natural Gas Fired 4Cycle Lean Burn Compressor Engines <50 HP
Nonpoint	Y	2310021202	Natural Gas Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP
Nonpoint		2310021203	Natural Gas Fired 4Cycle Lean Burn Compressor Engines 500+ HP
Nonpoint		2310021209	Total: All Natural Gas Fired 4Cycle Lean Burn Compressor Engines
Nonpoint	Y	2310021251	On-Shore Gas Production; Lateral Compressors 4 Cycle Lean Burn
Nonpoint	Y	2310021300	On-Shore Gas Production; Gas Well Pneumatic Devices
Nonpoint		2310021301	Natural Gas Fired 4Cycle Rich Burn Compressor Engines <50 HP
Nonpoint	Y	2310021302	Natural Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP
Nonpoint		2310021303	Natural Gas Fired 4Cycle Rich Burn Compressor Engines 500+ HP
Nonpoint		2310021309	Total: All Natural Gas Fired 4Cycle Rich Burn Compressor Engines
Nonpoint	Y PA only	2310021310	On-Shore Gas Production; Gas Well Pneumatic Pumps
Nonpoint	Y	2310021351	On-Shore Gas Production; Lateral Compressors 4 Cycle Rich Burn
Nonpoint	Y	2310021400	On-Shore Gas Production; Gas Well Dehydrators
Nonpoint		2310021401	Nat Gas Fired 4Cycle Rich Burn Compressor Engines <50 HP w/NSCR
Nonpoint		2310021402	Nat Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP w/NSCR
Nonpoint		2310021403	Nat Gas Fired 4Cycle Rich Burn Compressor Engines 500+ HP w/NSCR
Nonpoint		2310021411	On-Shore Gas Production; Gas Well Dehydrators - Flaring
Nonpoint		2310021450	On-Shore Gas Production; Wellhead
Nonpoint	Y PA only	2310021500	On-Shore Gas Production; Gas Well Completion - Flaring
Nonpoint	Y	2310021501	On-Shore Gas Production; Fugitives: Connectors
Nonpoint	Y	2310021502	On-Shore Gas Production; Fugitives: Flanges
Nonpoint	Y	2310021503	On-Shore Gas Production; Fugitives: Open Ended Lines
Nonpoint		2310021504	On-Shore Gas Production; Fugitives: Pumps
Nonpoint	Y	2310021505	On-Shore Gas Production; Fugitives: Valves
Nonpoint	Y	2310021506	On-Shore Gas Production; Fugitives: Other
Nonpoint	Y PA only	2310021509	On-Shore Gas Production; Fugitives: All Processes

Data Category	EPA uses	SCC	SCC Description (Abbreviated)
Nonpoint		2310021600	On-Shore Gas Production; Gas Well Venting
Nonpoint		2310021601	On-Shore Gas Production; Gas Well Venting - Initial Completions
Nonpoint		2310021602	On-Shore Gas Production; Gas Well Venting - Recompletions
Nonpoint	Y	2310021603	On-Shore Gas Production; Gas Well Venting - Blowdowns
Nonpoint		2310021604	On-Shore Gas Production; Gas Well Venting - Compressor Startups
Nonpoint		2310021605	On-Shore Gas Production; Gas Well Venting - Compressor Shutdowns
Nonpoint		2310021700	On-Shore Gas Production; Miscellaneous Engines
Nonpoint	*[****]	2310021801	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Pipeline Blowdowns and Pigging
Nonpoint	*[††††]	2310021802	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Pipeline Leaks
Nonpoint	*[‡‡‡‡]	2310021803	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Midstream gas venting for maintenance, startup, shutdown, or malfunction
Nonpoint		2310022000 through 2310022506	Off-Shore Gas Production; Total: All Processes, Storage Tanks: Condensate, Turbines: Natural Gas Boilers/Heaters: Natural Gas, Diesel Engines, Amine Unit Dehydrator, Fugitives, Connectors: Gas Streams, Fugitives, Flanges: Gas Streams, Fugitives, Valves: Gas, Fugitives, Other: Gas
Nonpoint		2310023000	Coal Bed Methane NG/Dewatering Pump Engines
Nonpoint		2310023010	On-Shore CBM Production/Storage Tanks: Condensate
Nonpoint		2310023030	On-Shore CBM Production/Tank Truck Railcar Loading: Condensate
Nonpoint		2310023100	On-Shore CBM Production/CBM Well Heaters
Nonpoint	Y	2310023102	On-Shore CBM Production/CBM Fired 2 Cycle Lean Burn Compressor Engines 50 to 499 HP
Nonpoint	Y	2310023202	On-Shore CBM Production/CBM Fired 4 Cycle Lean Burn Compressor Engines 50 to 499 HP
Nonpoint		2310023251	On-Shore CBM Production/Lateral Compressors 4 Cycle Lean Burn
Nonpoint	Y	2310023300	On-Shore CBM Production Pneumatic Devices
Nonpoint	Y	2310023302	On-Shore CBM Production/CBM Fired 4 Cycle Rich Burn Compressor Engines 50 to 499 HP
Nonpoint	Y	2310023310	Coal Bed Methane NG/Pneumatic Pumps
Nonpoint		2310023351	On-Shore CBM Production/Lateral Compressors 4 Cycle Rich Burn
Nonpoint		2310023400	Coal Bed Methane NG/Dehydrators
Nonpoint		2310023509	Coal Bed Methane Fugitives
Nonpoint	Y	2310023511	On-Shore CBM Production/Fugitives: Connectors

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[****], [5], [6] Created by request of UT

Data Category	EPA uses	SCC	SCC Description (Abbreviated)
Nonpoint	Y	2310023512	On-Shore CBM Production/Fugitives: Flanges
Nonpoint	Y	2310023513	On-Shore CBM Production/Fugitives: Open Ended Lines
Nonpoint	Y	2310023515	On-Shore CBM Production/Fugitives: Valves
Nonpoint	Y	2310023516	On-Shore CBM Production/Fugitives: Other
Nonpoint	Y	2310023600	On-Shore CBM Exploration: CBM Well Completion: All Processes
Nonpoint		2310023603	On-Shore CBM Production/CBM Well Venting - Blowdowns
Nonpoint		2310023606	On-Shore CBM Exploration/Mud Degassing
Nonpoint		2310030220 - 2310030401	Natural Gas Liquids; Gas Well Tanks – Flashing &Standing/Working/Breathing; Gas Well Water Tank Losses; Gas Plant Truck Loading
Nonpoint	Y	2310111100	On-shore Oil Exploration; Mud Degassing
Nonpoint	Y	2310111401	On-shore Oil Exploration; Oil Well Pneumatic Pumps
Nonpoint	Y	2310111700	On-shore Oil Exploration; Oil Well Completion: All Processes
Nonpoint		2310111701	On-Shore Oil Exploration; Oil Well Completion: Flaring
Nonpoint		2310112401	On-shore Oil Exploration; Oil Well Pneumatic Pumps
Nonpoint	Y	2310121100	Off-shore Oil Exploration; Mud Degassing
Nonpoint	Y	2310121401	Off-shore Oil Exploration; Gas Well Pneumatic Pumps
Nonpoint	Y	2310121700	Off-shore Oil Exploration; Gas Well Completion: All Processes
Nonpoint		2310122100	Off-shore Gas Exploration; Mud Degassing
Nonpoint	*PA only	2310300220	All Processes – Conventional Drill Rigs
Nonpoint	*PA only	2310321010	Oil and Gas Production – Conventional Storage Tanks – Condensate
Nonpoint	*PA only	2310321100	Oil and Gas Production – Conventional Gas Well Heaters
Nonpoint	*PA only	2310321400	Oil and Gas Production – Conventional Gas Well Dehydrators
Nonpoint	*PA only	2310321603	Oil and Gas Production – Conventional Gas Well Venting - Blowdowns
Nonpoint	*PA only	2310400220	All Processes – Unconventional Drill Rigs
Nonpoint	*PA only	2310421010	Oil and Gas Production – Unconventional Storage Tanks – Condensate
Nonpoint	*PA only	2310421100	Oil and Gas Production – Unconventional Gas Well Heaters
Nonpoint	*PA only	2310421400	Oil and Gas Production – Unconventional Gas Well Dehydrators
Nonpoint	*PA only	2310421603	Oil and Gas Production – Unconventional Gas Well Venting - Blowdowns
Point		31000101 through 31000506,	Various descriptions; Excludes 31000104 through 31000108 and 31000140 through 31000145, which are in the sector "Industrial Processes – Storage and Transfer"
Point		31088801 through 31088811	Fugitive Emissions; Specify in Comments Field
Point		31700101	Natural Gas Transmission and Storage Facilities; Pneumatic Controllers Low Bleed

For the nonpoint data category, S/L/Ts have four options for providing data to the NEI for the Oil and Gas Production Sector. They may: 1) accept the tool with the defaults populated in the tool by EPA, 2) choose to provide EPA with input data to incorporate in the tool, 3) run the tool themselves (presumably updating the inputs and subtracting point sources), or 4) use their own tools and methodology to provide estimates. If a submitting agency failed to let EPA know their preference via completing the nonpoint survey, then EPA data was input by default. Figure 4-18 shows these state-level data sources for the oil and gas sector.

Figure 4-18: Data source for Oil and Gas emissions in the 2017 NEI
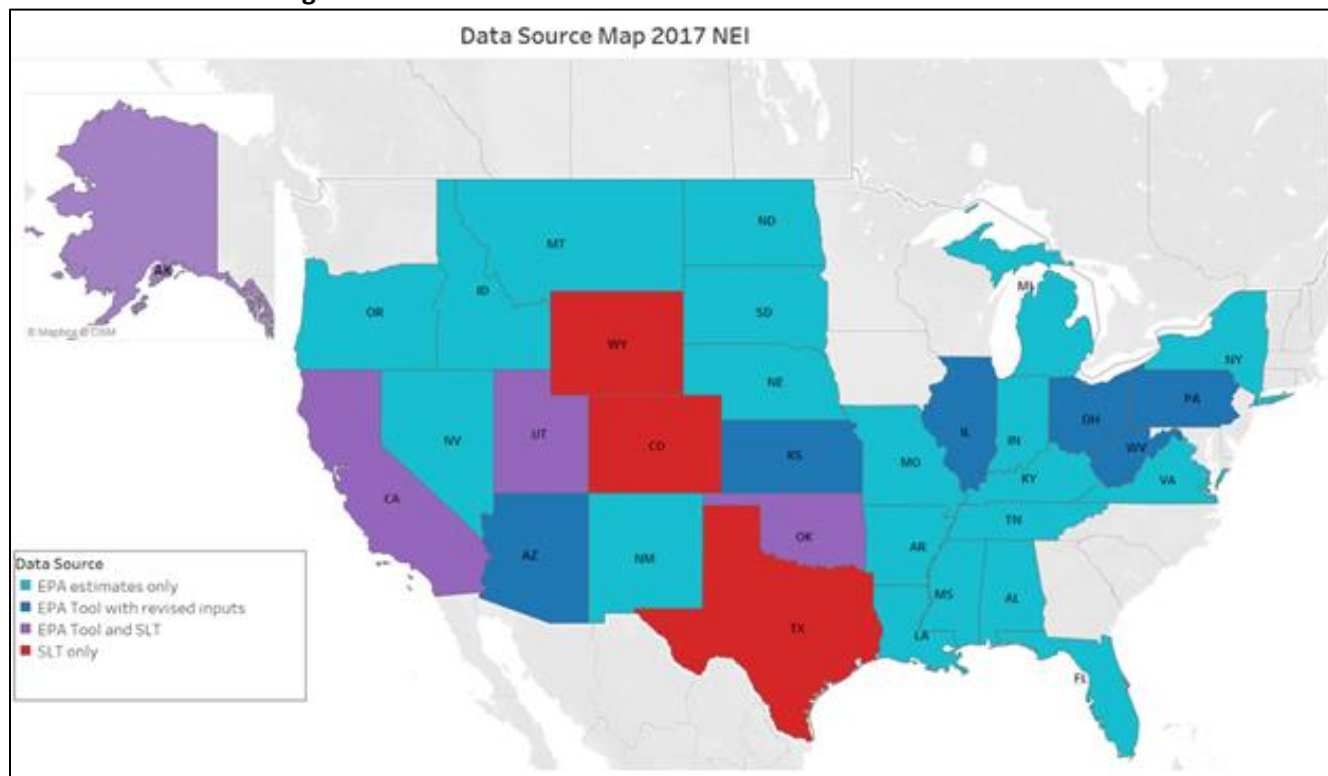
Table 4-132 summarizes the data that was submitted by states in the oil and gas production sector for both point and nonpoint.

Table 4-132: Data Source for Oil and Gas Production Data in the 2017 NEI

State	Nonpoint	Point
AL	EPA estimates only	Submitted to Point Inventory
AK	EPA Tool with revised inputs and SLT	Submitted to Point Inventory
AZ	EPA Tool with revised inputs	Submitted to Point Inventory
AR	EPA estimates only	Submitted to Point Inventory
CA	EPA Tool and SLT	Submitted to Point Inventory
CO	SLT only	Submitted to Point Inventory
CT		Submitted to Point Inventory
FL	EPA estimates only	Submitted to Point Inventory
GA		Submitted to Point Inventory
ID	EPA estimates only	Submitted to Point Inventory
IL	EPA Tool with revised inputs	Submitted to Point Inventory
IA		Submitted to Point Inventory
IN	EPA estimates only	Submitted to Point Inventory
KS	EPA Tool with revised inputs	Submitted to Point Inventory

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State	Nonpoint	Point
KY	EPA estimates only	Submitted to Point Inventory
LA	EPA estimates only	Submitted to Point Inventory
MA		Submitted to Point Inventory
MD	No estimates no activity this NEI	Submitted to Point Inventory
ME		Submitted to Point Inventory
MI	EPA estimates only	Submitted to Point Inventory
MN		Submitted to Point Inventory
MS	EPA estimates only	Submitted to Point Inventory
MO	EPA estimates only	Submitted to Point Inventory
MT	EPA estimates only	Submitted to Point Inventory
NC		Submitted to Point Inventory
NE	EPA estimates only	Submitted to Point Inventory
NJ		Submitted to Point Inventory
NV	EPA estimates only	Submitted to Point Inventory
NM	EPA estimates only	Submitted to Point Inventory
NY	EPA estimates only	Submitted to Point Inventory
ND	EPA estimates only	Submitted to Point Inventory
OH	EPA Tool with revised inputs	Submitted to Point Inventory
OK	EPA Tool and SLT	Submitted to Point Inventory
OR	EPA estimates only	
PA	EPA Tool with revised inputs	Submitted to Point Inventory
SC		Submitted to Point Inventory
SD	EPA estimates only	
TN	EPA estimates only	Submitted to Point Inventory
TX	SLT only	Submitted to Point Inventory
UT	EPA Tool and SLT	Submitted to Point Inventory
VA	EPA estimates only	Submitted to Point Inventory
WV	SLT only (used Tool)	Submitted to Point Inventory
WI		Submitted to Point Inventory
WY	SLT only	Submitted to Point Inventory

4.17.3 EPA emissions calculation approach: EPA Oil and Gas Emissions Estimation Tool

The EPA furthered the development of the existing oil and gas emissions estimation tool that was originally developed for the 2011 NEI, which is a MS Access database that uses a bottom-up approach to build a national inventory. More information on the tool can be found in the documentation provided by ERG, entitled "2017 Nonpoint Oil and Gas Emission Estimation Tool, version 1.2" in the file "Oil_and_Gas_Tool_Documentation_v1.2_2017.zip". There are two modules, as was put in place in the 2014 tool: Exploration and Production. Changes that have been incorporated in the 2017 Oil and Gas Production and Exploration tools since 2014 are addressed in the changes memos by ERG. The memos "2017 Oil and Gas Memos.zip" are from February 14 (the filename is 1_14 but the memo is from February), April 11, July 22, and October 23, 2019. In addition, a memo outlining the additional data from the GHG Reporting Program (subpart W) is entitled 2017 NEI Oil and Gas Tool Subpart W Analysis_3_14_2019.zip.

In general, the tool calculates emissions for each piece of equipment on a well pad (like condensate tanks or dehydrators, for example) in a county or basin, based on average equipment counts taken from either surveys, literature searches, or the GHG reporting program, also accounting for control devices and gas composition in

each county. County-level details are important, since well pads can vary significantly from region to region, basin to basin, and county to county. A well site in Denver, CO in the Denver-Julesburg Basin might look very different from one in the Marcellus Shale in PA, due to changes in technology over time (when the well was first drilled), geologic formations of the oil and gas reservoirs themselves (which also change over time—the ratio of oil to gas changes as pressure in the reservoir is released), and regulations in place guiding the equipment used on site.

The math used in the oil and gas tool is more complex than most other categories, as it uses equations like the ideal gas law and mass balances, in conjunction with more traditional emission rate equations (activity * EF = emissions); thus, the work is best completed in database format. Overall, there are hundreds of inputs to the oil and gas tool, and these are broken down into three basic categories: activity data, basin factors, and emission factors. These inputs to the tool are filled in by EPA, and published with the tool, along with their references. Region specific inputs are preferable and are used when available. Extrapolated inputs from nearby counties in the same basin are then used to fill in gaps in data. National defaults are filled in where no other data is available, and attempts are made to align inputs as much as possible with the GHG reporting program and emissions inventory.

4.17.3.1 *Activity data*

As with the 2014 Tool, the primary source of activity data is the commercially available database developed by DrillingInfo called HPDI, or also called the DI Desktop database. HPDI supplies activity such as number of wells, oil, gas, condensate, and water production, feet drilled, spud counts, and other data. There are cases where this data is not complete, and in those cases, EPA supplemented with data from RIGDATA, from various state oil and gas commissions, and directly from Tool users. The following SLTs provided updated activity inputs for the 2017 Tool:

- Arizona (Exploration data)
- Ohio (Production)
- Kansas (Production)
- Oklahoma (Production)
- Pennsylvania (Production)
- Texas (Production)
- Illinois (Production)
- West Virginia (Production/Exploration).

In addition, State/County FIPS codes were updated for several counties in South Dakota and Alaska, county-level average temperatures for 2017 were updated nationally, and county-level ozone attainment status as of 6/30/18 were updated.

Basin Factors

Basin factors include factors that are secondary to activity, and include assumptions about equipment counts on a per well basis, (e.g., the number of pneumatic controllers per well, or the average HP of an engine at a well site) as well as gas speciation profiles (fraction of benzene, toluene, xylene or ethylbenzene in natural gas at a particular point in the well pad, e.g., post separator).

For 2017 inputs, **GHGRP data** gathered under subpart W was analyzed to develop updated basin factors for several source categories including storage tanks, dehydrators, fugitive equipment leaks, heaters, pneumatic

devices, and wellhead compressor engines. See "[Summary of Analysis of 2017 GHGRP Subpart W Data for Use in the 2017 NEI Nonpoint Oil and Gas Emission Estimation Tool](#)" memo dated March 14, 2019.

Regarding **tank control and capture**, EPA updated default factors for condensate and oil storage tanks. These defaults have been applied nationally for all counties based on recent National Oil and Gas Committee discussions. From a cursory look, we believe there are several contributors to tank leaks and emissions evading being captured and routed to control devices:

- Inadequate design sizing of vapor collection systems or PRVs, seals etc,
- Inadequate staging down of pressure, resulting in flashing (stepping down the process in stages helps reduce the flash gas)
- Worn seals and gaskets on thief hatches and PRVs
- Ambient temperatures affect detection of leaks by IR camera (seems like the lowest frequency of leaks detected, 0.5% leaking, was mid-winter; this appears to be a function of ground temperature and the inability of the camera to distinguish between the vapor plume and the ground)
- Age of tanks/well pads/equipment
- VOC content/API Gravity
- High volume of liquid production
- Frequency of monitoring/compliance/enforcement—realization that rule efficiency and capture efficiency are tied

At this point in time, EPA does not have an exact figure to apply for this value but has started the process to try to quantify this amount and find it necessary to decrease the total amount of control because of the above known factors. In order to have a combined capture and control efficiency of 80%, control efficiency defaults were updated to 95% and capture efficiency defaults were updated to 84%. This was applied to oil tanks, condensate tanks, and condensate CBM tanks.

We updated select basin factors in **Ohio County, WV** based on ERG ORD study. Data was updated for condensate tanks, dehydrators, fugitives, gas-actuated pumps, heaters, pneumatic devices, produced water, and wellhead compressors.

The **"DEHYD_FRACTION_FLARES" for Alaska** was updated from "0" to "1" based on communication with the Alaska Department of Environmental Conservation (ADEC) on September 18, 2019.

We updated **gas composition data for Pennsylvania** was provided by the Pennsylvania Department of Environmental Protection (PADEP), and was included for gas-actuated pumps, fugitives, and pneumatic devices.

We updated gas composition data for **Liquids Unloading for the 5 counties in the Uinta Basin**, Utah was also included, using EPA SPECIATE4.5, 2016, Profile 95418.

4.17.3.2 *Emission factors*

Emission factors are also a part of the formula for estimating emissions, and in the Oil and Gas tool the nomenclature is set such that we only call the standard national factors, like from AP-42 combustion equations, "emission factors." Updates for AP-42 factors in the tool included 1) references for Artificial Lifts, Lateral Compressors, and Wellhead Compressors have been revised to provide specific details identifying AP-42 Section and table number, and 2) added AP-42 emission factors for PM10-FIL, PM25-FIL, and PM-CON for Artificial Lifts, CBM Dewatering Pumps, Dehydrators, Heaters, Lateral Compressors, and Wellhead Compressors.

Well completion emission factors have been changing over the last three inventory cycles. For the 2011 Tool, EPA started out using the CenSARA default factor (736 MCF/completion) for both conventional and

unconventional oil well completions as the national default. Based on EPA guidance from the reg development folks, we dropped this factor as the national default for both conventional and unconventional oil well completions, so there were no national default factors for oil well completions (see the 11/21/2014 OAP Changes Memo). Note that we still used the CenSARA factors for the CenSARA states.

For the 2014 Tool, we started out where we left off with the 2011 Tool. However, the NSPS OOOOa revisions were being proposed during development/revisions of the 2014 Tool, and data on unconventional oil well completions became available. In version 2 of 2014, the emission factor for unconventional well completions mentioned in the report came from Table 4-2 of the TSD for the NSPS OOOOa revisions. The final version of the 2014 Tool (v2) used this value (999 MCF/completion) as the national default EF for unconventional oil well completions.

For the 2017 Tool, we updated the default unconventional oil well completion EF to synchronize with the GHG Emissions Inventory based on data from the "Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017" (new value of 1602 MCF/completion) and began using the CenSARA EF for conventional oil well completions (736 MCF/completion) as the national default. This was documented in the 4/11/2019 Changes memo. These emission factors are used where no county-specific data was available.

Emissions factors for non-road engines used in drilling and hydraulic fracturing have been updated using the MOVES model to represent the 2017 calendar year.

4.17.3.3 Other tool changes

Coalbed Methane Dewatering Pumps have been added as a new source category. An SCC has been added for Coalbed Methane Dewatering Pump Engines (2310023000). There are currently no default input data (number of hours, HP, fraction electric, or load factors) for this category, so no default emission estimates are generated from the Tool.

Vapor Recovery Units (VRU) have been added as a control device for crude oil and condensate storage tanks. Previously, only combustion devices (flares, enclosed combustors) were considered. VRU prevalence on a county-level is expected to be available from data reported under GHGRP Subpart W.

We also provided the capability to address controls for produced water tanks in the 2017 tool.

4.17.3.4 Point source subtraction

Some states count upstream oil and gas production processes as point sources, and therefore have a need to subtract these from the nonpoint part of the inventory. The tool allows for point source subtraction on either an activity or emissions basis, and a few states have taken advantage of this feature. Because of the complicated process of data merging and selection, this process is less than perfect, in that if a source has CAP emissions to subtract but not HAPs (as they aren't included in their point inventory), the emissions for a single source may be divided across he point and nonpoint parts of the inventory. Thus, when an inventory looks at VOC emissions and compares these to a sum of HAP VOCs, there may appear to be inconsistencies.

4.17.3.5 State-specific correspondence

Alaska

After the draft selection was run, EPA reached out to ADEC to determine why there are orders of magnitudes of difference between tool estimates and ADEC's submission. Through Skype calls, EPA was educated on the inherent differences in how oil and gas operations are conducted in Alaska versus in the CONUS; this discussion

is captured in discussion notes "Sept. discussion notes with EPA and ERG" on the NEI Supplemental FTP site. In addition, ADEC staff determined that many emissions may still be missing from their permits and thus their inventories. It was mutually decided that Alaska would accept EPA estimates for the county/SCCs shown in Table 4-133.

Table 4-133: EPA Oil and Gas estimates added to Alaska for the 2017 NEI

FIPS	SOURCE_CATEGORY	SCC	SCC_SHORTENED
02122	FUGITIVES	2310011501	On-Shore Oil Production /Fugitives: Connectors
02122	FUGITIVES	2310011502	On-Shore Oil Production /Fugitives: Flanges
02122	FUGITIVES	2310011503	On-Shore Oil Production /Fugitives: Open Ended Lines
02122	FUGITIVES	2310011505	On-Shore Oil Production /Fugitives: Valves
02122	FUGITIVES	2310021501	On-Shore Gas Production /Fugitives: Connectors
02122	FUGITIVES	2310021502	On-Shore Gas Production /Fugitives: Flanges
02122	FUGITIVES	2310021503	On-Shore Gas Production /Fugitives: Open Ended Lines
02122	FUGITIVES	2310021505	On-Shore Gas Production /Fugitives: Valves
02122	FUGITIVES	2310021506	On-Shore Gas Production /Fugitives: Other
02122	LIQUIDS UNLOADING	2310021603	On-Shore Gas Production / Gas Well Venting - Blowdowns
02122	PNEUMATIC DEVICES	2310010300	Oil Production Pneumatic Devices
02122	PNEUMATIC DEVICES	2310021300	On-Shore Gas Production Pneumatic Devices
02122	WELL COMPLETIONS	2310111700	On-Shore Oil Exploration: Oil Well Completion: All Processes
02122	WELL COMPLETIONS	2310121700	On-Shore Gas Exploration: Gas Well Completion: All Processes
02185	FUGITIVES	2310011501	On-Shore Oil Production /Fugitives: Connectors
02185	FUGITIVES	2310011502	On-Shore Oil Production /Fugitives: Flanges
02185	FUGITIVES	2310011503	On-Shore Oil Production /Fugitives: Open Ended Lines
02185	FUGITIVES	2310011505	On-Shore Oil Production /Fugitives: Valves
02185	FUGITIVES	2310021501	On-Shore Gas Production /Fugitives: Connectors
02185	FUGITIVES	2310021502	On-Shore Gas Production /Fugitives: Flanges
02185	FUGITIVES	2310021503	On-Shore Gas Production /Fugitives: Open Ended Lines
02185	FUGITIVES	2310021505	On-Shore Gas Production /Fugitives: Valves
02185	FUGITIVES	2310021506	On-Shore Gas Production /Fugitives: Other

This amounted to the additions for Alaska's inventory shown in Table 4-134.

Table 4-134: Additional VOC emissions (tons/yr) added to the Alaska Oil and Gas inventory

Source Category	Kenai Peninsula	North Slope
WELL COMPLETIONS	46.9	-
LIQUIDS UNLOADING	17.7	-
FUGITIVES	184.4	127.4
PNEUMATIC DEVICES	182.6	-

Alaska agreed to research blowdowns and drill rigs for the 2020 NEI, but it was determined that these emissions were likely much less than what was estimated in the EPA oil and gas tool, so they were not included in the 2017 NEI for lack of a good estimate.

Alaska does not have storage tanks at well pads in the same way that they do in the continental US. For this reason, EPA and Alaska agreed to zero out these emissions. The tanks that do exist are mobile equipment and therefore are not permitted. From the emissions submitted in fee assessments, the emissions are very small, and not applicable to every well pad and every activity (well servicing, exploration of development drilling). ADEC acknowledged that produced fluids will sometimes be stored during drilling activities and then disposed down the well annulus either at the same location or an approved Class II injection well. There may be a short period of time that these fluids are on site and could result in some emissions.

EPA agreed to zero this out in the tool for the 2017 NEI. ADEC will review these tanks for the 2020 NEI and reconvene with EPA to determine if there is any value in adding this to the EPA tool.

For well completions and workovers, EPA acknowledged that based on some comparisons to subpart W methane emissions, North Slope emissions seem to be too high. EPA agreed to zero those out on the North Slope, and ADEC agreed to take the tool estimate for the other counties (similar order of magnitude for Cook Inlet, according to subpart W.)

ADEC researched the number of dehydrators, and, in reviewing the number provided and emissions reported, it seems like the proposed reduction of 98% to accommodate still vent control makes sense since most of these had emission controls. ADEC believes that the dehydrators are included in the reported NEI submittal are accurate and will agree to the 98% reduction for still vent controls.

Regarding associated gas emissions, ADEC said that it is a general state policy that venting/flaring is a waste of state resources and is a loss of money to operators. The Subpart W reporting shows this to be very small and does not compare to the tool volumes. EPA agreed to zero this out.

For Mud degassing, ADEC noted that most mudding operations are in a module that is within the drill rig. ADEC provided a slide with some of the mud facilities on the slide pack. Because they are in a structure, OSHA/AKOSH/Fire regulations are strict for safety purposes. ADEC will research this more for 2020. EPA agreed to zero this out in the tool for 2017.

Regarding pneumatic pumps and devices in the North Slope and Cook Inlet, pneumatic pumps are listed as an insignificant emission source, so it is not included in the permit or in any reports. ADEC agreed that the tool volumes for the devices and pumps were acceptable for 2017 since they were close to the Subpart W reporting. ADEC will research this for the 2020 NEI for EPA tool updates.

For liquids unloading, when compared to subpart W methane emissions, it is very small in the North Slope and EPA offered to zero this out. For Cook Inlet, the tool is very close to the Subpart W reporting, so ADEC agreed to keeping the tool estimates for the 2017 NEI.

California

The California Air Resource Board (CARB) submits their own data, for the most part, for the NEI. EPA reached out to the CARB to determine why there are orders of magnitude differences in the oil and gas sector. CARB replied that they stand by their estimates. EPA proposed that the SCCs that CARB included in their submission did not include these sources (based on a look at their Emissions Inventory Codes (EIC) to SCC mapping that CARB provided):

- 2310011001 Oil – Associated Gas Venting
- 2310011600 Artificial Lift Engines
- 2310010100 Oil Well Heaters

- 2310010200 Oil Well Tanks
- 2310000553 Produced water Oil Wells

CARB therefore changed their Nonpoint Survey to include EPA estimates for these 5 SCCs. California was the only state to resubmit data between November 2019 and April 2020 selection. This increased VOC by about 16,500 tons, which brings it more in line, but still lower than expectations.

Colorado

EPA contacted the Colorado Department of Public Health and Environment (CDPHE) regarding potentially missing carbon monoxide. CDPHE responded that they summed carbon monoxide for all area engines and submitted them to miscellaneous engines. CDPHE approved of EPA backfilling carbon monoxide for other combustion sources based on NOx. Most oil and gas development in La Platta County is on tribal lands; the portion on state land is minimal.

Oklahoma

The Oklahoma Department of Environmental Quality (OK DEQ) uses a mix of both EPA estimates (for the exploration module) and their own emissions using the oil and gas tool (production module only). OK DEQ allows EPA to do HAP augmentation for the SCCs that they submit. One difference between OK DEQ's SCC emissions dataset and EPA's SCCs are that OK DEQ aggregates their equipment-specific fugitive emissions into Fugitive All Process SCCs for oil, gas and CBM wells.

Pennsylvania

The PADEP relies on EPA to run the oil and gas tool but utilizes alternative SCCs for several source categories in order to differentiate their emissions for conventional and unconventional oil and gas operations. PA DEP provides unconventional well API numbers which EPA then subtracts from the tool to determine the conventional portion. The process is:

1) Run the tool with basin factors that the Mid-Atlantic Regional Air Management Association (MARAMA) provided for the 2014 NEI oil and gas sector for

- Artificial lifts
- Associated gas
- Condensate tanks
- Crude tanks
- Dehydrators
- Fugitives
- Gas-actuated pumps (oil and gas wells)

For associated gas, condensate tanks, crude oil tanks, and dehydrators, if the Tool sources were the 2017 GHGRP factors recently documented, these were not replaced. EPA also incorporated gas composition profiles provided by the PA DEP.

2) Remove the activity data related to the emissions data provided by PA using API numbers for unconventional wells.

3) Run the tool for adjusted emissions.

4) Use the "conventional only" SCCs to replace the more "general" Tool SCCs for 5 source categories:

a. Drilling
   b. Gas Well Condensate Tanks
   c. Gas Well Heaters
   d. Gas Well Dehydrators
   e. Gas Well Liquids Unloading

For perspective, here is the activity data:

   1) HPDI
      a. # wells = 80,343
      b. Gas Production = 5,476,303,221 MCF
      c. Liquids Production = 6,563,695 BBL
   2) PA Unconventional Wells (matched by API #)
      a. # wells = 5,765
      b. Gas Production = 3,655,597,522 MCF
      c. Liquids Production = 1,441,312 BBL

Thus,

   % Wells that match between PA unconventional and HPDI = 7% (5,765 wells/80,343 wells)
   % of Gas Production of PA unconventional wells and HPDI = 67% (3,655,597,522 MCF/5,476,303,221 MCF)
   % of Liquids Production of PA unconventional wells and HPDI = 22% (1,441,312 BBL/6,563,695 BBL)

While the Pennsylvania unconventional wells account for 67% of the gas production and 22% of the liquids production, it translates to approximately 2% of the VOC and benzene emissions. This makes sense, because the majority of the emission calculations in the tool are based on well counts, not production. Thus, running the tool for the remainder of the conventional wells (93%) will still produce the majority of emissions.

Utah

The Utah Division of Air Quality (UT DAQ) collects its own oil and gas inventory from the oil/gas extraction industry. They also use the EPA oil and gas tool to supplement source categories that are not collected through their inventory.

It should be noted that the UT DAQ inventory engine emissions are not broken down in the same categories (SCCs) used in the oil and gas tool. Thus, instead of using the tool's SCCs, the engine data is submitted to generic oil/gas production "miscellaneous engines" SCCs (CBM is also submitted to the misc gas SCC):

   2310011600 - Industrial Processes - Oil & Gas Production, On-Shore Oil Production, Miscellaneous Engines
   2310021700 - Industrial Processes - Oil & Gas Production, On-Shore Gas Production, Miscellaneous Engines

UT DAQ has been making a rigorous effort to find missing VOCs in their inventory. One method for doing this is to take subpart W data, determine the methane to VOC ratio, and estimate emissions. UT DAQ did this for several categories, some of which didn't exist as SCCs in the Emissions Inventory System.

- For liquids unloading, UT DAQ will submit to the same liquids unloading SCC we use in the tool.
- For associated gas venting and flaring: we compared the numbers of UT DAQ's estimate and the tool; the tool's is higher, so Greg won't submit this SCC, and the tool will backfill.
- For "blowdowns and pigging" there are legitimate reasons to create a new SCC, because EPA Region 8 is considering restricting these types of operations during inversion events, to prevent high ozone in wintertime, for example.

- For "midstream pipeline leaks" like when there's an upset at a compressor station, or the station is starting up, shutting down or malfunctioning or inoperable, EPA also sees a need to create a new SCC in the 231xxxx area of the SCC table. One option that we don't want to take is to put in with regular fugitives because they're different and we want to be able to discern between the two.

New SCCs, shown in Table 4-135, were created for pipeline blowdowns and pigging, pipeline leaks, midstream gas venting for maintenance, startup shutdown and maintenance.

Table 4-135: New SCCs created to assist UT DAQ's pipeline and midstream processes reporting

SCC	SCC Description
2310021801	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Pipeline Blowdowns and Pigging
2310021802	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Pipeline Leaks
2310021803	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Midstream gas venting for maintenance, startup, shutdown, or malfunction

Wyoming

The Wyoming Department of Environmental Quality (WY DEQ) has and submits its own oil and gas inventory. However, when QA'ing the inventory, Wyoming showed a large difference in VOC from gas well completions in Sublette County. In the 2014v2 NEI, there were 42,000 tons submitted. Conversations with WY DEQ showed that the 2014 VOC emissions for that county were not correct; submissions from Wyoming were in pounds, not tons, and a correction was attempted back in 2017 but was not successful. WY DEQ agreed that for the 2017 NEI, they would accept the EPA estimate for Sublette County for well completions. We tagged out the Nonpoint Survey response for SCC 2310021500 which essentially treats the record like "Supplement with EPA data."

In addition, WY DEQ used different SCCs for pneumatic pumps, oil tanks, and well completions. WY DEQ provided this information:

- 2310021500=Comp. Workover Vent & Flare (oil well) = 420.5 tons
- 2310111700=Comp. Workover Vent & Flare (gas well) = 14,327.9 tons
- 2310000660=Completion Engine (oil, gas well) = 64.2 tons
- 2310111401=Pneumatic Pump (oil well) = 71.7 ton
- 2310021310=Pneumatic Pump (gas well) = 1,375.8 tons
- 2310011020=Tanks & Pressurized Vessels (oil well) = 24,779.4 ton
- 2310021010=Tanks & Pressurized Vessels (gas well) = 11,616.6 tons

4.17.3.6 *Quality Assurance*

The following figures were produced to perform QA on the draft selection for NOX (Figure 4-19) and VOC (Figure 4-20) estimates; in both figures, "Emissions 2017 Feb-Select" (blue bars) represent the emissions that went into the 2017 NEI. Note that this is a log scale, and that states that submitted are the only ones that show up in yellow. The states that show the most differences are Alaska and California, so EPA reached out to those states. Note that the final NEI selection (in blue) shows a compromise between EPA's estimates and the SLT's original submissions. Details on these compromises and correspondence with EPA is documented in the previous section.

Figure 4-19: State-level 2017 NEI, SLT, and EPA NOX emission comparisons
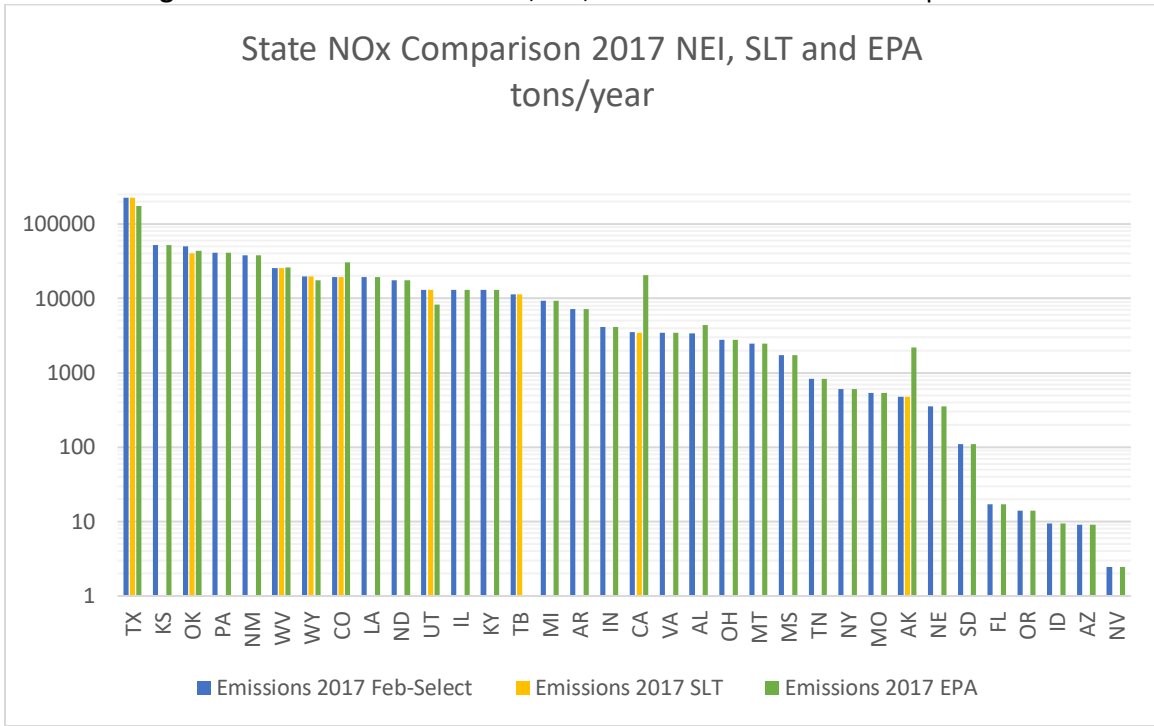
Figure 4-20: State-level 2017 NEI, SLT, and EPA VOC emission comparisons
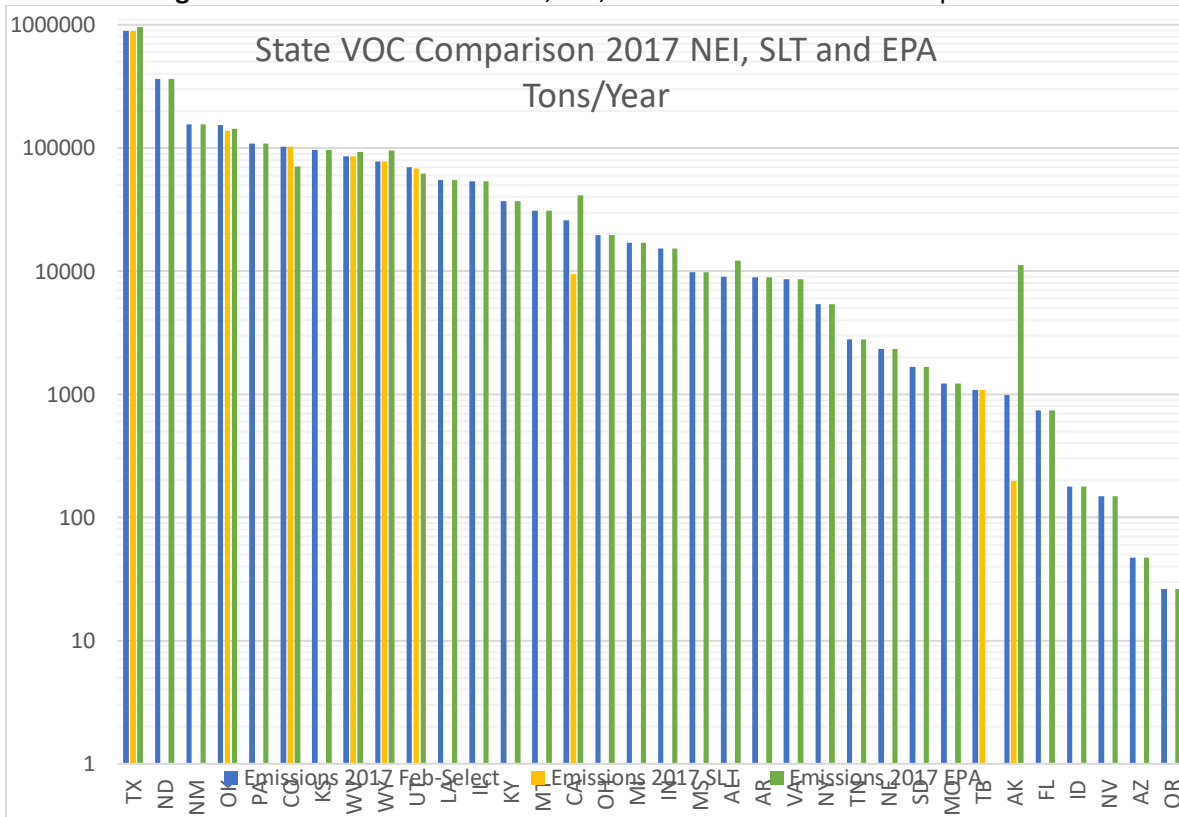
4.18 Miscellaneous Non-industrial NEC: Cremation – Human and Animal

4.18.1 Sector description

The cremation of human remains results in emissions of particulate matter, SO_2, NOx, VOC, CO, and HAPs. It is a significant source of mercury emissions, due to mercury in dental fillings, as well as mercury in blood and tissues. In 2017, human cremation resulted in the emissions of approximately 1.8 tons of mercury.

The cremation of animals also results in emissions of CAPs and HAPs, though it emits less mercury than human cremation. In 2017, animal cremation resulted in the emissions of approximately 2 lbs. of mercury.

SCCs for human and animal cremation are provided in Table 4-136.

Table 4-136: Human and animal cremation SCCs

SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
2810060100	Miscellaneous Area Sources	Other Combustion	Cremation	Humans
2810060200	Miscellaneous Area Sources	Other Combustion	Cremation	Animals

4.18.2 Sources of data

The paved road dust sector includes data from the S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-137 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Virginia only submitted emissions for human cremation. Maricopa county, Maryland, and Washoe counties did not include mercury estimates for either human or animal cremation. Rhode Island did not submit mercury estimates for animal cremation (but did for human cremation).

Table 4-137: Agencies that submitted human and/or animal cremation emissions

Region	Agency	S/L/T
1	Rhode Island Department of Environmental Management	State
3	Maryland Department of the Environment	State
3	Virginia Department of Environmental Quality	State
4	Knox County Department of Air Quality Management	Local
4	Memphis and Shelby County Health Department - Pollution Control	Local
5	Illinois Environmental Protection Agency	State
9	Maricopa County Air Quality Department	Local
9	Washoe County Health District	Local
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.18.3 EPA-developed emissions

The calculations for estimating emissions from human cremation involve estimating the number of deaths in each age group in each county, using data from the Centers for Disease Control and Prevention. The number of deaths is multiplied by the average weight by age group and the state-level cremation rate from the National Funeral Directors Association to estimate the total amount of cremations in each county in terms of mass. This

number is multiplied by an emissions factor to estimate the emissions of CAPs and HAPs. Emissions of mercury include emissions from mercury in fillings in teeth and in blood and tissues. The emissions from mercury in fillings are estimated based on data on the number of filled teeth per person in each age group and assumptions about the proportion of fillings that contain mercury and the amount of mercury in each filling.

The calculations for estimating emissions from animal cremation involve determining the number of cremated animals nationally and distributing this number to each county based on population. The number of cremated animals is multiplied by average weights for cats and dogs to determine the amount of cremations in each county in terms of mass. This number is multiplied by an emissions factor to estimate the emissions of CAPs and HAPS.

4.18.3.1 *Activity data*

<u>Human Cremation</u>

The activity data for human cremation is based on the number of deaths in each county in 13 age groups, from the Centers for Disease Control and Prevention WONDER database [ref 1]. Data for some counties are withheld in the WONDER database. These gaps are filled using the data on the total number of deaths by age group in each state (which includes the number of deaths that are withheld at the county level). First, the sum of the reported county-level number of deaths in each age group and state is subtracted from the reported state-level number of deaths in each age group to determine the total number of deaths withheld at the county level in each state and age group.

$$Deaths\_withheld_{s,a} = Deaths\_state_{s,a} - \sum Deaths\_county_{s,a} \qquad \text{(H1)}$$

Where:

$Deaths\_withheld_{s,a}$ = Total number of withheld deaths in state s in age group a
$Deaths\_state_{s,a}$ = Total number of deaths reported at the state level in state s in age group a
$Deaths\_county_{s,a}$ = Total number of deaths reported at the county level in state s in age group a

The total number of withheld deaths are distributed to the counties based on the proportion of population in those counties to the total state population.

$$Pop\_ratio_c = \frac{Pop_c}{Pop_s} \qquad \text{(H2)}$$

Where:

Pop_ratio_c = The population ratio used to distribute withheld deaths in state s to county c
Pop_c = The total population of county c
Pop_s = The total population of state s

The number of withheld deaths in each state is multiplied by the county population ratio to distribute the withheld deaths to the counties. Note that this step is only performed for counties where county-level data on number of deaths is withheld; this step is not performed where county-level data on deaths is reported.

$$Deaths_{c,a} = Deaths\_withheld_{s,a} \times Pop\_ratio_c \qquad \text{(H3)}$$

Where:

$Deaths_{c,a}$ = The number of deaths in county c in age group a

$Deaths\_withheld_{s,a}$ = Total number of withheld deaths in state s in age group a, from equation H1

Pop_ratio_c = The population ratio used to distribute withheld deaths in state s to county c, from equation H2

The total number of deaths in each county (either reported directly in the CDC WONDER database or estimated using equation H3) is multiplied by a state-level cremation rate, reported by the National Funeral Directors Association (NFDA) [ref 2], shown in Table 4-138. It is assumed that the state-level cremation rate applies to all counties within the state.

$$Cremations_{c,a} = Deaths_{c,a} \times Cremation\_rate_s \tag{H4}$$

Where:

$Cremations_{c,a}$ = The number of human cremations in county c in age group a

$Deaths_{c,a}$ = The number of deaths in county c in age group a

$Cremation\_rate_s$ = The rate of human cremations in state s, from Table 4-138 [ref 2]

Table 4-138: Human cremation rate by state

State	Cremation Rate		
Alabama	23.1%	Michigan	54.9%
Alaska	66.3%	Minnesota	57.2%
Arizona	66.1%	Mississippi	18.2%
Arkansas	32.7%	Missouri	39.7%
California	63.4%	Montana	72.8%
Colorado	68.6%	Nebraska	43.8%
Connecticut	50.3%	Nevada	76.9%
Delaware	46.2%	New Hampshire	70.3%
District of Columbia	40.0%	New Jersey	40.6%
Florida	62.4%	New Mexico	58.9%
Georgia	37.1%	New York	39.6%
Hawaii	72.7%	North Carolina	39.8%
Idaho	56.8%	North Dakota	35.3%
Illinois	42.8%	Ohio	42.3%
Indiana	36.6%	Oklahoma	39.0%
Iowa	42.2%	Oregon	74.1%
Kansas	44.6%	Pennsylvania	43.1%
Kentucky	24.5%	Rhode Island	46.6%
Louisiana	26.3%	South Carolina	37.4%
Maine	70.0%	South Dakota	35.4%
Maryland	40.6%	Tennessee	28.1%
Massachusetts	43.4%	Texas	39.3%
		Utah	31.2%

Vermont	67.3%		Wisconsin	52.5%
Virginia	36.1%		Wyoming	66.7%
Washington	75.5%			
West Virginia	27.3%			

The CDC provides estimates of the average weight of individuals in each age group [ref 3]. This number is multiplied by the number of cremations in each county in each age group and then summed across all age groups to estimate the total amount of cremations in tons in each county.

$$Cremations\_tons_c = \sum_{a=1}^{A} Cremations_{c,a} \times W_a \times \frac{1\ ton}{2,000\ lbs} \tag{H5}$$

Where:

$Cremations\_tons_c$= The weight of humans cremated in county c, in tons
$Cremations_c$ = The number of human cremations in county c, from equation H4
W_a = The average weight of individuals from age group a

Animal Cremation

The Pet Loss Professionals Alliance (PLPA) conducted a survey that estimated that there were 1,840,965 pet cremations in 2012, and that 99 percent of deceased pets are cremated [ref 4]. In addition, the Humane Society of the United States estimates that there are 2,700,000 adoptable dogs and cats euthanized in animal shelters each year [ref 5]. It is assumed that all of these shelter animals are cremated. Therefore, there are a total of approximately 4,540,965 animal creations each year. Note that this estimate does not double count the number of animal cremations, because the PLPA study counts the number of cremations of pets—i.e. animals that are owned by people—whereas the Humane Society estimates are for animals in shelters that were not adopted.

The population of cats and dogs is approximately 52.5 percent cats and 48.5 percent dogs [ref 5]. Using this percentage and the total number of pets and shelter animals cremated annually, a total number of cats and a total number of dogs cremated annually can be calculated.

$$Cremations_{c/d,US} = Ratio_{c/d} \times (Cremations\_pets_{US} + Cremations\_shelter_{US}) \tag{A1}$$

Where:

$Cremations_{c/d}$ = Total cats, c, or dogs, d, cremated annually in the United States
$Ratio_{c/d}$ = Ratio of cats, c, or dogs, d, in the pet population
$Cremations\_pets_{,US}$ = Total number of pets cremated annually in the United States
$Cremations\_shelter_{,US}$ = Total number of shelter animals cremated annually in the United States

The average weight of a domestic cat is approximately 4.5 kg (9.9 pounds) [ref 6]. The average weight of a dog is difficult to determine due to large differences in breeds, but an average across breeds is 48.5 pounds [ref 7]. Note that this is a straight average of the average adult weight for male and female dogs across breeds. It is not a weighted average that takes into account the popularity of different breeds in the United States. To calculate the weight, in tons, of both cats and dogs cremated annually, the average weight values are multiplied by the total number of cats and total number of dogs cremated annually.

$$Cremations\_tons_{c/d} = Cremations_{c/d} \times Weight_{c/d} \times \frac{1\ ton}{2,000\ pounds} \tag{A2}$$

Where:

$Cremations\_tons_{c/d,US}$ = Total weight, in tons, of cats, c, or dogs, d, cremated annually in the United States

$$Cremations_{c/d,US} \quad\quad = \text{Total cats, } c\text{, or dogs, } d\text{, cremated annually in the United States}$$

Weight$_{c/d}$ = Average weight per animal, in pounds, of cats, c, or dogs, d

Once the weight of cats and weight of dogs cremated annually has been calculated, these values can be summed to derive a total weight of animals cremated annually. The total weight of cremated animals in 2014 was approximately 53,441 tons.

$$Cremations\_tons_{animal} = Cremations\_tons_c + Cremations\_tons_d \quad\quad\quad (A3)$$

Where:

Cremations_tons$_{animal,US}$ = Total weight of animals cremated annually in the United States, in tons
Cremations_tons$_{c,US}$ = Total weight of cats, c, cremated annually in the United States, in tons
Cremations_tons$_{d,US}$ = Total weight of dogs, d, cremated annually in the United States, in tons

4.18.3.2 *Allocation procedure*

Human Cremation

The number of deaths is reported by the CDC at the county level. Therefore, these data do not need to be allocated. For counties with withheld data on the number of deaths, the total number of withheld deaths is distributed to counties based on the proportion of population in those counties, as described in equations H1-H3.

Animal Cremation

The estimated national-level total weight of animals cremated are allocated to the county level based on the ratio of population in each county to the total national population.

$$Cremations\_tons_{animal,c} = Cremations\_tons_{animal,US} \times \frac{Pop_c}{Pop_{US}} \quad\quad\quad (A1)$$

Where:

Cremations_tons$_{animal,c}$ = Total weight of animals cremated in county c, in tons
Cremations_tons$_{animal,US}$ = Total weight of animals cremated annually in the United States, in tons, from equation A3
Pop$_c$ = The total population of county c
Pop$_{US}$ = The total population of the United States

4.18.3.3 *Emission factors*

Human and Animal Cremation – Blood and Tissues

The emissions factors for human and animal cremation for CAPs are from AP-42 [ref 8], and a report by EPA on emissions tests of a crematory [ref 9], and are in units of pounds of emissions per ton cremated. The emissions factors for most HAPs are a report from the California Air Resources Board [ref 10], as well as from the EPA emissions test of a crematory. The mercury emissions factor is from a review of multiple studies [ref 11]. These emission factors do not include emissions from dental fillings. As shown in Table 4-139, EPA uses the same emissions factors for emissions from cremation of blood and tissues for both humans and animals.

Table 4-139: Emissions factors for the cremation of human and animal blood and tissues

Pollutant	Pollutant Code	Emission Factor (lbs/ton)	Source
Carbon Monoxide	CO	2.947	8
Lead	7439921	0.009	9
Nitrogen Oxides	NOX	3.560	8
PM10 Primary	PM10-PRI	3.036	8 (65% of total PM)
PM2.5 Primary	PM25-PRI	2.022	8 (43.3% of total PM)
Sulfur Dioxide	SO2	2.173	8
Volatile Organic Compounds	VOC	0.299	8
Acenaphthene	83329	1.303E-06	10
Acenaphthylene	208968	8.971E-07	10
Acetaldehyde	75070	9.269E-04	10
Anthracene	120127	2.389E-06	10
Arsenic	7440382	5.097E-04	10
Benzo(a)anthracene	56553	1.166E-07	10
Benzo(a)pyrene	192972	4.720E-07	10
Benzo(b)fluoranthene	205992	1.737E-07	10
Benzo(g,h,i)perylene	191242	5.874E-07	10
Benzo(k)fluoranthene	207089	1.486E-07	10
Beryllium	7440417	1.760E-05	10
Cadmium	7440439	2.940E-03	9
Chromium (VI)	18540299	1.829E-04	10
Chrysene	218019	2.880E-07	10
Cobalt	7440484	8.869E-05	10
Dibenz(a,h)anthracene	53703	1.349E-07	10
Fluoranthene	206440	1.337E-06	10
Fluorene	86737	3.760E-06	10
Formaldehyde	50000	2.469E-04	10
Hydrogen Chloride	7647010	3.595E+00	9
Hydrogen Fluoride	7664393	8.651E-03	10
Indeno(1,2,3-cd)pyrene	193395	1.440E-07	10
Mercury	7439976	1.324E-04	10
Naphthalene	91203	7.520E-04	10
Nickel	7440020	4.149E-04	10
Phenanthrene	85018	1.531E-05	10
Pyrene	129000	1.474E-06	10
Selenium	7782492	4.971E-04	10

Human Cremation – Dental Mercury

In addition to mercury emitted from the cremation of blood and tissues, mercury is also emitted due to the cremation of dental fillings. The Bay Area Air Quality Management District (BAAQMD) issued a report in 2012 estimating the average amount of mercury in teeth per person for ten age groups, based on data from CDC's National Health and Nutrition Examination Survey [ref 12]. Table 4-140 shows the estimated amount of material in restored teeth by age group from the BAAQMD study [ref 12], which is matched to the age groups used by the CDC Wonder database, which is the source of data on deaths by age group.

The BAAQMD memorandum is used to estimate that 31.6 percent of filled teeth in the 5-24 age groups contain amalgam. According to the American Dental Association (ADA 1998) more than 75 percent of restorations before the 1970s used dental amalgam, which declined to 50 percent by 1991. Using these numbers, it is assumed that 50 percent of the filled teeth for 25-44 age groups contain amalgam, 62.5 percent of filled teeth in the 45-64 age group, and 75 percent of filled teeth for people over 65. The Food and Drug Administration has discouraged the use of dental amalgam in children under 6 [ref 13]. While EPA does not have data on the percent of fillings containing dental amalgam for the 1-4 age group, it is assumed that this age group has approximately half the dental amalgam of the other age groups under 20 years old. It is also assumed that children under the age of 1 have no dental mercury. The analysis also assumes that 45 percent of all amalgam-containing fillings are mercury, based on information from the Food and Drug Administration [ref 13].

Table 4-140: Estimated amount of material in restored teeth

Age Groups in CDC WONDER Database	Age Groups in BAAQMD Memorandum	Avg. Material in Restored Teeth (g)	% of Fillings Containing Mercury
< 1 year	0-4 years[+]	0.000	0.0%
1-4 years		0.160	15.8%
5-9 years	5-14 years	0.720	31.6%
10-14 years			
15-19 years	15-24 years	1.070	31.6%
20-24 years			
25-34 years	25-34 years	2.230	50.0%
35-44 years	35-44 years	3.290	50.0%
45-54 years	45-54 years	4.310	62.5%
55-64 years	55-64 years	4.320	62.5%
65-74 years	65-74 years	3.780	75.0%
75-84 years	75-84 years	3.650	75.0%
85+ years	85+ years	2.960	75.0%

The emissions factor for mercury in teeth is calculated by multiplying the average amount of material in restored teeth per person by the percentage of fillings containing mercury in each age group and the proportion of mercury in dental amalgam (approximately 45 percent).

$$EF\_teeth_{Hg,a} = Material_a \times ContainHg_a \times HgProportion \times 0.0022 \frac{lb}{g} \qquad \text{(H6)}$$

Where:

$EF\_teeth_{Hg,a}$ = Emission factor for mercury emissions from teeth due to cremation for age group a, in lbs. per cremation

$Material_a$ = The average amount of material in restored teeth for age group a, in grams, from Table 4-140

$ContainHg_a$ = The proportion of people in age group a with fillings that contain mercury, from Table 4-140

$HgProportion$ = The proportion of dental amalgam that is mercury (approximately 45 percent)

4.18.3.4 *Controls*

There are no controls assumed for this source category.

4.18.3.5 *Emissions*

Human Cremation

To estimate the emissions of CAPs from human cremation, the total number of human cremations in each county, in tons, is multiplied by the emissions factor for each pollutant, from Table 4-139.

$$Emissions_{p,c} = Cremation\_tons_c \times EF_p \tag{H7}$$

Where:

$Emissions_{p,c}$ = Emissions of pollutant p from human cremation in county c, in pounds

$Cremations\_tons_c$ = The number of human cremations in county c, in tons

EF_p = Emissions factor for pollutant p from human cremation, in lbs. per ton

The emissions from mercury in teeth are estimated based on the number of cremations rather than the weight. To estimate the emissions of mercury from teeth during human cremation, the number of cremations in each age group is multiplied by the emissions factor for each age group and then summed across age groups.

$$Emissions\_teeth_{Hg,c} = \sum_{a=1}^{A} Cremations_{c,a} \times EF\_teeth_{Hg,a} \tag{H8}$$

Where:

$Emissions\_teeth_{Hg,c}$ = Emissions of mercury in teeth from human cremation in county c, in pounds

$Cremations_{c,a}$ = The number of human cremations in county c in age group a

$EF\_teeth_{Hg,a}$ = Emissions factor for mercury emissions from teeth due to cremation for age group a, in lbs. per cremation

The emissions from mercury from blood and tissues are estimated by multiplying the total number of cremations in each county, in tons, by the emissions factor for mercury from blood and tissues.

$$Emissions\_tissue_{Hg,c} = Cremations\_tons_c \times EF\_tissue_{Hg} \tag{H9}$$

Where:

$Emissions\_tissue_{Hg,c}$ = Emissions of mercury in tissues from human cremation in county c, in pounds

$Cremations\_tons_c$ = The number of human cremations in county c, in tons

$EF\_tissue_{Hg,a}$ = Emissions factor for mercury emissions from blood and tissues due to cremation for in lbs. per ton

The total emissions of mercury from cremation in each county is calculated by adding the emissions of mercury from teeth and the emissions of mercury from tissues.

$$Emissions_{Hg,c} = Emissions\_teeth_{Hg,c} + Emissions\_tissue_{Hg,c} \qquad \text{(H10)}$$

Where:

$Emissions_{Hg,c}$ = Emissions of mercury from human cremation in county c, in pounds
$Emissions\_teeth_{Hg,c}$ = Emissions of mercury in teeth from human cremation in county c, in pounds
$Emissions\_tissue_{Hg,c}$ = Emissions of mercury in tissues from human cremation in county c, in pounds

Animal Cremation

$$Emissions_{p,c} = Cremation\_tons_c \times EF_p \qquad \text{(A5)}$$

Where:

$Emissions_{p,c}$ = Emissions of pollutant p from animal cremation in county c, in pounds
$Cremations\_tons_c$ = The number of animal cremations in county c, in tons
EF_p = Emissions factor for pollutant p from animal cremation, in lbs. per ton

4.18.3.6 *Sample calculations*

Table 4-141 lists the sample calculations for estimating mercury emissions from human cremation in the 85+ age group and animal cremation of cats in Clark County, ID. To estimate the total emissions in Clark County, these steps would be repeated to estimate emissions from all age groups and from cremation of dogs.

