Brunswick Layover Environmental Assessment (EA)

Appendix D: Air Quality Assessment

September 2013

BRUNSWICK RAIL MAINTENANCE FACILITY

POTENTIAL AIR QUALITY IMPACTS OF PROPOSED FACILITY ON NEARBY SENSITIVE LAND USES

Parsons Brinckerhoff

August 2011

Introduction

The proposed Brunswick layover facility would service and store rail cars and locomotives. Primarily, the facility would store up to three trains in a heated space so that the locomotive engines could shut down at night during cold weather periods. Locomotive emissions, therefore, would be generated within the facility mostly during locomotive start-up periods in the morning and while idling for restocking and cleaning during brief visits during the day.

The proposed facility would be located near tracks that are being used by existing commuter and freight trains. Emission sources from the proposed facility would include:

- Six (three round-trip) commuter trains passing the site each day;
- One to two freight trains passing the site each day;
- Up to three commuter trains stored overnight within the proposed layover/maintenance building;
- Up to three commuter trains at the facility during the day for cleaning and restocking; and
- The HVAC system of the layover/maintenance building, which will to maintain the temperature inside the facility overnight at approximately 45 degree Fahrenheit.

A conservative (screening-level) air quality analysis was conducted, using the facility's schematic layout and the distance to nearby sensitive land uses, to estimate the potential air quality impacts of these emissions.

Pollutants of Concern

Criteria pollutants (i.e. pollutants for which national ambient air quality standards [NAAQS] have been established) and non-criteria toxic air contaminants (TACs) for which health risk values were developed by the U.S. Environmental Protection Agency (EPA) were considered in this analysis of potential localized impacts. The criteria pollutants considered are:

- Nitrogen dioxide (NO_2) from the diesel locomotives and the gas-fired HVAC system, and
- Particulate matter smaller than 10 microns (PM_{10}) and particulate matter smaller than 2.5 microns ($PM_{2.5}$) from diesel locomotives.

There are also a number of toxic pollutants (with various toxicities) that are either carcinogenic or non-carcinogenic that can potentially be released from diesel engine locomotive exhaust or stack (vents) of the gas-fired HVAC system of the maintenance building. These pollutants have the potential to cause cancer and other adverse health problems, including respiratory illnesses, and increased risk of heart disease.

Analysis of the representative TAC's were therefore conducted that considered both (long-term) carcinogenic and chronic non-carcinogenic and acute (short-term) health risks. For these analyses, PM_{10} emission factors were used to represent diesel PM.

Emission Factors and Rates

Emissions factors from the locomotives were estimated as follows:

- Diesel particulate matter (PM_{10}), $PM_{2.5}$, and NO_2 emissions from locomotives were estimated assuming emission standards applicable for old locomotives (i.e., manufactured before 2002), EPA Locomotive Emission Standards, Regulatory Support Document, 1998, Table 4-9, and locomotive emission rates were estimated based on a GE7FDL locomotive model, and appropriate notch settings, activity times, and idling durations;

- Emissions from the HVAC system of the maintenance building were estimated using EPA's "Compilation of Air Pollutant Emission Factors" (AP-42) emission factors for a natural gas system;
- TAC emitted from locomotive diesel engines were estimated using EPA AP-42 emission factors for speciated organic compounds for large stationary uncontrolled diesel-fuel engines (Table 3.4.-1 and 3.4.-3).
- TAC emitted from the HVAC system were estimated using EPA AP-42 emission factors for speciated organic compounds from natural gas combustion (Table 1.4.-3).

Emission rates for the locomotives were estimated based on the following layover facility operating scenario, which was supplied by the project's design engineers:

- Three trains would arrive in the evening, be stored overnight in the maintenance facility and depart in the morning;
- During the day, three trains would spend about 30 minutes idling within the facility for cleaning and restocking;
- One freight train a day travel would travel through the project area on the existing extended siding and one train every two days would travel by the project area on the new siding;
- The commuter trains, which are assumed to be 3,200 horse-power (hp) each, would idle for 30 minutes inside the building and will be moving in the project area for approximately 30 minutes over a 24-hr period (with the locomotive engines going through all notches [gears]) (Table 1); and
- The freight trains, which are assumed to be 4,200 hp each, would be moving in the project area for approximately 30 minutes over a 24-hr period (with the locomotive engines going through all notches [gears] (Table 2).

