APPENDIX H:
AIR QUALITY TECHNICAL TABLES

Table 1
Construction Schedule
BART to Livermore Extension
Livermore, California

Construction Tie	Segment Number	2020				2021				2022				2023				2024				Total Duration (months)
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Conventional BART (Project)																						
Hopyard to Hacienda	4					*	*	*	*	*	*	*	*	*	*	*	*					36
Hacienda to Tassajara	6					*	*	*	*	*	*	*	*	*	*	*	*					36
Tassajara Interchange	7					*	*	*	*	*	*	*	*									24
Tassajara to Fallon	8					*	*	*	*	*	*	*	*	*	*	*	*					36
Fallon Interchange	9					*	*	*	*	*	*	*	*									24
Fallon to Airway	10					*	*	*	*	*	*	*	*	*	*	*	*					36
Airway Interchange	11					*	*	*	*	*	*	*	*									24
Airway to Isabel Station	12					*	*	*	*	*	*	*	*	*	*	*	*					36
Isabel Interchange	13	*	*	*	*	*	*															18
Isabel Station BART	14	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*					48
Parking Garage / Surface South	16		*	*	*	*	*	*														18
Isabel Station to Yard	17	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*					48
Maintenance Facility / Yard	19							*	*	*	*	*	*	*	*	*	*					30
Campus Access Road	N/A							*														3
Hacienda Staging	N/A					*																3
Airway Staging	N/A					*																3
Isabel Staging	N/A	*																				3
Maintenance Facility / Yard Staging	N/A							*														3
DMU Alternative (EMU Option)																						
D/P Station Cross Transfer Platform	3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*					48
Hopyard to Hacienda	4	*	*	*	*	*	*				*	*	*	*	*	*	*					39
Hacienda Interchange	5	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*					48
Hacienda to Tassajara	6					*	*	*	*	*	*	*	*	*	*	*	*					36
Tassajara Interchange	7					*	*	*	*	*	*	*	*									24
Tassajara to Fallon	8					*	*	*	*	*	*	*	*	*	*	*	*					36
Fallon Interchange	9					*	*	*	*	*	*	*	*									24
Fallon to Airway	10					*	*	*	*	*	*	*	*	*	*	*	*					36
Airway Interchange	11					*	*	*	*	*	*	*	*									24
Airway to Isabel Station	12					*	*	*	*	*	*	*	*	*	*	*	*					36
Isabel Interchange	13	*	*	*	*	*	*															18
Isabel Station DMU/EMU	15	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*					48
Parking Garage / Surface South	16		*	*	*	*	*	*														18
Isabel Station to Yard	17	*	*	*	*	*	*	*	*	*	*	*	*	*	*							42
Maintenance Facility / Yard	18							*	*	*	*	*	*	*	*	*	*					30
Hacienda Staging	N/A	*																				3
Airway Staging	N/A					*																3
Isabel Staging	N/A	*																				3
Maintenance Facility / Yard Staging	N/A							*														3
Express Bus/BRT Alternative																						
Hopyard Interchange	1	*	*	*	*	*	*	*	*	*	*	*										33
D/P Station Express Bus Platform	2	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*				45
Hopyard to Hacienda	4	*	*	*	*	*	*	*	*	*	*	*										33
Hacienda Interchange	5	*	*	*	*	*	*	*	*	*	*	*										33
Pleasanton Station	20	*	*	*	*	*	*	*	*	*	*	*										33
Laughlin At Grade Parking	22	*	*	*	*	*	*	*	*	*	*	*										33
Hacienda Staging	N/A	*																				3

Notes:

[1] Construction phasing based on Project-specific assumptions.

[2] It was assumed that one month of staging would occur at the start of nearby construction. For example, for Conventional BART, Hacienda Staging would occur for the first month of construction activity at the Hopyard to Hacienda and Hacienda to Tassajara segments.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
DMU - Diesel Multiple Units
D/P - Dublin Pleasanton
EMU - Electrical Multiple Units

Table 2
Construction Off-Road Equipment List
BART to Livermore Extension
Livermore, California

Equipment Type	Horsepower	Load Factor	Total Usage Hours		
			Conventional BART (Project)	DMU Alternative (EMU Option)	Express Bus/BRT Alternative
Excavator	163	0.38	12,014	6,376	1,231
Dozer	255	0.40	10,109	5,365	1,036
Compactor	172	0.42	19,891	10,556	2,039
Loader	98	0.37	24,790	13,157	2,541
Dump Truck	400	0.38	19,281	10,233	1,976
Scrapers	362	0.48	9,638	5,115	988
Grader	175	0.41	6,589	3,497	675
Paver	126	0.42	452	528	91
Vibrator Compactor	81	0.38	179	210	36
Pile Drivers	206	0.50	1,840	2,320	1,680
Forklift	89	0.20	52,324	11,753	615
Crane	226	0.29	5,239	2,868	615
Air Compressors	78	0.48	210	210	120
Construction Generators	84	0.74	4,000	3,520	1,840

Notes:

[1] Horsepower and load factor are CalEEMod® (version 2013.2.2) defaults for calendar year 2020.

[2] Hours include those associated with construction and staging equipment use. Hours do not include those associated with minor bus infrastructure improvements.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
CalEEMod® - California Emissions Estimator Model
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units

References:

California Air Pollution Control Officers Association (CAPCOA). 2013. CalEEMod. Available at: http://www.caleemod.com.

Table 3
Construction Off-Road Emissions
BART to Livermore Extension
Livermore, California

Project and Alternatives	Construction Duration (days)	Emissions									
		Unmitigated					Mitigated				
		ROG	NO_x	Exhaust PM_{10}	Exhaust $PM_{2.5}$	CO_2e[4]	ROG	NO_x	Exhaust PM_{10}	Exhaust $PM_{2.5}$	CO_2e[4]
		lb/day				MT/Project	lb/day				MT/Project
Conventional BART (Project)	1,460	5.8	60	2.9	2.7	5,337	2.5	21	1.1	1.0	5,337
DMU Alternative (EMU Option)	1,460	3.0	31	1.5	1.4	2,867	1.5	13	0.67	0.62	2,867
Express Bus/BRT Alternative	1,551	0.67	6.9	0.32	0.30	706	0.60	6.1	0.28	0.26	706
Enhanced Bus Alternative	61	2.3	24	1.2	1.1	92	2.3	24	1.2	1.1	92

Notes:

[1] Off-road construction emissions were calculated using CalEEMod® (version 2013.2.2) based on the construction equipment details presented in Table 2.

[2] Mitigated emissions reflect the use of Tier 4 final equipment for specific equipment types, as listed below.
Conventional BART (Project) - compactors, dozers, dump trucks, scraping equipment, and loaders
DMU Alternative (EMU Option) - compactors, dozers, dump trucks, and scraping equipment
Express Bus/BRT Alternative - compactors

[3] Enhanced bus improvements are included for all alternatives. The bus improvements were conservatively approximated by scaling the sum of Conventional BART construction emissions, excluding Maintenance Facility/Yard activity, by the relative construction durations (i.e., BART Emissions*2 months/48 months). For each alternative, the total emissions is equal to the original scenario-specific emissions, plus the additional approximate emissions from bus improvements.

[4] Global warming potentials based on Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
CalEEMod® - California Emissions Estimator Model
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
lb - pound
MT - metric ton
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas

References:

California Air Pollution Control Officers Association (CAPCOA). 2013. CalEEMod. Available at: http://www.caleemod.com.
Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Available at http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf. Accessed: December 2016.

Table 4
Construction On-Road Trips
BART to Livermore Extension
Livermore, California

Project and Alternatives	Trip Type	Roundtrips	Total VMT
Conventional BART (Project)	Worker	92,814	2,301,794
	Vendor	63,522	927,414
	Hauling	53,056	2,122,240
DMU Alternative (EMU Option)	Worker	92,814	2,301,794
	Vendor	72,718	1,061,683
	Hauling	64,027	2,561,080
Express Bus/BRT Alternative	Worker	85,223	2,113,530
	Vendor	16,463	278,342
	Hauling	14,378	575,120

Notes:

[1] Trip lengths were based on CalEEMod® (version 2013.2.2) defaults for workers, vendors, and hauling, consistent with CalEEMod® User's Guide Appendix D. Worker trips are 12.4 miles, vendor trips are 7.3 miles, and hauling trips are 20 miles.

[2] Vendor and hauling trip rates were based on Project-specific construction assumptions.

[3] Worker trips were calculated assuming 100 roundtrips/day of construction (Project-specific assumption) and were adjusted to account for carpool and public transportation rates.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
CalEEMod® - California Emissions Estimator Model
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
VMT - Vehicle Miles Traveled

References:

California Air Pollution Control Officers Association (CAPCOA). 2013. CalEEMod. Available at: http://www.caleemod.com.

Table 5
Construction On-Road Emission Factors
BART to Livermore Extension
Livermore, California

Trip Type	Fleet Mix	Unit	ROG	NOx	Exhaust PM_{10}	Exhaust $PM_{2.5}$	CO_2e[1]
Worker	50% Light Duty Auto 25% Light Duty Trucks 1 25% Light Duty Trucks 2	g/mile	0.10	0.09	0.0020	0.0019	316
		g/trip	0.44	0.15	0.0026	0.0024	71
Vendor	100% Medium-Heavy Duty Trucks	g/mile	0.14	2.25	0.043	0.042	1,206
		g/trip	0.26	7.01	0.022	0.022	527
Hauling	100% Heavy-Heavy Duty Trucks	g/mile	0.15	4.41	0.020	0.019	1,652
		g/trip	0.21	7.22	0.025	0.025	565

Notes:

[1] Emission factors for each trip type were based on EMFAC2014 emission factors for Alameda County, Calendar Year 2020.

[2] Worker trip emission factors were weighted based on light duty auto, light duty trucks 1 and light duty trucks 2 emission factors and the fleet mix.

[3] Global warming potentials based on Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

Abbreviations:

BART - Bay Area Rapid Transit
CO_2e - carbon dioxide equivalent
EMFAC - California Air Resources Board Emissions Factor Model
g - gram
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas

References:

California Air Resources Board (ARB). 2014. EMFAC2014. Available at: https://www.arb.ca.gov/emfac/2014/
Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Available at http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf. Accessed: December 2016.

Table 6
Construction On-Road Emissions
BART to Livermore Extension
Livermore, California

Project and Alternatives	Construction Duration (days)	Emissions (lb/day)				
		lb/day				MT/Project
		ROG	NO_x	Exhaust PM_{10}	Exhaust $PM_{2.5}$	CO_2e
Conventional BART (Project)	1,460	1.3	21	0.15	0.14	5,682
DMU Alternative (EMU Option)	1,460	1.4	25	0.17	0.16	6,591
Express Bus/BRT Alternative	1,551	0.65	5.9	0.044	0.042	2,118
Enhanced Bus Alternative	61	1.1	16	0.12	0.11	189

Notes:

[1] On-road construction emissions for the Project, DMU Alternative (EMU Option), and Express Bus/BRT Alternative are calculated based on the total trips and vehicle miles in Table 4 and the emission factors in Table 5.

[2] Enhanced bus improvements are included for all alternatives. The bus improvements were conservatively approximated by scaling the sum of Conventional BART construction emissions, excluding Maintenance Facility/Yard activity, by the relative construction durations (i.e., BART Emissions*2 months/48 months). For each alternative, the total emissions is equal to the original scenario-specific emissions, plus the additional approximate emissions from bus improvements.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
lb - pound
MT - metric ton
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas

Table 7
Construction Total Emissions
BART to Livermore Extension
Livermore, California

Project and Alternatives[1,2]	Construction Duration (days)	Unmitigated Emissions					Mitigated Emissions[3]				
		ROG	NO_x	Exhaust PM_{10}	Exhaust $PM_{2.5}$	CO_2e	ROG	NO_x	Exhaust PM_{10}	Exhaust $PM_{2.5}$	CO_2e
		lb/day				MT/Project	lb/day				MT/Project
Conventional BART (Project)	1,460	17	80	3.1	2.8	11,019	14	42	1.3	1.2	11,019
DMU Alternative (EMU Option)	1,460	13	56	1.6	1.5	9,458	12	37	0.84	0.78	9,458
Express Bus/BRT Alternative	1,551	2.8	13	0.36	0.34	2,824	2.7	12	0.32	0.30	2,824
Enhanced Bus Alternative	61	13	40	1.3	1.2	281	Not Mitigated				
BAAQMD Significance Threshold (lb/day)		54	54	82	54	-	54	54	82	54	-

Notes:

[1] Total construction emissions include contributions from off-road equipment activity (Table 3), on-road traffic (Table 6), structural modifications associated with bus improvements (for Project and all alternatives), architectural coating of buildings (for the Conventional BART and DMU Alternative), and parking lot paving (for the DMU Alternative).