Table 4-141: Sample calculations for mercury emissions from human cremation for the 85+ age group and cremation of cats in Clark County, ID

Eq. #	Equation	Values for Clark County, ID	Result
H1	$Deaths\_withheld_{s,a}$ $= Deaths\_state_{s,a}$ $- \sum Deaths\_county_{s,a}$	$4,013 \; state \; level \; deaths$ $- 3,997 \; total \; county \; level \; deaths$	16 withheld deaths in Idaho
H2	$Pop_{ratio_c} = \dfrac{Pop_c}{Pop_s}$	$\dfrac{873 \; people \; in \; Clark \; County}{1,975 \; total \; population \; of \; counties \; with \; withheld \; death}$	0.442 population ratio
H3	$Deaths_{c,a}$ $= Deaths_{withheld_{s,a}}$ $\times Pop_{ratio_c}$	$16 \; withheld \; deaths \; \times 0.442 \; population \; ratio$	7 deaths in Clark County, ID
H4	$Cremations_{c,a}$ $= Deaths_{c,a}$ $\times Cremation_{rate_s}$	$7 \; deaths \; \times 56.8\% \; cremation \; rate$	4 cremations in Clark County, ID

Eq. #	Equation	Values for Clark County, ID	Result
H5	$Cremations\_tons_c$ $= \sum_{a=1}^{A} Cremations_{c,a} \times W_a$ $\times \frac{1\ ton}{2,000\ lbs}$	$4\ cremations\ \times 158.25\ lbs\ per\ person\ in$ $85 + age\ group\ \div 2000\ lbs\ per\ ton$	0.3165 tons cremations in Clark County, ID
H6	$EF\_teeth_{Hg,a}$ $= Material_a$ $\times ContainHg_a$ $\times HgProportion$ $\times 0.0022 \frac{lb}{g}$	$2.96\ g\ mercury\ \times 75\ \%\ with\ mercury\ \times$ $45\%\ of\ fillings\ are\ mercury\ \times 0.0022$	0.0022 lbs. mercury per cremation
H7	$Emissions_{p,c}$ $= Cremation_{tons_c} \times EF_p$	N/A	Completed in equation H9 for mercury
H8	$Emissions_{teeth_{Hg,c}}$ $= \sum_{a=1}^{A} Cremations_{c,a}$ $\times EF_{teeth_{Hg,a}}$	$4\ cremations \times 0.0022\ lbs\ per\ cremation$	0.0088 lbs. mercury from teeth in 85+ age group in Clark County, ID
H9	$Emissions_{tissue_{Hg,c}}$ $= Cremations_{tons_c}$ $\times EF_{tissue_{Hg}}$	$0.3165\ tons\ cremations\ \times\ 0.0015\ lbs\ per\ ton$	0.00047 lbs. mercury from tissues in 85+ age group in Clark County, ID
H10	$Emissions_{Hg,c}$ $= Emissions_{teeth_{Hg,c}}$ $+ Emissions_{tissue_{Hg,c}}$	$0.0088\ lbs\ from\ teeth + 0,00047\ lbs.\ from\ tissues$	0.0093 lbs. mercury from cremation of 85+ age group in Clark County ID
A1	$Cremations_{c/d,US}$ $= Ratio_{c/d}$ $\times (Cremations\_pets_{US}$ $+ Cremations\_shelter_{US})$	$52.5\%\ of\ cats\ in\ pet\ population$ $\times (1,840,965\ pet\ cremations$ $+ 2,700,000\ shelter\ animal\ cremations)$	2,384,006 cremated cats in the U.S.

Eq. #	Equation	Values for Clark County, ID	Result
A2	$Cremations_{tons\frac{c}{d}}$ $= Cremations_{\frac{c}{d}} \times Weight_{\frac{c}{d}}$ $\times \frac{1\ ton}{2,000\ pounds}$	$2,384,006\ cremated\ cats\ \times 9.9\ lbs\ per\ cat$ $\div 2000\ lbs\ per\ ton$	11,800 tons of cremated cats in the U.S.
A3	$Cremations_{tons\ animal}$ $= Cremations_{tons\ c}$ $+ Cremations_{tons\ d}$	N/A	Cremations of dogs are not estimated in this sample calculation
A4	$Cremations\_tons_{animal,c}$ $= Cremations\_tons_{animal,US}$ $\times \frac{Pop_c}{Pop_{US}}$	$11,800\ cremated\ cats\ \times \frac{873\ people\ in\ Clark}{329,164,967\ people\ in\ US}$	0.03 tons cats cremated in Clark County, ID
A5	$Emissions_{p,c}$ $= Cremation_{tons\ c} \times EF_p$	$0.03\ \times 0.0015\ lbs\ per\ ton$	0.000045 lbs. mercury emissions from cremation of cats in Clark County, ID

4.18.3.7 *Updates in 2017 methodology*

There is one slight change from the 2014 methodology for the estimation of emissions from human cremation. In the 2014 methodology, the emissions factor for mercury emissions from cremation of blood and tissues was in units of per cremation. In the 2017 methodology, EPA uses the same emissions factor, but converted it to a per-ton emissions factor. The per-ton emissions factor is multiplied by the number of tons cremated in each county.

The most significant difference from the 2014 methodology for the estimation of emissions from animal cremation is that EPA now estimates emissions of pollutants other than mercury. In the 2017 methodology, EPA uses the emissions factors for cremation of human blood and tissues to estimate emissions from animals.

4.18.3.8 *Puerto Rico and U.S. Virgin Islands*

Since insufficient data exists to calculate emissions from human cremation for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emissions factor. For each Puerto Rico and US Virgin Island county, the tons per capita emissions factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

Emissions from animal cremation are based on county population; therefore, the emissions from animal cremation in Puerto Rico and the Virgin Islands are calculated using the method described for the rest of the counties.

4.18.4 References

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12. Lundquist, J.H. 2012. Mercury Emissions from the Cremation of Human Remains. Bay Area Air Quality Management District.
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4.19 Miscellaneous Non-Industrial NEC: Residential Charcoal Grilling

4.19.1 Sector description

Residential barbecue grilling emissions include emissions from the burning of charcoal (including the use of lighter fluid) and emissions from all types of meat cooked on charcoal, gas, and electric grills. Combustion emissions from gas barbecue grills are not included. This source category (SCC=2810025000) is one of many components in the Miscellaneous Non-Industrial sector. The SCC description is "Miscellaneous Area Sources; Other Combustion; Charcoal Grilling - Residential (see 23-02-002-xxx for Commercial); Total".

4.19.2 Sources of data

This source category includes a mix of S/L/T data, where provided, and EPA-generated emissions. The agencies listed in Table 4-142 submitted emissions for residential charcoal grilling. Agencies not listed uses EPA estimates.

Table 4-142: Agencies reporting Residential Charcoal Grilling emissions

Region	Agency	S/L/T
1	Massachusetts Department of Environmental Protection	State
4	Memphis and Shelby County Health Department - Pollution Control	Local

Region	Agency	S/L/T
4	Metro Public Health of Nashville/Davidson County	Local
5	Illinois Environmental Protection Agency	State
6	Texas Commission on Environmental Quality	State
9	Maricopa County Air Quality Department	Local
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.19.3 EPA-developed emissions

Emissions from this source category include criteria pollutants, (CO, NOx, PM10-PRI, PM25-PRI and VOC) and HAP emissions from residential barbecue grilling. Sources of emissions include burning charcoal and using lighter fluid in charcoal grills, and cooking meat on charcoal, gas, and electric grills. To perform the relevant calculations data are needed on activities and emissions factors for those activities. Activity data includes information about total charcoal sold, total meat cooked, and total amount of lighter fluid used.

4.19.3.1 *Activity data*

There are three types of activity data for this source category: (1) amount of meat cooked on charcoal grills; (2) amount of meat cooked on gas and electric grills; and (3) number of grilling events using lighter fluid. Each of these types of activity data is discussed in the subsections below.

Meat cooked on charcoal grills

This source category includes emissions from the amount of charcoal burned and the amount of meat cooked.

The total amount of charcoal sold in the United States is based on data from the Heath, Patio, and Barbecue Association (HPBA) [ref 1], which is distributed to each county based on the proportion of 1-4 unit homes in each county, from the U.S. Census Bureau [ref 2]. This distribution procedure is discussed in more detail in Section 4.19.3.2. We assume that all charcoal sold is burned.

The amount of meat cooked is determined based on assumptions about the amount of meat cooked per pound of charcoal sold. This calculation assumes 17.64 charcoal briquettes per pound of charcoal sold [ref 3] and 0.033 pounds of meat cooked per briquette [ref 4]. These numbers are multiplied together to calculate a value of 0.588 pounds of meat cooked per pound of charcoal sold.

$$0.588 \; lb.\,meat\,cooked\,per\,lb.\,charcoal\,sold \qquad\qquad (1)$$
$$= 17.64 \; briquettes\,per\,lb.\,charcoal \times 0.033 \; lb.\,meat\,cooked\,per\,briquette$$

Meat cooked on gas and electric grills

The amount of meat cooked on gas grills is calculated based on assumptions about the ratio of gas grilling to charcoal grilling, including that charcoal grills represent 41% of grills and gas/electric grills represent 59% [ref 4], and that charcoal grills are used 27 times per year and gas/electric grills are used 45 times per year [ref 5]. This calculation results in an estimated ratio of 2.398, meaning that for every pound of meat cooked on a charcoal grill an additional 2.398 pounds of meat are cooked on a gas or electric grill.

$$2.398 \; gas \; or \; electric \; grilling \; ratio$$
$$= \frac{45 \; times \; per \; year \, (gas \; or \; electric) \times 59\% \; gas \; or \; electric \; grills}{27 \; times \; per \; year \, (charocal) \times 41\% \; charcoal \; grills} \quad (2)$$

The values from equations 1 and 2 are used with national data on the amount of charcoal sold from the HPBA [ref 1] to estimate the total amount of meat cooked on charcoal, gas, and electric grills. This national charcoal sales data is distributed to the counties based on the number of homes in each county, as described in the following section.

Grilling events using lighter fluid

This calculation is based on the percentage of homes that have a grill (80%) [ref 6], the percentage of grills that are charcoal grills (41%) [ref 5], the percentage of charcoal grills that use lighter fluid (37%) [ref 7], and the number of times per year that charcoal grills are used (27) [ref 6]. This results in a value of approximately 3.28 grilling events per household per year where lighter fluid is used.

$$3.28 \; grilling \; events \; with \; lighter \; fluid$$
$$= 80\% \; homes \; with \; a \; grill \times 41\% \; grills \; that \; are \; charcoal$$
$$\times \; 37\% \; charcoal \; grills \; that \; use \; lighter \; fluid \quad (3)$$
$$\times \; 27 \; times \; per \; year \; charcoal \; grills \; are \; used$$

This number is multiplied by the number of occupied homes in each county to determine the total number of grilling events in each county where lighter fluid is used. Seen Section 4.19.3.2 on allocation procedure for information on calculating the number of occupied 1-4-unit households.

$$n_{LF,c} = H_{c,o} \times 3.28 \quad (4)$$

Where:

$n_{LF.c}$	=	Number of grilling events in county c where lighter fluid is used
$H_{c,o}$	=	Total occupied households of 1-4 units in county c
3.28	=	Number of grilling events with lighter fluid per home, from equation 3

4.19.3.2 *Allocation procedure*

National data on the amount of charcoal sold is distributed to the counties based on the proportion of occupied 1-4-unit homes in each county. It is assumed that households in larger apartment buildings would not have the space to have or use an outdoor grill. The data on the number of occupied 1-4 unit homes in each county is from the U.S. Census Bureau American Community Survey [ref 2]. Occupied households between 1 and 4 units are estimated using the sum of total 1-4-unit households and the fraction of total occupied households in the US.

$$H_{c,o} = \sum_{units=1}^{units=4} H_{c,t} \times \frac{H_{US,o}}{H_{US,t}} \quad (5)$$

$$HR_c = \frac{H_{c,o}}{\sum_c H_o} \quad (6)$$

Where:

$H_{c,o}$	=	Total occupied households of 1-4 units in county c

$H_{c,t}$ = Total households in county c
$H_{US,o}$ = Total occupied households in the United States
$H_{US,t}$ = Total households in the United States
HR_c = Ratio of occupied households of 1-4 units in county *c* to total households of 1-4 units in United States

The national-level data on charcoal sales is distributed to the counties using the ratio from equation 6.

$$Charcoal_c = HR_c \times Charcoal_{US} \times 2000 \; lbs. \, per \, ton \qquad (7)$$

Where:
$Charcoal_c$ = Amount of charcoal sold in county *c*, in pounds
HR_c = Ratio of households of 1-4 units in county *c* to total households of 1-4 units in United States
$Charcoal_{US}$ = Amount of charcoal sold in the United States, in tons

The amount of charcoal sold in each county (from equation 7) is multiplied by the amount of meat cooked per pound of charcoal (from equation 1) to estimate the amount of meat cooked on charcoal grills in each county.

$$Meat_{charcoal,c} = Charcoal_c \times 0.588 \qquad (8)$$

Where:
$Meat_{charcoal,c}$ = Amount of meat cooked on charcoal grills in county *c*, in pounds
$Charcoal_c$ = Amount of charcoal sold in county *c*, in pounds
0.588 = Pounds of meat cooked per pound of charcoal, from equation 1

The amount of meat cooked on charcoal grills is used with the ratio from equation 2 to estimate the amount of meat cooked on gas or electric grills.

$$Meat_{gas/elec,c} = Meat_{charcoal,c} \times 2.398 \qquad (9)$$

Where:
$Meat_{gas/elec,c}$ = Amount of meat cooked on gas or electric grills in county *c*, in pounds
$Meat_{charcoal,c}$ = Amount of meat cooked on charcoal grills in county *c*, in pounds
2.398 = Ratio of meat cooked on gas or electric grills to charcoal grills, from equation 2

The amount of meat cooked on charcoal and on gas or electric grills is added together to determine the total amount of meat cooked on grills in each county.

$$Meat_{t,c} = Meat_{gas/elec,c} + Meat_{charcoal,c} \qquad (10)$$

Where:
$Meat_{t,c}$ = Total amount of meat cooked on grills in county *c*, in pounds
$Meat_{gas/elec,c}$ = Amount of meat cooked on gas or electric grills in county *c*, in pounds
$Meat_{charcoal,c}$ = Amount of meat cooked on charcoal grills in county *c*, in pounds

4.19.3.3 *Emission factors*

The emissions factors are shown in Table 4-143, including the actual emissions factor used in the calculations, and the original emissions factor from the reference, if it is different from the actual factor. The emissions factors for CO, NOX, PM10-PRI, PM25-PRI, and VOC are from EPA's report, *Emissions from Street Vendor Cooking Devices (Charcoal Grilling)* [ref 8]. There is also a separate emissions factor for VOC from lighter fluid, from the South Coast Air Quality Management District, Rule 1174 [ref 9]. The HAP emission factors are speciation factors from the EPA SPECIATE database [ref 10], which are speciation factors for charbroiling meat.

Table 4-143: Emissions Factors for Residential Grilling (2810025000)

Pollutant	Pollutant Code	Emissions Factor (original)	Emissions Factor Units (original)	Emissions Factor (actual)	Emissions Factor Units (actual)	Emissions Factor Reference
CO	CO	162.97a		325.93		
NOX	NOX	3.37a		6.74		
PM10-PRI	PM10-PRI	9.10a	g/kg meat	18.19	lbs./ton meat	6, Table E-2
PM25-PRI	PM25-PRI	n/a		14.56b		
VOC	VOC	0.94a		1.88		
				0.02	lbs./grilling event	6, section (c)(1)
1,3-Butadiene	106990			1.04E-02		
2,2,4-Trimethylpentane	540841			1.12E-03		
Acetaldehyde	75070			1.09E-01		
Anthracene	120127			1.09E-05		
Benzene	71432			8.26E-03		
Ethyl Benzene	100414			1.09E-03		
Fluoranthene	206440			3.98E-05		
Formaldehyde	50000			1.38E-01	lbs./lb. VOC	6
Hexane	110543			4.38E-03		
m-Xylene	108383			5.97E-04		
Naphthalene	91203			8.94E-04		
o-Xylene	95476			1.09E-03		
Phenanthrene	85018			1.20E-04		
Propionaldehyde	123386			5.01E-02		
p-Xylene	106423			5.97E-04		
Pyrene	129000			5.67E-05		
Toluene	108883			3.98E-03		

a. Based on average of test numbers MC1, MC2, MC3, MC6, MC7, and MC8 from the table showing emissions factors for emissions per kg meat cooked. See Table E-2 in Reference 9.
b. PM25-PRI emission factor is based on assumption that PM25-PRI = PM10-PRI × 0.8.

4.19.3.4 *Controls*

There are no controls assumed for this category.

4.19.3.5 *Emissions*

The emissions of PM10-PRI, PM25-PRI, and VOC for residential barbecue grilling are calculated by multiplying the amount of meat grilled in each county (from equation 10) by the emissions factors from Table 4-143.

$$E_{p,c} = \frac{Meat_{t,c}}{2000 \ lbs. \ per \ ton} \times EF_{p,meat} \qquad (11)$$

Where:

    $E_{p,c}$ =   Emissions of pollutant p from grilling meat in county c, in pounds

    $Meat_{t,c}$ =   Total amount of meat cooked on grills in county c, in pounds

    $EF_{p,meat}$ =   Emissions factor for pollutant p from grilling meat

It is assumed that CO and NOX emissions are from charcoal combustion, and there are no significant emissions of these pollutants from gas or electric grills. Therefore, to estimate CO and NOX emissions, the emissions factors for these pollutants are multiplied by the amount of meat cooked on charcoal (from equation 8), rather than the total amount of meat cooked.

$$E_{CO/NOX,c} = \frac{Meat_{charcoal,c}}{2000 \ lbs. \ per \ ton} \times EF_{CO/NOX} \qquad (11a)$$

Where:

    $E_{CO/NOX,c}$ = Emissions of pollutant CO or NOX from grilling meat in county c, in pounds

    $Meat_{charcoal,c}$ = Total amount of meat cooked on charcoal grills in county c, in pounds

    $EF_{CO/NOX}$ = Emissions factor for CO or NOX from grilling meat

For VOC, there is a separate calculation to account for emissions from lighter fluid use, in which the number of grilling events per year where lighter fluid is used (from equation 4) is multiplied by an emissions factor of 0.02 lbs. VOC/grilling event (Table 4-143).

$$E_{VOC,LF,c} = n_{LF,c} \times EF_{VOC,LF} \qquad (12)$$

Where:

    $E_{VOC,LF,c}$ = Emissions of VOC from lighter fluid use in county c, in pounds

    $n_{LF,c}$ = Number of grilling events in county c where lighter fluid is used

    $EF_{VOC,LF}$ = Emissions factor for VOC from lighter fluid use

These VOC emissions are added to the VOC emissions from grilling meat to determine the total VOC emissions from residential grilling.

$$E_{VOC,c} = E_{VOC,LF,c} + E_{VOC,meat,c} \qquad (13)$$

Where:

    $E_{VOC,c}$ = Total emissions of VOC from residential grilling in county c, in pounds

    $E_{VOC,LF,c}$ =   Emissions of VOC from lighter fluid use in county c, in pounds

    $E_{VOC,meat,c}$ = Emissions of VOC from grilling meat in county c, in pounds

Emissions of HAPs are calculated by multiplying the total VOC emissions by the speciation factors in Table 4-143.

$$E_{h,c} = E_{VOC,c} \times EF_h \qquad (14)$$

Where:

$E_{h,c}$ = Emissions of HAP h in county c, in pounds
$E_{VOC,c}$ = Total emissions of VOC from residential grilling in county c, in pounds
EF_h = Emissions factor for HAP h

4.19.3.6 *Example calculations*

Sample calculations for estimating VOC emissions from residential grilling in Ada County, ID, are shown in Table 4-144. Note that equations 1, 2, and 3 result in constant values for each county, so these calculations are not repeated here. See Section 4.19.3.1 for more information about these equations.

Table 4-144: Sample calculations for VOC emissions from residential grilling in Ada County, Idaho

Eq. #	Equation	Values for Ada County, ID	Result
5	$H_{c,o} = \sum\limits_{units=1}^{units=4} H_{c,t} \times \dfrac{H_{US,o}}{H_{US,t}}$	138,929 1 − 4 unit homes in Ada County × (154,408 occupied homes in Ada County) /(162,766 Total homes in Ada County)	131,795 occupied homes in Ada County, ID
4	$n_{LF,c} = H_{c,o} \times 3.28$	131,795 occupied homes in Ada County × 3.28 grilling events per home	432,287 grilling events in Ada County, ID
6	$HR_c = \dfrac{H_{c,o}}{\sum_c H_o}$	$\dfrac{131{,}795 \ occupied \ homes \ in \ Ada \ County}{89{,}010{,}502 \ homes \ in \ U.S.}$	0.00148 ratio of homes in Ada County, ID
7	$Charcoal_c = HR_c \times Charcoal_{US} \times 2000 \ lbs. per \ ton$	0.00148 × 890,910 tons charcoal × 2000 lbs. per ton	2,638,284.3 pounds charcoal in Ada County, ID
8	$Meat_{charcoal,c} = Charcoal_c \times 0.588$	2,638,284.3 lbs. charcoal × 0.588	1,551,311 lbs. meat grilled on charcoal grills in Ada County, ID
9	$Meat_{gas/elec,c} = Meat_{charcoal,c} \times 2.398$	1,551,311 lbs. meat × 2.398	3,720,044 lbs. meat grilled on gas or electric grills in Ada County, ID
10	$Meat_{t,c} = Meat_{gas/elec,c} + Meat_{charcoal,c}$	1,551,311 lbs. meat + 3,720,044 lbs. meat	5,271,355 lbs. meat grilled in Ada County, ID
11	$E_{p,c} = \dfrac{Meat_{t,c}}{2000 \ lbs. per \ ton} \times EF_{p,meat}$	$\dfrac{5{,}271{,}355 \ lbs. meat}{2000 \ lbs. per \ ton} \times 1.88 \ lbs. per \ ton$	4,955 lbs. VOC from grilling meat in Ada County, ID
12	$E_{VOC,LF,c} = n_{LF,c} \times EF_{VOC,LF}$	432,287 grilling events × 0.02 lb. per grilling event	8,645 lbs. VOC from lighter fluid in Ada County, ID

Eq. #	Equation	Values for Ada County, ID	Result
13	$E_{VOC,c} = E_{VOC,LF,c} + E_{VOC,meat,c}$	$4{,}955\ lbs.VOC + 8{,}645\ lbs.VOC$	13,601 lbs. VOC from residential grilling in Ada County, ID

4.19.3.7 *Changes from the 2014 methodology*

There is one change from the methodology used to estimate the 2014 v2 NEI. In 2014, emissions of CO and NOX were estimated by multiplying an emission factor by the amount of charcoal burned. The EPA reference reports emission factors both in terms of meat and charcoal grilled and in terms of just meat grilled [ref 8]. In order to maintain consistency with the emissions of other criteria pollutants, the 2017 methodology will use the emission factors for meat grilled. As a result, the CO and NOX emissions are estimated by multiplying the amount of meat grilled (rather than the amount of charcoal burned) by the emission factor. EPA maintains the assumption that CO and NOX are generated only by charcoal grills.

4.19.3.8 *Puerto Rico and U.S. Virgin Islands*

Emissions from Puerto Rico are calculated using the same method described above. Insufficient data exists to calculate emissions for the counties in the US Virgin Islands, so emissions are based on a proxy county in Florida: 12087, Monroe County. The total emissions in lbs. for this Florida County is divided by its population creating a lbs.-per-capita emission factor. For each US Virgin Island County, the lbs. per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which serves as the activity data. In these cases, the throughput (activity data) unit and the emissions factor denominator unit are "EACH".

4.19.4 References

1. Hearth, Patio and Barbecue Association (HPBA), Statistics/Barbecue Statistics/Charcoal Shipments for 2013, accessed April 2015.
2. U.S. Census Bureau. Community Facts, Housing, Selected Housing Characteristics, American Community Survey 5-Year Estimates, 2017.
3. Kingsford email on the weight of their charcoal briquettes 4/11/2015.
4. Hearth, Patio and Barbecue Association (HPBA), Statistics, BBQ Grill Shipments, accessed April 2015.
5. Hearth, Patio & Barbecue Association (HPBA), 2011 State of the Barbecue Industry Report, accessed April 2015.
6. Hearth, Patio & Barbecue Association (HPBA), 2014 State of the Barbecue Industry Report.
7. Hearth, Patio and Barbecue Association (HPBA) 3/23/2015 email from Jessica Boothe on how many people with charcoal grills use lighter fluid.
8. U.S. Environmental Protection Agency. 1999. Emissions from Street Vendor Cooking Devices (Charcoal Grilling), EPA/600/SR-99/048.
9. South Coast Air Quality Management District. October 5, 1990. "Rule 1174. "Control of Volatile Organic Compound Emissions from the Ignition of Barbecue Charcoal" accessed May 2015.
10. U.S. Environmental Protection Agency. 2014. SPECIATE Database, version 4.4. Speciation profile 4553, meat charbroiling. Speciation profile was adjusted to be based on VOC, rather than total organic gases (TOG), by removing methane from the profile.

4.20 Miscellaneous Non-Industrial NEC: Portable Gas Cans

4.20.1 Source category description

There are several sources of emissions associated with portable fuel containers (PFC) used for storage of gasoline. These sources include vapor displacement and spillage while refueling the gas can at the pump, spillage during transport, permeation and evaporation from the gas can during transport and storage, and vapor displacement and spillage while refueling equipment. Vapor displacement and spillage while refueling nonroad equipment from PFCs are included in the nonroad inventory. This section describes how other types of PFC emissions are accounted for in the NEI. This source category is one of many components in the Miscellaneous Non-industrial sector.

Table 4-145 shows the SCCs covered by this source category. The SCC level 3 and 4 descriptions are also provided. The leading SCC description is "Storage and Transport; Petroleum Product Storage" for all SCCs.

Table 4-145: PFC SCCs in the 2017 NEI

SCC	Description
2501011011	Residential Portable Gas Cans; Permeation
2501011012	Residential Portable Gas Cans; Evaporation (includes Diurnal losses)
2501011013	Residential Portable Gas Cans; Spillage During Transport
2501011014	Residential Portable Gas Cans; Refilling at the Pump - Vapor Displacement
2501011015	Residential Portable Gas Cans; Refilling at the Pump - Spillage
2501012011	Commercial Portable Gas Cans; Permeation
2501012012	Commercial Portable Gas Cans; Evaporation (includes Diurnal losses)
2501012013	Commercial Portable Gas Cans; Spillage During Transport
2501012014	Commercial Portable Gas Cans; Refilling at the Pump - Vapor Displacement
2501012015	Commercial Portable Gas Cans; Refilling at the Pump - Spillage

4.20.2 Sources of data

The agencies listed in Table 4-146 submitted PFC emissions; agencies not listed used EPA estimates for all PFC sources.

Table 4-146: Agencies reporting PFC emissions

Region	Agency	S/L/T
2	New Jersey Department of Environment Protection	State
2	New York State Department of Environmental Conservation	State
3	Delaware Department of Natural Resources and Environmental Control	State
3	Maryland Department of the Environment	State
5	Illinois Environmental Protection Agency	State
9	Maricopa County Air Quality Department	Local
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.20.3 EPA-developed emissions

For the 2017 NEI, where states did not submit their own data, we relied on an inventory developed for the Tier 3 motor vehicle and fuel standards rule [ref 1]. This inventory assumed all fuel dispensed from PFCs was E10, with an average RVP of 8.7 psi. Use of ethanol in gasoline fuels can increase evaporative emissions from PFCs, relative to E0, for several reasons. First, if E10 fuels have higher volatility than corresponding E0 fuels, that can increase evaporation and vapor displacement. Second, ethanol in gasoline increases permeation of fuel through gas can materials. Finally, the lower energy content of ethanol fuels leads to more frequent refueling, and, thus, greater emissions from spillage and displacement while filling the gas can at the pump.

The use of ethanol also changes the mix of hydrocarbons in the evaporated fuel. In particular, it can change the fraction of several hazardous air pollutants as well as ethanol.

As part of the 2007 regulation controlling emissions of hazardous pollutants from mobile sources (MSAT2 rule), EPA promulgated requirements to control VOC emissions from gas cans. The methodology we used to develop emission inventories for gas cans was developed for that regulation and is described in the regulatory impact analysis for the rule and in an accompanying technical support document [ref 2, ref 3]. However, while that regulation included estimates for spillage emissions occur when refueling equipment, most of these emissions is already included in the nonroad equipment inventory. Thus, we did not include these emissions in the PFC inventory for the NEI. Vapor displacement for nonroad equipment container refueling was also subtracted from vapor displacement in the PFC inventory to avoid double counting these emissions.

4.20.3.1 *VOC allocation*

For the NEI, emissions had to be separated into commercial and residential fuel container emissions. Total state level PFC emissions were allocated to the categories by using national level residential and commercial emission splits from the MSAT2 rule for each of the categories using the following equations:

$$E_{residentid,XXXX,YY} = E \times \left(\frac{\mathrm{Re}\,s}{\mathrm{Re}\,s + Com} \right) \tag{1}$$

$$E_{commercial,XXXX,YY} = E \times \left(\frac{Com}{\mathrm{Re}\,s + Com} \right) \tag{2}$$

where E was the emissions of the category being split, XXXX was year, YY was state, and Res and Com were the national residential and commercial PFC emissions.

Permeation and evaporation were also separated as follows:

$$E_{AAA,XXXX,YY,perm} = E_{AAA,XXXX,YY,perm\&evap} \times 0.3387 \tag{3}$$

$$E_{AAA,XXXX,YY,evap} = E_{AAA,XXXX,YY,perm\&evap} \times (1 - 0.3387) \tag{4}$$

The fraction 0.3387 represents the fraction of combined permeation and evaporative emissions attributable to permeation, based on data from the California Air Resources Board.

4.20.3.2 *VOC emissions*

Permeation and evaporation

These emissions are represented by the following SCCs:

- 2501011011 – Residential Portable Fuel Containers: Permeation
- 2501011012 – Residential Portable Fuel Containers: Evaporation
- 2501012011 – Commercial Portable Fuel Containers: Permeation
- 2501012012 – Commercial Portable Fuel Containers: Evaporation

Emissions from these SCCs are impacted by 2007 MSAT rule standards limiting evaporation and permeation emissions from these containers to 0.3 grams of hydrocarbons per day [ref 4]. Inventory estimates developed for calendar year 2018 in EPA's Tier 3 vehicle rule modeling platform [ref 5] reflect the impact of these standards, as well as impacts of RVP and oxygenate use. These Tier 3 inventories were interpolated from earlier 2015 and 2020 MSAT2 rule inventories and assumed 100% E10. They were judged to be reasonable approximations of the 2014 inventory, although increases in activity between 2014 and 2018 means emissions will be overestimated in the 2014 NEI.

Vapor Displacement

Vapor displacement emissions occur while refueling containers at the pump. These emissions are represented by the following SCCs:

- 2501011014 – Residential Portable Fuel Containers: Refilling at the Pump: Vapor Displacement
- 2501012014 – Commercial Portable Fuel Containers: Refilling at the Pump: Vapor Displacement

These emissions are not impacted by MSAT2 rule standards but are impacted by RVP and oxygenate use. Inventory estimates developed for calendar year 2018 in EPA's Tier 3 vehicle rule modeling platform were judged to be reasonable approximations of the 2014 inventory, although increases in activity between 2014 and 2018 means emissions will be overestimated in the 2014 NEI.

Spillage

Spillage occurs during transport and refilling at the pump. These emissions are represented by the following SCCs:

- 2501011013 – Residential Portable Fuel Containers: Spillage During Transport
- 2501011015 -- Residential Portable Fuel Containers: Refilling at the Pump: Spillage
- 2501012013 – Commercial Portable Fuel Containers: Spillage During Transport
- 2501012015 -- Commercial Portable Fuel Containers: Refilling at the Pump: Spillage

These emissions are not impacted by MSAT2 standards or RVP. However, composition of the emissions is impacted by oxygenate. VOC emissions for these SCCs are carried forward from 2011.

4.20.3.3 *Hazardous air pollutants*

Hazardous air pollutants found in liquid gasoline will be present as a component of VOC emissions. These MSATs include benzene, ethyl benzene, toluene, hexane, xylenes, 2,2,4-trimethylpentane, and naphthalene. For vapor displacement emissions of benzene and naphthalene, toxic to VOC ratios were obtained from headspace vapor

profiles from EPAct test fuels [ref 6]. For permeation emissions of these pollutants, vehicle permeation speciation data from Coordinating Research Council (CRC) technical reports E-77-2b and E-77-2c were used [ref 7, ref 8]. We relied on three-day diurnal profiles from the CRC data. For evaporative emissions resulting from changes in ambient temperatures, speciation data from the Auto/Oil program were used for E0 and E10 [ref 9]. Table 4-147 lists the toxic to VOC ratios for each type of PFC emission.

Table 4-147: Toxic to VOC ratios for benzene and naphthalene from PFCs

Pollutant	Process	Speciation Surrogate	E10
Benzene	Vapor Displacement	Vehicle Headspace	0.0087
	Permeation	Vehicle Permeation	0.0227
	Evaporation	Vehicle Evap	0.0340
Naphthalene	Vapor Displacement	Vehicle Headspace	0.0000
	Permeation	Vehicle Permeation	0.0004
	Evaporation	Vehicle Evap	0.0004

Emissions of other air toxics for permeation, evaporation, and vapor displacement were all estimated from the EPAct headspace vapor displacement profile for E10 (SPECIATE profile 8870). Toxic to VOC ratios are provided in Table 4-148.

Table 4-148: **Toxic to VOC ratios for Other HAPs (Vapor Displacement, Permeation, Spillage and Evaporation)**

Pollutant	Toxic to VOC Ratio
Ethylbenzene	0.0068
Hexane	0.0616
Toluene	0.0521
Xylenes (o,m,p)	0.0300
2,2,4-Trimethylpentane	0.0540

4.20.4 References

1. U. S. EPA. 2014. "Development of Air Quality Reference Case Upstream and Portable Fuel Container Inventories for the Tier 3 Final Rule." Memorandum from Rich Cook, Margaret Zawacki and Zoltan Jung to Docket, February 25, 2014, Docket No. EPA-HQ-OAR-2011-0135.
2. U. S. EPA. 2007. Final Regulatory Impact Analysis: Control of Hazardous Air Pollutants from Mobile Sources; EPA420-R-07-002; Office of Transportation and Air Quality, Ann Arbor, MI.
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5. U.S. EPA. 2014. Emissions Modeling Technical Support Document: Tier 3 Motor Vehicle and Emission and Fuel Standards. Office of Air Quality Planning and Standards, Research Triangle Park, NC, Report No. EPA-454/R-13-003, February 2014.

6. U. S. EPA. 2011. [Hydrocarbon Composition of Gasoline Vapor Emissions from Enclosed Fuel Tanks](). Office of Research and Development and Office of Transportation and Air Quality. Report No. EPA-420-R-11-018. EPA Docket EPA-HQ-OAR-2011-0135.
7. U. S. EPA. 2010. [Evaporative Emissions from In-Use Vehicles: Test Fleet Expansion (CRC E-77-2b)](). Prepared by Harold Haskew and Associates for Assessment and Standards Division, Office of Transportation and Air Quality, October, 2010.
8. Coordinating Research Council. 2010. [Study to Determine Evaporative Emission Breakdown, Including Permeation Effects and Diurnal Emissions, Using E20 Fuels on Aging Enhanced Evaporative Emissions Certified Vehicles](). Report No. E-77-2c.
9. Auto/Oil Air Quality Improvement Research Program. 1996. Phase I and II Test Data. Prepared by Systems Applications International, Inc.

4.21 Mobile – Commercial Marine Vessels

The 2017 NEI includes emissions from commercial marine vessel (CMV) activity in the 50 states, Puerto Rico, and US Virgin Isles, out to 200 nautical miles from the US coastline.

4.21.1 Sector description

The CMV sector includes boats (excluding pleasure craft covered by the MOVES/NONROAD model) and ships used either directly or indirectly in the conduct of commerce or military activity. Most vessels in this category are powered by diesel engines that are either fueled with distillate or residual fuel oil blends. In previous NEIs, we assumed that Category 3 (C3) vessels primarily used residual blends while Category 1 and 2 (C1 and C2) vessels typically used distillate fuels. For the 2017 NEI, SCCs and fuel details, including emission factors, have been updated.

The C3 inventory includes vessels which use C3 engines for propulsion. C3 engines are defined as having displacement above 30 liters per cylinder. The resulting inventory includes emissions from both propulsion and auxiliary engines used on these vessels, as well as those on gas and steam turbine vessels. Geographically, the inventories include port and interport emissions that occur within the area that extends 200 nautical miles (nm) from the official U.S. shoreline, which is roughly equivalent to the border of the U.S. Exclusive Economic Zone. Only some of these emissions are allocated to states based on official state boundaries that typically extend 3 miles offshore.

The C1 and C2 vessels tend to be smaller ships that operate closer to shore, and along inland and intercoastal waterways. Naval vessels are not included in this inventory, though Coast Guard vessels are included as part of the C1 and C2 vessels.

The CMV source category does not include recreational marine vessels, which are generally less than 100 feet in length, most being less than 30 feet, and powered by either inboard or outboard. These emissions are included in those calculated by the MOVES model; they reside in the nonroad data category and EIS "Mobile - Non-Road Equipment" sectors of the 2017 NEI.

The 2017 NEI CMV estimates no longer employ the emissions type (M=maneuvering, H=hotelling, C=cruise, Z=reduced speed zone) used in previous NEIs. Also, for 2017, new SCCs were created for CMV as noted in Table 4-149 below, to replace SCCs, shown in Table 4-150, used in previous NEI versions. Emission factors vary by SCC.

In addition, the 2017 NEI does not utilize shape files in the same manner as earlier NEIs. Although the detailed 2017 files used for air quality modeling have 1-hour emissions in detailed spatial grids, the NEI estimate are annual and in over-water-only shape file codes for port estimates and in county FIPs codes for underway

emissions. The port shapes do not cross counties and can be readily summed to individual port or to county. Shape files are posted on the [2017 NEI page](#) under the link [Commercial Marine Vessel GIS Shape Files (port and underway, current and retired)](#).

Table 4-149: New Commercial Marine Vessel SCCs and emission types in EPA estimates

SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four
2280002101	Mobile Sources	Marine Vessels, Commercial	Diesel	C1C2 Port emissions: Main Engine
2280002102	Mobile Sources	Marine Vessels, Commercial	Diesel	C1C2 Port emissions: Auxiliary Engine
2280002201	Mobile Sources	Marine Vessels, Commercial	Diesel	C1C2 Underway emissions: Main Engine
2280002202	Mobile Sources	Marine Vessels, Commercial	Diesel	C1C2 Underway emissions: Auxiliary Engine
2280002103	Mobile Sources	Marine Vessels, Commercial	Diesel	C3 Port emissions: Main Engine
2280002104	Mobile Sources	Marine Vessels, Commercial	Diesel	C3 Port emissions: Auxiliary Engine
2280002203	Mobile Sources	Marine Vessels, Commercial	Diesel	C3 Underway emissions: Main Engine
2280002204	Mobile Sources	Marine Vessels, Commercial	Diesel	C3 Underway emissions: Auxiliary Engine
2280003103	Mobile Sources	Marine Vessels, Commercial	Residual	C3 Port emissions: Main Engine
2280003104	Mobile Sources	Marine Vessels, Commercial	Residual	C3 Port emissions: Auxiliary Engine
2280003203	Mobile Sources	Marine Vessels, Commercial	Residual	C3 Underway emissions: Main Engine
2280003204	Mobile Sources	Marine Vessels, Commercial	Residual	C3 Underway emissions: Auxiliary Engine

Table 4-150: Retired Commerical Marine Vessel SCCs

SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four
2280002100	Mobile Sources	Marine Vessels, Commercial	Diesel	Port emissions
2280002200	Mobile Sources	Marine Vessels, Commercial	Diesel	Underway emissions
2280003100	Mobile Sources	Marine Vessels, Commercial	Residual	Port emissions
2280003200	Mobile Sources	Marine Vessels, Commercial	Residual	Underway emissions

4.21.2   Sources of data

EPA's CMV estimates use satellite-based automatic identification system (AIS) activity data from the US Coast Guard. The details of these calculation are available in the document "Methodology Documentation for EPA's Commercial Marine Emissions Estimates" on the [2017 NEI Data home page](#).

Five states submitted CMV emissions to EIS (California, Delaware, New Jersey, and Washington). Texas supplied estimates outside the EIS in retired SCCs. However, after review, all agreed to use of EPA's AIS estimates as superior to their submittals.

4.21.3 Quality assurance

The QA procedures on the EPA-developed CMV estimates are detailed in the CMV-specific documentation. Although SLT submittals were reviewed and compared to EPA's, no SLT estimates were used in the 2017 NEI.

4.22 Mobile – Locomotives (Nonpoint)

This section documents (rail) emissions in the nonpoint data category. Refer to Section 3.3 for information on rail yard emissions in the point data category.

4.22.1 Sector description

The locomotive sector includes railroad locomotives powered by diesel-electric engines. A diesel-electric locomotive uses 2-stroke or 4-stroke diesel engines and an alternator or a generator to produce the electricity required to power its traction motors. The locomotive source category is further divided up into categories: Class I line haul, Class II/III line haul, Passenger, Commuter, and Yard. Table 4-151 below indicates locomotive SCCs and whether they are included in EPA estimated emissions. If not in EPA estimates, then all emissions from that SCC that appear in the inventory are from S/L/T agencies.

Table 4-151: Locomotive SCCs, descriptions, and EPA estimation status

SCC	Description	EPA Estimated?	Data Category
2285002006	Mobile Sources Railroad Equipment Diesel Line Haul Locomotives: Class I Operations	Yes – at county-level	Nonpoint
2285002007	Mobile Sources Railroad Equipment Diesel Line Haul Locomotives: Class II / III Operations	Yes – at county-level	Nonpoint
2285002008	Mobile Sources Railroad Equipment Diesel Line Haul Locomotives: Passenger Trains (Amtrak)	Yes – at county-level	Nonpoint
2285002009	Mobile Sources Railroad Equipment Diesel Line Haul Locomotives: Commuter Lines	Yes – at county-level	Nonpoint
2285002010	Railroad Equipment Diesel Yard Locomotives	No	Nonpoint
28500201	Internal Combustion Engines Railroad Equipment Diesel Yard	Yes – as point sources	Point

4.22.2 Sources of data

The locomotives sector includes data from SLT agency-provided emissions data, and an EPA dataset of locomotive emissions. EPA-estimated emissions from select locomotive SCCs as indicated in Table 4-151 above. The agencies listed in Table 4-152 also submitted emissions to locomotive SCCs.

Table 4-152: Submitting SLT agencies with number of pollutants reported for each SCC

SLT dataset	Agency	2285002006	2285002007	2285002008	2285002009	2285002010	28500201
2017CARB	California	7	7	7	7	7	7
2017ILEPA	Illinois				7		
2017Maricopa	Maricopa County, AZ	7	7	7		7	7
2017MDDOE	Maryland	17	17	16	17		17
2017MNPCA	Minnesota						44

SLT dataset	Agency	2285002006	2285002007	2285002008	2285002009	2285002010	28500201
2017NCDAQ	North Carolina			10			
2017TR180	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	43					
2017TR181	Coeur d'Alene Tribe	43	43				
2017TR182	Nez Perce Tribe		43				
2017TR183	Kootenai Tribe of Idaho	43					
2017TXCEQ	Texas	43	43			43	43
2017UTDAQ	Utah	6		6		6	6
2017VADEQ	Virginia			6	6		
2017WADOE	Washington	6		6		6	6
2017WashoeCty	Washoe County, NV	6					5
2017ERTAC_Rail	EPA	52	52	52	52		52

4.22.3   EPA-developed emissions

EPA's 2017 rail emissions were developed by LADCO and the State of Illinois, with support from various other states in a collaborative team called Easter Regional Technical Advisory Committee (ERTAC). ERTAC used confidential line-haul activity data, in millions of gross ton (MGT) route miles per link, from the Federal Railroad Administration (FRA) for 2016. Adjusted rail fuel consumption index values were used to allocate each Class 1 railroad's fuel use to links based on MGT. The Association of American Railroads (AAR) provided ERTAC Rail with locomotive fleet mix information for 2017 for emission factor application. Since the rail link-based activity was confidential, ERTAC provided county-level emissions summaries to EPA.

Rail yard emissions were calculated based on supply fuel use and/or yard switcher counts provided by rail companies. For Class II and III rail lines, location data is available online as part of Bureau of Transportation Statistics' National Transportation Atlas Database (NTAD). Detailed documentation methodology for this work is available in the Specification Sheet: Rail 2017 National Emissions Inventory on the 2017 Supplemental data FTP site.

The ERTAC effort developed emissions for criteria pollutants and greenhouse gases.

4.22.3.1   *Hazardous Air Pollutant Emissions Estimates*

HAP emissions were estimated by applying speciation profiles to the VOC or PM estimates. These "HAP fractions" have been updated for 2017 [ref 1] and are thereby different than those used for 2014 NEI. These profiles are posted in the workbook "2017Rail_HAP_AugmentationProfileAssignmentFactors_20200128.xlsx" on the 2017 Supplemental data FTP site.

HAP estimates were calculated at the yard and link level, after the criteria emissions had been allocated. Where submitting agencies did not supply HAPs, those estimates were also derived via this VOC/PM speciation method.

4.22.4   Quality assurance

EPA and agency-submitted values were compared to find instances where point and nonpoint rail yard SCCs may duplicate. This occurs when agencies submitted nonpoint in the same counties where EPA had point yards. In

this case, where rail yard point locations existed within the county, SLT county-level emissions were reassigned to yards to avoid double counting point and county emissions estimates.

4.22.5 References

1. Reichle, L.J., R. Cook, C.A. Yanca, D.B. Sontag, 2015. Development of organic gas exhaust speciation profiles for nonroad spark-ignition and compression-ignition engines and equipment. Journal of the Air & Waste Management Association, Vol 65, 2015, Issue 10.

4.23 Solvents – Consumer and Commercial Solvent Use: Agricultural Pesticides

There are three sections in this documentation that discuss nonpoint sources of Consumer and Commercial Solvent Use. This section discusses agricultural pesticides; the following section discusses asphalt paving, and the third section discusses all other Solvent sources, including the remaining sources in the Consumer and Commercial Solvent Use sector. The reason these sources are broken up within this EIS sector is because the EPA methodologies for estimating the emissions are different.

4.23.1 Source category description

While Agricultural Pesticide Application is part of Consumer and Commercial Solvents sector, the nature of its methodology is significantly different from most of the other sources in this sector. Pesticides are substances used to control nuisance species and can be classified by targeted pest group: weeds (herbicides), insects (insecticides), fungi (fungicides), and rodents (rodenticides). They can be further described by their chemical characteristics: synthetics, non-synthetics (petroleum products), and inorganics. Different pesticides are made through various combinations of the pest-killing material, also called the active ingredient, and various solvents (which serve as carriers for the active ingredient). Both types of ingredients contain volatile organic compounds (VOC) that may be emitted to the air during application or after application as a result of evaporation [ref 1].

Approximately 68 to 75 percent of pesticides used in the United States are applied to agricultural lands, both cropland and pasture. Agricultural pesticides continue to be a cost-effective means of controlling weeds, insects, and other threats to the quality and yield of food production. Since application rates for a particular pesticide may vary from region to region, the regional application rates should be considered when estimating potential VOC emissions.

4.23.2 Sources of data

As seen in Table 4-153, this source category includes data from S/L/Ts and EPA for Agricultural application (SCC=2461850000). New Jersey and Marland also reported emissions for Surface Application (2461800001) and Soil Incorporation (2461800002). The leading SCC description is "Solvent Utilization; Miscellaneous Non-Industrial: Commercial" for all SCCs.

Table 4-153: Pesticide application SCCs estimates generated by EPA and S/L/Ts

SCC	Description	EPA	S/L/T
2461800001	Pesticide Application: All Processes; Surface Application		MD, NJ
2461800002	Pesticide Application: All Processes; Soil Incorporation		MD
2461850000	Pesticide Application: Agricultural; All Processes	X	X

The agencies listed in Table 4-154 submitted pesticide emissions; agencies not listed used EPA estimates.

Table 4-154: Agencies that submitted pesticide emissions in the 2017 NEI

Region	Agency	S/L/T
1	New Hampshire Department of Environmental Services	State
2	New Jersey Department of Environment Protection	State
3	Maryland Department of the Environment	State
4	Memphis and Shelby County Health Department - Pollution Control	Local
4	Metro Public Health of Nashville/Davidson County	Local
5	Illinois Environmental Protection Agency	State
9	California Air Resources Board	State
9	Maricopa County Air Quality Department	Local
10	Coeur d'Alene Tribe	Tribe
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.23.3 EPA-developed emissions

The USGS provides county-level estimates of pesticide application, in its preliminary county-level pesticide use estimates [ref 2]. These data provide information about the total application of each active ingredient in a pesticide product (e.g. 2,4-D, atrazine, captan). There are often many different pesticide products with the same active ingredient. For example, the California Department of Pesticide Regulation's (CA DPR) database [ref 3] lists 49 registered pesticide products with atrazine as the active ingredient, each with slightly different formulations, including different proportions of active ingredient and solvents. The CA DPR database includes information on the mass fraction of active ingredient in each pesticide product. EPA uses this information to calculate an average VOC emissions factor for each active ingredient listed in the CA DPR database. This VOC emissions factor is multiplied by the amount of active ingredient applied in each county, from the USGS report, to estimate VOC emissions in each county. For active ingredients not in the CA DPR database, a weighted emissions factor is calculated by weighting the emissions factors from the CA DPR database with total pounds of active ingredient reported in the USGS report. HAP emissions are calculated by multiplying the total pounds of active ingredients applied in each county by an emissions factor.

4.23.3.1 *Activity data*

The activity for pesticide application is the pounds of active ingredient applied per pesticide at the county level for the years 2016 and 2017, from the USGS preliminary county-level pesticide use estimates [ref 2] which gives county-level pesticide data in terms of kg of active ingredient applied. The data estimate preliminary annual county-level pesticide use for 387 herbicides, insecticides, and fungicides applied to agricultural crops grown in the conterminous United States during 2016 and 2017. For all states except California, pesticide-use data are compiled from proprietary surveys of farm operations located within U.S. Department of Agriculture Crop Reporting Districts (CRDs). Surveyed pesticide-use data are used in conjunction with county annual harvested-crop acres reported by the U.S. Department of Agriculture 2012 Census of Agriculture and the 2013 County Agricultural Production Survey to calculate use rates per harvested-crop acre, or an "estimated pesticide use" (EPest) rate, for each crop by year. County-use estimates are then calculated by USGS by multiplying EPest rates by harvested-crop acres for each pesticide crop combination. Use estimates for California in the USGS data are obtained from annual CA DPR Pesticide Use Reports.

The USGS report calculates both EPest-low and EPest-high rates. The EPest-high rates are used here to estimate VOC emissions. Both methods incorporated surveyed and extrapolated rates to estimate pesticide use for counties, but EPest-low and EPest-high estimations differ in how situations are treated when a CRD was surveyed and pesticide use was not reported for a pesticide-by-crop combination. If use of a pesticide on a crop is not reported in a surveyed CRD, EPest-low reports zero use in the CRD for that pesticide-by-crop combination. EPest-high, however, treats the unreported use for that pesticide-by-crop combination in the CRD as unsurveyed, and pesticide-by-crop use rates from neighboring CRDs and, in some cases, CRDs within the same Farm Resources Region are used to calculate the pesticide-by-crop EPest-high rate for that CRD.

Due to data limitations, the USGS report does not contain active ingredient usages for Alaska and Hawaii. However, the Census of Agriculture [ref 5] contains acres treated with pesticide by county for Alaska and Hawaii and these values are used to estimate emissions.

4.23.3.2   *Allocation procedure*

The activity data are reported at the county level and do not need to be allocated.

4.23.3.3   *Emission factors*

The VOC emissions factors are derived for each active ingredient based on the pesticide profiles database maintained by the CA DPR [ref 2]. This database contains the chemical formulation for pesticide products registered in the State of California and provides key inputs for the development of VOC emissions factors, including the mass fraction of the active ingredient and the emission potential (EP) of registered pesticide products. The EP value represents the VOC content of the pesticide product and it is determined empirically through thermogravimetric analysis. Since the CA DPR database lists both agricultural and non-agricultural pesticide products, it is necessary to screen out entries that were likely formulated as a consumer product. Pesticide products that contained terms suggesting non-agricultural applications are excluded. Terms used to screen out likely consumer products are listed in Table 4-155.

Table 4-155: Terms used to screen out consumer products

ALGAE	DEODORIZING	GERM	MRSA	STAIN
ANT	DETERGENT	HAMSTER	ORNAMENTAL	SWIM
BATHROOM	DISHWASHER	HOME	POND	TICK
BEDBUG	DISINFECT	HORNET	POTTY	TURF
BEE	DOG	HORSE	PRESCRIPTION	WASP
CAT	DRAIN	HOUSE	RAT	WIPES
CATTLE	EQUINE	INDOOR	ROACH	YARD
CLEANER	FLEA	KLEEN	RODENTICIDE	
DECK	FLY	LANDSCAPE	ROOF	
DEGREASER	FOGGER	LAWN	SANI	
DEODORIZER	GERBIL	MOUSE	SPA	

Each record in the CA DPR database is for a specific pesticide product, and provides the product name, primary active ingredient, mass percent of active ingredient, emission potential (EP), registration number, and method used to estimate the EP. The pesticide-specific EP of reactive organic gases (i.e., the mass percentage of product that contributes to VOC emissions) and the mass percent of active ingredient are used to calculate pesticide-specific VOC emissions factors.

The CA DPR emission potential database [ref 2] provides the pesticide-specific emissions potential of reactive organic gases (i.e., the mass percentage of each pesticide product that contributes to VOC emissions) and the mass percent of active ingredient. To determine the total amount of pesticide product applied (i.e. both the active ingredient and the solvent) the amount of active ingredient applied (from USGS data) [ref 3] is divided by the mass percent of active ingredient, which is divided by 100 to convert from percent to fraction.

$$TP_{pest,US} = \frac{AI_{pest,US}}{\frac{MP_{pest,US}}{100}}$$

(1)

Where:

$TP_{pest,US}$ = Total pesticide applied for each active ingredient in the United States, in lbs.
$AI_{pest,US}$ = Total active ingredient applied of each pesticide type in the United States, in lbs.
$MP_{pest,US}$ = Average mass percent of active ingredient in each pesticide type in the United States, in percent

Next, the total national-level VOC emissions from each pesticide type are estimated by multiplying the total pesticide applied by the pesticide-specific emissions potential of reactive organic gases (i.e., the mass percentage of each pesticide that contributes to VOC emissions), from the CA DPR database [ref 2].

$$E_{VOC,US,pest} = TP_{pest,US} \times \frac{EP_{rog,pest}}{100}$$

(2)

Where:

$E_{VOC,US,pest}$ = Total national-level VOC emissions for each pesticide type, in lbs.
$TP_{pest,US}$ = Total pesticide applied of each pesticide type in the United States, in lbs.
$EP_{rog,pest}$ = Emissions potential of reactive organic gases for each pesticide, expressed as % of pesticide mass

The VOC emissions factor for each pesticide type is calculated by dividing the total national-level VOC emissions for each pesticide type by the total active ingredient applied for each pesticide type.

$$EF_{pest} = \frac{E_{VOC,US,pest}}{AI_{pest,US}}$$

(3)

Where:

EF_{pest} = Pesticide-specific emissions factor, in pounds VOC / pound active ingredient
$E_{VOC,US,pest}$ = Total national-level VOC emissions for each pesticide type, in lbs.
$AI_{pest,US}$ = Total active ingredient applied of each pesticide type in the United States, in lbs.

For active ingredients not in the CA DPR database, a weighted average emissions factor (EF_avg) is calculated. This weighted average is estimated by weighting the emissions factors from the CA DPR database using the total pounds of active ingredient reported in the USGS report "Preliminary Estimates of Annual Agricultural Pesticide Use for Counties of the Conterminous United States, 2013" [ref 3]. A crosswalk between compound name in the USGS database and the chemical name in the CA DPR database is provided in Table 4-156. Note that any pesticide compound from the USGS database that is not in the CA DPR data are marked with the word

"AVERAGE," to denote that the weighted average VOC emissions factors of 0.4 pounds of VOC per pound of active ingredient is used to estimate VOC emissions for the application of that pesticide. The pesticide-specific VOC emissions factors for all pesticides from the CA DPR database are shown in Table 5 in the document "Agricultural Pesticides NEMO 2017 FINAL_4-2 update.doc" on the 2017 NEI Supplemental FTP site.