Emission rates for all applicable pollutants, together with the parameters used for the analyses, are provided in Table 3 thru 5.

Table 1
Commuter Locomotive Horse-Power and Load Factors

Notch	HP [1]	% HP in use	Percent Time in Notch [2]	Actual % time in use	Engine HP [3]	Equivalent HP Used in Analysis	Load Factors [4]
Idle	13	0.3%	47%	100%	11	11	0.3%
Dynamic	128	3.4%	6.2%	11.8%	109	13	
1	211	5.6%	7.0%	13.3%	179	24	
2	457	12.1%	5.1%	9.7%	388	38	
3	928	24.6%	5.7%	10.8%	787	85	
4	1,084	28.7%	4.7%	8.9%	919	82	
5	1,666	44.2%	4.0%	7.6%	1413	107	
6	2,375	62.9%	2.9%	5.5%	2014	111	
7	3,182	84.3%	1.4%	2.7%	2699	72	
8	3,773	100.0%	15.6%	29.7%	3,200	949	
Total for Moving Locomotive			100%	100%		1,492	47%

Assumptions:

1. Notch horsepower usage was obtained from tests conducted by Motive Power Company.

2. Percent time in each notch is based on EPA-estimated high power duty-cycles for locomotives.

3. Each commuter train locomotive is assumed to be 3,200 hp.

4. Average load factors were estimated for two operational modes: idling and moving. It is assumed that the engines go through all notches when moving.

Table 2
Freight Locomotive Horse-Power and Load Factors

Notch	HP (1)	% HP in use	Percent Time in Notch (2)	Actual % time in use	Engine HP (3)	Equivalent HP Used in Analysis	Load Factors (4)
Idle	13	0.3%	59.8%	100%	14	14	0.3%
Dynamic	128	3.4%	0.0%	0.0%	142	0	
1	211	5.6%	12.4%	30.8%	235	72	
2	457	12.1%	12.3%	30.6%	509	156	
3	928	24.6%	5.8%	14.4%	1033	149	
4	1084	28.7%	3.6%	9.0%	1207	108	
5	1666	44.2%	3.6%	9.0%	1855	166	
6	2375	62.9%	1.5%	3.7%	2644	99	
7	3182	84.3%	0.2%	0.5%	3542	18	
8	3773	100.0%	0.8%	2.0%	4,200	84	
Total for Moving Locomotive			100%	100%		866	21%

Assumptions:

1. Notch horsepower usage was obtained from tests conducted by Motive Power Company.
2. Percent time in each notch is based on EPA-estimated high power duty-cycles for locomotives.
3. Each freight train locomotive is assumed to be 4,200 hp.
4. Average load factors were estimated for two operational modes: idling and moving. It is assumed that the engines go through all notches when moving.

Table 3

PM_{10} Emission Rates for Commuter and Freight Locomotives

HMF Operations	Mode	Average Number of Locomotives	Engine Horsepower (hp)	Load Factor (%)	Tier 0 Emission Factors (g/bhp-hr)	PM_{10} Emission Rates 24-hour g/sec	PM_{10} Emission Rates Annual lb/year
Brunswick Mainline Truck Commuter Trains	Idle	5	3,200	0.3%	0.32	1.02E-	8.39E-
	Moving	6	3,200	47%	0.32	1.66E-	1.36E-
Brunswick Exist. & New Siding Freight Trains	Idle	1.5	4,200	0.3%	0.32	8.04E-05	6.61E-05
	Moving	1.5	4,200	21%	0.32	2.40E-	1.98E-
Total Train Emissions						1.92E-	1.58E-