[2] Enhanced bus improvements are included for all alternatives. The bus improvements were conservatively approximated by scaling the sum of Conventional BART construction emissions, excluding Maintenance Facility/Yard activity, by the relative construction durations (i.e., BART Emissions*2 months/48 months). For each alternative, the total emissions is equal to the original scenario-specific emissions, plus the additional approximate emissions from bus improvements.

[3] Emissions associated with the Enhanced Bus Alternative are not mitigated.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
lb - pound
MT - metric ton
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas

Table 8
Average Daily Construction-Related Emissions
BART to Livermore Extension
Livermore, California

	Average Daily Construction Emissions (pounds/day)			
	ROG	**NO_X**	**Exhaust PM_{10}/DPM[a]**	**Exhaust $PM_{2.5}$**
Conventional BART (Project)				
Off-Road Equipment Emissions	5.8	60	2.9	2.7
Truck and Vehicle Emissions	1.3	21	0.15	0.14
Paving Off-Gas Emissions	--	--	--	--
Architectural Coating Emissions	10	--	--	--
Total	17	80	3.1	2.8
Significance Thresholds	54	54	82	54
Above Threshold?	No	Yes	No	No

	Average Daily Construction Emissions (pounds/day)			
	ROG	**NO_X**	**Exhaust PM_{10}/DPM[a]**	**Exhaust $PM_{2.5}$**
DMU Alternative (EMU Option)				
Off-Road Equipment Emissions	3.0	31	1.5	1.4
Truck and Vehicle Emissions	1.4	25	0.17	0.16
Paving Off-Gas Emissions	--	--	--	--
Architectural Coating Emissions	8.8	--	--	--
Total	13	56	1.6	1.5
Significance Thresholds	54	54	82	54
Above Threshold?	No	Yes	No	No

	Average Daily Construction Emissions (pounds/day)			
	ROG	**NO_X**	**Exhaust PM_{10}/DPM[a]**	**Exhaust $PM_{2.5}$**
Express Bus/BRT Alternative				
Off-Road Equipment Emissions	0.67	6.9	0.32	0.30
Truck and Vehicle Emissions	0.65	5.9	0.044	0.042
Paving Off-Gas Emissions	0.0051	--	--	--
Architectural Coating Emissions	1.5	--	--	--
Total	2.8	13	0.36	0.34
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

	Average Daily Construction Emissions (pounds/day)			
	ROG	**NO_X**	**Exhaust PM_{10}/DPM[a]**	**Exhaust $PM_{2.5}$**
Enhanced Bus Alternative				
Off-Road Equipment Emissions	2.3	24	1.2	1.1
Truck and Vehicle Emissions	1.1	16	0.12	0.11
Paving Off-Gas Emissions	--	--	--	--
Architectural Coating Emissions	9.2	--	--	--
Total	13	40	1.3	1.2
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

Notes:

a. For purposes of this analysis, it is conservatively assumed that all PM_{10} is DPM.

b. Paving off-gas emissions from asphalt are calculated for the Laughlin Surface Parking Lot part of the Express Bus/BRT Alternative. It is assumed that new surface roads, I-580, and covered parking lots will not require asphalt paving.

c. Construction emissions for the Enhanced Bus Alternative are very conservatively based on scaling construction emissions from Conventional BART (excluding the Maintenance Facility/Yard construction activity) based on the duration of construction. Construction of the Conventional BART Project is estimated to take 48 months while the Enhanced Bus Alternative is estimated to take 2 months. The emissions shown in this table are average daily construction emissions (i.e., emissions divided by time). Therefore the average daily construction emissions for the Enhanced Bus Alternative are similar to the emissions for the Conventional BART Project, even though total emissions will be significantly less.

Table 9
Mitigated Average Daily Construction-Related Emissions
(DMU Alternative (EMU Option))
BART to Livermore Extension
Livermore, California

	Average Daily Construction Emissions (pounds/day)			
	ROG	**NO_X**	**Exhaust PM_{10}/DPM[a]**	**Exhaust $PM_{2.5}$**
Conventional BART (Project)				
Off-Road Equipment Emissions	2.5	21	1.1	1.0
Truck and Vehicle Emissions	1.3	21	0.15	0.14
Paving Off-Gas Emissions	0	0	0	0
Architectural Coating Emissions	10	0	0	0
Total	**14**	**42**	**1.3**	**1.2**
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

	Average Daily Construction Emissions (pounds/day)			
	ROG	**NO_X**	**Exhaust PM_{10}/DPM[a]**	**Exhaust $PM_{2.5}$**
DMU Alternative (EMU Option)				
Off-Road Equipment Emissions	1.5	13	0.67	0.62
Truck and Vehicle Emissions	1.4	25	0.17	0.16
Paving Off-Gas Emissions	0	0	0	0
Architectural Coating Emissions	8.8	0	0	0
Total	**12**	**37**	**0.84**	**0.78**
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

Notes:
a. For purposes of this analysis, it is conservatively assumed that all PM_{10} is DPM.

Table 10
Mitigated Average Daily Construction-Related Emissions
(Conventional BART and Express Bus/BRT Alternative)
BART to Livermore Extension
Livermore, California

	Average Daily Construction Emissions (pounds/day)			
	ROG	**NO_X**	**Exhaust PM_{10}/DPM[a]**	**Exhaust $PM_{2.5}$**
Express Bus/BRT Alternative				
Off-Road Equipment Emissions	0.60	6.1	0.28	0.26
Truck and Vehicle Emissions	0.65	5.9	0.044	0.042
Paving Off-Gas Emissions	0.0051	0	0	0
Architectural Coating Emissions	1.5	0	0	0
Total	**2.7**	**12**	**0.32**	**0.30**
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

Notes:

a. For purposes of this analysis, it is conservatively assumed that all PM_{10} is DPM.

Table 11
Operational Emission Inventory Components
BART to Livermore Extension
Livermore, California

Emission Component	Conventional BART (Project)	DMU Alternative (EMU Option)	Express Bus/BRT Alternative	Enhanced Bus Alternative
Mobile Vehicles				
Passenger Vehicles	X	X	X	X
Buses	X	X	X	X
Maintenance Trucks	X	X		
Shuttle Van	X			
Transit Operations				
BART Operation	X	X	X	
DMU/EMU Operation		X		
Station and Maintenance Area Operations				
Station Electricity	X	X		
Emergency Generators	X	X		
Water and Wastewater	X	X	X	X
Solid Waste	X	X	X	X
Solvent Use	X	X		
Area Coating	X	X	X	
Solar PV Generation	X	X		
Forklifts	X	X		

Notes:

[1] Not all emission components are sources of emissions. For example, avoided emissions due to solar PV electricity generation and diverted passenger vehicle trips are quantified as negative emissions.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
PV - photovoltaic

Table 12
Operational Mobile Emission Factors
BART to Livermore Extension
Livermore, California

Operational Year	Trip Type	Fleet Mix	Fuel Type	Unit	Emission Factors[1]				
					ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e[4]
2025	Passenger Vehicles[2]	50% Light Duty Auto 25% Light Duty Trucks 1 25% Light Duty Trucks 2	Gas, Diesel, Electric	g/mile	0.0091	0.046	0.046	0.019	249
				g/trip	0.50	0.068	0.0023	0.0021	58
	Non-LAVTA Buses	100% Urban Buses	Diesel	g/mile	0.82	19	1.2	0.74	2,404
				g/trip	9.1	96	2.6	2.5	9,766
	LAVTA Buses			g/mile	0.82	4.8	0.040	0.040	2,043
				g/trip	9.1	96	2.6	2.5	8,302
	Maintenance Trucks	100% Light-Heavy Duty Trucks 1	Diesel	g/mile	0.16	1.7	0.11	0.060	556
				g/trip	3.2	58	0.70	0.67	3,874
	Shuttle Van	100% Light-Heavy Duty Trucks 1	Diesel	g/mile	0.16	1.7	0.11	0.060	556
				g/trip	3.2	58	0.70	0.67	3,874
2040	Passenger Vehicles[2]	50% Light Duty Auto 25% Light Duty Trucks 1 25% Light Duty Trucks 2	Gas, Diesel, Electric	g/mile	0.004	0.021	0.045	0.018	184
				g/trip	0.22	0.016	0.0011	0.0010	40
	Non-LAVTA Buses	100% Urban Buses	Diesel	g/mile	0.20	5.0	0.95	0.45	2,117
				g/trip	2.8	35	0.89	0.85	8,731
	LAVTA Buses			g/mile	0.20	4.8	0.040	0.040	1,800
				g/trip	2.8	35	0.89	0.85	7,421
	Maintenance Trucks	100% Light-Heavy Duty Trucks 1	Diesel	g/mile	0.13	0.29	0.10	0.045	524
				g/trip	3.2	31	0.41	0.39	3,606
	Shuttle Van	100% Light-Heavy Duty Trucks 1	Diesel	g/mile	0.13	0.29	0.10	0.045	524
				g/trip	3.2	31	0.41	0.39	3,606

Notes:

[1] Emission factors for each trip type were based on EMFAC2014 emission factors for Alameda County, Calendar Years 2025 and 2040. Idling emission factors in g/idle-hour for urban buses and light-heavy duty trucks were calculated using EMFAC2014's Project-Level assessment for Alameda County.

[2] Passenger vehicle emission factors were weighted based on light duty auto, light duty trucks 1 and light duty trucks 2 emission factors and the fleet mix.

[3] The LAVTA urban bus PM_{10} and NO_x emission factors in g/mile were calculated based on an emissions factor of 0.01 g/bhp-hr and 1.2 g/bhp-hr, respectively (as required by the ARB Fleet Rule for Transit Agencies - Urban Bus Requirements, 13 CRR §2023.1), and a conversion factor from ARB's Carl Moyer Program Guidelines Appendix D Table D-28 for urban buses. Specific PM and NO_x reduction information was not available for non-LAVTA bus lines associated with the project, thus EMFAC2014-based emission factors are conservatively used.

[4] Global warming potentials based on Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

Abbreviations:

ARB - California Air Resources Board
BART - Bay Area Rapid Transit
CO_2e - carbon dioxide equivalent
EMFAC - California Air Resources Board Emissions Factor Model
g - gram
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas

References:

California Air Resources Board (ARB). 2014. EMFAC2014. Available at: https://www.arb.ca.gov/emfac/2014/
California Air Resources Board (ARB). 2015. Carl Moyer Program Guidelines. Available at:
Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Available at http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf. Accessed: December 2016.

Table 13
Operational Passenger Vehicle Emissions
BART to Livermore Extension
Livermore, California

Operational Year	Scenario	Project and Alternatives	Net New Annual VMT[1]	Net New Annual Trips[1]	Emissions[2]				
					tons/yr				
					ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
2025	Project	Conventional BART (Project)	-38,250,574	-1,590,000	-1.3	-2.1	-2.0	-0.82	-9,616
		DMU Alternative (EMU Option)	-28,578,215	-1,290,000	-0.99	-1.5	-1.5	-0.61	-7,191
		Express Bus/BRT Alternative	-13,357,023	-510,000	-0.41	-0.72	-0.69	-0.29	-3,355
		Enhanced Bus Alternative	-75,668	-90,000	-0.05	-0.01	-0.004	-0.002	-24
	Cumulative	Conventional BART + INP + garage	-32,649,225	-1,770,000	-1.3	-1.8	-1.7	-0.70	-8,232
		DMU/EMU + INP + garage	-21,858,079	-1,350,000	-0.96	-1.2	-1.1	-0.47	-5,521
		Express Bus/BRT + garage	-19,509,613	-750,000	-0.61	-1.0	-1.0	-0.42	-4,901
		Enhanced Bus + garage	-8,705,948	-330,000	-0.27	-0.47	-0.447	-0.186	-2,187
2040	Project	Conventional BART (Project)	-73,770,403	-2,473,847	-0.9	-1.7	-3.7	-1.5	-13,669
		DMU Alternative (EMU Option)	-42,745,966	-1,476,313	-0.53	-1.0	-2.1	-0.9	-7,922
		Express Bus/BRT Alternative	-28,586,697	-1,091,502	-0.38	-0.67	-1.4	-0.58	-5,302
		Enhanced Bus Alternative	-2,722,388	-2,816,263	-0.70	-0.11	-0.14	-0.06	-614
	Cumulative	Conventional BART + INP + garage	-82,390,212	-2,981,257	-1.1	-1.9	-4.1	-1.67	-15,275
		DMU/EMU + INP + garage	-49,924,896	-1,779,220	-0.63	-1.2	-2.5	-1.01	-9,255
		Express Bus/BRT + garage	-34,691,838	-1,084,605	-0.40	-0.8	-1.7	-0.70	-6,425
		Enhanced Bus + garage	-8,834,264	-232,518	-0.09	-0.21	-0.44	-0.18	-1,634

Notes:

[1] Passenger vehicle VMT and trips are project-specific estimates provided by Cambridge Systematics. The Project has a net negative impact on passenger vehicle traffic activity, resulting in negative (avoided) emissions.

