March 11, 2019

# SPECIFICATION SHEET: RAIL 2016beta Platform

Description: Nonpoint and Point locomotive (rail) emissions, for simulating 2016 U.S. air quality


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## 1. EXECUTIVE SUMMARY

Emissions from rail constitute an emerging issue in air quality as other sectors reduce their impact and many rail operations are active in some urban areas. Additionally, commuter rail operations are most active in urban areas. The 2016 inventory includes for the first time in a national emissions inventory commuter and passenger (Amtrak) rail. 2016 also saw the use of Google Earth imagery to identify yard activity and switcher counts. There are 5 distinct components of the 2016 Rail Inventory, although “Class I Line-Haul” comprises 86% of emissions. Base year inventories were processed with the Sparse Matrix Operating Kernel Emissions (SMOKE) modeling system version 4.6. SMOKE creates emissions in a format that can be input into air quality models. National and state-level emission summaries for key pollutants are provided.

## 2. INTRODUCTION

This document details the approach and data sources to be used for developing 2016 emissions for the nonpoint locomotive (rail) sector. The beta platform uses a new rail inventory developed by LADCO and the State of Illinois with support from various other states.

The rail sector includes all locomotives in the NEI nonpoint data category. Table 1 describes national fuel use and emissions totals for the 2016beta inventory. The 2016beta inventory source classification codes (SCCs) are shown in Table 2. This sector excludes railway maintenance locomotives. Railway maintenance emissions are included in the nonroad sector. The point source yard locomotives are included in the ptnonipm sector. In 2014NEIv2, rail yard locomotive emissions were present in both the nonpoint (rail sector) and point (ptnonipm sector) inventories. For the 2016 beta platform, rail yard locomotive emissions are only in the point inventory / ptnonipm sector. Therefore, SCC 2285002010 is not present in the beta platform rail sector.

**Table 1. Summary of ERTAC Rail Inventories: US Locomotive Emissions and Fuel Use for 2016***

| Rail Sector | Fuel Use (gal/year) | Emissions (tons/year) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | $NO_x$ | $PM_{2.5}$ | HC | $SO_2$ | CO | $NH_3$ | VOC |
| Class I Line-Haul | 3,203,595,133 | 489,562 | 14,102 | 21,727 | 332 | 94,020 | 294 | 22,879 |
| Class I Yard Switching | 205,024,565 | 40,255 | 1,023 | 2,504 | 21.2 | 6,286 | 18.8 | 2,636 |
| Class II and III Railroads | 144,858,501 | 34,503 | 977 | 1,511 | 15.0 | 4,251 | 13.3 | 1,511 |
| Commuter Railroads | 96,395,816 | 21,427 | 626 | 967 | 10.0 | 2,829 | 8.9 | 967 |
| Amtrak | 60,545,490 | 12,226 | 419 | 648 | 6.3 | 1,777 | 5.6 | 648 |

*2016 fuel use data used for Class I railroads and Amtrak; 2012 estimated and 2017 reported fuel use data used for Class II/III railroads; 2016 estimated and 2016/2017 reported fuel use data used for the Commuter railroads.

**Table 2. 2014NEIv2 SCCs for the rail sector**

| SCC | Sector | Description: Mobile Sources prefix for all |
|---|---|---|
| 2285002006 | rail | Railroad Equipment; Diesel; Line Haul Locomotives: Class I Operations |
| 2285002007 | rail | Railroad Equipment; Diesel; Line Haul Locomotives: Class II / III Operations |
| 2285002008 | rail | Railroad Equipment; Diesel; Line Haul Locomotives: Passenger Trains (Amtrak) |
| 2285002009 | rail | Railroad Equipment; Diesel; Line Haul Locomotives: Commuter Lines |
| 2285002010 | rail | Railroad Equipment; Diesel; Yard Locomotives |

# 3. INVENTORY DEVELOPMENT METHODS

### Class I Line-haul Methodology

In 2008 air quality planners in the eastern US formed the Eastern Technical Advisory Committee (ERTAC) for solving persistent emissions inventory issues. This work is the fourth inventory created by the ERTAC rail group. For the 2016 inventory, the Class I railroads granted ERTAC Rail permission to use the confidential link-level line-haul activity GIS data layer maintained by the Federal Railroad Administration (FRA). In addition, the Association of American Railroads (AAR) provided national emission tier fleet mix information. This allowed ERTAC Rail to calculate weighted emission factors for each pollutant based on the percentage of the Class I line-haul locomotives in each USEPA Tier level category. These two datasets, along with 2016 Class I line-haul fuel use data reported to the Surface Transportation Board[1] (Table 3), were used to create a link-level Class I emissions inventory, based on a methodology recommended by Sierra Research[2,3]. Rail Fuel Consumption Index (RFCI) is a measure of fuel use per ton mile of freight. This link-level inventory is nationwide in extent (Figure 1), but it can be aggregated at either the state or county level. It can also be converted into other formats for use in photochemical and dispersion air quality models.

**Table 3. Class I Railroad Reported Locomotive Fuel Use Statistics for 2016**

| Class I Railroads | 2016 R-1 Reported Locomotive Fuel Use (gal/year) | | RFCI (ton-miles/gal) | Adjusted RFCI (ton-miles/gal) |
|---|---|---|---|---|
| | Line-Haul* | Switcher | | |
| BNSF | 1,243,366,255 | 40,279,454 | 972.45 | 904.4703675 |
| Canadian National | 102,019,995 | 6,570,898 | 1,164.13 | 1,081.463412 |
| Canadian Pacific | 56,163,697 | 1,311,135 | 1,123.40 | 1,444.618538 |
| CSX Transportation | 404,147,932 | 39,364,896 | 1,072.31 | 1,043.743840 |
| Kansas City Southern | 60,634,689 | 3,211,538 | 988.72 | 994.508039 |
| Norfolk Southern | 437,110,632 | 28,595,955 | 919.90 | 905.508001 |
| Union Pacific | 900,151,933 | 85,057,080 | 1,041.79 | 1,094.796364 |
| **Totals:** | **3,203,595,133** | **204,390,956** | **1,006.2** | **992.470225** |

* Includes work trains; Adjusted RFCI values calculated from FRA gross ton-mile data as described on page 7. RFCI total is ton-mile weighted mean.

The Class I line-haul methodology is described in more detail in the three sections listed below.

**<u>1. Calculate Class I-Specific Emission Factors</u>**

USEPA provides annual default emission factors for locomotives based on operating patterns ("duty cycles") and the estimated nationwide fleet mixes for both switcher and line-haul

locomotives[4]. However, Tier level fleet mixes vary significantly between the Class I and Class II/III railroads. As can be seen in Figure 2, Class I railroad activity is highly regionalized in nature and is subject to variations in terrain across the country which can have a significant impact on fuel efficiency and overall fuel consumption.

For the 2016 inventory, the AAR provided a national line-haul Tier fleet mix profile representing the entire Class I locomotive fleet. A locomotive's Tier level determines its allowable emission rates based on the year when it was built and/or re-manufactured. The national fleet mix data was then used to calculate weighted average in-use emissions factors for the line-haul locomotives operated by the Class I railroads (Table 4).

