APPENDIX L

AIR QUALITY AND GREENHOUSE GAS EMISSIONS CALCULATIONS.

City of Seattle Manadatory Housing Affordability
Air Pollutant of Concern Emissions

MOVES2014 Emission Factors

Year	Vehicle Type	Pollutant	Emission Factor, g/mi
2015	Auto and Light Trucks	Carbon Monoxide (CO)	3.4347417803953
2015	Auto and Light Trucks	Oxides of Nitrogen (NOx)	0.4400546875743
2015	Auto and Light Trucks	PM2.5	0.0130365944704
2015	Auto and Light Trucks	VOC	0.1012908073651
2035	Auto and Light Trucks	Carbon Monoxide (CO)	1.1813150598788
2035	Auto and Light Trucks	Oxides of Nitrogen (NOx)	0.0572159525128
2035	Auto and Light Trucks	PM2.5	0.0074742771692
2035	Auto and Light Trucks	VOC	0.0224383543354
2015	Medium and Heavy Trucks	Carbon Monoxide (CO)	6.6874681780743
2015	Medium and Heavy Trucks	Oxides of Nitrogen (NOx)	5.0258978903930
2015	Medium and Heavy Trucks	PM2.5	0.2300680434034
2015	Medium and Heavy Trucks	VOC	0.5300218405968
2035	Medium and Heavy Trucks	Carbon Monoxide (CO)	0.9614989730936
2035	Medium and Heavy Trucks	Oxides of Nitrogen (NOx)	0.8260670920110
2035	Medium and Heavy Trucks	PM2.5	0.0345687988499
2035	Medium and Heavy Trucks	VOC	0.0554789906588

Note: PM10 and PM2.5 emission factors include exhaust, brakewear, and tirewear.

Emission factors proportioned based on population of source type in King County.

Auto and light truck vehicle type is average of MOVES source types 11, 21, 31, and 32.

Medium and heavy truck vehicle type is average of MOVES source types 41, 42, 43, 51, 52, 53, 54, 61, and 62.

City of Seattle Manadatory Housing Affordability
Air Pollutant of Concern Emissions

Vehicle Miles Traveled Annually

Vehicle Type	2015	2035 Alt 1	2035 Alt 2	2035 Alt 3
Auto and Light Duty Truck VMT	19,130,652	22,096,823	22,188,229	22,221,217
Medium & Heavy Truck VMT	957,759	1,170,154	1,170,039	1,170,244
Total VMT	20,088,411	23,266,977	23,358,268	23,391,461
Auto and Light Duty Truck VMT, %	95.2%	95.0%	95.0%	95.0%
Medium & Heavy Truck VMT, %	4.8%	5.0%	5.0%	5.0%

Source: GHG Appendix.

2015

Pollutant	Auto and Light Duty Trucks		Medium and Heavy Duty Trucks		Total Emissions, tpy
	Emission Factor, g/mi	Emissions Rate, tpy	Emission Factor, g/mi	Emissions Rate, tpy	
Carbon Monoxide (CO)	3.43474178	72.43	6.68746818	7.06	79.49
Oxides of Nitrogen (NOx)	0.44005469	9.28	5.02589789	5.31	14.59
PM2.5	0.08043877	1.70	0.29747022	0.31	2.01
VOC	0.10129081	2.14	0.53002184	0.56	2.70

Note: PM2.5 emission factors are the sum of the MOVES emission factor (exhaust, brakewear, tirewear) and a Seattle-area specific AP-42 road dust emission factor for PM2.5.

2035 Alternative 1

Pollutant	Auto and Light Duty Trucks		Medium and Heavy Duty Trucks		Total Emissions, tpy
	Emission Factor, g/mi	Emissions Rate, tpy	Emission Factor, g/mi	Emissions Rate, tpy	
Carbon Monoxide (CO)	1.18131506	28.77	0.96149897	1.24	30.01
Oxides of Nitrogen (NOx)	0.05721595	1.39	0.82606709	1.07	2.46
PM2.5	0.07487645	1.82	0.10197097	0.13	1.96
VOC	0.02243835	0.55	0.05547899	0.07	0.62

Note: PM2.5 emission factors are the sum of the MOVES emission factor (exhaust, brakewear, tirewear) and a Seattle-area specific AP-42 road dust emission factor for PM2.5.