Table 4-156: Crosswalk between USGS compound name and CA DPR chemical name

USGS Compound Name	CA DPR Compound Name
2,4-D	2,4-D
2,4-DB	2,4-DB ACID
6-BENZYLADENINE	AVERAGE
ABAMECTIN	ABAMECTIN
ACEPHATE	ACEPHATE
ACEQUINOCYL	ACEQUINOCYL
ACETAMIPRID	ACETAMIPRID
ACETOCHLOR	AVERAGE
ACIBENZOLAR	ACIBENZOLAR-S-METHYL
ACIFLUORFEN	ACIFLUORFEN, SODIUM SALT
ALACHLOR	ALACHLOR
ALDICARB	ALDICARB
ALUMINUM PHOSPHIDE	ALUMINUM PHOSPHIDE
AMECTOCTRADIN	AMETOCTRADIN
AMETRYN	AMETRYNE
AMINOPYRALID	AMINOPYRALID, TRIISOPROPANOLAMINE SALT
ASULAM	ASULAM, SODIUM SALT
ATRAZINE	ATRAZINE
AVIGLYCINE	AVERAGE
AZADIRACHTIN	AZADIRACHTIN
AZINPHOS-METHYL	AZINPHOS-METHYL
AZOXYSTROBIN	AZOXYSTROBIN
BACILLUS AMYLOLIQUIFACIEN	BACILLUS AMYLOLIQUEFACIENS STRAIN D747
BACILLUS CEREUS	BACILLUS CEREUS, STRAIN BP01
BACILLUS FIRMUS	BACILLUS FIRMUS (STRAIN I-1582)
BACILLUS PUMILIS	BACILLUS PUMILUS GHA 180
BACILLUS SUBTILIS	BACILLUS SUBTILIS GB03
BACILLUS THURINGIENSIS	BACILLUS THURINGIENSIS (BERLINER)
BENFLURALIN	AVERAGE
BENOMYL	BENOMYL
BENSULFURON	BENSULFURON METHYL
BENSULIDE	BENSULIDE
BENTAZONE	BENTAZON, SODIUM SALT
BIFENAZATE	BIFENAZATE
BIFENTHRIN	BIFENTHRIN
BISPYRIBAC	BISPYRIBAC-SODIUM
BOSCALID	BOSCALID

USGS Compound Name	CA DPR Compound Name
BROMACIL	BROMACIL
BROMOXYNIL	BROMOXYNIL BUTYRATE
BUPROFEZIN	BUPROFEZIN
BUTRALIN	AVERAGE
CALCIUM POLYSULFIDE	AVERAGE
CAPTAN	CAPTAN
CARBARYL	CARBARYL
CARBOPHENOTHION	CARBOPHENOTHION
CARBOXIN	CARBOXIN
CARFENTRAZONE-ETHYL	CARFENTRAZONE-ETHYL
CHINOMETHIONAT	AVERAGE
CHLORANTRANILIPROLE	CHLORANTRANILIPROLE
CHLORETHOXYFOS	AVERAGE
CHLORFENAPYR	CHLORFENAPYR
CHLORIMURON	AVERAGE
CHLORMEQUAT	CHLORMEQUAT CHLORIDE
CHLORONEB	CHLORONEB
CHLOROPICRIN	CHLOROPICRIN
CHLOROTHALONIL	CHLOROTHALONIL
CHLORPROPHAM	CHLORPROPHAM
CHLORPYRIFOS	CHLORPYRIFOS
CHLORSULFURON	CHLORSULFURON
CLETHODIM	CLETHODIM
CLODINAFOP	AVERAGE
CLOFENTEZINE	CLOFENTEZINE
CLOMAZONE	CLOMAZONE
CLOPYRALID	CLOPYRALID
CLORANSULAM-METHYL	AVERAGE
CLOTHIANIDIN	CLOTHIANIDIN
CONIOTHYRIUM MINITANS	CONIOTHYRIUM MINITANS STRAIN CON/M/91-08
COPPER	COPPER
COPPER HYDROXIDE	COPPER HYDROXIDE
COPPER OCTANOATE	COPPER OCTANOATE
COPPER OXYCHLORIDE	COPPER OXYCHLORIDE
COPPER OXYCHLORIDE S	COPPER OXYCHLORIDE SULFATE
COPPER SULF TRIBASIC	COPPER SULFATE (BASIC)
COPPER SULFATE	COPPER SULFATE (PENTAHYDRATE)
CPPU	AVERAGE
CRYOLITE	CRYOLITE
CUPROUS OXIDE	COPPER OXIDE (OUS)
CYANAMIDE	AVERAGE
CYAZOFAMID	CYAZOFAMID

USGS Compound Name	CA DPR Compound Name
CYCLANILIDE	CYCLANILIDE
CYCLOATE	CYCLOATE
CYDIA POMONELLA	AVERAGE
CYFLUFENAMID	CYFLUFENAMID
CYFLUTHRIN	CYFLUTHRIN
CYHALOFOP	CYHALOFOP-BUTYL
CYHALOTHRIN-GAMMA	AVERAGE
CYHALOTHRIN-LAMBDA	AVERAGE
CYMOXANIL	CYMOXANIL
CYPERMETHRIN	CYPERMETHRIN
CYPROCONAZOLE	AVERAGE
CYPRODINIL	CYPRODINIL
CYROMAZINE	CYROMAZINE
CYTOKININ	CYTOKININ
DAMINOZIDE	DAMINOZIDE
DAZOMET	DAZOMET
DCPA	AVERAGE
DECAN-1-OL	AVERAGE
DELTAMETHRIN	DELTAMETHRIN
DESMEDIPHAM	DESMEDIPHAM
DIAZINON	DIAZINON
DICAMBA	DICAMBA
DICHLOBENIL	DICHLOBENIL
DICHLOROPROPENE	AVERAGE
DICHLORPROP	DICHLORPROP, BUTOXYETHANOL ESTER
DICLOFOP	DICLOFOP-METHYL
DICLORAN	DICLORAN
DICLOSULAM	AVERAGE
DICOFOL	DICOFOL
DICROTOPHOS	DICROTOPHOS
DIENOCHLOR	DIENOCHLOR
DIETHATYL	DIETHATYL-ETHYL
DIFENOCONAZOLE	DIFENOCONAZOLE
DIFLUBENZURON	DIFLUBENZURON
DIFLUFENZOPYR	DIFLUBENZURON
DIMETHENAMID	DIMETHENAMID-P
DIMETHENAMID-P	DIMETHENAMID-P
DIMETHIPIN	DIMETHIPIN
DIMETHOATE	DIMETHOATE
DIMETHOMORPH	DIMETHOMORPH
DIMETHYL DISULFIDE	AVERAGE
DINOSEB	DINOSEB

USGS Compound Name	CA DPR Compound Name
DINOTEFURAN	DINOTEFURAN
DIQUAT	DIQUAT DIBROMIDE
DISULFOTON	DISULFOTON
DITHIOPYR	DITHIOPYR
DIURON	DIURON
DODINE	DODINE
EMAMECTIN	EMAMECTIN BENZOATE
ENDOSULFAN	ENDOSULFAN
ENDOTHAL	ENDOTHALL, DISODIUM SALT
EPTC	EPTC
ESFENVALERATE	ESFENVALERATE
ETHALFLURALIN	ETHALFLURALIN
ETHEPHON	ETHEPHON
ETHION	ETHION
ETHOFUMESATE	ETHOFUMESATE
ETHOPROPHOS	ETHOPROP
ETOXAZOLE	ETOXAZOLE
ETRIDIAZOLE	AVERAGE
FAMOXADONE	AVERAGE
FATTY ALCOHOLS	AVERAGE
FENAMIDONE	FENAMIDONE
FENAMIPHOS	FENAMIPHOS
FENARIMOL	FENARIMOL
FENBUCONAZOLE	FENBUCONAZOLE
FENBUTATIN OXIDE	FENBUTATIN-OXIDE
FENHEXAMID	FENHEXAMID
FENOXAPROP	FENOXAPROP-ETHYL
FENOXYCARB	FENOXYCARB
FENPROPATHRIN	FENPROPATHRIN
FENPYROXIMATE	FENPYROXIMATE
FENTIN	FENTIN HYDROXIDE
FERBAM	FERBAM
FIPRONIL	FIPRONIL
FLAZASULFURON	FLAZASULFURON
FLONICAMID	FLONICAMID
FLORASULAM	FLORASULAM
FLUAZIFOP	FLUAZIFOP-BUTYL
FLUAZINAM	FLUAZINAM
FLUBENDIAMIDE	FLUBENDIAMIDE
FLUCARBAZONE	AVERAGE
FLUDIOXONIL	FLUDIOXONIL
FLUFENACET	AVERAGE

USGS Compound Name	CA DPR Compound Name
FLUMETRALIN	FLUOMETURON
FLUMETSULAM	AVERAGE
FLUMICLORAC	FLUMICLORAC-PENTYL
FLUMIOXAZIN	FLUMIOXAZIN
FLUOMETURON	FLUOMETURON
FLUOPICOLIDE	FLUOPICOLIDE
FLUOPYRAM	FLUOPYRAM
FLUOXASTROBIN	FLUOXASTROBIN
FLURIDONE	FLURIDONE
FLUROXYPYR	FLUROXYPYR
FLUTHIACET-METHYL	AVERAGE
FLUTOLANIL	FLUTOLANIL
FLUTRIAFOL	FLUTRIAFOL
FLUVALINATE-TAU	AVERAGE
FLUXAPYROXAD	FLUXAPYROXAD
FOMESAFEN	AVERAGE
FORAMSULFURON	FORAMSULFURON
FORMETANATE	FORMETANATE HYDROCHLORIDE
FOSETYL	FOSETYL-AL
GALLEX	META-CRESOL
GAMMA AMINOBUTYRIC ACID	AVERAGE
GIBBERELLIC ACID	GIBBERELLINS
GLUFOSINATE	GLUFOSINATE-AMMONIUM
GLYPHOSATE	GLYPHOSATE
HALOSULFURON	HALOSULFURON-METHYL
HARPIN PROTEIN	HARPIN PROTEIN
HEXAZINONE	HEXAZINONE
HEXYTHIAZOX	HEXYTHIAZOX
HYDRAMETHYLNON	HYDRAMETHYLNON
HYDRATED LIME	CALCIUM HYDROXIDE
HYDROGEN PEROXIDE	HYDROGEN PEROXIDE
HYMEXAZOL	AVERAGE
IBA	IBA
IMAZALIL	IMAZALIL
IMAZAMETHABENZ	IMAZAMETHABENZ
IMAZAMOX	IMAZAMOX
IMAZAPIC	IMAZAPIC
IMAZAPYR	IMAZAPYR
IMAZAQUIN	AVERAGE
IMAZETHAPYR	IMAZETHAPYR
IMAZOSULFURON	IMAZOSULFURON
IMIDACLOPRID	IMIDACLOPRID

USGS Compound Name	CA DPR Compound Name
INDAZIFLAM	INDAZIFLAM
INDOXACARB	INDOXACARB
IODOSULFURON	AVERAGE
IPCONAZOLE	IPCONAZOLE
IPRODIONE	IPRODIONE
ISOXABEN	ISOXABEN
ISOXAFLUTOLE	AVERAGE
KAOLIN CLAY	KAOLIN
KINOPRENE	KINOPRENE
KRESOXIM-METHYL	KRESOXIM-METHYL
LACTOFEN	AVERAGE
L-GLUTAMIC ACID	GLUTAMIC ACID
LINURON	LINURON
MALATHION	MALATHION
MALEIC HYDRAZIDE	MALEIC HYDRAZIDE
MANCOZEB	MANCOZEB
MANDIPROPAMID	MANDIPROPAMID
MANEB	MANEB
MCPA	MCPA
MCPB	MCPB, SODIUM SALT
MECOPROP	MECOPROP-P
MEFENOXAM	MEFENOXAM
MEPIQUAT	MEPIQUAT CHLORIDE
MESOSULFURON	MESOSULFURON-METHYL
MESOTRIONE	MESOTRIONE
METALAXYL	METALAXYL
METALDEHYDE	METALDEHYDE
METAM	METAM-SODIUM
METAM POTASSIUM	METAM-SODIUM
METCONAZOLE	METCONAZOLE
METHAMIDOPHOS	METHAMIDOPHOS
METHIDATHION	METHIDATHION
METHIOCARB	METHIOCARB
METHOMYL	METHOMYL
METHOXYFENOZIDE	METHOXYFENOZIDE
METHYL BROMIDE	METHYL BROMIDE
METHYL BROMIDE	METHYL BROMIDE
METHYL IODIDE	METHYL IODIDE
METHYL PARATHION	METHYL PARATHION
METIRAM	METIRAM
METOLACHLOR	METOLACHLOR
METOLACHLOR-S	METOLACHLOR

USGS Compound Name	CA DPR Compound Name
METRAFENONE	METRAFENONE
METRIBUZIN	METRIBUZIN
METSULFURON	METSULFURON-METHYL
MEVINPHOS	MEVINPHOS
MSMA	MSMA
MYCLOBUTANIL	MYCLOBUTANIL
MYROTHECIUM VERRUCARIA	MYROTHECIUM VERRUCARIA, DRIED FERMENTATION SOLIDS
NALED	NALED
NAPHTHYLACETAMIDE	AVERAGE
NAPHTHYLACETIC ACID	AVERAGE
NAPROPAMIDE	NAPROPAMIDE
NAPTALAM	NAPTALAM, SODIUM SALT
NEEM OIL	AVERAGE
NICOSULFURON	NICOSULFURON
NORFLURAZON	NORFLURAZON
NOSEMA LOCUSTAE CANN	NOSEMA LOCUSTAE SPORES
NOVALURON	NOVALURON
ORTHOSULFAMURON	ORTHOSULFAMURON
ORYZALIN	ORYZALIN
OXADIAZON	OXADIAZON
OXAMYL	OXAMYL
OXYDEMETON-METHYL	OXYDEMETON-METHYL
OXYFLUORFEN	OXYFLUORFEN
OXYTETRACYCLINE	OXYTETRACYCLINE HYDROCHLORIDE
PACLOBUTRAZOL	PACLOBUTRAZOL
PARAQUAT	PARAQUAT DICHLORIDE
PARATHION	PARATHION
PELARGONIC ACID	AVERAGE
PENDIMETHALIN	PENDIMETHALIN
PENOXSULAM	PENOXSULAM
PENTHIOPYRAD	PENTHIOPYRAD
PERMETHRIN	PERMETHRIN
PETROLEUM DISTILLATE	PETROLEUM DISTILLATES
PETROLEUM OIL	PETROLEUM NAPHTHENIC OILS
PHENMEDIPHAM	PHENMEDIPHAM
PHORATE	PHORATE
PHOSMET	PHOSMET
PHOSPHORIC ACID	PHOSPHORIC ACID
PICLORAM	PICLORAM
PINOXADEN	PINOXADEN
PIPERONYL BUTOXIDE	PIPERONYL BUTOXIDE
POLYHEDROSIS VIRUS	POLYHEDRAL OCCLUSION BODIES (OB'S) OF THE NUCLEAR

USGS Compound Name	CA DPR Compound Name
POLYOXORIM	AVERAGE
POTASSIUM BICARBONATE	POTASSIUM BICARBONATE
POTASSIUM OLEATE	AVERAGE
PRIMISULFURON	AVERAGE
PRODIAMINE	PRODIAMINE
PROFENOFOS	PROFENOFOS
PROHEXADIONE	PROHEXADIONE CALCIUM
PROMETRYN	PROMETRYN
PROPAMOCARB HCL	PROPAMOCARB HYDROCHLORIDE
PROPANIL	PROPANIL
PROPARGITE	PROPARGITE
PROPAZINE	PROPAZINE
PROPICONAZOLE	PROPICONAZOLE
PROPOXYCARBAZONE	AVERAGE
PROPYZAMIDE	PROPYZAMIDE
PROSULFURON	AVERAGE
PROTHIOCONAZOLE	PROTHIOCONAZOLE
PSEUDOMONAS FLUORESCENS	PSEUDOMONAS FLUORESCENS, STRAIN A506
PYMETROZINE	PYMETROZINE
PYRACLOSTROBIN	PYRACLOSTROBIN
PYRAFLUFEN ETHYL	PYRAFLUFEN-ETHYL
PYRASULFOTOLE	AVERAGE
PYRETHRINS	PYRETHRINS
PYRIDABEN	PYRIDABEN
PYRIMETHANIL	PYRIMETHANIL
PYRIPROXYFEN	PYRIPROXYFEN
PYRITHIOBAC-SODIUM	PYRITHIOBAC-SODIUM
PYROXASULFONE	AVERAGE
PYROXSULAM	PYROXSULAM
QUINCLORAC	QUINCLORAC
QUINOXYFEN	QUINOXYFEN
QUINTOZENE	AVERAGE
QUIZALOFOP	QUIZALOFOP-ETHYL
RIMSULFURON	RIMSULFURON
ROTENONE	ROTENONE
SABADILLA	SABADILLA ALKALOIDS
SAFLUFENACIL	SAFLUFENACIL
SETHOXYDIM	SETHOXYDIM
SILICATES	SILICA AEROGEL
SIMAZINE	SIMAZINE
SODIUM CHLORATE	SODIUM CHLORATE
SODIUM CHLORATE	SODIUM CHLORATE

USGS Compound Name	CA DPR Compound Name
SPINETORAM	SPINETORAM
SPINOSYN	SPINOSAD
SPIRODICLOFEN	SPIRODICLOFEN
SPIROMESIFEN	SPIROMESIFEN
SPIROTETRAMAT	SPIROTETRAMAT
STREPTOMYCIN	STREPTOMYCIN
SULFCARBAMIDE	AVERAGE
SULFENTRAZONE	SULFENTRAZONE
SULFOMETURON	SULFOMETURON-METHYL
SULFOSATE	AVERAGE
SULFOSULFURON	SULFOSULFURON
SULFOXAFLOR	SULFOXAFLOR
SULFUR	SULFUR
SULFURIC ACID	SULFURIC ACID
TCMTB	TCMTB
TEBUCONAZOLE	TEBUCONAZOLE
TEBUFENOZIDE	TEBUFENOZIDE
TEBUPIRIMPHOS	AVERAGE
TEBUTHIURON	TEBUTHIURON
TEFLUTHRIN	AVERAGE
TEMBOTRIONE	TEMBOTRIONE
TERBACIL	TERBACIL
TERBUFOS	AVERAGE
TETRABOROHYDRATE	AVERAGE
TETRACONAZOLE	TETRACONAZOLE
TETRATHIOCARBONATE	AVERAGE
THIABENDAZOLE	THIABENDAZOLE
THIACLOPRID	THIACLOPRID
THIAMETHOXAM	THIAMETHOXAM
THIAZOPYR	THIAZOPYR
THIDIAZURON	THIDIAZURON
THIENCARBAZONE-METHYL	AVERAGE
THIFENSULFURON	THIFENSULFURON-METHYL
THIOBENCARB	THIOBENCARB
THIODICARB	THIODICARB
THIOPHANATE-METHYL	THIOPHANATE-METHYL
THIRAM	THIRAM
TOPRAMEZONE	AVERAGE
TRALKOXYDIM	TRALKOXYDIM
TRIADIMEFON	TRIADIMEFON
TRIADIMENOL	TRIADIMENOL
TRI-ALLATE	TRIALLATE

USGS Compound Name	CA DPR Compound Name
TRIASULFURON	AVERAGE
TRIBENURON METHYL	TRIBENURON-METHYL
TRIBUFOS	AVERAGE
TRICLOPYR	TRICLOPYR, BUTOXYETHYL ESTER
TRIFLOXYSTROBIN	TRIFLOXYSTROBIN
TRIFLOXYSULFURON	TRIFLOXYSULFURON-SODIUM
TRIFLUMIZOLE	TRIFLUMIZOLE
TRIFLURALIN	TRIFLURALIN
TRIFLUSULFURON	AVERAGE
TRINEXAPAC	TRINEXAPAC-ETHYL
TRITICONAZOLE	TRITICONAZOLE
UNICONAZOLE	UNICONIZOLE-P
VINCLOZOLIN	VINCLOZOLIN
ZETA-CYPERMETHRIN	AVERAGE
ZINC	ZINC CHLORIDE
ZINEB	ZINEB
ZIRAM	ZIRAM
ZOXAMIDE	AVERAGE

The emissions factor is calculated for these active ingredients based on calculating a weighted average emissions factor for all active ingredients. The weights are determined by dividing the active ingredient applied for each pesticide type by the total active ingredients applied for all pesticides types. These weights are multiplied by the emissions factor for each pesticide (calculated in equation 3), and then summed to determine the weighted average emissions factor.

$$EF_{avg} = \sum_{pest=1}^{PEST} \frac{AI_{pest,US}}{\sum_{pest=1}^{PEST} AI_{pest,US}} \times EF_{pest} \tag{4}$$

Where:

EF_{avg} = Weighted average emissions factor, in pounds VOC / pound active ingredient
$AI_{pest,US}$ = Total active ingredient applied of each pesticide type in the United States, in lbs.
EF_{pest} = Pesticide-specific emissions factor, in pounds VOC / pound active ingredient

The HAP emissions factors are from EIIP and are based on vapor pressure of the active ingredient [ref 1]. Compounds with a vapor pressure between 1×10^{-4} and 1×10^{-6} mm Hg at 20°C to 25°C have an emissions factor of 700 lbs./ton (or 0.35 lbs./lb.). Compounds with a vapor pressure greater than 1×10^{-4} mm Hg at 20°C to 25°C have an emissions factor of 1,160 lbs./ton (or 0.58 lbs./lb.). The subset of HAPs is extracted from the list of active ingredients and is shown in Table 4-157 along with the HAP emissions factors. If the calculated emissions factor for any HAP is greater than the VOC emissions factor for that active ingredient, calculated in equation 3, then the HAP emissions factor is set equal to the VOC emissions factor.

Table 4-157: HAP Emissions Factors

Compound	Pollutant Code	Vapor Pressure (mm Hg at 20°C to 25°C)	Emissions Factor (lbs. per lb. active ingredient)	Source
2,4-D	94757	8×10^{-6}	0.35	Reference 1, Tables 9.4-2 and 9.4-4
CAPTAN	133062	8×10^{-8}	0.1441	Set equal to VOC emissions factor calculated from the CA DPR. See Table 4-156.
CARBARYL	63252	1.2×10^{-6}	0.3208	Set equal to VOC emissions factor calculated from the CA DPR. See Table 4-156.
METHYL BROMIDE	74839	1,420	0.58	Vapor pressure: Reference 2 Emissions factor: Reference 1, Table 9.4-4
METHYL IODIDE	74884	400	0.58	Vapor pressure: Reference 4 Emissions factor: Reference 1, Table 9.4-4
PARATHION	56382	5×10^{-6}	0.35	Reference 1, Tables 9.4-2 and 9.4-4
TRIFLURALIN	1582098	1.1×10^{-4}	0.58	Reference 1, Tables 9.4-2 and 9.4-4

For Alaska and Hawaii, data from the conterminous United States is used to develop average emissions factors by pollutant in terms of emissions per acre treated with pesticides. This is calculated by summing the total emissions by pollutant for the conterminous United States and dividing by the total acres treated in the conterminous United States.

4.23.3.4 Controls

There are no controls assumed for this category.

4.23.3.5 Emissions

VOC and HAP emissions are calculated by multiplying the amount of active ingredient applied in each county, from the USGS database, by the appropriate emissions factor. The emissions factor for VOC is calculated using equations 1-4. The emissions factors for the HAPs are listed in Table 4-157.

The VOC emissions are calculated by multiplying the active ingredients applied in each county per year by the corresponding emissions factor.

$$E_{VOC,c} = \sum AI_{pest,c} \times EF_{pest} \times \frac{1\ ton}{2000\ lb} \tag{5}$$

Where:

$E_{VOC,c}$ = Annual emissions of VOC from pesticide active ingredient applications in county c, in tons
$AI_{pest,c}$ = Active ingredient of each pesticide type applied in county c, in pounds
EF_{pest} = Pesticide-specific emissions factor, in pounds VOC / pound active ingredient

Note that if the active ingredient (AI_{pest}) is included in the CA DPR database, then the pesticide-specific emissions factor is used (EF_{pest}); for all other active ingredients, the weighted average emissions factor is used (EF_{avg}).

The HAP emissions are calculated by multiplying the active ingredients applied in each county per year by the corresponding emissions factor. The HAPs listed in Table 4-157 correspond to the active ingredients in the USGS database. For example, emissions of the HAP captan only occur from applications of the active ingredient captan. Emissions are then summed across pesticide types to estimate the total county-level emissions for each HAP.

$$E_{p,c} = \sum_{pest=1}^{PEST} AI_{pest,c} \times EF_{p,pest} \qquad (6)$$

Where:

$E_{p,c}$	=	Emissions of pollutant p from pesticide applications in county c, in lbs.
$EF_{p,pest}$	=	Emissions factor for pollutant p, in pounds emissions / pound active ingredient
$AI_{pest,c}$	=	Active ingredient of each pesticide type applied in county c, in pounds

Note that the HAP emissions factors are from the EIIP [ref 1]. If the HAP emissions factor for a certain pesticide type exceeds the VOC emissions factor calculated for that pesticide type as calculated in equations 1 and 2, then the HAP emissions factor is set equal to the VOC emissions factor.

For Alaska and Hawaii, emissions are estimated by multiplying the acres treated with pesticides by pollutant-specific emissions per acre emissions factors.

4.23.3.6 *Example calculations*

Table 4-158 lists sample calculations to determine the VOC and 2,4-D emissions from 2,4-Dichlorophenoxy Acetic Acid (2,4-D). The sample calculations show the emission calculations for the pesticide 2,4-D only. To estimate the total county-level emissions, the process would need to be repeated for each pesticide.

Table 4-158: Sample calculations for VOC/HAP emissions from 2,4-D agricultural pesticide application in Autauga County, AL

Eq. #	Equation	Values for Autauga County, AL	Result
1	$TP_{pest,US} = \dfrac{AI_{pest,US}}{\dfrac{MP_{pest,US}}{100}}$	$\dfrac{41{,}912{,}210 \; lbs \; 2{,}4-D \; active \; ingredient}{\dfrac{4.84 \; mass \; percent}{100}}$	865,954,752 lbs total 2,4-D pesticide applied in the United States
2	$E_{VOC,US,pest} = TP_{pest,US} \times \dfrac{EP_{rog,pest}}{100}$	$865{,}954{,}752 \; lbs \; total \; 2{,}4 \\ -D \; pesticide \; \times \dfrac{4.0}{100}$	34,638,190 lbs VOC emissions from 2,4-D in the United States
3	$EF_{pest} = \dfrac{E_{VOC,US,pest}}{AI_{pest,US}}$	$\dfrac{34{,}638{,}190 \; lbs \; VOC}{41{,}912{,}210 \; lbs \; 2{,}4-D \; active \; ingredient}$	0.826 lbs. VOC/ lb. 2,4-D active ingredient

Eq. #	Equation	Values for Autauga County, AL	Result
4	$$EF_{avg} = \sum_{pest=1}^{PEST} \frac{AI_{pest}}{\sum_{pest=1}^{PEST} AI_{pest}} \times EF_{pest}$$	N/A	This calculation is not needed, as 2,4-D is included in the CA DPR database.
5	$$E_{VOC,c} = \sum AI_{pest,c} \times EF_{pest} \times \frac{1\ ton}{2000\ lb}$$	$$8020\ lbs.\ 2,4-D\ active\ ingredient \times 0.826\ \times \frac{1\ ton}{2000\ lb}$$	3.31 tons VOC emissions from 2,4-D in Autauga County, AL
6	$$E_{p,c} = \sum_{pest=1}^{PEST} AI_{pest,c} \times EF_{p,pest}$$	$$8020\ lbs.\ 2,4-D\ active\ ingredient \times 0.35$$	2,807 pounds 2,4-D emissions from 2,4-D in Autauga County, AL

4.23.3.7 *Changes from the 2014 methodology*

As discussed in Section 4.23.3.1, EPA developed an emissions estimation methodology for Alaska and Hawaii counties that was not used for the 2014 NEI.

4.23.3.8 *Puerto Rico and U.S. Virgin Islands*

Since insufficient data exist to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emissions factor. For each Puerto Rico and US Virgin Island county, the tons per capita emissions factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.23.4 References

1. U.S. Environmental Protection Agency. 2001. Emissions Inventory Improvement Program, Vol. 3, Ch. 9, Pesticides - Agricultural and Nonagricultural, Section 5.1, p. 9.5-4.
2. United States Geological Survey. 2017. Archived preliminary county-level pesticide use estimates.
3. Personal communication from Pam Wofford, California Department of Pesticide Regulation to Jonathan Dorn, Abt Associates, "CDPR_Emission_Potential_Database_10_2015.xlsx", January 2016
4. U.S. Environmental Protection Agency. 2000. Health Effects Notebook for Hazardous Air Pollutants.
5. U.S. Department of Agriculture, 2012, 2012 Census of Agriculture, National Agricultural Statistics Service.

4.24 Solvents – Consumer and Commercial Solvent Use: Asphalt Paving

4.24.1 Source category description

Asphalt paving is the process of applying asphalt concrete to seal or repair the surface of roads, parking lots, driveways, walkways, or airport runways. Asphalts for paving are mainly used in two ways. They are either mixed with aggregates at plants and hauled to the paving site and then compacted on the road, or they are sprayed in relatively thin layers with or without aggregates. Plant mixed asphalt products are called asphalt concrete mix. As seen in Figure 4-21, these can be produced and laid down hot, using asphalt cements, or cold, using emulsions or cutbacks. These mixes usually contain about 5% asphalt and 95% aggregates by weight. Aggregates give the mix most of its ability to carry or resist loads while the asphalt coats and binds the aggregate structure.

Hot laid mixes, also called hot mix asphalt (HMA), are produced by mixing heated aggregates and asphalt cements in special mixing plants. These very strong, stiff mixes are usually used for surface and subsurface layers in highways, airports, parking lots, and other areas which carry heavy or high-volume traffic. HMA uses an asphaltic binding agent which includes asphalt cement as well as any material added to modify the original asphalt cement properties. Cold asphalt mixes are produced by mixing damp, cold aggregates with emulsions or cutbacks at mixing plants — either stationary plants or portable ones brought to the site. Although not as strong and stiff as hot mix, cold mixes may be more economical and flexible, and less polluting. They are used for areas with intermediate and low traffic, for open graded mixes, and for patching. Sprayed asphalt applications include asphalt-aggregate applications, usually called surface treatments or seal coats, and asphalt-only applications such as tack coat, prime coat, fog seal, and dust prevention [ref 1].

Figure 4-21: Types of Asphalt Paving processes
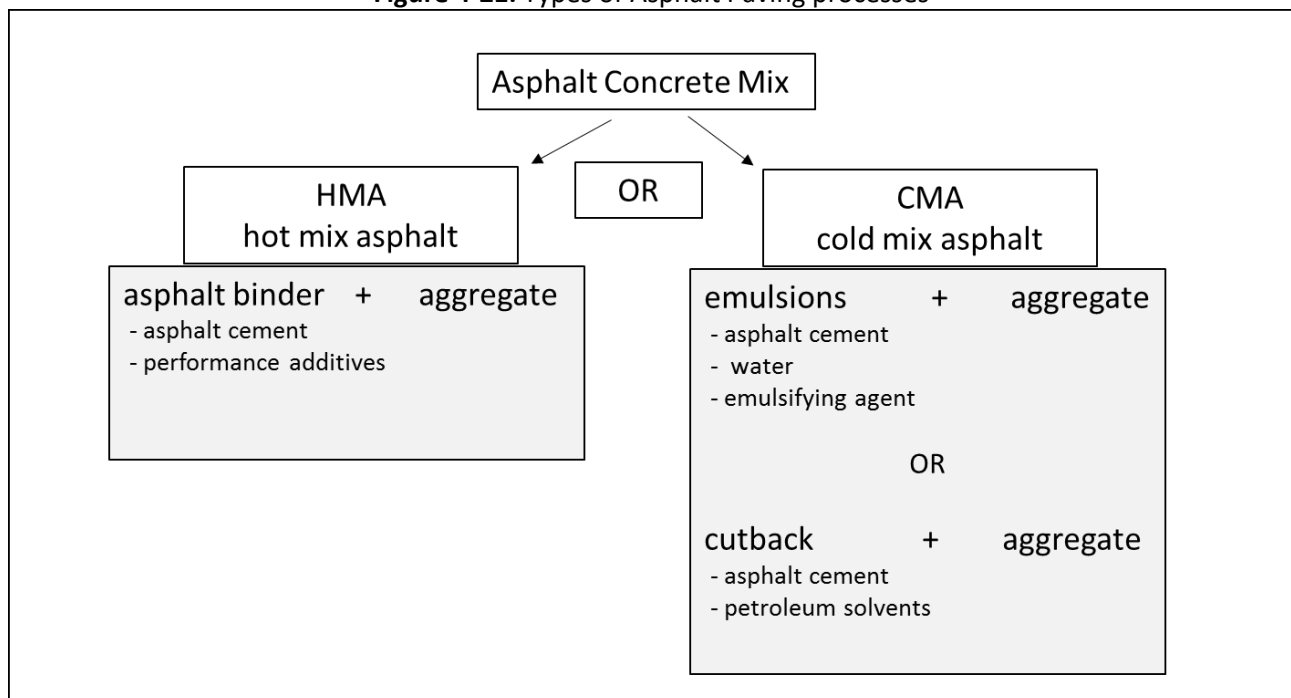
A new, third type of mix, warm-mix asphalt (WMA), has become increasingly popular. In this type of mixture, various methods are used to significantly reduce mix production temperature by 30 to over 100°F. These methods include (1) using chemical additives to lower the high-temperature viscosity of the asphalt binder; (2) techniques involving the addition of water to the binder, causing it to foam; and (3) two-stage processes

involving the addition of hard and soft binders at different points during mix production. WMA has several benefits, including lower cost (since significantly less fuel is needed to heat the mix), lower emissions and so improved environmental impact, and potentially improved performance because of decreased age hardening [ref 2].

Note that these source categories do <u>not</u> include emissions from the use of hot mix asphalt (HMA) or warm mix asphalt (WMA). Estimates of emissions of volatile organic compounds (VOC), and hazardous air pollutants (HAPs) from asphalt paving are based on the amount of cutback and emulsified asphalt used.

4.24.2 Sources of data

As seen in Table 4-159, this source category includes data from the S/L/T agency submitted data and the default EPA generated emissions. EPA estimates emissions for both cutback and emulsified asphalt paving. New Jersey and Maryland also reported emissions for "Asphalt Application: All Processes; Total: All Solvent Types" (2461020000). The leading SCC description is "Solvent Utilization; Miscellaneous Non-industrial: Commercial" for all SCCs.

Table 4-159: Asphalt Paving SCCs in the 2017 NEI

SCC	Description	EPA	S/L/T
2461020000	Asphalt Application: All Processes; Total: All Solvent Types		X
2461021000	Cutback Asphalt; Total: All Solvent Types	X	X
2461022000	Emulsified Asphalt; Total: All Solvent Types	X	X

The agencies listed in Table 4-160 reported emissions for at least one of the above SCCs. Maryland, New Jersey and Washoe county reported emissions for the general "Asphalt Application SCC" (2461020000) as these emissions were not covered by cutback and emulsified estimates.

Table 4-160: Agencies that reported emissions for Asphalt application in the 2017 NEI

Region	Agency	S/L/T
1	New Hampshire Department of Environmental Services	State
2	New Jersey Department of Environment Protection	State
3	Delaware Department of Natural Resources and Environmental Control	State
3	Maryland Department of the Environment	State
3	Virginia Department of Environmental Quality	State
4	Memphis and Shelby County Health Department - Pollution Control	Local
4	Metro Public Health of Nashville/Davidson County	Local
5	Illinois Environmental Protection Agency	State
6	Texas Commission on Environmental Quality	State
8	Utah Division of Air Quality	State
9	California Air Resources Board	State
9	Maricopa County Air Quality Department	Local
9	Washoe County Health District	Local
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe

Region	Agency	S/L/T
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe

4.24.3 EPA-developed emissions

The calculations for estimating the emissions from asphalt use involve first estimating the amount of cutback and emulsified asphalt used in each county. The amount of state-level cutback and emulsified asphalt used in 2008 is available from an Asphalt Institute report. Asphalt use is adjusted to 2017 using a ratio of the vehicle miles traveled (VMT) in the US in 2017 to US VMT in 2008. The amount of state-level asphalt used is then distributed to the counties based on the county-level utilization of paved roads. The total amount of asphalt used is multiplied by emissions factors for VOC and HAPS to estimate emissions of these pollutants from asphalt usage.

4.24.3.1 *Activity data*

The activity data for this source category is the amount of cutback and emulsified asphalt used, which is from a 2008 survey from the Asphalt Institute [ref 3]. The 2008 data are used for the 2008, 2011, and 2014 NEI, as research suggests that more recent data are not readily available. The 2008 asphalt data are adjusted to account for changing use of roads, parking lots, driveways, walkways, or airport runways, using ratio of US VMT in 2017 to US VMT in 2008. State-level VMT data are obtained from the Federal Highway Administration (FHWA) report: *State-level annual vehicle miles traveled (VMT) by FHWA road class, 2017* [ref 4].

$$VMTFrac = \frac{VMT_{US,y}}{VMT_{US,2008}} \tag{1}$$

$$AU_{s,t} = VMTFrac \times UAU_{s,t} \tag{2}$$

Where:

VMTFrac	=	The fraction of US VMT in 2008 to US VMT in 2013
$VMT_{US,2008}$	=	Total VMT in the US in 2008
$VMT_{US,y}$	=	Total VMT in the US in 2013
$AU_{s,t}$	=	The amount of asphalt type *t* used in state *s,* in tons of asphalt per year, from equation 2
$UAU_{s,t}$	=	The amount of unadjusted asphalt type *t* used in state *s,* in tons of asphalt per year, from Table 4-161

Table 4-161 shows the total state-level amount of cutback and emulsified asphalt used in the U.S in 2008. The process used to distribute the state-level amount of asphalt used to the counties is discussed in section 4.24.3.2.

Table 4-161: State-level asphalt usage (tons) in 2008

State	Cutback	Emulsified
Alabama	1,728	18,988
Alaska	0	1,108
Arizona	7,917	62,416
Arkansas	1,442	9,201
California	30,657	151,767
Colorado	331	837
Connecticut	0	0

State	Cutback	Emulsified
Delaware	0	0
District of Columbia	0	150
Florida	809	19,459
Georgia	1,136	7,848
Hawaii	0	0
Idaho	2,880	41,805
Illinois	18,889	146,873
Indiana	290	17,427
Iowa	4,874	13,570
Kansas	3,641	0
Kentucky	456	16,137
Louisiana	175	6,418
Maine	0	0
Maryland	0	2,080
Massachusetts	0	805
Michigan	52	31,250
Minnesota	1,604	67,082
Mississippi	259	45,035
Missouri	7,385	36,933
Montana	1,614	17,880
Nebraska	2,997	35,376
Nevada	948	15,971
New Hampshire	0	0
New Jersey	0	0
New Mexico	320	58,048
New York	0	32,954
North Carolina	0	143
North Dakota	7,323	22,701
Ohio	3,214	22,777
Oklahoma	8,724	9,157
Oregon	865	34,918
Pennsylvania	26,844	69,671
Rhode Island	0	0
South Carolina	0	0
South Dakota	19,034	44,691
Tennessee	894	34,561
Texas	14,618	154,613
Utah	549	7,039
Vermont	0	0
Virginia	670	41,249
Washington	5,774	24,263
West Virginia	0	3,581
Wisconsin	8,188	18,925
Wyoming	227	5,292

4.24.3.2 *Allocation procedure*

Asphalt usage data are not available at the county-level, therefore state –level data are allocated to the county based on road utilization numbers calculated from FHWA data.

State-level VMT data are obtained from the FHWA report: *State-level annual vehicle miles traveled (VMT) by FHWA road class, 2017* [ref 4]. EPA used the state-level data and 2011 MOVES data to allocate VMT to the county-level.

$$VMT_{c,r} = MOVES_{c,r} \times \frac{VMT_{s,r}}{MOVES_{s,r}} \tag{3}$$

Where:

$VMT_{c,r}$ = The amount of VMT on road type r in county c from EPA, in millions of miles
$MOVES_{c,r}$ = The amount of VMT on road type r in county c from the 2011 MOVES run
$VMT_{s,r}$ = The amount of VMT on road type r in state s from FHWA, in millions of miles
$MOVES_{s,r}$ = The amount of VMT on road type r in state s from the 2011 MOVES run

The county-level VMT is used to calculate the fraction of VMT in each county.

$$VMTFr_{c,r} = \frac{VMT_{c,r}}{VMT_{s,r}} \tag{4}$$

Where:

$VMTFr_{c,r}$ = The fraction of VMT on road type r in county c
$VMT_{c,r}$ = The amount of VMT on road type r in county c from EPA, in millions of miles
$VMT_{s,r}$ = The amount of VMT on road type r in state s from FHWA, in millions of miles

State-level lane-miles [ref 5] and paved road miles [ref 6] from FHWA are used to calculate an estimate of state lane-miles that are paved by road type.

$$PLM_{s,r} = \frac{PM_{s,r}}{PUM_{s,r}} \times LM_{s,r} \tag{5}$$

Where:

$PLM_{s,r}$ = The amount of paved lane-miles of road type r in state s, in miles
$PM_{s,r}$ = The amount of paved road miles of road type r in state s from FHWA, in miles
$PUM_{s,r}$ = The amount of paved and unpaved miles of road type r in state s from FHWA, in miles
$LM_{s,r}$ = The amount of lanes miles of road type r in state s from FHWA, in miles

State-level VMT from FHWA and paved lane-miles (from equation 3) are used to calculate a state-level utilization measure for paved roads by road type.

$$U_{s,r} = \frac{VMT_{s,r}}{PLM_{s,r}} \tag{6}$$

Where:

$U_{s,r}$ = Utilization of paved road type r in state s
$VMT_{s,r}$ = The amount of VMT on road type r in state s from FHWA
$PLM_{s,r}$ = The amount of paved lane-miles of road type r in state s

County-level utilization of paved roads by road type is calculated based on the fraction of county-level VMT (from equation 2).

$$U_{c,r} = VMTFr_{c,r} \times U_{s,r} \tag{7}$$

Where:

$U_{c,r}$ = Utilization of paved road type r in state s
$VMTFr_{c,r}$ = The fraction of VMT on road type r in county
$U_{s,r}$ = Utilization of paved road type r in state s

County-level utilization values are summed across all road types and then summed to the state level.

$$U_c = \sum_r U_{c,r} \tag{8}$$

$$U_s = \sum_c U_c \tag{9}$$

Where:

U_s = The total utilization of paved roads in state s
U_c = The total utilization of paved roads in county c
$U_{c,r}$ = Utilization of paved road type r in state s

The fraction of county-level utilization is calculated based on the ratio of total utilization at the county level to state level.

$$UFr_c = \frac{U_c}{U_s} \tag{10}$$

Where:

UFr_c = The fraction of paved road utilization in county c
U_s = The total utilization of paved roads in state s
U_c = The total utilization of paved roads in county c

County-level asphalt usage is the calculated by multiplying the fraction of county-level paved road utilization by the amount of cutback and emulsified asphalt used from Table 4-161.

$$AU_{c,t} = UFr_c \times AU_{s,t} \tag{11}$$

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Where:

$AU_{c,t}$ =   The amount of asphalt type t used in county c, in tons of asphalt per year
UFr_c =   The fraction of paved road utilization in county c
$AU_{s,t}$ =   The amount of asphalt type t used in state s, in tons of asphalt per year, from Table 4-161

4.24.3.3 *Emission factors*

The emissions factors for VOC and HAPs are developed based on information from material safety and data sheets (MSDS) for cutback and emulsified asphalt provided in Table 4-162 and Table 4-163, respectively.

Table 4-162: Cutback Asphalt MSDS

Product Supplier	MSDS/SDS ID
Valero	2013V04
Asphalt Emulsion Industries	CUT-SDS-1
Martin Asphalt Company	Jan 2007
Mohawk Asphalt Emulsions	UN1999
Asphalt & Fuel Supply	211
Valero	211
Valero	210

Table 4-163: Emulsified Asphalt MSDS

Product Supplier	MSDS/SDS ID
Marathon	0137MAR019
Marathon	0138MAR019
Asphalt Emulsion Industries	EMU-SDS-1
U.S. Oil & Refining Co.	951

Emissions factors for HAPs are calculated using the assumptions found in Table 4-164 and Table 4-165 from the average of MSDS values for cutback and emulsified asphalt, respectively.

Table 4-164: Chemical Composition Assumptions for Cutback Asphalt

Pollutant	Average % by Weight	% Weight Volatilized
Naphtha	40	95
Naphthalene & PAH	0.58	95
Toluene	0.59	95
Xylene	0.99	95
Benzene	0.19	95
Ethylbenzene	0.49	95
Hydrogen Sulfide	0.09	95

Table 4-165: Chemical Composition Assumptions for Emulsified Asphalt

Pollutant	Average % by Weight	% Weight Volatilized
Naphtha	10	95
Naphthalene & PAH	0.29	95
Hydrogen Sulfide	0.09	95

The total amount of cutback asphalt used nationally is 190,613 tons and the amount of emulsified asphalt used

is 1,374,693 tons.

$$Z_{US,p,t} = AU_{US,t} \times 2000\,\frac{lbs.}{ton} \times \%W_{p,t} \times \%V_p \tag{12}$$

$$EF_{p,t} = \frac{Z_{US,p,t}}{AU_{US,t}} \tag{13}$$

Where:

$Z_{US,p,t}$ = The amount of pollutant p emitted from use of asphalt type t in the United States, in lbs. of pollutant per year

$EF_{p,t}$ = Emissions factor for pollutant p from asphalt type t, in lbs. of pollutant per ton of asphalt

$AU_{US,t}$ = Total usage of asphalt type t, in tons of asphalt per year

$\%W_{p,t}$ = Average percent by weight of pollutant p from asphalt type t

$\%V_p$ = Average percent weight of pollutant p volatilized

Emission factors for VOC are calculated by summing the amount of pollutant emitted each year for all HAPs, except hydrogen sulfide.

$$EF_{voc,t} = \frac{\sum_p Z_t}{AU_{US,t}} \tag{14}$$

Where:

$EF_{voc,t}$ = VOC emissions factor for asphalt type t, in lbs. of VOC per ton of asphalt

$Z_{p,t}$ = The amount of pollutant emitted from use of asphalt type t, where p is equal to all pollutants except hydrogen sulfide, in lbs. of pollutant per year

$AU_{US,t}$ = Total usage of asphalt type t, in tons of asphalt per year

The resulting emissions factors for asphalt paving are reported in Table 4-166 and Table 4-167.

Table 4-166: Emissions Factors for Cutback Asphalt Usage

Pollutant	Pollutant Code	Emissions Factor	Emissions Factor Units
Volatile Organic Compounds	VOC	813.96	lbs./ton asphalt
Benzene	71432	3.6	lbs./ton asphalt
Ethylbenzene	100414	9.3	lbs./ton asphalt
Naphthalene	91203	11.0	lbs./ton asphalt
Toluene	108883	11.2	lbs./ton asphalt
Xylenes (mixed isomers)	1330207	18.8	lbs./ton asphalt
Hydrogen Sulfide	7783064	1.7	lbs./ton asphalt

Source: Based on MSDS values from Table 4-164

Table 4-167: Emissions Factors for Emulsified Asphalt Usage

Pollutant	Pollutant Code	Emissions Factor	Emissions Factor Units
Volatile Organic Compounds	VOC	195.5	lbs./ton asphalt
Naphthalene	91203	5.5	lbs./ton asphalt

Pollutant	Pollutant Code	Emissions Factor	Emissions Factor Units
Hydrogen Sulfide	7783064	1.7	lbs./ton asphalt

Source: Based on MSDS values from Table 4-165

4.24.3.4 *Controls*

There are no controls assumed for this category.

4.24.3.5 *Emissions*

The total asphalt usage in each county is multiplied by the emissions factors in Table 4-166 and Table 4-167 to estimate emissions.

$$E_{p,c,t} = EF_{p,t} \times AU_{c,t} \qquad (15)$$

Where:

$E_{p,c,t}$ = Annual emissions of pollutant *p* in county *c* from use of asphalt type *t*, in lbs. of pollutant
$EF_{p,t}$ = Emissions factor for pollutant *p* from asphalt type *t*, in lbs. of pollutant per ton of asphalt
$AU_{c,t}$ = The amount of asphalt type *t* used in county *c*, in tons of asphalt per year

4.24.3.6 *Example calculations*

Table 4-168 lists sample calculations to determine the VOC emissions from emulsified asphalt used in Barnstable County, Massachusetts. The equations 2 through 7 use asphalt use on rural interstates as an example; however, these calculations would need to be repeated for all 14 FHWA road types.

Table 4-168: Sample calculations for VOC emissions from emulsified asphalt use in Barnstable County, Massachusetts

Eq. #	Equation	Values for Barnstable County, MA	Result
1	$VMTFr = \dfrac{VMT_{US,y}}{VMT_{US,2008}}$	$\dfrac{3{,}025{,}659 \; Million \; Miles}{2{,}973{,}509 \; Million \; Miles}$	1.02 VMT fraction between 2008 and 2017
2	$AU_{s,t} = VMTFrac \times UAU_{s,t}$	$1.02 \times 805 \; tons \; of \; emulsified \; asphalt \; in \; MA$	819 tons of adjusted emulsified asphalt used in MA
3	$VMT_{c,r} = MOVES_{c,r} \times \dfrac{VMT_{s,r}}{MOVES_{s,r}}$	Barnstable County VMT on rural interstates from EPA	153,721,475.26 vehicle miles traveled on rural interstates in Barnstable County, MA
4	$VMTFr_{c,r} = \dfrac{VMT_{c,r}}{VMT_{s,r}}$	$\dfrac{153.72 \; million \; vehicle \; mi. \; in \; Barnstable \; County}{778.15 \; million \; vehicle \; mi. \; in \; MA}$	0.198 fraction of rural interstate VMT in Barnstable County, MA
5	$PLM_{s,r} = \dfrac{PM_{s,r}}{PUM_{s,r}} \times LM_{s,r}$	$\dfrac{63.65 \; paved \; mi.}{63.65 \; total \; mi.} \times 275.25 \; lane \; mi.$	275.25 rural interstate paved lane miles in MA
6	$U_{s,r} = \dfrac{VMT_{s,r}}{PLM_{s,r}}$	$\dfrac{778.15 \; million \; vehicle \; mi. \; in \; MA}{275.25 \; paved \; lane \; mi. \; in \; MA}$	2.83 utilization factor of paved rural interstates in MA

Eq. #	Equation	Values for Barnstable County, MA	Result
7	$U_{c,r} = VMTFr_{c,r} \times U_{s,r}$	$0.198\ VMT\ fraction \times 2.83\ utilization\ factor$	0.558 utilization factor of paved rural interstates in Barnstable County, MA
8	$U_c = \sum_r U_{c,r}$	$\sum Utilization\ of\ all\ paved\ roads\ in\ Barnstable$ (This is based on repeating calculations for equations 1-5 for all 14 FHWA road types.)	2.18 Barnstable County utilization of paved roads in MA
9	$U_s = \sum_c U_c$	$\sum Utilization\ of\ paved\ roads\ in\ all\ counties\ in\ MA$	46.20 utilization of paved roads in MA
10	$UFr_c = \dfrac{U_c}{U_s}$	$\dfrac{2.18\ utilization\ in\ Barnstable\ County}{46.20\ utilization\ in\ MA}$	0.05 fraction of utilization of paved roads in Barnstable County, MA
11	$AU_{c,t} = UFr_c \times AU_{s,t}$	$0.05\ fraction\ utilized\ in\ Barnstable\ County \times$ $819\ tons\ emulsified\ asphalt\ in\ MA$	37.91 tons of emulsified asphalt used in Barnstable County, MA
12	$P_{p,t} = AU_{US,t} \times 2000\dfrac{lbs.}{ton} \times \%W_{p,t} \times \%V_p$	$1{,}350{,}999\ tons\ emulsified\ asphalt\ per\ year \times$ $2000\dfrac{lbs.}{ton} \times 0.10 \times 0.95$	256,689,810 lbs. naphtha emitted per year from emulsified asphalt
		$1{,}350{,}999\ tons\ emulsified\ asphalt\ per\ year \times$ $2000\dfrac{lbs.}{ton} \times 0.0029 \times 0.95$	7,444,004 lbs. naphthalene emitted per year from emulsified asphalt
13	$EF_p = \dfrac{P_p}{AU_{US,t}}$	N/A	Emissions factors for HAPs are not used to calculate the emissions factor for VOC
14	$EF_{voc,t} = \dfrac{\sum_p Z_t}{AU_{US,t}}$	$\dfrac{256{,}689{,}810\ lbs.\ naptha + 7{,}444{,}004\ lbs.\ naphthalen}{1{,}350{,}999\ tons\ of\ emulsified\ asphalt}$	195.51 lbs. VOC emitted per ton of emulsified asphalt used
15	$E_{p,c,t} = EF_{p,t} \times AU_{c,t}$	$195.51\ lbs.\ VOC\ per\ top\ emulsified\ asphalt \times$ $37.91\ tons\ emulsified\ asphalt$	7,411.78 tons VOC emitted from emulsified asphalt use in Barnstable County, MA

4.24.3.7 Changes from the 2014 methodology

State-level asphalt use is adjusted in the 2017 methodology using a ratio of VMT in the inventory year to VMT in 2008, the year of the original asphalt data.

4.24.3.8 Puerto Rico and U.S. Virgin Islands

Insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, so emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island County, the tons per capita emission factor is multiplied by the county population (from the same year as

the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.24.4 References

1. Wisconsin Transportation Bulletin, No. 1, Understanding and Using Asphalt, 1996.
2. National Cooperative Highway Research Program (NCHRP) Report 673. A Manual for Design of Hot Mix Asphalt with Commentary, 2011.
3. Asphalt Institute, 2008. 2008 Asphalt Usage Survey for the United States and Canada.
4. FHWA, 2017. Functional System Travel-2017, Annual Vehicle Miles (Table VM-2).
5. FHWA, 2017. Functional System Lane-Length-2017, Lane-Miles (Table HM-60).
6. FHWA, 2017. Functional System Length-2017, Miles by Type of Surface - Rural (Table HM-51).

4.25 Solvents: All other Solvents

This section includes discussion on all nonpoint solvent sources except for agricultural pesticide application (see Section 4.23) and asphalt paving (see Section 4.24). The reason these sources are discussed separately is because the EPA methodologies for estimating the emissions are different.

4.25.1 Sector description

Solvent utilization includes a variety of industrial, commercial and residential applications of solvents that are not captured in the point source inventory. Estimates of emissions of volatile organic compounds (VOC) and hazardous air pollutants (HAPs) from solvent utilization are based on national-level estimates of solvent usage from the Freedonia Group [ref 1].

4.25.2 Sources of data

EPA's solvent category includes architectural surface coatings, industrial surface coatings, degreasing, graphic arts, dry cleaning, consumer and commercial (includes personal care products and household products), automotive aftermarket, adhesives and sealants, and FIFRA related products (pesticides excluding those for agricultural use).

Table 4-169 shows for solvents, the nonpoint SCCs covered by the EPA estimates and where SLTs submitted data. The SCC level 2, 3 and 4 SCC descriptions are also provided. The SCC level 1 description is "Solvent Utilization" for all SCCs. Note that the SCCs in this list are only the SCCs that either the EPA used or the submitting State agencies used in the 2017 NEI, and not a comprehensive list of all "active" Solvent SCCs. Also note the solvent SCCs (see table footnote) that were discussed in previous sections.

Table 4-169: Nonpoint solvent SCCs in the 2017 NEI

SCC	Description	EPA	S/L/T	Sector
2401001000	Surface Coating; Architectural Coatings; Total: All Solvent Types	X	X	Solvent - Non-Industrial Surface Coating
2401005000	Surface Coating; Auto Refinishing: SIC 7532; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401005700	Surface Coating; Auto Refinishing: SIC 7532; Top Coats		X	Solvent - Industrial Surface Coating & Solvent Use
2401008000	Surface Coating; Traffic Markings; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use

SCC	Description	EPA	S/L/T	Sector
2401010000	Surface Coating; Textile Products: SIC 22; Total: All Solvent Types		X	Solvent - Industrial Surface Coating & Solvent Use
2401015000	Surface Coating; Factory Finished Wood: SIC 2426 thru 242; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401020000	Surface Coating; Wood Furniture: SIC 25; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401025000	Surface Coating; Metal Furniture: SIC 25; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401030000	Surface Coating; Paper: SIC 26; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401035000	Surface Coating; Plastic Products: SIC 308; Total: All Solvent Types		X	Solvent - Industrial Surface Coating & Solvent Use
2401040000	Surface Coating; Metal Cans: SIC 341; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401045000	Surface Coating; Metal Coils: SIC 3498; Total: All Solvent Types		X	Solvent - Industrial Surface Coating & Solvent Use
2401050000	Surface Coating; Miscellaneous Finished Metals: SIC 34 - (341 + 3498); Total: All Solvent Types		X	Solvent - Industrial Surface Coating & Solvent Use
2401055000	Surface Coating; Machinery and Equipment: SIC 35; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401060000	Surface Coating; Large Appliances: SIC 363; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401065000	Surface Coating; Electronic and Other Electrical: SIC 36 - 363; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401070000	Surface Coating; Motor Vehicles: SIC 371; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401075000	Surface Coating; Aircraft: SIC 372; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401080000	Surface Coating; Marine: SIC 373; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401085000	Surface Coating; Railroad: SIC 374; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401090000	Surface Coating; Miscellaneous Manufacturing; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401100000	Surface Coating; Industrial Maintenance Coatings; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401200000	Surface Coating; Other Special Purpose Coatings; Total: All Solvent Types	X	X	Solvent - Industrial Surface Coating & Solvent Use
2415000000	Degreasing; All Processes/All Industries; Total: All Solvent Types	X	X	Solvent - Degreasing

SCC	Description	EPA	S/L/T	Sector
2420000000	Dry Cleaning; All Processes; Total: All Solvent Types	X	X	Solvent - Dry Cleaning
2420000055	Dry Cleaning; All Processes; Perchloroethylene		X	Solvent - Dry Cleaning
2420000999	Dry Cleaning; All Processes; Solvents: NEC		X	Solvent - Dry Cleaning
2425000000	Graphic Arts; All Processes; Total: All Solvent Types	X	X	Solvent - Graphic Arts
2425010000	Graphic Arts; Lithography; Total: All Solvent Types		X	Solvent - Graphic Arts
2425020000	Graphic Arts; Letterpress; Total: All Solvent Types		X	Solvent - Graphic Arts
2425030000	Graphic Arts; Rotogravure; Total: All Solvent Types		X	Solvent - Graphic Arts
2425040000	Graphic Arts; Flexography; Total: All Solvent Types		X	Solvent - Graphic Arts
2440000000	Miscellaneous Industrial; All Processes; Total: All Solvent Types		X	Solvent - Industrial Surface Coating & Solvent Use
2440020000	Miscellaneous Industrial; Adhesive (Industrial) Application; Total: All Solvent Types		X	Solvent - Industrial Surface Coating & Solvent Use
2460000000	Miscellaneous Non-industrial: Consumer and Commercial; All Processes; Total: All Solvent Types		X	Solvent - Consumer & Commercial Solvent Use
2460100000	Miscellaneous Non-industrial: Consumer and Commercial; All Personal Care Products; Total: All Solvent Types	X	X	Solvent - Consumer & Commercial Solvent Use
2460200000	Miscellaneous Non-industrial: Consumer and Commercial; All Household Products; Total: All Solvent Types	X	X	Solvent - Consumer & Commercial Solvent Use
2460400000	Miscellaneous Non-industrial: Consumer and Commercial; All Automotive Aftermarket Products; Total: All Solvent Types	X	X	Solvent - Consumer & Commercial Solvent Use
2460500000	Miscellaneous Non-industrial: Consumer and Commercial; All Coatings and Related Products; Total: All Solvent Types	X	X	Solvent - Consumer & Commercial Solvent Use
2460600000	Miscellaneous Non-industrial: Consumer and Commercial; All Adhesives and Sealants; Total: All Solvent Types	X	X	Solvent - Consumer & Commercial Solvent Use
2460800000	Miscellaneous Non-industrial: Consumer and Commercial; All FIFRA Related Products; Total: All Solvent Types	X	X	Solvent - Consumer & Commercial Solvent Use

SCC	Description	EPA	S/L/T	Sector
2460900000	Miscellaneous Non-industrial: Consumer and Commercial; Miscellaneous Products (Not Otherwise Covered); Total: All Solvent Types	X	X	Solvent - Consumer & Commercial Solvent Use
2461023000	Miscellaneous Non-industrial: Commercial; Asphalt Roofing; Total: All Solvent Types		X	Solvent - Consumer & Commercial Solvent Use
2461100000	Miscellaneous Non-industrial: Commercial; Solvent Reclamation: All Processes; Total: All Solvent Types		X	Solvent - Consumer & Commercial Solvent Use

The agencies listed in Table 4-170 submitted at least VOC emissions for the EIS sectors discussed in this section: Consumer & Commercial Use, Degreasing, Dry Cleaning, Graphic Arts, Industrial Surface Coating & Solvent Use, and Non-Industrial Surface Coating. Agencies not listed used EPA estimates for the entire sector.

Table 4-170: Agencies that reported emissions for Solvents in the 2017 NEI

Region	Agency	S/L/T	Consumer/ Commercial	Degreasing	Dry Cleaning	Graphic Arts	Industrial Surface Coating	Non-Industrial Surface Coating
1	Massachusetts Department of Environmental Protection	State	X	X		X	X	X
1	New Hampshire Department of Environmental Services	State		X		X	X	X
1	Rhode Island Department of Environmental Management	State	X	X	X	X	X	
2	New Jersey Department of Environment Protection	State	X	X	X	X	X	X
2	New York State Department of Environmental Conservation	State					X	
3	Delaware Department of Natural Resources and Environmental Control	State	X	X	X	X	X	X
3	Maryland Department of the Environment	State	X	X	X	X	X	X
3	Virginia Department of Environmental Quality	State	X	X	X	X	X	X
4	Georgia Department of Natural Resources	State					X	
4	Memphis and Shelby County Health Department - Pollution Control	Local	X	X	X	X	X	X
4	Metro Public Health of Nashville/Davidson County	Local	X	X	X	X	X	X
5	Illinois Environmental Protection Agency	State	X	X	X	X	X	X
5	Minnesota Pollution Control Agency	State	X	X	X	X	X	X
6	Texas Commission on Environmental Quality	State	X	X	X	X	X	X
8	Utah Division of Air Quality	State	X	X	X	X	X	X
9	California Air Resources Board	State	X	X	X	X	X	X
9	Maricopa County Air Quality Department	Local	X	X	X	X	X	X
9	Washoe County Health District	Local	X	X	X	X	X	X

10	Coeur d'Alene Tribe	Tribe	X	X	X	X	X	X
10	Idaho Department of Environmental Quality	State	X	X	X	X	X	X
10	Kootenai Tribe of Idaho	Tribe	X	X			X	X
10	Nez Perce Tribe	Tribe	X	X	X	X	X	X
10	Northern Cheyenne Tribe	Tribe	X					X
10	Oregon Department of Environmental Quality	State	X	X	X	X	X	X
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	X	X	X	X	X	X

4.25.3 EPA-developed emissions

The emissions from solvent use are calculated based on national-level data on solvent use from the Freedonia Group [ref 1]. This data is used to develop emissions factors per capita, per employee, or per lane mile of highway, depending on the SCC. The emissions factors are used to estimate VOC emissions in each county. HAP emissions are estimated using the VOC emissions and HAP speciation factors. Because the data from Freedonia is for total solvent use, point source emissions must be subtracted to estimate the nonpoint source emissions.

4.25.3.1 *Activity data*

The activity data for solvent utilization varies by SCC; it is based on population data from the U.S. Census Bureau, lane miles data from the Federal Highway Administration, or employment data from the U.S. Census Bureau.

<u>Population</u>

The activity data for the categories listed in Table 4-171 are based on county-level population data. Population data are from the U.S. Census Bureau's population estimates for 2017 [ref 2].

Table 4-171: Source Categories That Use Population Activity Data

SCC	Description
2401001000	Architectural Coatings
2401100000	Industrial Maintenance Coatings
2401200000	Other Special Purpose Coatings
2460100000	All Personal Care Products
2460200000	All Household Products
2460400000	All Automotive Aftermarket Products
2460600000	All Adhesives and Sealants
2460800000	All FIFRA Related Products
2460500000	All Coatings and Related Products
2460900000	Misc. Products

<u>Lane Miles</u>

County-level lane mile data are used as activity data for one source category (Table 4-172). The Federal Highway Administration (FHWA) provides state-level lane mile data yearly as part of the Highway Statistics Report [ref 3]. State-level data is allocated to the county level using population data. The process used to distribute the state-level lane miles data to the counties is discussed in section 4.25.3.2.

Table 4-172: Source Categories That Use Lane Mile Activity Data

SCC	Description
2401008000	Traffic Markings

Employment Data

The source categories listed in Table 4-173 use county-level employment data as activity data. Employment data are provided by the U.S. Census Bureau's 2016 County Business Patterns (CBP) [ref 4].

Table 4-173: Source Categories That Use Employment Activity Data

SCC	Description	NAICS
2401005000	Auto Refinishing	81112, 4411, 4412
2401015000	Factory Finished Wood	321
2401020000	Wood Furniture	337110, 337121, 337122, 337127*, 337211, 337212, 337215*
2401025000	Metal Furniture	337124, 337127*, 337214, 337215*
2401030000	Paper	322220
2401040000	Metal Cans	33243
2401055000	Machinery and Equipment	3331, 3332, 3333, 33341
2401060000	Large Appliances	3352
2401065000	Electronics and Other Electrical	331318, 331420, 331491, 335921, 335929, 335311
2401070000	Motor Vehicles	3361, 3362, 3363
2401075000	Aircraft	3364
2401085000	Railroad	3365
2401080000	Marine	3366, 488390
2401090000	Misc. Manufacturing	339, 3369
2415000000	Degreasing: All Processes/All Industrial	331, 332, 333, 334, 335, 336, 337, 339, 441, 483, 484, 485, 488, 8111, 8112
2425000000	Graphic Arts	32311, 322211, 322212, 322219, 322220, 322230, 322291, 322299
2420000000	Dry Cleaning	812320

*Employment data is split equally between Wood Furniture and Metal Furniture source categories

Employment data for select NAICS codes and counties must be allocated based on state-level data. The process used to distribute the state-level amount employment data to the counties is discussed in section 4.25.3.2.

4.25.3.2 *Allocation procedure*

Lane Miles

Lane miles data is published yearly by FHWA at the state-level. Population data is used to allocate the state-level data to the county-level. In order to allocate the state-level data, a fraction of county to state-level population is created.

$$PFrac_c = \frac{P_c}{P_{st}} \tag{1}$$

Where:

$PFrac_c$	=	Population fraction for county c
P_c	=	Population of county c
P_{st}	=	Population of state st where county c is located

This fraction is then applied to the state-level lane miles data to estimate county-level lane miles.

$$LM_c = PFrac_c \times LM_{st} \tag{2}$$

Where:

LM_c	=	Lane-miles in county c
$PFrac_c$	=	Population fraction for county c
LM_{st}	=	Lane miles in state st where county c is located

Employment Data

Employment data are from the U.S. Census Bureau's 2016 CBP. Due to concerns with releasing confidential business information, the CBP does not release exact numbers for a given North American Industrial Classification Standard (NAICS) code if the data can be traced to an individual business. Instead, a series of range codes is used. Many counties and some smaller states have only one business per NAICS code, leading to withheld data in the county and/or state business pattern data. To estimate employment in counties and states with withheld data, the following procedure is used for NAICS code 322220.

To gap-fill withheld state-level employment data:

a. State-level data for states with known employment in NAICS 322220 are summed to the national level.
b. The total sum of state-level known employment from step a is subtracted from the national total reported employment for NAICS 322220 in the national-level CBP to determine the employment total for the withheld states.
c. Each of the withheld states is assigned the midpoint of the range code reported for that state. Table 4-174 lists the range codes and midpoints.
d. The midpoints for the states with withheld data are summed to the national level.
e. An adjustment factor is created by dividing the number of withheld employees (calculated in step b of this section) by the sum of the midpoints (step d).
f. For the states with withheld employment data, the midpoint of the range for that state (step c) is multiplied by the adjustment factor (step e) to calculate the adjusted state-level employment for landfills.

These same steps are then followed to fill in withheld data in the county-level business patterns.

g. County-level data for counties with known employment are summed by state.
h. County-level known employment is subtracted from the state total reported in state-level CBP (or, if the state-level data are withheld, from the state total estimated using the procedure discussed above).
i. Each of the withheld counties is assigned the midpoint of the range code (Table 4-174).
j. The midpoints for the counties with withheld data are summed to the state level.

k. An adjustment factor is created by dividing the number of withheld employees (step h) by the sum of the midpoints (step j).
l. For counties with withheld employment data, the midpoints (step i) are multiplied by the adjustment factor (step k) to calculate the adjusted county-level employment for landfills.

Table 4-174: Ranges and midpoints for data withheld from state and county business patterns

Employment Code	Ranges	Midpoint
A	0-19	10
B	20-99	60
C	100-249	175
E	250-499	375
F	500-999	750
G	1,000-2,499	1,750
H	2,500-4,999	3,750
I	5,000-9,999	7,500
J	10,000-24,999	17,500
K	25,000-49,999	37,500
L	50,000-99,999	75,000
M	100,000+	

For example, take the 2016 CBP data for NAICS 322220 (paper bag and coated and treated paper manufacturing) in Kentucky provided in Table 4-175.

Table 4-175: 2016 County Business Pattern for NAICS 322220 in Kentucky

State FIPS	County FIPS	County Name	NAICS	Employment Code	Employment
21	015	Boone	322220	F	withheld
21	041	Carroll	322220	B	withheld
21	097	Harrison	322220	F	withheld
21	111	Jefferson	322220		391
21	117	Kenton	322220	A	withheld
21	211	Shelby	322220		338
21	213	Simpson	322220	F	withheld
21	219	Todd	322220	B	withheld

Note: Counties in Kentucky that do not have employment in paper bag and coated and treated paper manufacturing are excluded from this table.

1. The total number of known county-level employees in Kentucky is 729.

2. The state-level CBP reports 2,517 employees for NAICS 322220 in Kentucky. This means there are 1,788 employees total for the 6 counties for which data are withheld.

3. The counties with withheld data are assigned midpoints according to their employment code in Table 4-174. For example, Carroll County is given a midpoint of 60 employees (since range code B is 20-99) and Kenton County is given a midpoint of 10 employees.

4. The state total of the midpoints for all withheld counties is 2,380 employees.

5. The adjustment factor is 1,788/2,380 = 0.7513.

6. The adjusted employment for Carroll County is 60 × 0.7513 = 45. Kenton County has an adjusted employment of 10 × 0.7513 = 8 employees.

4.25.3.3 *Emission factors*

Emissions factors for most solvent utilization categories are based on national-level estimates of solvent usage from the Freedonia Group [ref 1]. The Freedonia data includes historical usage of solvents in 2015 and projected solvent usage for 2020. Assuming a linear change in solvent demand, EPA estimated solvent usage for 2017 (Table 4-176).

Table 4-176: Solvent Usage (million lbs) in the US

Description	2015	2017	2020
Paints & Coatings Solvent Demand: Architectural	735	777	840
Paints & Coatings Solvent Demand: Other	1,318	1,321	1,325
Printing Ink Solvent Demand	1,132	1,134	1,138
Cleaning Products Solvent Demand: Household	653	657	662
Cleaning Products Solvent Demand: Industrial & Institutional	385	390	398
Cosmetics & Toiletries Solvent Demand	628	645	670
Adhesives & Sealants Solvent Demand	572	600	643
Transportation Solvent Demand: Motor Vehicles	61	62	64
Dry Cleaning	20	18	16

Table 13, in the document "Solvent NEMO 2017 FINAL_7-8-2019_4-2 updated.docx" on the 2017 NEI Supplemental FTP site, shows a crosswalk between the source categories and the data used to calculate their emissions factors. Some categories, such as personal care products, use only the Freedonia Group data. For these categories, the emissions factor is calculated by dividing the total amount of solvent used by the categories' activity data.

$$EF_s = \frac{F_s \times 1,000,000}{A_s}$$

(3)

Where:
- EF_s = Emissions factor for source category s
- F_s = The Freedonia Group data for source category s, in million pounds per year
- A_s = National-level activity data for source category s, either population, lane miles, or employment

Freedonia data does not include usage estimates for all surface coating categories, therefore, additional data is used to allocate the non-architectural solvent data to the SCC level. A previous version of this methodology used data from the U.S. Census Bureau's report on Paint and Allied Products to determine solvent use from surface coating, but this report was not produced after 2010 [ref 5]. EPA grew the 2010 data from the most recent version of this report to estimate solvent use for surface coating in 2017. The estimated 2017 value is used to calculate the fraction of non-architectural coating use from each source category for surface coating. This

fraction is then applied to total non-architectural solvent demand from the Freedonia Group to calculate 2017 solvent use for surface coating categories.