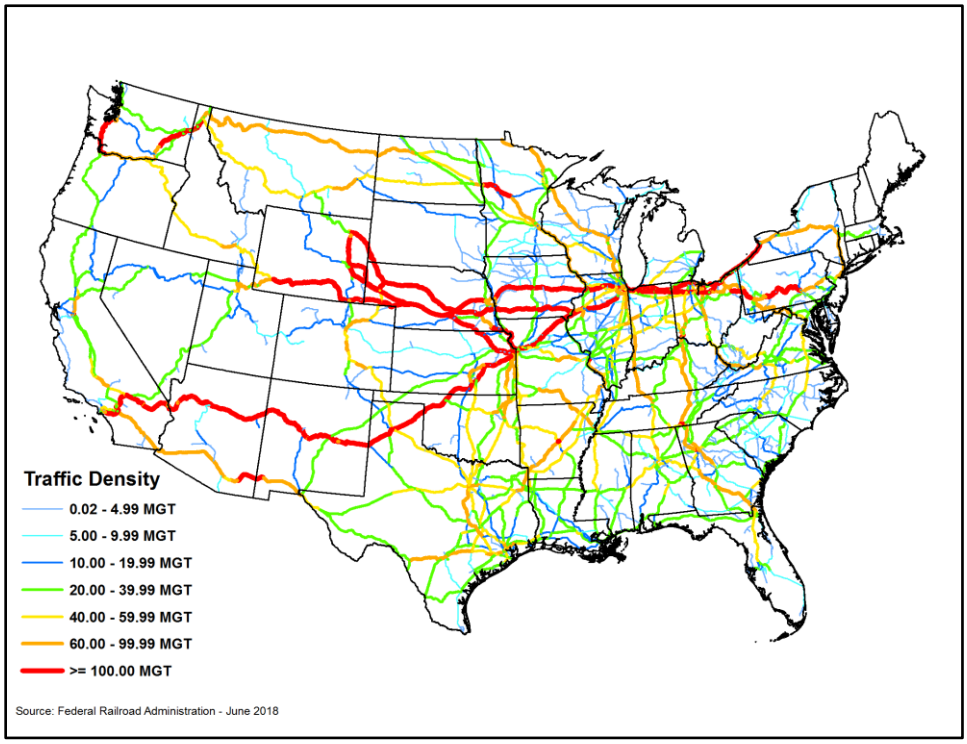


**Figure 1. 2016 US Railroad Traffic Density in Millions of Gross Tons per Route Mile (MGT)[5]**

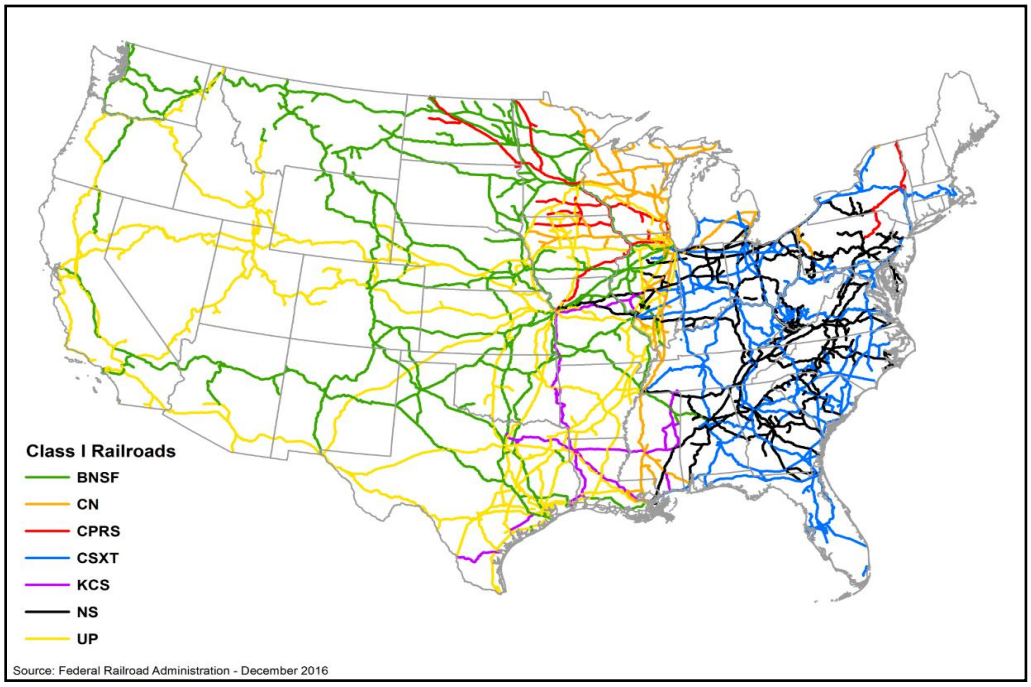


**Figure 2. Class I Railroads in the United States[5]**

**Table 4. 2016 Line-haul Locomotive Emission Factors by Tier, AAR Fleet Mix (grams/gal)[4]**

| Tier Level | AAR Fleet Mix Ratio | $PM_{10}$ | HC | $NO_x$ | CO |
|---|---|---|---|---|---|
| Uncontrolled (pre-1973) | 0.047494 | 6.656 | 9.984 | 270.4 | 26.624 |
| Tier 0 (1973-2001) | 0.188077 | 6.656 | 9.984 | 178.88 | 26.624 |
| Tier 0+ (Tier 0 rebuilds) | 0.141662 | 4.16 | 6.24 | 149.76 | 26.624 |
| Tier 1 (2002-2004) | 0.029376 | 6.656 | 9.776 | 139.36 | 26.624 |
| Tier 1+ (Tier 1 rebuilds) | 0.223147 | 4.16 | 6.032 | 139.36 | 26.624 |
| Tier 2 (2005-2011) | 0.124536 | 3.744 | 5.408 | 102.96 | 26.624 |
| Tier 2+ (Tier 2 rebuilds) | 0.093607 | 1.664 | 2.704 | 102.96 | 26.624 |
| Tier 3 (2012-2014) | 0.123113 | 1.664 | 2.704 | 102.96 | 26.624 |
| Tier 4 (2015 and later) | 0.028988 | 0.312 | 0.832 | 20.8 | 26.624 |
| **2016 Weighted EF's** | **1.000000** | **4.117** | **6.153** | **138.631** | **26.624** |

Based on values in EPA Technical Highlights: Emission Factors for Locomotives, EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009.

Weighted Emission Factors (EF) per pollutant for each gallon of fuel used (grams/gal or lbs/gal) were calculated for the US Class I locomotive fleet based on the percentage of line-haul locomotives certified at each regulated Tier level (Equation 1; Table 4).

**Equation (1)** $$EF_i = \sum_{T=1}^{9} (EF_{iT} * f_T)$$

where:

| | | |
|---|---|---|
| $EF_i$ | = | Weighted Emission Factor for pollutant i for Class I locomotive fleet (g/gal). |
| $EF_{iT}$ | = | Emission Factor for pollutant i for locomotives in Tier T (g/gal) (Table LH3). |
| $f_T$ | = | Percentage of the Class I locomotive fleet in Tier T expressed as a ratio. |

While actual engine emissions will vary within Tier level categories, the approach described above likely provides reasonable emission estimates, as locomotive diesel engines are certified to meet or exceed the emission standards for each Tier. It should be noted that actual emission rates may increase over time due to engine wear and degradation of the emissions control systems. In addition, locomotives may be operated in a manner that differs significantly from the conditions used to derive line-haul duty-cycle estimates.

Emission factors for other pollutants are not Tier - specific because these pollutants are not directly regulated by USEPA's locomotive emission standards. $PM_{2.5}$ was assumed to be 97% of $PM_{10}$ [4], the ratio of VOC to HC was assumed to be 1.053, and the emission factors used for $SO_2$ and $NH_3$ were 0.093888 g/gal[4] and 83.3 mg/gal[6], respectively. The 2016 $SO_2$ emission factor is based on the nationwide adoption of 15 ppm ultra-low sulfur diesel (ULSD) fuel by the rail industry. Greenhouse gases (GHGs) were estimated using the emission factors shown in Table 5. Note that non-road engine and fuel specific information is sparse for these conversions and that locomotive and marine engines are not subject to general non-road fuel or engine standards.

**Table 5. EPA Greenhouse Gas Emission Factors for Locomotive Diesel Fuel (grams/gal)[7]**

| | $CO_2$ | $N_2O$ | $CH_4$ |
|---|---|---|---|
| Locomotive diesel | 1.015E4 | 0.26 | 0.80 |

## 2. Calculate Class I Railroad-Specific Rail Fuel Consumption Index Values

Railroad Fuel Consumption Index (RFCI) values were calculated for each Class I railroad using the system-wide line-haul fuel consumption (FC) and gross ton-mile (GTM) data reported in their annual R-1 reports submitted to the Surface Transportation Board[1] (Equation 2). These values represent the average number of gross ton-miles produced per gallon of diesel fuel

burned by each Class I railroad for a given year. RFCI values vary between Class I railroads depending on factors such as average locomotive fuel efficiency, severity of grades, and differences in operational practices related to train speed, train tonnage, and train type mix (e.g., intermodal, unit, and manifest).