[2] Operational on-road passenger vehicle emissions calculated based on the passenger vehicle total trips and vehicle miles and the emission factors shown in Table 12.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - bus rapid transit
CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
INP - Isabel Neighborhood Plan
MT - metric tons
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
N_2O - nitrous oxide
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas
VMT - vehicle miles traveled
yr - year

Table 14
Operational Bus Emissions
BART to Livermore Extension
Livermore, California

Operational Year	Scenario	Project and Alternatives	Net New Annual VMT[1]	Net New Annual Trips[1]	Emissions[2]				
					tons/yr				
					ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
2025	Project and Cumulative	Conventional BART (Project)	592,392	29,896	0.56	4.3	0.11	0.08	1,251
		DMU Alternative (EMU Option)	592,392	29,896	0.56	4.3	0.11	0.08	1,251
		Express Bus/BRT Alternative	738,089	29,628	0.69	4.2	0.04	0.04	1,528
		Enhanced Bus Alternative	660,713	28,068	0.62	3.7	0.04	0.04	1,369
2040	Project and Cumulative	Conventional BART (Project)	592,392	29,896	0.14	3.2	0.08	0.05	1,103
		DMU Alternative (EMU Option)	592,392	29,896	0.14	3.2	0.08	0.05	1,103
		Express Bus/BRT Alternative	738,089	29,628	0.17	4.0	0.03	0.03	1,347
		Enhanced Bus Alternative	660,713	28,068	0.15	3.6	0.03	0.03	1,207

Notes:

[1] Bus activity changes attributed to the Project are based on schedule information provided by Arup, as shown in the Bus Operations Memo (August 2015) and updated in February 2017. Net New Annual VMT is based on the number of net new trips between the Project (or Alternative) and No Project, provided in the Bus Operations Memo. Ramboll Environ estimated route distance using Google Earth and GIS tools. Net New Trips multiplied by the Trip Length gives the Net New Annual VMT. The Net New Annual VMT used in the Air Quality, Greenhouse Gas, and Energy sections may differ from the Net New Annual VMT used in the Transportation section due to different methods in deriving trip length. However, differences are expected to be small (less than 5%), and the VMT used for the Air Quality, Greenhouse Gas, and Energy analysis is more conservative.

[2] Operational on-road bus emissions calculated based on the bus total trips and vehicle miles and the emission factors in Table 12. It was assumed that each bus trip includes five minutes of idling.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
MT - metric tons
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas
VMT - vehicle miles traveled
yr - year

References:

Arup. February 2017. *Final Proposed Bus Operating Plans for BLVX Alternatives.*

Table 15
Operational Maintenance Truck and Shuttle Emissions
BART to Livermore Extension
Livermore, California

Source	Operational Year	Scenario	Project and Alternatives	Net New Annual VMT[1]	Net New Annual Idling[1]	Emissions[2]				
						tons/yr				
				mile/yr	hours/yr	ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
Maintenance Trucks	2025	Project and Cumulative	Conventional BART (Project)	8,030	122	1.9E-03	2.3E-02	1.1E-03	6.2E-04	4.9
			DMU Alternative (EMU Option)	8,030	122	1.9E-03	2.3E-02	1.1E-03	6.2E-04	4.9
			Express Bus/BRT Alternative	0	0	0	0	0	0	0
			Enhanced Bus Alternative	0	0	0	0	0	0	0
	2040	Project and Cumulative	Conventional BART (Project)	8,030	122	1.6E-03	6.8E-03	9.2E-04	4.5E-04	4.6
			DMU Alternative (EMU Option)	8,030	122	1.6E-03	6.8E-03	9.2E-04	4.5E-04	4.6
			Express Bus/BRT Alternative	0	0	0	0	0	0	0
			Enhanced Bus Alternative	0	0	0	0	0	0	0
Shuttles	2025	Project and Cumulative	Conventional BART (Project)	7,300	243	2.2E-03	2.9E-02	1.1E-03	6.6E-04	5.0
			DMU Alternative (EMU Option)	0	0	0	0	0	0	0
			Express Bus/BRT Alternative	0	0	0	0	0	0	0
			Enhanced Bus Alternative	0	0	0	0	0	0	0
	2040	Project and Cumulative	Conventional BART (Project)	7,300	243	1.9E-03	1.1E-02	9.0E-04	4.7E-04	4.7
			DMU Alternative (EMU Option)	0	0	0	0	0	0	0
			Express Bus/BRT Alternative	0	0	0	0	0	0	0
			Enhanced Bus Alternative	0	0	0	0	0	0	0

Notes:

[1] Annual VMT and idling hours provided by Project sponsor based on expected maintenance yard operations. Two maintenance trucks are expected to travel approximately 11 miles per day and idle for a total of 10 minutes per day.

[2] Operational maintenance truck emissions calculated based on the maintenance truck total vehicle miles and idling hours and the emission factors in Table 12.

[3] Operational shuttle emissions calculated based on the shuttle total vehicle miles and idling hours and the emission factors in Table 12.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
INP - Isabel Neighborhood Plan
MT - metric tons
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas
VMT - vehicle miles traveled
yr - year

Table 16
Operational BART Emissions
BART to Livermore Extension
Livermore, California

Operational Year	Scenario	Project and Alternatives	Net New Annual Rail Car-Miles[1]	Emissions[2,3] tons/yr				MT/yr
				ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
2025	Project and Cumulative	Conventional BART (Project)	2,895,844	0	0	0	0	664
		DMU Alternative (EMU Option)	558,771	0	0	0	0	128
		Express Bus/BRT Alternative	111,839	0	0	0	0	26
		Enhanced Bus Alternative	-	0	0	0	0	0
2040	Project and Cumulative	Conventional BART (Project)	2,942,659	0	0	0	0	674
		DMU Alternative (EMU Option)	1,165,551	0	0	0	0	267
		Express Bus/BRT Alternative	495,158	0	0	0	0	113
		Enhanced Bus Alternative	-	0	0	0	0	0

Notes:

[1] Annual rail car-miles and trips provided by Connetics Transportation Group based on expected BART operations.

[2] Emissions account for electricity demand for BART operations and energy demand for rail car maintenance. Electricity use was estimated using a traction electricity demand of 4.51 kWh/rail car-mile from the 2009 BART to Livermore Draft Environmental Impact Report, Section 3.15, Energy (2009). Traction electricity demand was based on historical traction electricity consumption data and rail car-miles. Maintenance energy was based on an energy demand of 7,060 BTU/rail car-mile, as published in the Caltrans Energy and Transportation Systems report, Table E-13

[3] The electricity CO_2e emission factor is based on BART 2017 electricity portfolio projections, which is assumed to serve as a conservative assumption of electricity intensity for Project years 2025 and 2040. Global warming potentials used in these projections are based on the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR). The impact of using SAR potentials as opposed to Fourth Assessment Report potentials (which is used throughout the rest of the GHG analysis) is expected to be less than 2%.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
BTU - British thermal unit
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
kWh - kilowatt-hour
MT - metric tons
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas
VMT - vehicle miles traveled
yr - year

References:

Bay Area Rapid Transit. *E-mail communications with N. Miksis.* January 2017.
California Department of Transportation. *Energy and Transportation Systems*. 1983. Available online at: ftp://ftp.odot.state.or.us/techserv/Geo-Environmental/Air_Noise_Energy/Energy/. Accessed: December 2016.

Table 17
Operational DMU Emissions
BART to Livermore Extension
Livermore, California

Operational Year	Scenario	Project and Alternatives	Net New Annual Rail Car-Miles[1]	Net New Annual Trips[1]	Emissions[2,3]				
					tons/yr				
			mile/yr	trips/yr	ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
2025	Project and Cumulative	Conventional BART (Project)	0	0	0	0	0	0	0
		DMU Alternative (EMU Option)	776,400	25,265	0.77	1.5	0.077	0.077	2,404
		Express Bus/BRT Alternative	0	0	0	0	0	0	0
		Enhanced Bus Alternative	0	0	0	0	0	0	0
2040	Project and Cumulative	Conventional BART (Project)	0	0	0	0	0	0	0
		DMU Alternative (EMU Option)	864,100	27,439	0.86	1.7	0.086	0.086	2,675
		Express Bus/BRT Alternative	0	0	0	0	0	0	0
		Enhanced Bus Alternative	0	0	0	0	0	0	0

Notes:

[1] Annual rail car-miles and trips provided by Connetics Transportation Group based on expected DMU operations.

[2] Emissions account for energy use for DMU operations and energy demand for rail car maintenance. Energy use rates for running (in kWh/mile) were based on the 2008 LTK Report, "DMU and LRV Comparison," where DMU rates were modeled after eBART DMU operations. DMU energy use rates are estimated to be 4.5 kWh/rail car-mile and account for Project-specific assumptions for average rail cars per train and miles per roundtrip. Maintenance energy was based on an energy demand of 7,060 BTU/rail car-mile, as published in the Caltrans Energy and Transportation Systems report, Table E-13 (1983). Global warming potentials for direct (non-electricity) emissions are based on Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

[3] It is assumed that the unit uses electricity while idling at stations. The electricity CO_2e emission factor is based on BART 2017 electricity portfolio projections, which is assumed to serve as a conservative assumption of electricity intensity for Project years 2025 and 2040. Global warming potentials used in these projections are based on the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR). The impact of using SAR potentials as opposed to Fourth Assessment Report potentials (which is used throughout the rest of the GHG analysis) is expected to be less than 2%.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
BTU - British thermal unit
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
kWh - kilowatt-hour
MT - metric tons
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas
yr - year

References:

Bay Area Rapid Transit. *E-mail communications with N. Miksis.* January 2017.

California Air Pollution Control Officers Association (CAPCOA). 2013. CalEEMod. Available at: http://www.caleemod.com.

California Department of Transportation. *Energy and Transportation Systems*. 1983. Available online at: ftp://ftp.odot.state.or.us/techserv/Geo-Environmental/Air_Noise_Energy/Energy/. Accessed: December 2016.

Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Available at http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf. Accessed: December 2016.

LTK Engineering Services. *eBART Phase I Project to Hillcrest Terminal: DMU and LRV Comparison*. 2008.

Table 18
Operational EMU Emissions
BART to Livermore Extension
Livermore, California

Operational Year	Scenario	Project and Alternatives	Net New Annual Car-Miles[1]	Net New Annual Trips	Emissions[2,3]				
					tons/yr				
			mile/yr	trips/yr	ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
2025	Project and Cumulative	Conventional BART (Project)	0	0	0	0	0	0	0
		DMU Alternative (EMU Option)	776,400	25,265	0	0	0	0	171
		Express Bus/BRT Alternative	0	0	0	0	0	0	0
		Enhanced Bus Alternative	0	0	0	0	0	0	0
2040	Project and Cumulative	Conventional BART (Project)	0	0	0	0	0	0	0
		DMU Alternative (EMU Option)	864,100	27,439	0	0	0	0	190
		Express Bus/BRT Alternative	0	0	0	0	0	0	0
		Enhanced Bus Alternative	0	0	0	0	0	0	0

Notes:

[1] Annual VMT and trips provided by Connetics Transportation Group based on expected EMU operations.

[2] Emissions account for energy use for EMU operations and energy demand for car maintenance. Energy use rates for running (in kWh/mile) and idling (in kWh/idle-minute) were based on the 2008 LTK Report, "DMU and LRV Comparison," where EMU factors were modeled after electric LRV operations. EMU energy use rates are estimated to be 4.3 kWh/car-mile and 1.8 kWh/idle-minute, and account for Project-specific assumptions for average cars per train, miles per roundtrip, and idling time per trip. Maintenance energy was based on an energy demand of 7,060 BTU/car-mile, as published in the Caltrans Energy and Transportation Systems report, Table E-13 (1983).

[3] The electricity CO_2e emission factor is based on BART 2017 electricity portfolio projections, which is assumed to serve as a conservative assumption of electricity intensity for Project years 2025 and 2040. Global warming potentials used in these projections are based on the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR). The impact of using SAR potentials as opposed to Fourth Assessment Report potentials (which is used throughout the rest of the GHG analysis) is expected to be less than 2%.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
BTU - British thermal unit
CalEEMod® - California Emissions Estimator Model
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
kWh - kilowatt-hour
MT - metric tons
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas
yr - year

References:

Bay Area Rapid Transit. *E-mail communications with N. Miksis.* January 2017.
California Air Pollution Control Officers Association (CAPCOA). 2013. CalEEMod. Available at: http://www.caleemod.com.
California Department of Transportation. *Energy and Transportation Systems*. 1983. Available online at: ftp://ftp.odot.state.or.us/techserv/Geo-Environmental/Air_Noise_Energy/Energy/. Accessed: December 2016.
Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Available at http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf. Accessed: December 2016.
LTK Engineering Services. *eBART Phase I Project to Hillcrest Terminal: DMU and LRV Comparison*. 2008.