To grow the 2010 Paint and Allied Products data to 2017, EPA uses the U.S. Census Bureau's Annual Survey of Manufactures data on the value of paint shipments in 2010 and 2016 [ref 6], the most recent data at the time of the publication of this methodology. At the time Using the relevant product codes (see Table 4-177), the value of paint shipments are summed for each category for 2010 and 2016. There are not corresponding product codes for all surface coating SCCs; in these cases, the general paint and coating manufacturing data are used. The 2016 value of shipments for each category are converted to 2010 USD by multiplying by 0.9075, a conversation factor from the U.S. Bureau of Labor Statistics [ref 7].

$$TS_{s,y} = \sum_{NAICS} VS_y \tag{4}$$

$$TS_{s,2016c} = TS_{s,2016} \times 0.9075 \tag{5}$$

Where:

$TS_{s,y}$ = Total value of shipments for source category s in year in year y, in thousand dollars
VS_y = Value of shipments in year y, in thousand dollars
$NAICS$ = NAICS codes corresponding to source category s
$TS_{s,2016c}$ = Total value of shipments for source category s in 2016, converted to 2010 USD

A ratio of the 2010 value of shipments, from the Survey of Manufactures, to 2010 volume of paint, from the Paint and Allied Products report, was then used with the converted 2016 value of shipments to estimate the 2016 volume of paint.

$$VP_{s,2016} = TS_{s,2016c} \times \frac{VP_{s,2010}}{TS_{s,2010}} \tag{6}$$

Where:

$VP_{s,2016}$ = Volume of paint for source category s in 2016, in thousand gallons
$TS_{s,2016c}$ = Total value of shipments for source category s in 2016, converted to 2010 USD
$VP_{s,2010}$ = Volume of paint for source category s in 2010, in thousand gallons
$TS_{s,2010}$ = Total value of shipments for source category s in 2010, in thousand dollars

The estimated volume of paint in 2016 is then used to create a 2016 to 2010 paint ratio (Table 4-177). The paint ratio represents the fraction change in surface coating solvent use in each source category between 2010 and 2016. For example, a paint ratio greater than 1 means there was an increase in solvent use in that source category between 2010 and 2016.

$$PR_s = \frac{VP_{s,2016}}{VP_{s,2010}} \tag{7}$$

Where:

PR_s = 2016-2010 Paint Ratio
$VP_{s,2016}$ = Volume of paint for source category s in 2016, in thousand gallons
$VP_{s,2010}$ = Volume of paint for source category s in 2010, in thousand gallons

Table 4-177: 2016-2010 paint ratio

Product Codes	Description	Paint Ratio
325510	Paint and coating manufacturing	1.246
321	Wood Products	1.327
337	Furniture	1.196
32222/322220	Paper bag and coated and treated paper manufacturing	0.981
332431 & 332439	Metal Can and Container Manufacturing	0.835
3352	Household Appliances	1.121
3361	Motor Vehicle Manufacturing	1.513
3364	Aircraft Manufacturing	1.262
336510	Railroad rolling stock manufacturing	1.461
3366	Boat Manufacturing	1.088
339	Misc. Manufacturing	0.929
3331, 3332, 3333,33341	Machinery Manufacturing	0.901
335921, 335929, 335311	Electronics Manufacturing	0.944

The paint ratios are multiplied by the volume of paint sold in 2010 from the Paint and Allied Products report for each SCC to estimate the volume of paint sold in 2017.

$$VP_{s,2017} = PR_s \times VP_{s,2010}$$ (8)

(8)Where:

$VP_{s,2017}$ = Volume of paint for source category s in 2017, in thousand gallons

PR_s = 2016-2010 Paint Ratio for source category s, from Table 4-177

$VP_{s,2010}$ = Volume of paint for source category s in 2010, in thousand gallons

The total amount of non-architectural coatings from the Paint and Allied Products data [ref 5] is also calculated in order to estimate the fraction of non-architectural coatings for each SCC. The report includes data on the total amount of coatings sold in 2010, as well as the amount of architectural and powder coatings sold; these values are subtracted from the total to estimate the volume of non-architectural coatings (Table 4-178). These values are adjusted to 2017 using the paint and coating manufacturing paint ratio.

$$NAC_{2017} = (TC_{2010} - AC_{2010} - PC_{2010}) \times PR_{paint\ and\ coatings}$$ (9)

Where:

NAC_{2017} = Volume of non-architectural coatings sold in 2017, in gallons

TC_{2010} = Total volume of coatings sold in 2010, in gallons

AC_{2010} = Volume of architectural coatings sold in 2010, in gallons

PC_{2010} = Volume of powder coatings sold in 2010, in gallons

$PR_{paint\ and\ coatings}$ = Paint ratio for paint and coating manufacturing, from Table 4-177

Table 4-178: Coatings sold (gallons) in 2010

Type of Coating	Amount Sold
Volume of Total Coatings Sold	1,301,333,355
Volume of Architectural Coatings	651,626,800
Volume of Powder Coatings	75,774,600

Type of Coating	Amount Sold
Volume of Non-architectural Coatings	573,931,955

The volume of paint sold in 2017 for each SCC (from equation 8) is then divided by the total volume of non-architectural coatings to estimate the fraction of non-architectural paint from each SCC. This fraction is then multiplied by the volume of solvent demand from "paints and coatings: other" for 2017 from Freedonia.

$$NAFrac_s = \frac{VP_{s,2017} \times 1000}{NAC_{2017}} \tag{10}$$

$$SD_{s,2017} = NAFrac_s \times Oth_{2017} \tag{11}$$

Where:

$NAFrac_s$ = Fraction of non-architectural coatings from source category s
$VP_{s,2017}$ = Volume of paint for source category s in 2017, in thousand gallons
NAC_{2017} = Volume of non-architectural coatings sold in 2017, in gallons
$SD_{s,2017}$ = Solvent demand for source category s in 2017, in million pounds
Oth_{2017} = Other paint and coatings solvent demand in 2017 from Freedonia, in million pounds

After solvent use is estimated for each surface coating category, equation 3 is used to calculate the emissions factor for each SCC.

There are three exceptions to this method for surface coating solvents: aircraft coatings, railroad coatings, and other special purpose coatings. Data for solvent use for other special purpose coatings is not available in the 2010 version of the Paint and Allied Products Report. Therefore, data for special purpose coatings from the 2006 version of the report was pulled forward and adjusted to 2017 using the same method as reported above.

The Paint and Allied Products report also aggregates aircraft and railroad coatings in the "other transportation equipment finishes" category. The 2010 volume of paint is grown to 2017 and used to determine solvent demand by the same method as described above. Solvent demand for the other transportation category was then divided in half and assigned equally to the aircraft and railroad SCCs.

Emissions factors for the three Consumer and Commercial categories—including FIFRA related products, coatings and related products, and misc. products—are not estimated by using Freedonia data, but rather come from EPA's Air Emissions Inventory Improvement Program (EIIP) [ref 8].

The architectural coatings, industrial maintenance coatings, and consumer solvents source categories have controlled emissions factors that are used for states that have enacted regulations to control the VOC emissions from these types of solvents. These controlled emissions factors are discussed in section 4.25.3.4. VOC emissions factors for all SCCs in this category are listed in Table 4-179.

Table 4-179: VOC Emissions Factors (lb/each) for Solvent Utilization

SCC	Description	Emissions Factor	Activity Data	Source
2401001000	Architectural Coatings	2.36	Pop.	Freedonia Group, U.S. Census Bureau
2401001000	Architectural Coatings (controlled)	1.88	Pop.	ERTAC, U.S. Census Bureau
2401005000	Auto Refinishing	75.58	Emp.	Freedonia Group, U.S. Census Bureau

SCC	Description	Emissions Factor	Activity Data	Source
2401008000	Traffic Markings	9.80	Lane Miles	Freedonia Group, U.S. Census Bureau
2401015000	Factory Finished Wood	44.71	Emp.	Freedonia Group, U.S. Census Bureau
2401020000	Wood Furniture	282.87	Emp.	Freedonia Group, U.S. Census Bureau
2401025000	Metal Furniture	769.02	Emp.	Freedonia Group, U.S. Census Bureau
2401030000	Paper	398.22	Emp.	Freedonia Group, U.S. Census Bureau
2401040000	Metal Cans	2,239.43	Emp.	Freedonia Group, U.S. Census Bureau
2401055000	Machinery and Equipment	34.28	Emp.	Freedonia Group, U.S. Census Bureau
2401060000	Large Appliances	168.96	Emp.	Freedonia Group, U.S. Census Bureau
2401065000	Electronic and Other Electrical	15.58	Emp.	Freedonia Group, U.S. Census Bureau
2401070000	Motor Vehicles	160.31	Emp.	Freedonia Group, U.S. Census Bureau
2401075000	Aircraft	15.40	Emp.	Freedonia Group, U.S. Census Bureau
2401085000	Railroad	212.90	Emp.	Freedonia Group, U.S. Census Bureau
2401080000	Marine	176.75	Emp.	Freedonia Group, U.S. Census Bureau
2401090000	Misc. Manufacturing	69.99	Emp.	Freedonia Group, U.S. Census Bureau
2401100000	Industrial Maintenance Coatings	0.36	Pop.	Freedonia Group, U.S. Census Bureau
2401100000	Industrial Maintenance Coatings (controlled)	0.15	Pop.	ERTAC, U.S. Census Bureau
2401200000	Other Special Purpose Coatings	0.01	Pop.	Freedonia Group, U.S. Census Bureau
2415000000	Degreasing: All Processes/All Industries	32.36	Emp.	Freedonia Group, U.S. Census Bureau
2425000000	Graphic Arts	1,583.65	Emp.	Freedonia Group, U.S. Census Bureau
2460100000	All Personal Care Products	1.96	Pop.	Freedonia Group, U.S. Census Bureau
2460100000	All Personal Care Products (controlled)	1.15	Pop.	Ozone Transport Commission, U.S. Census Bureau
2460200000	All Household Products	1.99	Pop.	Freedonia Group, U.S. Census Bureau
2460200000	All Household Products (controlled)	1.17	Pop.	Ozone Transport Commission, U.S. Census Bureau
2460400000	All Automotive Aftermarket Products	0.19	Pop.	Freedonia Group, U.S. Census Bureau
2460400000	All Automotive Aftermarket Products (controlled)	0.11	Pop.	Ozone Transport Commission, U.S. Census Bureau
2460600000	All Adhesives and Sealants	1.82	Pop.	Freedonia Group, U.S. Census Bureau
2460600000	All Adhesives and Sealants (controlled)	1.07	Pop.	Ozone Transport Commission, U.S. Census Bureau
2460800000	All FIFRA Related Products	1.78	Pop.	EIIP, III:5, Table 5.4-1

SCC	Description	Emissions Factor	Activity Data	Source
2460800000	All FIFRA Related Products (controlled)	1.05	Pop.	Ozone Transport Commission, U.S. Census Bureau
2460500000	All Coatings and Related Products	0.95	Pop.	EIIP, III:5, Table 5.4-1
2460500000	All Coatings and Related Products (controlled)	0.56	Pop.	Ozone Transport Commission, U.S. Census Bureau
2460900000	Misc. Products	0.07	Pop.	EIIP, III:5, Table 5.4-1
2460900000	Misc. Products (controlled)	0.04	Pop.	Ozone Transport Commission, U.S. Census Bureau
2420000000	Dry Cleaning	20.40	Emp.	Freedonia Group, U.S. Census Bureau*
2420000000	Dry Cleaning	118.35	Emp	Freedonia Group, U.S. Census Bureau*

* Dry cleaning emissions factor assumes that 85 percent of dry cleaning solvents are perchloroethylene, which are not considered VOCs.

4.25.3.4 *Controls*

Some states have regulations that limit the VOC content of solvent-containing products that are sold. In this methodology, these controls are taken into account where appropriate by using the controlled emissions factors shown in Table 4-179. In particular, the emissions factors for architectural coatings and industrial maintenance coatings are reduced for the states listed in Table 4-180, based on calculations done for the 2011 National Emissions Inventory by the Eastern Regional Technical Advisory Committee (ERTAC).

In addition, EPA developed controlled emissions factors for the consumer solvent categories, including personal care products, household products, automotive aftermarket products, adhesives and sealants, FIFRA regulated products, coatings, and miscellaneous consumer products. The controlled emissions factors were taken from the Ozone Transport Commission, based on emissions factors for states that had implemented model rules for consumer solvents [ref 9]. Note that the Ozone Transport Commission includes a single emissions factor for all consumer solvents (5.15 lbs./person), while EPA uses individual emissions factors for each of the seven consumer solvent categories. To estimate controlled emissions factors for the individual solvent categories, the uncontrolled emissions factors were scaled so that the sum of the factors equaled 5.15 lbs./person.

Table 4-180: States for which controlled emissions factors are used

State	Architectural Coatings	Industrial Maintenance Coatings	Consumer Solvents
AZ	ü	ü	
CA	ü	ü	ü
CT	ü	ü	ü
DE	ü	ü	ü
DC	ü	ü	ü
ME	ü	ü	ü
MD	ü	ü	ü
MA	ü	ü	ü
NH	ü	ü	ü
NJ	ü	ü	ü
NY	ü	ü	ü

State	Architectural Coatings	Industrial Maintenance Coatings	Consumer Solvents
PA	ü	ü	ü
RI	ü	ü	ü
TX	ü	ü	
VT	ü	ü	
VA	ü	ü	ü

The solvent tool also allows users to adjust emissions factors to account for controls and to implement a county-level control factor.

4.25.3.5 *Emissions*

Total VOC emissions from solvent utilization are calculated by multiplying the activity data for the source category by the calculated emissions factor for that category.

$$E_{VOCc,s} = A_{c,s} \times EF_{VOC,s} \tag{12}$$

Where:

$E_{VOC,c,s}$ = Annual VOC emissions in county c for source category s, in tons per year
$A_{c,s}$ = Activity data for county c associated with source category s
$EF_{VOC,s}$ = Calculated VOC emissions factor for source category s

HAP emissions are estimated using the VOC emissions and HAP speciation factors shown in Table 4-181. This step is completed after the point source subtraction step discussed in Section 4.25.3.6.

$$E_{p,c,s} = E_{VOC,c,s} \times SF_{p,s} \tag{13}$$

Where:

$E_{p,c,s}$ = Annual emissions of HAP p county c for source category s, in tons per year
$E_{VOC,c,s}$ = Annual VOC emissions in county c for source category s, in tons per year
$SF_{p,s}$ = Speciation factor for HAP p for source category s

Table 4-181: HAP speciation factors for solvent use

SCC	Pollutant Code	Pollutant Description	Speciation Factor
2401001000	123911	1,4-Dioxane (1,4-Diethyleneoxide)	0.00002
2401001000	584849	2,4-Toluene diisocyanate	0.00002
2401001000	101688	4,4'-Methylenediphenyl diisocyanate (MDI)	0.00014
2401001000	75070	Acetaldehyde	0.0001
2401001000	117817	Bis(2-ethylhexyl)phthalate (DEHP)	0.00003
2401001000	98828	Cumene	0.00038
2401001000	84742	Dibutyl phthalate	0.00002
2401001000	131113	Dimethyl phthalate	0.00001

SCC	Pollutant Code	Pollutant Description	Speciation Factor
2401001000	100414	Ethylbenzene	0.00248
2401001000	107211	Ethylene glycol	0.05049
2401001000	50000	Formaldehyde	0.00002
2401001000	171	Glycol Ethers	0.02065
2401001000	110543	Hexane	0.00015
2401001000	67561	Methanol	0.012184699
2401001000	80626	Methyl methacrylate	0.00012
2401001000	108101	Methyl isobutyl ketone(Hexone)	0.000980163
2401001000	91203	Naphthalene	0.00046
2401001000	100425	Styrene	0.00102
2401001000	108883	Toluene	0.0397
2401001000	121448	Triethylamine	0.00006
2401001000	108054	Vinyl acetate	0.00012
2401001000	1330207	Xylenes (mixed isomers)	0.0034
2401020000	75070	Acetaldehyde	0.000009278807
2401020000	98828	Cumene	0.0009639853
2401020000	84742	Dibutyl phthalate	0.00018094569
2401020000	100414	Ethylbenzene	0.019958574
2401020000	107211	Ethylene glycol	0.00033653798
2401020000	67561	Methanol	0.05260697
2401020000	71556	Methyl Chloroform	0.07981741
2401020000	108101	Methyl isobutyl ketone(Hexone)	0.024820633
2401020000	91203	Naphthalene	0.00022361889
2401020000	108883	Toluene	0.15552238
2401020000	1330207	Xylenes (mixed isomers)	0.04961
2401005000	107211	Ethylene glycol	0.0016
2401005000	171	Glycol Ethers	0.00953
2401005000	108101	Methyl isobutyl ketone (Hexone)	0.0103
2401005000	108883	Toluene	0.018
2401005000	1330207	Xylenes (mixed isomers)	0.0034
2401015000	171	Glycol Ethers	0.01382
2401015000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401015000	108883	Toluene	0.0397
2401015000	1330207	Xylenes (mixed isomers)	0.0034
2401100000	171	Glycol Ethers	0.01382
2401100000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401100000	108883	Toluene	0.0397
2401100000	1330207	Xylenes (mixed isomers)	0.0034
2401200000	171	Glycol Ethers	0.01382
2401200000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401200000	108883	Toluene	0.0397

SCC	Pollutant Code	Pollutant Description	Speciation Factor
2401200000	1330207	Xylenes (mixed isomers)	0.0034
2401090000	171	Glycol Ethers	0.01382
2401090000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401090000	108883	Toluene	0.0397
2401090000	1330207	Xylenes (mixed isomers)	0.0034
2401080000	171	Glycol Ethers	0.01382
2401080000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401080000	108883	Toluene	0.0397
2401080000	1330207	Xylenes (mixed isomers)	0.0034
2401085000	171	Glycol Ethers	0.01382
2401085000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401085000	108883	Toluene	0.0397
2401085000	1330207	Xylenes (mixed isomers)	0.0034
2401075000	171	Glycol Ethers	0.01382
2401075000	108101	Methyl isobutyl ketone(Hexone)	0.0397
2401075000	108883	Toluene	0.0397
2401075000	1330207	Xylenes (mixed isomers)	0.0034
2401070000	171	Glycol Ethers	0.01382
2401070000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401070000	108883	Toluene	0.0397
2401070000	1330207	Xylenes (mixed isomers)	0.0034
2401065000	171	Glycol Ethers	0.01382
2401065000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401065000	108883	Toluene	0.0397
2401065000	1330207	Xylenes (mixed isomers)	0.0034
2401060000	171	Glycol Ethers	0.01382
2401060000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401060000	108883	Toluene	0.0397
2401060000	1330207	Xylenes (mixed isomers)	0.0034
2401055000	171	Glycol Ethers	0.01382
2401055000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401055000	108883	Toluene	0.0397
2401055000	1330207	Xylenes (mixed isomers)	0.0034
2401040000	171	Glycol Ethers	0.01382
2401040000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401040000	108883	Toluene	0.0397
2401040000	1330207	Xylenes (mixed isomers)	0.0034
2401030000	171	Glycol Ethers	0.01382
2401030000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401030000	108883	Toluene	0.0397
2401030000	1330207	Xylenes (mixed isomers)	0.0034

SCC	Pollutant Code	Pollutant Description	Speciation Factor
2401025000	171	Glycol Ethers	0.01382
2401025000	108101	Methyl isobutyl ketone(Hexone)	0.0103
2401025000	108883	Toluene	0.0397
2401025000	1330207	Xylenes (mixed isomers)	0.0034
2401008000	108883	Toluene	0.0397
2401008000	1330207	Xylenes (mixed isomers)	0.0034
2415000000	108883	Toluene	0.078204196
2460900000	67561	Methyl Alcohol	0.0933
2460900000	108883	Toluene	0.00268
2460800000	67561	Methyl Alcohol	0.0933
2460800000	108883	Toluene	0.003221139
2460600000	67561	Methyl Alcohol	0.0933
2460600000	108883	Toluene	0.003221139
2460500000	67561	Methyl Alcohol	0.0933
2460500000	108883	Toluene	0.00268
2460400000	107211	Ethylene Glycol	0.1595
2460400000	67561	Methyl Alcohol	0.0933
2460400000	108883	Toluene	0.00268
2460200000	67561	Methyl Alcohol	0.0933
2460200000	108883	Toluene	0.003221139
2460100000	67561	Methyl Alcohol	0.0933
2460100000	108883	Toluene	0.003529334
2460000000	67561	Methyl Alcohol	0.0933
2460000000	108883	Toluene	0.00268
2425000000	67561	Methyl Alcohol	0.02634987
2425000000	108101	Methyl Isobutyl Ketone	0.0004259
2425000000	108883	Toluene	0.0397
2425000000	1330207	Xylene	0.0034
2401015000	107211	Ethylene glycol	0.0045
2401100000	107211	Ethylene glycol	0.0045
2401200000	107211	Ethylene glycol	0.0045
2401090000	107211	Ethylene glycol	0.0045
2401080000	107211	Ethylene glycol	0.0045
2401085000	107211	Ethylene glycol	0.0045
2401075000	107211	Ethylene glycol	0.0045
2401070000	107211	Ethylene glycol	0.0045
2401065000	107211	Ethylene glycol	0.0045
2401060000	107211	Ethylene glycol	0.0045
2401055000	107211	Ethylene glycol	0.0045
2401040000	107211	Ethylene glycol	0.0045
2401030000	107211	Ethylene glycol	0.0045

SCC	Pollutant Code	Pollutant Description	Speciation Factor
2401025000	107211	Ethylene glycol	0.0045
2415000000	110543	N-hexane	0.000057282
2415000000	111773	Methyl carbitol (2-(2-methoxyethoxy)ethanol) (degme)	0.019346982
2415000000	112345	2-(2-butoxyethoxy)ethanol (butyl carbitol)	0.03330946
2415000000	127184	Perchloroethylene (Tetrachloroethylene)	0.010597163
2415000000	1330207	Xylenes (Mixed Isomers)	0.087841886
2415000000	67561	Methyl alcohol (methanol)	0.050236279
2415000000	71432	Benzene	0.001432049
2415000000	71556	1,1,1-trichloroethane	0.053014454
2415000000	75092	Dichloromethane (methylene chloride)	0.00614349
2415000000	79016	Trichloroethylene	0.030201913
2415000000	86748	Carbazole	0.001074037
2415000000	91203	Naphthalene	4.29615E-05
2415000000	98828	Isopropylbenzene (or cumene; 2-Phenylpropane)	4.29615E-05

4.25.3.6 *Point source subtraction*

Point source subtraction is necessary for this category to ensure that solvent emissions are not double counted with the point source inventory. In order to accomplish this, nonpoint source solvent SCCs must be linked to corresponding point SCCs, using point source emissions data supplied by state, local, or tribal (SLT) agencies and a point-nonpoint source crosswalk, shown in Table 14 in the appendix of document "Solvent NEMO 2017 FINAL_7-8-2019_4-2 updated.docx" on the 2017 NEI Supplemental FTP site.

Point source subtraction should be completed at the county level using *uncontrolled* point source emissions.[16]

$$NP_{s,c} = TE_{s,c} \times PS_{s,c} \qquad\qquad (14)$$

Where:

$NP_{s,c}$ = Nonpoint source solvent emissions in county *c* for source category *s*, in tons per year
$TE_{s,c}$ = Total solvent emissions *s* in county *c* for source category *s*, in tons per year
$PS_{s,c}$ = Point source solvent emissions in county *c* for source category *s*, in tons per year

If county-level data is not available, state-level emissions can be allocated to the county level using population or employment data.

Note that if point source subtraction results in a negative number because the point source emissions from solvents are larger than the estimated total emissions from solvents, the Solvent Tool will zero out emissions for that source category in that county.

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[16] There is one point source category for Adhesives and Sealants (40200710) that maps to the nonpoint Adhesives and Sealants category (2460600000). The Solvents methodology assumes that emissions from the nonpoint Adhesives and Sealants category are controlled in some states, as discussed in section 4.25.3.4. However, these controls are specific to consumer solvents, rather than the types of solvents likely used by point sources. Therefore, EPA still recommends subtracting *uncontrolled* point source emissions for this source category.

After point source subtraction, the HAP emissions are speciated from the estimated nonpoint source VOC emissions, as discussed in section 4.25.3.5.

4.25.3.7 *Example calculations*

Table 4-182 lists sample calculations to determine the VOC emissions from traffic coating solvent utilization in Apache County, Arizona.

Table 4-182: Sample calculations for VOC emissions from solvent utilization in Apache County, AZ

Eq. #	Equation	Values for Apache County, AZ	Result
1	$$PFrac_c = \frac{P_c}{P_{st}}$$	$$\frac{71{,}606 \; people \; in \; Apache \; County}{7{,}016{,}270 \; people \; in \; Arizona}$$	0.0102 share of the population of Arizona in Apache County
2	$$LM_c = PFrac_c \times LM_{st}$$	$0.0102 \times 144{,}959 \; lane \; miles \; in \; Arizona$	1,479 lane miles in Apache County
3	$$EF_s = \frac{F_s \times 1{,}000{,}000}{A_s}$$	N/A	Equation 3 is not used at this point in the method for traffic coatings
4	$$TS_{s,y} = \sum_{NAICS} VS_y$$	Product code 325510 is used for traffic coatings	2010 value of shipments is 19,994,229 thousand USD. 2016 value of shipments is 27,445,132 thousand USD
5	$$TS_{s,2016c} = TS_{s,2016} \times 0.9075$$	$27{,}445{,}132 \; thous. \; USD \times 0.9075$	Value of 2016 paint shipments in 2010 USD is 24,906,457 thousand USD
6	$$VP_{s,2016} = TS_{s,2016c} \div \frac{TS_{s,2010}}{VP_{s,2010}}$$	$24{,}906{,}457 \; thous. \, USD \div \dfrac{19{,}994{,}229 \; thous. \, USD}{1{,}301{,}333 \; thous. \, gal. \, paint}$	1,621,048 thousand gallons of paint sold in 2016
7	$$PR_s = \frac{VP_{s,2016}}{VP_{s,2010}}$$	$\dfrac{1{,}621{,}048 \; thous. \, gal. \, of \, paint \; in \; 2016}{1{,}301{,}333 \; thous. \, gal. \, of \, paint \; in \; 2010}$	1.246 ratio of 2016 to 2010 paint
8	$$VP_{s,2017} = PR_s \times VP_{s,2010}$$	$1.246 \times 37{,}335 \; thous. \, gal. \, traffic \; coatings \; sold \; in \; 2010$	46,508 thousand gallons of traffic coatings sold in 2017

Eq. #	Equation	Values for Apache County, AZ	Result
9	$NAC_{2017} = (TC_{2010} - AC_{2010} - PC_{2010}) \times PR_{paint\ and\ coatings}$	$(1{,}301{,}333{,}355\ gal. - 651{,}626{,}800\ gal. - 75{,}774{,}600\ gal.) \times 1.246$	714,936,882 gallons of non-architectural coatings sold in 2017
10	$NAFrac_s = \dfrac{VP_{s,2017} \times 1000}{NAC_{2017}}$	$\dfrac{46{,}508\ thous.\ gal.\ traffic\ coatings \times 1000}{714{,}936{,}882\ gal.\ non-arch.\ coatings}$	6.5% of non-architectural coatings sold in 2017 are traffic coatings
11	$SD_{s,2017} = NAFrac_s \times Oth_{2017}$	$6.5\% \times 1{,}320.80\ mil.\ lbs.\ other\ solvent\ demand\ in\ 2017$	85.92 million pounds of traffic coating solvent demand in 2017
3	$EF_s = \dfrac{F_s \times 1{,}000{,}000}{A_s}$	$\dfrac{85.92 mil.\ lbs.\ traffic\ coatings\ sold\ in\ 2017 \times 1{,}000{,}000}{8{,}765{,}578\ lane\ miles\ in\ 2017}$	9.80 pounds of VOC emitted per lane mile
12	$E_{VOCc,s} = A_{c,s} \times EF_{VOC,s}$	$1{,}479\ lane\ miles \times 9.80\ lbs.\ VOC\ per\ lane\ mile$	14,498 lbs. of VOC emitted from traffic coatings in Apache County, AZ

4.25.3.8 *Changes from the 2014 methodology*

There are no significant changes from the methodology used to calculate the 2014 v2 NEI emissions.

4.25.3.9 *Puerto Rico and U.S. Virgin Islands*

Emissions from Puerto Rico are calculated using the same method described above. For the U.S. Virgin Islands, emissions are calculated using 2010 population data [ref 10], because 2016 Census Data does not exist for the U.S. Virgin Islands.

4.25.4 References

1. The Freedonia Group. 2016. Industry Study #3429, Solvents.
2. U.S. Census Bureau. 2017 Total Population, American Community Survey.
3. Federal Highway Administration. Highway Statistics 2017, section 4.4.1.4.
4. U.S. Census Bureau. 2016 County Business Patterns.
5. U.S. Census Bureau. 2010. MA325F: Paints and Allied Products.
6. U.S. Census Bureau. 2016. Annual Survey of Manufactures.
7. U.S. Bureau of Labor Statistics. CPI Inflation Calculator.
8. U.S. Environmental Protection Agency. 1996. Air Emissions Inventory Improvement Program (EIIP), Volume III: Chapter 5 Consumer and Commercial Solvent Use.
9. Ozone Transport Commission. 2016. Technical Support Document for the 2011 Ozone Transport Commission/Mid-Atlantic Northeastern Visibility Union Modeling Platform. Appendix A.
10. U.S. Census Bureau, Decennial Censuses, 2010 Census: Summary File 1.

4.26 Waste Disposal: Composting

There are four sections in this documentation that discuss nonpoint inventory Waste Disposal. This section discusses Composting, the next section (4.27) discusses Open Burning, and the third section (4.28) discusses Publicly-Owned Treatment Works (POTWs), and the fourth section was a broad discussion of nonpoint non-combustion sources of mercury (see Section 4.2), which included several Waste Disposal sector sources. The reason these sources are broken up within this EIS sector is because the EPA methodologies for estimating the emissions are different.

4.26.1 Source category description

Greenwaste composting includes the diversion of yard waste, food waste, and other biogenic waste from landfills to composting facilities. Estimates of emissions of volatile organic compounds (VOC), ammonia (NH3), and three hazardous air pollutants (HAPs), acetaldehyde; methanol; and naphthalene, from greenwaste composting are based on the amount of food and yard waste composted. Composting of biogenic waste is currently not included in emissions estimates for this category as activity data on this waste type is not available.

Note that this source category does <u>not</u> include the composting of biosolids from wastewater treatment plants or manure management facilities. There are separate SCCs for biosolids (2680001000) and for a mixture of greenwaste and biosolids (2680002000). EPA is not currently estimating emissions for these SCCs. If S/L/Ts report any emissions for the mixture SCC, emissions from the greenwaste portion of that mixture may be duplicative of some or all of the EPA emissions estimates described here. Note also that this source category estimates emissions from composting facilities but does <u>not</u> estimate emissions from backyard composting.

4.26.2 Sources of data

Table 4-183 shows, for composting, the SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The SCC level 3 and 4 SCC descriptions are also provided. The SCC level 1 and leading level 2 descriptions is "Waste Disposal, Treatment, and Recovery; Composting:" for all SCCs.

Table 4-183: Composting SCCs in the 2017 NEI

SCC	Description	EPA	S/L/T
2680001000	100% Biosolids (e.g., sewage sludge, manure, mixtures of these matls); All Processes		X
2680002000	Mixed Waste (e.g., a 50:50 mixture of biosolids and green wastes); All Processes		X
2680003000	100% Green Waste (e.g., residential or municipal yard wastes); All Processes	X	X

The agencies listed in Table 4-184 submitted emissions for composting in the 2017 NEI. Agencies not listed used EPA estimates unless they responded "No…" in the nonpoint survey.

Table 4-184: Agencies reporting composting emissions in the 2017 NEI

Region	Agency	100% Green Waste	100% Biosolids	Mixed Waste
1	Massachusetts Department of Environmental Protection	X		
4	Louisville Metro Air Pollution Control District	X		
4	Memphis and Shelby County Health Department - Pollution Control	X		
4	Metro Public Health of Nashville/Davidson County	X		
4	North Carolina Department of Environmental Quality			X

7	Iowa Department of Natural Resources	X		
8	Utah Division of Air Quality	X		
9	California Air Resources Board		X	
9	Maricopa County Air Quality Department	X		
10	Nez Perce Tribe	X		

4.26.3 EPA-developed emissions

The calculations for estimating the emissions from greenwaste composting involve first estimating the amount of food and yard waste composted in each county. The amount of state-level food waste composted is available from the EPA report *Food Waste Management in the United States, 2014* [ref 1]. The amount of state-level yard waste composted is estimated by calculating the per-capita amount of yard waste composted using national data from the EPA report *Advancing Sustainable Materials Management: 2015 Fact Sheet* [ref 2] and multiplying that by the state population. The state-level yard and food waste are summed together and distributed to the counties based on the proportion of employment at solid waste landfills. The total amount of greenwaste composted is multiplied by emissions factors for VOC and NH3 to estimate emissions of these pollutants from greenwaste composting.

4.26.3.1 *Activity Data*

The activity data for this source category is the amount of food and yard waste composted, which is estimated using data from two EPA reports: the national-level amount of yard waste composted comes from *Advancing Sustainable Materials Management: 2015 Fact Sheet* and the state-level amount of food waste composted comes from *Food Waste Management in the United States, 2014* [ref 1, ref 2]. Table 4-185 shows the total national-level amount of yard waste generated and recovered for composting.

Table 4-185: Annual Waste (million tons) generated and recovered in the US in 2015

Material	Waste Generated	Waste Recovered
Yard trimmings	34.72	21.29

The values from Table 4-185 are used with the U.S. population in 2017 of 329 million people [ref 3] to determine per-capita values of food and yard waste recovered for composting.

$$PC_{yard,US} = \frac{W_{yard,US}}{P_{US}}$$

(1)

Where:

$PC_{yard,US}$ = Per-capita yard waste recovered for composting in the US, in tons per person per year
$W_{yard,US}$ = Total annual yard waste recovered in the US, in tons/year
P_{US} = US population

This calculation results in per-capita values of approximately 0.066 tons per person per year of yard waste recovered for composting. Please note that EPA data on composting does not include backyard composting.

The per-capita yard waste values from equation 1 are multiplied by the population of each state to estimate the state-level amount of yard waste recovered for composting.

$$W_{yard,s} = PC_{yard,US} \times P_s \qquad (2)$$

Where:

$W_{yard,s}$ = Annual yard waste recovered for composting in state s, in tons
$PC_{yard,US}$ = Per-capita yard waste recovered for composting in the US, in tons per person per year
P_s = Population of state s

EPA reports the amount of food waste composted at the state level in the report *Food Waste Management in the United States, 2015* [Table 3 in ref 1]. These values are shown in Table 4-186. EPA collected these data from state environmental websites and contacts with state agencies. The data year for each state is listed and represents the latest data available. The data were not altered from the original reference for use in this methodology.

Table 4-186: State-level food waste composting (tons)

State	Food Composted	Data Year	State	Food Composted	Data Year
California	715,119	2012	Nevada	35,869	2014
Colorado	29,130	2013	New Hampshire	110	2012
Connecticut	4,644	2013	New Jersey	28,634	2012
Delaware	17,626	2013	New York	44,405	2013
Florida	158,711	2014	North Carolina	38,014	2014
Georgia	8,021	2014	Ohio	81,450	2014
Hawaii	39,287	2014	Oregon	50,143	2013
Indiana	13,525	2013	Pennsylvania	56,851	2013
Iowa	4,334	2010	Rhode Island	150	2014
Kansas	1,127	2010	South Carolina	4,277	2014
Maine	1,658	2010	Tennessee	1,500	2013
Maryland	69,643	2014	Texas	188	2012
Massachusetts	2,753	2014	Vermont	14,738	2013
Michigan	8,700	2013	Virginia	2,454	2014
Minnesota	46,751	2013	Washington	65,221	2013
Mississippi	242	2013	Wisconsin	8,677	2013
Missouri	16,000	2014	**Total**	**1,569,952**	

The state-level amount of total greenwaste composted is the sum of the state-level food and yard waste composted.

$$W_{GW,s} = W_{yard,s} + W_{food,s} \qquad (3)$$

Where:

$W_{GW,s}$ = Annual total greenwaste recovered for composting in state s, in tons
$W_{yard,s}$ = Annual yard waste recovered for composting in state s, in tons
$W_{food,s}$ = Annual food waste recovered for composting in state s, in tons, from Table 4-186

The process used to distribute the state-level amount of greenwaste composted to the counties is discussed in next section.

4.26.3.2 *Allocation Procedure*

Comprehensive data on the county locations of composting facilities is not available. As a result, the analysis assumes that greenwaste composting facilities are co-located with solid waste landfills.

State-level food greenwaste composting activity (from equation 3) is allocated to the county-level using employment at solid waste landfills (NAICS code 562212). Specifically, state-level estimates of greenwaste collected for composting are multiplied by the ratio of county- to state- level number of employees at landfills.

$$EmpFrac_c = \frac{Emp_c}{Emp_s} \tag{4}$$

Where:

$EmpFrac_c$	=	The fraction of landfill employees in county c
Emp_c	=	The number of landfill employees in county c
Emp_s	=	The number of landfill employees in state s

Employment data are from the U.S. Census Bureau's 2016 County Business Patterns (CBP) [ref 4]. Due to concerns with releasing confidential business information, the CBP does not release exact numbers for a given NAICS code if the data can be traced to an individual business. Instead, a series of range codes is used. Many counties and some smaller states have only one solid waste landfill, leading to withheld data in the county and/or state business pattern data. To estimate employment in counties and states with withheld data, the following procedure is used for NAICS code 562212.

To gap-fill withheld state-level employment data:

   a. State-level data for states with known employment in NAICS 562212 are summed to the national level.
   b. The total sum of state-level known employment from step a is subtracted from the national total reported employment for NAICS 562212 in the national-level CBP to determine the employment total for the withheld states.
   c. Each of the withheld states is assigned the midpoint of the range code reported for that state. Table 4-187 lists the range codes and midpoints.
   d. The midpoints for the states with withheld data are summed to the national level.
   e. An adjustment factor is created by dividing the number of withheld employees (calculated in step b of this section) by the sum of the midpoints (step d).
   f. For the states with withheld employment data, the midpoint of the range for that state (step c) is multiplied by the adjustment factor (step e) to calculate the adjusted state-level employment for landfills.

These same steps are then followed to fill in withheld data in the county-level business patterns.

   g. County-level data for counties with known employment are summed by state.
   h. County-level known employment is subtracted from the state total reported in state-level CBP (or, if the state-level data are withheld, from the state total estimated using the procedure discussed above).
   i. Each of the withheld counties is assigned the midpoint of the range code (Table 4-187).
   j. The midpoints for the counties with withheld data are summed to the state level.

k. An adjustment factor is created by dividing the number of withheld employees (step h) by the sum of the midpoints (step j).
l. For counties with withheld employment data, the midpoints (step i) are multiplied by the adjustment factor (step k) to calculate the adjusted county-level employment for landfills.

Table 4-187: Ranges and midpoints for data withheld from state and county business patterns

Employment Code	Ranges	Midpoint
A	0-19	10
B	20-99	60
C	100-249	175
E	250-499	375
F	500-999	750
G	1,000-2,499	1,750
H	2,500-4,999	3,750
I	5,000-9,999	7,500
J	10,000-24,999	17,500
K	25,000-49,999	37,500
L	50,000-99,999	75,000
M	100,000+	

For example, take the 2016 CBP data for NAICS 562212 (Landfills) in Arizona provided in Table 4-188.

Table 4-188: 2016 County Business Pattern for NAICS 562212 in Arizona

State FIPS	County FIPS	County Name	NAICS	Employment Code	Employment
04	001	Apache	562212	B	withheld
04	007	Gila	562212	A	withheld
04	012	La Paz	562212	A	withheld
04	013	Maricopa	562212		296
04	015	Mohave	562212	B	withheld
04	017	Navajo	562212	B	withheld
04	021	Pinal	562212		40
04	023	Santa Cruz	562212		withheld
04	025	Yavapai	562212	A	withheld
04	027	Yuma	562212	B	withheld

Note: Counties in Arizona that do not have employment in solid waste landfills are excluded from this table.

13. The total number of known county-level employees in Arizona is 336.

14. The state-level CBP reports 522 employees for NAICS 562212 in Arizona. This means there are 186 employees total for the 8 counties for which data are withheld.

15. The counties with withheld data are assigned midpoints according to their employment code in Table 4-187. For example, Apache County is given a midpoint of 60 employees (since range code B is 20-99) and Gila County is given a midpoint of 10 employees.

16. The state total of the midpoints for all withheld counties is 270 employees.

17. The adjustment factor is 186/272 = 0.6889.

18. The adjusted employment for Apache County is 60 × 0.6889 = 41. Gila County has an adjusted employment of 10 × 0.6889 = 7 employees.

Once county- and state-level employment have been estimated, the ratio of county to state employees (from equation 4) is calculated and multiplied by the state-level greenwaste recovered for composting (from equation 3) to calculate the amount of waste composted in each county.

$$W_{GW,c} = EmpFrac_c \times W_{GW,s} \tag{5}$$

Where:

$W_{GW,c}$ = Annual total greenwaste composted in county c, in tons
$W_{GW,s}$ = Annual total greenwaste recovered for composting in state s, in tons
$EmpFrac_c$ = The fraction of landfill employees in county c

4.26.3.3 *Emissions Factors*

Emissions factors for greenwaste composting are reported in Table 4-189. The emissions factors for VOC and ammonia (NH3) are taken from the California Air Resources Board Emissions Inventory Methodology for Composting Facilities [ref 5] and are unaltered from the original reference. The emissions factors for the HAPs (acetaldehyde, methanol, and naphthalene) are taken from Kumar et al [ref 6].

Table 4-189: Emissions Factors for Composting of Greenwaste (2680003000)

Pollutant	Pollutant Code	Emissions Factor	Emissions Factor Units	Emissions Factor Reference
VOC	VOC	4.67	lbs./ton compost	5
Ammonia	NH3	0.66		
Acetaldehyde	75070	0.0014	lbs./lbs. VOC	6
Methanol	67561	0.1279		
Naphthalene	91203	0.005		

4.26.3.4 *Controls*

There are no controls assumed for this category.

4.26.3.5 *Emissions*

The total annual greenwaste composted in each county is multiplied by the emissions factors in The ammonia emissions factor was obtained from an EPA report [ref 4] and the VOC emissions factor was based on a TriTAC study [ref 5]. Emissions factors for HAPs were derived using 1996 area source emissions estimates that were provided by Bob Lucas [ref 6] and the 1996 nationwide flow rate [ref 7]. These HAP emissions factors were then multiplied by the 2008 to 2002 VOC emissions factor ratio (0.85/9.9) to obtain the final HAP emissions factors applied in the 2017 inventory.

 to estimate emissions. For VOC and NH3, the emissions are multiplied by a conversion factor to convert from pounds to tons.

$$E_{p,c} = W_{GW,c} \times EF_p \times \frac{1\ ton}{2000\ lbs.} \tag{6}$$

Where:

$E_{p,c}$	=	Annual emissions of pollutant p in county c, in tons for VOC and NH3 and lbs. for HAPs
$W_{GW,c}$	=	Annual total greenwaste recovered for composting in state s, in tons
EF_p	=	Emissions factor for pollutant p, in tons of pollutant per ton of greenwaste composted

Emissions of HAPs are estimated by applying speciation factors found in Table 4-189 to annual VOC emissions. For HAPS, no conversion factor is needed, and the emissions are reported in tons.

$$E_{h,c} = E_{VOC,c} \times SF_h \tag{7}$$

Where:

$E_{h,c}$	=	Annual emissions of HAP h in county c, in tons per year
$E_{VOC,c}$	=	Annual VOC emissions in county c, in tons
SF_h	=	Speciation factor for HAP h, in tons of HAP emissions per ton of VOC emissions

4.26.3.6 *Sample Calculations*

Table 4-190 lists sample calculations to determine the VOC emissions from composting of greenwaste in Apache County, Arizona.

Table 4-190: Sample calculations for VOC emissions from greenwaste composting in Apache County, AZ

Eq. #	Equation	Values for Apache County, AZ	Result
1	$PC_{yard,US} = \dfrac{W_{yard,US}}{P_{US}}$	$\dfrac{21.08\ million\ tons\ yard\ waste}{329\ million\ people}$	0.064 tons yard waste per person per year
2	$W_{yard,s} = PC_{yard,US} \times P_s$	$0.064\ tons\ yard\ waste\ per\ person$ $\times\ 7{,}016{,}270\ people\ in\ AZ$	449,041 tons yard waste composted in AZ
3	$W_{GW,s} = W_{yard,s} + W_{food,s}$	$449{,}041\ tons\ yard\ waste$ $+\ 0\ tons\ food\ waste$	443,520 tons green-waste composted in AZ
4	$EmpFrac_c = \dfrac{Emp_c}{Emp_s}$	$\dfrac{41\ employees\ in\ Apache\ County}{522\ employees\ in\ AZ}$	0.079 fraction of solid waste employees in Apache County, AZ
5	$W_{GW,c} = EmpFrac_c \times W_{GW,s}$	$0.079\ fraction$ $\times\ 443{,}520\ tons\ greenwaste\ composted$	35,038 tons greenwaste composted in Apache County, AZ

Eq. #	Equation	Values for Apache County, AZ	Result
6	$E_{p,c} = W_{GW,c} \times EF_p$ $\times \dfrac{1\ ton}{2000\ lbs.}$	35,038tons greenwaste $\times\ 4.67\ lbs.\ VOC\ per\ ton\ greenwaste$ $\times \dfrac{1\ ton}{2000\ lbs.}$	82 tons VOC emissions from greenwaste composting in Apache County, AZ

4.26.3.7 *Changes from 2014 Methodology*

There are no significant changes from the methodology used to calculate the 2014 v2 NEI emissions.

4.26.3.8 *Puerto Rico and U.S. Virgin Islands Emissions Calculations*

Emissions from Puerto Rico are calculated using the same method described above. For the U.S. Virgin Islands, emissions are calculated using 2010 population data [ref 7], since 2014 Census Data does not exist for the U.S. Virgin Islands.

4.26.4 References

1. U.S. EPA. 2016. Food Waste Management in the United States, 2014. Office of Resource Conservation and Recovery.
2. U.S. EPA. 2018. Advancing Sustainable Materials Management: Facts and Figures Report, 2015 Facts and Figures Sheet, Table1. Generation, Recovery, and Discards of Products in MSW, 2015.
3. U.S. Census Bureau. 2017 Total Population, American Community Survey.
4. U.S. Census Bureau. 2016 County Business Patterns.
5. California Air Resources Board. 2015. ARB Emissions Inventory Methodology for Composting Facilities. Table A-4. Emission factor data taken from Draft Staff Report on Proposed Amended Rule 1133.1 (chipping and grinding activities) and Proposed Rule 1133.3 (emissions reductions from greenwaste composting operations),Table III-3.
6. Kumar, A., C.P. Alaimo, R. Horowitz, F.M. Mitloehner, M.J. Kleeman, and P.G. Green. 2011. Volatile organic compound emissions from green waste composting: Characterization and ozone formation. Atmospheric Environment, 45:1841-1848.
7. U.S. Census Bureau, Decennial Censuses, 2010 Census: Summary File 1.

4.27 Waste Disposal: Open Burning

4.27.1 Source category description

This source category includes several types of intentional burning for waste disposal purposes, except for agricultural purposes. This source category includes open burning of municipal solid waste, land clearing debris, and different types of yard waste.

Open burning of yard waste is the purposeful burning of leaf and brush species in outdoor areas, and emission estimates for leaf and brush waste burning are a function of the amount of waste burned per year. Open burning of land clearing debris is the purposeful burning of debris, such as trees, shrubs, and brush, from the clearing of land for the construction of new buildings and highways. Emission estimates from open burning of land clearing debris are a function of the amount of material or fuel subject to burning per year. Open burning of residential household waste (RHW) is the purposeful burning of RHW in outdoor areas. Emission estimates for RHW burning are a function of the amount of waste burned per year.

4.27.2 Sources of data

Table 4-191 shows, for open burning, the nonpoint SCCs in the 2017 NEI, whether generated by EPA, or provided by SLTs. The SCC level 3 and 4 descriptions are also provided and the SCC level 1 and 2 descriptions are "Waste Disposal, Treatment, and Recovery; Open Burning" for all SCCs.

Table 4-191: Open burning SCCs in the 2017 NEI

SCC	Description	EPA	S/L/T
2610000100	All Categories; Yard Waste - Leaf Species Unspecified	X	X
2610000300	All Categories; Yard Waste - Weed Species Unspecified (incl Grass)		X
2610000400	All Categories; Yard Waste - Brush Species Unspecified	X	X
2610000500	All Categories; Land Clearing Debris (use 28-10-005-000 for Logging Debris Burning)	X	X
2610030000	Residential; Household Waste (use 26-10-000-xxx for Yard Wastes)	X	X

The agencies listed in Table 4-192 submitted emissions for the three types of open burning discussed in this section: residential household waste, yard waste (leaf, weed and brush), and land clearing debris. Some agencies submitted emissions with zero emissions for some sources. Agencies not listed used EPA estimates for these sources.

Table 4-192: Agencies that reported emissions for Open Burning in the 2017 NEI

Agency	Household Waste	Yard Waste	Land Clearing Debris
California Air Resources Board	X	X	
Coeur d'Alene Tribe	X	X	X
Delaware Department of Natural Resources and Environmental Control	X	X	X
Georgia Department of Natural Resources			X
Idaho Department of Environmental Quality	X	X	
Illinois Environmental Protection Agency	X	X	X
Kootenai Tribe of Idaho	X	X	X
Maricopa County Air Quality Department	0		X
Maryland Department of the Environment	X	X	X
Memphis and Shelby County Health Department - Pollution Control			X
Metro Public Health of Nashville/Davidson County	X	X	X
Minnesota Pollution Control Agency	X		
New Jersey Department of Environment Protection	X	X	0
New York State Department of Environmental Conservation		X	
Nez Perce Tribe	X	X	X
North Carolina Department of Environmental Quality	X	X	X
Northern Cheyenne Tribe	X	X	
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	X	X	X

Agency	Household Waste	Yard Waste	Land Clearing Debris
Texas Commission on Environmental Quality	X	X	
Utah Division of Air Quality	X	X	0
Washington State Department of Ecology	X		X
Washoe County Health District	X	X	

4.27.3 EPA-developed emissions for yard waste

The calculations for estimating the emissions from the burning of yard waste involve first estimating the amount of leaf and brush waste generated in each county. The amount of waste generated in the U.S. is available from the EPA report *Advancing Sustainable Materials Management: 2015 Fact Sheet* [ref 1]. The amount of county-level yard waste burned is estimated by calculating the per capita amount of leaf and brush waste generated using the national data from the EPA report, and multiplying that by the number of people likely to burn waste in each county. The number of people likely to burn waste is based on the rural population in each county from the 2010 census. The total amount of yard waste burned is multiplied by emissions factors for criteria air pollutants (CAPs) and hazardous air pollutants (HAPs) to estimate emissions of these pollutants from yard waste burning.

4.27.3.1 *Activity data*

The activity data for this source category is the amount of leaf and brush waste generated, which is estimated using data the EPA report *Advancing Sustainable Materials Management: 2015 Fact Sheet* [ref 1]. The report presents the total mass of waste generated from the residential and commercial sectors in the United States by type of waste for the calendar year 2015.

Table 4-193 shows the national-level yard waste generated and the corresponding per capita values. The per capita value of yard waste subject to burning was developed based on EPA's total amount of waste generated {Table 1 in ref 1]. According to the 2010 version of the same EPA report, residential waste generation accounts for 55-65% of the total waste from the residential and commercial sectors [ref 2]; for the per capita calculation, the median value of 60% of total waste generated is assumed. This number is multiplied by the amount of yard waste generated and divided by the U.S. population in 2015 (319 million people) [ref 3] to determine the per capita amount of yard waste generated in the United States.

$$PC_{yw} = \frac{YW \times 0.60}{P_{y,US}} \tag{1}$$

Where:

PC_{yw} = Per capita value of yard waste in the US, in tons per person
YW = Annual yard waste generated, in million tons
$P_{y,US}$ = Population of the US for year of inventory, in million people

The per capita value of yard waste is estimated to be 0.065 tons per person in 2015.

Table 4-193: Annual Waste Generated in the US in 2015

Material	Weight Generated (million tons)	Tons per person
Yard	34.50	0.065

As open burning is generally not practiced in urbanized areas, only the rural population in each county is assumed to practice open burning. The rural and urban populations are taken from 2010 U.S. Census data [ref 4]. It is assumed that 24% of the rural population burns yard waste [ref 5].

$$PBurn_c = RPop_c \times 0.24 \tag{2}$$

Where:

$PBurn_c$ = Population likely to burn in county c
$RPop_c$ = Rural population in county c in 2010

The number of people likely to burn waste in each county (from equation 2) is then used with the value of per capita yard waste generated (from equation 1) and two assumptions to determine the amount of leaf and brush waste burned. The first assumption concerns the composition of yard waste; of the total amount of yard waste generated, yard waste composition is assumed to be 25 percent leaves, 25 percent brush, and 50 percent grass by weight [ref 6]. However, open burning of grass clippings is not typically practiced by homeowners, and as such only estimates for leaf burning and brush burning are developed.

The second assumption adjusts for variations in vegetation; the percentage of forested acres (including rural forest and urban forest) is determined using Version 2 of the Biogenic Emission Landuse Database (BELD2) within the Biogenic Emissions Inventory System (BEIS). Based on this percentage, county-level yard waste values are adjusted according to the values in Table 4-194. To better account for the native vegetation that likely occurs in residential yards of farming states, agricultural land acreage is subtracted before calculating the percentage of forested acres. All municipios in Puerto Rico and counties in the U.S. Virgin Islands, Hawaii, and Alaska were assumed to have greater than 50 percent forested acres.

$$LW_c = PBurn_c \times PC_{yw} \times YWFr_t \times AF_{fa,c} \tag{3}$$

$$BW_c = PBurn_c \times PC_{yw} \times YWFr_t \times AF_{fa,c} \tag{4}$$

Where:

LW_c = Annual leaf waste burned in county c, in tons
BW_c = Annual brush waste burned in county c, in tons
$PBurn_c$ = Population likely to burn in county c, from equation 2
PC_{yw} = Per capita value of yard waste in the US, in tons per person, from equation 1
$YWFr_t$ = Fraction of total yard waste for waste type t (leaf or brush)
$AF_{fa,c}$ = Adjustment factor based on percent of forested acres in county c, from Table 4-194

Table 4-194: Adjustment for Percentage of Forested Acres

Percent Forested Acres per County	Adjustment for Yard Waste Generated
< 10%	0% generated

Percent Forested Acres per County	Adjustment for Yard Waste Generated
≥ 10% & < 50%	50% generated
≥ 50%	100% generated

4.27.3.2 *Allocation procedure*

National values for the amount of waste generated are distributed to the counties based on rural population, as described in Section 4.27.3.1.

4.27.3.3 *Emission factors*

Emissions factors for open burning of yard are reported in Table 4-195 and Table 4-196. The emissions factors for CAPs are from AP-42 [ref 7], the emissions inventory improvement program [ref 8], and an ERTAC workgroup [ref 10]. For burning of leaves, emissions factors for PM25 are calculated by multiplying the PM10 emissions factor by a ratio of 0.7709. Emissions factors for HAPs are from an EPA Control Technology Center report [ref 9].

Table 4-195: Emissions Factors for Open Burning of Leaf Species

Pollutant	Pollutant Code	Emission Factor (original)	Emission Factor Units (original)	Emission Factor (converted)	Emission Factor Units (converted)	Reference & Table No.
CO	CO	112	lbs./ton	--	--	Reference 7, Table 2.5-6
Nitrogen Oxides	NOX	6.2	lbs./ton	--	--	Reference 10
PM10-FIL	PM10-FIL	38	lbs./ton	--	--	Reference 7, Table 2.5-6
PM10-PRI	PM10-PRI	38	lbs./ton	--	--	Reference 7, Table 2.5-6
PM25-FIL	PM25-FIL	29.3	lbs./ton	--	--	0.7709 * PM10
PM25-PRI	PM25-PRI	29.3	lbs./ton	--	--	0.7709 * PM10
Sulfur Dioxide	SO2	0.76	lbs./ton	--	--	Reference 10
VOC	VOC	28	lbs./ton	--	--	Reference 7, Table 2.5-6
Cumene	98828			0.01325	lbs./ton	Reference 9
Ethyl Benzene	100414			0.048	lbs./ton	Reference 9
Phenol	108952			0.115	lbs./ton	Reference 9
Styrene	100425			0.1015	lbs./ton	Reference 9

Table 4-196: Emissions Factors for Open Burning of Brush Species

Pollutant	Pollutant Code	Emission Factor (original)	Emission Factor Units (original)	Emission Factor (converted)	Emission Factor Units (converted)	Reference & Table No.
CO	CO	140	lbs./ton	--	--	Reference 7, Table 2.5-5
Nitrogen Oxides	NOX	5	lbs./ton	--	--	Reference 10
PM10-PRI	PM10-PRI	17	lbs./ton	--	--	Reference 8
PM10-FIL	PM10-FIL	17	lbs./ton	--	--	Reference 8

Pollutant	Pollutant Code	Emission Factor (original)	Emission Factor Units (original)	Emission Factor (converted)	Emission Factor Units (converted)	Reference & Table No.
PM25-PRI	PM25-PRI	13.1	lbs./ton	--	--	0.7709 * PM10
PM25-FIL	PM25-FIL	13.1	lbs./ton	--	--	0.7709 * PM10
Sulfur Dioxide	SO2	1.66	lbs./ton	--	--	Reference 10
VOC	VOC	28	lbs./ton	--	--	Reference 7, Table 2.5-5
Cumene	98828			0.01325	lbs./ton	Reference 9
Ethyl Benzene	100414			0.048	lbs./ton	Reference 9
Phenol	108952			0.115	lbs./ton	Reference 9
Styrene	100425			0.1015	lbs./ton	Reference 9

4.27.3.4 Controls

Controls for residential yard waste burning are generally in the form of a ban on open burning of waste in a given municipality or county. However, literature suggests that burn bans are not 100% effective. It is therefore assumed that approximately 25% of the residents that may burn yard waste would burn do so even if a ban is in place. For counties that have burn bans, the assumption is applied by multiplying 0.25 by the annual waste burned. Currently no counties are assumed to have burn bans in place.

$$If\ county\ c\ has\ a\ burn\ ban \tag{5}$$
$$Then\ LW_c = LW_c \times 0.25$$

$$If\ county\ c\ has\ a\ burn\ ban \tag{6}$$
$$Then\ BW_c = BW_c \times 0.25$$

Where:

LW_c = Annual leaf waste burned in county c, in tons
BW_c = Annual brush waste burned in county c, in tons

4.27.3.5 Emissions

The annual amount of leaf and brush waste burned in each county is multiplied by the emissions factors listed in Table 4-195 and Table 4-196 to estimate emissions. Emissions for leaves and residential brush are calculated separately, since emission factors vary by yard waste type.

$$E_{p,c} = LW_c \times EF_p \tag{7}$$

$$E_{p,c} = BW_c \times EF_p \tag{8}$$

Where:

$E_{p,c}$ = Annual emissions of pollutant p in county c
LW_c = Annual leaf waste burned in county c, in tons
BW_c = Annual brush waste burned in county c, in tons
EF_p = Emission factor for pollutant p, in lbs. of pollution per ton of waste burned

4.27.3.6 *Example calculations*

Table 4-197 lists sample calculations to determine the CO emissions from open burning of yard waste in Autauga County, Alabama.

Table 4-197: Sample calculations for CO emissions from open burning in Autauga County, AL

Eq. #	Equation	Values for Autauga County, AL	Result
1	$$PC_{yw} = \frac{YW \times 0.60}{P_{y,US}}$$	$$\frac{34.5\ million\ tons \times 0.60}{318.85\ million\ people}$$	0.065 tons yard waste per person per year
2	$$PBurn_c = RPop_c \times 0.24$$	$22,921\ people \times 0.24$	5,501 people likely to burn in Autauga County, AL
3	$$LW_c = PBurn_c \times PC_{yw} \times YWFr_t \\ \times AF_{fa,c}$$	$5,501\ people \times 0.065\ tons \times 0.25 \\ \times 1$	89.39 tons of leaf waste burned in Autauga County, AL
4	$$BW_c = PBurn_c \times PC_{yw} \times YWFr_t \\ \times AF_{fa,c}$$	$5,501\ people \times 0.065\ tons \times 0.25 \\ \times 1$	89.39 tons of brush waste burned in Autauga County, AL
5	$$If\ county\ c\ has\ a\ burn\ ban \\ Then\ LW_c = LW_c \times 0.25$$	N/A	Autauga County, AL does not have a burn ban
6	$$If\ county\ c\ has\ a\ burn\ ban \\ Then\ BW_c = BW_c \times 0.25$$	N/A	Autauga County, AL does not have a burn ban
7	$$E_{p,c} = LW_c \times EF_p$$	$89.39\ tons\ of\ leaf\ waste \\ \times 112\ lbs.per\ ton$	5.01 tons CO emissions from burning of leaf waste in Autauga County, AL
8	$$E_{p,c} = BW_c \times EF_p$$	$89.39\ tons\ of\ brush\ waste \times \\ 140\ lbs.per\ ton$	6.26 tons CO emissions from burning of brush waste in Autauga County, AL

4.27.3.7 *Changes from the 2014 methodology*

The 2017 emissions inventory methodology for yard waste burning includes a change to the method for determining population likely to burn. The 2014 v2 NEI methodology determined the population likely to burn by identifying the rural and "like rural" population in each county in 2010 and using the fraction of 2010 rural and like rural population to total population in order to determine the rural population in 2014. The 2017 methodology only uses the 2010 rural population to determine the population likely to burn.

4.27.3.8 *Puerto Rico and U.S. Virgin Islands*

Emissions from Puerto Rico are calculated using the same method described above. For the U.S. Virgin Islands, emissions are calculated using 2010 population data, since 2017 Census Data does not exist for the U.S. Virgin Islands.

4.27.3.9 *References*

1. U.S. Environmental Protection Agency. 2018. Advancing Sustainable Materials: 2015 Fact Sheet, Table 1. Generation, Recovery and Discards of Materials in MSW, 2015 (in millions of tons and percent of generation of each material).
2. U.S. Environmental Protection Agency. 2011. Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2010—Fact Sheet, p. 4.
3. U.S. Census Bureau. Total Population, American Community Survey.
4. U.S. Census Bureau, Decennial Censuses, 2010 Census: Summary File 1.
5. Environment Canada. 2001. "Household Garbage Disposal and Burning." Prepared by Environics Research Group.
6. Two Rivers Regional Council of Public Officials and Patrick Engineering, Inc. 1994. "Emission Characteristics of Burn Barrels," prepared for the U.S. Environmental Protection Agency, Region V.
7. U.S. Environmental Protection Agency. 1992. AP-42, Fifth Edition, Volume 1, Chapter 2: Solid Waste Disposal. Section 2.5: Open Burning.
8. Eastern Research Group, Inc. Emissions Inventory Improvement Program. Volume III: Chapter 16, Open Burning. 2001.
9. U.S. Environmental Protection Agency, Control Technology Center. 1997. Evaluation of Emissions from the Open Burning of Household Waste in Barrels. EPA-600/R-97-134a.
10. Huntley, Roy, 2009. Spreadsheet "state_comparison ERTAC SS_version7_4 Nov 23 2009.xls".

4.27.4 EPA-developed emissions for land clearing debris

The emissions from open burning from land clearing debris are estimated based on the number of acres disturbed from non-residential, residential, and road construction. The number of acres disturbed is multiplied by a fuel loading factor to determine the amount of land clearing debris burned in each county. This number is multiplied by emissions factors to determine emissions of CAPs and HAPs.