**Equation (2)** $$RFCI_{RR} = \frac{GTM_{RR}}{FC_{RR}}$$

where:

| | | |
|---|---|---|
| $RFCI_{RR}$ | = | Railroad Fuel Consumption Index (gross ton-miles/gal) per RR. |
| $GTM_{RR}$ | = | Gross Ton-Miles (GTM), annual system-wide gross ton miles of freight transported per RR. (R-1 Report Schedule 755, Line 104) |
| $FC_{RR}$ | = | Annual system-wide fuel consumption by line-haul and work trains per RR (gal). (R-1 Report Schedule 750, Lines 1 and 6). |

Due to the complexities and errors involved with coding traffic density MGT data onto the FRA's GIS network, there are discrepancies between the R-1 report GTM totals and the GTM totals obtained from the FRA's GIS data layer for each Class I railroad. These GTM discrepancies in turn cause problems in matching ERTAC Rail's aggregated link-level fuel use estimates for each Class I railroad with their R-1 line-haul fuel use totals. To address this problem, adjusted RFCI values were calculated using the FRA gross ton-mile totals for each Class I railroad in place of the R-1 GTM data (Equation 2a). This change ensured that each Class I railroad's line-haul fuel use total matched what was recorded in their R-1 reports, regardless of any problems with the FRA MGT data. This in turn enabled ERTAC Rail to generate link-level inventories that matched the emissions totals from system-level calculations.

**Equation (2a)** $$RFCI_{RRA} = \frac{GTM_{RR-FRA}}{FC_{RR}}$$

where:

| | | |
|---|---|---|
| $RFCI_{RRA}$ | = | Adjusted Railroad Fuel Consumption Index (gross ton-miles/gal) per Class I railroad RR. |
| $GTM_{RR\text{-}FRA}$ | = | Gross Ton-Miles (GTM), annual system-wide gross ton-miles of freight transported per RR. (FRA 2016 GIS network) |
| $FC_{RR}$ | = | Annual system-wide fuel consumption by line-haul and work trains per RR (gal). (R-1 Report Schedule 750, Lines 1 and 6). |

## 3. Calculate Emissions per Link

Emissions of pollutant i per link L ($E_{iL}$) were calculated using the four-part process described below (Equation 3):

a) The number of gross-ton miles (GTM) for each Class I railroad operating on link L was determined by converting the MGT value to gross tons, dividing the gross tons value by the number of Class I railroads operating on the link, then multiplying this final value by the link length in miles.
b) The gross ton-mile value for each railroad operating on the link was then divided by the adjusted RFCI value for that railroad to calculate the number of gallons of diesel fuel used by that railroad on the link.
c) The link-level fuel use value for each railroad was then multiplied by the nationwide Class I line-haul emission factor for pollutant i to determine that railroad's emissions value for the link.
d) The Class I railroad emissions total for the link was calculated by summing all the individual railroad pollutant emission values.

It is important to note that this approach splits the line-haul MGT activity data on each link evenly between all the Class I railroads operating on a specific link. No data is provided in the FRA GIS data layer to apportion MGT traffic density values between multiple railroads operating on the same link.

**Equation (3)** $$E_{iL} = \sum_{RR=1}^{N} \frac{\left(\frac{MGT_L * 10^6}{N}\right) * l_L}{RFCI_{RRA}} * EF_{iRR}$$

where:

| | | |
|---|---|---|
| $E_{iL}$ | = | Emissions of pollutant i per link L (tons/year). |
| $N$ | = | Number of Class I railroads operating on link L. |
| $MGT_L$ | = | Millions of Gross Tons hauled per link per year from the FRA database ($10^6$ tons/yr)[9]. |
| $l_L$ | = | Link length from the FRA database (miles). |
| $EF_i$ | = | Weighted Emission Factor for pollutant i per railroad RR (Equation 1; tons/gal). |
| $RFCI_{RRA}$ | = | Adjusted Railroad Fuel Consumption Index per railroad RR (Equation 2a; gross ton-miles/gal). |

## Yards Methodology

Early in the project the group identified that the past methods for locating and calculating activity at yards was flawed. The older method looked at MGT data on yards that were identified as yard links. Later, data showed that the older method resulted in activity at yards that were inactive (false positive) and missed important yards (false negative) that were not identified in the FRA data. It was agreed that past methods needed significant overhaul to the underlying data to create an acceptable inventory. Step one was to request that all Class 1 railroads should supply fuel use or yard locomotive counts by yard with yard coordinates. Three railroads provided data (BNSF, UP, KCS). This activity data was matched to existing yard locations and data. For all yards for that company that had activity data in past but no updated data, the old activity data was zeroed out. New yards were generated where no prior yard existed. Past efforts also relied on the yard name to identify locations. The problem with this is that many yard names are not unique (e.g., North Yard, South Yard). The updated and future methodology will use EPA's Emissions Inventory System (EIS) IDs to identify yards. EIS is a database system used by US EPA to store emissions inventory data. Since the railroads only supplied switcher counts, a fuel use per switcher value was calculated. This was done by dividing company fuel use by the number of identified switchers for each railroad and then that value was used to allocate fuel use to each yard. Total yard fuel use by company was obtained from the 2016 R-1 reports. Table 6 shows the 2016 yard fuel use by company.

**Table 6. Surface Transportation Board R-1 Fuel Use Data - 2016**

| Railroad | 2016 Yard Fuel Use (gal) | Identified Switchers | Per Switcher Fuel Use (gal) |
|---|---|---|---|
| BNSF | 40,279,454 | 445 | 90,515 |
| CSXT | 39,364,896 | 417 | 94,385 |
| CN | 6,570,898 | 79 | 83,175 |
| KCS | 3,211,538 | 177 | 18,144 |
| NS | 28,595,955 | 462 | 61,896 |
| CPRS | 1,311,135 | 70 | 18,730 |
| UP | 85,057,080 | 1289 | 65,986 |
| All Class I's | **204,390,956** | **2,939** | **61,834** |

Four railroads did not supply yard specific activity. After lengthy discussions, the inventory developers agreed to look at yards for four companies (CN, CP, NS, and CSX) with Google Earth and identify the number of visible switchers in the images. Training materials were generated that help reviewers recognize those attributes which are identifiable from remotely sensed images. LADCO, Illinois, and Michigan worked over a series of calls to identify all Canadian National (CN) and Canadian Pacific (CP) yards since most of their yards are in the LADCO region or immediately upwind. LADCO worked with the ERTAC Rail committee and found several volunteers from the group that reviewed CSX and Norfolk Southern (NS) yards in the eastern United States. Training calls and a well-defined spreadsheet structure provided sufficient training to get quality representation of those two companies' yard activities. This method suggested that slug switchers could be identified as partial switchers. A slug switcher is a locomotive without a diesel engine that generates traction from its electric motors. Slug switchers get their power from a companion "mother unit" switcher. It was important to properly identify slugs so that the switcher counts were not artificially inflated. Both CSX and NS have extensive fleets of slugs used in both line-haul and switching service. A follow up document with more detailed methodologies will act as a companion to this document so future developers can use these methods to identify yard activity.

After obtaining all the yard activity data, a spreadsheet was completed that contained all fuel use and emissions calculations for yards. Emissions rates were generated by creating weighted emissions rates for the Class 1 fleet based on EPA certification[4]. The average $NO_x$ emission rate was 178 grams/gallon of fuel burned. Final emissions calculations were then exported within the spreadsheet to a FF10 file format for export to SMOKE and the NEI as necessary. Additional comment fields and action flags were added to help NEI and modeling integrators understand the source of changes from the 2014 emissions inventory. These flags included options for: coordinate update, name updated, owner updated, permanently closed, duplicate entry, and

not a Class 1 yard. All the emissions calculations and activity data can be found in the emission calculation sheets available with this documentation. Figure 3 shows the distribution of yards in the 2016 inventory.