2035 Alternative 2

Pollutant	Auto and Light Duty Trucks		Medium and Heavy Duty Trucks		Total Emissions, tpy
	Emission Factor, g/mi	Emissions Rate, tpy	Emission Factor, g/mi	Emissions Rate, tpy	
Carbon Monoxide (CO)	1.18131506	28.89	0.96149897	1.24	30.13
Oxides of Nitrogen (NOx)	0.05721595	1.40	0.82606709	1.07	2.46
PM2.5	0.07487645	1.83	0.10197097	0.13	1.96
VOC	0.02243835	0.55	0.05547899	0.07	0.62

Note: PM2.5 emission factors are the sum of the MOVES emission factor (exhaust, brakewear, tirewear) and a Seattle-area specific AP-42 road dust emission factor for PM2.5.

2035 Alternative 3

Pollutant	Auto and Light Duty Trucks		Medium and Heavy Duty Trucks		Total Emissions, tpy
	Emission Factor, g/mi	Emissions Rate, tpy	Emission Factor, g/mi	Emissions Rate, tpy	
Carbon Monoxide (CO)	1.18131506	28.94	0.96149897	1.24	30.18
Oxides of Nitrogen (NOx)	0.05721595	1.40	0.82606709	1.07	2.47
PM2.5	0.07487645	1.83	0.10197097	0.13	1.97
VOC	0.02243835	0.55	0.05547899	0.07	0.62

Note: PM2.5 emission factors are the sum of the MOVES emission factor (exhaust, brakewear, tirewear) and a Seattle-area specific AP-42 road dust emission factor for PM2.5.

Summary

Pollutant	2015	2035 Alternative 1	2035 Alternative 2	2035 Alternative 3
Carbon Monoxide (CO)	79.49	30.01	30.13	30.18
Oxides of Nitrogen (NOx)	14.59	2.46	2.46	2.47
PM2.5	2.01	1.96	1.96	1.97
VOC	2.70	0.62	0.62	0.62

City of Seattle Manadatory Housing Affordability
Air Pollutant of Concern Emissions

Road Dust Calculations

Source: AP-42 Handbook, Chapter 13.2.1, page 5

Equation:

E equals $[k (sL)^{0.91} \times (W)^{1.02}]*(1-P/4N)$

where:

k	=	particle size multiplier for particle size range and units of interest. k = particle size multiplier. The AP-42 value for PM10 is 1.00 g/mile and that for PM2.5 is 0.25 g/mile.
sL	=	road surface silt loading (grams per square meter)
W	=	average weight (tons) of *all the vehicles* traveling the road (2.4 tons)
P	=	number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period, and
N	=	number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly)

For the Seattle Area):

For PM_{10}			**For $PM_{2.5}$**		
k	=	1	k	=	0.25
sL	=	0.1	sL	=	0.1
W	=	2.4	W	=	2.4
P	=	150	P	=	150
N	=	365	N	=	365
Therefore:			Therefore:		
E	=	**0.269609**	E	=	**0.067402** gm/mile

City of Seattle Manadatory Housing Affordability
Air Pollutant of Concern Emissions

Natural Gas Usage

Parameter	Existing	Alternative 1	Alternative 2	Alternative 3
Residential natural gas usage, MMBtu/yr	2,322,628	262,044	349,999	353,822
Commercial natural gas usage, MMBtu/yr	285,357	76,653	85,854	84,953
Total natural gas usage, MMBtu/yr	2,607,985	338,697	435,853	438,775

Note: Based on residential building calculated natural gas usage.

Natural Gas Usage Criteria Pollutant of Concern Emissions

Pollutant	Emission Factor, lb/MMBtu	Emissions Rate, tpy			
		Existing	Alternative 1	Alternative 2	Alternative 3
NOX	0.092	120.17	15.61	20.08	20.22
CO	0.039	51.14	6.64	8.55	8.60
VOC	0.005	7.03	0.91	1.18	1.18
PM2.5	0.006	7.29	0.95	1.22	1.23

Note: Based on AP-42, Chapter 1.4, Tables 1.4-1 and 1.4-2. PM2.5 assumed to be condensable fraction emission factor.