4.27.4.1 *Activity data*

The amount of material burned is estimated using the county-level total number of acres disturbed by residential, non-residential, and road construction. County-level weighted loading factors are applied to the total number of construction acres to convert acres to tons of available fuel.

<ins>Acres Disturbed from Non-Residential Construction</ins>

The activity data for this non-residential construction is the acreage disturbed from non-residential construction, which is estimated using data from the U.S. Census Bureau's *Annual Value of Construction Put in Place in the U.S* [ref 1]. and a conversion factor from MRI's *Estimating Particulate Matter Emissions from Construction Operations, Final Report* [ref 2]. The national-level non-residential construction spending data are allocated to the county-level based on the proportion of non-residential construction employees in each county. Employment data are taken from the U.S. Census Bureau's 2016 County Business Patterns (CBP), and gaps in employment data are filled using a process described in detail in section 4.27.4.2.

$$EmpFr_c = \frac{Emp_c}{Emp_{US}} \qquad (1)$$

$$CS_c = EmpFr_c \times CS_{US} \qquad (2)$$

Where:

$EmpFr_c$ = The fraction of non-residential construction employees in county c
Emp_c = The number of non-residential construction employees in county c
Emp_{US} = The number of non-residential construction employees in the US
CS_c = Non-residential construction spending in county c
CS_{US} = Non-residential construction spending in the US

Non-residential construction spending is converted to acres disturbed using a conversion factor from MRI's report. For the average acres disturbed per million dollars of non-residential construction, MRI reported a conversion factor of 2 acres/$1 million (in 1992 constant dollars). The 1992 conversion factor is adjusted to 2017 using the *Price Deflator (Fisher) Index of New Single-Family Houses under Construction* [ref 3]. In 2017 the conversion factor was 1.009 acres per million dollars spent on non-residential construction activities.

$$Apd_{2017} = \frac{2 \ acres}{\$1 \ million} \times \frac{PD_{1992}}{PD_{2017}} \qquad (3)$$

Where:

Apd_{2017} = Acres disturbed per million dollars in 2017
PD_{1992} = Price Deflator (Fisher) Index value in 1992
PD_{2017} = Price Deflator (Fisher) Index value in 2017

County-level non-residential construction spending (from equation 2) is then multiplied by this conversion factor to estimate county-level acreage disturbed from non-residential construction activities.

$$ANR_c = CS_c \times Apd_{2017} \qquad (4)$$

Where:

ANR_c = Acres disturbed from non-residential construction in county c
CS_c = Non-residential construction spending in county c, in million dollars
Apd_{2017} = Acres disturbed per million dollars in 2017

Acres Disturbed from Residential Construction

The US Census Bureau has 2017 data for *Housing Starts - New Privately Owned Housing Units Started* [ref 4, ref 5], which provides regional level housing starts based on the groupings of 1 unit, 2-4 units, 5 or more units. Regional-level results are also provided in Table 4-198 for quarterly totals and 1-unit structures [ref 5]. The 2- to 4-unit category is broken down using a ratio calculated from the 2000 US Census Bureau *National Housing Starts* data for 2 and 3-4 units [ref 6], for each quarter in 2017. Note that 2000 is the last full year when Census housing starts data were available separately for 2-unit and 3-4-unit homes. Table 4-199 shows a breakdown of the 2 units and 3-4-unit structures based on the following calculation.

$$S_{Q,n} = \left(\frac{U_n}{U_t}\right) \times S_{Q,2-4} \qquad (5)$$

Where:

    $S_{Q,n}$ =   Housing starts, by quarter, Q, and number of units, n (2 units or 3-4 units), in thousand units

    U_n =   Number of housing starts by number of units, n, from the 2000 *National Housing Starts* data, in thousand housing starts

    U_t =   Total number of housing starts for both 2 units and 3-4 units from the 2000 *National Housing Starts* data, in thousand housing starts

    $S_{Q,2-4}$ =   Number of 2-4 units by quarter, Q, from the 2017 *New Privately Owned Housing Units Started by Purpose and Design* data, in thousand units

Table 4-198: Housing Start Data for 2017

Quarter	Total	Structure			Region				Starts of Structures with 1 unit			
		1 unit	2 to 4 units	5 units or more	NE	MW	S	W	NE	MW	S	W
Q1-14	267.0	181.0	2.0	84.0	24.0	29.0	150.0	64.0	12.0	21.0	107.0	41.0
Q2-14	327.0	238.0	3.0	86.0	31.0	56.0	152.0	89.0	16.0	41.0	122.0	58.0
Q3-14	319.0	230.0	3.0	86.0	31.0	50.0	155.0	84.0	20.0	35.0	119.0	56.0
Q4-14	290.0	200.0	3.0	87.0	28.0	45.0	141.0	76.0	15.0	33.0	104.0	48.0

Table 4-199: Breakdown of 2- to 4-unit structures in 2017

Quarter	Structure		
	2 to 4 units	2 units	3-4 units
Q1-14	2.0	0.74	1.26
Q2-14	3.0	1.11	1.89
Q3-14	3.0	1.11	1.89
Q4-14	3.0	1.11	1.89

Ratios of the number of 2, 3 and 4, and 5-unit structures are then used to estimate the number of structures of each type in each region. The ratios are calculated by dividing the housing starts by quarter for each unit type by the total housing starts for buildings with more than 2 units.

$$r_{Q,n} = \frac{S_{Q,n}}{S_{Q.t}} \qquad (6)$$

Where:

    $r_{Q,n}$ =   Ratio of structures with number of units, n, to total number of units by quarter, Q

    $S_{Q,n}$ =   Housing starts, by quarter, Q, and number of units, n, from distributed calculation in Step 1 for the 2-unit or 3-4-unit categories or directly from the 2017 *New Privately Owned Housing Units Started by Purpose and Design* data for the 5 units or more category, in thousand housing starts

    $S_{Q,t}$ =   Housing starts, by quarter, Q, for total number of units greater than 2 units, t (excludes 1-unit category), in thousand housing starts

The ratio is then used to distribute the 2017 *New Privately Owned Housing Units Started by Purpose and Design* [ref 5] regional data for all unit types to the 2, 3-4, or 5 or more unit categories within each Census region – Northeast, Midwest, South, and West.

$$A_{Q,n,rgn} = r_{Q,n} \times (RS_{t,rgn} - RS_{1,rgn}) \tag{7}$$

Where:

$A_{Q,n,rgn}$ = Number of housing units started in quarter Q, by number of units, n, and region of the country, rgn, in thousand units

$r_{Q,n}$ = Ratio of structures with number of units, n, to total number of units by quarter, Q

$RS_{t,rgn}$ = Total regional starts from the 2017 *New Privately Owned Housing Units Started by Purpose and Design* data, in thousand housing starts

$RS_{1,rgn}$ = Regional starts of structures with 1 unit from the 2017 *New Privately Owned Housing Units Started by Purpose and Design* data, in thousand housing starts

Data from the Census report *New Privately Owned Housing Units Authorized Unadjusted Units* [ref 7] is used to calculate a conversion factor to determine the ratio of structures to units in the 5 or more unit category. The conversion factor is calculated by dividing the total number of units in structures with 5 or more units by region [ref 6] by the total number of buildings with 5 or more units by region [ref 7].

$$CF_5 = \frac{U_{5,rgn}}{B_{5,rgn}} \tag{8}$$

Where:

$CF_{5,rgn}$ = Ratio of 5 units or more to the number of buildings with 5 units or more by region, rgn

$U_{5,rgn}$ = Total number of 5 or more units by region, rgn

$B_{5,rgn}$ = Total number of buildings with 5 or more units by region, rgn

Structures started by category are then calculated at a regional level by summing the number of housing unit starts across all four quarters and dividing the by number of units in each building type. For the 3-4-unit type, the number of units per building is 3.5. The value is multiplied by 1,000 because the Census data are in units of thousand building starts.

For buildings with 1, 2, or 3-4 units:

$$B_{n,rgn} = \frac{(\sum_{Q1}^{Q4} A_{Q.n.rgn}) \times 1{,}000}{n} \tag{9}$$

Where:

$B_{n,rgn}$ = Number of building starts by the unit number category, n, and by region, rgn

$A_{Q,n,rgn}$ = Number of housing units started in quarter Q, by number of units, n, and region of the country, rgn, in thousand units

n = Number of units per building

For buildings with 5 or more units:

$$B_{n,rgn} = \frac{\left(\sum_{Q1}^{Q4} A_{Q.n.rgn}\right) \times 1{,}000}{CF_5}$$

(10)

Where:

    $B_{n,rgn}$ =   Number of building starts by the unit number category, *n*, and by region, *rgn*

    $A_{Q,n,rgn}$ =   Number of housing units started in quarter *Q*, by number of units, *n*, and region of the country, *rgn*, in thousand units

    CF_5 =   Ratio of 5 units or more to the number of buildings with 5 units or more

Annual county building permit data were purchased from the US Census Bureau for 2017 [ref 8]. The 2017 County Level Residential Building Permit dataset has 2017 data to allocate regional housing starts to the county level. This results in county level housing starts by number of units.

The number of building permits for each unit number category by region is calculated by summing the county-level Census data to the region level.

$$BP_{n,rgn} = \sum BP_{n,c}$$

(11)

Where:

    $BP_{n,rgn}$ =   Number of building permits by the unit number category, *n*, and by region, *rgn*

    $BP_{n,c}$ =   Number of building permits by the unit number category, *n*, and by county, *c*

The ratio of the number of building permits by county to the total number of building permits by region in which the county is located, for each unit number category, is then calculated.

$$R_{BP,c} = \frac{BP_{n,c}}{BP_{n,rgn}}$$

(12)

Where:

    $R_{BP,c}$ =   Ratio building permits, *BP*, to total regional building permits in county *c*

    $BP_{n,c}$ =   Number of building permits by the unit number category, *n*, and by county, *c*

    $BP_{n,rgn}$ =   Number of building permits by the unit number category, *n*, and by region, *rgn*

The final number of building starts for each unit type category is then calculated at the county-level by multiplying the number of structures started at the regional level and the building permit ratio.

$$B_{n,c} = B_{n,rgn} \times R_{BP,c}$$

(13)

Where:

    $B_{n,c}$ =   Number of building starts by the unit number category, *n*, and by county, *c*

    $B_{n,rgn}$ =   Number of building starts by the unit number category, *n*, and by region, *rgn*

    $R_{BP,c}$ =   Ratio building permits, *BP*, to total regional building permits in county, *c*

The number of acres of surface area disturbed by the construction of residential buildings is calculated for

apartment buildings, buildings with 2 units, and buildings with 1 unit. Table 4-200 shows the assumptions used for the surface area disturbed for each unit type. Buildings with unit types of 3-4 and 5 or more are grouped together as apartments in this step.

Table 4-200: Surface soil removed per unit type

Structure	Acres disturbed
1-Unit	1/4 acre/structure
2-Unit	1/3 acre/structure
Apartment	1/2 acre/structure

The acres of soil disturbed by the construction of residential buildings are calculated for apartment buildings, buildings with 2 units, and buildings with 1 unit.

$$AR_{n,c} = B_{n.c} \times a_n$$ (14)

Where:

$AR_{n,c}$ =   Surface soil disturbed by building construction by county, c, and unit type category, n, in acres
$B_{n,c}$ =   Number of building starts by the unit number category, n, and by county, c
a_n =   Acres of surface soil disturbed by each unity type category, n. See Table 4-200.

Acres Disturbed by Road Construction

The activity data for this source category is the acreage disturbed from new road construction, which is estimated using data from FHWA's *Highway Statistics, State Highway Agency Capital Outlay 2014, Table SF-12A* [ref 9] and FLDOT's *Generic Cost per Mile Models* [ref 10]. From the FHWA table, the following columns are used: New Construction, Relocation, Added Capacity, Major Widening, and Minor Widening. These columns are also differentiated according to the following six classifications:

1. Interstate, urban
2. Interstate, rural
3. Other arterial, urban
4. Other arterial, rural
5. Collectors, urban
6. Collectors, rural

Construction spending for each road type is summed across all construction types to determine the total annual highway spending for each road type.

$$HS_{s,r} = \sum_{ct} S_{s,r}$$ (15)

Where:

$HS_{s,r}$ =   Annual highway spending for road type r in state s, in dollars
ct =   Construction type
$S_{s,r}$ =   Annual spending per construction type for road type r in state s, in dollars

State expenditure data are converted to miles of new road and acres disturbed per mile of new road based on

conversions obtained from FLDOT [ref 10]. These conversions are shown in Table 4-201 and the acres disturbed per mile conversions are calculated by multiplying the total affected roadway width (including all lanes, shoulders, and areas affected beyond the road width) by one mile and converting the resulting land area to acres.

$$RC_{m,s,r} = \frac{HS_{s,r}}{TDM}$$ (16)

$$RC_{a,s,r} = RC_{m,s,r} \times ADM$$ (17)

Where:

$RC_{m,s,r}$ = Miles of FHWA road type r constructed in state s
$RC_{a,s,r}$ = Acres of land disturbed for construction of FHWA road type r in state s
$HS_{s,r}$ = Annual highway spending for road type r in state s
TDM = Conversion of dollars spent to road miles constructed, in thousand dollars per mile
ADM = Conversion of road miles constructed to acres disturbed, in acres per mile

Table 4-201: Spending per Mile and Acres Disturbed per Mile by Highway Type

Road Type	Thousand Dollars per mile	Total Affected Roadway Width (ft)*	Acres Disturbed per mile
Urban Areas, Interstate	6,895	94	11.4
Rural Areas, Interstate	3,810	89	10.8
Urban Areas, Other Arterials	4,112	63	7.6
Rural Areas, Other Arterials	2,076	55	6.6
Urban Areas, Collectors	4,112	63	7.6
Rural Areas, Collectors	2,076	55	6.6
*Total Affected Roadway Width = (lane width (12 ft) * number of lanes) + (shoulder width * number of shoulders) + area affected beyond road width (25 ft)			

The acres of land disturbed by road type can then be summed across all road types in a state to calculate the total state-level acreage disturbed due to new road construction.

$$ARC_s = \sum_r RC_{a,s}$$ (18)

Where:

ARC_s = Acres of land disturbed for all road construction in state s
$RC_{a,s}$ = Acres of land disturbed for construction of FHWA road type r in state s

Similar to residential construction, county-level building permits data from the U.S. Census Bureau are used to allocate the state-level acres disturbed by road construction to the county [ref 11]. Specifically, the ratio of the county-to state-level number of building starts is calculated and multiplied by the state-level acreage disturbed (from equation 18) to estimate the county-level acreage disturbed by road construction.

$$BFrac_c = \frac{Build_c}{Build_s} \tag{19}$$

$$ARC_c = ARC_s \times BFrac_c \tag{20}$$

Where:

$BFrac_c$ = The fraction of building starts in county c
$Build_c$ = The number of building starts in county c
$Build_s$ = The number of building starts in state s
ARC_c = Acres of land disturbed for road construction in county c
ARC_s = Acres of land disturbed for all road construction in state s

<u>Converting Acres Disturbed to Tons of Land Clearing Debris Burned</u>

The total acres disturbed by all construction types is calculated by summing the acres disturbed from residential, non-residential, and road construction.

$$TAD_c = ANR_c + \left(\sum AR_{n.c}\right) + ARC_c \tag{21}$$

Where:

TAD_c = Total acres disturbed in from nonresidential, residential, and road construction in county c
ANR_c = Acres disturbed from non-residential construction in county c
$AR_{n,c}$ = Acres of surface soil disturbed from residential construction in county c and unit type category n (summed to one value for residential construction for the county)
ARC_c = Acres of land disturbed for road construction in county c

Version 2 of the Biogenic Emissions Land cover Database (BELD2) within EPA's Biogenic Emission Inventory System (BEIS) is used to identify the acres of hardwoods, softwoods, and grasses in each county.

Because BELD2 does not contain data on Alaska and Hawaii, the acres of hardwoods, softwoods, and grasses in each county is estimated by using the state-level land cover statistics from the USGS National Land Cover Database on the percent land cover under each vegetation type [ref 12]. These percentages are multiplied by the county area (acres), from the U.S. Census Bureau [ref 13].

$$A_{AK/HI,c,f} = LA_{AK/HI,c} \times LC_{AK/HI,\%,f} \tag{22}$$

Where:

$A_{AK/HI,c,f}$ = Total acres of each fuel type, f, for each county, c, in Alaska or Hawaii
$LA_{AK/HI,c,}$ = County acres from the U.S. Census Bureau of each fuel type, f, for each county, c, in Alaska or Hawaii
$LC_{AK/HI,\%,f}$ = Land cover percentages for each fuel type (hardwood, softwood, grass) in Alaska or Hawaii

Table 4-202 presents the average fuel loading factors by vegetation type. The average loading factors for slash hardwood and slash softwood are adjusted by a factor of 1.5 to account for the mass of tree that is below the soil surface that would be subject to burning once the land is cleared [ref 14]. Weighted average county-level loading factors are calculated by multiplying the average loading factors by the percent contribution of each type of vegetation class to the total land area for each county.

$$WFLF_{c,f} = \frac{A_{c,f}}{A_{c,total}} \times LF_f \qquad (23)$$

Where:

$WFLF_{c,f}$ = Weighted average fuel loading factor by for fuel type f in county c

$A_{c,f}$ = Acres of land cover in county c, by fuel type f (from BELD2 for continental U.S.; from equation 22 for Alaska and Hawaii)

$A_{c,total}$ = Total acres of land cover of all fuel types in county c

LF_f = Fuel loading factor by fuel type, f, in tons/acre, from Table 4-202

Table 4-202: Fuel Loading Factors by Vegetation Type

Vegetation Type	Unadjusted Average Fuel Loading Factor (Ton/acre)	Adjusted Average Fuel Loading Factor (Ton/acre)
Hardwood	66	99
Softwood	38	57
Grass	4.5	Not Applicable

The weighted average county-level loading factors for each fuel type are then summed across fuel types to calculate a single weighted average loading factor for each county.

$$WFLF_c = \sum_f WFLF_{c,f} \qquad (24)$$

Where:

$WFLF_c$ = Weighted average fuel loading factors for county c

$WFLF_{c,f}$ = Weighted average fuel loading factor by for fuel type f in county c

The county-level total acres disturbed are then multiplied by the weighted average loading factor to derive tons of land clearing debris.

$$LCD_c = TAD_c \times WFLF_c \qquad (25)$$

Where:

$LCDc$ = Land clearing debris in county c, in tons

TAD_c = Total acres disturbed in county c

$WFLF_c$ = Weighted average fuel loading factors for county c

The total land clearing debris burned per county is calculated by multiplying acres of land clearing debris by county by a control factor, based on the percent of urban land from the 2010 U.S. Census data [ref 13]. See Section 4.27.4.4 for more information on the control factor.

$$BLCD_c = LCD_c \times CF_c \qquad (26)$$

Where:

$BLCD_c$ = Land clearing debris burned in county c, in tons
$LCDc$ = Land clearing debris in county c, in tons
CF_c = Control factor. The control factor is 1 for counties with less than 80% urban population and 0 for Colorado or in counties with an urban population of 0.8% or more based on the 2010 U.S. Census data [ref 13] as no burning occurs in these counties. See Section 4.27.4.4 for more information on the control factor.

4.27.4.2 *Allocation procedure*

Acres disturbed by Non-residential Construction – County business patterns allocation

Employment data are obtained from the U.S. Census Bureau's 2016 County Business Patterns (CBP) [ref 15]. Due to concerns with releasing confidential business information, the *CBP* does not release exact numbers for a given NAICS code if the data can be traced to an individual business. Instead, a series of employment flags is used. To estimate employment in counties and states with withheld data, the following procedure is used for NAICS code 2362 (non-residential construction).

To gap-fill withheld state-level employment data:
1. State-level data for states with known employment are summed to the national level.
2. State-level known employment is subtracted from the national total reported in the national-level CBP.
3. Each of the withheld states is assigned the midpoint of the employment flag. Table 4-203 lists the employment flags and midpoints.
4. The midpoints for the states with withheld data are summed to the national level.
5. An adjustment factor is created by dividing the number of withheld employees (calculated in step 2 of this section) by the sum of the midpoints (step 4)
6. For the states with withheld employment data, the midpoint of the range for that state (step 3) is multiplied by the adjustment factor (step 5) to calculate the adjusted state-level employment for non-residential construction.

These same steps are then followed to fill in withheld data in the county-level business patterns.
1. County-level data for counties with known employment are summed by state.
2. County-level known employment is subtracted from the state total reported in state-level CBP (or, if the state-level data are withheld, from the state total estimated using the procedure discussed above).
3. Each of the withheld counties is assigned the midpoint of the employment flag (Table 4-203).
4. The midpoints for the counties with withheld data are summed to the state level.
5. An adjustment factor is created by dividing the number of withheld employees (step 2) by the sum of the midpoints (step 4).
6. For counties with withheld employment data, the midpoints (step 3) are multiplied by the adjustment factor (step 5) to calculate the adjusted county-level employment for non-residential construction.

Note that step 5 adjusts all counties within each state with withheld employment data by the same state-based proportion. It is unlikely that actual employment corresponds exactly with this smoothed adjustment method, but this method is the best option given the availability of the data.

Table 4-203: Ranges and midpoints for data withheld from State and County Business Patterns

Employment Flag	Employment Range	Midpoint
A	0-19	10
B	20-99	60

Employment Flag	Employment Range	Midpoint
C	100-249	175
E	250-499	375
F	500-999	750
G	1,000-2,499	1,750
H	2,500-4,999	3,750
I	5,000-9,999	7,500
J	10,000-24,999	17,500
K	25,000-49,999	37,500
L	50,000-99,999	75,000
M	100,000+	

For example, take the 2016 CBP data for NAICS 2362 (nonresidential construction) in Arizona provided in Table 4-204.

Table 4-204: 2016 CBP for NAICS 2361 in Arizona

State FIPS	County FIPS	NAICS	Employment Flag	Employment
04	001	2362	B	withheld
04	003	2362		125
04	005	2362		166
04	007	2362		24
04	011	2362	B	withheld
04	012	2362	A	withheld
04	013	2362		8,580
04	015	2362		64
04	017	2362		53
04	019	2362		2,085
04	021	2362		115
04	023	2362		16
04	025	2362		260
04	027	2362		233

1. The total of employees not including withheld counties is 11,831.
2. The state-level CBP reports 11,721 employees for NAICS 2362. The difference is 110.
3. Withheld counties are given the midpoint of the employment range. County 001 is given a midpoint of 60 (since employment flag A is 20 – 99) and County 012 is given a midpoint of 10 (since employment flag H is 0 – 19).
4. State total for these all withheld counties is 130.
5. 110/130 = 0.846.
6. The adjusted employment for county 001 is 60 × 0.846 = 51.36 employees. County 012 has an adjusted employment of 10 × 0.846 = 8.46 employees.

The county-level employment data are used to allocate the national-level non-residential construction spending data to the county-level (see equation 1).

Acres disturbed by Residential Construction – Building permits allocation

Annual county building permit data were purchased from the U.S. Census Bureau for 2017 [ref 8] and used to allocate regional housing starts to the county level. This results in county level housing starts by number of units. See equations 11-13 in section 4.27.4.1.

Acres Disturbed by Road Construction – Building permits allocation

State-level estimates of acres disturbed by road construction is distributed to the counties based on county-level data on residential building starts from the U.S. Census Bureau [ref 11]. See equations 19 and 20 in section 4.27.4.1.

4.27.4.3 *Emission factors*

Emissions factors are reported in Table 4-205 below. Emissions factors for CAPs and HAPs are from the AP-42 and U.S. EPA Emissions Inventory Improvement Program [ref 16, ref 17]. The PM25 to PM10 emissions factor ratio for brush burning (0.7709) is multiplied by the PM10 emissions factors for land clearing debris burning to develop PM25 emissions factors. Emissions factors for HAPs are from an EPA Control Technology Center report [ref 18].

Table 4-205: Emissions Factors for Open Burning of Land Clearing Debris (SCC 2610000500)

Pollutant	Pollutant Code	Emissions Factor (lb/ton)	Emission Factor Reference
VOC	VOC	11.3	Reference 16, Table 2.5-5, a
NOX	NOX	4.0	Reference 16, Table 2.5-5, b
CO	CO	164.8	Reference 17, Table 16.4-2, c
PM10-FIL	PM10-FIL	20.4	Reference 17, Table 16.4-2, c
PM25-FIL	PM25-FIL	18.6	Reference 17, Table 16.4-2, c
PM10-PRI	PM10-PRI	20.4	Reference 17, Table 16.4-2, c
PM25-PRI	PM25-PRI	18.6	Reference 17, Table 16.4-2, c
Cumene	98828	0.012	Reference 16, Table 16.4-3, d
Ethyl Benzene	100414	0.048	Reference 16, Table 16.4-3, d
Phenol	108952	0.115	Reference 16, Table 16.4-3, d
Styrene	100425	0.102	Reference 16, Table 16.4-3, d

a. Average of factors for forest residues.
b. Emissions factor is from footnote to Table 2.5-5
c. Average of factors from Table 16.4-2 except for last two rows (test burn with blower)
d. Average of factors from Table 16.4-3 except for last two columns (test burn with blower)

4.27.4.4 *Controls*

Controls for land clearing debris burning are generally in the form of a ban on open burning of waste in a given municipality or county. Counties that are more than 80% urban by land area determined by the 2010 U.S. Census data [ref 13], are assumed not to practice any open burning of land clearing debris. Therefore, CAP and HAP emissions from open burning of land clearing debris are zero in these counties.

Additionally, it is assumed that even in counties that are less than 80% urban by land area, open burning will only be practiced in areas that are rural. Therefore, the total land clearing debris burned per county (from equation 26) will be scaled based on the fraction of rural land area in each county from the 2010 Census.

$$BLCD_{r,c} = BLCD_c \times \frac{RLand_c}{TLand_c}$$ (27)

Where:

$BLCD_{r,c}$ = Land clearing debris burned in rural areas by county, c, in tons
$BLCD_c$ = Land clearing debris burned by county, c, in tons
$RLand_c$ = Amount of rural land by land area in county c
$TLand_c$ = Total amount of land in county c

Further controls on burning (i.e., burn bans in rural areas) are represented by multiplying the land clearing debris burned in rural counties by a burn ban's effectiveness; effectiveness is a value between 0 and 1.

$$BLCD_{r,c} = BLCD_{r,c} \times BE_c$$ (28)

Where:

$BLCD_{r,c}$ = Land clearing debris burned in rural areas by county, c, in tons
BE_c = Burn ban effectiveness in county c

In this methodology, burn ban effectiveness is represented by a single value between 0 and 1 that is multiplied by the amount of land clearing debris burned in the rural areas of each county. In practice, the burn ban effectiveness is a function of both a rule's penetration and effectiveness. Rule penetration refers to the extent to which a regulation covers emissions for a specified controlled area, and effectiveness concerns the ability of the regulatory program to achieve emissions reductions compared to full compliance. By default, the burn ban effectiveness for each county is 1 (i.e. the methodology assumes no burn bans in each county), although this may be updated by state, local, or tribal agencies.

4.27.4.5 *Emissions*

County-level criteria pollutant and HAP emissions are calculated by multiplying the mass of land clearing debris burned in rural areas per year (from equation 28) by an emissions factor from Table 4-205.

$$E_{c,p} = BLCD_{r,c} \times EF_p \times \frac{1\ ton}{2000\ lb}$$ (29)

Where:

$E_{c,p}$ = Emissions by county, c, and pollutant, p, in tons
$BLCD_{r,c}$ = Land clearing debris burned in rural areas by county, c, in tons
EF_p = Emissions factor by pollutant, p, in pounds/ton

4.27.4.6 *Example calculations*

Table 4-206 shows sample calculations for PM25-PRI emissions from open burning of land clearing debris in McLean County, Illinois. Equations 5 through 7 use the first quarter (Q1) of 2017 for 2-unit structures as an example. However, these calculations would need to be repeated to calculate values for all 4 quarters for all 3

unit sizes. Note that structures with 5 or more units and structures with 1 unit with or without a basement have additional steps not shown in the sample calculations here. Equations 15 through 20 use urban roads as an example for acres of land disturbed from road construction. For full calculations of acres of land disturbed from road construction the calculations for rural roads would also need to be incorporated.

Table 4-206: Sample calculations for PM25-PRI emissions from open burning of land clearing debris in McLean County, IL

Eq. #	Equation	Values for McLean County, IL	Result
1	$$EmpFr_c = \frac{Emp_c}{Emp_{US}}$$	$$\frac{140\ nonres\ construction\ employees}{581{,}963\ nonres\ construction\ employees}$$	0.000241 fraction on non-residential construction employees in McLean County, IL
2	$$CS_c = EmpFr_c \times CS_{US}$$	$0.000241\ fraction\ of\ employees$ $\times\ \$\ 347{,}666\ million\ in\ nonres$ $construction\ spending\ in\ the\ US$	\$83.79 million in non-residential construction spending in McLean County, IL
3	$$Apd_{2017} = \frac{2\ acres}{\$1\ million} \times \frac{PD_{1992}}{PD_{2017}}$$	$$\frac{2\ acres\ disturbed}{\$1\ million} \times \frac{57\ in\ 1992}{113\ in\ 2017}$$	1.009 acres disturbed per million dollars spent on non-residential construction spending, nationally
4	$$ANR_c = CS_c \times Apd_y$$	$\$83.79\ million \times 1.009\ \dfrac{acres\ disturbed}{million\ \$}$	84.4 acres disturbed from non-residential construction in McLean County, IL
5	$$S_{Q,n} = \left(\frac{U_n}{U_t}\right) \times S_{Q,2-4}$$	$\left(\dfrac{14\ two\ unit\ housing\ starts\ in\ 2002}{38\ total\ housing\ starts\ in\ 2002}\right)$ $\times$ $2\ two\ to\ four\ unit\ housing\ starts\ in\ Q1\ 20$	0.74 thousand housing starts for 2-unit structures in Q1 2017, nationally
6	$$r_{Q,n} = \frac{S_{Q,n}}{S_{Q.t}}$$	$$\frac{0.74\ two\ unit\ housing\ starts}{72\ two\ or\ more\ unit\ housing\ starts}$$	0.01 ratio of buildings with 2 units to all units greater than 2 for Q1 2017, nationally

Eq. #	Equation	Values for McLean County, IL	Result
7	$A_{Q,n,rgn} = r_{Q,n} \times (RS_t - RS_1)$	0.01 $\times (21 \text{ total Q1 housing starts in Midwest}$ $- 14 \text{ one unit housing starts in Midwest})$	0.07 thousand housing starts for 2-unit structures for Q1 2017 in the Midwest
8	$CF_5 = \dfrac{U_{5,rgn}}{B_{5,r}}$	N/A	Equation is for 5 or more unit buildings; example is for 2-unit buildings
9	$B_{n,rgn} = \dfrac{(\sum A_{Q.n.rgn}) \times 1{,}000}{n}$	$\dfrac{0.775 \text{ two unit structures } \times 1{,}000}{2 \text{ units per building}}$	388 2-unit structures constructed in the Midwest
10	$B_{n,rgn} = \dfrac{(\sum A_{Q.n.rgn}) \times 1{,}000}{CF_5}$	N/A	Equation is for 5 or more unit buildings; example is for 2-unit buildings
11	$BP_{n,rgn} = \sum BP_{n,c}$	$\sum \text{Midwest two unit building permits}$	1,571 2-unit structure building permits in the Midwest
12	$R_{BP,c} = \dfrac{BP_{n,c}}{BP_{n,rgn}}$	$\dfrac{1 \text{ McLean County building permits}}{1{,}571 \text{ Midwest building permits}}$	0.000637 ratio of county-level building permits to regional-level building permits in McLean County, IL
13	$B_{n,c} = B_{n,rgn} \times R_{BP,c}$	$388 \text{ two unit building starts in the Midwe}$ $\times 0.000637$	0.25 total 2-unit structure building starts for McLean County, IL
14	$AR_{n,c} = B_{n.c} \times a_n$	$0.25 \text{ two unit structures}$ $\times 0.33 \text{ acres per structure}$	0.08 acres surface soil disturbed by 2-unit structures in McLean County, IL

Eq. #	Equation	Values for McLean County, IL	Result
15	$$HS_{s,r} = \sum_{ct} S_{s,r}$$	$20,399,000 + $33,029,000 + $93,892,000	$147,320,000 spent on urban interstate construction in IL
		$58,519,000 + $2,626,000 + $35,1367,000 + $206,057,000 + $17,193,000	$319,532,000 spent on urban other arterial construction in IL
		$16,093,000 + $338,000 + $355,000	$16,786,000 spend on urban collector construction in IL
16	$$RC_{m,s,r} = \frac{HS_{s,r}}{TDM}$$	$$\frac{\$147,320,000}{6,895,000 \ \$ \ per \ mile}$$	21.4 miles of urban interstate constructed in IL
		$$\frac{\$319,532,000}{4,112,000 \ \$ \ per \ mile}$$	77.7 miles of urban other arterial constructed in IL
		$$\frac{\$16,786,000}{4,112,000 \ \$ \ per \ mile}$$	4.1 miles of urban collector constructed in IL
17	$$RC_{a,s,r} = RC_{m,s,r} \times ADM$$	$21.4 \ miles \times 11.4 \ acres \ per \ mile$	242.9 acres disturbed from urban interstate construction in IL
		$77.7 \ miles \times 7.6 \ acres \ per \ mile$	589.6 acres disturbed from urban other arterial construction in IL
		$4.1 \ miles \times 7.6 \ acres \ per \ mile$	31 acres disturbed from urban collector construction in IL
18	$$ARC_s = \sum_{r} RC_{a,s}$$	$242.9 \ acres + 589.6 \ acres + 31 \ acres$	863.5 acres disturbed from urban road construction in IL

Eq. #	Equation	Values for McLean County, IL	Result
19	$$BFrac_c = \frac{Build_c}{Build_s}$$	$$\frac{246\ building\ starts\ in\ McLean\ County}{20{,}578\ building\ starts\ in\ IL}$$	0.012 fraction of building starts in McLean County, IL
20	$$ARC_c = ARC_s \times BFrac_c$$	$863.5\ acres \times 0.012$	10.4 acres disturbed from urban road construction in McLean County, IL
21	$$TAD_c = ANR_c + \left(\sum S_{n.c}\right) + ARC_c$$	$84.4\ acres + 62.02^*\ acres$ $+ 13.95^{**}\ acres$ * note that the value for residential construction is for all unit types, not just 2-unit buildings as shown in example above ** note the value for road construction is for all road types, not just urban roads as shown in the example above	160.4 total acres disturbed in McLean County, IL
22	$$A_{AK/HI,c,f} = LA_{AK/HI,c} \times LC_{AK/HI,\%,f}$$	N/A	Equation is for Alaska or Hawaii
23	$$WFLF_{c,f} = \frac{A_{c,f}}{A_{total}} \times LF_f$$	$$\frac{17{,}516\ acres}{758{,}793\ acres} \times 99\ tons\ per\ acre$$	2.3 tons/ acre weighted factor for hardwood fuel in McLean County, IL
		$$\frac{0\ acres}{758{,}793\ acres} \times 57\ tons\ per\ acre$$	0.0 tons/ acre weighted factor for softwood fuel in McLean County, IL
		$$\frac{741{,}276\ acres}{758{,}793\ acres} \times 4.5\ tons\ per\ acre$$	4.4 tons/ acre weighted factor for grass fuel in McLean County, IL
24	$$WFLF_c = \sum WFLF_{c,f}$$	$2.3\dfrac{tons}{acre} + 0.0\dfrac{tons}{acre} + 4.4\dfrac{tons}{acre}$	6.7 tons/acre weighted factor for all fuels in McLean County, IL
25	$$LCD_c = TAD_c \times WFLF_c$$	$160.4\ acres \times 6.7\dfrac{tons}{acre}$	1,071 tons of land clearing debris in McLean County, IL

Eq. #	Equation	Values for McLean County, IL	Result
26	$BLCD_c = LCD_c \times CF_c$	$1{,}071\ tons \times 1\ control\ factor$	1,071 tons of land clearing debris burned in McLean County, IL
27	$BLCD_{r,c} = BLCD_c \times \dfrac{RLand_c}{TLand_c}$	$1{,}071\ tons$ $\times \dfrac{2{,}923{,}414{,}473\ m^2\ rural\ land}{3{,}064{,}933{,}852\ m^2\ total\ land}$	1,022 tons of land clearing debris burned in rural areas in McLean County, IL
28	$E_{c,p} = BLCD_{r,c} \times EF_p \times \dfrac{1\ ton}{2000\ lb}$	$1{,}022\ tons \times 13.1053\ \dfrac{lb}{ton} \times \dfrac{1\ ton}{2000\ lb}$	6.7 tons PM25-PRI emissions in McLean County, IL

4.27.4.7 Changes from the 2014 methodology

The main change to this methodology from the methodology used to calculate the 2014 v2 NEI is that the estimated amount of land clearing debris in each county is multiplied by the fraction of rural land area in each county. This step was not done in the methodology used for the 2014 v2 NEI.

4.27.4.8 Puerto Rico and U.S. Virgin Islands

Since insufficient data exist to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emissions factor. For each Puerto Rico and US Virgin Island county, the tons per capita emissions factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.27.4.9 References

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5. U.S. Census Bureau. 2018. New Privately Owned Housing Units by Purpose and Design.
6. U.S. Census Bureau. 2001. Housing Starts. Table 1.
7. U.S. Census Bureau, New Privately Owned Housing Units Authorized - Unadjusted Units for Regions, Divisions, and States, Annual 2017, Table 2au.
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4.27.5 EPA-developed emissions for residential household waste

The calculations for estimating the emissions from the burning of residential household waste (RHW) involve first estimating the amount of combustible waste generated in each county. The amount of waste generated in the U.S. is available from the EPA report, *Advancing Sustainable Materials Management: 2015 Fact Sheet* [ref 1]. The amount of county-level RHW burned is estimated by calculating the per capita amount of RHW generated using the national data from EPA and multiplying that by the number of people likely to burn waste in each county. The number of people likely to burn waste is based on the rural population in each county from the 2010 census. To estimate emissions from RHW burning, pollutant emissions factors are multiplied by the amount of combustible waste burned. Emissions factors for PM, VOC, and HAPs are from the literature, whereas emissions factors for CO, NOX, and SO2 are adjusted based on the ratio of total waste to combustible waste.

4.27.5.1 *Activity data*

The activity data for this source category is the amount of RHW burned in each county, which is estimated using data the EPA report *Advancing Sustainable Materials Management: 2015 Fact Sheet* [ref 1]. The report presents the total mass of waste generated from the residential and commercial sectors in the United States by type of waste for the calendar year 2015.

Table 4-207 shows the total national-level waste generated by type and the corresponding per capita values. Per capita values of RHW subject to burning were developed based on EPA's total amount of waste generated in 2015. According to the 2010 version of the same EPA report, residential waste generation accounts for 55-65% of the total waste from the residential and commercial sectors [ref 2]; for the per capita calculation, the median value of 60% of total waste generated is assumed. This number is multiplied by the sums of the total and combustible waste, respectively. Each number is then divided by the U.S. population in 2017 (329 million people) [ref 3] to determine separate per capita values for total and combustible waste. Note that yard waste is not included in either per capita value as emissions from the burning of yard waste are calculated in separate SCCs.

$$PC_{cwaste} = \frac{\sum_{Com} W \times 0.60}{P_{y,US}} \qquad (1)$$

$$PC_{twaste} = \frac{\sum_T W \times 0.60}{P_{US}} \qquad (2)$$

Where:

PC_{cwaste} = Per capita value of combustible waste in the U.S., in tons per person
PC_{twaste} = Per capita value of total waste in the U.S., in tons per person
Com = Types of combustible waste (not including yard waste)
T = All types of waste (not including yard waste)
W = Annual weight of waste, in million tons
$P_{y,US}$ = Population of the U.S. for year of inventory, in million people

The per capita value of combustible household waste is estimated to be 0.354 tons generated per person in 2015, and the per capita value of total waste is 0.420 tons generated per person.

Table 4-207: Annual RHW generated (tons/person) in the U.S. in 2015

Material	Weight Generated (million tons)	Total per person	Combustible per person
Paper	68.61	0.129	0.129
Glass	11.48	0.022	0
Metals			
Steel	17.69	0.033	0. 0
Aluminum	3.53	0.007	0.0
Other nonferrous	2.04	0.004	0.0
Total Metals	*23.26*	*0.044*	*0.0*
Plastics	32.25	0.061	0.061
Rubber/leather	8.21	0.015	0.015
Textiles	16.22	0.031	0.031
Wood	16.12	0.030	0.030
Other	4.44	0.008	0.008
Total Materials	*180.59*	*0.340*	*0.274*
Other wastes			
Food	38.40	0.072	0.072
Yard	34.50	0.0	0.0
Miscellaneous inorganic	3.97	0.007	0.007
Total Other	*76.87*	*0.080*	*0.080*
TOTAL RHW	**257.46**	**0.420**	**0.354**

Source: Reference 1, Table 1

As open burning of RHW is generally not practiced in urban areas, only the rural population in each county is assumed to practice open burning. The rural and urban populations are taken from 2010 U.S. Census data for each county [ref 4]. It is assumed that 24% of the rural population burns RHW [ref 5].

$$PBurn_c = RPop_c \times 0.24 \qquad (3)$$

Where:

$RPop_{,c}$ = Rural population in county *c* in 2010
$PBurn_c$ = Population likely to burn RHW in county *c*

The number of people likely to burn waste in each county (from equation 3) is then used with the values of per capita household waste subject to burning (from equations 1 and 2) to determine the amount of household RHW burned.

$$CWst_c = PBurn_c \times PC_{cwaste} \tag{4}$$

Where:

$CWst_c$ = Annual combustible RHW burned in county c, in tons
$PBurn_c$ = Population likely to burn in county c
PC_{cwaste} = Per capita value of combustible waste in the U.S., in tons per person

4.27.5.2 *Allocation procedure*

National values for the amount of waste generated are distributed to the counties based on rural population, as described in Section 4.27.5.1.

4.27.5.3 *Emission factors*

Emissions factors for open burning of RHW are reported in Table 4-208. The emissions factors for CO, NOX, PM, SO2, and VOC and some HAPs are from AP-42 [ref 6] and the EPA report *Evaluation of Emissions from the Open Burning of Household Waste in Barrels* [ref 7]. Emissions factors for HAPs are from an EPA Office of Research and Development report [ref 8] and a Minnesota Pollution Control Agency Report [ref 9]. For HAP emissions factors from the EPA Control Technology Center report [ref 7], the emissions factors are based on an average of emissions factors for non-recyclers. This assumes that a person burning RHW in their yard is more likely to be a non-recycler than an avid recycler.

Table 4-208: Emission factors for Open Burning of RHW

Pollutant	Pollutant Code	Emission Factor (original)	Emission Factor Units (original)	Emission Factor (converted)	Emission Factor Units (converted)	Reference & Table No.
Carbon Monoxide	CO	85	lbs./ton	100.61	lbs./ton	Reference 6, Table 2.5-1; original factor based on total waste; converted factor based on combustible waste
Nitrogen Oxides	NOX	6	lbs./ton	7.10	lbs./ton	Reference 6, Table 2.5-1; original factor based on total waste; converted factor based on combustible waste
PM10-FIL	PM10-FIL	18.76	g/kg	38	lbs./ton	Reference 7 (average of non-recyclers)

Pollutant	Pollutant Code	Emission Factor (original)	Emission Factor Units (original)	Emission Factor (converted)	Emission Factor Units (converted)	Reference & Table No.
PM10-PRI	PM10-PRI	18.76	g/kg	38	lbs./ton	Reference 7 (average of non-recyclers)
PM25-FIL	PM25-FIL	17.44	g/kg	34.8	lbs./ton	Reference 7 (average of non-recyclers)
PM25-PRI	PM25-PRI	17.44	g/kg	34.8	lbs./ton	Reference 7 (average of non-recyclers)
Sulfur Oxides	SO2	1	lbs./ton	1.184	lbs./ton	Reference 6, Table 2.5-1; original factor based on total waste; converted factor based on combustible waste
VOC	VOC	-	mg/kg	7.409	lbs./ton	Reference 6, Table 3-6 (sum of HAP VOC emissions factors)
1,2,4-trichlorobenzene	120821	0.1	mg/kg	2.00E-04	lbs./ton	Reference 8, Table 3-6
1,4-dichlorobenzene	106467	0.03	mg/kg	6.00E-05	lbs./ton	Reference 8, Table 3-6
2,4,6-Trichlorophenol	88062	0.19	mg/kg	3.80E-04	lbs./ton	Reference 8, Table 3-6
2-Methylnapthalene	91576	8.53	mg/kg	1.70E-02	lbs./ton	Reference 8, Table 3-6
Acenaphthene	83329	0.64	mg/kg	1.28E-03	lbs./ton	Reference 8, Table 3-6
Acenaphthylene	208968	7.34	mg/kg	1.47E-02	lbs./ton	Reference 8, Table 3-6
Acetaldehyde	75070	428.4	mg/kg	8.55E-01	lbs./ton	Reference 8, Table 3-6
Acetophenone	98862	4.69	mg/kg	9.36E-03	lbs./ton	Reference 8, Table 3-6
Acrolein	107028	26.65	mg/kg	5.32E-02	lbs./ton	Reference 8, Table 3-6
Anthracene	120127	1.3	mg/kg	2.59E-03	lbs./ton	Reference 8, Table 3-6
Benz[a]anthracene	56553	1.51	mg/kg	3.01E-03	lbs./ton	Reference 8, Table 3-6
Benzene	71432	979.75	mg/kg	1.96E+00	lbs./ton	Reference 8, Table 3-6

Pollutant	Pollutant Code	Emission Factor (original)	Emission Factor Units (original)	Emission Factor (converted)	Emission Factor Units (converted)	Reference & Table No.
Benzo[a]pyrene	50328	1.4	mg/kg	2.79E-03	lbs./ton	Reference 8, Table 3-6
1,3-Butadiene	106990	141.25	mg/kg	2.82E-01	lbs./ton	Reference 8, Table 3-6
Benzo[b]fluoranthene	205992	1.86	mg/kg	3.71E-03	lbs./ton	Reference 8, Table 3-6
Benzo[g,h,i,]Perylene	191242	1.3	mg/kg	2.59E-03	lbs./ton	Reference 8, Table 3-6
Benzo[k]fluoranthene	207089	0.67	mg/kg	1.34E-03	lbs./ton	Reference 8, Table 3-6
Bis (2-Ethylhexyl) Phthalate	117817	23.79	mg/kg	4.75E-02	lbs./ton	Reference 8, Table 3-6
Chloromethane	74873	163.25	mg/kg	3.26E-01	lbs./ton	Reference 8, Table 3-6
Chrysene	218019	1.8	mg/kg	3.59E-03	lbs./ton	Reference 8, Table 3-6
Cresol/Cresylic Acid (Mixed Isomers)	1319773	68.77	Mg/kg	1.37E-01	lbs./ton	Reference 8, Table 3-6
Dibenzo[a,h]anthracene	53703	0.27	mg/kg	5.40E-04	lbs./ton	Reference 8, Table 3-6
Dibutyl Phthalate	84742	3.45	mg/kg	6.89E-03	lbs./ton	Reference 8, Table 3-6
Ethyl Benzene	100414	181.75	mg/kg	3.63E-01	lbs./ton	Reference 8, Table 3-6
Fluoranthene	206440	2.77	mg/kg	5.53E-03	lbs./ton	Reference 8, Table 3-6
Fluorene	86737	2.99	mg/kg	5.97E-03	lbs./ton	Reference 8, Table 3-6
Formaldehyde	50000	443.65	mg/kg	8.85E-01	lbs./ton	Reference 8, Table 3-6
Dibenzofuran	132649	3.64	mg/kg	7.26E-03	lbs./ton	Reference 8, Table 3-6
Hexachlorobenzene	118741	0.04	mg/kg	8.00E-05	lbs./ton	Reference 8, Table 3-6
Hydrogen Chloride	7647010	5.31E-01	lbs./ton	5.31E-01	lbs./ton	Reference 6
Hydrogen Cyanide	74908	8.75E-01	lbs./ton	8.75E-01	lbs./ton	Reference 6
Indeno[1,2,3-c,d]pyrene	193395	1.27	mg/kg	2.53E-03	lbs./ton	Reference 8, Table 3-6
Isophorone	78591	9.25	mg/kg	1.85E-02	lbs./ton	Reference 8, Table 3-6
Methylene Chloride	75092	17	mg/kg	3.39E-02	lbs./ton	Reference 8, Table 3-6
Mercury	7439976	8.74E-04	lbs./ton	-	-	Reference 9

Pollutant	Pollutant Code	Emission Factor (original)	Emission Factor Units (original)	Emission Factor (converted)	Emission Factor Units (converted)	Reference & Table No.
Naphthalene	91203	11.36	mg/kg	2.27E-02	lbs./ton	Reference 8, Table 3-6
Pentachloronitrobenzene	82688	0.01	mg/kg	2.00E-05	lbs./ton	Reference 8, Table 3-6
Phenanthrene	85018	5.33	mg/kg	1.06E-02	lbs./ton	Reference 8, Table 3-6
Phenol	108952	112.66	mg/kg	2.25E-01	lbs./ton	Reference 8, Table 3-6
Polychlorinated Biphenyls (PCBs)	1336363	0.126	mg/kg	2.51E-04	lbs./ton	Reference 8, Table 3-6
Propionaldehyde	123386	112.6	mg/kg	2.25E-01	lbs./ton	Reference 8, Table 3-6
Pyrene	129000	3.18	mg/kg	6.35E-03	lbs./ton	Reference 8, Table 3-6
Styrene	100425	527.5	mg/kg	1.05E+00	lbs./ton	Reference 8, Table 3-6
Toluene	108883	372	mg/kg	7.42E-01	lbs./ton	Reference 8, Table 3-6
Xylenes (Mixed Isomers)	1330207	38	mg/kg	7.58E-02	lbs./ton	Reference 8, Table 3-6

a. Emissions factor for 1,4-Dichlorobenzene is reported as <1 mg/kg. The factor used for this methodology assumes that the actual value is 0.333 mg/kg.
b. Emissions factor for Pentachlorophenol is reported as <0.0025 and <0.0018 g/kg. The factor used for this methodology assumes that the actual value is 5.3E-05 g/kg.

The emissions factors for PM, VOC, and HAPs were developed based on the amount of combustible waste burned. Emissions factors for CO, NOX, and SO2 were developed based on the amount of total waste burned; therefore, these factors need to be adjusted to be used with the values of combustible waste burned. This is accomplished by multiplying the emissions factors by a ratio of the total per capita waste to combustible per capita waste in 2015.

$$EF_{p,Com} = EF_{p,T} \times \frac{PC_{twaste}}{PC_{cwaste}} \tag{5}$$

Where:

EF_p	=	Emission factor for pollutant p, in lbs. of pollution per ton of waste burned
Com	=	Types of combustible waste (not including yard waste)
T	=	All types of waste (not including yard waste)
PC_{cwaste}	=	Per capita value of combustible waste in the US, in tons per person
PC_{twaste}	=	Per capita value of total waste in the US, in tons per person

4.27.5.4 *Controls*

Controls for residential household waste burning are generally in the form of a ban on open burning of waste in a given municipality or county. However, literature suggests that burn bans are not 100% effective. It is therefore assumed that approximately 25% of the residents that may burn trash in the yard would burn waste even if a ban is in place. For counties that have burn bans, the assumption is applied by multiplying 0.25 by the annual waste burned. Currently no counties are assumed to have burn bans in place.

$$If\ county\ c\ has\ a\ burn\ ban \qquad\qquad (6)$$
$$Then\ CWst_c = CWst_c \times 0.25$$

Where:

$CWst_c$ = Annual combustible RHW burned in county c, in tons

4.27.5.5 *Emissions*

The annual amount of combustible RHW burned in each county is multiplied by the emissions factors listed in Table 4-208 to estimate emissions.

$$(7)$$
$$E_{p,c} = CWst_c \times EF_{p,Com}$$

Where:

$E_{p,c}$ = Annual emissions of pollutant *p* in county *c*
$EF_{p,Com}$ = Emission factor for pollutant *p*, in lbs. of pollution per ton of combustible waste burned
$CWst_c$ = Annual combustible RHW burned in county c, in tons

4.27.5.6 *Example calculations*

Table 4-209 lists sample calculations to determine the CO and VOC emissions from open burning in Autauga County, Alabama.

Table 4-209: Sample calculations for CO and VOC emissions from open burning in Autauga County, AL

Eq. #	Equation	Values for Autauga County, AL	Result
1	$PC_{cwaste} = \dfrac{\sum_{Com} W \times 0.60}{P_{y,US}}$	$\dfrac{188.22\ million\ tons\ of\ waste \times 0.60}{318.85\ million\ people}$	0.354 tons combustible waste per person per year
2	$PR_{twaste} = \dfrac{\sum_{NC} W \times 0.60}{P_{US}}$	$\dfrac{222.96\ million\ tons\ of\ waste \times 0.60}{318.85\ million\ people}$	0.420 tons total waste per person per year
3	$PBurn_c = RPop_c \times 0.24$	$22,921\ people \times 0.24$	5,501 people likely to burn in Autauga County, AL

Eq. #	Equation	Values for Autauga County, AL	Result
4	$$CWst_c = PBurn_c \times PC_{cwaste}$$	$5{,}501\ people \times$ $0.354\ tons\ combustible\ \text{waste}\ per\ person$	1,947.4 tons of combustible waste burned in Autauga County, AL
5	$$EF_{p,Com} = EF_{p,T} \times \frac{PC_{twaste}}{PC_{cwaste}}$$	$85\ lbs.\,per\ ton \times \dfrac{0.42\ tons\ per\ person}{0.354\ tons\ per\ person}$	100.8 lbs. of CO per ton of combustible waste burned
6	$If\ county\ c\ has\ a\ burn\ ban$ $Then\ CWst_c = CWst_c$ $\times 0.25$	N/A	Autauga County, AL does not have a burn ban
7	$$E_{p,c} = CWst_c \times EF_{p,Com}$$	$1{,}947.4\ tons \times 100.8\ lbs.\,per\ ton$	98.14 tons CO emissions from burning of RHW in Autauga County, AL
7		$1{,}947.4\ tons \times 8.46\ lbs.\,per\ ton$	8.23 tons VOC emissions from burning of RHW in Autauga County, AL

4.27.5.7 Changes from the 2014 methodology

The 2017 emissions inventory methodology for RHW burning includes changes to the method for determining population likely to burn, and changes to the emissions factors for CO, NOX, and SO2. The 2014 v2 NEI methodology determined the population likely to burn by identifying the rural and "like rural" population in each county in 2010 and using the fraction of 2010 rural and like rural population to total population in order to determine the rural population in 2014. The 2017 methodology only uses the 2010 rural population to determine the population likely to burn.

Additionally, the 2014 v2 NEI methodology used emissions factors for CO, NOX, and SO2 that corresponded to the amount of combustible plus non-combustible waste burned. The 2017 methodology uses a ratio of combustible to total waste burned in order to adjust the CO, NOX, and SO2 emissions factors to be used with the amount of combustible waste burned.

4.27.5.8 Puerto Rico and U.S. Virgin Islands

Emissions from Puerto Rico are calculated using the same method described above. For the U.S. Virgin Islands, emissions are calculated using 2010 population data, since 2017 Census Data does not exist for the U.S. Virgin Islands.

4.27.5.9 References

1. U.S. Environmental Protection Agency. 2018. Advancing Sustainable Materials: 2015 Fact Sheet, Table 1. Generation, Recovery and Discards of Materials in MSW, 2015 (in millions of tons and percent of generation of each material).
2. U.S. Environmental Protection Agency. 2011. Municipal Solid Waste Generation, Recycling, and Disposal

in the United States: Facts and Figures for 2010—Fact Sheet, p. 4.

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9. Babineau, I., Wu, C.Y., Jackson, A., Minnesota Pollution Control Agency. 2016. "Emission Factor Development for Mercury Emitted From Municipal Solid Waste during Processing and Handling." In proceedings of the 109th Annual Meeting of the A&WMA, New Orleans, LA.

4.28 Waste Disposal: Nonpoint POTWs

4.28.1 Source category description

This source category, Publicly Owned Treatment Works (POTW), includes treatment works owned by a state, municipality, city, town, special sewer district, or other publicly owned and financed entity as opposed to a privately (industrial) owned treatment facility. The definition includes intercepting sewers, outfall sewers, sewage collection systems, pumping, power, and other equipment. The wastewater treated by these POTWs is generated by industrial, commercial, and domestic sources [ref 1]. The SCC that EPA uses for estimated nonpoint emissions is 2630020000; the SCC description is "Waste Disposal, Treatment, and Recovery; Wastewater Treatment; Public Owned; Total Processed".

4.28.2 Sources of data

The agencies listed in Table 4-210 submitted emissions for POTWs; agencies not listed used EPA estimates.

Table 4-210: Agencies that submitted POTW emissions in the 2017 NEI

Region	Agency	S/L/T
2	New York State Department of Environmental Conservation	State
3	Maryland Department of the Environment	State
4	Knox County Department of Air Quality Management	Local
4	Memphis and Shelby County Health Department - Pollution Control	Local
4	Metro Public Health of Nashville/Davidson County	Local
5	Illinois Environmental Protection Agency	State
6	Texas Commission on Environmental Quality	State
8	Utah Division of Air Quality	State
9	California Air Resources Board	State
9	Maricopa County Air Quality Department	Local
9	Washoe County Health District	Local
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State

Region	Agency	S/L/T
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe
10	Washington State Department of Ecology	State

4.28.3 EPA-developed emissions

The calculations for estimating the emissions from POTWs involve multiplying the wastewater flow rate by emissions factors for VOCs, NH3, and 53 HAPs.

4.28.3.1 *Activity data*

The activity data for this source category is the wastewater flow rate. The EPA Clean Watersheds Needs Survey provides flow rate by facility and estimates the national POTW flow rate in 2012 for all facilities as 32,822 million gallons per day (MMGD) [ref 2]. The nationwide flow rate includes Puerto Rico and the US Virgin Islands. To estimate flow rates in 2017, facility-level daily flow rates in 2012 are multiplied by the ratio of 2017 to 2012 population in the county where the facility resides [ref 3]. County-level annual 2017 wastewater flow rates are calculated by summing the daily flow rates for all POTWs within the county and multiplying by 365 days in a year.

$$(1)$$

$$FR_{c,2017} = \sum_{f=1}^{n} FR_{f,2012} \times 365 \times \frac{P_{c,2017}}{P_{c,2012}}$$

Where:

$FR_{c,2017}$ = The annual wastewater flow rate of county c in 2017
$FR_{f,2012}$ = The daily wastewater flow rate at facility f in 2012
$P_{c,2017}$ = Total population of county c in 2017
$P_{c,2012}$ = Total population of county c in 2012

4.28.3.2 *Allocation procedure*

For a given county, county-level wastewater flow rates are calculated by summing the flow rates for all POTWs within the county.

4.28.3.3 *Emission factors*

Emissions factors for POTWs are reported in Table 4-211. The ammonia emissions factor was obtained from an EPA report [ref 4] and the VOC emissions factor was based on a TriTAC study [ref 5]. Emissions factors for HAPs were derived using 1996 area source emissions estimates that were provided by Bob Lucas [ref 6] and the 1996 nationwide flow rate [ref 7]. These HAP emissions factors were then multiplied by the 2008 to 2002 VOC emissions factor ratio (0.85/9.9) to obtain the final HAP emissions factors applied in the 2017 inventory.

Table 4-211: Emission Factors for Publicly Owned Treatment Works

Pollutant	Pollutant Code	Emissions Factor (lbs./MMGAL)	Emissions Factor Reference(s)
1,1,2,2-Tetrachloroethane	79345	1.75E-06	6, 7
1,1,2-Trichloroethane	79005	1.17E-06	6, 7
1,2,4-Trichlorobenzene	120821	8.67E-05	6, 7
1,3-Butadiene	106990	2.51E-05	6, 7
1,4-Dichlorobenzene	106467	2.16E-04	6, 7
1-Chloro-2,3-Epoxypropane	106898	4.52E-06	6, 7
2,4-Dinitrotoluene	121142	4.81E-05	6, 7
2-Nitropropane	79469	2.92E-07	6, 7
Acetaldehyde	75070	3.10E-04	6, 7
Acetonitrile	75058	3.45E-04	6, 7
Acrolein	107028	3.84E-04	6, 7
Acrylonitrile	107131	3.86E-04	6, 7
Allyl Chloride	107051	1.94E-05	6, 7
Ammonia	NH3	1.69E-01	4
Benzene	71432	6.73E-03	6, 7
Benzyl Chloride	100447	8.17E-06	6, 7
Biphenyl	92524	7.52E-05	6, 7
Carbon Disulfide	75150	4.32E-03	6, 7
Carbon Tetrachloride	56235	1.12E-03	6, 7
Chlorobenzene	108907	4.83E-04	6, 7
Chloroform	67663	6.44E-03	6, 7
Chloroprene	126998	2.38E-05	6, 7
Cresols/Cresylic Acid (Isomers and Mixture)	1319773	1.61E-06	6, 7
Dimethyl Sulfate	77781	1.31E-06	6, 7
Ethyl Acrylate	140885	1.75E-06	6, 7
Ethyl Benzene	100414	7.66E-03	6, 7
Ethylene Oxide	75218	2.22E-04	6, 7
Formaldehyde	50000	1.97E-05	6, 7
Glycol Ethers	171	1.15E-02	6, 7
Hexachlorobutadiene	87683	7.29E-07	6, 7
Hexachlorocyclopentadiene	77474	5.83E-07	6, 7
Methanol	67561	1.14E-02	6, 7
Methyl Chloroform	71556	5.63E-04	6, 7
Methyl Isobutyl Ketone	108101	2.69E-03	6, 7
Methyl Methacrylate	80626	3.11E-04	6, 7
Methyl Tert-Butyl Ether	1634044	6.37E-05	6, 7
Methylene Chloride	75092	9.10E-03	6, 7
N,N-Dimethylaniline	121697	3.22E-04	6, 7
Naphthalene	91203	1.31E-03	6, 7
Nitrobenzene	98953	6.56E-06	6, 7
O-Toluidine	95534	1.75E-06	6, 7
P-Dioxane	123911	1.79E-05	6, 7
Propionaldehyde	123386	3.50E-06	6, 7

Pollutant	Pollutant Code	Emissions Factor (lbs./MMGAL)	Emissions Factor Reference(s)
Propylene Dichloride	78875	1.15E-05	6, 7
Propylene Oxide	75569	7.32E-04	6, 7
Styrene	100425	2.73E-03	6, 7
Tetrachloroethylene	127184	4.27E-03	6, 7
Toluene	108883	1.23E-02	6, 7
Trichloroethylene	79016	3.06E-04	6, 7
Vinyl Acetate	108054	7.66E-05	6, 7
Vinyl Chloride	75014	6.71E-06	6, 7
Vinylidene Chloride	75354	4.23E-04	6, 7
Volatile Organic Compounds	VOC	8.50E-01	5
Xylenes (Mixture of O, M, And P Isomers)	1330207	5.98E-02	6, 7

4.28.3.4 *Controls*

There are no controls assumed for this category.

4.28.3.5 *Emissions*

Emissions are estimated by multiplying an emissions factor by the county flow rate. A conversion factor was used to convert pounds to tons.

$$(2)$$

$$E_{p,c,2017} = FR_{c,2017} \times EF_p \times \frac{1\ ton}{2000\ lbs.}$$

Where:

$E_{p,c,2017}$ = Nonpoint emissions in 2017 of pollutant p in county c, in tons
$FR_{c,2017}$ = Flow rate in 2017 in county c, in MMGY
EF_p = Emissions factor for pollutant p, in lbs. per MMGAL

4.28.3.6 *Point source subtraction*

The county-level flow rates include all facilities reported as POTWs in the EPA Clean Watersheds Needs Survey. In some cases, SLT agencies might include facilities under their point source inventory reporting. In these cases, SLT agencies have two options for submitting state-level point source data to EPA for point source subtraction:

- **Option A:** County-level flow rates associated with POTWs reported as point sources; or
- **Option B:** County-level emissions of VOC and NH3 for POTWs reported as point sources.

4.28.3.7 *Example calculations*

Table 4-212 lists sample calculations to determine the benzene emissions for nonpoint source POTWs for Autauga County, Alabama.