Table 19
Operational Station Electricity
BART to Livermore Extension
Livermore, California

Operational Year	Scenario	Project and Alternatives	Electricity Usage[1] (kWh/year)	Emissions[2]				
				tons/yr				MT/yr
				ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
2025	Project and Cumulative	Conventional BART (Project)	2,847,609	0	0	0	0	126
		DMU Alternative (EMU Option)	2,847,609	0	0	0	0	126
		Express Bus/BRT Alternative	-	0	0	0	0	-
		Enhanced Bus Alternative	-	0	0	0	0	-
2040	Project and Cumulative	Conventional BART (Project)	2,847,609	0	0	0	0	126
		DMU Alternative (EMU Option)	2,847,609	0	0	0	0	126
		Express Bus/BRT Alternative	-	0	0	0	0	-
		Enhanced Bus Alternative	-	0	0	0	0	-

Notes:

[1] Electricity use is based on the average, including losses, from calendar years 2012-2014 for an existing and comparable BART station in East Dublin/Pleasanton.

[2] The electricity CO_2e emission factor is based on BART 2017 electricity portfolio projections, which is assumed to serve as a conservative assumption of electricity intensity for Project years 2025 and 2040. Global warming potentials used in these projections are based on the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR). The impact of using SAR potentials as opposed to Fourth Assessment Report potentials (which is used throughout the rest of the GHG analysis) is expected to be less than 2%.

Abbreviations:

BAAQMD - Bay Area Air Quality Management District
BRT - Bus Rapid Transit
BART - Bay Area Rapid Transit
CalEEMod® - California Emissions Estimator Model
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
kWh - kilowatt-hour
MT - metric tons
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas
yr - year

References:

Bay Area Rapid Transit. *E-mail communications with N. Miksis.* January 2017.

California Air Pollution Control Officers Association (CAPCOA). 2013. CalEEMod. Available at: http://www.caleemod.com.

Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Available at http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf. Accessed: December 2016.

Table 20
Operational Generator Emissions
BART to Livermore Extension
Livermore, California

Isabel Station Engine Parameters	ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
ARB Diesel-Fired Emission Factor (g/bhp-hr)[1]	0.26	4.6	0.02	0.02	526
Annual Usage (hr/yr)	24				
Rated Power (bhp)	3,351				

Operational Year	Scenario	Project and Alternatives	Isabel Station Generator Emissions[2]				
			tons/yr				MT/yr
			ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
2025 and 2040	Project and Cumulative	Conventional BART (Project)	0.023	0.40	0.002	0.002	42
		DMU Alternative (EMU Option)	0.023	0.40	0.002	0.002	42
		Express Bus/BRT Alternative	0	0	0	0	0
		Enhanced Bus Alternative	0	0	0	0	0

Maintenance Facility Engine Parameters	ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
ARB Diesel-Fired Emission Factor (g/bhp-hr)[1]	0.16	2.9	0.15	0.15	526
Annual Usage (hr/yr)	50				
Rated Power (bhp)	670				

Operational Year	Scenario	Project and Alternatives	Maintenance Facility Generator Emissions[3]				
			tons/yr				MT/yr
			ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
2025 and 2040	Project and Cumulative	Conventional BART (Project)	0.006	0.11	0.006	0.006	18
		DMU Alternative (EMU Option)	0.006	0.11	0.006	0.006	18
		Express Bus/BRT Alternative	0	0	0	0	0
		Enhanced Bus Alternative	0	0	0	0	0

Notes:

[1] Diesel engine emission factors for NMHC, NO_x, PM_{10}, and $PM_{2.5}$ based on ARB Off-Road Compression-Ignition (Diesel) Engine Tier 2 Standards. Emission factors for ROG and TOG were converted from NMHC using USEPA hydrocarbon conversion factors (USEPA 2010). Emission factor for CO_2 from AP-42, Section 3.4 (USEPA 1996). PM_{10} and $PM_{2.5}$ emission factors for the Isabel Station engine assume 85% control with the use of a diesel particulate filter (DPF).

[2] Emissions assume one 2500-kW (3351-HP) emergency generator operated 24 hours/year for non-emergency maintenance and testing. Note that this analysis conservatively assumes operation at 100% capacity (load factor = 1) during emissions tests.

[3] Emissions assume one 500-kW (670-HP) emergency generator operated 50 hours/year for non-emergency maintenance and testing. Note that this analysis conservatively assumes operation at 100% capacity (load factor = 1) during emissions tests.

Abbreviations:

ARB - [California] Air Resources Board
BART - Bay Area Rapid Transit
bhp - brake horsepower
BRT - Bus Rapid Transit
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
DPF - Diesel Particulate Filter
EMU - Electrical Multiple Units
g - gram
hr - hour
HP - horsepower
kW - kilowatt
MT - metric tons
NMHC - non-methane hydrocarbons
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas
TOG - total organic gas
USEPA - United States Environmental Protection Agency
yr - year

References:

ARB/USEPA. Table 1: ARB and USEPA Off-Road Compression-Ignition (Diesel) Engine Standards. Available online at: http://www.arb.ca.gov/msprog/ordiesel/documents/Off-Road_Diesel_Stds.xls

USEPA. 1996. AP 42, Volume I, Fifth Edition (1996). §3.3 Gasoline And Diesel Industrial Engines. Available online at: http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s03.pdf

USEPA. 2010. Conversion Factors for Hydrocarbon Emission Components, NR-002d. EPA-420-R-10-015. July. Available online at: http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2010/420r10015.pdf

Table 21
Operational Solvent Emissions
BART to Livermore Extension
Livermore, California

Operational Year	Scenario	Project and Alternatives	Solvent Usage[1] (gal/year)	Emissions[2]				
				tons/yr				MT/yr
				ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
2025 and 2040	Project and Cumulative	Conventional BART (Project)	20	0.08	0	0	0	0
		DMU Alternative (EMU Option)	20	0.08	0	0	0	0
		Express Bus/BRT Alternative	0	0	0	0	0	0
		Enhanced Bus Alternative	0	0	0	0	0	0

Notes:

[1] Solvent usage in the form of brake cleaners and wipe cleaner solvents are estimated to be less than 20 gallons per year, with total emissions not to exceed 150 pounds/year, in accordance with the BAAQMD permitting exemption in Regulation 2-1-118-9.1

[2] VOC content in solvents and surface cleaners will comply with the BAAQMD VOC limit in Regulation 8-4-302.3.

Abbreviations:

BAAQMD - Bay Area Air Quality Management District
BRT - Bus Rapid Transit
BART - Bay Area Rapid Transit
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
gal - gallons
MT - metric tons
NO - nitric oxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxide compounds (NO + NO_2)
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas
VOC - volatile organic compounds
yr - year

References:

Bay Area Air Quality Management District. Current Rules. Available at: http://www.baaqmd.gov/rules-and-compliance/current-rules. Accessed: December 2016.

Table 22
Operational Area Coating Emissions
BART to Livermore Extension
Livermore, California

Operational Year	Scenario	Alternative	Total Floor Area	Total Building Surface Area[1]	Application Rate[2]	Paint VOC EF[3]		Emissions[4]				
						Indoor	Outdoor	lbs/yr				MT/yr
			square feet			g/L		ROG	NO_x	PM_{10}	$PM_{2.5}$	CO_2e
2025 and 2040	Project and Cumulative	Conventional BART (Project)	1,379,033	2,758,066	10%	100	150	1,438	-	-	-	-
		DMU Alternative (EMU Option)	1,172,599	2,345,199	10%	100	150	1,223	-	-	-	-
		Express Bus/BRT Alternative	291,967	329,308	10%	100	150	172	-	-	-	-
		Enhanced Bus Alternative	-	-	-	-	-	-	-	-	-	-

Notes:

[1] Consistent with CalEEMod® (version 2013.2.2), non-residential building surface area is assumed to be 2 times the floor area. Also consistent with CalEEMod®, the parking painted area is assumed to be 6% of the total surface area.

[2] Consistent with CalEEMod®, 10% of all surfaces are assumed to be coated each year.

[3] Based on BAAQMD paint VOC regulations, 100 g/L for flat paints, generally used indoors, and 150 g/L for all other architectural coatings. Building area is assumed to be 75% indoors and 25% outdoors, consistent with CalEEMod®.

[4] Uses CalEEMod® assumption that 1 gallon of paint covers 180 square feet.

Abbreviations:

BAAQMD - Bay Area Air Quality Management District
BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
CalEEMod® - California Emissions Estimator Model
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EF - emission factor
EMU - Electrical Multiple Units
g - gram
L - liter
MT - metric tons
NO_x - nitrogen oxide compounds (NO + NO_2)
NO_2 - nitrogen dioxide
NO - nitric oxide
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
ROG - reactive organic gas
VOC - volatile organic compounds
yr - year

References:

California Air Pollution Control Officers Association (CAPCOA). 2013. CalEEMod. Available at: http://www.caleemod.com.

Table 23
Operational Water and Wastewater Emissions
BART to Livermore Extension
Livermore, California

Operational Year	Scenario	Project and Alternatives	Water Consumption[1] gallon/yr	Emission Source	2025 and 2040 Emissions[2,3] MT CO_2e/yr
					2025 and 2040
2025 and 2040	Project and Cumulative	Conventional BART (Project)	5,488,117	**Indirect Emissions from Water and Wastewater**	
				Supply Water	1.54
				Treat Water	0.08
				Distribute Water	0.93
				Treat Wastewater	1.39
				Direct Emissions from Wastewater Treatment	
				Septic Tank	2.37
				Aerobic Processes	2.08
				Facultative Lagoons	0.83
2025 and 2040	Project and Cumulative	DMU Alternative (EMU Option)	3,636,758	**Indirect Emissions from Water and Wastewater**	
				Supply Water	1.02
				Treat Water	0.05
				Distribute Water	0.61
				Treat Wastewater	0.92
				Direct Emissions from Wastewater Treatment	
				Septic Tank	1.86
				Aerobic Processes	1.63
				Facultative Lagoons	0.65
2025 and 2040	Project and Cumulative	Express Bus/BRT Alternative	1,326,426	**Indirect Emissions from Water and Wastewater**	
				Supply Water	0.37
				Treat Water	0.02
				Distribute Water	0.22
				Treat Wastewater	0.34
				Direct Emissions from Wastewater Treatment	
				Septic Tank	0.74
				Aerobic Processes	0.65
				Facultative Lagoons	0.26
2025 and 2040	Project and Cumulative	Enhanced Bus Alternative	688,715	**Indirect Emissions from Water and Wastewater**	
				Supply Water	0.19
				Treat Water	0.01
				Distribute Water	0.12
				Treat Wastewater	0.17
				Direct Emissions from Wastewater Treatment	
				Septic Tank	0.42
				Aerobic Processes	0.37
				Facultative Lagoons	0.15

Notes:

[1] Water consumption includes use at the Dublin/Pleasanton and Isabel stations, the Maintenance Facility, and wayside facilities. Estimates of consumption are primarily based on historical usage at existing and comparable BART facilities, scaled for anticipated level of activity. Energy use consists of upstream electricity to supply, treat, and distribute water and downstream electricity to treat wastewater.

[2] Water electricity intensity factors and wastewater treatment emission factors consistent with CalEEMod® (version 2013.2.2), for Alameda County.

[3] The electricity CO_2e emission factor is based on PG&E CO_2 projections for 2020 and CalEEMod® (version 2013.2.2) defaults for CH_4 and N_2O. This is a conservative estimate, as electricity GHG emissions are expected to decrease by 2025 and 2040. Global warming potentials are based on Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

Abbreviations:

ARB - [California] Air Resources Board
BART - Bay Area Rapid Transit
CalEEMod® - California Emissions Estimator Model
CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
GHG - greenhouse gas
MT - metric tons
N_2O - nitrous oxide
yr - year

References:

Bay Area Rapid Transit. *BLX Utilities Demand Table.* May 2017.
California Air Pollution Control Officers Association (CAPCOA). 2013. CalEEMod. Available at: http://www.caleemod.com.
Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Available at http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf. Accessed: December 2016.

Table 24
Operational Solid Waste Emissions
BART to Livermore Extension
Livermore, California

Operational Year	Scenario	Project and Alternatives	Waste Disposal[1] ton/yr	2025 and 2040 Emissions[2,3] MT CO_2e/yr
2025 and 2040	Project and Cumulative	Conventional BART (Project)	888	447
2025 and 2040	Project and Cumulative	DMU Alternative (EMU Option)	458	231
2025 and 2040	Project and Cumulative	Express Bus/BRT Alternative	206	103
2025 and 2040	Project and Cumulative	Enhanced Bus Alternative	103	52

Notes:

[1] Waste estimates include disposal at the Dublin/Pleasanton and Isabel stations, the Maintenance Facility, and wayside facilities. Estimates of disposal are primarily based on historical generation at existing and comparable BART facilities, scaled for anticipated level of activity.