City of Seattle Manadatory Housing Affordability
Air Pollutant of Concern Emissions

Air Pollutant of Concern Summary in Tons Per Year

	Existing			Alternative 1			Alternative 2			Alternative 3		
Pollutant	**Transportation**	**Natural gas**	**Total**	**Transportation**	**Natural gas**	**Total**	**Transportation**	**Natural gas**	**Total**	**Transportation**	**Natural gas**	**Total**
NOX	14.59	120.17	134.76	2.46	15.61	18.07	2.46	20.08	22.55	2.47	20.22	22.69
CO	79.49	51.14	130.63	30.01	6.64	36.66	30.13	8.55	38.68	30.18	8.60	38.78
PM2.5	2.01	7.29	9.30	1.96	0.95	2.90	1.96	1.22	3.18	1.97	1.23	3.19
VOC	2.70	7.03	9.73	0.62	0.91	1.53	0.62	1.18	1.80	0.62	1.18	1.80

City of Seattle Mandatory Housing Affordability
Greenhouse Gas Emissions Calculations

GHG Emissions Summary

Source	Alternative 1	Alternative 2	Alternative 3
Transportation (Citywide)	-118,000	-90,000	-90,000
Building Energy - Residential	9,565	12,775	12,915
Building Energy - Commercial	2,252	2,522	2,495
Solid Waste	20,263	25,165	25,076
Total	**-85,921**	**-49,538**	**-49,515**

Note: Transportation values from GHG appendix.

City of Seattle Mandatory Housing Affordability
Greenhouse Gas Emissions Calculations

Building - Residential: Natural Gas Usage and Emission Factors

Parameter	Value	Source/Notes
Single-family households, kBTU/DU/day	27,463	CalEEMod land use subtype: Single Family Housing; Average of all Climate Zones with extremes removed)
Multi family large, kBTU/DU/day	8,797	CalEEMod land use subtype: Apartments Mid Rise; Average of all Climate Zones with extremes removed)
Multi family small, kBTU/DU/day	13,233	CalEEMod land use subtype: Apartments Low Rise; Average of all Climate Zones with extremes removed)
CO2 emission factor (natural gas), lb/MMBTU	117.647059	CalEEMod Appendix D, Default Data Tables
CH4 emission factor (natural gas), lb/MMBTU	0.0022549	CalEEMod Appendix D, Default Data Tables
N2O emission factor (natural gas), lb/MMBTU	0.00215686	CalEEMod Appendix D, Default Data Tables
Residential target reduction	32%	Climate Action Plan, page 34

Building - Residential: Natural Gas Use GHG Emissions

Parameter	2015	Alternative 1	Alternative 2	Alternative 3	Source/Notes
Total households	290,576	45,361	62,363	62,107	
Single-family households	188,122	11,500	14,259	14,236	Assumed to be all outside villages units
Multi family large	35,775	10,361	15,607	12,408	Assumed to be total housing units in Urban Centers (First Hill-Capitol Hill, Northgate, Ravenna (U District 2) [Source: Land Use Chapter 20170508]
Multi family small	66,679	23,500	32,497	35,463	Assumed to be all other house units
Total natural gas use, MMBTU/yr	2,322,628	262,044	349,999	353,822	
Single-family households	1,885,708	115,274	142,930	142,700	
Multi family large	114,869	33,268	50,112	39,841	
Multi family small	322,051	113,502	156,956	171,282	
Total CO2e emissions, MT CO2e/yr	124,671	14,066	18,787	18,992	
Single-family households	101,219	6,188	7,672	7,660	
Multi family large	6,166	1,786	2,690	2,139	
Multi family small	17,287	6,092	8,425	9,194	
Total CO2e emissions (with reduction), MT CO2e/yr	84,777	9,565	12,775	12,915	
Single-family households (with reduction)	68,829	4,208	5,217	5,209	
Multi family large (with reduction)	4,193	1,214	1,829	1,454	
Multi family small (with reduction)	11,755	4,143	5,729	6,252	

City of Seattle Mandatory Housing Affordability
Greenhouse Gas Emissions Calculations