Table 4-212: Sample calculations for benzene emissions for nonpoint source POTWs for Autauga County, AL

Eq. #	Equation	Values for Autauga County, AL	Result
1	$$FR_{c,2017} = \sum_{f=1}^{n} FR_{f,2012} \times 365 \\ \times \frac{P_{c,2017}}{P_{c,2012}}$$	$2.866 \; MMGD \times 365 \; days \times$ $\frac{55,504 \; people}{54,927 \; people}$	1,057.07 MMGY
2	$$E_{p,c,2017} = FR_{c,2017} \times EF_p \\ \times \frac{1 \; ton}{2000 \; lbs.}$$	$1,057.07 \; MMGY \times 0.00673 \; lb/MMG \times$ $\frac{1 \; ton}{2000 \; lbs.}$	0.003557 tons benzene per year

4.28.3.8 *Changes from the 2014 methodology*

County-level flow rates in 2017 were determined by summing facility-level data to the county-level rather than allocating the national flow rate to counties based on the ratio of county to US population.

4.28.3.9 *Puerto Rico and U.S. Virgin Islands*

Emissions from Puerto Rico are calculated using the same method described above. For the U.S. Virgin Islands, emissions are not multiplied by the ratio of 2017 to 2012 population since 2017 Census Data does not exist for the U.S. Virgin Islands.

4.28.4 References

1. U.S. EPA, 64FR57572, National Emission Standards for Publicly Owned Treatment Works, Final Rule, 40 CFR Part 63, 26 October 1999.
2. U.S. Environmental Protection Agency, Clean Watersheds Needs Survey 2012 Data and Reports, Detail Report.
3. U.S. Census Bureau. Total Population, American Community Survey.
4. Stephen M. Roe, Melissa D. Spivey, Holly C. Lindquist, Kirstin B. Thesing, and Randy P. Strait, E.H. Pechan & Associates, Inc., Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources – Draft Final Report, prepared for U.S. Environmental Protection Agency, Emission Inventory Improvement Program, April 2004.
5. Prakasam Tata, Jay Witherspoon, Cecil Lue-Hing (eds.), VOC Emissions from Wastewater Treatment Plants: Characterization, Control, and Compliance, Lewis Publishers, 2003, p. 261.
6. Memorandum from Bob Lucas, U.S Environmental Protection Agency to Greg Nizich, U.S. Environmental Protection Agency, "Review of Baseline Emissions Inventory," 16 October 1998.
7. U.S. Environmental Protection Agency, Facilities Database (Needs Survey) - Frequently Asked Questions, accessed 30 April 2019.

5 Nonroad Equipment – Diesel, Gasoline and Other

Although "nonroad" is used to refer to all mobile sources that are not on-highway, this section addresses nonroad equipment other than locomotives, aircraft, or commercial marine vessels. Locomotive emissions from railyards and aircraft and associated ground support equipment are described in Section 3. The nonpoint portion of locomotives and commercial marine vessel emissions will be provided with the nonpoint section when it is later-available with the full 2017 NEI release.

5.1 Sector Description

This section deals specifically with emissions processes calculated by the nonroad component of EPA's MOVES model (herein referred to as MOVES-Nonroad) [ref 1] and the family of off-road models used by California [ref 2]. They include nonroad engines and equipment, such as lawn and garden equipment, construction equipment, engines used in recreational activities, portable industrial, commercial, and agricultural engines. Nonroad equipment emissions are included in every state, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands.

Nonroad mobile source emissions are generated by a diverse collection of equipment from lawn mowers to locomotive support. MOVES-Nonroad estimates emissions from nonroad mobile sources using a variety of fuel types, as shown in Table 5-1.

Table 5-1: MOVES-Nonroad equipment and fuel types

Equipment Types	Fuel Types
Recreational	
Construction	
Industrial	
Lawn and Garden	
Agriculture	
Commercial	Compressed Natural Gas (CNG)
Logging	Diesel
Airport Ground Support Equipment (GSE; excludes aircraft)*	Gasoline
Underground Mining	Liquified Petroleum Gas (LPG)
Oilfield**	
Pleasure Craft (recreational marine; excludes commercial marine vessels)	
Railroad (excludes locomotives)	

*Although MOVES-Nonroad estimates emissions from GSE, the results are not used in the NEI. NEI GSE estimates are instead calculated via the Federal Aviation Administration's Aviation Environmental Design Tool (AEDT).

**Although MOVES-Nonroad estimates emissions from Oilfield equipment, the results are not used in the NEI, because they are duplicative of results from EPA's Oil and Gas Tool used in nonpoint source calculations.

5.2 MOVES-Nonroad

MOVES2014b, the latest public release of EPA's Motor Vehicle Emissions Simulator (MOVES) Model, estimates daily emissions for total hydrocarbons (THC), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO_2), particulate matter 10 microns and less (PM_{10}), and sulfur dioxide (SO_2), as well as calculating fuel consumption. MOVES2014b (version 20180726 [ref 1] uses ratios from some of these emissions to calculate emissions for particular matter 2.5 microns and less ($PM_{2.5}$), methane, ammonia (NH_3), four more aggregate hydrocarbon groups (NMHC, NMOG, TOG, and VOC), 14 hazardous air pollutants (HAPs), 17 dioxin/furan congeners, 32 polycyclic aromatic hydrocarbons, and six metals. For a complete list of these pollutants, see Table 5-2. All the input and activity data required to run MOVES-Nonroad are contained within the MOVES default database, which is distributed with the model. State- and county-specific data can be used by creating a supplemental database known as a county database (CDB) and specifying it in the MOVES run specification (runspec). State, local and tribal (S/L/T) agencies can update the data within the CDBs to produce emissions estimates that accurately reflect local conditions and equipment usage. MOVES first uses the data in the CDBs and fills in any missing data from the MOVES default database.

Table 5-2: Pollutants produced by MOVES-Nonroad for 2017 NEI

Pollutant ID	Pollutant Name	Pollutant ID	Pollutant Name
1	Total Gaseous Hydrocarbons	83	Phenanthrene particle
2	Carbon Monoxide (CO)	84	Pyrene particle
3	Oxides of Nitrogen (NOx)	86	Total Organic Gases
5	Methane (CH_4)	87	Volatile Organic Compounds
20	Benzene	88	NonHAPTOG
21	Ethanol	90	Atmospheric CO_2
22	MTBE	99	Brake Specific Fuel Consumption (BSFC)
23	Naphthalene particle	100	Primary Exhaust PM_{10} - Total
24	1,3-Butadiene	110	Primary Exhaust $PM_{2.5}$ - Total
25	Formaldehyde	130	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin
26	Acetaldehyde	131	Octachlorodibenzo-p-dioxin
27	Acrolein	132	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin
30	Ammonia (NH_3)	133	Octachlorodibenzofuran
31	Sulfur Dioxide (SO_2)	134	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin
40	2,2,4-Trimethylpentane	135	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin
41	Ethyl Benzene	136	2,3,7,8-Tetrachlorodibenzofuran
42	Hexane	137	1,2,3,4,7,8,9-Heptachlorodibenzofuran
43	Propionaldehyde	138	2,3,4,7,8-Pentachlorodibenzofuran
44	Styrene	139	1,2,3,7,8-Pentachlorodibenzofuran
45	Toluene	140	1,2,3,6,7,8-Hexachlorodibenzofuran
46	Xylene	141	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin
60	Mercury Elemental Gaseous	142	2,3,7,8-Tetrachlorodibenzo-p-Dioxin
61	Mercury Divalent Gaseous	143	2,3,4,6,7,8-Hexachlorodibenzofuran
62	Mercury Particulate	144	1,2,3,4,6,7,8-Heptachlorodibenzofuran
63	Arsenic Compounds	145	1,2,3,4,7,8-Hexachlorodibenzofuran
65	Chromium 6+	146	1,2,3,7,8,9-Hexachlorodibenzofuran
66	Manganese Compounds	168	Dibenzo(a,h)anthracene gas
67	Nickel Compounds	169	Fluoranthene gas

Pollutant ID	Pollutant Name	Pollutant ID	Pollutant Name
68	Dibenzo(a,h)anthracene particle	170	Acenaphthene gas
69	Fluoranthene particle	171	Acenaphthylene gas
70	Acenaphthene particle	172	Anthracene gas
71	Acenaphthylene particle	173	Benz(a)anthracene gas
72	Anthracene particle	174	Benzo(a)pyrene gas
73	Benz(a)anthracene particle	175	Benzo(b)fluoranthene gas
74	Benzo(a)pyrene particle	176	Benzo(g,h,i)perylene gas
75	Benzo(b)fluoranthene particle	177	Benzo(k)fluoranthene gas
76	Benzo(g,h,i)perylene particle	178	Chrysene gas
77	Benzo(k)fluoranthene particle	181	Fluorene gas
78	Chrysene particle	182	Indeno(1,2,3,c,d)pyrene gas
79	Non-Methane Hydrocarbons	183	Phenanthrene gas
80	Non-Methane Organic Gases	184	Pyrene gas
81	Fluorene particle	185	Naphthalene gas
82	Indeno(1,2,3,c,d)pyrene particle		

5.3   Default MOVES code and database

The nonroad runs were executed using MOVES2014b, the most current publicly-released version of MOVES available at the time. The code version for this release is moves20180726. The default database is movesdb20181022, the same one released publicly with MOVES2014b.

Additionally, national updates that were made to the MOVES2014b default database for the 2016v1 Platform were used in the MOVES-Nonroad run for the 2017 NEI. This includes updated surrogate data for allocating national populations of Agricultural and Construction equipment to the state and county levels, as described in the 2016v1 Platform Nonroad Mobile Emissions Specification Sheet [ref 4].

5.4   Additional Data: Nonroad County Databases (CDBs)

MOVES uses county databases (CDBs) to provide detailed local information for developing nonroad emissions. The EPA encouraged S/L/T agencies to submit MOVES-Nonroad CDBs to the Emission Inventory System (EIS) for the 2017 NEI. Data not provided in CDBs is automatically supplied from the MOVES default database. As is also true for MOVES onroad runs, even if an agency submitted fuel or meteorological data, the EPA's values for these data parameters were used. Fuels values were developed specifically for the 2017 NEI, based on the extensive refinery gate batch dataset collected as a part of EPA's fuel compliance programs. The meteorological data were provided by OAQPS and were derived from a Weather Research and Forecasting Model (WRF) version 3.8 [ref 5] run.

Table 5-3 shows the selection hierarchy for the nonroad data category. The modified MOVES default database for MOVES2014b containing refinements to construction and agricultural sectors [ref 4], (movesdb20181022_nrupdates) and state-submitted inputs in CDBs were used to run MOVES-Nonroad to produce emissions for all states other than California. California-submitted emissions were used.

Table 5-3: Selection hierarchy for the Nonroad Mobile data category

Priority	Dataset	Notes
1	Responsible Agency Data Set	Several tribes submitted nonroad emissions: Northern Cheyenne Tribe, Kootenai Tribe of Idaho, Coeur d'Alene Tribe, Nez Perce Tribe, Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho. California submitted emissions calculated with their own model, OFFROAD2007.*
2	2017EPA_Ca_MOVES	Includes California CAPs and HAPs speciated from California VOC and PM based on MOVES ratios
3	2017EPA_MOVES	EPA defaults and S/L/T-supplied input data from 2017 NEI process

* Metro Public Health of Nashville/Davidson County also successfully submitted nonroad emissions but agreed that EPA MOVES data should be used instead.

EPA asked S/L/T agencies to provide model inputs (CDBs) for 2017. Table 5-4 shows the S/L/T agencies that submitted nonroad model inputs for the 2017 NEI via the EIS Gateway. Table 5-4 also shows data carried over from prior NEI submittals for the LADCO states for day and month allocations. Two agencies submitted CDBs through the EIS are not listed in the table (Delaware state and Davidson County, Tennessee), because they provided only a ZoneMonthHour table that EPA did not use in the 2017 NEI.

Table 5-4: Submitted MOVES-Nonroad input tables, by agency.

State Code	State or County(ies) in the Agency	nrbaseyearequippopulation (source populations)	nrdayallocation (allocation to day type)	nrfuelsupply (allocation of fuels)	nrgrowthindex (population growth)	nrhourallocation (allocation to diurnal pattern)	nrmonthallocation (seasonal allocation)	nrsourceusetype (yearly activity)	nrstatesurrogate (allocation to counties)	countyyear (stage II information)	nrequipmenttype (surrogate selection)	nrsurrogate (surrogate identification)	nrscc (SCCs)
4	Arizona - Maricopa Co.	A		X				A	A	A	A	A	
9	Connecticut	A											
13	Georgia			A					A				
16	Idaho		C										
17	Illinois						D						
18	Indiana		C				D						
19	Iowa		C				D						
26	Michigan		C				D						
27	Minnesota	A	C				D						
29	Missouri						D						
36	New York	A	A	X	A	A	A	A	A				
39	Ohio		C				D						
48	Texas	A	A	X			A	A	A		A	A	A
49	Utah	B	A		A	A			E				
53	Washington								A		A	A	
55	Wisconsin						D						

A Submitted data.

B Submitted data with modification: deleted records that were not snowmobile source types 1002-1010.

C 2014NEIv2 data used for 2017 NEI.

D Spreadsheet "ladco_nei2017_nrmonthallocation.xlsx" (see discussion below)

E Submitted data with modification: deleted records that were not the snowmobile surrogate ID 14.

X Submitted data not used in 2017 NEI. The GA NRFuelSupply table is only used to divide counties into groups.

The 557 submitted CDBs used for the MOVES-Nonroad run are included in the full set of 3,225 CDBs collected together in 2017_NonroadCDBs.zip in the 2017 NEI Supplemental nonroad mobile data FTP site. Outside of the 557 CDBs with the data inputs outlined above in Table 5.4, EPA also created a new CDB for each of the other US counties with only the fuel tables to receive the information EPA developed from the refinery gate batch dataset. The rest were run using the MOVES default database, which does not require CDBs. A list of all 3,225 U.S. counties and their corresponding CDBs, if any, is available in 2017_nonroad_counties_FinalList.xlsx. These supplemental nonroad mobile data contents are listed in Table 5-5 and are all available on the 2017 NEI Supplemental nonroad mobile data FTP site.

Table 5-5: Contents of the Nonroad Mobile supplemental folder

	File or Folder	Description
1	2017_NonroadCDBs.zip	Submitted nonroad CDBs used to run MOVES2014b and EPA CDBs containing only 2017 EPA fuels.
2	2017_nonroad_counties_FinalList.xlsx	List of all counties and their CDBs.
3	2017_zonemonthhour.zip	Zonemonthhour table (meteorology data).
4	2017_NonroadRunspecs.zip	Runspecs for all counties.
7	2017_postprocess_nraq_nrvoc.zip	Post-processing scripts for MOVES runs.
8	2017NR_CaEIS_SCC_Crosswalk.xlsx	File mapping California emission inventory codes (EICs) to EPA SCCs.

5.5 MOVES runs

In the 2017 NEI Supplemental nonroad mobile data FTP site, the Excel® file 2017_nonroad_counties_nei2014v1_FinalList.xlsx lists all 3,225 counties and their corresponding CDBs. The CDBs that were used are in 2017_NonroadCDBs.zip in the online NRSupplemental Data folder. If no CDB was listed for a county, that county was run with the MOVES default database for MOVES2014b (movesdb20180517). The supplemental nonroad mobile data is listed in Table 5-5.

MOVES was run for each county in a single, separate run specification file (runspec). All the runspecs are in the 2017_NonroadRunspecs.zip file in the online NRSupplemental Data folder. The MOVES-Nonroad runs were checked for completeness and absence of error messages in the run logs. The output was post-processed to consolidate each county into a single database and to produce SMOKE-ready input. The scripts that performed these processes are in 2017_postprocess_nraq_nrvoc.zip in the 2017 NEI Supplemental nonroad mobile data FTP site. The MOVES runs created monthly, day type (weekday and weekend) total inventories for every U.S. county, and post-processing scaled the day totals to monthly and annual values.

The following additional steps were taken on the monthly MOVES nonroad outputs to prepare data for loading into EIS:

1. The gas and particle components of PAHs (e.g., Chrysene, Fluorene) were combined.
2. The individual mercury species were combined into total mercury (i.e., pollutant 7439976).
3. Emissions were aggregated from the more detailed SCCs modeled in MOVES to the SCCs modeled in SMOKE.

4. Modes for exhaust and evaporative were removed from pollutant names and separated out into the emis_type data field in flat file 10 files that were then loaded into EIS.
5. Pollutants produced by MOVES but not accepted in the NEI were removed (e.g., ethanol, NONHAPTOG, and total hydrocarbons).
6. Five speciated $PM_{2.5}$ species were added based on speciation profiles (i.e., elemental carbon, organic carbon, nitrate, sulfate and other $PM_{2.5}$).
7. DIESEL-PM10 and DIESEL-PM25 were added by copying the PM_{10} and $PM_{2.5}$ pollutants (respectively) as DIESEL-PM pollutants for all diesel SCCs.
8. Airport ground support equipment emissions were removed.
9. Oil and gas field equipment emissions were removed.
10. Emissions from Wade Hampton Census Area, Alaska (FIPS code 02270) were reassigned to Kusilvak Census Area (FIPS code 02158) to reflect a name and FIPS code change for 2017.
11. Incorporated California-submitted nonroad emissions.

Following the completion of the MOVES runs, railway maintenance emissions were removed from specific counties / census areas in Alaska because Alaska DEC specified that this type of activity not happen in those areas. Specifically, emissions from SCCs 2285002015, 2285004015, 2285006015 were removed from the following counties / census areas: 02013, 02016, 02050, 02060, 02070, 02100, 02105, 02110, 02130, 02150, 02158, 02164, 02180, 02185, 02188, 02195, 02198, 02220, 02240, 02261, 02275, and 02282. Alaska DEC also specified some counties / census areas in which logging and agricultural emissions do not happen, but the emissions for the specified SCCs were already zero in the specified areas.

5.6   Use of California Submitted Emissions

California submitted criteria and HAP nonroad emissions for EPA's use in the NEI. California estimates emissions with a California-specific model and converts them from their EIC codes to SCC codes via a crosswalk (2017NR_CaEIS_SCC_Crosswalk.xlsx). The California criteria emissions were used directly. However, the HAP values were incongruent with the criteria estimates.

MOVES was run for California to establish county/SCC-level ratios of VOC/VOC-HAP and PM/HAP-metal. The ratios were applied to California-provided VOC and PM to estimate HAPs. VOC-HAP and HAP-Metals are indicated in Table 5-6.

Table 5-6: HAPs calculated using MOVES ratios for California Nonroad SCCs

Pollutant	Pollutant Code	HAP Type
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562394	HAP-VOC
1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	35822469	HAP-VOC
1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673897	HAP-VOC
1,2,3,4,7,8-Hexachlorodibenzofuran	70648269	HAP-VOC
1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	39227286	HAP-VOC
1,2,3,6,7,8-Hexachlorodibenzofuran	57117449	HAP-VOC
1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	57653857	HAP-VOC
1,2,3,7,8,9-Hexachlorodibenzofuran	72918219	HAP-VOC
1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	19408743	HAP-VOC
1,2,3,7,8-Pentachlorodibenzofuran	57117416	HAP-VOC
1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	40321764	HAP-VOC
1,3-Butadiene	106990	HAP-VOC
2,2,4-Trimethylpentane	540841	HAP-VOC

Pollutant	Pollutant Code	HAP Type
2,3,4,6,7,8-Hexachlorodibenzofuran	60851345	HAP-VOC
2,3,4,7,8-Pentachlorodibenzofuran	57117314	HAP-VOC
2,3,7,8-Tetrachlorodibenzofuran	51207319	HAP-VOC
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	1746016	HAP-VOC
Acenaphthene	83329	HAP-VOC
Acenaphthylene	208968	HAP-VOC
Acetaldehyde	75070	HAP-VOC
Acrolein	107028	HAP-VOC
Anthracene	120127	HAP-VOC
Arsenic	7440382	HAP-Metal
Benz[a]Anthracene	56553	HAP-VOC
Benzene	71432	HAP-VOC
Benzo[a]Pyrene	50328	HAP-VOC
Benzo[b]Fluoranthene	205992	HAP-VOC
Benzo[g,h,i,]Perylene	191242	HAP-VOC
Benzo[k]Fluoranthene	207089	HAP-VOC
Chromium (VI)	18540299	HAP-Metal
Chrysene	218019	HAP-VOC
Dibenzo[a,h]Anthracene	53703	HAP-VOC
Ethyl Benzene	100414	HAP-VOC
Fluoranthene	206440	HAP-VOC
Fluorene	86737	HAP-VOC
Formaldehyde	50000	HAP-VOC
Hexane	110543	HAP-VOC
Indeno[1,2,3-c,d]Pyrene	193395	HAP-VOC
Manganese	7439965	HAP-Metal
Mercury	7439976	HAP-Metal
Naphthalene	91203	HAP-VOC
Nickel	7440020	HAP-Metal
Octachlorodibenzofuran	39001020	HAP-VOC
Octachlorodibenzo-p-Dioxin	3268879	HAP-VOC
Phenanthrene	85018	HAP-VOC
Propionaldehyde	123386	HAP-VOC
Pyrene	129000	HAP-VOC
Styrene	100425	HAP-VOC
Toluene	108883	HAP-VOC
Xylenes (Mixed Isomers)	1330207	HAP-VOC

In addition, CO_2 data were added to the California data based on EPA estimates, because CO_2 emissions were not provided in the submission. We also speciated CARB total $PM_{2.5}$ and PM_{10} using the same approach as for other states and copied the $PM_{2.5}$ and PM_{10} to DIESEL-PM "pollutants" for all diesel SCCs.

5.7   References for nonroad mobile

1. MOVES-Nonroad, its documentation and technical reports can be found here: Nonroad Technical Reports.

2. CARB's group of models for off-road equipment may be linked to from this site: Mobile Source Emissions Inventory.

3. MOVES2014b, its default database, documentation and technical reports.

4. National Emissions Inventory Collaborative (2019). Specification Sheet – 2016v1 Platform Nonroad Mobile Emissions. Retrieved from the Specification Sheet: Mobile Nonroad.

5. Detailed information on The Weather Research & Forecasting Model (WRF) may be found here: Weather Research and Forecasting Model and here: Skamarock, W.C., et al., National Center for Atmospheric Research, Mesoscale and Microscale Meteorology Division, Boulder CO, June 2008, NCAR/TN-475+STR, A Description of the Advanced Research WRF Version 3,

6. Crosswalk of CA EIC to SCC: 2017NR_CaEIS_SCC_Crosswalk.xlsx

6 Onroad Mobile – All Vehicles and Refueling

6.1 Sector description

Onroad mobile sources include emissions from motorized vehicles that are normally operated on public roadways. This includes passenger cars, motorcycles, minivans, sport-utility vehicles, light-duty trucks, heavy-duty trucks, and buses. The sector includes emissions generated from parking areas as well as emissions while the vehicles are moving. The sector also includes "hoteling" emissions, which refers to the time spent idling in a diesel long-haul combination truck during federally mandated rest periods of long-haul trips.

The 2017 NEI is comprised of emission estimates calculated based on the MOVES model run with S/L/T-submitted activity data when provided, except for California and tribes, for which the NEI includes submitted emissions. In cases where S/L/T submitted data is not provided, EPA-developed default activity based on data from the Federal Highway Administration.

6.2 Overview of Input Data Sources for 2017

EPA received new MOVES county database (CDB) submittals (1,693 databases) from S/L/T agencies and new 2017 vehicle registration data MOVES tables from the Coordinating Research Council (CRC) A-115 project [ref 1], which EPA adapted and applied in some areas of the country. The new CDBs and registration data required a re-analysis to determine counties with similar fleet characteristics for representative county groups. Like 2014NEIv2, age distributions for representative county CDBs reflect a population-weighted average of the member county age distributions. Also unchanged from 2014 v2, EPA relied on vehicle speed and vehicle-miles traveled (VMT) distributions from the CRC A-100 study [ref 2] for some areas of the country. The CDBs and representative county groups are discussed in Sections 6.5 and 6.8.2.1, respectively.

6.2.1 New 2017 Vehicle Populations and Fleet Characteristics

In areas where there is no acceptable S/L/T data available, the 2017 NEI onroad inventory is based on 2017 vehicle populations, source type age distributions, and fuel type fractions from the CRC A-115 study. The CRC procured a July 1, 2017 draw date vehicle registration database from IHS Markit (IHS). Motorcycles are an exception to the July 1 draw date, because they were only available for January. The dataset contained a county-level summary of all registered vehicles in the US, which IHS retrieves from each state's Department of Motor Vehicles (DMV) and compiles. IHS then decodes vehicle identification numbers (VINs) to assign each vehicle a MOVES source type code. The database IHS provided to CRC did not include VINs or identify individual vehicles, but rather was a summary of the population in each county by parameters including make, model, model year, gross vehicle weight (GVW) class, and other fields. A finding reported by CRC A-115 was that the 2014 IHS dataset reflected higher light-duty vehicle populations than corresponding state agency analyses of the same DMV data, and the differences tend to increase with increasing age (older vehicles). Through the CRC A-115 study, adjustment factors were developed for older vehicles and the discrepancy in the vehicle counts was dealt with by releasing MOVES input datasets based on both the raw and adjusted information. The adjustment factors were based on differences in LDV population by model year for one state in the year 2014, applied to all areas of the US for 2017. EPA repeated the comparison of IHS and state agency data but with updated 2017 information and a wider geographic area of 16 S/L/T agencies as described below.

Although 32 S/L/T agencies participated in the data submittal process, only half provided both LDV populations (MOVES `SourceTypeYear` table) and age distributions (MOVES `SourceTypeAgeDistribution` table) based on registration data from a time period relevant for comparison with the 2017 IHS data. These 16 agencies developed their MOVES inputs based on a 2017 or 2018 draw date of registration data. Some of the other agencies provided only one type of data (e.g., population but no age distribution) or data with outdated (e.g., year 2013) or unknown draw dates. For the 16 areas that could be compared, EPA first re-apportioned the relative populations of passenger cars (source type 21) and light-duty trucks (source types 31 and 32) at the county level to match IHS to account for state inconsistencies in VIN decoding. EPA then allocated each county's LDV source type population to vehicle model years for comparison with IHS and found that the IHS populations for 2017 were higher than the state data by 6.5 percent for cars and 5.9 percent for light-trucks. Similar to the 2014 comparison for one state by CRC, EPA found that the discrepancies in the 2017 data between IHS and states are larger for older vehicles. Table 6-1 shows the adjustments EPA made to the 2017 IHS data prior to use in the NEI.

Table 6-1: Older vehicle adjustments showing the fraction of IHS vehicle populations to retain for 2017 NEI

Model Year	Cars	Light
pre-1989	0.675	0.769
1989	0.730	0.801
1990	0.732	0.839
1991	0.740	0.868
1992	0.742	0.867
1993	0.763	0.867
1994	0.787	0.842
1995	0.776	0.865
1996	0.790	0.881
1997	0.808	0.871
1998	0.819	0.870
1999	0.840	0.874
2000	0.838	0.896
2001	0.839	0.925
2002	0.864	0.921
2003	0.887	0.942
2004	0.926	0.953
2005	0.941	0.966
2006	1	0.987
2007-2017	1	1

EPA also removed the county-specific fractions of antique license plate vehicles present in the registration summary from IHS. Nationally, the prevalence of antique plates is only 0.8 percent, but it is as high as 6 percent in some states (e.g., Mississippi). All states without any CDB submittals received the EPA age distribution data, and some states with submittals were overridden, as decided on a case-by-case basis. Section 6.3 lists the submitted data that was accepted vs. replaced with the EPA age distribution data for the 2017 NEI.

EPA calculated the adjustment factors representing the fraction of population remaining, with two exceptions. The model year range from 2006/2007 to 2017 received no adjustment and the model year 1987 received a capped adjustment that equals the adjustment for model year 1988. The Table 6-1 adjustments were applied to the 2017 IHS-based age distributions from CRC project A-115 prior to use in the NEI.

In addition to removing the older and antique plate vehicles from the IHS data, EPA also removed outlier age distributions that showed excessively "new" fleets, usually for light commercial trucks, in about 25 counties. The

most extreme example of this was a light commercial truck age distribution where over 50 percent of the population in the entire county is 0 or 1 year old. This situation where the registration data reflects a county-wide young fleet is possible, for example, if the headquarters of a leasing or rental company owns a lot of vehicles relative to the county-wide vehicle population. We dealt with these cases by preferentially excluding them from the representative county calculation of age distribution. For counties that were the only county in the group, we made a substitution with an age distribution for the same source type from another county in the same metropolitan statistical area (MSA). This clean-up step avoids creating artificial low spots of LDV emissions in these outlier counties.

In areas where submitted vehicle population data were accepted for NEI, EPA still reapportioned the relative populations of cars vs. light-duty trucks (while retaining the magnitude of the light-duty vehicles from the submittals) using the county-specific percentages from the IHS data. In this way, the categorization of cars versus light trucks is consistent from state to state. The county total light-duty vehicle populations were preserved through this process.

6.2.2   EPA Default Vehicle Speeds and VMT Distributions

Previously, the Coordinating Research Council sponsored the A-100 project to develop improved, local inputs of vehicle speeds and VMT distributions for use in MOVES and SMOKE based on vehicle telematics data [ref 2]. NEIs prior to 2014v2 used nationwide averages for MOVES inputs `AvgSpeedDistribution,` `HourVMTFraction,` and `DayVMTFraction` in many counties without submitted information. Similar to 2014 v2, for 2017 NEI, several states reviewed the CRC A-100 data products specific to their counties and requested that EPA use the CRC data instead of the submittal. EPA reviewed all submitted data on speed distributions, and hour/day VMT fractions and in some cases where the submitted data did not show appropriate distinctions between road, weekday/weekend, and vehicle types EPA overrode submittals with the county-specific information available from CRC A-100. The 2017 NEI also incorporates SMOKE input files based on the CRC A-100 hourly speed distributions and diurnal and weekly VMT temporal profiles.

Additional diurnal and weekly VMT temporal profiles were developed based on the DayVMTFraction and HourVMTFraction tables from the MOVES CDBs. For states and counties where DayVMTFraction and HourVMTFraction tables were submitted by local agencies, temporal profiles based on those tables were used in place of the CRC A-100-based profiles, with some exceptions as outlined below.

For weekly temporal profiles, since the DayVMTFraction table only specifies a total weekday and total weekend allocation instead of allocations for each individual day of the week, new weekly profiles were developed based on a combination of DayVMTFractions and the CRC A-100-based profiles. Total weekday and total weekend allocation are based on DayVMTFraction, while individual day allocation (e.g., Monday as a fraction of the total weekday allocation, Sunday as a fraction of the total weekend allocation) are based on CRC A-100. DayVMTFraction tables were used in all states and counties with locally submitted data, except for school buses and refuse trucks. The vast majority of school bus and refuse truck activity occurs on weekdays, and locally submitted DayVMTFraction tables did not account for that; therefore, a high weekday / low weekend profile was used nationwide for school buses and refuse trucks. For diurnal temporal profiles, all locally submitted HourVMTFraction tables were used as-is, except for invalid data (e.g., profiles with 100% of activity concentrated in hour 1). HourVMTFraction values and profiles are distinct for weekdays and weekends.

6.3 Sources of data and selection hierarchy

The EPA calculated the onroad emissions for 2017 for all states using the most recent version of MOVES, MOVES2014b (code version: 20180726, database version: movesdb20181022). The sources of MOVES input data vary by area, representing a mix of local data, past NEI data, EPA defaults, and some MOVES defaults. More state and local agencies than ever before have submitted local input data for MOVES. The S/L/T agencies that submitted data for 2017 are listed below in Section 6.10. The EPA used programs within the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system that integrate with MOVES to generate the emission inventories in all 50 states for each hour of the year. These emissions are summed over all hours and across road types to develop the emissions for the NEI. For the state of California, the EPA used onroad emissions provided by California based on the EMFAC model.

As in past NEIs, the data selection hierarchy for 2017 favored local input data over EPA-developed information. For areas that did not submit a MOVES CDB for this NEI, the EPA used a 2017 CDB containing EPA-developed information including 2017 VMT, population, and hoteling activity with new activity specific to 2017, as described in Section 6.8.4.

6.4 California-submitted onroad emissions

California is the only state agency for which an onroad *emissions* submittal was used in the 2017 NEI. California uses their own emission model, EMFAC 2017, which uses EICs instead of SCCs. For the 2014NEIv2, the EPA and California worked together to develop a code mapping to better match EMFAC's EICs to EPA MOVES' detailed set of SCCs that distinguish between off-network and on-network and brake and tire wear emissions. This level of detail is needed for modeling but not specifically for the NEI, because the NEI uses simplified/more aggregated SCCs than used in modeling. The mapping file was updated for the 2017 NEI by the California Air Resource Board (CARB) and applied to the EMFAC outputs prior to providing the data to EPA.

California provided their CAP emissions, excluding NH_3, by county using EPA SCCs after applying the mapping. For the 2017 NEI, we needed to add NH_3, HAPs, CO_2, N_2O, and methane. HAPs and methane were added using MOVES-based scaling factors – for example, the ratio of emissions for a HAP compared to either VOC or $PM_{2.5}$ (excluding brake and tire PM) from MOVES, for each county and SCC in California. The basis pollutant is VOC for all VOC HAPs (e.g., benzene, hexane), and is $PM_{2.5}$ for all metals and for dioxins/furans. PAHs have both a gas component and particulate component, and so the basis pollutant for each PAH was chosen to be either VOC, $PM_{2.5}$, or a mix ($PM_{2.5}$ for diesel, and VOC for other fuel types, including gasoline) based on the relative magnitude of the gas and particulate components of each HAP from MOVES. The pollutant basis for each HAP is listed in Table 6-2. A table of factors (2017NEI_California_onroad_HAP_augmentation_factors.csv) used to augment the California emissions is referenced in the supporting data Table 6-10.

Table 6-2: CAP pollutant basis for each HAP for California onroad

Pollutant code	Description	Basis for gasoline	Basis for diesel
100414	Ethylbenzene	VOC	VOC
100425	Styrene	VOC	VOC
106990	Butadiene, 1,3-	VOC	VOC
107028	Acrolein	VOC	VOC
108883	Toluene	VOC	VOC
110543	Hexane	VOC	VOC
120127	Anthracene	VOC	VOC
123386	Propionaldehyde	VOC	VOC
129000	Pyrene	VOC	$PM_{2.5}$

Pollutant code	Description	Basis for gasoline	Basis for diesel
1330207	Xylenes (mixed isomers)	VOC	VOC
1746016	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
18540299	Chromium VI	$PM_{2.5}$	$PM_{2.5}$
191242	Benzo[g,h,i,]Perylene	$PM_{2.5}$	$PM_{2.5}$
193395	Indeno[1,2,3-c,d]Pyrene	$PM_{2.5}$	$PM_{2.5}$
19408743	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
205992	Benzo[b]Fluoranthene	VOC	$PM_{2.5}$
206440	Fluoranthene	VOC	$PM_{2.5}$
207089	Benzo[k]Fluoranthene	VOC	$PM_{2.5}$
208968	Acenaphthylene	VOC	VOC
218019	Chrysene	VOC	$PM_{2.5}$
3268879	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
35822469	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
39001020	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
39227286	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
40321764	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
50000	Formaldehyde	VOC	VOC
50328	Benzo[a]Pyrene	$PM_{2.5}$	$PM_{2.5}$
51207319	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
53703	Dibenzo[a,h]Anthracene	$PM_{2.5}$	$PM_{2.5}$
540841	Trimethylpentane, 2,2,4-	VOC	VOC
55673897	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
56553	Benz[a]Anthracene	VOC	$PM_{2.5}$
57117314	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
57117416	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
57117449	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
57653857	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
60851345	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
67562394	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
70648269	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
71432	Benzene	VOC	VOC
72918219	Dioxins/Furans	$PM_{2.5}$	$PM_{2.5}$
7439965	Manganese	$PM_{2.5}$	$PM_{2.5}$
7439976	Mercury, Unspeciated	$PM_{2.5}$	$PM_{2.5}$
7440020	Nickel	$PM_{2.5}$	$PM_{2.5}$
7440382	Arsenic	$PM_{2.5}$	$PM_{2.5}$
75070	Acetaldehyde	VOC	VOC
83329	Acenaphthene	VOC	VOC
85018	Phenanthrene	VOC	VOC
86737	Fluorene	VOC	VOC
91203	Naphthalene	VOC	VOC

NH_3, CO_2, and N_2O were added using a different method. For these three pollutants, the state-wide emissions total matches MOVES, but distributed to counties and SCCs using California-provided data from another pollutant (for NH_3, this was CO; for CO_2 and N_2O, this was SO_2). This way, the overall magnitude of emissions is based on MOVES, but the distribution of those emissions between counties and vehicles is based on California

data. The factors used for these pollutants are computed by taking MOVES state total emissions divided by the CARB state total for CO or SO2. The pollutant emissions are computed as follows:

$CO2 = SO2 * 115363.66$

$N2O = SO2 * 3.06$

$NH3 = CO * 0.019$

CARB estimates onroad refueling emissions outside of the EMFAC model; they provided these to the EPA, and we assigned them to the onroad refueling SCC 2201000062 (Mobile Sources**;** Highway Vehicles - Gasoline; Refueling; Total Spillage and Displacement). The two EIC codes mapped to this SCC are: EIC 33037811000000 (Petroleum Marketing / Vehicle Refueling – Vapor Displacement Losses / Gasoline (Unspecified)) and EIC 33038011000000 (Petroleum Marketing / Vehicle Refueling – Spillage / Gasoline (Unspecified)). The refueling dataset provided by CARB included HAPs, but for consistency with the non-refueling emissions, refueling HAPs were instead recomputed using the same methodology as the non-refueling emissions.

6.5 Agency-submitted MOVES inputs

Many state and local agencies provided county-level MOVES inputs in the form of CDBs. This established format requirement enables the EPA to more efficiently scan for errors and manage input datasets. The EPA screened all submitted data using several quality assurance scripts that analyze the individual tables in each CDB to look for missing or unrealistic data values. The EPA also reviewed submitted age distributions, speed distributions, and hourly VMT distributions in consideration of whether to accept these data vs. county-specific EPA defaults.

6.5.1 Overview of MOVES input submissions

State and local agencies prepare complete sets of MOVES input data in the form of one CDB per county. One way agencies can ensure a correctly formatted CDB is to use the MOVES graphical user interface (GUI) county data manger (CDM) importer. With a proper template created for a single county, a larger set of counties (e.g., statewide) can be updated systematically with county-specific information if the preparer has well-organized county data and familiarity with MySQL queries. However, there is no requirement of MySQL experience to prepare the NEI submittal because the user can instead rely on the CDM to help build the individual CDBs one at a time. Table 6-3 lists the tables in each CDB and describes its content or purpose. Note that several of the tables are optional, which means that they may be left blank without consequence to a MOVES run's completeness of results. If an optional CDB table is populated, the data override MOVES internal calculations and produce a different result that may better represent local conditions.

Table 6-3: MOVES2014b CDB tables

Table Name	Description of Content
auditlog	Information about the creation of the database
avft	Fuel type fractions
avgspeeddistribution	Average speed distributions
county	Description of the county
countyyear	Description of the Stage 2 refueling control program
dayvmtfraction	Fractions to distribute VMT between day types
fuelformulation	Fuel properties
fuelsupply	Fuel differences by month of year

Table Name	Description of Content
fuelusagefraction	Fraction of the time that E85 vs. gasoline is used in flex-fuel engine vehicles
hotellingactivitydistribution	*Optional table* – fraction of hoteling hours in which the power source is the main engine, diesel APU, electric APU, or engine-off
hotellinghours	*Optional table* – total hoteling hours
hourvmtfraction	Fractions to distribute VMT across hours in a day
hpmsvtypeday	VMT input by HPMS vehicle group, month, and day type (1 of 4 options)
hpmsvtypeyear	VMT input by HPMS vehicle group, as annual total (2 of 4 options)
imcoverage	Description of the inspection and maintenance program
importstartsopmodedistribution	*Optional table* – engine soak distributions
monthvmtfraction	Fractions to distribute VMT across 12 months of the year
roadtype	*Optional table* – fraction of highway driving time spent on ramps
roadtypedistribution	Fractions to distribute VMT across the road types
sourcetypeagedistribution	Distribution of vehicle population by age
sourcetypedayvmt	VMT input by source use type, month, and day type (3 of 4 options)
sourcetypeyear	Vehicle populations
sourcetypeyearvmt	VMT input by source use type, as annual total (4 of 4 options)
starts	*Optional table* – starts activity, replacing the MOVES-generated starts table
startshourfraction	*Optional table* – fractions to distribute starts across hours in a day
startsmonthadjust	*Optional table* – fractions to vary the vehicle starts by month of year
startsperday	*Optional table* – total number of starts in a day
startssourcetypefraction	*Optional table* – fractions to distribute starts among MOVES source types
state	Description of the state
year	Year of the database
zone	Allocations of starts, extended idle and vehicle hours parked to the county
zonemonthhour	Temperature and relative humidity values
zoneroadtype	Allocation of source hours operating to the county
emissionratebyage	Implementation of California standards [not normally part of a CDB but included for NEI because state-specific data is applicable]

S/L/T agencies submitted a total of 1,693 CDBs for the 2017 NEI. Previously, agencies submitted 1,816 CDBs for the 2014 NEI and 1,426 CDBs for the 2011 NEI. Agencies submitting data through the EPA Emissions Inventory System (EIS), provided completed CDBs (i.e., each required table populated), along with documentation and a submission checklist indicating which of the CDB tables contained local data. Table 6-4 summarizes these submission checklists, showing the number of counties within each submittal for which the information was local data, as opposed to a default. Empty slots in the table indicate that the state or county did not provide local data for that particular CDB table. The grand totals of counties across all states show that VMT and population (found in the 'HPMSVtypeYear' and 'sourceTypeYear' tables, respectively) were the most commonly provided local data types.

Figure 6-1 shows the geographic coverage of CDB submissions where the state or local agency submitted data that was used for at least one table (dark blue). The light blue areas are counties for which the NEI uses EPA default 2017 CDBs.

Figure 6-1: Counties for which agencies submitted local data for at least 1 CDB table*
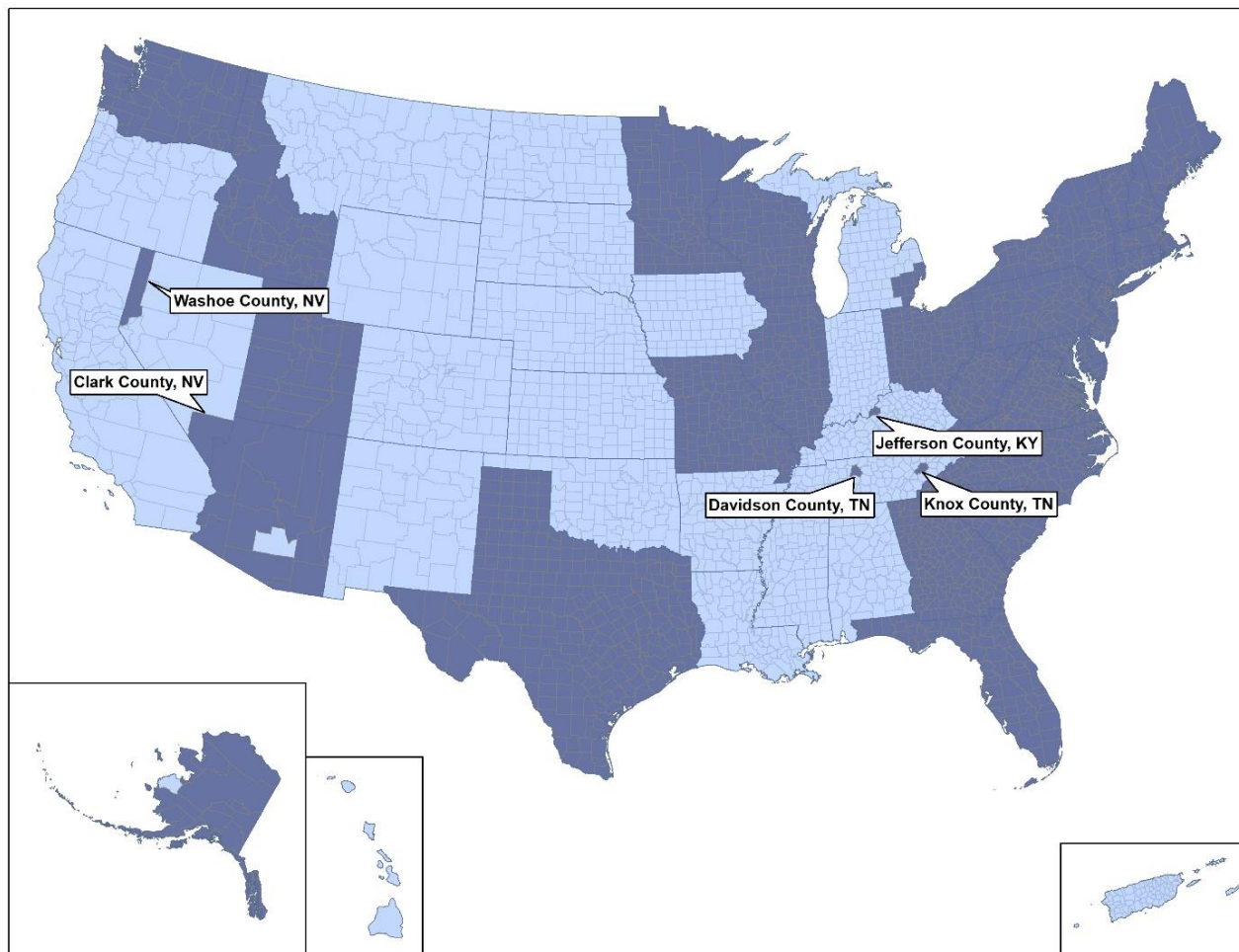
* Submitting areas are shown in dark blue

Table 6-4: Number of counties with submitted data, by state and key MOVES CDB table

State/County	avft	avgspeeddistribution	countyyear	Dayvmtfraction	fuelformulation	fuelsupply	fuelusagefraction	hotellingactivitydistribution	hotellinghours	hourvmtfraction	hpmsvtypeyear	imcoverage	monthvmtfraction	onroadretrofit	roadtype	roadtypedistribution	sourcetypeagedistribution	sourcetypeyear	sourcetypeyearvmt	starts	startsperday
Alaska	32	32									32				32	32	32	32			
Arizona																		12			
Arizona (Maricopa)	1	1	1	1	1	1				1	1	1	1			1	1	1			
Arizona (Pima)	1	1		1						1	1	1	1			1	1	1			
Connecticut		8	8	8			8			8	8	8	8			8	8	8			
Delaware	3	3	3	3	3	3	3	3	3	3	3	3	3			3	3	3			
District of Columbia		1		1	1	1	1			1	1	1	1			1	1	1			
Florida		67		67						67	67	67	67			67	67	67			
Georgia		24	13	1			47			24	159	13	159		24	159	159	159			20
Idaho	44	44		44	44	44	44			44	44	44	44			44	44	44			
Illinois		102	10	102	10	10	10			102	102	11	102			102	102	102			
Kentucky (Jefferson)		1									1					1	1	1			
Maine		16		16	16	16	16			16	16	1	16			16	16	16			
Maryland	24	24	24	24	24	24	24			24	24	24	24			24	24	24			
Massachusetts			14								14	14				14	14	14			
Michigan		7								7			7			7	7	7			
Minnesota	87	87				87	87				87			87		87	87	87			
Missouri	48		5	115			11			115	115	5	115								
Nevada (Clark)	1			1						1		1	1			1	1	1	1		
Nevada (Washoe)		1		1						1	1	1	1			1	1				
New Hampshire											10					10	10	10			
New Jersey	21	21	21	21	21	21	21	21	21	21	21	21	21	21		21	21	21			

State/County	avft	avgspeeddistribution	countyyear	Dayvmtfraction	fuelformulation	fuelsupply	fuelusagefraction	hotellingactivitydistribution	hotellinghours	hourvmtfraction	hpmsvtypeyear	imcoverage	monthvmtfraction	onroadretrofit	roadtype	roadtypedistribution	sourcetypeagedistribution	sourcetypeyear	sourcetypeyearvmt	starts	startsperday
New York	62	62	62	62	62	62	62	62	62	62	62	62	62			62	62	62			
North Carolina		18			3	3				18	100	48				100	100	100			
Ohio		88	16	88	8	8	88			88	88	7	88			88	88	88			
Pennsylvania		67		67	67	67	67			67	67	67	67			67	67	67			
Rhode Island		5		5						5	5	5	5			5	5	5			
South Carolina	46						46				46							46			
Tennessee				1						1	1	1	1			1	1	1			
Tennessee (Knox)		1		1						1	1		1			1	1	1			
Texas	25	254	25	254	25	25		25	25	254	254	25	254		25	254	254	254		25	
Utah	29	29	29		29	29					29	5			29	29	29	29			
Vermont							14				14	14	14			14	14	14	14		
Virginia		30	17	40	13	13				40	133	10	40			133	133	133			
Washington	1			39		1				39	39	5	39			39	39	39			
West Virginia				55						55	55		55				55	55			
Wisconsin		8	9				72				72	7				72	72	72	72		
Total	**65**	**100**	**57**	**101**	**76**	**90**	**77**	**34**	**34**	**105**	**168**	**70**	**119**	**10**	**33**	**146**	**152**	**157**	**87**	**25**	**20**

6.5.2   QA checks on MOVES CDB Tables

The EPA reviewed lists of CDB data errors flagged by quality assurance scripts and reviewed graphs of submitted age distributions, speed distributions, and hour VMT fractions. The quality assurance scripts report the potential errors by compiling a list into a summary database table. The list of potential errors includes the CDB name, table name, a numeric error code, and in some cases the suspect data value or sum of values. EPA reviewed all potential errors, identified which ones needed to be addressed, and then coordinated with the responsible state/local agency to clarify whether the data were correct or needed revision.

The quality assurance scripts are designed to identify not only the types of errors that would cause MOVES to crash (e.g., missing or badly formatted tables) but also those that would give erroneous results. EPA reviewed the graphs of submitted age distributions, speeds, and VMT hourly fractions to consider their use vs. alternative county-level data available from CRC studies. Examples of suspected unreasonable values include (a) a mix of vehicle type population or VMT that shows more heavy-duty vehicles or VMT than shown for light-duty, (b) age distributions that are skewed to older vehicles rather than newer, or (c) atypical VMT temporal patterns such as significantly higher VMT in winter than summer, which we would not normally expect, or higher VMT overnight than during daytime. The quality assurance scripts used for the CDBs are available with the QA_scripts_or_2017.zip archive as listed in the supporting data in Table 6-10.

Many of the 1693 submitted CDBs required at least one update due to missing or incorrect data, incorrect table formatting, or excess data (more than required), which was removed prior to use. The missing or incorrect data included the following problems:

- Age distribution represented a different data year than 2017 (i.e., LDV recession "dip" shifted by several years)
- Incorrect table keys on CDB tables (`SourceTypeAgeDistribution`, `RoadType`)
- Incorrect column order on CDB tables (`IMCoverage`, `RoadType`)
- Missing weekend (day type 2) activity in CDB tables: (`AvgSpeedDistribution,` `HourVMTFraction`)
- Weekday activity (day type 5) repeated as weekend activity (day type 2)
- Empty tables for `year` and/or `roadTypeDistribution` tables
- Inconsistent splits of cars and light-duty trucks across states
- Ramp fractions unrealistically high (e.g., 60% up to 100%)
- IMCoverage table covered gasoline but not flex-fuel vehicles
- IMCoverage table contained wrong countyID
- RoadType table incorrect structure
- Expected VMT tables required for MOVES2014b (SourceTypeDayVMT, SourceTypeYearVMT, and HPMSVtypeDay) were missing
- Values sum to 0 for some source types in the `RoadTypeDistribution` table
- Old data (year 2014) re-submitted for `HotellingHours`
- Old MOVES default data (year 2014) submitted for `HotellingActivityDistribution`
- Erroneous, missing, or gap-filled values in `hourVMTFraction`
  - 100% of VMT allocated to hour 1 for road types thought to not exist in the county.
  - Missing data for weekdays (day type 5)
  - Flat hourly profiles for some source types
  - Statewide average data applied to all counties in a state
  - MOVES default data submitted
  - Multiple-hour blocks used in the profile instead of hourly variation

- Erroneous or gap-filled values in `avgSpeedDistribution`
  - 75 mph on nearly all road types and hours
  - Zero time in bin 1 (speeds 0 to 2.5 mph), even on unrestricted roads (surface streets with intersections).
  - No variation in speeds by hour of day or weekday/weekend
  - No variation in speeds by road type
  - Speeds notably higher (instead of lower or similar) during weekday peak periods

The EPA resolved each of the above data problems by coordinating with state/local agencies individually and/or presenting intentions during monthly meetings with the multi-jurisdictional organization (MJO) MOVES workgroup. In some cases, the agency preferred to submit a corrected CDB, which the EPA contractor (ERG) reviewed again to verify the intended correction. In other cases, the agency provided the EPA with instructions for a "spot correction" to a table or simply accepted the EPA's proposed update. ERG also corrected formatting problems with the database tables. In some cases, tables had missing data fields and/or table keys; the missing fields did not house important content, but their presence is required for MOVES to run. EPA's final decisions on the data source (submittal vs. EPA-developed information) for age distribution, speed distribution, and hourly VMT fractions can be found in the documentation spreadsheet "2017v1 Documentation of CDB Input Data_20200327.xlsx" posted with the 2017 NEI supplemental data files.

6.6   Tribal Emissions Submittals

Tribal onroad emissions were submitted and used in the 2017 NEI. The submitting tribal agencies are listed in Table 6-5.

Table 6-5: Tribes that Submitted Onroad Mobile Emissions Estimates for the 2017 NEI

Coeur d'Alene Tribe
Kootenai Tribe of Idaho
Nez Perce Tribe
Northern Cheyenne Tribe
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho

6.7   EPA default MOVES inputs

6.7.1   Sources of default data by MOVES CDB table

The EPA used CDBs constructed with EPA-generated data for counties where agencies did not submit input data. The EPA developed new 2017 estimates of VMT, vehicle population, and hoteling at the county- and SCC-level for use in the subsequent SMOKE-MOVES processing step and inserted these data into the CDBs where states did not provide data. The SMOKE files contain this information at the resolution of SCC, which includes the source type, fuel type, and road type. When inserted into the CDB table for source type VMT (sourceTypeYearVMT), we sum over the fuel and road type. Similarly, for population, we sum over the SCC fuel type to aggregate population to the source type level for the CDB table containing population (sourceTypeYear). In contrast, the hoteling activity detail is much more disaggregated in the two MOVES tables (hotelingHours and hotelingActivityDistribution) compared to the SMOKE FF10 hoteling file. The script that inserts these data into the set of "all CDBs" (ReverseFF10_Script_20200317.plx) is listed in Table 6-10. States and counties with CDBs that included EPA-generated activity and projected CDBs are those indicated by light blue shading in Figure 6-1. Table 6-6 below lists the sources of default information by MOVES CDB table. The spreadsheet "2017v1

" provides specific information about where state-supplied data were used versus default data. Additional detail on processing steps in the IHS data to create `AVFT` and `SourceTypeAgeDistribution` is provided below Table 6-6.

Table 6-6: Source of EPA-developed information for key data tables in MOVES CDBs

CDB Table	Default content for 2017 NEI
Avft	2017 IHS data
Avgspeeddistribution	CRC A-100 study
Dayvmtfraction	CRC A-100 study
Fuelformulation	Based on EPA estimates for each county from 2017 refinery gate batch data
Fuelsupply	Based on EPA estimates for each county from 2017 refinery gate batch data
Fuelusagefraction	MOVES2014b default E85 usage
hotellingactivitydistribution	MOVES2014b default APU vs. Main Engine fractions
Hotellinghours	2017 EPA estimates of hoteling based on 2017 VMT
Hourvmtfraction	CRC A-100 study
Hpmsvtypeday	Empty by default
Hpmsvtypeyear	Empty by default
Imcoverage	MOVES2014b
importstartsopmodedistribution	Empty by default
Monthvmtfraction	MOVES2014b
Roadtype	MOVES2014b default ramp fraction of 0.08
Roadtypedistribution	EPA estimates based on FHWA
sourcetypeagedistribution	2017 IHS data adapted from CRC A-115
Sourcetypedayvmt	Empty by default
Sourcetypeyear	2017 IHS data adapted from CRC A-115
Sourcetypeyearvmt	2017 VMT based on FHWA data
Starts	Empty by default
Startshourfraction	Empty by default
Startsmonthadjust	Empty by default
Startsperday	Empty by default
startssourcetypefraction	Empty by default
Zonemonthhour	2017 meteorology data averaged by county
Emissionratebyage	The `emissionratebyage` tables for some LEV states were populated using appropriate data described in the guidance for states adopting California emission standards. These were provided to MOVES as separate databases from the CDB.

Preparation of `AVFT` and `SourceTypeAgeDistribution` CDB Tables

As mentioned above in Section 6.2.1, national vehicle population data from IHS for 2017 were used to derive updated age distributions adjusted to remove older vehicles (MOVES `sourceTypeAgeDistribution` table) and fuel type splits by source type and model year (MOVES `AVFT` table) in the CDBs. These data were computed at the county level for the set of "all CDBs" and were a weighted average over county groups for the set of representative CDBs used in the MOVES runs for NEI. In both cases, EPA preferred to use local data so where

they were found to be acceptable. Local data were used preferentially and supplemented with the EPA-developed information where needed. In the EPA-developed data, the source registration data does not reliably distinguish between short-haul and long-haul activity, and so source types 52 and 53 (single unit trucks) have the same age distributions, as do source types 61 and 62 (combination unit trucks). In addition, all age distributions for long-haul trucks (source types 53 and 62) are a national average, because these vehicles are expected to travel long distances from the county where they are registered. The CRC A-115 report details all assumptions and gap filling necessary to ensure MOVES compatibility.

6.7.2   Default California emission standards

The EPA populated an alternative MOVES database table 'EmissionRateByAge' in the CDBs for some counties in the states that have adopted emission standards from California's Low Emission Vehicle (LEV) program. Table 6-7 shows states that adopted the California standards and the year the program began in each state. We developed these tables to be consistent with the EPA guidance for LEV modeling provided on the EPA web site [ref 3]. The LEV database is included with MOVES_Input_DBs.zip that is available with the supporting data described in Table 6-10.

Table 6-7: States adopting California LEV standards and start year

FIPS State ID	State Name	LEV Program Start Year
06	California	1994
09	Connecticut	2008
10	Delaware	2014
23	Maine	2001
24	Maryland	2011
25	Massachusetts	1995
34	New Jersey	2009
36	New York	1996
41	Oregon	2009
42	Pennsylvania	2008
44	Rhode Island	2008
50	Vermont	2000
53	Washington	2009

6.8   Calculation of Emissions

6.8.1   Preparation of onroad emissions data for the continental U.S.

The 2017 NEI includes onroad emissions for every county. The same approach was used for counties inside the continental U.S. and in the outlying states and territories: the first step is to run MOVES at the county level to produce lookup tables of emission rates for representative counties, using scripts designed to integrate MOVES with the SMOKE modeling system (i.e., SMOKE-MOVES). The SMOKE-MOVES approach adapted for NEI leverages gridded hourly temperature and relative humidity information available from meteorological modeling used for air quality modeling. This set of programs was developed by the EPA and is also used by states and regional planning organizations to compute onroad mobile source emissions for regional air quality modeling. SMOKE-MOVES requires emission rate "lookup" tables generated by MOVES that differentiate

emissions by process (running, start, vapor venting, etc.), vehicle type, road type, temperature, speed, hour of day, etc.

To generate the MOVES emission rates for counties in each state across the U.S., the EPA used an automated process to run MOVES to produce emission factors by temperature and speed for a set of "representative counties," to which every other county could be mapped, as detailed below. Using the calculated MOVES emission rates, SMOKE selected appropriate emissions rates for each county, hourly temperature, SCC, and speed bin and multiplied the emission rate by activity (VMT, vehicle population, or hoteling hours) to produce emissions. These calculations were done for every county, grid cell, and hour in the continental U.S. and aggregated by county and SCC for use in the 2017 NEI. The MOVES "RunSpec" files (that provide MOVES input data for each representative county) are provided in the supplementary materials (see 2017_runspecs_zmh.zip in Table 6-10). MOVES was run with two special input databases: an LEV table (see Section 6.7.2) and a database to keep MOVES from making adjustments to NOx based on humidity levels (see Section 6.8.3 for more details). The databases are included in MOVES_Input_DBs.zip as described in Table 6-10.

SMOKE-MOVES tools are incorporated into recent versions of SMOKE and can be used with different versions of the MOVES model. For the 2017 NEI, the EPA used the latest publicly released version: MOVES2014b (version 20180726) [ref 4]. Creating the NEI onroad mobile source emissions with SMOKE-MOVES requires numerous steps, as described in the sections below:

- Determine which counties will be used to represent other counties in the MOVES runs (see Section 6.8.2.1).

- Determine which months will be used to represent other month's fuel characteristics (see Section 6.8.2.2).

- Create representative CDB inputs needed for the MOVES runs (see Section 6.8.6).

- Create inputs needed both by MOVES and by SMOKE, including a list of temperatures and activity data (see Section 6.8.4).

- Run MOVES to create emission factor tables (see Section 6.8.8).

- Run SMOKE to apply the emission factors to activity data to calculate emissions (see Section 6.8.9).

- Aggregate the results at the county-SCC level for the NEI, summaries, and quality assurance (see Section 6.8.10).

- Added five speciated $PM_{2.5}$ species based on speciation profiles (i.e., elemental carbon, organic carbon, nitrate, sulfate and other $PM_{2.5}$). See Section 6.8.10.

- Added DIESEL-PM10 and DIESEL-PM25 by copying the PM_{10} and $PM_{2.5}$ pollutants (respectively; exhaust emissions only) as DIESEL-PM pollutants for all diesel SCCs. See Section 6.8.10.

Some things to note about the 2017 NEI that are different from the 2014NEIv2 are:

- SMOKE now adjusts NO_X emission factors to account for humidity impacts on the pollutant using the hourly, gridded met data. To support this change, MOVES was run with relative humidity adjustments to NO_X turned off (see nonoxadj_moves2014b.zip from MOVES_InputDbs.zip in Table 6-10).

- SMOKE now reads in the distribution of vehicle speeds by 16 speed bins by 24 hours for weekday and weekend day types.

Some notes about the treatment of specific pollutants are as follows:

- Manganese/7439965 includes the brake and tire contribution.

- Gasoline with 85 percent ethanol (E85) was tracked as a separate fuel.

- Brake and tire PM were tracked separately from exhaust processes, although all non-refueling processes were combined into broader SCCs prior to loading into EIS.

6.8.2   Representative counties and fuel months

6.8.2.1   *Representative counties*

Although the EPA develops a CDB for each county in the nation, we only run MOVES for a subset of these to control the computation time and cost. The representative county approach is also supported by the concept that the majority of the important emissions-determining differences among counties can be accounted for by assigning counties to groups with similar properties such as fleet age, a shared I/M program, and shared fuel controls (e.g., low RVP for summer gasoline). The county used to provide emission rates covering other counties is called the "representative county." The MCXREF file listed in Table 6-10 provides the mapping of each county to its representative county. Usually the same MCXREF file is used for all MOVES processes.

In the SMOKE-MOVES framework, temperature- and speed-specific data from the representative county emission factor lookup tables are multiplied with the activity data for all counties within the corresponding county group. The activity data specific to individual counties in the inventory includes VMT, vehicle population, hoteling hours, and hourly speed distributions.

The EPA analyzed the 2017 submitted CDBs, the new 2017 age distributions derived from CRC A-115, and some MOVES data for non-submitting areas, in order to group similar counties and select representative counties for 2017. In line with previous modeling platforms, the MOVES input data considered for county grouping included state, altitude, fuel region, presence of an inspection and maintenance (I/M) program, light-duty vehicle average age, and ramp fraction.

1. **State.** Only counties within the same state were allowed to be in the same representative county group.

2. **Altitude.** The altitude of each county came from the MOVES database `county` table. Values are either 'L' for low altitude (most counties) or 'H' for high. For purposes of representative county selection, counties in the states of Colorado, Nevada, New Mexico, and Utah are considered high altitude, while all other counties are considered low altitude.