[2] Solid waste landfill gas emissions calculation consistent with CalEEMod® (version 2013.2.2), for Alameda County.

[3] Global warming potentials based on Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

Abbreviations:

ARB - [California] Air Resources Board
BART - Bay Area Rapid Transit
CalEEMod® - California Emissions Estimator Model
CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
GHG - greenhouse gas
IPCC - Intergovernmental Panel on Climate Change
MT - metric tons
N_2O - nitrous oxide
yr - year

References:

Bay Area Rapid Transit. *BLX Utilities Demand Table.* May 2017.
Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Available at http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf. Accessed: December 2016.
California Air Pollution Control Officers Association (CAPCOA). 2013. CalEEMod. Available at: http://www.caleemod.com.

Table 25
Operational Forklift Emissions
BART to Livermore Extension
Livermore, California

Alternative	Parameters	Unit	Value
Conventional BART (Project) and DMU Alternative (EMU Option)	Hours of Operation per Day	hr/day	8
	Operation Day per Year	days/year	365
	# of Forklift Needed	# of forklift	2
	Forklift Horsepower[1]	HP	75
	Forklift Load Factor[2]	-	0.20
	Unit Conversion	kW/hp	0.75
	Energy Efficiency[3]	-	0.64
	2025/2040 CO_2e Intensity Factor[4]	lb/MWh	97.3
	2025/2040 Total Forklift Emissions	**MT CO_2e/yr**	**4.5**

Notes:

[1] Industrial average based on review of electric forklift product specifications.

[2] Default values from ARB's In-Use Offroad Equipment Inventory Model (OFFROAD2011).

[3] The equipment energy efficiency is estimated by multiplying the average Charge Return Factor and Power Factor present in PG&E's efficient forklift battery charger fact sheet.

Charge Return Factor: the ratio of energy supplied to the battery to energy delivered by the battery.
Power Factor: the ratio of real power performing work to apparent power in an electrical system.

[4] The electricity CO_2e emission factor is based on BART 2017 electricity portfolio projections, which is assumed to serve as a conservative assumption of electricity intensity for Project years 2025 and 2040. Global warming potentials used in these projections are based on the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR). The impact of using SAR potentials as opposed to Fourth Assessment Report potentials (which is used throughout the rest of the GHG analysis) is expected to be less than 2%.

Abbreviations:

ARB - [California] Air Resources Board
BART - Bay Area Rapid Transit
CO_2e - carbon dioxide equivalent
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
GHG - greenhouse gas
hp - horsepower
hr - hour
kW - kilowatt
lb - pound
MT - metric tons
MWh - megawatt-hour
PG&E - Pacific Gas and Electric Company
yr - year

References:

Bay Area Rapid Transit. *E-mail communications with N. Miksis.* January 2017.
Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Available at http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf. Accessed: December 2016.

Pacific Gas and Electric (PG&E). 2009. Emerging Technologies Fact Sheet: Efficient Forklift Battery Charger. Available at: https://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/moneybacksolutions/grocery/fb_ib/forklift_battery_charger_fs.pdf. Accessed: December 2016.

Table 26
Operational Solar PV Greenhouse Gas Emission Reductions
BART to Livermore Extension
Livermore, California

Project and Alternatives	Parameters	Unit	Value
Conventional BART (Project) and DMU Alternative (EMU Option)	DC System Size[1]	kW	1000
	Annual Average Solar Radiation[1]	kWh/m^2/day	5.59
	Annual Electricity Generation[1]	kWh/year	1,557,588
	2025/2040 CO_2e Intensity Factor[2]	lb/MWh	97.3
	2025 Solar PV Emissions	**MT CO_2e/yr**	-69
	2040 Solar PV Emissions		-59

Notes:

[1] System size, average solar radiation, and annual system generation were determined using default commercial rooftop solar array assumptions in the National Renewable Energy Laboratory's PVWatts tool. Available online at: http://pvwatts.nrel.gov/pvwatts.php

[2] The electricity CO_2e emission factor is based on BART 2017 electricity portfolio projections, which is assumed to serve as a conservative assumption of electricity intensity for Project years 2025 and 2040. Global warming potentials used in these projections are based on the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR). The impact of using SAR potentials as opposed to Fourth Assessment Report potentials (which is used throughout the rest of the GHG analysis) is expected to be less than 2%.

Abbreviations:

BART - Bay Area Rapid Transit
CO_2e - carbon dioxide equivalent
DC - direct current
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
hp - horsepower
hr - hour
kW - kilowatt
kWh - kilowatt-hour
lb - pound
m^2 - square meters
MT - metric tons
MWh - megawatt-hour
PV - photovoltaic
yr - year

References:

Bay Area Rapid Transit. *E-mail communications with N. Miksis.* January 2017.
Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Available at http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf. Accessed: December 2016.

Table 27
Average Net New Daily Operational Emissions (2025)
BART to Livermore Extension
Livermore, California

	Average Net New Daily Operational Emissions (pounds/day)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Conventional BART (Project)				
Mobile Sources				
General Traffic	-6.9	-11	-11	-4.5
Buses	3.1	23	0.59	0.42
Maintenance Trucks	0.01	0.1	0.006	0.003
Shuttle Van	0.01	0.2	0.006	0.004
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.12	2.2	0.011	0.011
Standby Diesel Generator (Maintenance Facility)	0.03	0.6	0.030	0.030
Area Sources				
Solvent Use	0.41	-	-	-
Area Coating	3.9	-	-	-
Total	0.75	15	-10	-4.0
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

	Average Net New Daily Operational Emissions (pounds/day)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
DMU Alternative				
Mobile Sources				
General Traffic	-5.4	-8.5	-8.0	-3.4
Buses	3.1	23	0.59	0.42
DMU	4.2	8.5	0.42	0.42
Maintenance Trucks	0.010	0.13	0.0060	0.0034
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.12	2.2	0.011	0.011
Standby Diesel Generator (Maintenance Facility)	0.03	0.6	0.030	0.030
Area Sources				
Solvent Use	0.41	-	-	-
Area Coating	3.4	-	-	-
Total	5.8	26	-7.0	-2.5
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

	Average Net New Daily Operational Emissions (pounds/day)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
EMU Option				
Mobile Sources				
General Traffic	-5.4	-8.5	-8.0	-3.4
Buses	3.1	23	0.59	0.42
Maintenance Trucks	0.010	0.13	0.0060	0.0034
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.12	2.2	0.011	0.011
Standby Diesel Generator (Maintenance Facility)	0.03	0.6	0.030	0.030
Area Sources				
Solvent Use	0.41	-	-	-
Area Coating	3.4	-	-	-
Total	1.6	18	-7.4	-2.9
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

	Average Net New Daily Operational Emissions (pounds/day)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Express Bus/BRT Alternative				
Mobile Sources				
General Traffic	-2.3	-3.9	-3.8	-1.6
Buses	3.8	23	0.22	0.22
Area Sources				
Area Coating	0.47	-	-	-
Total	2.0	19	-3.5	-1.3
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

	Average Net New Daily Operational Emissions (pounds/day)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Enhanced Bus Alternative				
Mobile Sources				
General Traffic	-0.27	-0.058	-0.022	-0.010
Buses	3.4	21	0.20	0.20
Total	3.1	20	0.17	0.19
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

Table 28
Net New Annual Operational Emissions (2025)
BART to Livermore Extension
Livermore, California

	Maximum Net New Annual Operational Emissions (short tons/year)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Conventional BART (Project)				
Mobile Sources				
General Traffic	-1.3	-2.1	-2.0	-0.82
Buses	0.56	4.3	0.11	0.076
Maintenance Trucks	0.0019	0.0230	0.0011	0.00062
Shuttle Van	0.0022	0.0294	0.0011	0.00066
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.023	0.40	0.0020	0.0020
Standby Diesel Generator (Maintenance Facility)	0.006	0.11	0.0055	0.0055
Area Sources				
Solvent Use	0.075	-	-	-
Area Coating	0.72	-	-	-
Total	0.14	2.8	-1.8	-0.73
Significance Thresholds	10	10	15	10
Above Threshold?	No	No	No	No

	Maximum Net New Annual Operational Emissions (short tons/year)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
DMU Alternative				
Mobile Sources				
General Traffic	-1.0	-1.5	-1.5	-0.61
Buses	0.56	4.3	0.11	0.076
DMU	0.77	1.5	0.077	0.077
Maintenance Trucks	0.0019	0.023	0.0011	0.00062
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.023	0.40	0.0020	0.0020
Standby Diesel Generator (Maintenance Facility)	0.006	0.11	0.0055	0.0055
Area Sources				
Solvent Use	0.075	-	-	-
Area Coating	0.61	-	-	-
Total	1.1	4.8	-1.3	-0.45
Significance Thresholds	10	10	15	10
Above Threshold?	No	No	No	No

	Maximum Net New Annual Operational Emissions (short tons/year)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
EMU Option				
Mobile Sources				
General Traffic	-1.0	-1.5	-1.5	-0.61
Buses	0.56	4.3	0.11	0.076
Maintenance Trucks	0.0019	0.023	0.0011	0.00062
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.023	0.40	0.0020	0.0020
Standby Diesel Generator (Maintenance Facility)	0.006	0.11	0.0055	0.0055
Area Sources				
Solvent Use	0.075	-	-	-
Area Coating	0.61	-	-	-
Total	0.29	3.2	-1.4	-0.53
Significance Thresholds	10	10	15	10

Above Threshold?	No	No	No	No
	Maximum Net New Annual Operational Emissions (short tons/year)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Express Bus/BRT Alternative				
Mobile Sources				
General Traffic	-0.41	-0.72	-0.69	-0.29
Buses	0.69	4.2	0.040	0.039
Area Sources				
Area Coating	0.09	-	-	-
Total	0.37	3.4	-0.65	-0.25
Significance Thresholds	10	10	15	10
Above Threshold?	No	No	No	No
	Maximum Net New Annual Operational Emissions (short tons/year)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Enhanced Bus Alternative				
Mobile Sources				
General Traffic	-0.050	-0.011	-0.0041	-0.0018
Buses	0.62	3.7	0.036	0.036
Total	0.57	3.7	0.032	0.034
Significance Thresholds	10	10	15	10
Above Threshold?	No	No	No	No

Table 29
Average Net New Daily Operational Emissions (2040)
BART to Livermore Extension
Livermore, California

	Average Net New Daily Operational Emissions (pounds/day)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Conventional BART (Project)				
Mobile Sources				
General Traffic	-4.9	-9.5	-20	-8.2
Buses	0.75	18	0.5	0.3
Maintenance Trucks	0.009	0.04	0.005	0.002
Shuttle Van	0.01	0.06	0.005	0.003
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.12	2.2	0.011	0.011
Standby Diesel Generator (Maintenance Facility)	0.03	0.6	0.030	0.030
Area Sources				
Solvent Use	0.41	-	-	-
Area Coating	3.9	-	-	-
Total	0.37	11	-20	-7.9
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

	Average Net New Daily Operational Emissions (pounds/day)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
DMU Alternative				
Mobile Sources				
General Traffic	-2.9	-5.5	-12	-4.8
Buses	0.8	18	0.5	0.30
DMU	4.7	9.4	0.5	0.47
Maintenance Trucks	0.0087	0.037	0.0051	0.00247
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.12	2.2	0.011	0.011
Standby Diesel Generator (Maintenance Facility)	0.03	0.6	0.030	0.030
Area Sources				
Solvent Use	0.41	-	-	-
Area Coating	3.4	-	-	-
Total	6.5	25	-11	-3.9
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

	Average Net New Daily Operational Emissions (pounds/day)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
EMU Option				
Mobile Sources				
General Traffic	-2.9	-5.5	-12	-4.8
Buses	0.75	18	0.5	0.3
Maintenance Trucks	0.0087	0.037	0.0051	0.00247
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.12	2.2	0.011	0.011
Standby Diesel Generator (Maintenance Facility)	0.03	0.6	0.030	0.030
Area Sources				
Solvent Use	0.41	-	-	-
Area Coating	3.4	-	-	-
Total	1.8	15	-11	-4.4
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

	Average Net New Daily Operational Emissions (pounds/day)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Express Bus/BRT Alternative				
Mobile Sources				
General Traffic	-2.1	-3.7	-7.9	-3.2
Buses	0.93	22	0.192	0.191
Area Sources				
Area Coating	0.47	-	-	-
Total	-0.68	18	-7.7	-3.0
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