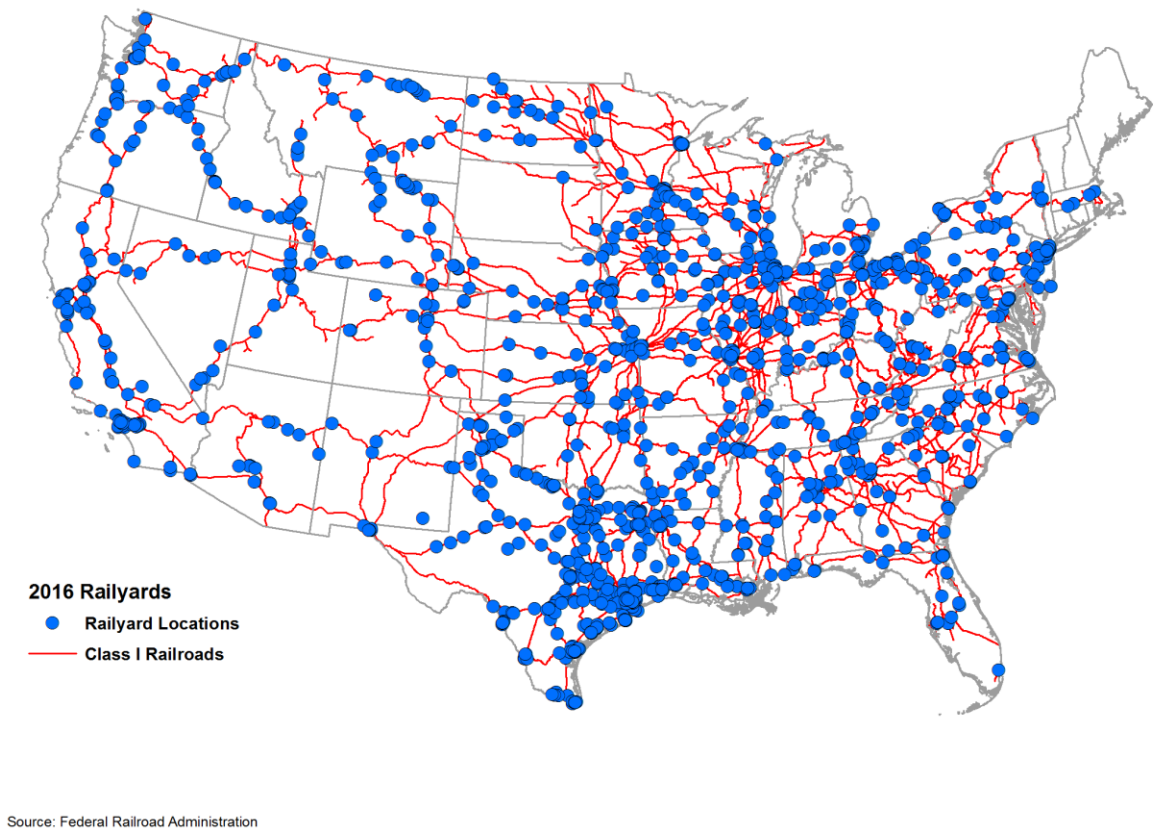


**Figure 3. 2016 Rail Yard Locations in the United States**

### Class II and III and Commuter Methodology

There are approximately 560 Class II and III Railroads operating in the United States, most of whom are members of the American Short Line and Regional Railroad Association (ASLRRA)[8]. While there is a lot information about individual Class II and III railroads available online, a significant amount of effort would be required to convert this data into a usable format for the creation of emission inventories. In addition, the Class II and III rail sector has been in considerable flux since the railroad industry was deregulated under the Staggers Act in 1980. Some states have conducted independent surveys of their Class II and III railroads and produced emission estimates, but no national level emissions inventory existed for this sector of the railroad industry prior to ERTAC Rail's work for the 2008 NEI[9].

Class II and III railroad activities account for 4% of the total locomotive fuel use in the combined ERTAC Rail emission inventories and for approximately 35% of the industry's national freight rail track mileage[5]. These railroads are widely dispersed across the country (Figure 4) and often utilize older, higher emitting locomotives than their Class I counterparts. Class II and III railroads provide transportation services to a wide range of industries. Individual railroads in this sector range from small switching operations serving a single industrial plant to large regional railroads that operate hundreds of miles of track.

The ERTAC Rail Class II and III inventory contains a comprehensive nationwide GIS database of locations where short line and regional railroads operate. It also provides a comprehensive spatial allocation of Class II/III locomotive emissions based on the nationwide Class II/III fuel use data reported by the ASLRRA. Figure 4 shows the distribution by link of Class II/III railroads and commuter railroads. This inventory will be useful for regional and local modeling, helps identify where Class II and III railroads may need to be better characterized, and provides a strong foundation for the future development of a more accurate nationwide short line and regional railroad emissions inventory. The data sources, calculations, and assumptions used to develop the Class II/III inventory are described below.

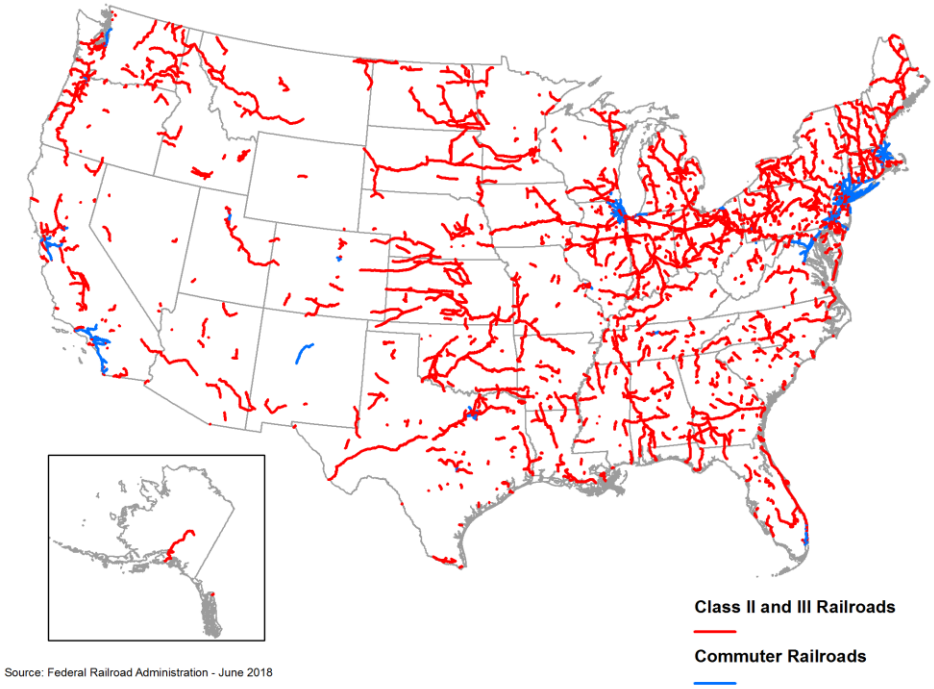


**Figure 4. Class II and III Railroads in the United States[5]**

**1. Locate Class II and III Railroads**

Identification and correct placement of Class II and III railroads was an important first step, requiring a comprehensive electronic dataset. The FRA GIS data layer used for the Class I inventories also identifies links owned or operated by specific short line or regional railroads using reporting mark identification codes. A complete list of reporting marks is included with the inventory. The locations of these links along with related data including reporting mark, railroad name, number of links, route miles owned or operated, and total route miles of links were extracted by ERTAC Rail. While the FRA GIS data layer contains confidential data for the Class I railroads, the spatial location of Class II and III links (Figure 4) and related attribute data are public information. This data is available online as part of Bureau of Transportation Statistics' National Transportation Atlas Database (NTAD)[10].

**2. Select/Calculate Emission Factors**

While some Class II and III railroads have purchased brand new locomotives in recent years, most of the locomotives in this sector served for decades in Class I fleets before being sold to the Class II or III railroads. As a result, a large portion of the Class II and III locomotive fleet consists of uncontrolled locomotives built before 1973. To better characterize this rail sector, ERTAC Rail requested that the AAR, through its Railinc subsidiary, provide a national line-haul Tier fleet mix profile for 2016. The national fleet mix data was then used to calculate weighted average in-use emissions factors for the locomotives operated by the Class II and III railroads (Table 7).

**Table 7. Class II/III emission factors based on a conversion factor of 20.8 bhp-hr/gal**

| Tier Level | Railinc Fleet Mix Ratio | $PM_{10}$ | HC | $NO_x$ | CO |
|---|---|---|---|---|---|
| Uncontrolled (pre-1973) | 0.484296 | 6.656 | 9.984 | 270.4 | 26.624 |
| Tier 0 (1973-2001) | 0.432286 | 6.656 | 9.984 | 178.88 | 26.624 |
| Tier 0+ (Tier 0 rebuilds) | 0.000000 | 4.16 | 6.24 | 149.76 | 26.624 |
| Tier 1 (2002-2004) | 0.002364 | 6.656 | 9.776 | 139.36 | 26.624 |
| Tier 1+ (Tier 1 rebuilds) | 0.000000 | 4.16 | 6.032 | 139.36 | 26.624 |
| Tier 2 (2005-2011) | 0.034786 | 3.744 | 5.408 | 102.96 | 26.624 |
| Tier 2+ (Tier 2 rebuilds) | 0.000000 | 1.664 | 2.704 | 102.96 | 26.624 |
| Tier 3 (2012-2014) | 0.039514 | 1.664 | 2.704 | 102.96 | 26.624 |
| Tier 4 (2015 and later) | 0.006754 | 0.312 | 0.832 | 20.8 | 26.624 |
| **2016 Weighted EF's** | **1.000000** | **6.314** | **9.475** | **216.401** | **26.624** |

Based on values in EPA Technical Highlights: Emission Factors for Locomotives, EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009.