3. **Fuel Region.** "Fuel region" refers to a region of counties sharing similar gasoline fuel properties. For example, those within a state's reformulated gasoline (RFG) area. The data source was the `regionCounty` table from the `moves201x_2017fuels_or_otaq_20191210` database listed in Table 6-10.

4. **IM Bin.** The IM bin is a value of either "0" (no IM) or "1" (has IM) to indicate whether the county is part of an inspection & maintenance program area in in 2017. We added a third value "2" (yes IM in 2017, but no IM in future years), to further separate from the "1" category for North Carolina counties which will no longer require I/M after 2018. The extra category of "2" allows the emissions benefit to be modeled in future years with the same county groups. The data source for presence of an I/M program was primarily the 2017 submittals for the NEI. If a county did not positively identify an I/M program in a submittal or did not have a submittal, the yes/no determination comes from the MOVES database `IMCoverage` table for year 2017.

5. **Mean Light-Duty Age.** The age distribution of light-duty vehicles (passenger cars, passenger trucks, and light commercial trucks) were condensed into a single population-weighted average age by county, reflecting the number of years old in 2017. The mean age was then binned into the six categories listed below. Only counties that share the same bin were allowed to be in the same representative county group. The source of the data was submitted age distributions that EPA accepted for use in NEI, supplemented elsewhere by the adapted 2017 IHS data from CRC A-115.

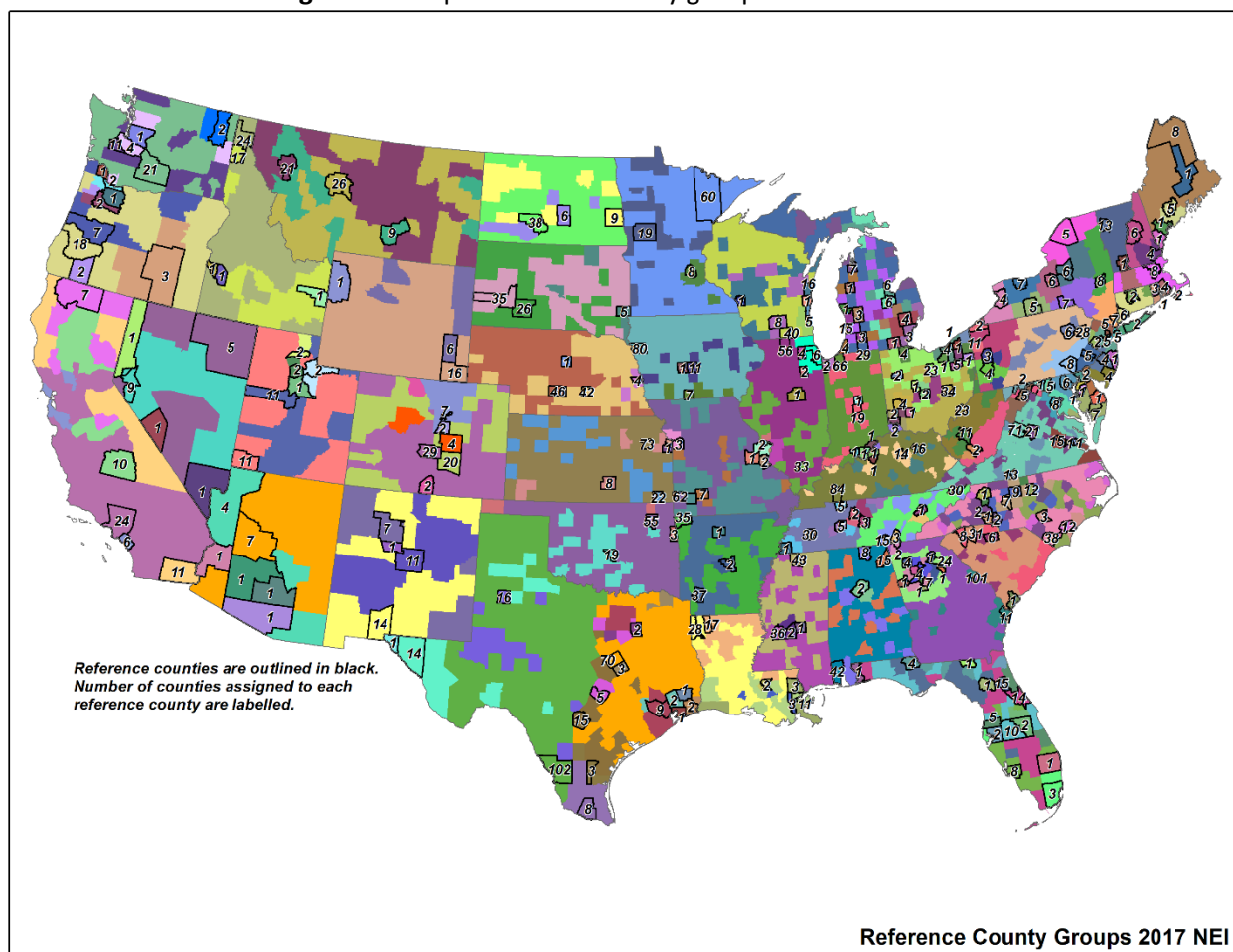| Bin	Description (Mean age in number of years old in 2017)
1	0.0 ≤ Mean Age < 7.0
2	7.0 ≤ Mean Age < 9.0
3	9.0 ≤ Mean Age < 11.0
4	11.0 ≤ Mean Age < 13.0
5	13.0 ≤ Mean Age < 15.0
6	15.0 ≤ Mean Age

6. **Ramp bin.** MOVES2014b uses a parameter with a value between 0 and 1 called "ramp fraction" to divide the time driving on restricted access roads into highway ramps and non-ramp. MOVES assigns ramp driving a more aggressive drive schedule, and therefore they have higher emission rates than cruise on highways. The data source for ramp fraction was the 2017 submittals, and the MOVES default value of 0.08 ramp fraction elsewhere. Each county's ramp fraction was binned into the five categories below.

Bin	Description
1	0 ≤ ramp fraction < 0.05
2	0.05 ≤ ramp fraction < 0.09
3	0.09 ≤ ramp fraction < 0.13
4	0.13 ≤ ramp fraction < 0.17
5	0.17 ≤ ramp fraction

State requests. Several agencies provided comments to EPA on the selection of representative counties for their states: Maryland, New York, New Jersey, and Wisconsin.

After grouping similar counties, the county with the highest VMT in each group was selected as the representative county. Figure 6-2 displays a map of the representative counties by state and their corresponding county groups. The MCXREF file listed in Table 6-10 provides the mapping of each specific county to its representative county and a map showing the visualization of the county groups (2017NEI_representative_county_groups.png) are provided. A spreadsheet that includes the data used in the development of the representative counties is included with the supporting data described in Table 6-10 (2017_Representative_Counties_Analysis_20191220.xlsx).

Figure 6-2: Representative county groups for the 2017 NEI

Reference counties are outlined in black.
Number of counties assigned to each
reference county are labelled.

Reference County Groups 2017 NEI

6.8.2.2 *Fuel Months*

A "fuel month" indicates when a particular set of fuel properties should be used in a MOVES simulation. Similar to the representative county, the fuel month reduces the computational time of MOVES by using a single month to represent a set of months during which a specific fuel has been used in a representative county. Because there are winter fuels and summer fuels, the EPA used January to represent October through April and July to represent May through September. For example, if the grams/mile exhaust emission rates in January are identical to February's rates for a given representative county, and temperature (as well as other factors), then we use a single fuel month to represent January and February. In other words, only one of the months needs to be modeled through MOVES to obtain the necessary emission factors. The hour-specific VMT, temperature and other factors for February are still used to calculate emissions in February, but the emission factors themselves do not need to be created, since one month can sufficiently represent the other month. The fuel months used for each representative county are provided in the MFMREF file in the supplementary materials (see Table 6-10 for access information).

6.8.2.3 *Fuels*

For the 2017 NEI, fuel property information included in locally-supplied CDBs was replaced with a fuel supply developed by EPA (moves201x_2017fuels_or_otaq_20191210). The EPA fuel supply was derived from refinery production compliance data, market fuel survey data, and known federal and local regulatory requirements. For

a national inventory such as the NEI, this approach provides a more consistent and comprehensive result with respect to fuel use and fuel impacts on emission rates. More details on development of the MOVES fuel supply is available in this MOVES technical support document: Fuel Supply Defaults: Regional Fuels and the Fuel Wizard in MOVES2014b [ref 5].

The 2017 NEI fuel supply was created by starting with the 2016 NEI fuels and applying adjustments derived from updated gasoline production data. This was done by comparing 2017 to 2016 gasoline properties as reported on the OTAQ Compliance Division website. These adjustments covered six fuel properties and were made separately for summer and winter season and conventional and reformulated gasoline.

For 2017 the nationwide fuel supply assumed 100% market share E10 ethanol blends in gasoline. All diesel was assumed to be 15 ppm sulfur, and onroad diesel was 100% market share B5 biodiesel blends nationwide.

6.8.3 Temperature and humidity

Ambient temperature can have a large impact on emissions. Low temperatures are associated with high start emissions for many pollutants. High temperatures and high relative humidity are associated with greater running emissions due to the increase in the heat index and resulting higher engine load for air conditioning. High temperatures also are associated with higher evaporative emissions.

The 12-km gridded meteorological input data for the entire year of 2017 covering the continental U.S. were derived from simulations of version 3.8 of the Weather Research and Forecasting Model (WRF), Advanced Research WRF core [ref 6]. The WRF Model is a mesoscale numerical weather prediction system developed for both operational forecasting and atmospheric research applications. The Meteorology-Chemistry Interface Processor (MCIP) [ref 7] was used as the software for maintaining dynamic consistency between the meteorological model, the emissions model, and air quality chemistry model.

The EPA applied the SMOKE program Met4moves [ref 8] to the gridded, hourly meteorological data (output from MCIP) to generate a list of the maximum temperature ranges, average relative humidity, and temperature profiles that are needed for MOVES to create the emission-factor lookup tables. "Temperature profiles" are arrays of 24 temperatures that describe how temperatures change over a day, and they are used by MOVES to estimate vapor venting emissions. The hourly gridded meteorological data (output from MCIP) was also used directly by SMOKE (see Section 6.8.9).

The temperature lists were organized based on the representative counties and fuel months as described in Section 6.8.2. Temperatures were analyzed for all of the counties that are mapped to the representative counties, i.e., for the county groups, and for all the months that were mapped to the fuel months. The EPA used Met4moves to determine the minimum and maximum temperatures in a county group for the January fuel month and for the July fuel month, and the minimum and maximum temperatures for each hour of the day. Met4moves also generated temperature profiles using the minimum and maximum temperatures and 10 °F intervals. In addition to the meteorological data, the representative counties and the fuel months, Met4moves uses spatial surrogates to determine which grid cells from the meteorological data have roads and uses the WRF temperature and relative humidity data from those areas. For example, if a county had a mountainous area with no roads, the grid cells with no roads would be excluded from the meteorological processing. The spatial surrogates used for the 2017 NEI were based on activity data such as link-based VMT for the year 2016, with the goal of better characterizing the spatial variability of the onroad mobile source emissions. The use of these new spatial surrogates required updates to the cross reference of surrogate assignments by vehicle type and process.

For the 2017 NEI, MOVES was run with the database nonoxadj_moves2014b (part of MOVES_Input_DBs.zip in Table 6-10) to prevent the model from making adjustments to NOx based on humidity levels. Instead, gridded hourly humidity values are used in SMOKE-MOVES to compute NOx adjustments to the unadjusted emissions output from MOVES.

Met4moves computes the range of temperatures needed by each representative county for each fuel month (i.e., 5 month summer season or 7 month winter season). When the emission factors are applied by SMOKE, the appropriate temperature bin and fuel month are used to compute the emissions. The EPA used a 5 °F temperature bin size for RatePerDistance (RPD), RatePerVehicle (RPV), and RatePerHour (RPH).

Met4moves can be run in daily or monthly mode for producing SMOKE input. In monthly mode, the temperature range is determined by looking at the range of temperatures over the whole month for that specific grid cell. Therefore, there is one temperature range per grid cell per month. While in daily mode, the temperature range is determined by evaluating the range of temperatures in that grid cell for each day. The output for the daily mode is one temperature range per grid cell per day and is a more detailed approach for modeling the vapor venting RatePerProfile (RPP) based emissions. The EPA ran Met4moves in daily mode for the 2017 NEI. The temperature data output from Met4moves (2017NEI_RepCounty_Temperatures.zip) are provided with the supporting data in Table 6-10.

The resulting temperatures for the representative counties are provided in the supplementary materials (see Table 6-10 for access information). The gridded, hourly temperature data used are publicly available only upon request and with provision of a disk media to copy these very large datasets.

6.8.4   VMT, vehicle population, speed, and hoteling activity data

The activity data used to compute onroad mobile source emissions for the 2017 NEI uses EPA-computed data where state/local agencies did not provide their own data. These "default" (but county-specific) data were derived from Federal Highway Administration Data (FHWA) information including the published *Highway Statistics 2017* [ref 9]*,* along with county-level VMT data allocated to vehicle type, fuel type, and road type. Some additional data sources were also used. The development of the default data is described in detail in 2017Default_Onroad_Activity_Data_Documentation.pdf, which is provided with the supporting data in Table 6-10.

As discussed above, SMOKE combines the MOVES emission factors for each representative county with county-specific VMT, population, and hoteling data to compute the emissions for each individual county. These activity data are provided to SMOKE in a flat file format, and the source of the data varies according to area of the country and depending on whether the state/local agency submitted data for the 2017 NEI. The final activity data is a combination of submitted data and EPA-developed data. The data are provided with the supporting data in Table 6-10 (2017NEI_onroad_activity_final.zip).

For the counties for which an agency submitted a CDB (the dark blue areas shown previously in Figure 6-1), the EPA ran scripts to extract the agency-submitted data from the CDBs and reformatted it into the flat file text file format that can be input to SMOKE (i.e., FF10). For the non-submitting areas of the U.S. (light blue areas in Figure 6-1), the EPA VMT, population, and hoteling were used. The 2017 default speeds are from the CRC A-100 study. The CDBs use a distribution of speeds specific to hour, vehicle and road type, and weekday/weekend day types. SMOKE uses these same data, but the 16 speed bin distributions are averaged by hour, SCC, county, and weekday/weekend days. The speed data used for the 2017 NEI (2017NEI_speed_spdist.zip) are included with the supporting data in Table 6-10.

The FF10 creation scripts that read submitted CDBs are described separately by activity type below, followed by discussion on how the EPA created the default 2017 activity data for VMT, population, speed, and hoteling for non-submitting areas.

6.8.4.1 *VMT FF10 file creation*

The FF10-generation scripts read VMT flexibly from either the MOVES CDB table `sourceTypeYearVMT,` which contains annual VMT organized by MOVES source type, or `HPMSVtypeYear,` which contains annual VMT by groups of MOVES source types. The scripts disaggregate the VMT into fuel type, model year, and road type using a combination of other CDB tables as well as some MOVES default tables. First, the annual VMT is divided into model year using the CDB table with age distribution and the MOVES default database table containing relative annual mileage accumulation by age (`SourceTypeAge`). The scripts use these tables to create travel fractions for each source type and model year that sums to one (1) by source type.

Next, the VMT is further divided into fuel type categories of gasoline, diesel, CNG, E85, and electric vehicles – preferentially by using submitted MOVES CDB tables `AVFT` to determine the split of engine-fuel types by model year and `FuelUsageFraction` to determine the percent of flex-fuel engines that actually use E85. Flex-fuel engines refer to those capable of operating on either E85 or conventional gasoline, the percentage of which could be a function of local availability of the alternative fuel. Because the AVFT and FuelUsageFraction tables are optional tables in a MOVES CDB, they were not always populated in a submitted database. In cases where data were not provided, the FF10-generation scripts automatically default to MOVES national distributions of fuel types and/or E85 availability, using the `SampleVehiclePopulation` and `FuelUsageFraction` tables of the model default database to fill the missing data. It is worth noting that several states do not have any VMT (or vehicle population) associated with flex-fuel vehicles because they submitted data indicating either no flex-fuel vehicle population or zero E85 fuel supply in the CDB tables.

Finally, the FF10-generation scripts read the CDB table `RoadTypeDistribution` to further split VMT (by fuel type) into the four MOVES road types (urban and rural, restricted and unrestricted access). The scripts aggregate VMT across model years to the SCC level (i.e., MOVES source type, fuel type, and road type) and reports annual and monthly VMT (using the `MonthVMTFraction` CDB table) for each SCC in each county into a consolidated list.

6.8.4.2 *Population FF10 file creation*

The FF10-generation script that creates the SMOKE vehicle population (i.e., VPOP) data operates similarly to the VMT script just described, except that the calculations do not use travel fractions to disaggregate population by model year. First, the script reads the CDB `SourceTypeYear` table, which contains 2017 population by MOVES source type and divides it into model years based on the submitted CDB `SourceTypeAgeDistribution` table. For each vehicle model year, the scripts apportion vehicle populations to fuel types using the submitted CDB tables `AVFT' and `FuelUsageFraction,' or, if no data were provided, uses the national default corresponding data tables described in Section 6.8.4.1.

The FF10 scripts then aggregate population from the model year level back up to the SCC level (MOVES source type and fuel type, and the road type 1). The CreateFF10 script and the Reverse FF10 script that pull activity data in and out of CDBs are included with the or_scripts_2017.zip file that is included with the supporting data described in Table 6-10.

After the vehicle population and VMT data were finalized, the population and VMT were compared by county and source type to look for inconsistencies between the two datasets. Specifically, counties and source types with an unreasonably high miles per year per-vehicle average (VMT divided by VPOP) were identified and addressed. For counties and source types with a VMT/VPOP ratio above the threshold in Table 6-8, the vehicle

population was increased so that the new VMT/VPOP ratio would equal the maximum allowable ratio. The thresholds used were based on the 90th to 95th percentile of VMT/VPOP ratio for each source type. The vehicle populations were adjusted to produce reasonable VMT/VPOP ratios because MOVES can output unrealistic emission factors when the VMT/VPOP ratios are extremely high.

Table 6-8: Maximum allowable miles-per-year per-vehicle average by source type

MOVES source type	Source type description	Maximum VMT/VPOP ratio (miles per year)
11	Motorcycle	7,500
21	Passenger Car	31,000
31	Passenger Truck	31,000
32	Light Commercial Truck	31,000
41	Intercity Bus	130,000
42	Transit Bus	90,000
43	School Bus	30,000
51	Refuse Truck	60,000
52	Single Unit Short-haul Truck	45,000
53	Single Unit Long-haul Truck	60,000
54	Motor Home	7,000
61	Combination Short-haul Truck	150,000
62	Combination Long-haul Truck	150,000

6.8.4.3   *Speed FF10 file creation*

SMOKE uses speed data for all counties to lookup the appropriate VMT-based emission factors by speed bin and SCC. The FF10 "SPEED" input for SMOKE is one of two speed-related inputs; the other, described below, contains hourly speed distributions by SCC and county, separately for weekdays and weekends. The FF10 speed file for SMOKE contains a single daily average speed by SCC and county as an annual average and for each of the 12 months.

The FF10-generation scripts read the CDB table `avgSpeedDistribution,' which contains the fraction of VMT by 16 speed bins for each source type, day type (weekday/weekend), and hour. The scripts calculate a weighted average to arrive at the average day values.

6.8.4.4   *Speed Distribution*

The SPDPRO file was used to develop previous NEI datasets, but for 2017 NEI, the SPDIST was used instead of the SPDPRO. The SPDIST file is generated by reformatting the MOVES `avgSpeedDistribution` CDB table into a form that can be accepted by SMOKE. The speed distribution (SPDIST) input for SMOKE is optional. Out of the three possible ways to model vehicle speeds in SMOKE, SPDIST provides the highest resolution to best match vehicle activity with the lookup tables of emission factors, which for the running processes are listed by MOVES 16 speed bins. The SPDIST file lists the fraction of time in each hour spent in each of the 16 speed bins, for weekday and weekend day types, by county, source type, and road type. MOVES provides distinct emission factors for each of the 16 speed bins, and the SPDIST tells SMOKE-MOVES how to weight each of the speed bins when computing the total emissions. For example, if the SPDIST specifies 55% of time is spent in speed bin 8 and 45% of time is spent in speed bin 9 for a particular county, hour/day, and SCC, the emission factors for those two speed bins are weighted according to those ratios. The SMOKE-MOVES calculations also take unit conversions into account, as the SPDIST fractions are per unit time, while RPD emission factors are per unit distance.

6.8.4.5 *Hoteling FF10 file creation.*

Hoteling activity refers to the time spent idling in a diesel long-haul combination truck during federally-mandated rest periods of long-haul trips. Drivers may spend these rest periods with the main engine on, a smaller auxiliary power unit (APU) engine on, plugged into an electric source if available, or simply leave the engine off. MOVES and the NEI track the emissions from hoteling using the main engine idling versus those from APUs separately. SMOKE reads each type of hoteling hours by SCC and matches them to the appropriate MOVES emission factor from the `RatePerHour' lookup table.

Submitting agencies have the option to directly provide MOVES with the number of hoteling hours (via the 'hotellingHours' table) and the percent of trucks by model year that use APUs (the 'hotellingActivityDistribution' table). These CDB tables are optional. When they are present, the FF10-generation scripts read them and translate them into the FF10 formats for SMOKE. If they are empty, the FF10-generation scripts calculate the hoteling consistently with the methodology used internally to MOVES when these tables are empty. Thus, the scripts multiply the VMT for diesel-fueled long-haul combination truck VMT on restricted access roads (urban and rural together) and with the national average rate of hoteling. For the 2017 NEI, the national average rate of hoteling was estimated by EPA to be 0.007248 hours per mile, which is a reduction from the 0.027337 hours per mile average used for 2014 NEI. The scripts use the submitted fractions of APU usage where available and rely on MOVES defaults otherwise.

For the 2017 NEI, EPA calculated all hoteling hours from the final VMT by SCC and county. These hoteling hours were inserted into the final set of "all CDBs" released with the modeling platform (see Section 6.10). The representative CDBs were not updated, nor do they need these data to generate hoteling emission factors. For the 2017 NEI, an adjustment to hoteling was made to address concerns raised by stakeholders about hoteling hours being artificially concentrated in areas with large amounts of combination truck VMT, but which were not necessarily areas that trucks stopped to take long rest breaks. This is particularly an issue in heavily traveled urban areas. The hoteling hours per county were compared to the number of truck stop spaces identified in the Shapefile on which the surrogate that spatially allocates hoteling emissions to grid cells is based. This Shapefile was created collaboratively with states during the development of the 2011 NEI and updated during subsequent NEI efforts. In the analysis, for each county, the maximum number of hoteling hours per year that could be supported by the number of specified parking spaces was computed using the formula:

*max hours / year = number of spaces * 24 hours / day * 365 days / year*

This assumes that all spaces are filled at all hours of the day. The maximum number of hours was subtracted from the number of hours assigned to that county to determine if the county was over-allocated with hoteling hours as compared to the known spots. For counties with at least 2 million over-allocated hours, a manual review of truck stop spaces was conducted using Google Earth. In cases where evidence of additional spaces was found, the number of spaces was adjusted and a factor was computed so that when that factor was multiplied by hours, the max hours per year matched those available with the adjusted number of spaces (i.e., hoteling hours were no longer over-allocated to the county). For the remaining over-allocated counties, no analysis was performed and a factor to adjust the hoteling hours down to match the max hours per year for each county was computed and applied, although it was assumed that any county can support a minimum of 105,120 hoteling hours (i.e., 12 spaces' worth). No adjustments to hoteling hours were made in counties for which hoteling hours were substantially under-allocated as compared to the number of available spots. Ideally, hoteling hours would be properly allocated to counties by someone familiar with traffic patterns in the local area. The spreadsheet used for this analysis (2017NEI_hoteling_by_county_versus_truck_stop_parking_20200117.xlsx) is listed in Table 6-10.

6.8.5   Public release of the NEI county databases

Two sets of 2017 CDBs are available for download: (1) seeded CDBs, which have been altered to produce emission rates for all sources, roads and processes, and (2) unseeded CDBs intended to be used with MOVES Inventory Calculation. The unseeded CDBs are available for all U.S. counties, but the seeded CDBs are only available for the representative counties. See Table 6-10 for access details.

6.8.6   Seeded CDBs

The seeded county databases can be used with MOVES to generate emission factor lookup tables for SMOKE-MOVES. In order to create representative county CDBs for MOVES runs for SMOKE-MOVES modeling, the EPA performed a "seeding" step, whereby values of zero (0) were updated to a small value of 1e-15. This seeding ensures that the lookup tables will be fully populated regardless of whether the representative county itself included activity for all of the categories covered. Seeding is necessary because counties mapping to the representative county may require an emission factor that would otherwise be missing. Note that the seeded CDBs each contain activity data for *all* of the counties represented by the CDB, not for a single county. The scripts used to develop the seeded CDBs are included in the or_scripts_2017.zip file described in Table 6-10.

6.8.7   Unseeded CDBs

In contrast to the seeded CDBs, the unseeded CDBs do not have any seeding performed on them and include activity data only for the individual county. This set of CDBs is true to the local conditions and could be used for MOVES inventory mode runs. The unseeded CDBs merge the databases that were agency-submitted with the default CDBs for 2017 with updates based on CRC A-115 and CRC A-100 study data. The unseeded CDB tables `SourceTypeYearVMT,` `SourceTypeYear,` `HotellingHours,` and `HotellingActivityDistribution` are consistent with the SMOKE-ready files of 2017 VMT, population, and hoteling. Activity data can be taken in and out of the unseeded individual county CDBs using the CreateFF10 and ReverseFF10 scripts included in the or_scripts2017.zip file described in Table 6-10.

6.8.8   Run MOVES to create emission factors

The EPA ran MOVES for each representative county using January fuels and July fuels for the range of temperatures spanned by the represented county group and set of months associated with each fuel set (January and July). A runspec generator script created a series of runspecs (MOVES jobs) based on the outputs from Met4moves temperature information for all months of the year. Specifically, the script used a 5-degree temperature bin with the minimum and maximum temperature ranges from Met4moves and used the idealized diurnal profiles from Met4moves to generate a series of MOVES runs that captured the full range of temperatures for the county group for the months assigned to each fuel. The MOVES runs resulted in four emission factors tables for each representative county and fuel month: rate per distance (RPD), rate per vehicle (RPV), rate per hour (RPH), and rate per profile (RPP). After the MOVES runs were completed, the post-processor script Moves2smk converted the MySQL tables into EF files that can be read by SMOKE. For more details on Moves2smk, see the SMOKE documentation [ref 10]. The post-processor scripts are available in 2017nei_or_postprocessing_jars.zip as described in Table 6-10.

6.8.9   Run SMOKE to create emissions

To prepare the NEI emissions, the EPA first generated emissions at an hourly resolution using more detailed SCCs than are found in the NEI (i.e., by road type and aggregate processes). The SMOKE-MOVES program Movesmrg performs this function by combining activity data, meteorological data, and emission factors to

produce gridded, hourly emissions. The EPA ran Movesmrg for each of the four sets of emission factor tables (RPD, RPV, RPH, and RPP). During the Movesmrg run, the program used the hourly, gridded temperature (for RPD, RPV, and RPH) or daily, gridded temperature profile (for RPP) to select the proper emissions rates and compute emissions. These calculations were done for all counties and SCCs in the SMOKE inputs, covering the continental U.S., as well as separate runs covering outlying areas (e.g. Alaska and Hawaii).

The emissions processes in RPD model the on-roadway driving emissions. This includes the following emission processes: vehicle exhaust, evaporation, evaporative permeation, refueling, brake wear, and tire wear. For RPD, the activity data is monthly VMT, monthly speed (i.e., SMOKE variable of SPEED), and hourly speed distributions (i.e., SPDIST in SMOKE). The SMOKE program Temporal takes temporal profiles specific to vehicle type and road type and distributes the monthly VMT to day of the week and hour. Movesmrg reads the speed distribution data for that county and SCC and the temperature from the gridded hourly (MCIP) data and uses these values to look-up the appropriate emission factors (EFs) from the representative county's EF table. It then multiplies this EF by temporalized and gridded VMT for that SCC to calculate the emissions for that grid cell and hour. This is repeated for each pollutant and SCC in that grid cell. The default diurnal and weekly VMT temporal profiles are based on the CRC A-100 study, which was completed in time for the 2014NEIv2.

The emission processes in RPV model the parked emissions. This includes the following emission processes: vehicle exhaust, evaporative, evaporative permeation, and refueling. For RPV, the activity data is vehicle population (VPOP). Movesmrg reads the temperature from the gridded hourly data and uses the temperature plus SCC and the hour of the day to look up the appropriate EF from the representative county's EF table. It then multiplies this EF by the gridded VPOP for that SCC to calculate the emissions for that grid cell and hour. This repeats for each pollutant and SCC in that grid cell.

The emissions processes in RPH model the parked emissions for combination long-haul trucks (source type 62) that are hoteling. This includes the following modes: extended idle and APUs. For RPH, the activity data is monthly hoteling hours. The SMOKE program Temporal takes a temporal profile and distributes the monthly hoteling hours to day of the week and hour. Movesmrg reads the temperature from the gridded hourly (MCIP) data and uses these values to look-up the appropriate emission factors from the representative county's EF table. It then multiplies this EF by temporalized and gridded HOTELING hours for that SCC to calculate the emissions for that grid cell and hour. This is repeated for each pollutant and SCC in that grid cell.

The emission processes in RPP model the parked emissions for vehicles that are key-off. This includes the mode vehicle evaporative (fuel vapor venting). For RPP, the activity data is VPOP. Movesmrg reads the gridded diurnal temperature range (Met4moves' output for SMOKE). It uses this temperature range to determine a similar idealized diurnal profile from the EF table using the temperature min and max, SCC, and hour of the day. It then multiplies this EF by the gridded VPOP for that SCC to calculate the emissions for that grid cell and hour. This repeats for each pollutant and SCC in that grid cell.

The result of the Movesmrg processing is hourly data as well as daily reports for each of the four processing streams (RPD, RPV, RPH, and RPP). The results include emissions for every county in the continental U.S.

6.8.10 Post-processing to create an annual inventory

For the purposes of the NEI, the EPA needed emissions data by county, SCC and pollutant. The EPA ran SMOKE-MOVES at a more detailed level including road type and emission processes (e.g., extended idle) and summed over road types and processes to create the more aggregate NEI SCCs. The EPA developed and used a set of scripts to combine the emissions from the four sets of reports and from all days to create the annual inventory.

The post processing scripts are named aq_cb6_saprc_1Aug2019, nata_20200204, and nei_20170718. They are available in the platform documentation (see Section 6.10).

Five speciated PM$_{2.5}$ pollutants were added to the NEI data for summary purposes. Note that air quality modeling uses a finer breakdown of these pollutants. The added pollutants are based on speciation profiles (i.e., elemental carbon, organic carbon, nitrate, sulfate and other PM$_{2.5}$). DIESEL-PM10 and DIESEL-PM25 were also added by copying the PM$_{10}$ and PM$_{2.5}$ pollutants (respectively) as DIESEL-PM pollutants for all diesel SCCs. See Section 2.2.5 for more details.

6.8.11 Additional MOVES and SMOKE runs with EPA-generated age distributions

Comparisons of emissions data output from SMOKE-MOVES between 2016 and 2017 showed some unexpected increases in emissions from 2016 to 2017. Various MOVES inputs were reviewed for their potential to contribute to these increases. The initial MOVES and SMOKE runs incorporated state and local agency-submitted age distribution tables. A second set of MOVES and SMOKE runs was then performed based on EPA-generated age distribution tables for all submitting state and local agencies. The outputs from the runs with agency-submitted and EPA-generated age distributions were then compared with each other and with prior year datasets. Based on the emissions differences, it was found that some agency-submitted age distributions were a substantial contributor to increases in emissions from 2016 to 2017.

The agency-submitted and EPA-generated age distributions were plotted and reviewed for unusual features. These plots were used to help guide the final decisions in terms of whether agency-submitted age distributions would be used for each state and source type. Submitting agencies were notified of these decisions through memoranda developed for each agency. The EPA contacted a few agencies that had unusual issues with their age distributions. The final decisions on the use of agency-submitted vs EPA-generated age distributions are summarized in the spreadsheet 2017v1 Documentation of CDB Input Data_20200327.xlsx. After the age distribution decisions were made, it was not necessary to perform a third set of MOVES and SMOKE runs. Instead, results from the first two runs were merged, using emissions from the first run for areas where agency-submitted age distributions were accepted, and emissions from the second run where EPA-generated age distributions were used.

6.9   Summary of quality assurance methods

The EPA performed a series of checks and comparisons against both the inputs and the resulting emissions to quality assure the onroad inventory. These checks are in addition to the ones described on the underlying CDBs. The following is a list of the more significant checks that were performed:

- The 2017 NEI emissions were compared to the 2016v1 platform and 2014v2 emissions to make sure that all SCCs, counties, and pollutants were covered and as a general quality assurance of the emissions. As a result of this comparison, age distributions were changed from submittal to EPA default for the county for a handful of states and source types. This is documented in the spreadsheet 2017v1 Documentation of CDB Input Data_20200327.xlsx available for download with the platform.

- Comparisons of 2017 with 2016 and 2014NEIv2 emissions were done using spreadsheets that compared emissions from the three years using various groupings, including but not limited to county-level, the first 6 digits of the SCC (fuel + MOVES source type), and grouping by light-duty and heavy-duty.

- Maps of county-level CAP and select HAP emissions were prepared for each MOVES source type and rate (e.g., RPD), including maps of the difference between 2017 emissions versus 2016v1 and 2014NEIv2 emissions.

The maps and spreadsheets helped to identify areas with suspect activity data or emission factors, and the EPA followed up on any suspect areas to investigate further and resolve problems if any were found. Folders containing a number of QA maps, plots, and summaries are referenced as part of the supporting data in Table 6-10.

6.10 Supporting data

Onroad 2017 emissions were computed by EPA estimates based primarily on input data submitted by state and local agencies and secondarily using EPA-developed input data, except for the state of California. Table 6-9 provides the submittal history of these county databases. The onroad scripts and data files used in the calculations are listed in Table 6-10. The files and datasets listed in Table 6-10 are all available on the 2017 NEI Supplemental Data FTP site.

Table 6-9: Agency submittal history for Onroad Mobile inputs and emissions

Agency Organization	Onroad CDB Submission Date (MM/DD/YYYY)	Onroad Emissions Submission Date (MM/DD/YYYY)	Notes
Alaska Department of Environmental Conservation	02/05/2019		
Arizona Department of Environmental Quality	02/07/2019		
Clark County Department of Air Quality	01/14/2019		
Connecticut Bureau of Air Management	02/05/2019		
Department of Energy and Environment (Washington D.C.)	01/09/2019		
Delaware Department of Natural Resources	01/15/2019		
Florida Department of Environmental Protection	02/04/2019		
Georgia Department of Natural Resources	09/13/2018		
Idaho Department of Environmental Quality	02/05/2019		
Illinois EPA	09/27/2018		
Knox County (Tennessee) Department of Air Quality Management	01/02/2019		

Agency Organization	Onroad CDB Submission Date (MM/DD/YYYY)	Onroad Emissions Submission Date (MM/DD/YYYY)	Notes
Louisville (Kentucky) Metro Air Pollution Control District	02/21/2019		
Maine Department of Environmental Protection	02/06/2019		
Maricopa County (Arizona) Air Quality Department	09/28/2018		
Maryland Department of the Environment	02/05/2019		
Massachusetts Department of Environmental Protection	02/05/2019		
Metro Public Health of Nashville/Davidson County	02/08/2019		
Michigan Department of Environmental Quality	01/15/2019		
Minnesota Pollution Control Agency	03/05/2019		
Missouri Department of Natural Resources	01/15/2019	04/09/2019	
New Hampshire Department of Environmental Services	12/03/2018		
New Jersey Department of Environment Protection	02/13/2019		
New York Department of Environmental Conservation	02/19/2019	04/09/2019	
North Carolina DEQ, Division of Air Quality	02/13/2019		
Ohio EPA	02/05/2019		
Pennsylvania Department of Environmental Protection	02/08/2019		
Pima Association of Governments (Tuscon, Arizona)	01/31/2019		

Agency Organization	Onroad CDB Submission Date (MM/DD/YYYY)	Onroad Emissions Submission Date (MM/DD/YYYY)	Notes
Rhode Island Department of Environmental Management			EPA constructed the Rhode Island CDBs from spreadsheets provided by RIDEM.
South Carolina Department of Health and Environmental Control	02/05/2019		
Texas Commission on Environmental Quality	02/07/2019		TCEQ later provided a correction to the CDB for Travis County.
Utah Division of Air Quality	12/20/2018		
Vermont Department of Environmental Conservation	02/05/2019		
Virginia Department of Environmental Quality	02/06/2019		
Washington State Department of Ecology	02/06/2019		
Washoe County (Nevada) Health District, Air Quality Management Division	03/19/2019		
West Virginia Division of Air Quality	01/14/2019		
Wisconsin Department of Natural Resources	02/08/2019		

Table 6-10: Onroad Mobile data file references for the 2017 NEI

	File Name	Description
1	2017NEI_default_onroad_activity_approach.pdf	Describes method used for EPA default VMT, VPOP, data used in counties for which data were not submitted by S/L/T agencies.
2	Folder *CDBs_for_all_counties* contains 2017_CDBs_stateXX.zip where XX is the two-digit state FIPS code	"*Unseeded*" CDBs for all counties in the U.S. archived separately by state. These may not produce fully populated emission rates tables across all categories without "seeding". Activity data and age distributions are specific to each county and not aggregated.

	File Name	Description
3	Folder *CDBs_for_rep_counties* contains 2017_RepCDBs_Seeded_26march2020.zip	"*Seeded*" CDBs for representative counties in the continental U.S. used to develop 2017 NEI. These should produce fully populated rates tables because values of zero in the MOVES input tables have been updated to small numbers (1e-15). Age distributions and AVFT are vehicle-population-weighted across all represented counties. VMT and population are summed across all represented counties.
4	Folder *CDBs_for_rep_counties* contains 2017_RepCounty_Runspecs.zip	The MOVES2014b run specifications (runspecs) for the representative counties for running MOVES in emissions rate mode (used for SMOKE-MOVES). Note that CDB names should be updated to the YYYYMMDD version date 20200326. The archive "2017_runspecs_zmh.zip" contains 60,879 individual archive files with a .jar extension, which can be unzipped using most standard unzipping software. Each jar contains one MOVES runspec file and the corresponding meteorology input database required for a single MOVES run for NEI. EPA divided the 60,879 runs across 706 computers using Amazon Web Services. Each computer ran between 86 and 87 MOVES runs in series, on average. The number of MOVES runs corresponds to 353 representative counties, 2 fuel months, and approximately 86-87 met conditions per county-month combination.
5	2017NEI_onroad_activity_final.zip	All three data types are in FF10 format for SMOKE and are a combination of EPA estimates, agency submittals, and corrections: 1.Vehicle population by county and SCC covering every county in the U.S., 2.VMT annual and monthly by county and SCC covering every county in the U.S., and 3.Hoteling hours annual and monthly by county covering every county in the U.S. including hours of extended idle and hours of auxiliary power units for combination long-haul trucks only.

	File Name	Description
6	2017NEI_RepCounty_Temperatures.zip	The temperature and relative humidity bins for running MOVES to create the full range of emissions factors necessary to run SMOKE-MOVES and the ZMH files used to run MOVES. Generated by running the SMOKE Met4moves program.
7	MFMREF_2017nei_27mar2020_v1.csv	Fuels cross reference (MFMREF) is a table that maps representative fuel months to calendar months for each representative county. The MFMREF file is an input to SMOKE.
8	MCXREF_2017nei_18mar2020_v1.csv 2017NEI_representative_county_groups.png	County cross reference file (MCXREF) is a table that shows every US county along with the representative county used as its surrogate. The MCXREF is an input to SMOKE. A map showing the county groups is also available.
9	2017NEI_speed_spdist.zip	These data are in FF10 format for SMOKE and are a combination of EPA estimates, agency submittals, and corrections: 1. Average speed in miles per hour, annual and monthly values, by county and SCC covering every county in the U.S. and 2. Weekend and weekday hourly speed distributions (SPDIST) in miles per hour, by county and SCC covering every county in the U.S.
10	The archive *QA_scripts_or_2017.zip* includes the QA script: CDB_QA_Checks_MOVES2014b_v2_upd.sql ERG_20191023.sql	Scripts designed to catch errors that would cause MOVES to fail during a run and to identify unreasonable data values.
11	The archive *or_scripts_2017.zip* includes the FF10 generation scripts: 1_HPMS_VMT_POP_db_20190422.sql 2_CreateFF10_fromMOVES2014CDB_v6_20200107.sql	FF10 generation scripts read CDB tables and produce SMOKE-formatted activity input files for use in SMOKE-MOVES. The SMOKE files include VMT, vehicle population, hoteling hours, speed, and SPDPRO.
12	The archive *or_scripts_2017.zip* contains the script ReverseFF10_Script_20200317.plx	The reverse FF10 script populates CDBs from SMOKE-formatted activity files VMT, vehicle population, and hoteling hours to fill the MOVES CDB tables SourceTypeYearVMT, SourceTypeYear, HotellingHours, and HotellingActivityDistribution.

	File Name	Description
13	Folders with QA / review products: *age_distribution_plots* *draft_emissions_review* *emissions_and_activity_maps* *summaries*	Plots, maps, and summaries for quality assurance and data visualization are available in several folders to assist interested parties in better understanding the data.
14	2017v1 Documentation of CDB Input Data_20200327.xlsx	Spreadsheet that shows how state-submitted and default data were merged together to prepare 2017 NEI.
15	2017_Representative_Counties_Analysis_20191220.xlsx	Spreadsheet of representative county characteristics.
16	2017NEI_hoteling_by_county_versus_ truck_stop_parking_20200117.xlsx	Spreadsheet documenting computation of adjustment factors applied to hoteling hours where there were more hours assigned than the available truck stop parking spaces could support.
17	The archive *2017nei_or_postprocessing_jars.zip* includes the scripts postprocess_aq_cb6_saprc_1Aug2019.jar postprocess_nata_20200204.jar postprocess_nei_20160718.jar	MOVES lookup table post-processing scripts that can create emission factor tables for various chemical mechanisms and purposes (e.g., the NEI).
18	The archive *or_scripts_2017.zip* includes the script and fuels data table: UpdateFuels_20191226.plx moves201x_2017fuels_or_otaq_20191210	Perl script that inserts 2017 fuels provided by OTAQ into each CDB. The 2017 fuels are listed in the MySQL database `moves201x_2017fuels_or_otaq_20191210`
19	The archive *or_scripts_2017.zip* includes the script and meteorological data tables: UpdateMet_20200319.plx met_2017nei_local_no_temp_adj met_2017nei_local_no_temp_adj_outsideco nus	Perl script that inserts met data into set of "all CDBs" intended for inventory mode. The representative CDBs do not use this data. The 2017 met data is listed in the MySQL database `met_2017nei_local_no_temp_adj.`

	File Name	Description
20	The archive *or_scripts_2017.zip* includes the representative county seeding scripts: SeedingScript_ERG.sql `seed` seedCDBs.py	These items can be used to seed a set of representative CDBs so that they produce complete lookup tables. SeedingScript_ERG.sql is a MySQL script that turns 0 values into small values of 1e-15. The MySQL database `seed` is required by the script. The python script seedCDBs.py is a wrapper to run the MySQL script "SeedingScript_ERG.sql" on a batch of CDBs. This script also updates the version of the CDB name to the current date (YYYYMMDD format). The CDB naming convention is `c01015y2017_YYYYMMDD` for county 1015 calendar year 2017.
21	2017NEI_California_onroad_HAP_augmentation_factors.csv	Factors used to augment the California Air Resources Board submitted criteria pollutant data with HAPs.
22	The archive *MOVES_Input_DBs.zip* includes databases LEV.zip and nonoxadj_moves2014b.zip	Databases used when running MOVES include LEV.zip that represents where California LEV rules apply and nonoxadj_moves2014b.zip which causes MOVES not to make humidity-based adjustments to NOx emissions, so that they can instead by applied using hourly, grid-cell based humidity values.

6.11 References for onroad mobile

1. Coordinating Research Council. 2019. Developing Improved Vehicle Population Inputs for the 2017 National Emissions Inventory. Report No. A-115.
2. Coordinating Research Council. 2017. Improvement of Default Inputs for MOVES and SMOKE-MOVES: Final Report. Report No. A-100.
3. U.S. EPA, Tools to Develop or Convert MOVES Inputs, LEV and early NLEV modeling information for MOVES2014-20141022.
4. U.S. EPA, MOVES2014b: Latest Version of MOtor Vehicle Emission Simulator (MOVES).
5. U.S. EPA, MOVES Onroad Technical Reports.
6. The Weather Research & Forecasting Model, Skamarock, W.C., et al., National Center for Atmospheric Research, Mesoscale and Microscale Meteorology Division, Boulder CO, June 2008, NCAR/TN-475+STR, A Description of the Advanced Research WRF Version 3.8.
7. Meteorology-Chemistry Interface Processor (MCIP) version 4.3.
8. User's Guide for SMOKE, including MOVES integration tools.
9. Federal Highway Administration, Highway Statistics 2017.
10. Scripts that interface between SMOKE and MOVES, MOVES Utility Scripts and SMOKE-MOVES.

7   Events – Wild and Prescribed Fires

7.1   Sector description and overview

Wildfires and prescribed burns (Wildland Fires in sum, WLFs) that occur during the inventory year are included in the NEI as "event" sources. Emissions from these fires, as well as agricultural fires, make up the National Fire Emissions Inventory (NFEI). For the 2017 NFEI, the EPA calculated emissions from agricultural fires separately from WLF emissions as described elsewhere in this TSD. This portion of the document describes the calculation of WLF emissions portion of the 2017 NEI.

Estimated emissions from wildfires and prescribed burns in the 2017 NEI (termed in the remainder of this section as the "2017 NEI"—as this section only pertains to WLFs) are calculated from burned area data. Input data sets are collected from State/Local/Tribal (S/L/T) agencies and from national agencies and organizations. S/L/T agencies that provide input data were also asked to complete the NEI Wildland Fire Inventory Database Questionnaire, which consists of a self-assessment of data completeness. Raw burned area data compiled from S/L/T agencies and national data sources are cleaned and combined to produce a comprehensive burned area data set. Emissions are then calculated using fire emission models that rely on burned area as well as fuel and weather information. The resulting emissions are compiled by date and location as day-specific emission estimates.

For purposes of emission inventory preparation, wildland fire (WLF) is defined as "any non-structure fire that occurs in the wildland (an area in which human activity and development are essentially non-existent, except for roads, railroads, power lines, and similar transportation facilities). Wildland fire activity is categorized by the conditions under which the fire occurs. These conditions influence important aspects of fire behavior, including smoke emissions. In the 2017 NEI, data processing is conducted differently depending on the fire type, as defined below:

Wildfire (WF): "any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire."

Prescribed (Rx) fire: "any fire intentionally ignited by management actions in accordance with applicable laws, policies, and regulations to meet specific land or resource management objectives." Prescribed fire is one type of fuels treatment. Fuels treatments are vegetation management activities intended to modify or reduce hazardous fuels. Fuels treatments include prescribed fires, wildland fire use, and mechanical treatment.

Agricultural burning is a type of prescribed fire, specifically used on land used or intended to be used for raising crops or grazing. This is dealt with in a different section of this document.

Pile burning is a type of prescribed fire in which fuels are gathered into piles before burning. In this type of burning, individual piles are ignited separately. Pile burn emissions are not currently included in the NEI due to lack of usable data and default methods. EPA continues to work to develop methods for estimating emissions of this source type.

Table 7-1 lists the Source Classification Codes (SCCs) that define the different types of WLFs in the 2017 NEI, both for EPA data and for S/L/T agency data. The leading SCC description for these SCCs is "Miscellaneous Area Sources; Other Combustion - as Event". Since the 2014 NEI, the EPA has compiled WLF emissions by smoldering and flaming phases. The SCCs shown in Table 7-1 are used to denote this differentiation. There are five valid

SCCs for events in EIS for the 2017 NEI, and EPA reports estimates into each of these SCCs. One difference to note for the 2017 NEI is that we have included a specific SCC (2801500170) that houses only the grassland fires of "Flint Hills," which occur over much of KS and a small part of OK. The other SCCs are carried over from the 2014 NEI. The SCCs that were available for pile burns in the 2014 NEI have been omitted here, since EPA does not yet have a default method for estimating those emissions. In addition, other grassland fires (other than "Flint Hills" fires) are processed via the SF2/BS process described below and inventoried along with other wildfires. Please note that in the 2014 NEI, these grassland fires were all inventoried as part of agricultural fires (in the nonpoint data category), and here we are switching to housing them in the events data category. This decision was made based on some analysis done during the 2016 Modeling Platform Collaborative inventory process [ref 1].

Table 7-1: SCCs for wildland fires

SCC	Description
2801500170	Grassland fires; prescribed
2810001001	Forest Wildfires; Smoldering; Residual smoldering only (includes grassland wildfires)
2810001002	Forest Wildfires; Flaming (includes grassland wildfires)
2811015001	Prescribed Forest Burning; Smoldering; Residual smoldering only
2811015002	Prescribed Forest Burning; Flaming

7.2 Sources of data

The WLF EIS sectors include data only from three components: S/L/T agency-provided emissions data for Georgia and Washington (day-specific data in events format), the EPA dataset created from SMARTFire version 2 (SF2/BS), which used available state inputs, and a PM2.5 speciation file that contains the five components of PM2.5 for each fire. This merged information is the basis of the WLF 2017 NEI. The hierarchy of data used to compile the 2017 NEI was very straightforward: the PM2.5 speciation dataset comes first, followed by Georgia's and Washington's submitted emissions data, followed by EPA's dataset, as shown in Table 7-2.

Table 7-2: 2017 NEI Wildfire and Prescribed Fires selection hierarchy

Priority	Dataset Name	Dataset Content	Is Dataset in EIS?
1	PM2.5 Speciation	PM2.5 species for all data	Yes
1	State/Local/Tribal Data	Submitted data as discussed above	Yes
2	2017EPA_EVENT	Emissions from SFv2	Yes

The NEI includes only Georgia and Washington-provided data for that S/L/T; in other words, there were no additions with any EPA-based data based on the questionnaire GA and WA submitted that indicated their submissions were complete for each of these states. Both Georgia and Washington were supplied HAP to VOC ratios by EPA, which they used to estimate HAPs based on their VOC emissions to calculate HAP emissions, so that these emissions calculations were used consistent with what was used for the remainder of the U.S. via the EPA methods. In 2017, while tribes submitted some WLF emissions data, they were not explicitly used in the BS/SF2 processing. Instead, EPA used the nationwide NEI WLF emission estimates and developed tribal land emission estimates using appropriate shapefiles and GIS. These estimates over tribal lands are available as part of the public release of 2017 Events data.

The S/L/Ts were not permitted to submit PM2.5 speciated emissions, which are required in the NEI. These PM species pollutants include EC, OC, SO4, NO3, and "other" (PMFINE). These were estimated for all events data (WA, GA, and all other states) by EPA using the fractions shown in Table 7-3.

Table 7-3: PM species for all events, computed as fraction of total PM2.5

Species	Fraction
PEC	0.0323
POC	0.4688
PNO3	0.0003
PSO4	0.0013
PMFINE	0.4973

7.3 EPA methods summary

Preparation of the EPA WLF emissions begins with raw input data and ends with daily estimates of emissions from flaming combustion and smoldering combustion phases. Flaming combustion is combustion that occurs with a flame. Flaming combustion is more complete combustion and is more prevalent with fuels that have a high surface-to-volume ratio, a low bulk density, and low moisture content. Smoldering combustion is combustion that occurs without a flame. Smoldering combustion is less complete and produces some pollutants, such as $PM_{2.5}$, VOCs, and CO at higher rates than flaming combustion. Smoldering combustion is more prevalent with fuels that have low surface–to-volume ratios, high bulk density, and high moisture content. Models sometimes differentiate between smoldering emissions that are lofted with a smoke plume and those that remain near the ground (residual emissions). In the 2017 NEI, all flaming emissions are made up of any component that has a flaming component to it while the smoldering emissions are the residual smoldering component that is generated by the CONSUME model, as described further below. The emissions estimates were estimated and compiled separately for flaming and smoldering combustion phases of fire to facilitate air quality modeling and fine-scale research in areas such as health impacts of smoke emissions, where the known impacts of varying PM and VOC composition by combustion phase likely play a role.

In the 2017 NEI process, EPA developed draft 2017 emission estimates based just on default information. S/L/Ts had an opportunity to review these estimates and: 1) accept them as final, 2) submit activity data and a questionnaire (as detailed below), or 3) provide comments. In developing final 2017 WLF estimates, EPA took into consideration all 3 of these items. If an S/L/T accepted the draft estimates, those estimates were not changed in the process to develop final estimates.

7.3.1 National Fire Information Data

Numerous fire information databases are available from U.S. national government agencies. Some of the databases are available via the internet while others must be obtained directly from agency staff. Table 7-4 provides the national fire information databases that were used for the EPA's 2017 NEI methods for wildland fire emissions estimates, including the website where the 2017 data were downloaded.

Table 7-4: National fire information databases used in EPA's 2017 NEI wildland fire emissions estimates

Dataset Name	Fire Types	Format	Agency	Coverage	Source
Hazard Mapping System (HMS)	WF/ RX	CSV	NOAA	North America	Hazard Mapping System Fire and Smoke Product

Dataset Name	Fire Types	Format	Agency	Coverage	Source
Geospatial Multi-Agency Coordination (GeoMAC)	WF	SHP	USGS	Entire US	Geosciences and Environmental Change Science Center
Incident Command System Form 209: Incident Status Summary (ICS-209)	WF/ RX	CSV	Multi	Entire US	FAMWEB Data Warehouse ICS-209
National Association of State Foresters (NASF)	WF	CSV	Multi	Participating US states	FAMWEB Home
Forest Service Activity Tracking System (FACTS)	RX	SHP	USFS	Entire US	Hazardous Fuel Treatment Reduction: Polygon
US Fish and Wildland Service (USFWS) fire database	WF/ RX	CSV	USFWS	Entire US	Direct communication with USFWS

The Hazard Mapping System (HMS) was developed in 2001 by the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite and Data Information Service (NESDIS) as a tool to identify fires over North America in an operational environment. The system utilizes geostationary and polar orbiting environmental satellites. Automated fire detection algorithms are employed for each of the sensors. When possible, HMS data analysts apply quality control procedures for the automated fire detections by eliminating those that are deemed to be false and adding hotspots that the algorithms have not detected via a thorough examination of the satellite imagery.

The HMS product used for the 2017 NEI inventory consisted of daily comma-delimited files containing fire detect information including latitude-longitude, satellite used, time detected, and other information. Landcover was spatially associated with each HMS detects using the Cropland Data Layer (CDL). HMS detects over croplands were removed from the input files so that only wildland fires are included. Unlike in prior wildland fire NEIs all grassland fire HMS satellite detects were included in the EPA's 2017 NEI wildland fire emissions estimates. These grassland fires were processed through SmartFire2 and BlueSky with the other wildland fires.

GeoMAC (Geospatial Multi-Agency Coordination) is an online wildfire mapping application designed for fire managers to access maps of current U.S. fire locations and perimeters. The wildfire perimeter data is based upon input from incident intelligence sources from multiple agencies, GPS data, and infrared (IR) imagery from fixed wing and satellite platforms. Fires in the year-specific GeoMAC shapefile with dates outside of 2017 were removed. Some polygons have geometries which cause errors in SmartFire2 processing. These problematic polygons were simplified using standard GIS methods.

The Incident Status Summary, also known as the "ICS-209" is used for reporting specific information on significant fire incidents. The ICS-209 report is a critical interagency incident reporting tool giving daily 'snapshots' of the wildland fire management situation and individual incident information which include fire behavior, size, location, cost, and other information. Data from two tables in the ICS-209 database were merged and used for the EPA's 2017 NEI wildland fire emissions estimates: the SIT209_HISTORY_INCIDENT_209_REPORTS table contained daily 209 data records for large fires, and the SIT209_HISTORY_INCIDENTS table contained summary data for additional smaller fires. Some entries in the ICS-209 database contained location and date errors. In situations where the errors were obvious in nature, such as swapped latitude and longitudes or a typo in the year of the data, then appropriate corrections were made.

Fires with unclear location and date issues or those fires without an associated burned area were removed. Significant location errors for some large fires were noted and corrected in the 2017 ICS-209 database.

The National Association of State Foresters (NASF) is a non-profit organization composed of the directors of forestry agencies in the states, U.S. territories, and District of Columbia to manage and protect state and private forests, which encompass nearly two-thirds of the nation's forests. The NASF compiles fire incident reports from agencies in the organization and makes them publicly available. The NASF fire information includes dates of fire activity, acres burned, and fire location information. Similar to entries in the ICS-209 database, entries with obvious and resolvable date and location errors were corrected. Fires with unclear location and date issues or those fires without an associated burned area were removed.

The US Forest Service (USFS) compiles a variety of fire information every year. Year 2017 data from the USFS Natural Resource Manager (NRM) Forest Activity Tracking System (FACTS) were acquired and used for 2017 NEI emissions inventory development. This database includes information about activities related to fire/fuels, silviculture, and invasive species. The FACTS database consists of shapefiles for prescribed burns that provide acres burned and start and ending time information. As detailed earlier, all fires labeled as pile burns were removed because the EPA does not currently develop emissions for pile burning.

The US Fish and Wildland Service (USFWS) also compiles wildfire and prescribed burn activity on their federal lands every year. Year 2017 data were acquired from USFWS through direct communication with USFWS staff and were used for 2017 NEI emissions inventory development. The USFWS fire information provided fire type, acres burned, latitude-longitude, and start and ending times. As with the FACTS dataset, fires labeled as pile burns were removed because the EPA does not currently develop emissions for pile burning.

7.3.2   State/Local/Tribal fire information

As in previous NEI years and building off the 2016 modeling platform collaborative efforts, S/L/Ts were asked to submit fire occurrence/activity data for the 2017 NEI. A template form containing the desired format for data submittals was provided to S/L/T air agencies. A map of all states that returned the template form is shown in Figure 7-1. States that did not return the template form are shown in gray and had emissions based only on national default data. In total, 20 states returned the template form for the EPA's 2017 NEI wildland fire emissions estimates processing. The states that returned the forms directly to the EPA are Alaska, Alabama, Arizona, Delaware, Georgia, Florida, Hawaii, Iowa, Kansas, Massachusetts, New Jersey, Nevada, North Carolina, South Carolina, Utah, and Washington. Four other states -Idaho, Montana, Oregon, and Wyoming- had forms returned by the Western Regional Air Partnership (WRAP) as part of the Fire Emissions Tracking System (FETS). In addition to supplying activity data, S/L/Ts that supplied such data were also requested to complete a questionnaire to help EPA determine how complete their activity data submissions were.

Figure 7-1: 2017 NEI Wildland Fire Data Sources including S/L/Ts
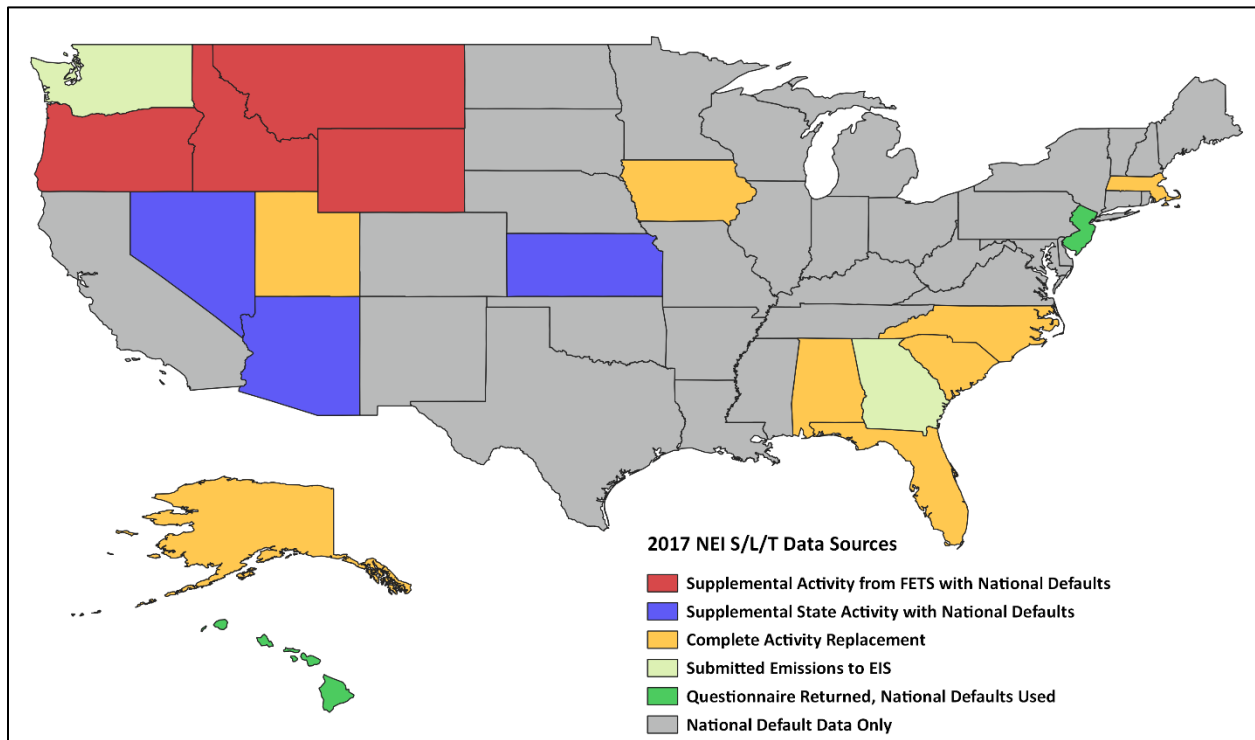
When fire activity or emissions were provided by S/L/Ts the data were evaluated by EPA and further feedback on the data submitted by the state was requested at times. Table 7-5 provides a summary of the type of data submitted by each S/L/T agency and includes spatial, temporal, acres burned, and other information provided by the agencies.

Table 7-5: Brief description of fire activity information submitted for 2017 NEI inventory use.

S/L/T name	Fire Types	Description
Alaska	WF/RX	Latitude-longitude, FCCS fuel beds, and acres burned for wildfire and prescribed burns
Alabama	WF/RX	Start and end dates, latitude-longitude, and acres burned for wildfire and prescribed burns
Arizona	RX	Day-specific, latitude-longitude, and acres burned for prescribed burns
Delaware	RX	Day-specific, latitude-longitude, and fuel loading for prescribed burns. Opted to use national default datasets
Florida	WF/RX	Start and end dates, latitude-longitude, and acres burned for wildfire and prescribed burns
Georgia	WF/RX	Emissions data submitted included all fires types via EIS. The wildfire and prescribed burn data were provided as daily, point emissions sources.
Iowa	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns. Did not contain end dates.
Idaho	RX	Day-specific, latitude-longitude, acres burned, and fuel loading for prescribed burns. Data included pile burn activity, which was removed prior to emissions estimation.
Kansas	RX	Day-specific, county-centroid, and acres burned for Flint Hills prescribed grassland burning

S/L/T name	Fire Types	Description
Massachusetts	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns. Did not contain end dates.
Montana	RX	Day-specific, latitude-longitude, acres burned, and fuel loading for prescribed burns. Data included pile burn activity, which was removed prior to emissions estimation.
New Jersey	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns. Did not contain end dates. Opted to use national default datasets.
North Carolina	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns. Camp Lejeune activity carried forward from 2014 estimates.
Nevada	WF	Day-specific, latitude-longitude, and acres burned for wildfires.
Oregon	RX	Day-specific, latitude-longitude, acres burned, and fuel loading for prescribed burns. Data included pile burn activity, which was removed prior to emissions estimation.
South Carolina	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns
Utah	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns
Washington	WF/RX	Emissions data submitted included all fires types via EIS. The wildfire and prescribed burn data were provided as daily, point emissions sources.
Wyoming	RX	Day-specific, latitude-longitude, acres burned, and fuel loading for prescribed burns. Data included pile burn activity, which was removed prior to emissions estimation.