	Average Net New Daily Operational Emissions (pounds/day)			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Enhanced Bus Alternative				
Mobile Sources				
General Traffic	-3.8	-0.62	-0.77	-0.32
Buses	0.83	19.6	0.17	0.17
Total	-3.0	19	-0.59	-0.15
Significance Thresholds	54	54	82	54
Above Threshold?	No	No	No	No

Table 30
Net New Annual Operational Emissions (2040)
BART to Livermore Extension
Livermore, California

	Maximum Net New Annual Operational Emissions (short tons/year			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Conventional BART (Project)				
Mobile Sources				
General Traffic	-0.90	-1.7	-3.7	-1.5
Buses	0.14	3.2	0.084	0.054
Maintenance Trucks	0.002	0.007	0.0009	0.0005
Shuttle Van	0.002	0.01	0.0009	0.0005
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.023	0.40	0.0020	0.0020
Standby Diesel Generator (Maintenance Facility)	0.006	0.11	0.0055	0.0055
Area Sources				
Solvent Use	0.075	-	-	-
Area Coating	0.72	-	-	-
Total	0.068	2.0	-3.6	-1.4
Significance Thresholds	10	10	15	10
Above Threshold?	No	No	No	No

	Maximum Net New Annual Operational Emissions (short tons/year			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
DMU Alternative				
Mobile Sources				
General Traffic	-0.53	-1.0	-2.1	-0.87
Buses	0.14	3.2	0.084	0.054
DMU	0.86	1.7	0.086	0.086
Maintenance Trucks	0.002	0.007	0.0009	0.0005
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.023	0.40	0.0020	0.0020
Standby Diesel Generator (Maintenance Facility)	0.006	0.11	0.0055	0.0055
Area Sources				
Solvent Use	0.075	-	-	-
Area Coating	0.61	-	-	-
Total	1.2	4.5	-2.0	-0.72
Significance Thresholds	10	10	15	10
Above Threshold?	No	No	No	No

	Maximum Net New Annual Operational Emissions (short tons/year			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
EMU Option				
Mobile Sources				
General Traffic	-0.53	-1.0	-2.1	-0.87
Buses	0.14	3.2	0.084	0.054
Maintenance Trucks	0.002	0.007	0.0009	0.0005
Stationary Sources				
Standby Diesel Generator (Isabel Station)	0.023	0.40	0.0020	0.0020
Standby Diesel Generator (Maintenance Facility)	0.006	0.11	0.0055	0.0055
Area Sources				
Solvent Use	0.075	-	-	-
Area Coating	0.61	-	-	-
Total	0.32	2.8	-2.1	-0.81
Significance Thresholds	10	10	15	10
Above Threshold?	No	No	No	No

	Maximum Net New Annual Operational Emissions (short tons/year			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Express Bus/BRT Alternative				
Mobile Sources				
General Traffic	-0.38	-0.67	-1.4	-0.58
Buses	0.17	4.0	0.035	0.035
Area Sources				
Area Coating	0.086	-	-	-
Total	-0.12	3.3	-1.4	-0.55
Significance Thresholds	10	10	15	10
Above Threshold?	No	No	No	No

	Maximum Net New Annual Operational Emissions (short tons/year			
	ROG	**NO_X**	**PM_{10}**	**$PM_{2.5}$**
Enhanced Bus Alternative				
Mobile Sources				
General Traffic	-0.70	-0.11	-0.14	-0.058
Buses	0.15	3.6	0.031	0.031
Total	-0.54	3.5	-0.11	-0.027
Significance Thresholds	10	10	15	10
Above Threshold?	No	No	No	No

Table 31
Modeling Parameters for Construction, Transit Sources, and Emergency Generators
BART to Livermore Extension
Livermore, California

Source	Source Type	Source Dimension (m)	Number of Sources	Release Height[1] (m)	Initial Horizontal Dimension[2] (m)	Initial Vertical Dimension[3] (m)	Width[4] (m)
Construction Equipment	Volume	20	Variable	5	9.3	1.40	---
DMU	Line	Variable Length	Variable	3.6	---	3.34	9.0
Bus Routes	Line	Variable Length	Variable	3.4	---	1.79	8.6
Bus Stations (Idling)	Volume	21.5	Multiple	3.4	5	0.79	---
Maintenance Yard	Volume	20	Multiple	5	9.3	1.40	---
Source	**Source Type**	**Source Dimension**	**Number of Sources**	**Release Height (m)**	**Exhaust Temperature (K)**	**Exit Velocity (m/s)**	**Stack Diameter (m)**
Emergency Generator (Isabel Station)[5]	Point	---	1	4.1	763.85	45.3	0.2
Emergency Generator (Maintenance Facility)[6]	Point	---	1	3.66	739.82	45.3	0.18

Notes:

[1] The SCAQMD Localized Significance Threshold Methodology (SCAQMD 2008) was used for setting up construction volume sources. Release height for bus emission source was based on the exhaust release height from a proposed bus type.

[2] For adjacent volume sources the initial horizontal dimension was calculated as the center-to-center distance divided by 2.15; for single volume sources, center-to-center distance divided by 4.3 (USEPA 2004).

[3] The initial vertical dimension for the construction area source is explicitly given in the SCAQMD LST methodology. For bus routes the initial vertical dimension was calculated based on the Haul Road Work Group Final Report (USEPA 2012). For idling buses, the initial vertical dimension is calculated as the release height divided by 4.3.

[4] The width of the line source is consistent with the Haul Road Work Group Final Report (USEPA 2012). The vehicle width is assumed to be 2.6 meters with an additional 6 meters added (3 meters to both sides) to account for the mechanical turbulence from moving vehicles.

[5] Stack parameters for the Isabel Station emergency generator were provided by the client. These correspond to a 2.5-MW Caterpillar generator set. All parameters provided were used in the modeling except exit velocity, where a more conservative default value was used (STI 2011).

[6] Stack parameters for the maintenance yard emergency generator were default parameters obtained from The San Francisco Community Risk Reduction Plan: Technical Support Documentation. [Bay Area Air Quality Management District (BAAQMD), San Francisco Department of Public Health, San Francisco Planning Department. 2012]

Abbreviations:

BART - Bay Area Rapid Transit
HRA - Health Risk Assessment
K - degrees Kelvin
LST - Localized Significance Thresholds
m - meter
s - seconds
SCAQMD - South Coast Air Quality Management District
STI - Sonoma Technology, Inc.
USEPA - United States Environmental Protection Agency

References:

SCAQMD. 2008. Localized Significance Threshold Methodology. Available online at: http://www.aqmd.gov/docs/default-source/ceqa/handbook/localized-significance-thresholds/final-lst-methodology-document.pdf?sfvrsn=2

STI. 2011. Technical Memorandum: Default modeling parameters for stationary sources.

USEPA. 2004. User's Guide for the AMS/EPA Regulatory Model - AERMOD. September.
Available online at: http://www.epa.gov/scram001/dispersion_prefrec.htm.

USEPA. 2012. Haul Road Workgroup Final Report Submission to EPA-OAQPS. March.
Available online at: https://www3.epa.gov/ttn/scram/reports/Haul_Road_Workgroup-Final_Report_Package-20120302.pdf

Table 32
Modeling Adjustment Factor
BART to Livermore Extension
Livermore, California

Receptor Type	Scenario	MAF
Daycare	Construction[1]	2.4
	Operation[2]	1
Hospital	Construction[3]	1
	Operation[2]	1
Recreational	Construction[1]	2.4
	Operation[2]	1
Residential	Construction[3]	1
	Operation[2]	1
School	Construction[1]	2.4
	Operation[2]	1

Notes:

[1] Construction is assumed to occur 14 hours/day and 5 days/week when the daycare children, recreational users and school children are exposed. The models annualized construction emissions over 24 hour/day and 7 days/ week. In accordance with OEHHA's recommendation (Cal/EPA 2015), a modeling adjustment factor (MAF) of 2.4 ([24 hours/14 hours] x [7days/5 days]) was applied to the annual average concentrations used in the evaluation for the daycare children, recreational users and school children to account for an construction emission schedule of 14 hours/day, 5 days/week.

[2] Operational emissions were assumed to be continuous (i.e., 24 hours/day, 7 days/ week), therefore no adjustment was needed in the calculation of exposure point concentrations for the operational scenarios.

[3] The models annualized construction emissions over 24 hour/day and 7 days/week. The residents were assumed to be exposed to the construction emissions continuously, therefore no adjustment is needed in the calculation of exposure point concentrations for the residents.

Abbreviations:

Cal/EPA - California Environmental Protection Agency
MAF - Modeling Adjustment Factor
OEHHA - Office of Environmental Health Hazard Assessment

Reference:

OEHHA. 2015. Air Toxics Hot Spots Program Risk Assessment Guidelines. Guidance Manual for Preparation of Health Risk Assessments. February.

Table 33
Exposure Parameters - Operational Scenario
BART to Livermore Extension
Livermore, California

Receptor Type	Scenario Start Year [6]	Receptor Age Group	Exposure Parameters					
			Daily Breathing Rate (DBR)	Exposure Duration (ED)	Fraction of Time at Home (FAH)	Exposure Frequency (EF)	Averaging Time (AT)	Intake Factor, Inhalation (IF_{inh})
			[L/kg-day]	[years]	[unitless]	[days/year]	[days]	[m^3/kg-day]
Daycare Child [1]	2025	Age 0-< 2 Years	900	2	--	250	25550	0.018
		Age 2-< 9 Years	500	4	--	250	25550	0.020
	2040	Age 0-< 2 Years	900	2	--	250	25550	0.018
		Age 2-< 9 Years	500	4	--	250	25550	0.020
Hospital [2]	2025	Age 0-< 2 Years	1090	1	--	350	25550	0.015
	2040	Age 0-< 2 Years	1090	1	--	350	25550	0.015
Recreational [3]	2025	Age 0-< 2 Years	300	2	--	104	25550	0.0024
		Age 2-<16 Years	130	13	--	104	25550	0.0069
		Age 2-<16 Years	130	1	--	104	25550	0.00053
		Age 16-< 30 Years	60	14	--	104	25550	0.0034
	2040	Age 0-< 2 Years	300	2	--	104	25550	0.0024
		Age 2-<16 Years	130	14	--	104	25550	0.0074
		Age 16-< 30 Years	60	14	--	104	25550	0.0034
Resident [4]	2025	3rd Trimester	361	0.25	1	350	25550	0.0012
		Age 0-< 2 Years	1090	2	1	350	25550	0.030
		Age 2-<16 Years	572	12.75	1	350	25550	0.10
		Age 2-<16 Years	572	1.25	1	350	25550	0.010
		Age 16-< 30 Years	261	14	0.73	350	25550	0.037
	2040	3rd Trimester	361	0.25	1	350	25550	0.0012
		Age 0-< 2 Years	1090	2	1	350	25550	0.030
		Age 2-<16 Years	572	14	1	350	25550	0.11
		Age 16-< 30 Years	261	14	0.73	350	25550	0.037
School Child [5]	2025	Age 2-<16 Years	520	9	--	180	25550	0.033
	2040	Age 2-<16 Years	520	9	--	180	25550	0.033

Notes:

[1] The exposure frequency for daycare children reflects default exposure frequency for workers from OEHHA (2015) assuming that daycare children are at daycare centers while the parents are at work. The total exposure duration for daycare children reflects default duration suggested by BAAQMD (2016) and OEHHA (2015). Daycare children are assumed to be at daycare centers 10 hours/day, with 2 hours conducting moderate intensity activities outdoor and 8 hours conducting light intensity activities indoor. Daily breathing rates for daycare children reflect time-weighted average of 95th percentile moderate intensity breathing rates and light intensity breathing rates from OEHHA (2015).

[2] The child patients are conservatively assumed to be at an in-patient medical facility for 350 days per year for one year. The daily breathing rate is conservatively assumed to be the same as the default daily breathing rates for a 0-2 year old child residents from OEHHA (2015) and BAAQMD (2016).

Table 33
Exposure Parameters - Operational Scenario
BART to Livermore Extension
Livermore, California

[3] The recreational users are conservatively assumed to be exposed at a recreational facility near the Site 2 hours/event, 2 events/week every week. Daily breathing rates for the recreational users reflect the 95th percentile moderate intensity breathing rates from OEHHA's Hot Spots guidelines (2015).

[4] The total exposure duration, and exposure frequency for residents reflect default exposure assumptions for residents from OEHHA (2015) and BAAQMD (2016). The daily breathing rates for residents reflect recommended daily breathing rates for residents from BAAQMD (2016)as follows: 95th percentile 24-hour daily breathing rate for 3rd trimester and age 0-<2 years; 80th percentile for age 2-<9, 2-<16, and 16-30 years. Fraction of time spent at home is conservatively assumed to be 1 (i.e. 24 hours/day) for age groups from the third trimester to less than 16 years old. Based on the OEHHA 2015 Guidance, the age group 16 to 30 years old is estimated to be at school or work for 6.5 hours of the day. Therefore, the fraction of time spent at home is assumed to be 0.73 (17.5 hours/24 hours per day) for this age group.