Table 4

$PM_{2.5}$ Emission Rates for Commuter and Freight Locomotives

HMF Operations	Mode	Average Number of Locomotives	Engine Horsepower (hp)	Load Factor (%)	Tier 0 Emission Factors (g/bhp-hr)	$PM_{2.5}$ (1) Emission Rates 24-hour g/sec	$PM_{2.5}$ (1) Emission Rates Annual lb/year
Brunswick Mainline Truck Commuter Trains	Idle	5	3,200	0.3%	0.32	9.39E-	7.72E-
	Moving	6	3,200	47%	0.32	1.53E-	1.25E-
Brunswick Exist. & New Siding Freight Trains	Idle	1.5	4,200	0.3%	0.32	7.40E-05	6.08E-05
	Moving	1.5	4,200	21%	0.32	2.21E-	1.98E-
Total Train Emissions						**1.76E-**	**1.47E-**

1. $PM_{2.5}$ emissions are assumed to be 92% of the PM_{10} emissions

Table 5
NO_2 Emission Rates for Commuter and Freight Locomotives

HMF Operations	Mode	Average Number of Locomotives	Engine Horsepower (hp)	Load Factor (%)	Tier 0 Emission Factors (g/bhp-hr)	NO_2 Emission Rates 24-hour	Annual
						g/sec	lb/year
Brunswick Mainline Truck Commuter Trains	Idle	5	3,200	0.3%	8.6	2.74E-03	2.26E-
	Moving	6	3,200	47%	8.6	4.46E-01	3.66E-
Brunswick Exist. & New Siding Freight Trains	Idle	1.5	4,200	0.3%	8.6	1.24E+00	1.78E-03
	Moving	1.5	4,200	21%	8.6	6.46E-02	5.31E-
Total Train Emissions						1.76E+00	4.23E-

Dispersion Modeling

As the operation of the layover facility has the potential to cause health impacts on nearby sensitive land uses due to emissions from the locomotives and HVAC system, a conservative (preliminary) dispersion modeling analysis was conducted. EPA's AERMOD atmospheric dispersion model was used to simulate physical conditions and predict pollutant concentrations at nearby receptor locations.

AERMOD is generally applied to estimate impacts from simple point-source emissions from stacks, as well as emissions from volume and area sources. The model accepts actual hourly meteorological observations and directly estimates hourly and average concentrations for various time periods. Regulatory default options and the rural dispersion algorithm of the AERMOD model were conservatively used in the analysis.

A Cartesian grid network was developed around the facility that includes the rail tracks and the maintenance building. Based on a sketch of the prototypical facility, the closest sensitive land uses are approximately 175 feet from the existing mainline track. Therefore, the first row in Cartesian grid was placed at 175 feet south from the facility. However, the maximum concentrations found at 175 feet (or more) from the facility in any direction were used to estimate facility maximum potential impacts. These values were then added to estimated background values for the project area, and total concentrations compared with applicable federal air quality standards and health-related guideline values.

Emissions from locomotive train operations were simulated as area sources and emissions from the maintenance building's HVAC system were simulated as a point source. An emissions release height was assumed to be 3.6 meters (12) to approximate the height of the locomotive exhaust, and 10 meters (33 feet) to approximate the height of the maintenance building. Meteorological data from Boston Logan Airport were used for analysis.

Health Risk

The maximum estimated concentrations of representative TACs were used to calculate cumulative cancer risks, chronic noncancer and acute hazard indexes associated with layover facility operations.

Cancer Risk

From the multiple pollutants that may be emitted from locomotive diesel vehicular exhaust and gas-fired HVAC system operations, three pollutants are considered by EPA as carcinogens for which cancer unit risk factors were developed. These are benzene, acetaldehyde, and formaldehyde. The maximum individual cancer risk for each pollutant and total incremental cancer risks associated with these pollutants releases were calculated. Metal elements bounded to PM from natural gas combustion, such as arsenic, cadmium, nickel, and others, were considered as part of the PM10.