In order to develop a format that could be ingested into SMARTFire or directly into Bluesky certain preprocessing steps were taken with the S/L/T submitted datasets. The names of columns and formats were changed to match what the processors required. Additionally, all datasets were reviewed for invalid locations or those that were spatially identified as occurring outside the submitting state. Obvious location errors, such as those where the latitude and longitude were swapped or a sign was missing, were fixed. The Alabama and Iowa submittals contained many valid locations that were outside of the respective state by a large distance. Without additional information identifying an activity location within the respective state, these records were dropped. Overall the records dropped accounted for a very small portion of the total activity.

The temporal approach for the S/L/T varied based on the information provided in the submitted data and direction from the individual agencies. Iowa, Kansas, and Massachusetts submitted activity without end dates. Each of these states provided direction to assume that all fires lasted for a single day. Alabama, Florida, North Carolina, South Carolina, and Utah all provided end dates along with start dates, however it was necessary to apportion the activity to each day in the range to develop daily emissions. In the case of Alabama, North Carolina, and South Carolina multi-day fires were assumed to have an equal proportion of the total event activity on each day of the event. Alaska, Florida, and Utah utilized a different approach where an attempt was made to reconcile the daily events in SmartFire2 against the HMS activity. Where a multi-day event could be matched to HMS detections the number of HMS detections on each day within the event were used to apportion the total event activity. When a spatial and temporal match could not be made between the submitted data a flat approach was used for the multi-day event as described for Alabama, North Carolina, and South Carolina.

The following states required additional preprocessing steps:

- **Alaska.** Start and end dates were not included in the submission. Dates were filled from the national default data using the submitted location information and fire name. After some discussion, Alaska approved of the use of EPA WLF estimates for their entire domain.
- **Kansas.** The activity for the Flint Hills region was spatially reapportioned from the county-level to 2011 NLCD grass land area at centroids of 4 km grid cells. Weighting of activity was done using the area of overlap between the grass land grid cells and the respective county.
- **North Carolina**. The 247-day long Pocosin fire was dropped from the submitted data with direction from the state.

7.3.3   Emissions Estimation Methodology

The national and S/L/T data mentioned earlier were used to estimate daily wildfire and prescribed burn emissions from flaming combustion and smoldering combustion phases for the 2017 NEI inventory. Flaming combustion is more complete combustion than smoldering and is more prevalent with fuels that have a high surface-to-volume ratio, a low bulk density, and low moisture content. Smoldering combustion occurs without a flame, is a less complete burn, and produces some pollutants, such as PM2.5, VOCs, and CO, at higher rates than flaming combustion. Smoldering combustion is more prevalent with fuels that have low surface-to-volume ratios, high bulk density, and high moisture content. Models sometimes differentiate between smoldering emissions that are lofted with a smoke plume and those that remain near the ground (residual emissions), but for the purposes of the 2017 NEI inventory the residual smoldering emissions were allocated to the smoldering SCCs ending in "1", while the lofted smoldering emissions were assigned to the flaming emissions SCCs ending in "2".

Figure 7-2 is a schematic of the data processing stream for the 2017 NEI inventory for wildfire and prescribe burn sources. The EPA's 2017 NEI wildland fire emissions estimates were estimated using Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SMARTFIRE2) and BlueSky Framework. SMARTFIRE2 is an algorithm and database system that operate within a geographic information system (GIS). SMARTFIRE2 combines multiple sources of fire information and reconciles them into a unified GIS database. It reconciles fire data from space-borne sensors and ground-based reports, thus drawing on the strengths of both data types while avoiding double-counting of fire events. At its core, SMARTFIRE2 is an association engine that links reports covering the same fire in any number of multiple databases. In this process, all input information is preserved, and no attempt is made to reconcile conflicting or potentially contradictory information (for example, the existence of a fire in one database but not another). Further details of the SMARTFIRE2 process as applied to NEI development can be found in the literature [ref 2].

For the 2017 NEI inventory, the national and S/L/T fire information was input into SMARTFIRE2 and then merged and reconciled together based on user-defined weights for each fire information dataset. The relative weights used for the national data stream are shown in Table 7-6. A dataset type with a higher ranking gets preference for that attribute in the reconciled activity. The output from SMARTFIRE2 was daily acres burned by fire type, and latitude-longitude coordinates for each fire. The fire type assignments were made using the fire information datasets. If the only information for a fire was a satellite detect for fire activity, then Figure 7-3 was used to make fire type assignment by state and by month.

Figure 7-2: Processing flow for fire emission estimates in the 2017 NEI inventory

Input Data Sets
(state/local/tribal and national data sets)

Data Preparation

Data Aggregation and Reconciliation
(SmartFire2)

Daily fire locations
with fire size and type

Fuel Moisture and
Fuel Loading Data

Smoke Modeling (BlueSky Framework)

Daily smoke emissions
for each fire

Emissions Post-Processing

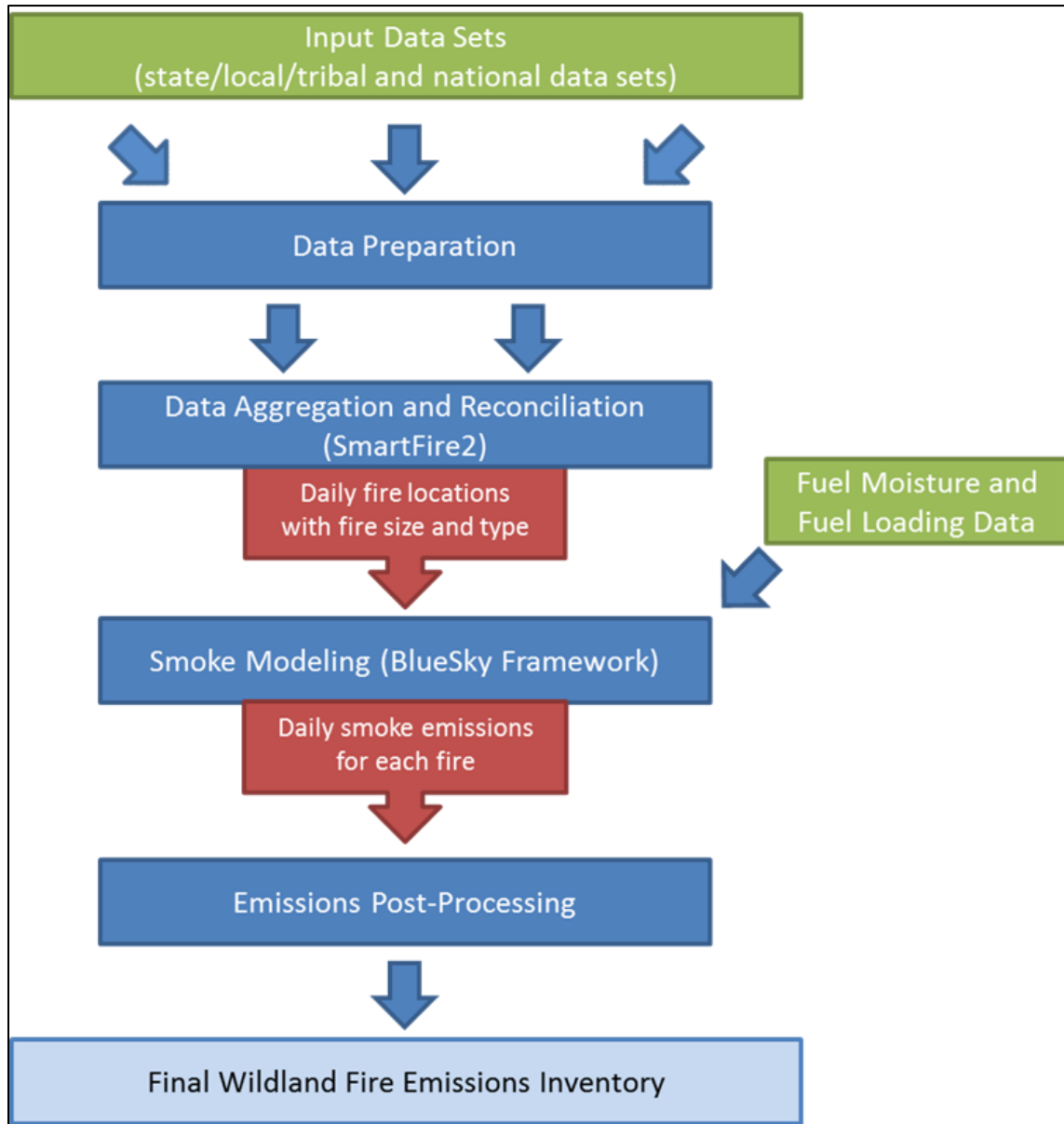Final Wildland Fire Emissions Inventory

Figure 7-3: Default fire type assignment by state and month in cases where a satellite detect is only source of fire information

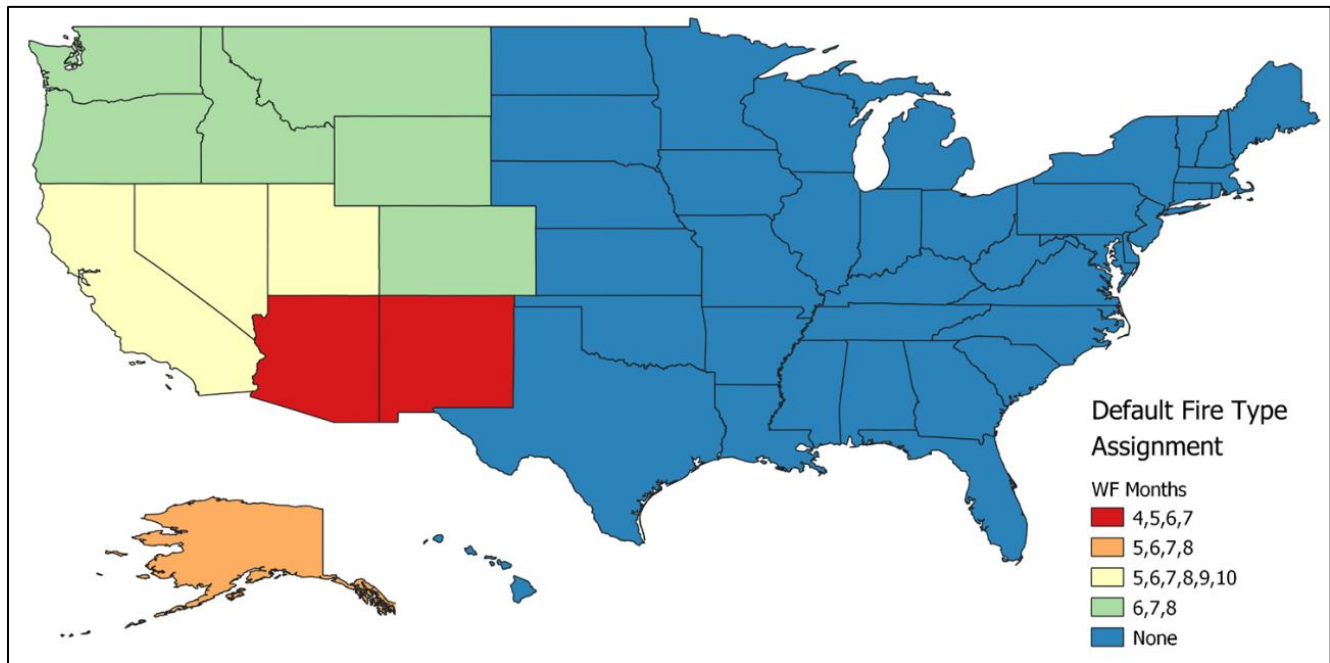**Table 7-6:** 2017 National SmartFire2 Reconciliation Weights

Rank	Location Weight	Size Weight	Shape Weight	Growth Weight	Name Weight	Fire Type Weight
1	SLT Supplemental Data	SLT Supplemental Data	GeoMAC	SLT Supplemental Data	GeoMAC	SLT Supplemental Data
2	GeoMAC	GeoMAC	FACTS	HMS	ICS-209	ICS-209
3	HMS	FACTS	HMS	GeoMAC	NASF	GeoMAC
4	FACTS	ICS-209	SLT Supplemental Data	ICS-209	FETS	NASF
5	ICS-209	FETS	FETS	NASF	USFWS	FETS
6	FETS	NASF	ICS-209	USFWS	FACTS	FACTS
7	NASF	USFWS	NASF	FETS	HMS	USFWS
8	USFWS	HMS	USFWS	FACTS	SLT Supplemental Data	HMS

Supplemental S/L/T activity from Arizona, Idaho, Montana, Nevada, Oregon, and Wyoming were incorporated with the national defaults into the national data reconciliation stream. States that submitted complete activity datasets were not processed through SmartFire2 with the default national activity. An exception is for those states that used HMS fire detections for daily apportionment of activity data. Alaska, Florida, and Utah all had their submitted data reconciled against the HMS fire detections. All resulting activity that was identified only through HMS was removed from the final activity dataset so that only state-submitted event values were used for emissions estimates. State-submitted activity from Iowa, Kansas, Massachusetts, North Carolina, and South

Carolina were not processed through SmartFire2. Instead each activity dataset was converted into daily activity files in a format that can be read directly by the BlueSky Framework.

The BlueSky Modeling Framework version 3.5 (revision #38169) was used to calculate fuel loading and consumption, and emissions using various models depending on the available inputs as well as the desired results. The contiguous United States and Alaska, where Fuel Characteristic Classification System (FCCS) fuel loading data are available, were processed using the modeling chain described in Figure 7-4. The Fire Emissions Production Simulator (FEPS) in the BlueSky Framework generated all the CAP emission factors for wildland fires used in the 2017 NEI inventory [ref 3]. The HAP emission factors used in this work came from Urbanski, 2014 [ref 4]. These emission factors were regionalized and handled differently by wild and prescribed fire. Table 7-7 below outlines the regionalization scheme used while Table 7-8 and Table 7-9 show the HAP EFs employed in this work separately for wild and prescribed fires. Note the differences, in bold in Table 7-7, for wildfires and prescribed burning region assignments for Alaska and Wisconsin.

Table 7-7: Emission factor regions used to assign HAP emission factors for the 2017 NEI

Region	Wildfires	Prescribed burning
Region 1	AZ, CA, IA, IL, IN, KS, MO, NM, NV, OH, OK, TX	AZ, CA, IA, IL, IN, KS, MO, NM, NV, OH, OK, TX
Region 2	**AK**, AL, AR, CT, DC, DE, FL, GA, HI, KY, LA, MA, MD, ME, MI, MN, MS, NC, NH, NJ, NY, PA, PR, RI, SC, TN, VA, VI, VT, **WI**, WV	AL, AR, CT, DC, DE, FL, GA, HI, KY, LA, MA, MD, ME, MI, MN, MS, NC, NH, NJ, NY, PA, PR, RI, SC, TN, VA, VI, VT, WV
Region 3	CO, ID, MT, ND, NE, OR, SD, UT, WA, WY	**AK**, CO, ID, MT, ND, NE, OR, SD, UT, WA, **WI**, WY

Table 7-8: Prescribed fire HAP emission factors (lb/ton fuel consumed) for the 2017 NEI

| HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
1,3-Butadiene (HAP 106990)	0.272326792	0.516619944	0.362434922	0.272326792	0.516619944	0.362434922
Acetaldehyde (HAP 75070)	1.678013616	1.283540248	2.240688827	1.678013616	1.283540248	2.240688827
Acetonitrile (HAP 75058)	0.322386864	0.064076892	0.43051662	0.322386864	0.064076892	0.43051662
Acrolein (HAP 107028)	0.512615138	0.646776131	0.684821786	0.512615138	0.646776131	0.684821786
Acrylic Acid (HAP 79107)	0.070084101	0.058069684	0.094112936	0.070084101	0.058069684	0.094112936
Anthracene (HAP 120127)	0.005	0.005	0.005	0.005	0.005	0.005
Benz(a)anthracene (HAP 56553)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Benzene (HAP 71432)	0.450540649	0.566680016	0.600720865	0.450540649	0.566680016	0.600720865
Benzo(a)fluoranthene (HAP 203338)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Benzo(a)pyrene (HAP 50328)	0.00148	0.00148	0.00148	0.00148	0.00148	0.00148
Benzo(c)phenanthrene (HAP 195197)	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039
Benzo(e)pyrene (HAP 192972)	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266
Benzo(ghi)perylene (HAP 191242)	0.00508	0.00508	0.00508	0.00508	0.00508	0.00508
Benzo(k)fluoranthene (HAP 207089)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026

HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
Benzofluoranthenes (HAP 56832736)	0.00514	0.00514	0.00514	0.00514	0.00514	0.00514
Carbonyl Sulfide (HAP 463581)	0.000534	0.000534	0.000534	0.000534	0.000534	0.000534
Chrysene (HAP 218019)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Fluoranthene (HAP 206440)	0.00673	0.00673	0.00673	0.00673	0.00673	0.00673
Formaldehyde (HAP 50000)	2.515018022	3.366039247	4.475370445	2.515018022	3.366039247	4.475370445
Indeno(1,2,3-cd)pyrene (HAP 193395)	0.00341	0.00341	0.00341	0.00341	0.00341	0.00341
m,p-Xylenes (HAP 1330207)	0.216259511	0.160192231	0.288346015	0.216259511	0.160192231	0.288346015
Methanol (HAP 67561)	2.306768122	1.974369243	5.036043252	2.306768122	1.974369243	5.036043252
Methyl Chloride (HAP 74873)	0.128325	0.128325	0.128325	0.128325	0.128325	0.128325
Methylanthracene (HAP 26914181)	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823
Methylbenzopyrenes (HAP 65357699)	0.00296	0.00296	0.00296	0.00296	0.00296	0.00296
Methylchrysene (HAP 41637905)	0.0079	0.0079	0.0079	0.0079	0.0079	0.0079
Methylpyrene, fluoranthene (HAP 2381217)	0.00905	0.00905	0.00905	0.00905	0.00905	0.00905
n-Hexane (HAP 110543)	0.048057669	0.024028835	0.064076892	0.048057669	0.024028835	0.064076892
Naphthalene (HAP 91203)	0.486583901	0.398478174	0.650780937	0.486583901	0.398478174	0.650780937
o-Xylene (HAP 95476)	0.07609131	0.050060072	0.100120144	0.07609131	0.050060072	0.100120144
Perylene (HAP 198550)	0.000856	0.000856	0.000856	0.000856	0.000856	0.000856
Phenanthrene (HAP 85018)	0.005	0.005	0.005	0.005	0.005	0.005
Pyrene (HAP 129000)	0.00929	0.00929	0.00929	0.00929	0.00929	0.00929
Styrene (HAP 100425)	0.10412495	0.080096115	0.138165799	0.10412495	0.080096115	0.138165799
Toluene (HAP 108883)	0.344413296	0.398478174	0.45855026	0.344413296	0.398478174	0.45855026

Table 7-9: Wildfire HAP emission factors (lbs/ton fuel consumed) for the 2017 NEI

HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
1,3-Butadiene (HAP 106990)	0.272326792	0.140168202	0.362434922	0.272326792	0.140168202	0.362434922
Acetaldehyde (HAP 75070)	1.678013616	1.908289948	2.240688827	1.678013616	1.908289948	2.240688827
Acetonitrile (HAP 75058)	0.322386864	0.600720865	0.43051662	0.322386864	0.600720865	0.43051662
Acrolein (HAP 107028)	0.512615138	0.582699239	0.684821786	0.512615138	0.582699239	0.684821786
Acrylic Acid (HAP 79107)	0.070084101	0.080096115	0.094112936	0.070084101	0.080096115	0.094112936
Anthracene (HAP 120127)	0.005	0.005	0.005	0.005	0.005	0.005
benz(a)anthracene (HAP 56553)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Benzene (HAP 71432)	0.450540649	1.101321586	0.600720865	0.450540649	1.101321586	0.600720865
Benzo(a)fluoranthene (HAP 203338)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Benzo(a)pyrene (HAP 50328)	0.00148	0.00148	0.00148	0.00148	0.00148	0.00148

HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
Benzo(c)phenanthrene (HAP 195197)	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039
Benzo(e)pyrene (HAP 192972)	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266
Benzo(ghi)perylene (HAP 191242)	0.00508	0.00508	0.00508	0.00508	0.00508	0.00508
Benzo(k)fluoranthene (HAP 207089)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Benzofluoranthenes (HAP 56832736)	0.00514	0.00514	0.00514	0.00514	0.00514	0.00514
Carbonyl Sulfide (HAP 463581)	0.000534	0.000534	0.000534	0.000534	0.000534	0.000534
Chrysene (HAP 218019)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Fluoranthene (HAP 206440)	0.00673	0.00673	0.00673	0.00673	0.00673	0.00673
Formaldehyde (HAP 50000)	2.515018022	3.954745695	4.475370445	2.515018022	3.954745695	4.475370445
Indeno(1,2,3-cd)pyrene (HAP 193395)	0.00341	0.00341	0.00341	0.00341	0.00341	0.00341
m,p-Xylenes (HAP 1330207)	0.216259511	0.120144173	0.288346015	0.216259511	0.120144173	0.288346015
Methanol (HAP 67561)	2.306768122	2.613135763	5.036043252	2.306768122	2.613135763	5.036043252
Methyl Chloride (HAP 74873)	0.128325	0.128325	0.128325	0.128325	0.128325	0.128325
Methylanthracene (HAP 26914181)	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823
Methylbenzopyrenes (HAP 65357699)	0.00296	0.00296	0.00296	0.00296	0.00296	0.00296
Methylchrysene (HAP 41637905)	0.0079	0.0079	0.0079	0.0079	0.0079	0.0079
Methylpyrene,-fluoranthene (HAP 2381217)	0.00905	0.00905	0.00905	0.00905	0.00905	0.00905
n-Hexane (HAP 110543)	0.048057669	0.054064878	0.064076892	0.048057669	0.054064878	0.064076892
Naphthalene (HAP 91203)	0.486583901	0.554665599	0.650780937	0.486583901	0.554665599	0.650780937
o-Xylene (HAP 95476)	0.07609131	0.054064878	0.100120144	0.07609131	0.054064878	0.100120144
Perylene (HAP 198550)	0.000856	0.000856	0.000856	0.000856	0.000856	0.000856
Phenanthrene (HAP 85018)	0.005	0.005	0.005	0.005	0.005	0.005
Pyrene (HAP 129000)	0.00929	0.00929	0.00929	0.00929	0.00929	0.00929
Styrene (HAP 100425)	0.10412495	0.11814177	0.138165799	0.10412495	0.11814177	0.138165799
Toluene (HAP 108883)	0.344413296	0.480576692	0.45855026	0.344413296	0.480576692	0.45855026

Figure 7-4: BlueSky Modeling Framework
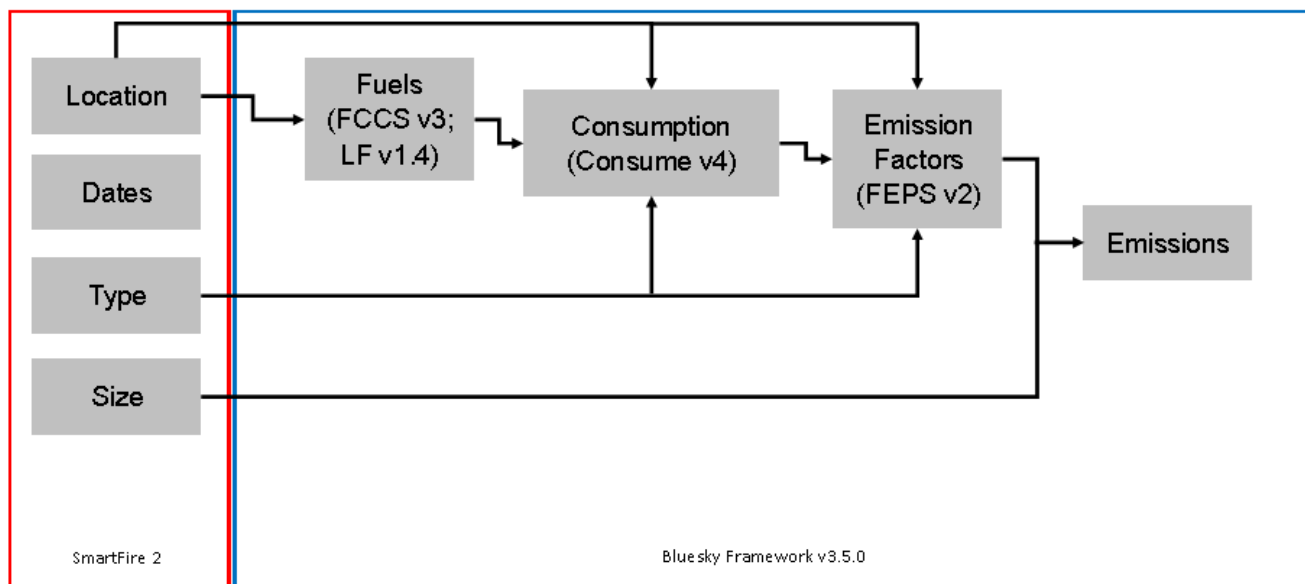
For the 2017 NEI inventory, the FCCSv2 spatial vegetation cover was upgraded to the LANDFIRE v1.4 fuel vegetation cover. The FCCSv3 fuel bed characteristics were implemented along with LANDFIREv1.4 to provide better fuel classification for the BlueSky Framework. The LANDFIREv1.4 raster data were aggregated from the native resolution and projection to 200-meter resolution using a nearest-neighbor methodology. Aggregation and reprojection was required to allow these data to work in the BlueSky Framework.

Outputs from each BlueSky Framework processing stream were aggregated into an annual file. Fires identified as being over water by FCCS were removed because they produce no fuel consumption in the CONSUME model and thus no emissions. Emissions for some prescribed burns were proportionally adjusted to account for an overestimate of duff consumption in CONSUME. Those states in the eastern United States had duff consumption capped at 5 tons per acre, while those in the west had duff consumption capped at 20 tons per acre.

7.4 Quality Assurance (QA) of Final Results

Different types of QA were generally applied with the different parts of the process described above. The summary below briefly describes the QA checks used in these processes.

7.4.1 Input Fire Information Data Sets

- Reviewed input data sets to identify data gaps.
- Identified fire incidents that appeared to be double-counted in individual data sets and removed duplicate records.
- Examined fires with long durations or conflicts between date fields such as start date and report date to identify fires that may have erroneous dates and made necessary corrections.
- Reviewed fire locations to ensure that they fell within the United States. Obvious errors in data entry such as the reversal of latitude and longitude were corrected where possible.
- Reviewed large and small fires in each data set for validity.
- Modified distant fires (in different states) with the same names to ensure that the events were not associated.

7.4.2   Daily Fire Locations from SmartFire2

Quality assurance actions applied to daily fire locations from SmartFire2 included:

- Checked the location, fire type, duration, underlying fire activity input data, final shape, and final size for large fire events (i.e., area burned >20,000 acres) to ensure that the results were reasonable.
- Checked large fire events by state and by name, removed duplicate events, and renamed fires as needed.
- Reviewed large fire events with multiple data sources to ensure that SmartFire2 reconciliation rankings were correct and produced sensible results.
- Identified and removed fire event duplicates incorrectly created by the SmartFire2 reconciliation process.
- Checked fire events with large differences between the calculated fire area and the geometric fire area. Since the shape and area are calculated separately in SmartFire2, a large discrepancy can indicate errors in reconciliation. For the 2014 NWLFEI, no errors of this sort were identified.

7.4.3   Emissions Estimates

Quality assurance actions applied to resulting emissions estimates included:

- Checked the location of all final fires and emission estimates. Fires falling outside of the United States were removed. Some fires near the border were retained if fuel information was available in that location.
- Identified fire records that were incorrectly associated and adjusted fire event size and emissions proportionally.
- Produced and reviewed summary tables and plots of the 2017 fire inventory data.
- Compared acres burned by state to National Interagency Fire Center (NIFC) data to ensure the summary values were within reasonable range, knowing that NIFC acres burned tend to be underestimated.

7.4.4   Additional quality assurance on final results, and some post-final corrections

WLF emissions developed using the methods described above were compared to EPA's 2016 estimates, and all the way back to 2005, since the models used are similar. The spatial (and temporal) patterns seen in the data correspond to what was expected in 2017. In general, 2017 was a "worse" fire year than many previous years (including 2016 and 2014) as more acres were burned, so the emissions are expected to be higher in 2017 compared to 2014 and 2016. The trends graphic shown in the next section below (see Figure 7-5 and Figure 7-6) indicates how the 2017 PM2.5 estimates compare to other years (using similar methods). These trends represent only the lower 48 states.

After completing the 2017 WLF in February 2020 and posting summary files on the 2017 NEI Data Website on February 27, 2020, EPA was alerted by the state of MN to a potential error in the way our 2017 methods estimate HAP emissions in areas of the country where there is a prevalence of prescribed fires burning duff-based fuels. In such cases, our methods caused HAPs to be incorrectly estimated due to the fact that the HAP emissions process was done outside of the BSF process; this caused HAP and CAP trends to differ in direction for these types of fuels.

Further review of 2017 Event emissions identified a discrepancy between CAPs and HAPs for approximately 0.5% of fires nationally. Three states were primarily affected: FL, LA, and MN. The issue stemmed from how the post-BSF RX duff adjustments were done. HAPs are calculated off of consumption post-BSF, while the CAPs are

calculated in the BSF pathway. The CONSUME module in the BSF over-estimates the duff consumed for prescribed fires over fuel beds with high duff fuel loading in regions such as Minnesota. Prescribed fire emissions are adjusted based on region to limit the duff consumption produced by CONSUME to a more reasonable value. The processing stream properly adjusts these high duff loading fires for CAP pollutants, however for the NEI process, the HAP pollutants are calculated separately. As a result, the HAP pollutants were not adjusted in the same way as the CAP pollutants resulting in overall higher than expected HAP values.

To adjust the emissions appropriately, EPA took the duff adjustment emissions logic that sets a region-based cap on duff consumption and applied it to the consumption values, then recalculated the HAPs for the fires where there is a reduction in consumption due to a reduction in duff consumption. We verified the CAP numbers calculated with this adjusted consumption against what was previously generated and calculated the new HAP numbers. As noted earlier, three states had notable HAP reductions: FL, LA, and MN. Other states had much smaller reductions.

These revisions were processed through the Emissions Inventory System (EIS) and summary files were posted on the [2017 NEI Data website](#) on April 8, 2020.

Another area that has been identified as a potential disconnect is between the NEI and SPECIATE, and also involves the HAPs that are in the inventory for 2017 NEI for WLFs. The HAP emission estimates in the 2017 NEI come directly from the way processing was done in the BSF for HAPs by combustion phase. The WLF VOC profiles that are in SPECIATE5.0 [ref 5] come from the work of Urbanski [ref 4]. In the case of SPECIATE5.0, these profiles were created directly from the data in the Urbanski paper. The factors were regionalized based on the fuels tested based on the EFs for the 187 species tested and computed weight percent of each that can be multiplied by VOC to get HAP emission estimates.

Urbanski emissions factors are provided as regionalized mass factors by fire type regardless of combustion phase. The NEI HAPs are calculated by applying the Urbanski emissions factors directly to the total biomass consumed by fire as calculated in CONSUME. NEI CAPs are calculated in FEPS v2 using combustion phase-specific emissions factors. In FEPS the mass factor for VOC is approximately 3 times higher for the smoldering and residual phases than for the flaming phase. The differences in how the HAP and CAP factors are provided and applied result in different rates of change in the individual NEI pollutants within the emissions classes as total consumption changes. These rates differ depending on the relative proportion of each combustion phase in each individual fire. Speciation profiles from SPECIATE are applied to inventory VOC, which is calculated from the total of the flaming and smoldering phase VOC emissions or the total residual phase VOC depending on SCC. The HAP values calculated with the speciation profiles therefore implicitly contain the differences in factors by phase for the CAP values, whereas the NEI HAP values reflect the application of factors without consideration of phase

EPA feels that the NEI HAP values are more reasonable as they better reflect what was presented in Urbanski, which contains EFs for a complete fire regardless of phase type (a weighted average). We suggest using the NEI HAPs to represent WLFs in all assessments with 2017 moving forward.

7.5 Emissions Summaries

This section shows several graphics and tables that describe emissions of wild and prescribed fires in the 2017 NEI based on the methods discussed above.

In Figure 7-5 and Figure 7-6, the trend in PM2.5 emissions and acres burned is shown from 2006 to 2017. Over this 12-year time frame similar SF2/BS frameworks were used to estimate these emissions. However, it should

be noted that the estimates are much more robust for NEI years (2008, 2011, 2014 and 2017) since S/L/T involvement and data acquisition from S/L/Ts is much higher. In addition, year 2016 was generated with limited national fire information databases. It can be noted from both these graphics that the year to year variability is more controlled by wildfire activity. In recent years, however, the amount of prescribed fire activity has been on the rise as seen in Figure 7-5 and Figure 7-6. At this point, it is unclear whether this is due to true increases in prescribed fire activity across the US, or whether its increasing due to better and more complete reporting.

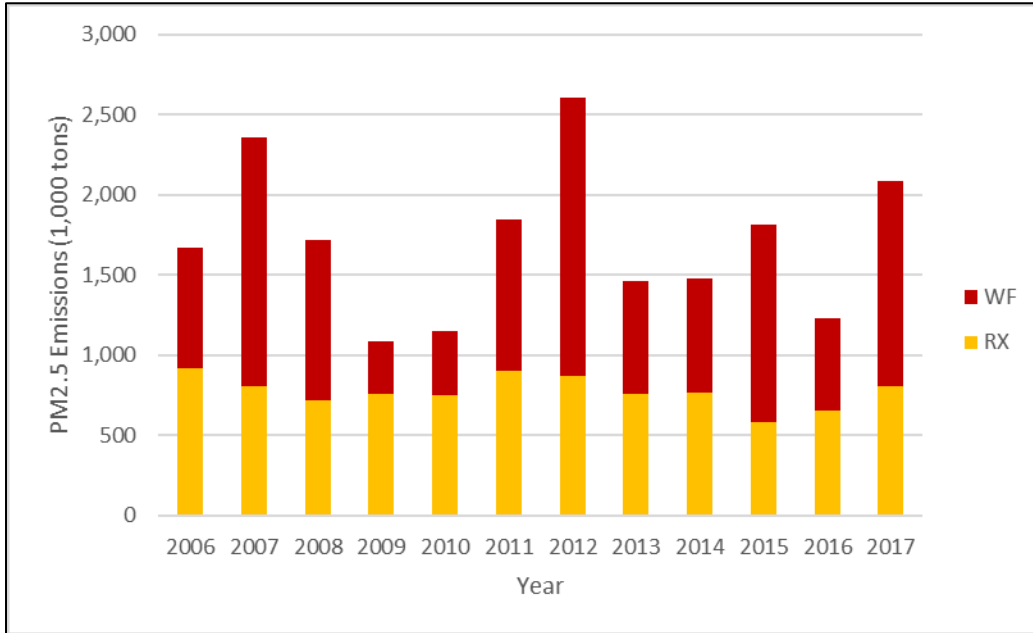**Figure 7-5:** Annual comparison of PM$_{2.5}$ emissions for lower 48 states

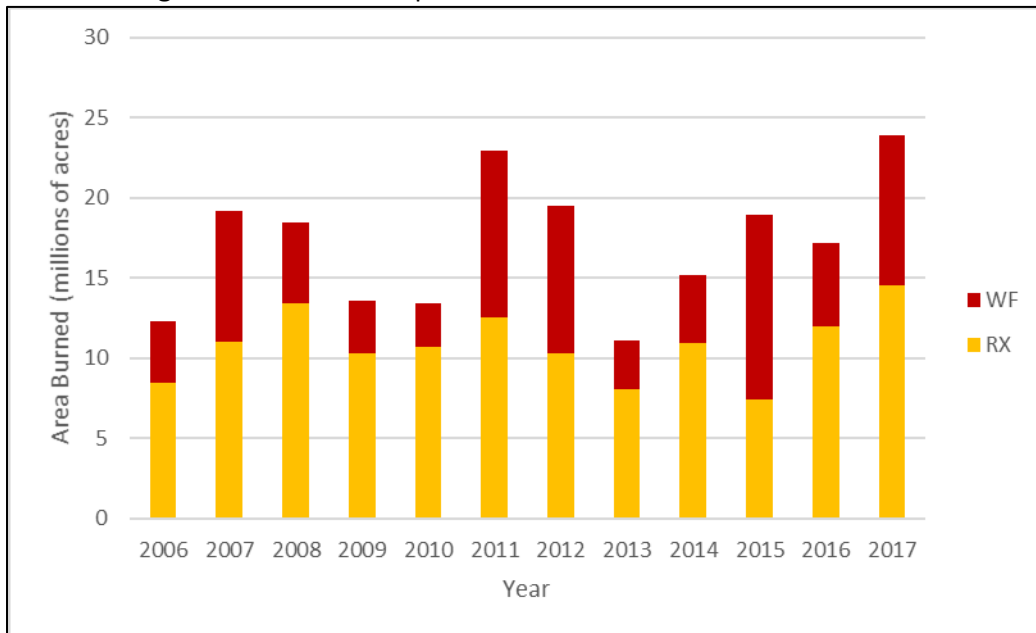**Figure 7-6:** Annual comparison of area burned for lower 48 states

Table 7-10 shows acres burned, PM2.5, NOx and VOC emissions by the states of AK, HI, and all the lower 48 states combined. Alaska has a significant amount of the total acres burned in the US in 2017, and (as evident

from Figure 7-5 and Figure 7-6) 2017 was a generally bad fire year compared to the other 11 years shown in the trend lines above.

Table 7-10: CONUS (lower 48 states) and Alaska and Hawaii fire type information for 2017 NEI WLFs

Fire Type	Millions of Acres	PM2.5 (Tons)	NOx (Tons)	VOC (Tons)
CONUS Wildfires	8.67	1,283,871	192,966	3,518,534
CONUS Prescribed	14.54	803,347	164,209	2,037,071
Alaska All	0.67	372,386	37,882	1,061,964
Hawaii All	0.01	936	190	2,478
Total	23.90	2,460,540	395,247	6,620,048

Figure 7-7 and Figure 7-8 show acres burned and PM2.5 emissions for all fires by month in 2017. The total emissions that result from month-to-month result from a combination of different fuels that burn in different fires. It is seen that wild fires are more prevalent in the hotter months, and prescribed fires occur more often in the colder months of 2017.

Figure 7-7: Monthly acres burned by fire type for 2017 NEI CONUS Wildland Fires
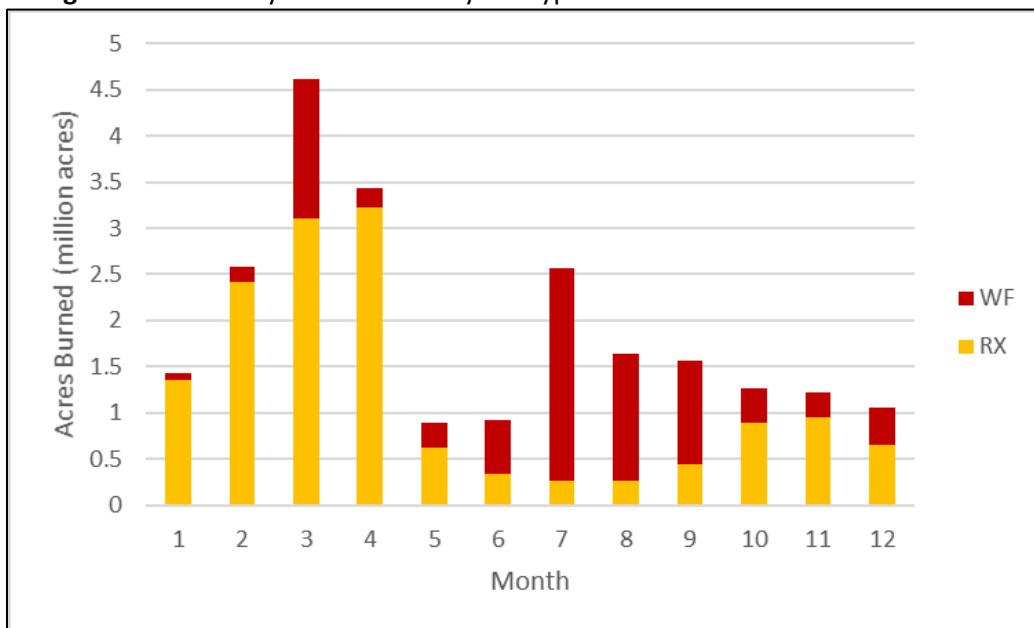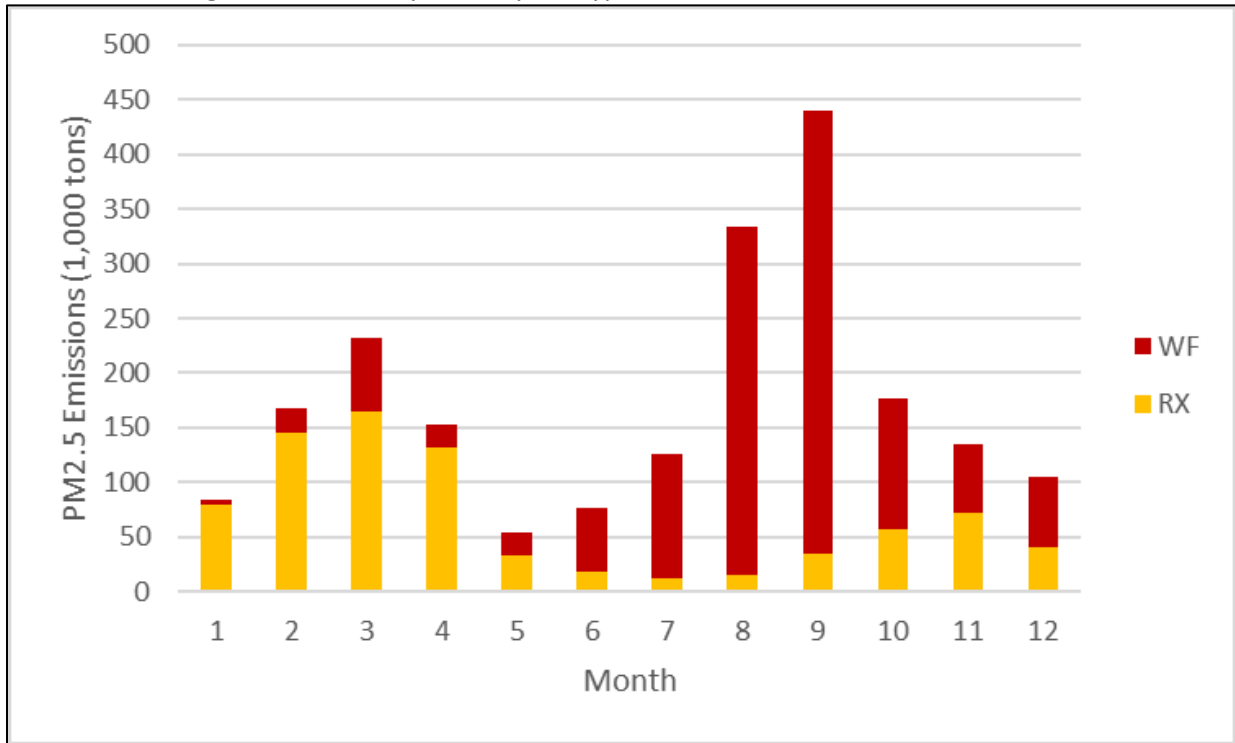
Figure 7-8: Monthly PM₂.₅ by fire type for 2017 NEI CONUS Wildland Fires

Next, Table 7-11 shows a summary of acres burned and PM2.5 by state, fire type and combustion phase. In terms of total WLF acres burned, several states are shown to have more than one million acres burned in 2017, with KS and TX being the highest acres burned states. However, due to the nature of fuels burned and the type of fire that occurs in the various States, CA and AK are highest for estimated PM2.5 emissions**.**

Table 7-11: Summary of acres burned and PM$_{2.5}$ emissions by state, fire type, and combustion phase

State	Area (Acres)			PM2.5 Emissions (tons)					
				Prescribed			Wildfire		
	Prescribed	Wildfire	Total	Flaming	Smoldering	Total	Flaming	Smoldering	Total
Alabama	784,520	19,865	804,385	31,835	5,221	37,055	2,075	297	2,372
Alaska	26,915	647,524	674,439	1,343	47	1,390	229,027	141,969	370,996
Arizona	207,248	430,594	637,841	7,033	5,903	12,937	23,566	8,656	32,222
Arkansas	602,658	33,908	636,566	45,972	9,959	55,931	7,352	1,311	8,662
California	156,371	1,377,051	1,533,422	8,687	4,594	13,280	224,304	108,122	332,426
Colorado	92,125	174,825	266,951	4,343	2,134	6,477	9,711	4,096	13,807
Connecticut	710	264	974	64	10	74	64	12	76
Delaware	1,920	22	1,942	85	25	110	3	0	4
Florida	1,431,895	200,509	1,632,404	50,024	8,413	58,436	12,537	1,521	14,058
Georgia	1,075,287	53,551	1,128,838	38,131	4,782	42,913	5,765	2,683	8,449
Hawaii	5,000	5,865	10,865	357	213	571	347	18	366
Idaho	111,534	695,123	806,657	7,753	3,491	11,244	93,352	40,224	133,576
Illinois	147,286	1,980	149,266	13,616	3,924	17,539	559	178	737
Indiana	47,916	1,251	49,167	3,258	1,158	4,416	207	46	253
Iowa	17,856	9,532	27,387	1,177	352	1,530	1,200	268	1,468
Kansas	2,784,939	421,000	3,205,939	89,153	4,159	93,312	17,529	884	18,413
Kentucky	118,110	23,779	141,889	8,762	1,918	10,680	6,870	1,291	8,160
Louisiana	643,794	16,875	660,670	44,070	10,274	54,344	1,920	272	2,192
Maine	2,349	1,003	3,352	222	70	291	271	115	386
Maryland	11,953	1,961	13,914	564	181	745	186	60	246
Massachusetts	80	368	449	7	2	9	83	45	128
Michigan	34,644	4,827	39,471	1,970	722	2,692	1,203	395	1,598
Minnesota	157,607	9,578	167,185	8,968	5,640	14,608	1,518	1,312	2,831
Mississippi	513,094	20,878	533,972	19,508	3,225	22,732	826	97	922
Missouri	801,412	17,989	819,402	77,657	13,261	90,918	4,624	899	5,523
Montana	133,191	1,056,885	1,190,076	7,942	4,769	12,712	133,093	58,425	191,518
Nebraska	163,474	875	164,348	7,395	1,667	9,062	91	24	115
Nevada	12,836	1,151,120	1,163,955	233	80	314	17,563	1,375	18,938
New Hampshire	2,282	140	2,422	221	71	292	41	14	56

State	Area (Acres)			PM2.5 Emissions (tons)					
	Prescribed	Wildfire	Total	Prescribed			Wildfire		
				Flaming	Smoldering	Total	Flaming	Smoldering	Total
New Jersey	19,893	6,159	26,052	1,175	313	1,487	487	115	603
New Mexico	91,479	172,643	264,122	2,070	1,043	3,113	10,950	5,775	16,725
New York	7,491	1,525	9,016	574	142	716	322	77	399
North Carolina	182,685	37,267	219,953	7,006	1,708	8,715	3,551	542	4,094
North Dakota	157,283	13,461	170,744	5,435	2,808	8,243	516	111	627
Ohio	20,800	1,481	22,280	1,539	603	2,142	304	50	354
Oklahoma	1,079,262	501,268	1,580,530	44,799	6,142	50,942	36,015	3,831	39,846
Oregon	203,293	615,390	818,683	16,835	9,465	26,300	151,873	61,866	213,739
Pennsylvania	25,551	1,567	27,118	2,295	613	2,908	322	60	381
Rhode Island	303	31	334	26	3	29	6	1	7
South Carolina	417,008	13,808	430,816	16,299	4,258	20,556	1,290	162	1,451
South Dakota	82,349	77,052	159,401	4,059	1,136	5,196	12,861	3,782	16,643
Tennessee	183,020	1,500	184,520	12,901	2,214	15,114	322	44	365
Texas	1,562,103	711,212	2,273,315	47,970	7,185	55,154	19,796	6,690	26,486
Utah	11,193	240,773	251,966	526	227	753	18,477	9,469	27,946
Vermont	1,473	46	1,519	89	32	120	10	2	12
Virginia	140,941	8,006	148,947	7,719	1,776	9,495	1,960	314	2,274
Washington	128,978	425,330	554,308	2,420		2,420	83,296	41,508	124,804
West Virginia	44,206	6,187	50,393	4,246	1,218	5,465	1,813	348	2,161
Wisconsin	67,153	738	67,891	3,890	1,013	4,903	145	51	196
Wyoming	60,190	104,883	165,072	3,619	1,301	4,920	4,373	1,252	5,625
Grand Total	**14,575,658**	**9,319,469**	**23,895,127**	**665,841**	**139,466**	**805,307**	**1,144,579**	**510,655**	**1,655,233**

Figure 7-9 and Figure 7-10 show 2017 total area (acres) burned and PM2.5 emissions by state, respectively. It summarizes the data in Table 7-11 in map format. The Southeast states are seen to be dominated by prescribed fires and the western states by wildfires. This is a typical pattern we see from NEI-to-NEI. In addition, for acres burned, KS is seen to dominate and for PM2.5 emissions, CA (in the lower 48) is seen to be dominant.
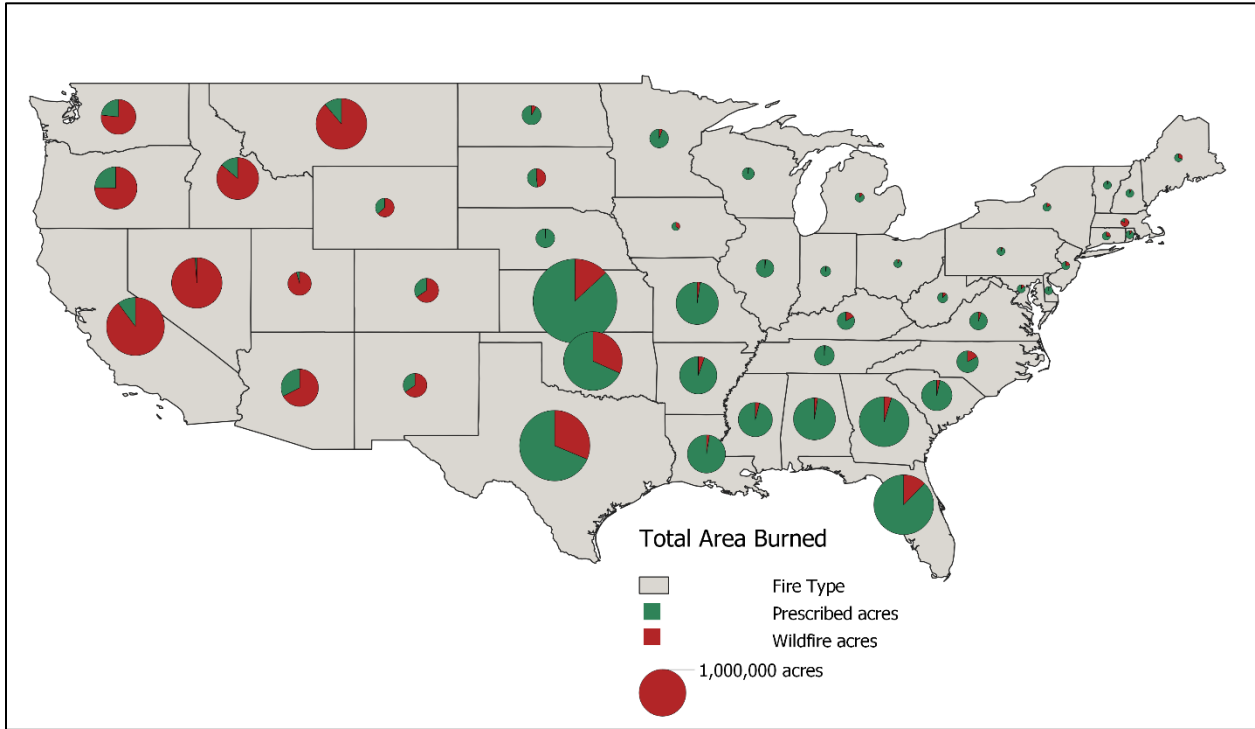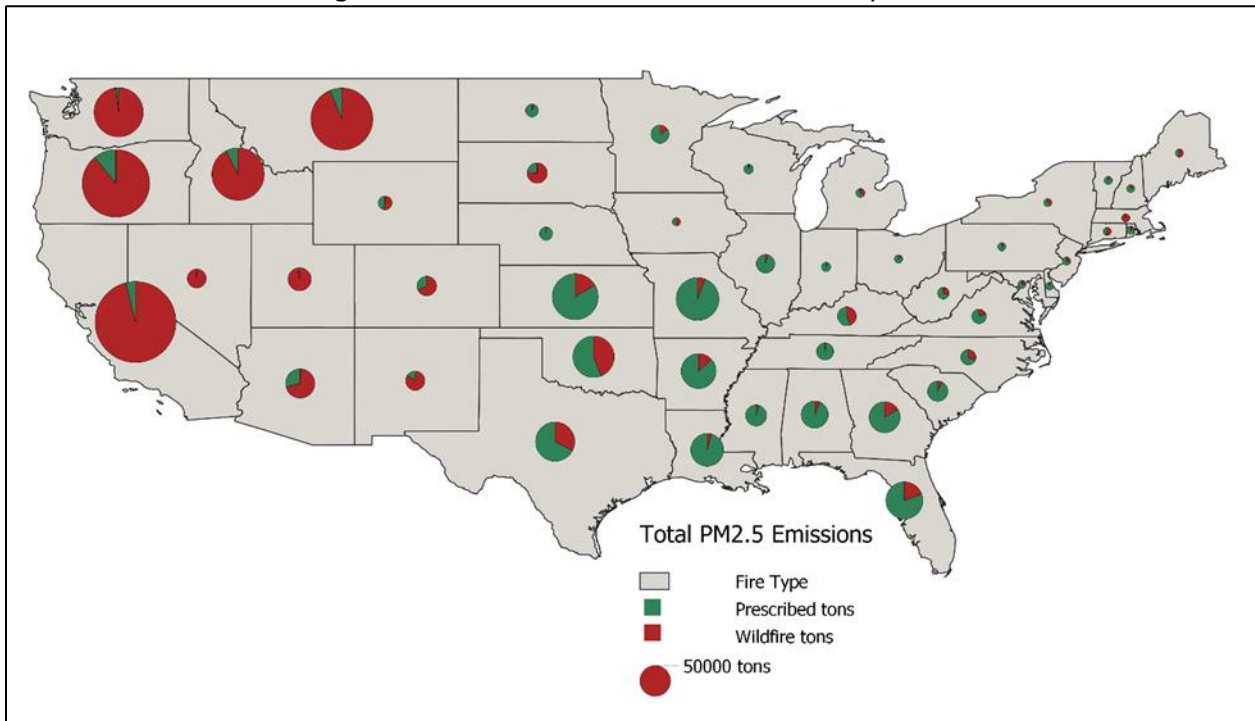
Figure 7-9: Total 2017 NEI area burned by state

Figure 7-10: Total 2017 NEI PM2.5 emissions by state

PM2.5 emissions per square mile are shown in Figure 7-11and acres burned per square mile are shown in Figure 7-12. The patterns seen correspond to the other graphics and tables shown in this section and are fairly typical of a given NEI for WLFs.

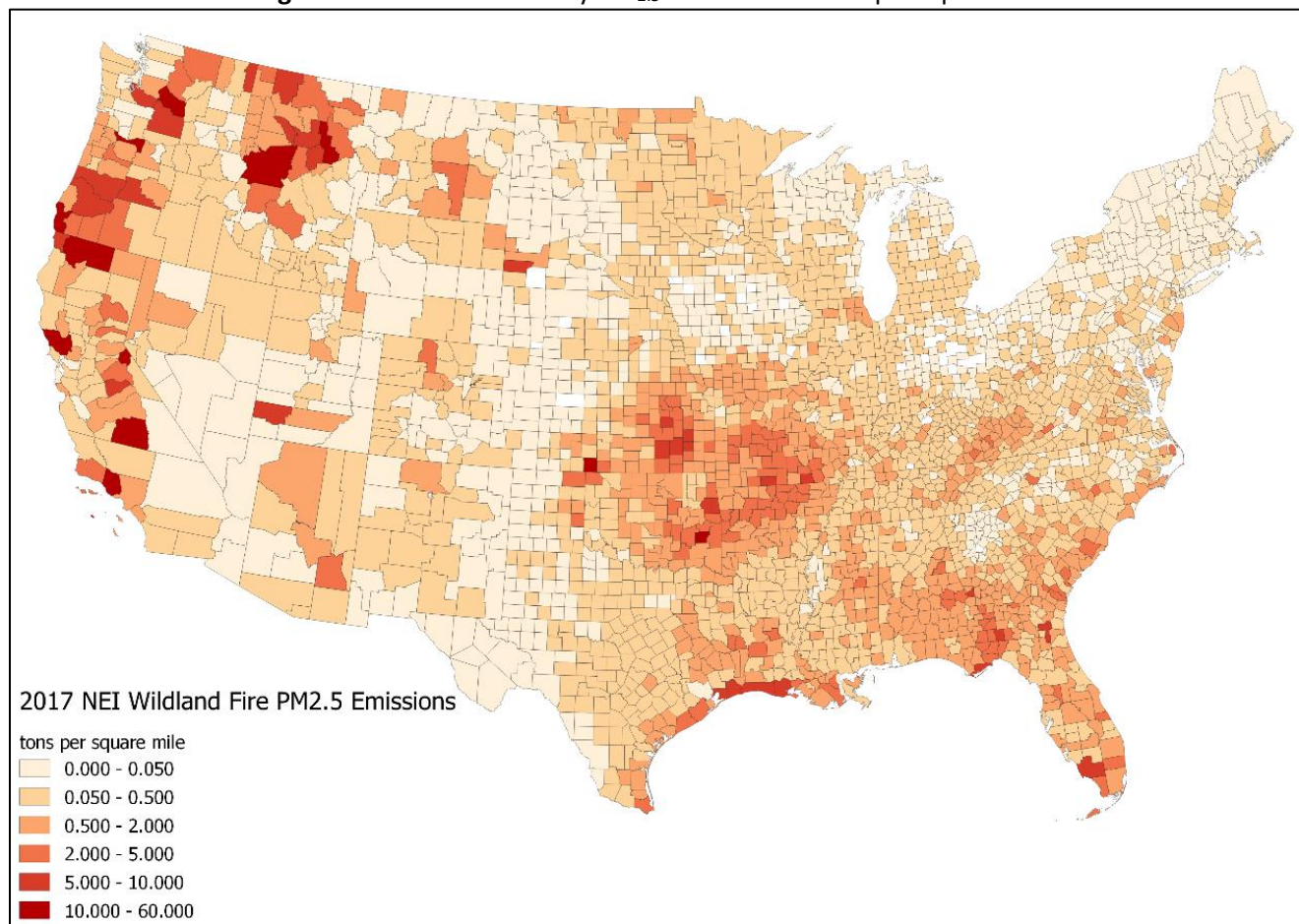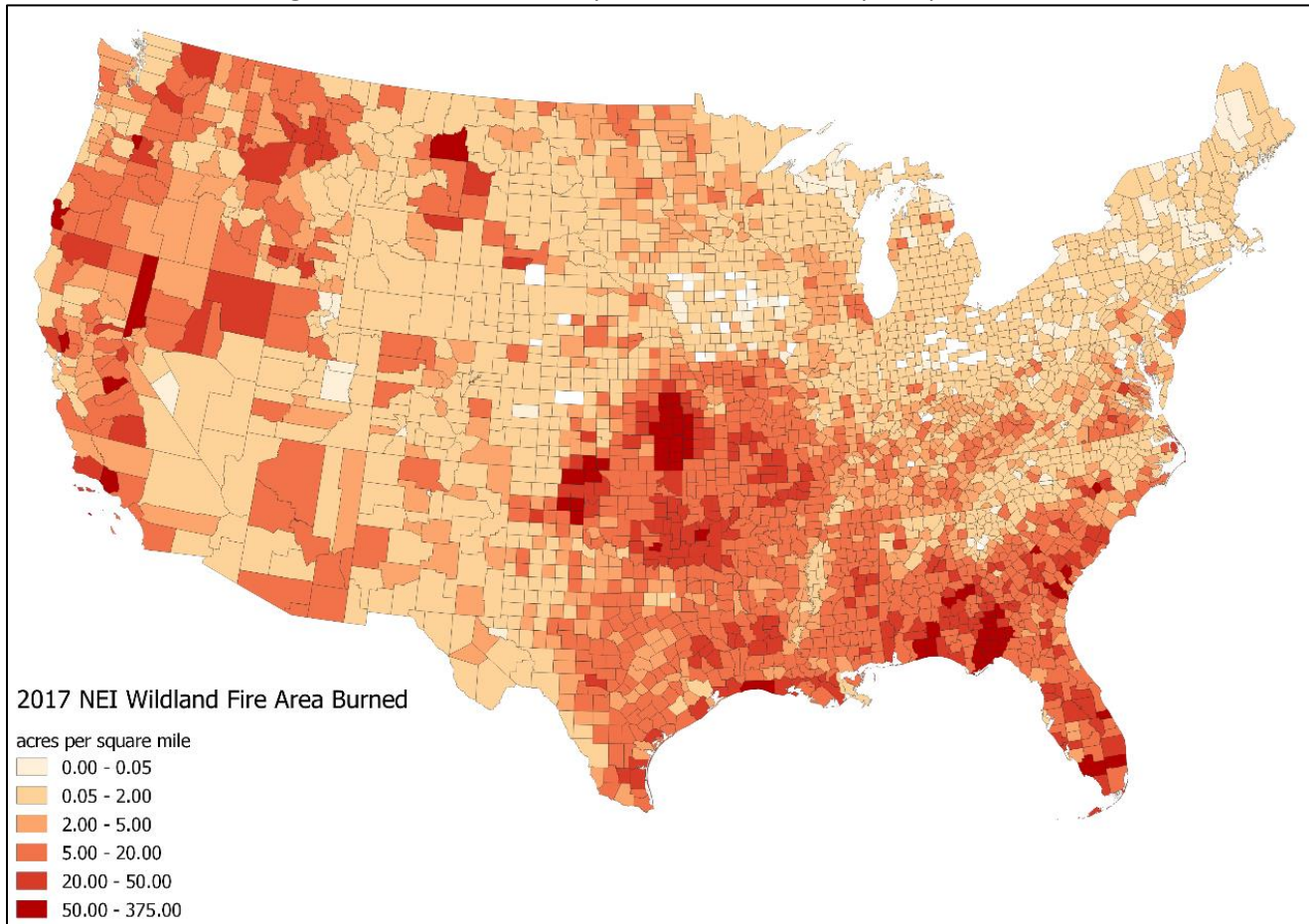**Figure 7-11:** 2017NEI county PM$_{2.5}$ emissions in tons per square mile

2017 NEI Wildland Fire PM2.5 Emissions

tons per square mile
- 0.000 - 0.050
- 0.050 - 0.500
- 0.500 - 2.000
- 2.000 - 5.000
- 5.000 - 10.000
- 10.000 - 60.000

Figure 7-12: 2017NEI county area burned in acres per square mile

2017 NEI Wildland Fire Area Burned

acres per square mile
- 0.00 - 0.05
- 0.05 - 2.00
- 2.00 - 5.00
- 5.00 - 20.00
- 20.00 - 50.00
- 50.00 - 375.00

7.6 References

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2. Larkin, N.K., S. M. Raffuse, S. Huang, N. Pavlovic, and V. Rao, *The Comprehensive Fire Information Reconciled Emissions (CFIRE) Inventory: Wildland Fire Emissions Developed for the 2011 and 2014 U.S. National Emissions Inventory*, submitted to JAWMA, Dec 2019.

3. Larkin, N.K., S.M. O'Neill, R. Solomon, C. Krull, S. Raffuse, M. Rorig, J. Peterson, and S.A. Ferguson. 2009. The BlueSky smoke modeling framework. *International Journal of Wildland Fire*, 18, 906-920

4. Urbanski S.P. (2014) Wildland fire emissions, carbon, and climate: emissions factors. Forest Ecology and Management, 317, 51-60.

5. EPA's SPECIATE 5.0, June 2020.