Emission factors for $PM_{2.5}$, $SO_2$, $NH_3$, VOC, and GHGs were calculated in the same manner as those used for Class I line-haul inventory described above.

## 3. Calculate Emissions

The ASLRRA compiles fuel use data from the Class II and III railroads every two years. ERTAC Rail contacted the ASLRRA and obtained a copy of their 2014 Fact Book[8], which contains fuel use data for 2012. The FRA GIS data layer was used determine the total number of route miles operated by short line and regional railroads in 2016. These datasets can be combined to calculate a national average Fuel Use Factor (FUF) for all Class II and III railroads (Equation 7).

**Equation (4)** $$FUF = \frac{FuelUse_{ASLRRA}}{RouteMiles_{FRA}} = \frac{148{,}000{,}000\,gal}{53{,}311\,miles} = 2{,}776.16\,\frac{gal}{mile}$$

The Fuel Use Factor of 2,776.16 gallons per mile was multiplied by the number of route miles operated by each Class II and III railroad in each county in the US as coded in the FRA GIS data layer. These county-level fuel use estimates by railroad were then multiplied by the pollutant emission factors to calculate the number of tons of each pollutant emitted by railroad by county by year. These railroad/county-specific emissions data were then aggregated to produce county, state, and national emission estimates for the entire Class II and III rail industry.

Further modifications were made to the estimates to reflect actual fuel use data collected for specific Class II and III railroads, including entries of '0' for railroads known to have ceased operation.

Special coding was implemented in the calculation spreadsheet to balance and renormalize fuel use when company-specific fuel use was added to the calculations. When company-specific fuel was added but it was expected that that company's fuel use was likely not in the AASLRR's survey, then that company's fuel use was not subtracted from the 148 Million original amount[8]. Most commuter operations were not part of ASLRRA. Route mileage for those railroads also need to be deducted from the "total class 2/track miles" to make the equations above balance.

Railroad-specific fuel use data were provided by Delaware, Maryland, Michigan, for New Jersey railroads and the Indiana Harbor Belt (IHB). The difference was added to the ASLRRA fuel use total of 148,000,000 gallons, which yielded a final national fuel use total 149,258,111.3 gallons. This introduced a small overestimation error of less than 1% into the national emission totals for each pollutant. Emission totals for each of the other individual Class II/III railroads were unaffected by this problem.

Commuter rail operations were calculated in the same way that Class II and III were calculated. The primary difference is that data was collected from National Transit Database [11] which showed expenditures by commuter companies and an estimation of fuel use could be generated. Table 8 shows the list of commuter railroads reviewed. The assumption was that 95% of fuel and lube costs went into the purchase of fuel and that the 2016 price of fuel was $1.93.

**Table 8. Expenditures and Fuel Use for commuter rail.**

| FRA Code | System | Cities Served | Propulsion Type | DOT Fuel & Lube Costs | Reported/Estimated Fuel |
|---|---|---|---|---|---|
| ACEX | Altamont Corridor Express (ACE) | San Jose / Stockton | Diesel | $889,828 | 437,998.24 |
| CMRX | Capital MetroRail | Austin | Diesel | No data | n/a |
| DART | A-Train | Denton | Diesel | $0 | 0.00 |
| DRTD | Denver RTD: A&B Lines | Denver | Electric | $0 | 0.00 |
| JPBX | Caltrain | San Francisco / San Jose | Diesel | $7,002,612 | 3,446,881.55 |
| LI | MTA Long Island Rail Road | New York | Electric and Diesel | $13,072,158 | 6,434,481.92 |
| MARC | MARC Train | Baltimore / Washington, D.C. | Diesel and Electric | $4,648,060 | ***4,235,297.57*** |
| MBTA | MBTA Commuter Rail | Boston / Worcester / Providence | Diesel | $37,653,001 | ***12,142,826.00*** |
| MNCW | MTA Metro-North Railroad | New York / Yonkers / Stamford | Electric and Diesel | $13,714,839 | 6,750,827.49 |
| NICD | NICTD South Shore Line | Chicago / South Bend | Electric | $181,264 | 0.00 |
| NIRC | Metra | Chicago | Diesel and Electric | $52,460,705 | ***25,757,673.57*** |
| NJT | New Jersey Transit | New York / Newark / Trenton / Philadelphia | Electric and Diesel | $38,400,031 | ***16,991,164.00*** |
| NMRX | New Mexico Rail Runner Express | Albuquerque / Santa Fe | Diesel | $1,597,302 | 786,236.74 |
| CFCR | SunRail | Orlando | Diesel | $856,202 | 421,446.58 |

| FRA Code | System | Cities Served | Propulsion Type | DOT Fuel & Lube Costs | Reported/Estimated Fuel |
|---|---|---|---|---|---|
| MNRX | Northstar Line | Minneapolis | Diesel | $708,855 | 348,918.26 |
| Not Coded | SMART | San Rafael-Santa Rosa (Opened 2017) | Diesel | n/a | 0.00 |
| NRTX | Music City Star | Nashville | Diesel | $456,099 | 224,504.69 |
| SCAX | Metrolink | Los Angeles / San Bernardino | Diesel | $19,245,255 | 9,473,052.98 |
| SDNR | NCTD Coaster | San Diego / Oceanside | Diesel | $1,489,990 | 733,414.77 |
| SDRX | Sounder Commuter Rail | Seattle / Tacoma | Diesel | $1,868,019 | 919,491.22 |
| SEPA | SEPTA Regional Rail | Philadelphia | Electric | $483,965 | 0.00 |
| SLE | Shore Line East | New Haven | Diesel | No data | n/a |
| TCCX | Tri-Rail | Miami / Fort Lauderdale / West Palm Beach | Diesel | $5,166,685 | 2,543,186.92 |
| TREX | Trinity Railway Express | Dallas / Fort Worth | Diesel | No data | n/a |
| UTF | UTA FrontRunner | Salt Lake City / Provo | Diesel | $4,044,265 | 1,990,700.39 |
| VREX | Virginia Railway Express | Washington, D.C. | Diesel | $3,125,912 | 1,538,661.35 |
| WSTX | Westside Express Service | Beaverton | Diesel | No data | n/a |

Reported fuel use values were used for MARC, MBTA, Metra, and New Jersey Transit.

All commuter operation fuel use was assumed to not be included in the ASLRRA national fuel use total. Additional coding was added to the spreadsheets to segregate the commuter railroads from the Class II and III railroads so that the appropriate SCC codes could be entered into the emissions calculation sheet. The spreadsheets were also modified to generate FF10 county level inventories summed for all railroads in the county.

**Passenger Rail Inventory development.**

For the first time in the 2016 inventory, passenger rail emissions were included. Amtrak is the only company that belongs to this group. Calculation methodologies mimic those of Class II and III and Commuter with a few modifications. Since the FRA data did not have link level activity for Amtrak and resources were limited to create link level activity (fuel use or train miles), the assumption was made that there would be an even density of fuel use along all tracks. We instructed states to modify the distributions by analyzing Amtrak's 2016 route schedules to derive passenger train miles. Illinois and Connecticut did this and were able to enter modified fuel use numbers for those states based on Amtrak's 2016 average of 2.2 gallons per passenger train-mile data. In addition, Connecticut provided additional data for selected counties in Massachusetts, New Hampshire, and Vermont. Figure 5 shows the distribution of Amtrak links.

**Figure 5. Amtrak Routes with Diesel-powered Passenger Trains**

Amtrak also submitted company-specific fleet mix information and a company-specific emission rate was derived. This rate was 25% lower that the default Class II and III and commuter emission rate. The default and company specific fleet mix values for non-Class I line-haul engines is in Table 9. The resultant emissions rated in lbs/gallon are in Table 10.