The cancer risk calculation procedure, methodology and equations were based on the EPA Human Health Risk Assessment Protocol (HHRAP, Appendix B, Tables B-5-1 and C-2-1), together with EPA approved health values for cancer risk assessments.

Chronic Noncancer Hazard Index

Pollutants considered are those for which non-cancer RfC (reference dose concentration) guideline values, including diesel PM, are available from EPA's Integrated Risk Information System (IRIS) or Prioritized Chronic Dose-Response Values for Screening Risk Assessments (EPA, Table 1, June 2007).

Calculations of chronic noncancer hazard index were based on the HHRAP, Appendix B, Tables C-2-1 and C-2-2) methodology and equations.

Acute Hazard Index

Acute hazard index analysis was based on HHRAP methodology and equations (HHRAP Appendix C, Table C-4-1 and B Table B-6-1).

Results

Criteria Pollutants

Total estimated concentrations of the criteria pollutants are provided in Table 6. As shown, layover facility emissions of the criteria pollutants would not cause an exceedance of an NAAQS.

Table 6
Total Estimated Concentration of the Criteria Pollutants

Pollutant	Time Period	NAAQS (ug/m3)	Estimated Impacts (ug/m3)	Background Conc. (ug/m3)*	Total Estimated Concentrations (ug/m3)	Exceed NAAQS?
NO_2	Annual	100	23.4	22.6	46	No
PM_{10}	24-hr	150	4.0	56.0	60	No
$PM_{2.5}$	24-hr	35	3.8	20.2	24	No
	Annual	15	0.8	10.42	11	No

*These are the highest values recorded at any of the State's ambient monitors in Portland Maine in 2008.

Toxic Pollutants

Chronic Noncancer Risk

As shown in Table 7, the total chronic noncancer hazard index (HI) found at a distance of 175 feet or more from the facility (0.0072) is less than 1. As such, potential chronic noncancer risks associated with layover facility operations are not considered to be significant.

Cancer Risks

Incremental cancer risks (dCR) were estimated using the maximum concentrations found at the 175 feet or more from the facility. Based on the results of this analysis (Table 7), it was determined that the overall incremental cancer impacts from all pollutants combined (5.2E-08) would be below the applicable significant threshold of one in-one million (1E-06), and, therefore, is not considered to be significant.

Acute Risk

As shown in Table 8, the total acute hazard index (AI) found at the 175 feet or more from the facility (0.078) is less than 1. As such, potential acute health risks associated with layover facility operations are not considered to be significant

Table 7
Cancer Risk and Non-Cancer Hazard Index Results

No.	Contaminant	CAS No.	Annual Conc. (C_a)	Exposure Concentration (EC) Carcinogen	Exposure Concentration (EC) Non-Carcinogen	URF	dCR	RfC	HQ
			ug/m^3	ug/m^3	ug/m^3	$(ug/m3)^{-1}$		mg/m^3	
1	Acrolein	107-02-8	0.00013		1.28E-04			2.0E-05	6.39E-03
2	Formaldehyde	50-00-0	0.00174	7.15E-04	1.67E-03	1.30E-05	9.29E-09	9.8E-03	1.70E-04
3	Acetaldehyde	75-07-0	0.00043	1.75E-04	4.09E-04	2.20E-06	3.85E-10	9.0E-03	4.54E-05
4	Benzene	71-43-2	0.01310	5.38E-03	1.26E-02	7.80E-06	4.20E-08	3.0E-02	4.19E-04
5	Xylene	1330-20-7	0.00327		3.13E-03			1.0E-01	3.13E-05
6	Toluene	108-88-3	0.00475		4.56E-03			5.0E+00	9.12E-07
7	Diesel PM (PM10)		8.77E-01		8.41E-01			5.0E+00	1.68E-04
	Cumulative Cancer Risk						5.2E-08		
	EPA Cancer Risk Threshold						1E-06		
	Total Hazard Index (HI)								7.2E-03
	Hazard Index Threshold								1

Calculations described on the following page.