[5] The exposure frequency and total exposure duration for the school children reflect default exposure frequency and duration for school children from OEHHA (2015) and BAAQMD (2016). Daily breathing rates for school children reflect the 95th percentile moderate intensity breathing rates from OEHHA (2015).

[6] Two operational scenarios were evaluated for the operation beginning year in 2015 and for the full build-out in 2040.

Intake Calculation:

IF_{inh} = DBR * FAH * EF * ED * CF / AT

CF = 0.001 (m^3/L)

Abbreviations:

AT - averaging time
BAAQMD - Bay Area Air Quality Management District
DBR - daily breathing rate
ED - exposure duration
EF - exposure frequency
FAH - fraction of time at home
IF_{inh} - intake factor
kg - kilogram
L - liter
m3 - cubic meter
OEHHA - Office of Environmental Health Hazard Assessment

References:

BAAQMD. 2016. Air Toxics NSR ProgramHealth Risk Assessment (HRA) Guidelines. January.
OEHHA. 2015. Air Toxics Hot Spots Program Risk Assessment Guidelines. Guidance Manual for Preparation of Health Risk Assessments. February.

Table 34
Exposure Parameters - Construction Scenario
BART to Livermore Extension
Livermore, California

Receptor Type	Scenario Start Date [6]	Receptor Age Group	Exposure Parameters					
			Daily Breathing Rate (DBR) [L/kg-day]	Exposure Duration (ED) [6] [years]	Fraction of Time at Home (FAH) [unitless]	Exposure Frequency (EF) [days/year]	Averaging Time (AT) [days]	Intake Factor, Inhalation (IF_{inh}) [m^3/kg-day]
Daycare Child [1]	Year 1 Quarter 1	Age 0-<2 Years	900	2.0	--	250	25550	0.018
		Age 2-<9 Years	500	2.0	--	250	25550	0.010
	Year 2 Quarter 1	Age 0-<2 Years	900	2.0	--	250	25550	0.018
		Age 2-<9 Years	500	1.0	--	250	25550	0.0049
Hospital [2]	Year 1 Quarter 1	Age 0-<2 Years	1090	1.0	--	350	25550	0.015
	Year 2 Quarter 1	Age 0-<2 Years	1090	1.0	--	350	25550	0.015
Recreational [3]	Year 1 Quarter 1	Age 0-<2 Years	300	2.0	--	104	25550	0.0024
		Age 2-<16 Years	160	2.0	--	104	25550	0.0013
	Year 2 Quarter 1	Age 0-<2 Years	300	2.0	--	104	25550	0.0024
		Age 2-<16 Years	160	1.0	--	104	25550	0.0007
Resident [4]	Year 1 Quarter 1	3rd Trimester	361	0.25	1.0	350	25550	0.0012
		Age 0-<2 Years	1090	2.0	1.0	350	25550	0.030
		Age 2-<9 Years	631	2.0	1.0	350	25550	0.017
	Year 2 Quarter 1	3rd Trimester	361	0.25	1.0	350	25550	0.0012
		Age 0-<2 Years	1090	2.0	1.0	350	25550	0.030
		Age 2-<9 Years	631	0.75	1.0	350	25550	0.0065
School Child [5]	Year 1 Quarter 1	Age 2-<9 Years	640	4.0	--	180	25550	0.018
	Year 2 Quarter 1	Age 2-<9 Years	640	3.0	--	180	25550	0.014

Notes:

[1] The exposure frequency for daycare children reflects default exposure frequency for workers from OEHHA (2015) assuming that daycare children are at daycare centers while the parents are at work. Daycare children are assumed to be at daycare centers 10 hours/day, with 2 hours conducting moderate intensity activities outdoor and 8 hours conducting light intensity activities indoor. Daily breathing rates for daycare children reflect time-weighted average of 95th percentile moderate intensity breathing rates and light intensity breathing rates from OEHHA (2015).

[2] The child patients are conservatively assumed to be at an in-patient medical facility for 350 days per year for one year. The daily breathing rate is conservatively assumed to be the same as the default daily breathing rates for a 0-2 year old child residents from OEHHA (2015) and BAAQMD (2016).

Table 34
Exposure Parameters - Construction Scenario
BART to Livermore Extension
Livermore, California

[3] The recreational users are conservatively assumed to be exposed at a recreational facility near the Site 2 hours/event, 2 events/week every week. Daily breathing rates for the recreational users reflect the 95th percentile moderate intensity breathing rates from OEHHA's Hot Spots guidelines (2015).

[4] The total exposure duration, and exposure frequency for residents reflect default exposure assumptions for residents from OEHHA (2015) and BAAQMD (2016). The daily breathing rates for residents reflect recommended daily breathing rates for residents from BAAQMD (2016) as follows: 95th percentile 24-hour daily breathing rate for 3rd trimester and age 0-<2 years; 80th percentile for age 2-<9. Fraction of time spent at home is conservatively assumed to be 1 (i.e., 24 hours/day) for age groups from the third trimester to less than 9 years old.

[5] The exposure frequency and total exposure duration for the school children reflect default exposure frequency and duration for school children from OEHHA (2015) and BAAQMD (2016). Daily breathing rates for school children reflect the 95th percentile moderate intensity breathing rates from OEHHA (2015).

[6] Two construction scenarios were evaluated based on the two exposure starting dates that are anticipated to have the highest risks (i.e. Year 1 Quarter 1, and Year 2 Quarter 1). The exposure durations for daycare children, child patients, recreational users, and school children during construction reflect the proposed construction schedules under these two exposure starting dates. Exposure duration for hospital patients is a conservative estimate of one total year during construction.

Intake Calculation:

IF_{inh} = DBR * FAH * EF * ED * CF / AT

CF = 0.001 (m^3/L)

Abbreviations:

AT - averaging time
BAAQMD - Bay Area Air Quality Management District
DBR - daily breathing rate
ED - exposure duration
EF - exposure frequency
FAH - fraction of time at home
IF_{inh} - intake factor
kg - kilogram
L - liter
m^3 - cubic meter
OEHHA - Office of Environmental Health Hazard Assessment

References:

BAAQMD. 2016. Air Toxics NSR ProgramHealth Risk Assessment (HRA) Guidelines. January.
OEHHA. 2015. Air Toxics Hot Spots Program Risk Assessment Guidelines. Guidance Manual for Preparation of Health Risk Assessments. February.

Table 35
Carcinogenic Toxicity Value for DPM
BART to Livermore Extension
Livermore, California

Source	Chemical	Inhalation Cancer Potency Factor
		$[mg/kg\text{-}day]^{-1}$
All Sources	DPM	1.1

Abbreviations:

ARB - [California] Air Resources Board
BART - Bay Area Rapid Transit
Cal/EPA - California Environmental Protection Agency
DPM - diesel particulate matter
mg/kg-day - milligrams per kilogram per day
OEHHA - Office of Environmental Health Hazard Assessment

Reference:

Cal/EPA. 2016. Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values. September. Available at: https://www.arb.ca.gov/toxics/healthval/contable.pdf

Table 36
Age Sensitivity Factor
BART to Livermore Extension
Livermore, California

Receptor Type	Period	Receptor Age Group[1]	ASF[2] (unitless)
All Receptors	Construction and Operation	3rd Trimester	10
		Age 0-<2 Years	10
		Age 2-<9 Years	3
		Age 2-<16 Years	3
		Age 16-30 Years	1

Notes:

[1] Age sensitivity factors are applicable for the age groups relevant to each receptor type listed in Tables 25 and 26.

[2] The age sensitivity factors are as recommended in the 2015 OEHHA Hot Spots Guidance (OEHHA 2015) for each age group.

Abbreviation:

ASF - Age sensitivity factor
BART - Bay Area Rapid Transit
OEHHA - Office of Environmental Health Hazard Assessment

References:

OEHHA. 2015. Air Toxics Hot Spots Program Risk Assessment Guidelines. Guidance Manual for Preparation of Health Risk Assessments. February.

Table 37
Stationary Source Screening Health Impacts
BART to Livermore Extension
Livermore, California

Scenario	Facility Number[1]	Facility Name	Facility Street Address	UTM Easting (m)	UTM Northing (m)	Distance to MEISR[2] (m)	Distance Adjustment Multiplier	Cancer Risk Scaling Factor[3]	Estimated Lifetime Excess Cancer Risk[3,4] (in a million)	Estimated $PM_{2.5}$ Concentration[4] ($\mu g/m^3$)
Conventional BART (Project)	--[5]	--	--	--	--	--	--	--	--[2]	--[2]
DMU Alternative (EMU Option)	--[5]	--	--	--	--	--	--	--	--[2]	--[2]
Express Bus/BRT Alternative	18895	Bay Area Rapid Transit	5067 IRON HORSE PKWY	597,198	4,173,402	98	0.25	1.37	5.72	4.3E-03
	14075	S F Bay Area Rapid Transit District	5801 OWENS DRIVE	597,250	4,173,185	262	0.05		4.13	5.4E-03
								Total	**9.9**	**9.7E-03**
Enhanced Bus Alternative	18895	Bay Area Rapid Transit	5067 IRON HORSE PKWY	597,198	4,173,402	380	0.04	1.37	0.92	6.9E-04
	14075	S F Bay Area Rapid Transit District	5801 OWENS DRIVE	597,250	4,173,185	595	0.04		3.31	4.3E-03
								Total	**4.2**	**5.0E-03**

Notes:

[1] All sources within 1,000 feet of the MEISR were included as per the BAAQMD Stationary Source Screening Analysis Tool. Source information was obtained from the Alameda County Stationary Source Screening tool with additional details provided by BAAQMD.

[2] The distance presented here is from the source to the MEISR.

[3] BAAQMD screening tools' calculated impacts are based on previous OEHHA guidance (2003). Per BAAQMD recommendations, cancer risks were conservatively scaled by a factor of 1.37 to account for the updated exposure parameters and calculation methodologies in OEHHA 2015 guidance.

[4] The adjusted health impacts listed in the table above were calculated using the health impacts estimated using BAAQMD Stationary Source Screening Analysis Tool and were adjusted using the BAAQMD Diesel Risk Multiplier since all sources were diesel generators.

[5] There are no permitted stationary sources within 1,000 feet of the MEISR.

Abbreviations:

BAAQMD - Bay Area Air Quality Management District
BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
ft - feet
m - meter
$\mu g/m^3$ - microgram per cubic meter
MEISR - Maximally Exposed Individual Sensitive Receptor
OEHHA - Office of Environmental Health Hazard Assessment
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
UTM - Universal Transverse Mercator

References:

BAAQMD. 2012. Stationary Source Screening Analysis Tool. Santa Clara County. May 30. Available at: http://www.baaqmd.gov/plans-and-climate/california-environmental-quality-act-ceqa/ceqa-tools
OEHHA. 2015. Air Toxics Hot Spots Program Risk Assessment Guidelines. Guidance Manual for Preparation of Health Risk Assessments. February.