**Table 9. Fleet mix fraction for default and company specific fleet mix.**

| OWNER | UNCONTROLLED | TIER 0 | TIER 0+ | TIER 1 | TIER 1+ | TIER 2 | TIER 2+ | TIER 3 | TIER 4 |
|---|---|---|---|---|---|---|---|---|---|
| Class2/3 | 0.484296 | 0.432286 | 0.0000 | 0.002364 | 0.0000 | 0.034786 | 0.0000 | 0.039514 | 0.006754 |
| Amtrak | 0.070900 | 0.85430 | 0.0748 | 0.00000 | 0.0000 | 0.00000 | 0.0000 | 0.00000 | 0.00000 |
| CSAO | 0.3419 | 0.3759 | 0.2024 | 0.0000 | 0.0003 | 0.0345 | 0.0030 | 0.0421 | 0.0000 |
| METRA | 0.0460 | 0.2810 | 0.4970 | 0.1760 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

**Table 10. Company specific emission rate lbs/gallon**

| EF Group | Weighted CO EF | Weighted VOC EF* | Weighted NOx EF | Weighted PM10 EF | Weighted PM25 EF | Weighted NH3 EF | Weighted SO2 EF |
|---|---|---|---|---|---|---|---|
| default | 0.058696 | 0.020888 | 0.477082 | 0.013921 | 0.013504 | 0.000184 | 0.000207 |
| UNCONT | 0.058696 | 0.023178 | 0.596130 | 0.014674 | 0.014234 | 0.000184 | 0.000207 |
| Amtrak | 0.058696 | 0.021394 | 0.403866 | 0.014262 | 0.013834 | 0.000184 | 0.000207 |
| CSAO | 0.058702 | 0.019268 | 0.437043 | 0.012842 | 0.012457 | 0.000184 | 0.000207 |
| METRA | 0.058696 | 0.017828 | 0.356403 | 0.011939 | 0.011581 | 0.000184 | 0.000207 |

* Note: The Class II-III commuter emission factor used for VOC is really for hydrocarbons, not VOC.

**Rail Inventory Methodology References**


1. STB R-1 reports. Available at: http://www.stb.dot.gov/stb/industry/econ_reports.html
2. "Revised Inventory Guidance for Locomotive Emissions"; Report No. SR2004-06-01. Prepared for Southeastern States Air Resource Managers (SESARM) by Sierra Research Inc. June 2004.
3. "Research Project: Development of Railroad Emission Inventory Methodologies"; Report No. SR2004-06-02. Prepared for Southeastern States Air Resource Managers (SESARM) by Sierra Research, Inc. June 2004
4. "EPA Technical Highlights: Emission Factors for Locomotives", EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. Available at: https://nepis.epa.gov
5. Confidential 2016 Class I railroad traffic density GIS shapefile provided by Raquel Wright of the Federal Railroad Administration.
6. "Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources", Draft Final Report. Prepared for EPA/STAPPA-ALAPCO Emission Inventory Improvement Program by E.H. Pechan & Assoc. April 2004. Supported by personal communication (5/6/2010) with Craig Harvey, US EPA, OTAQ, and Robert Wooten, NC DENR. Available at: http://www.epa.gov/sites/production/files/2015-08/documents/eiip_areasourcesnh3.pdf
7. "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005". EPA 430-R-07-002, Annex 3.2, U.S. Environmental Protection Agency, April 2007. Available at: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2005

8. American Short Line and Regional Association (ASLRRA) 2014 Fact Book (available from the ASLRRA on request).
9. Bergin, M., Harrell, M., Janssen, M. "Locomotive Emission Inventories for the United States from ERTAC Rail". U.S. EPA, 20th International Emission Inventory Conference. Tampa, Florida. August 13-16, 2012. Available at: https://www3.epa.gov/ttnchie1/conference/ei20/session8/mbergin.pdf
10. US DOT, Bureau of Transportation Statistics, National Transportation Atlas Database. Available at: https://www.bts.gov/geospatial/national-transportation-atlas-database
11. National Transit Database: Transit Operating Expenses. Available at: https://www.transit.dot.gov/ntd/data-product/2016-operating-expenses

**Other Data Sources**

North Carolina separately provided passenger train (SCC 2285002008) emissions for use in the platform. We used NC's passenger train emissions instead of the corresponding emissions from the LADCO dataset.

None of these rail inventory sources included HAPs. For VOC speciation, EPA preferred augmenting the inventory with HAPs and using those HAPs for integration, rather than running the sector as a no-integrate sector. So, NBAFM emissions were added to the rail inventory using the same augmentation factors as are used to augment HAPs in the NEI.

## 4. ANCILLARY DATA

**Spatial Allocation**

Spatial allocation of rail emissions to the national 12km domain used for air quality modeling is accomplished using spatial surrogates. Spatial surrogates map county polygons to the uniformly spaced grid cells of a modeling domain. The rail sector uses spatial surrogates based on railroad density. The source of this data is an older version of the FRA database of link level activity but was simplified to protect the original FRA confidential link level activity data. Reports summarizing total emissions by spatial surrogate at the state and county level are included in the emissions modeling workgroup reports package. National emissions by spatial surrogate are provided in Table 11.

**Table 11. 2016beta rail emissions by spatial surrogate (36US3 domain; tons/year)**

| Srg | Description | CO | NH3 | NOX | PM10 | PM2.5 | SO2 | VOC |
|---|---|---|---|---|---|---|---|---|
| **261** | NTAD Total Railroad Density | 4,657 | 15 | 33,822 | 1,084 | 1,051 | 16 | 1,626 |
| **271** | NTAD Class 1 2 3 Railroad Density | 98,224 | 307 | 523,394 | 15,528 | 15,063 | 346 | 24,365 |

**Temporal Allocation**

A monthly temporal profile for freight rail was developed from AAR data for the year 2016: https://www.aar.org/data-center/rail-traffic-data/, Monthly Rail Traffic Data, Total Carloads & Intermodal. Alpha platform used a similar profile based on data for year 2014.

Passenger trains use a flat monthly profile. Monthly passenger miles data are available; however, it is not known if there is a correlation between passenger miles and actual rail emissions. This is because passenger trains often operate on a fixed schedule, independent of actual passenger traffic. So, it was decided to not apply a monthly profile to passenger train emissions.

All sources in the rail sector use a flat profile for both day-of-week and hour-of-day temporalization.

Reports summarizing total emissions according to the monthly, day-of-week, and hour-of-day temporal profile assignments are included in the emissions modeling workgroup reports package at the state and county level. A national report of emissions by monthly profile is in Table 12.

**Table 12. 2016beta rail emissions by monthly profile (tons/yr)**

| Monthly profile | CO | NH3 | NOX | PM10 | PM2.5 | SO2 | VOC |
|---|---|---|---|---|---|---|---|
| **262** | 4,657 | 15 | 33,822 | 1,084 | 1,051 | 16 | 1,626 |
| **RAILF16** | 98,272 | 307 | 523,776 | 15,540 | 15,074 | 347 | 24,382 |

**Chemical Speciation**

The rail sector includes speciation of PM2.5 and VOC emissions. All VOC speciation in this sector employs NBAFM integration. All rail PM2.5 emissions use speciation profile 91106 (HDDV

exhaust). All rail VOC emissions use speciation profile 8774 (diesel exhaust). $NO_x$ is speciated to HONO (0.8%), NO (90%), and $NO_2$ (9.2%) for all rail sources nationwide.

**Table 13. VOC and PM Speciation Profiles.**

**VOC profile 8774 (entire rail sector; 100% integrate)**

| CB Species | NONHAPTOG | molec wt |
|---|---|---|
| ALDX | 0.0242 | 42.5375 |
| ETH | 0.2484 | 28.0532 |
| ETHA | 0.0224 | 30.069 |
| ETHY | 0.0812 | 26.0373 |
| IOLE | 0.0293 | 55.207 |
| ISOP | 0.001858 | 68.117 |
| KET | 0.009095 | 18.0264 |
| OLE | 0.0977 | 28.1488 |
| PAR | 0.3928 | 14.4819 |
| PRPA | 0.027 | 44.0956 |
| SOAALK | 0.2064 | 89.3857 |
| TERP | 0.001443 | 136.234 |
| TOL | 0.0339 | 94.9032 |
| UNR | 0.001482 | 14.4463 |
| XYLMN | 0.0291 | 106.2893 |

| | |
|---|---|
| VOC-to-TOG | 1.022959 |

**PM2.5 profile 91106 (entire rail sector)**

| CB Species | Mass Fraction |
|---|---|
| PCA | 0.000583 |
| PCL | 0.000205 |
| PEC | 0.7712 |
| PFE | 0.000262 |
| PK | 0.000038 |
| PMOTHR | 0.004091 |
| PNCOM | 0.0439 |
| PNO3 | 0.001141 |
| POC | 0.1756 |
| PSO4 | 0.00295 |
| PTI | 0.000004 |

## 5. EMISSIONS PROJECTION METHODS

The 2016 beta platform projections have not yet been finalized at the time that this was written.

