Memorandum: Development of 2011 Railroad Component for National Emissions Inventory

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

MEMORANDUM

TO: Laurel Driver/US EPA

FROM: Heather Perez, Susan McClutchey, and Richard Billings/ERG

DATE: September 5, 2012

SUBJECT: Development of 2011 Railroad Component for National Emissions Inventory

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1.0 Introduction

As part of Work Assignment 5-07 under EPA Contract EP-D-07-097, entitled "Mobile Source Emission Inventories – FY12," ERG developed growth factors for Class I and Class II and III railroads that were applied to the 2008 emission values developed for the National Emission Inventory (NEI) to approximate emission levels in 2011. The emissions were allocated to line haul shape IDs and yard locations based on 2008 allocations. ERG provided the EPA with the 2011 estimated railroad emissions as an Access database for inclusion into EIS staging tables by the EPA WAM.

This report documents the development of the growth factors (Section 2), application of these growth factors to 2008 data are discussed in Section 3 along with a summary of the 2001 emissions estimates. Lastly A listing of references used in this study are presented in Section 4.

2.0 2008/2011 Railroad Growth Factors

Railroad freight traffic data were obtained from a variety of sources including the Department of Transportation's Bureau of Transportation Statistics (BTS) and Surface Transportation Board, The Department of Energy's Annual Energy Outlook (AEO), the American Association of Railroads (AAR), and the American Short Lines and Regional Railroad Association.

Initially growth rates were reviewed as reported for the AEO's 2012 reference case. These rates were developed relative to billions of ton miles traveled. Data that specifically covered the period from 2008 to 2011 were not included in the data table, so earlier reports (2008-2011) were compiled and reviewed. When the separate reports were evaluated together, the actual and projected annual growth rates were inconsistent. This observation suggested that the commercial rail freight market had a high degree of uncertainty associated with it for the study period.

This observation about the volatility of the market was substantiated when aggregated quarterly rail traffic data from the BTS were reviewed. Their data showed a peak in 2008 followed by a significant decline in activity for multimodal rail traffic. Gradually the rail freight market was returning to the 2008 activity level, though the 2011 data point suggests that activities were slightly under the 2008 peak. Note that the rail traffic data presented in Figure 1 is for intermodal freight traffic and is only provided as a general indicator of rail activities.