Building - Commercial: Jobs Information and Assumptions

Parameter	2015	Alternative 1	Alternative 2	Alternative 3	Notes
Total jobs	211,148	51,734	57,262	57,099	
By Location					
Outside Villages	85,478	20,790	22,848	22,879	
Inside Villages/Centers	69,226	18,710	20,635	21,005	
Urban Center	56,444	12,234	13,779	13,215	*Urban Center in EIS scope includes First Hill-Capitol Hill, Northgate, and Ravenna [U District (2)]*
By Type					
Warehouse jobs	83,934	9,000	9,000	9,000	
Commercial jobs	127,214	42,734	48,262	48,099	

Building - Commercial: Assumptions Used

Parameter	Value	Notes
Warehouse natural gas usage, kBTU/sf	3.5	CalEEMod Appendix D, Default Data Tables (Unrefrigerated Warehouse-No Rail, Average of all Climate Zones)
Commercial natural gas usage, kBTU/scf	12.1	CalEEMod Appendix D, Default Data Tables (General Office Space, Average of all Climate Zones)
Warehouse, sf/job	450	From Seattle Comprehensive Plan GHG Calculations
Commercial (general), sf/job	300	From Seattle Comprehensive Plan GHG Calculations
Commercial (downtown), sf/job	275	From Seattle Comprehensive Plan GHG Calculations
CO2 emission factor (natural gas), lb/MMBTU	117.647059	CalEEMod Appendix D, Default Data Tables
CH4 emission factor (natural gas), lb/MMBTU	0.0022549	CalEEMod Appendix D, Default Data Tables
N2O emission factor (natural gas), lb/MMBTU	0.00215686	CalEEMod Appendix D, Default Data Tables
Commercial target reduction	45%	Climate Action Plan, page 34

Building - Commercial: GHG Emissions

Parameter	2015	Alternative 1	Alternative 2	Alternative 3	Notes
Warehouse building area, ksf	37,770	4,050	4,050	4,050	
Total commercial, ksf	53,686	16,185	18,268	18,064	
General commercial building area, ksf	38,164	12,820	14,479	14,430	
Downtown commercial building area, ksf	15,522	3,364	3,789	3,634	
Total natural gas usage, MMBTU/yr	285,357	76,653	85,854	84,953	
Warehouse natural gas usage, MMBTU/yr	48,252	5,174	5,174	5,174	
Commercial natural gas usage, MMBTU/yr	237,106	71,479	80,680	79,779	
Total CO2e emissions, MT CO2e/yr	15,258	4,094	4,585	4,537	
CO2e emissions (warehouse natural gas usage), MT CO2e/yr	2,590	278	278	278	
CO2e emissions (commercial natural gas usage), MT CO2e/yr	12,668	3,816	4,307	4,259	
Total CO2e emissions (with reduction), MT CO2e/yr	15,258	2,252	2,522	2,495	
CO2e emissions (warehouse natural gas usage with reduction), MT CO2e/yr	2,590	153	153	153	
CO2e emissions (commercial natural gas usage with reduction), MT CO2e/yr	12,668	2,099	2,369	2,342	

City of Seattle Mandatory Housing Affordability
Greenhouse Gas Emissions Calculations

Solid Waste Related GHG Emissions

From Appendix D of the Climate Action Plan:

Parameter	Alternative 1	Alternative 2	Alternative 3	Source/Notes
Residential waste per capita, tons/resident	0.18	0.18	0.18	
Commercial waste per capita, tons/employee	0.32	0.32	0.32	
Emissions per ton disposed, MT CO2e/ton	0.85	0.85	0.85	
Household size assumption, persons/household	2.06	2.06	2.06	From Transportation GHG analysis
Households	45,361	62,363	62,107	
Population	93,444	128,468	127,940	
Employee increases, persons	51,734	57,262	57,099	
Residential waste generation, tons	16,820	23,124	23,029	
Commercial waste generation, tons	16,555	18,324	18,272	
Total waste generation, tons	33,375	41,448	41,301	
Seattle Current Diversion Rate	58%	58%	58%	Source: Seattle Public Utilities 2015 Recycling Rate Report (Year 2015; Overall)
2030 Diversion Rate Goal	70%	70%	70%	
Total Waste adjusted for diversion, tons	23,839	29,606	29,501	
Waste Emissions, MT CO2e/yr	20,263	25,165	25,076	