## 6. EMISSIONS PROCESSING REQUIREMENTS

Rail emissions were processed for air quality modeling using the Sparse Matrix Operator Kernel Emissions (SMOKE[1]) modeling system. Emissions estimates enter the emissions processing steps by County and SCC code for all categories, except yards which are processed as point sources with a single discrete point identifying each yard. Because day-of-week temporalization is flat for all sources, a single representative day per month is processed. This is a 2-D sector in which all emissions are output to a single layer gridded emissions file. Emissions Estimates are by County and SCC code. For point source yards in the ptnonipm sector, default stack characteristics are applied to all yards to ensure that emissions end up in the lowest vertical layer of the modeled atmosphere.

## 7. EMISSIONS SUMMARIES

Table 13 compares annual, national total rail emissions for the 2016 beta platform to rail emissions from previous modeling platforms. Table 146 and Table 157 show similar comparisons for state total rail NOx and VOC emissions, respectively.

Additional rail plots and maps are available online through the LADCO website[2] and the Intermountain West Data Warehouse[3].

Descriptions of the emissions platform cases shown in the tables and plots below are as follows:

2011en, 2023en, 2028el = Final 2011, 2023, and 2028 cases from the 2011v6.3 platform

2014fd = 2014NEIv2 and 2014 NATA

2016fe = 2016 alpha platform (grown from 2014NEIv2)

2016ff = 2016 beta platform

[1] http://www.smoke-model.org/index.cfm
[2] https://www.ladco.org/technical/modeling-results/2016-inventory-collaborative/
[3] http://views.cira.colostate.edu/iwdw/eibrowser2016

**Table 135. Comparison of national, 2016 annual total rail emissions (tons/yr)**

| Pollutant | 2011en | 2014fd | 2016fe | 2016ff | 2023en | 2028el |
|---|---|---|---|---|---|---|
| CO | 122,966 | 118,830 | 118,830 | 102,929 | 145,922 | 157,955 |
| NH3 | 347 | 363 | 363 | 322 | 376 | 379 |
| NOX | 792,506 | 675,704 | 675,704 | 557,598 | 564,195 | 460,217 |
| PM10 | 25,930 | 20,806 | 20,806 | 16,624 | 14,255 | 10,684 |
| PM2.5 | 23,990 | 19,226 | 19,226 | 16,125 | 13,182 | 9,878 |
| SO2 | 7,941 | 822 | 822 | 363 | 340 | 367 |
| VOC | 40,904 | 34,865 | 34,865 | 26,008 | 21,417 | 17,096 |

**Table 146. Comparison of state, 2016 annual total NOx emissions (tons/yr)**

| State | 2011en | 2014fd | 2016fe | 2016ff | 2023en | 2028el |
|---|---|---|---|---|---|---|
| Alabama | 15,280 | 12,122 | 12,122 | 10,224 | 10,712 | 8,700 |
| Alaska | 1,120 | 976 | 976 | 382 | 808 | 713 |
| Arizona | 22,523 | 18,719 | 18,719 | 16,970 | 15,401 | 12,301 |
| Arkansas | 16,484 | 14,443 | 14,443 | 11,355 | 11,440 | 9,229 |
| California | 37,250 | 43,963 | 43,963 | 27,586 | 39,471 | 34,899 |
| Colorado | 14,601 | 9,973 | 9,973 | 7,906 | 10,059 | 8,075 |
| Connecticut | 1,324 | 627 | 627 | 1,032 | 1,065 | 975 |
| Delaware | 406 | 248 | 248 | 250 | 300 | 248 |
| District of Columbia | 185 | 111 | 111 | 200 | 126 | 99 |
| Florida | 8,283 | 5,390 | 5,390 | 5,942 | 6,033 | 5,020 |
| Georgia | 20,127 | 14,732 | 14,732 | 12,833 | 14,029 | 11,350 |
| Hawaii | 2 | 4 | 4 | 0 | 2 | 2 |
| Idaho | 8,154 | 7,507 | 7,507 | 6,354 | 5,742 | 4,678 |
| Illinois | 42,230 | 33,942 | 33,942 | 33,086 | 29,451 | 23,837 |
| Indiana | 20,092 | 18,260 | 18,260 | 15,518 | 14,200 | 11,594 |
| Iowa | 23,393 | 20,173 | 20,173 | 16,580 | 16,233 | 13,095 |
| Kansas | 34,484 | 28,001 | 28,001 | 21,757 | 23,943 | 19,322 |
| Kentucky | 14,990 | 10,016 | 10,016 | 8,128 | 10,357 | 8,330 |
| Louisiana | 10,319 | 9,115 | 9,115 | 7,508 | 7,123 | 5,726 |
| Maine | 1,283 | 1,315 | 1,315 | 1,005 | 1,365 | 1,361 |
| Maryland | 2,912 | 2,160 | 2,160 | 2,726 | 1,991 | 1,591 |
| Massachusetts | 4,157 | 4,467 | 4,467 | 3,998 | 2,660 | 2,195 |
| Michigan | 6,172 | 5,333 | 5,333 | 4,627 | 4,719 | 4,042 |
| Minnesota | 17,705 | 18,239 | 18,239 | 13,781 | 12,564 | 10,286 |
| Mississippi | 7,598 | 6,888 | 6,888 | 5,711 | 5,318 | 4,315 |
| Missouri | 32,362 | 26,939 | 26,939 | 20,227 | 22,154 | 17,707 |
| Montana | 23,022 | 21,338 | 21,338 | 18,471 | 15,938 | 12,837 |
| Nebraska | 69,700 | 54,917 | 54,917 | 37,241 | 47,411 | 37,729 |

| State | 2011en | 2014fd | 2016fe | 2016ff | 2023en | 2028el |
|---|---|---|---|---|---|---|
| Nevada | 6,414 | 5,767 | 5,767 | 4,315 | 4,387 | 3,505 |
| New Hampshire | 384 | 399 | 399 | 311 | 408 | 407 |
| New Jersey | 4,615 | 3,722 | 3,722 | 5,308 | 3,019 | 2,504 |
| New Mexico | 24,139 | 19,656 | 19,656 | 19,208 | 16,455 | 13,115 |
| New York | 13,992 | 12,409 | 12,409 | 12,737 | 10,272 | 8,471 |
| North Carolina | 9,804 | 6,773 | 6,773 | 5,830 | 5,533 | 5,533 |
| North Dakota | 14,937 | 14,890 | 14,890 | 10,798 | 10,471 | 8,505 |
| Ohio | 32,095 | 27,400 | 27,400 | 23,618 | 22,474 | 18,239 |
| Oklahoma | 18,485 | 17,624 | 17,624 | 14,349 | 12,911 | 10,461 |
| Oregon | 8,609 | 7,335 | 7,335 | 6,135 | 6,303 | 5,262 |
| Pennsylvania | 18,044 | 17,256 | 17,256 | 14,355 | 13,130 | 10,764 |
| Rhode Island | 74 | 60 | 60 | 54 | 78 | 78 |
| South Carolina | 7,886 | 4,332 | 4,332 | 4,102 | 5,431 | 4,359 |
| South Dakota | 3,931 | 3,762 | 3,762 | 2,621 | 3,024 | 2,599 |
| Tennessee | 16,229 | 11,545 | 11,545 | 9,521 | 11,193 | 8,992 |
| Texas | 61,716 | 49,085 | 49,085 | 46,400 | 43,098 | 34,866 |
| Utah | 6,122 | 5,640 | 5,640 | 5,259 | 4,230 | 3,402 |
| Vermont | 634 | 718 | 718 | 579 | 675 | 673 |
| Virginia | 16,879 | 12,841 | 12,841 | 9,815 | 11,504 | 9,068 |
| Washington | 13,932 | 14,357 | 14,357 | 14,766 | 9,706 | 7,885 |
| West Virginia | 10,404 | 6,941 | 6,941 | 5,808 | 7,246 | 5,757 |
| Wisconsin | 11,249 | 13,006 | 13,006 | 10,109 | 7,848 | 6,354 |
| Wyoming | 35,769 | 28,103 | 28,103 | 20,204 | 24,180 | 19,160 |
| Puerto Rico | 0 | 0 | 0 | | 1 | 1 |
| Tribal Data | 3 | 2,166 | 2,166 | | 2 | 2 |