Table 38
Roadway Screening Health Impacts
BART to Livermore Extension
Livermore, California

Description[1]	Segment[2]	Distance from Roadway to MEISR[3] (ft)	Average Daily Traffic[4] (vehicles/day)	MEISR	Road Direction[5]	Direction to MEISR from Roadway	BAAQMD Screening Impacts[6,7,8]	
							Lifetime Excess Cancer Risk[6] (in a million)	$PM_{2.5}$ Concentration ($\mu g/m^3$)
Project Impact								
Conventional BART (2040)	606515-4173176	923	10,658	Cancer Risk and $PM_{2.5}$	East-West	North	1.3	0.016
Cumulative Impact								
Conventional BART (2025)	605891-4173459	675	19,184	Cancer Risk and $PM_{2.5}$	N-S	E	3.1	0.045
	605925-4173249	621	11,260		E-W	N	2.0	0.026
	605948-4173331	454	14,722		E-W	N	3.2	0.043
	606234-4173316	239	25,081		E-W	N	8.7	0.12
	606515-4173176	918	10,509		E-W	N	1.3	0.016
	I-580	--	--		--	N	107	0.57
						Total:	**126**	**0.82**
DMU Alternative (EMU Option) (2025)[9]	605891-4173459	675	19,243	DMU/EMU Cancer Risk and EMU $PM_{2.5}$[9]	N-S	E	3.1	0.045
	605925-4173249	621	11,296		E-W	N	2.0	0.026
	605948-4173331	454	11,972		E-W	N	2.6	0.035
	606234-4173316	239	25,361		E-W	N	8.8	0.12
	I-580	--	--		--	N	107	0.57
						Total:	**124**	**0.80**
DMU Alternative (2025)	604438-4173353	503	12,919	DMU $PM_{2.5}$	N-S	W	--	0.019
	605037-4173335	279	24,752		E-W	S	--	0.056
	I-580	--	--		--	S	--	1.1
						Total:	**--**	**1.1**
Express Bus/BRT Alternative (2025)	596980-4173664	709	12,174	Cancer Risk and $PM_{2.5}$	N-S	E	1.9	0.027
	597135-4173152	620	11,452		N-S	W	1.1	0.01
	597145-4173387	105	10,588		E-W	N	6.9	0.10
	597160-4173283	318	11,452		N-S	W	2.0	0.025
	597129-4173351	106	18,593		E-W	N	12	0.17
	597216-4173509	386	10,608		N-S	W	1.5	0.019
	I-580	--	--		--	N	102	0.51
						Total:	**127**	**0.86**
Enhanced Bus Alternative (2025)	597214-4173694	97	12,178	Cancer Risk and $PM_{2.5}$	N-S	E	8.4	0.12
	596980-4173664	875	12,163		N-S	E	1.5	0.022
	597298-4173795	44	28,282		E-W	S	17	0.24
	I-580	--	--		--	N	40	0.20
						Total:	**67**	**0.58**
Conventional BART (2040)	605864-4173514	680	10,375	Cancer Risk and $PM_{2.5}$	N-S	E	1.7	0.024
	605891-4173459	675	30,148		N-S	E	4.8	0.069
	605948-4173331	454	18,003		E-W	N	4.0	0.053
	606172-4173220	601	11,891		E-W	N	2.2	0.029
	I-580	--	--		--	N	107	0.57
						Total:	**120**	**0.75**

Table 38
Roadway Screening Health Impacts
BART to Livermore Extension
Livermore, California

DMU Alternative (EMU Option) (2040)[9]	605864-4173514	680	10,229	DMU/EMU Cancer Risk and EMU $PM_{2.5}$[9]	N-S	E	1.6	0.024
	605891-4173459	675	29,085		N-S	E	4.6	0.067
	605948-4173331	454	14,633		E-W	N	3.2	0.043
	606172-4173220	601	11,844		E-W	N	2.1	0.028
	I-580	--	--		--	N	107	0.57
						Total:	**119**	**0.73**
DMU Alternative (2040)	604438-4173353	503	15,239	DMU $PM_{2.5}$	N-S	W	**--**	0.023
	I-580	--	--		--	S	**--**	1.1
						Total:	**--**	**1.1**
Express Bus/BRT Alternative (2040)	596763-4173745	87	43,702	Cancer Risk and $PM_{2.5}$	E-W	S	17	0.23
	596980-4173664	10	13,842		N-S	E	20	0.29
	597214-4173694	763	13,946		N-S	W	0.98	0.012
	I-580	--	--		--	N	40	0.20
						Total:	**78**	**0.73**
Enhanced Bus Alternative (2040)	597214-4173694	97	13,959	Cancer Risk and $PM_{2.5}$	N-S	E	9.6	0.14
	596980-4173664	875	14,143		N-S	E	1.7	0.025
	597298-4173795	44	38,478		E-W	S	21	0.30
	I-580	--	--		--	N	40	0.20
						Total:	**73**	**0.66**

Notes:

[1] For the Project analysis, only Alternatives that have road segments with an increase in average daily traffic volume > 10,000 vehicles per day are shown. For the cumulative analysis, all roadway segments with average daily traffic volume > 10,000 vehicles per day are included.

[2] Unique road segment identifier based on the UTM Coordinates of the midpoint of the road segment (UTM Zone 10, NAD83).

[3] For a screening assessment, the table provides health impacts to the maximally exposed individual sensitive receptor (MEISR). Distances presented represent the distance from the nearest edge of the roadway to the MEISR.

[4] Peak hourly traffic volumes were provided by ARUP for 2025 and 2050 for the Proposed Project, each Alternative, and the No Project Alternative. Peak hourly traffic volumes were then scaled to average daily traffic volume. For the Project analysis, the difference in average daily traffic volume was then calculated between the Proposed Project and the No Project Alternative and each Alternative and the No Project Alternative. The above screening analysis for the Project includes individual road segments with an increase in average daily traffic volume > 10,000 vehicles per

[5] For road segments that are neither North-South nor East-West, road direction was set to the orientation that results in higher concentrations/risks.

[6] BAAQMD screening tools' calculated impacts are based on previous OEHHA guidance. Per BAAQMD recommendations, cancer risks were conservatively scaled by a factor of 1.37 to account for the updated exposure parameters and calculation methodologies in OEHHA 2015 guidance.

[7] Screening estimates of health impacts were estimated with the BAAQMD Roadway Screening Analysis Calculator (BAAQMD 2015). The screening tool does not allow calculation of impacts from roadways that are over 1,000 ft from the MEIR. Roadways outside of the 1,000 ft "zone of influence" were not considered in the analysis.

[8] Screening estimates of health impacts for I-580 were estimated with the BAAQMD Highway Screening Analysis Calculator (BAAQMD 2011).

[9] Values are applicable for the DMU Alternative cancer risk and EMU Option cancer risk and $PM_{2.5}$ concentration. The DMU $PM_{2.5}$ MEISR is at a separate location.

Abbreviations:

ADT - Average Daily Traffic
BAAQMD: Bay Area Air Quality Management District
BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
ft - feet
INP - Isabel Neighborhood Plan
MEISR - Maximally Exposed Individual Sensitive Receptor
$\mu g/m^3$ - microgram per cubic meter
NAD83 - North American Datum 1983
OEHHA - Office of Environmental Health Hazard Assessment
$PM_{2.5}$ - particulate matter with an aerodynamic diameter of 2.5 microns or less
UTM - Universal Transverse Mercator

References:

BAAQMD. 2015. Roadway Screening Analysis Calculator. Available online at: http://www.baaqmd.gov/plans-and-climate/california-environmental-quality-act-ceqa/ceqa-tools
BAAQMD. 2011. Highway Screening Analysis Calculator. Available online at: http://www.baaqmd.gov/plans-and-climate/california-environmental-quality-act-ceqa/ceqa-tools
OEHHA. 2015. Air Toxics Hot Spots Program Risk Assessment Guidelines. Guidance Manual for Preparation of Health Risk Assessments. February.

Table 39
Odor Analysis - Construction
BART to Livermore Extension
Livermore, California

Project and Alternatives[4]	Source Group	Emissions[1]		Maximum Concentration[2]		Maximum Ratio of Concentration to Odor Threshold[3]
		DPM / PM_{10}	ROG	DPM / PM_{10}	ROG	
		lbs / day	lbs / day	µg / m^3	µg / m^3	
Conventional BART (Project)	Off-road	2.9	5.8	0.11	0.22	0.00018
	Trucks	0.15	1.3		0.97	0.0017
DMU Alternative	Off-road	1.5	3.0	0.12	0.24	0.00019
	Trucks	0.17	1.4		0.98	0.0017
Express Bus/BRT Alternative	Off-road	0.32	0.67	0.039	0.081	0.00007
	Trucks	0.044	0.65		0.57	0.0010
Overall Maximum						**0.0017**

Notes:

[1] Average Daily Construction-Related Emissions. Concentration of odor causing chemicals for each Project Alternative is conservatively estimated using the highest ROG-to-DPM ratios. Emissions by source group are obtained from Table 8.

[2] DPM/PM_{10} concentration represents the maximum total concentration modeled at all receptors. ROG concentration represents the maximum concentration estimated by scaling the maximum DPM concentration by ROG-to-DPM emission ratio: $MaxConc_{ROG} = MaxConc_{DPM} \times (Emiss_{ROG} / Emiss_{DPM})$

[3] Maximum ratio of concentration to odor threshold is determined using following methodology:
a) Maximum total predicted ROG concentrations were speciated using USEPA SPECIATE Database (USEPA, 2014). ROG concentrations estimated using ROG/DPM emission ratios for off-road equipment were speciated using concentration profile for offroad sources (USEPA, 2014; Profile #3161); ROG concentration derived using ROG/DPM emission ratio for trucks were speciated using concentration profile for offroad sources (USEPA, 2014; Profile 4674).
b) Ratios of maximum concentration over respective odor threshold concentration were calculated for all speciated ROGs for which odor thresholds were available (Amoore 1983).
c) Value shown in table represents the maximum ratio of concentration to odor threshold of all ROG components with odor thresholds taken from the compilation of odor thresholds in Amoore (1983).

[4] Construction associated with the Enhanced Bus Alternative are limited to bus improvements such as excavation, paving, and construction of bus bulbs, bus shelters, and signage and are considered to be de minimis. Therefore, an analysis of the Enhanced Bus Alternative is not included here.

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
DMU - Diesel Multiple Units
lb - pound
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
DPM - diesel particulate matter
ROG - reactive organic gas
µg - microgram
m^3 - cubic meter

References:

Amoore, J.E. and Hautala, E., Odor as an Aid to Chemical Safety: Odor Thresholds Compared with Threshold Limit Values and Volatilities for 214 Industrial Chemicals in Air and Water Dilution, *J. Appl. Toxicology*, Vol. 3(6), 1983, pp. 272-290.

USEPA. 2014. Speciate Database, Version 4.4. February. Available at: http://www.epa.gov/ttnchie1/software/speciate/. Accessed June 12, 2017.

Table 40
Odor Analysis - Operational Scenario
BART to Livermore Extension
Livermore, California

Operational Year	Project and Alternatives	Source Group	Emissions[1]		Maximum Concentration[2]		Maximum Ratio of Concentration to Odor Threshold[3]
			DPM/PM_{10}	ROG	DPM/PM_{10}	ROG	
			lbs/day	lbs/day	$\mu g/m^3$	$\mu g/m^3$	
2025	Conventional BART (Project)	Buses	0.59	3.1	0.036	0.19	0.00034
	DMU Alternative	Buses	0.59	3.1	0.048	0.25	0.00044
		DMU	0.42	4.2		0.48	0.00039
	EMU Option	Buses	0.59	3.1	0.037	0.19	0.00034
	Express Bus/BRT Alternative	Buses	0.22	3.8	0.027	0.48	0.00084
	Enhanced Bus Alternative	Buses	0.20	3.4	0.042	0.72	0.00128
	Overall Maximum						**0.00128**

Notes:

[1] Average net new daily operational emissions for a given source group. Concentration of odor causing chemicals for each Project Alternative is conservatively estimated using the highest ROG-to-DPM ratios (only applies for DMU Alternative). Emissions by source group are obtained from Table 27. Emissions of maintenance trucks, shuttle van, and standby emergency generators are significantly lower compared to that of buses and DMU and are not included.

[2] DPM/PM_{10} concentration represents the maximum total concentration modeled at all receptors. ROG concentration represents the maximum concentration estimated by scaling the maximum DPM concentration by ROG-to-DPM emission ratio:
$MaxConc_{ROG} = MaxConc_{DPM} \times Emiss_{ROG} / Emiss_{DPM}$

[3] Maximum ratio of concentration to odor threshold is determined using following methodology:
a) Maximum total predicted ROG concentrations were speciated using USEPA SPECIATE Databased (USEPA 2014). ROG concentrations estimated using ROG/DPM emission ratios for buses were speciated using concentration profiles for onroad sources (USEPA 2014; Profiles 4674 and 4741); ROG concentration derived using ROG/DPM emission ratio for DMU was speciated using concentration profile for offroad sources (USEPA 2014; Profiles 3161).
b) Ratios of maximum concentration over respective odor threshold concentration were calculated for all speciated ROGs for which odor thresholds were available (Amoore 1983)
c) Value shown in table represents the maximum ratio of concentration to odor threshold of all ROG components with odor thresholds taken from the compilation of odor thresholds in Amoore (1983). For buses it also represents the maximum ratio determined using two onroad SPECIATE profiles (USEPAa, USEPAb).

Abbreviations:

BART - Bay Area Rapid Transit
BRT - Bus Rapid Transit
DMU - Diesel Multiple Units
EMU - Electrical Multiple Units
lb - pound
PM_{10} - particulate matter with an aerodynamic diameter less than 10 microns
DPM - diesel particulate matter
ROG - reactive organic gas
µg - microgram
m^3 - cubic meter

References:

Amoore, J.E. and Hautala, E., Odor as an Aid to Chemical Safety: Odor Thresholds Compared with Threshold Limit Values and Volatilities for 214 Industrial Chemicals in Air and Water Dilution, *J. Appl. Toxicology* , Vol. 3(6), 1983, pp. 272-290.

USEPA. 2014. Speciate Database, Version 4.4. February. Available at: http://www.epa.gov/ttnchie1/software/speciate/. Accessed June 12, 2017.

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