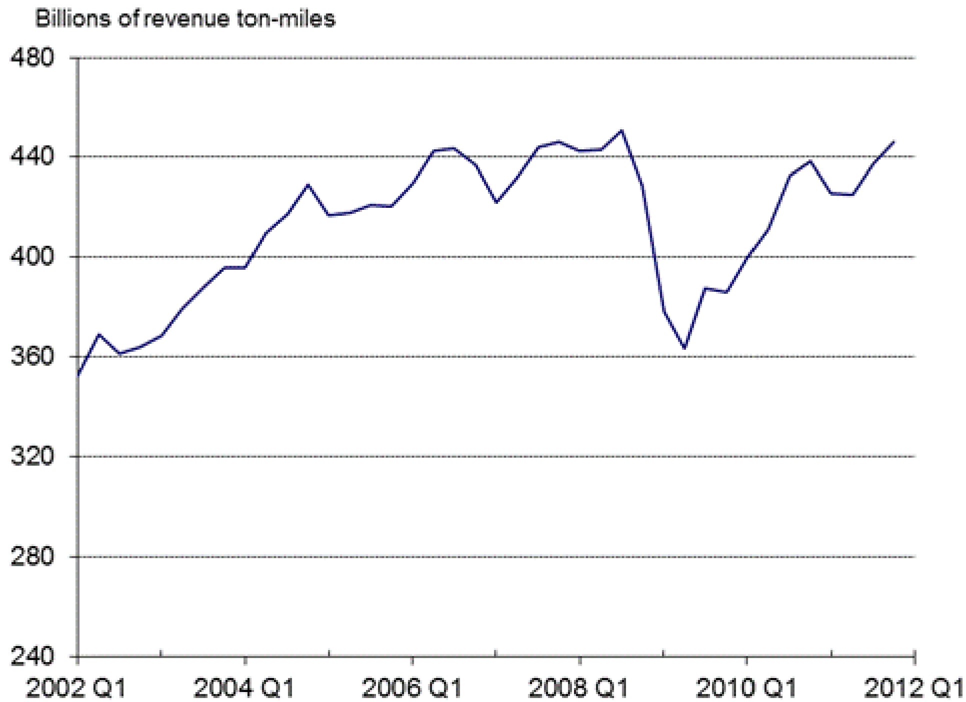

Figure 1. Intermodal Rail Traffic 2002 to 2012

ERG compiled railroad freight traffic data from the 2008 and 2011 R-1 reports submitted by all Class I rail lines to the Surface Transportation Board. The R-1 data are more comprehensive than the BTS's intermodal study as it includes all freight shipped by Class I railways. For the most part, the R-1 data follow the Trends noted in Figure 1 with one exception: the Soo Line saw an increase in traffic of over 45%. The Soo Lines business activities were investigated to understand the anomaly in their freight traffic data. The Soo Line acquired the Dakota, Minnesota and Eastern Railroad and the Iowa, Chicago & Eastern Railroad in late 2008. It is believed that this merger is the cause of the increased activity reported by the Soo line.

When all the rail traffic data are aggregated, the Soo line's freight traffic has a relatively small impact on the overall trend as it is the smallest of the Class I railways. The percent change from 2008 to 2011 for total ton-miles (including the Soo line) is -2.479.

Table 1. Class I Railroad Ton Miles Activity for 2008 and 2011

	Total Revenue Ton-miles of Freight (thousands)		Total non-Revenue Ton-miles of Freight (thousands)		Total Revenue and non-Revenue Ton-miles of Freight (thousands)		% change from 2008 to 2011
	2008	2011	2008	2011	2008	2011	
BNSF	664,384,072	648,431,637	5,997,398	6,117,197	670,381,470	654,548,834	-2.362
CSXT	248,121,469	228,394,651	347,234	1,216,165	248,468,703	229,610,816	-7.590
GTC	53,452,403	51,253,084	624,848	518,201	54,077,251	51,771,285	-4.264
KCSR	29,624,261	30,485,863	6,077	1,338,343	29,630,338	31,824,206	7.404
NS	195,343,113	191,712,562	273,331	1,267,931	195,616,444	192,980,493	-1.348
Soo	23,681,180	34,581,354	241,414	333,090	23,922,594	34,914,444	45.948
UP	562,629,694	544,397,317	5,187,410	5,485,720	567,817,104	549,883,037	-3.158
				Total	**1,789,913,904**	**1,745,533,115**	**-2.479**

ERG also tried to obtain rail freight trend data from the Association of American Railroads (AAR), but their current posted data only extend back to 2009. It was noted that the AAR data are used in the in the BTS's National Transportation Statistics and are similar to the data in Table 1.

Because Class II and III rail operations are often affected differently by changes in the economy than Class I railways, data were obtained from the American Short Lines and Regional Railroad Association to assess their growth rate for the study period. Unfortunately, freight traffic data in terms of ton-miles was not available, so information regarding employee hours for 2008 and 2011 were evaluated, quantifying a decline in activity of 8.37 percent. It is possible that this decline overstates the actual change in Class II and III rail traffic, as employee efficiency may also change during periods of economic uncertainty.

Lastly, it should be noted that growing the 2008 data using these measures does not account for improved locomotive efficiency. Because the price of railroad fuel increased over the study period and because fuel usage is such a large component of rail finances; when demand declines, railways often use their newer, more efficient locomotives and retire the older engines to reduce their system-wide fuel consumption. Under these conditions, less fuel would be needed to move cargo, suggesting that actual 2011 emissions may be slightly less than those estimated for this project.

3.0 Emissions Estimate Summary

The railroad component of the 2008 NEI was provided by ERTAC. ERTAC revised their data since the 2008 NEI was posted. Prior to scaling the 2008 data to represent 2011, the 2008 NEI data set was amended to include the updates in the latest version of the ERTAC data. Note there were no changes to the Class I line haul operations which represent the largest rail emission source. The latest 2008 ERTAC data set for Class II/III line haul operations contained additional state and railroad provided data as well as an updated fuel use factor. These revisions were re applied to the county level and re-aggregated to match the latest ERTAC data set. The yard engine data also had slightly different emissions and record counts. The new yard emissions were summed and reallocated to new yards which were assigned unique IDs and EIS/GIS point locations.

The growth factors developed in Section 2 were applied to the updated 2008 railroad emission estimates using the following equation to approximate 2011 emissions:

$$EE_{2011ij} = EE_{2008ij} \times (1 + GF_i / 100)$$

Where:

EE_{2011ij}	=	2011 railroad emission estimate for operation type i and pollutant j (Tons/Yr)
EE_{2008ij}	=	2008 railroad emission estimate for operation type i and pollutant j (Tons/Yr)
GF_i	=	2011/2008 growth factor for operation type i (Class 1 railroad and all yard operations = -2.475percent and Class 2 and 3 operations = -8.37 percent)
$_i$	=	Rail operation type (Class 1 line haul, Class 2 and 3 line haul, and yard operations)
$_j$	=	criteria pollutant and regulated HAPs.