**Table 157. Comparison of state, 2016 annual total VOC emissions (tons/yr)**

| State | 2011en | 2014fd | 2016fe | 2016ff | 2023en | 2028el |
|---|---|---|---|---|---|---|
| Alabama | 779 | 601 | 601 | 476 | 407 | 324 |
| Alaska | 52 | 45 | 45 | 17 | 32 | 29 |
| Arizona | 1,121 | 939 | 939 | 794 | 559 | 430 |
| Arkansas | 805 | 721 | 721 | 530 | 414 | 325 |
| California | 2,924 | 3,431 | 3,431 | 1,284 | 1,859 | 1,604 |
| Colorado | 726 | 499 | 499 | 371 | 367 | 286 |
| Connecticut | 52 | 24 | 24 | 46 | 42 | 41 |
| Delaware | 21 | 21 | 21 | 11 | 12 | 10 |
| District of Columbia | 9 | 6 | 6 | 9 | 4 | 3 |
| Florida | 393 | 258 | 258 | 275 | 223 | 186 |
| Georgia | 1,030 | 730 | 730 | 598 | 533 | 420 |
| Hawaii | 0 | 0 | 0 | 0 | 0 | 0 |

| State | 2011en | 2014fd | 2016fe | 2016ff | 2023en | 2028el |
|---|---|---|---|---|---|---|
| Idaho | 406 | 374 | 374 | 296 | 214 | 172 |
| Illinois | 2,103 | 1,695 | 1,695 | 1,565 | 1,087 | 857 |
| Indiana | 1,020 | 901 | 901 | 723 | 542 | 435 |
| Iowa | 1,177 | 1,013 | 1,013 | 774 | 604 | 474 |
| Kansas | 1,698 | 1,396 | 1,396 | 1,014 | 873 | 687 |
| Kentucky | 743 | 500 | 500 | 379 | 378 | 295 |
| Louisiana | 491 | 454 | 454 | 351 | 250 | 195 |
| Maine | 50 | 51 | 51 | 45 | 60 | 65 |
| Maryland | 158 | 102 | 102 | 125 | 79 | 62 |
| Massachusetts | 196 | 212 | 212 | 178 | 95 | 77 |
| Michigan | 287 | 251 | 251 | 214 | 180 | 158 |
| Minnesota | 852 | 912 | 912 | 643 | 458 | 371 |
| Mississippi | 363 | 340 | 340 | 267 | 190 | 151 |
| Missouri | 1,613 | 1,356 | 1,356 | 946 | 806 | 621 |
| Montana | 1,119 | 1,068 | 1,068 | 863 | 572 | 449 |
| Nebraska | 3,489 | 2,770 | 2,770 | 1,740 | 1,721 | 1,315 |
| Nevada | 324 | 292 | 292 | 204 | 162 | 125 |
| New Hampshire | 15 | 16 | 16 | 14 | 18 | 20 |
| New Jersey | 217 | 181 | 181 | 236 | 109 | 90 |
| New Mexico | 1,191 | 989 | 989 | 899 | 590 | 453 |
| New York | 670 | 601 | 601 | 585 | 375 | 315 |
| North Carolina | 492 | 335 | 335 | 273 | 193 | 193 |
| North Dakota | 723 | 740 | 740 | 504 | 379 | 302 |
| Ohio | 1,640 | 1,361 | 1,361 | 1,100 | 855 | 679 |
| Oklahoma | 903 | 876 | 876 | 668 | 470 | 373 |
| Oregon | 424 | 357 | 357 | 285 | 242 | 202 |
| Pennsylvania | 935 | 846 | 846 | 668 | 508 | 421 |
| Rhode Island | 3 | 2 | 2 | 2 | 3 | 4 |
| South Carolina | 394 | 216 | 216 | 193 | 199 | 155 |
| South Dakota | 183 | 180 | 180 | 121 | 116 | 102 |
| Tennessee | 827 | 575 | 575 | 444 | 419 | 326 |
| Texas | 3,418 | 2,496 | 2,496 | 2,169 | 1,778 | 1,398 |
| Utah | 333 | 280 | 280 | 245 | 169 | 131 |
| Vermont | 25 | 28 | 28 | 26 | 30 | 32 |
| Virginia | 896 | 643 | 643 | 459 | 431 | 333 |
| Washington | 741 | 686 | 686 | 690 | 385 | 304 |
| West Virginia | 527 | 347 | 347 | 271 | 263 | 207 |
| Wisconsin | 544 | 649 | 649 | 472 | 283 | 224 |
| Wyoming | 1,805 | 1,421 | 1,421 | 944 | 879 | 666 |
| Puerto Rico | 0 | 0 | 0 | | 0 | 0 |
| Tribal Data | 0 | 81 | 81 | | 0 | 0 |

**Table 18. Rail Emissions by SCC and Pollutant**

| Region | Pollutant | SCC | SCC Description | 2016ff |
|---|---|---|---|---|
| National | CO | 2285002006 | Line Haul Locomotives: Class I Operations | 94,020 |
| National | CO | 2285002007 | Line Haul Locomotives: Class II / III Operations | 4,251 |
| National | CO | 2285002008 | Line Haul Locomotives: Passenger Trains (Amtrak) | 1,828 |
| National | CO | 2285002009 | Line Haul Locomotives: Commuter Lines | 2,829 |
| National | NH3 | 2285002006 | Line Haul Locomotives: Class I Operations | 294 |
| National | NH3 | 2285002007 | Line Haul Locomotives: Class II / III Operations | 13 |
| National | NH3 | 2285002008 | Line Haul Locomotives: Passenger Trains (Amtrak) | 6 |
| National | NH3 | 2285002009 | Line Haul Locomotives: Commuter Lines | 9 |
| National | NOX | 2285002006 | Line Haul Locomotives: Class I Operations | 489,562 |
| National | NOX | 2285002007 | Line Haul Locomotives: Class II / III Operations | 34,214 |
| National | NOX | 2285002008 | Line Haul Locomotives: Passenger Trains (Amtrak) | 12,539 |
| National | NOX | 2285002009 | Line Haul Locomotives: Commuter Lines | 21,283 |
| National | PM10-PRI | 2285002006 | Line Haul Locomotives: Class I Operations | 14,538 |
| National | PM10-PRI | 2285002007 | Line Haul Locomotives: Class II / III Operations | 1,001 |
| National | PM10-PRI | 2285002008 | Line Haul Locomotives: Passenger Trains (Amtrak) | 442 |
| National | PM10-PRI | 2285002009 | Line Haul Locomotives: Commuter Lines | 642 |
| National | PM25-PRI | 2285002006 | Line Haul Locomotives: Class I Operations | 14,102 |
| National | PM25-PRI | 2285002007 | Line Haul Locomotives: Class II / III Operations | 971 |
| National | PM25-PRI | 2285002008 | Line Haul Locomotives: Passenger Trains (Amtrak) | 428 |
| National | PM25-PRI | 2285002009 | Line Haul Locomotives: Commuter Lines | 623 |
| National | SO2 | 2285002006 | Line Haul Locomotives: Class I Operations | 332 |
| National | SO2 | 2285002007 | Line Haul Locomotives: Class II / III Operations | 15 |
| National | SO2 | 2285002008 | Line Haul Locomotives: Passenger Trains (Amtrak) | 6 |
| National | SO2 | 2285002009 | Line Haul Locomotives: Commuter Lines | 10 |
| National | VOC | 2285002006 | Line Haul Locomotives: Class I Operations | 22,879 |
| National | VOC | 2285002007 | Line Haul Locomotives: Class II / III Operations | 1,503 |
| National | VOC | 2285002008 | Line Haul Locomotives: Passenger Trains (Amtrak) | 663 |
| National | VOC | 2285002009 | Line Haul Locomotives: Commuter Lines | 963 |