Cancer Risk (dCR) and Non-Cancer Hazard Quotient (HQ) Calculations

All calculations of inhalation cancer risk and hazard quotients are based on the EPA's Human Health Risk Assessment Protocol (HHRAP) methodology and equations.

Ca values are based on the equation presented in HHRAP (Table B-5-1) using compound-specific emission rates

Ca	annual concentration estimated by the AERMOD model, ug/m3
EC	exposure concentration, ug/m3 (HHRAP, Appendix B, Table C-2-1) EC = Ca x EF x ED/AT x 365 days/year or EC = Ca x Fc, where
EF	exposure frequency, days/year, assumed by EPA to be equal 350 days/year
ED	exposure duration; Reasonable maximum exposure duration by EPA (RME) for Adult Resident = 30 years
AT	averaging time, years; AT is assumed by EPA to be equal 70 years
Fc	Fc = EF x ED/AT x 365 = 0.410958
dCR	individual lifetime cancer risk through direct inhalation of carcinogen dCR = EC x URF (HHRAP, Appendix C, Table C-2-1), where
URF	Inhalation unit risk factor, (ug/m3)-1. Source: EPA Integrated Risk Information System (IRIS)

Non-Cancer Hazard Quotients

EC	exposure concentration, ug/m3 (the same equation for EC, as above, except that ED=AT=30 years) EC = Ca x Fnc, where
Fnc	Fnc = 0.958904 (EF x ED/AT x 365)
RfC	reference concentration, mg/m3. Source: EPA Integrated Risk Information System (IRIS)
HQ	hazard quotient for direct inhalation of non-carcinogen HQ = EC x 0.001/RfC (HHRAP, Appendix C, Table C-2-2)
0.001	units conversion factor, mg/ug

Table 8
Acute Hazard Index Results (AI)

No.	Contaminant	CAS No.	1-hr Conc. (C_{acute})	Acute Exposure Criteria (AIEC)	Acute Quotients (AHQ)
			ug/m^3	mg/m^3	
1	Acrolein	107-02-8	0.01440	1.9E-04	7.6E-02
2	Formaldehyde	50-00-0	0.14358	9.4E-02	1.5E-03
3	Acetaldehyde	75-07-1	0.04620	8.1E+01	5.7E-07
4	Benzene	71-43-2	1.42002	1.3E+00	1.1E-03
5	Xylene	50-00-0	0.35400	2.2E+01	1.6E-05
6	Toluene	50-00-0	0.51500	3.7E+01	1.4E-05
Total Acute Hazard Index					7.8E-02
Acute Hazard Index Threshold					1

Potential Health Effects from Acute Exposure

All calculations of acute hazard quotients are based on the EPA's Human Health Risk Assessment Protocol (HHRAP) methodology and equations.

C_{acute} 1-hr concentration estimated by the AERMOD, ug/m3

C_{acute} values are based on the equation presented in HHRAP (Table B-6-1) using compound-specific emission rates

AIEC acute inhalation exposure criteria, mg/m3

AHQ acute hazard quotient, unitless

AHQ = C_{acute} x 0.001/AIEC (HHRAP, Appendix C, Table C-4-1)

0.001 units conversion factor, mg/ug

Conclusions

The result of these analyses are that the potential air quality impacts associated with emissions of the criteria and toxic pollutants releases from DBMSF operations are the following:

1. Maximum estimated criteria pollutant concentrations at nearby sensitive land uses are within (do not exceed) the NAAQS and, as such, project impacts are not considered to be significant;
2. The total chronic noncancer hazard index is less than threshold value of 1 and, therefore, is not considered to be significant;
3. The total acute hazard index is less than the threshold value of 1 and, therefore, is not considered to be significant; and
4. Total incremental cancer risk found is less than 1 per million and, therefore, is not considered to be significant.