The 2011 emissions using the above approach are presented in Table 2 along with the updated 2008 values for each locomotive category. HAP emissions for each locomotive category are presented in the Appendix of this report.

Table 2. 2008 and 2011 Annual Emission Estimates by Locomotive Category (Tons)

	Class I		Class II/III		Switch		Total	
Pollutant	**2008**	**2011**	**2008**	**2011**	**2008**	**2011**	**2008**	**2011**
CO	110,969	108,218	4,631	4,244	9,231	9,002	124,830	121,463
NH_3	347	339	14	13	28	27	389	379
NO_X	754,433	735,731	47,035	43,100	74,431	72,586	875,899	851,417
PM_{10}	25,477	24,846	1,158	1,061	2,105	2,053	28,740	27,960
PM_{25}	23,439	22,858	1,065	976	2,042	1,991	26,546	25,826
SO_2	7,836	7,642	327	300	624	608	8,787	8,550
VOC	39,952	37,000	1,829	1,676	5,125	4,998	46,905	43,674

4.0 References

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Appendix A – 2011 HAP Emissions by Locomotive Category

Table A-1. 2011 HAP Emissions by Locomotive Category (Tons per year)

Pollutant	Class I Emissions	Class II/III	Switch	Total
1,3-Butadiene	113.899	4.866	9.186	127.950
2,2,4-Trimethylpentane	82.974	3.758	11.208	97.940
Acenaphthene	0.738	0.032	0.060	0.830
Acenaphthylene	10.413	0.445	0.850	11.708
Acetaldehyde	659.298	28.164	53.178	740.640
Acrolein	109.648	4.684	8.845	123.176
Ammonia	338.587	13.276	26.958	378.820
Anthracene	2.461	0.105	0.201	2.767
Arsenic	0.009	0.000	0.001	0.010
Benz[a]Anthracene	0.395	0.017	0.032	0.444
Benzene	90.721	3.875	7.317	101.913
Benzo[a]Pyrene	0.070	0.003	0.006	0.079
Benzo[b]Fluoranthene	0.157	0.007	0.013	0.176
Benzo[g,h,i,]Perylene	0.078	0.003	0.006	0.088
Benzo[k]Fluoranthene	0.128	0.005	0.011	0.144
Beryllium	0.696	0.030	0.058	0.783
Cadmium	0.696	0.030	0.058	0.783
Carbon Dioxide	--	1,617,263.311	3,283,729.797	4,900,993.109
Carbon Monoxide	108,217.732	4,243.692	9,001.821	121,463.245
Chromium (VI)	0.049	0.002	0.004	0.056
Chromium III	0.096	0.004	0.008	0.108
Chrysene	0.292	0.012	0.024	0.329
Ethyl Benzene	74.000	3.351	9.996	87.348
Fluoranthene	1.840	0.079	0.151	2.070
Fluorene	3.417	0.146	0.279	3.842
Formaldehyde	1,519.044	64.891	122.519	1,706.454
Hexane	203.501	9.216	27.490	240.207
Indeno[1,2,3-c,d]Pyrene	0.067	0.003	0.006	0.075
Lead	2.088	0.089	0.173	2.350
Manganese	0.051	0.002	0.004	0.057
Mercury	0.696	0.030	0.058	0.783
Naphthalene	63.268	2.702	5.193	71.163
Nickel	0.163	0.007	0.013	0.183
Nitrogen Oxides	735,730.789	43,099.979	72,586.140	851,416.909
Phenanthrene	13.805	0.590	1.127	15.521
PM_{10} Primary (Filt + Cond)	24,845.831	1,060.928	2,052.942	27,959.702
$PM_{2.5}$ Primary (Filt + Cond)	22,858.165	976.001	1,991.354	25,825.519

Table A-1. 2011 HAP Emissions by Locomotive Category (Tons per year)

Pollutant	Class I Emissions	Class II/III	Switch	Total
Propionaldehyde	225.701	10.222	30.489	266.411
Pyrene	2.591	0.111	0.213	2.914
Styrene	77.700	3.519	10.496	91.715
Sulfur Dioxide	7,641.578	299.635	608.406	8,549.619
Toluene	118.400	5.362	15.994	139.757
Volatile Organic Compounds	37,000.155	1,675.721	4,998.128	43,674.003
Xylenes (Mixed Isomers)	177.601	8.043	23.991	209.635

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