AIR QUALITY REPORT

Foster Road Streetscape: Southeast 50th to Southeast 84th Avenue
Multnomah County

Key Number 18022

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Contents

1. Introduction

An Air Quality analysis was conducted for the Foster Road Streetscape Project from Southeast 50^{th} Avenue to Southeast 90^{th} located in Portland, Oregon. The project will improve pedestrian safety crossing, bus stops, bike parking and facilities and signal synchronization equipment along the corridor. The project will also convert four lane sections of Foster to three lane sections which changes the channelization at a number of intersections which is a trigger for air conformity analysis. The project uses state funding and is not subject to transportation conformity requirements but the analysis was conducted for informational purposes. The project is located within the Portland carbon monoxide (CO) maintenance area. The 8 Hour CO concentrations in the opening year (2017) and design year (2035) were predicted to be 2.4 parts per million (ppm) and 1.7 ppm respectively. These concentrations are well below the 8 hour CO National Ambient Air Quality standards (NAAQs) of 9 ppm. The 1 hour CO concentrations for 2017 and 2035 will be 2.9 ppm and 2.1 ppm respectively, which are also well below the 1 hour CO NAAQs of 35 ppm. In both 2017 and 2035, the CO concentrations with the project are slightly lower than without the project because traffic volumes decrease as the roadway changes from four lanes to three lanes.

The project area Mobile Source Air Toxic (MSAT) emissions are expected to decrease in the future relative to existing conditions.

2. Project Description

The Southeast Foster Road Safety and Sidewalk Enhancement Project will design and construct elements of the Foster Road Transportation and Streetscape Plan (adopted in 2003 and updated in 2013) along Southeasst Foster Road between Southeast 50th Avenue and Southeast 90th Avenue. Four lane sections of Foster Road will be reduced to three lane sections. This project will strategically focus on improving pedestrian and bicycle crossing safety and access to transit. The project will provide additional enhanced crossing safety treatments at existing marked crosswalks and add enhanced marked crosswalks and curb extensions to provide safer and more frequent crossing opportunities. The enhanced crossing safety treatments are proposed at non-signalized marked crosswalks. They will include new median islands with Rectangular Rapid Flash Beacons (RRFB), high-visibility, ladder bar marked crosswalks, signage, advanced stop bar and signage, or similar treatments should new research and technology emerge between now and project design.

The project will also upgrade several existing signals that have outdated equipment to provide greater safety and compliance. Improvements include new signal poles and mast arms, signal head back plates for greater visibility, microwave pedestrian detection to extend the "Don't Walk" phase for slow-moving pedestrians that remain in the crosswalk at the end of the regular phase, in-road vehicle detectors to extend the red light to avoid crashes from red light running, count-down pedestrian signal heads, accessible push buttons, new ADA curb ramps and wider sidewalks near the intersection.

Figure 1 shows the project location. Figure 2 shows the project schematic. Figure 3 shows the roadway design for the one intersection analyzed. Figures are located at the end of the report.

3. Traffic Analysis

The traffic data was provided by Portland Bureau of Transportation (PBOT, 2016). The traffic data included peak hour operation data for the signalized intersection for opening year (2017) and design year (2035) for 10 signalized intersections. The worst-case scenario in terms of air quality was selected based on the level of service data (LOS), delay, volume to capacity ratio (V/C) and sum of approaching volumes for opening year 2017 and design year 2035. For the peak hour in 2035, the worst performing intersection in the traffic analysis was SE 50th and Foster Road; however, this intersection is not part of the Foster 3-lane project. Therefore the second worst performing intersection was selected for analysis which is the intersection of SE 82nd and Foster Road. Table 1 shows the operation traffic data for the Build scenario in 2035. Appendix B shows the traffic data for all years for No Build and Build scenarios. The SYNCHRO data used in modeling is included in Appendix B.

Table 1. Traffic Summary for Foster Road for Design Year Build Scenario 2035 PM Peak Hour

Intersection with Foster Road	V/C [1]	Delay (sec/veh)	LOS[2]	Sum of Approaching Volumes
Southeast 50th	1.10	92.6	F	4135
Southeast 52nd	0.84	31.8	C	2285
Southeast 56th	0.57	13.3	B	1530
Southeast Holgate	0.91	52.8	D	2415
Southeast 64th	0.55	6.1	A	1250
Southeast 67th	0.52	5.9	A	1340
Southeast 72nd	0.81	29.7	C	2125
Southeast 78th	0.39	5.0	A	1175
Southeast 82nd	**1.11**	**87.9**	**F**	**3725**
Southeast 87th	0.52	3.3	A	1580

Note: SE 50th and Foster has worst case traffic however no changes to laneage are occurring there and it was not selected for analysis.

1 Volume to Capacity Ratio

2 LOS- Level of Service

3 Bold row is worst case scenario selection

4. Existing Air Quality

Portland is a CO maintenance area. Portland will be at the end of their 2nd Maintenance Plan on October 2, 2017 and transportation conformity will no longer apply. Metro is responsible for regional transportation conformity in the Portland area. In accordance with the guidance in the ODOT Air quality Manual (September 2008), a concentration of 2.0 ppm was used as the ambient background concentration in the project area.

The Portland–Vancouver area became "in attainment" for ozone with the revocation of the federal 1 hour ozone standard in June 2005. The area is still subject to the no backsliding provisions of the revised standard but does not require a conformity analysis for ozone. All other pollutants are in attainment.

5. CO Hot Spot Analysis Methodology

A hot spot analysis must demonstrate that the highest Build CO concentration is below the CO NAAQs and the project conforms to the State Implementation Plan (SIP) for the Portland Area Carbon Monoxide Maintenance Plan. A SIP is a document that outlines the strategies and emission control measures that show how an area will improve air quality and meet the NAAQs. The hot spot analysis includes determining the vehicular emission rates and then using those emission rates in a dispersion model to predict the highest CO concentration. If the modeled worst case intersection scenario does not cause a violation of the NAAQs, then it is assumed all other project intersection scenarios would also not cause a violation of the NAAQs.

5.1. Emission Model

The Environmental Protection Agency (EPA) approved model MOVES2014a (EPA, 2015) calculates emission factors for a variety of gasoline and diesel fueled roadway vehicles. MOVES2014a accounts for progressively more stringent tailpipe emission standards over the vehicle model years evaluated. The MOVES2014a input files include the applicable climate data, fuel characteristics, local vehicle mix and anti-tampering programs for the project area. Emissions were calculated based on a typical winter day because colder temperatures result in higher CO concentrations. The afternoon hour was selected as the worst-case scenario based on LOS, V/C ratio and vehicle volume. MOVES peak hour 16:00 -16:59 was used to represent the afternoon peak hour of 4:00 to 5:00 p.m. The model was run for 2017 and 2035 for roadway speeds within the project area.

MOVES2014a input files were developed by ODOT using database files provided by Metro, default data and project specific data. The databases from Metro include fuel supply, fuel formulation, inspection and maintenance program, meteorological and source type age distribution (Metro, 2015). Using the MOVES2014a database provided by Metro ensures consistency with regional analysis. Default data was used for Fuel Usage Fraction and Alternative Vehicles Fuels Technologies databases. Two project specific databases were developed by ODOT based on the vehicle speeds by link, and also the vehicle type distribution for the project area. Based on professional judgement, the low emitting vehicle program was not included in these emissions runs as they provide minimum change in the CO emissions and from recently completed CO analyses in the Portland area they provide little to no change in concentrations which are already well below the CO NAAQs. Table 2 and 3 summarize the MOVES runspec inputs and MOVES database sources.

Table 2. MOVES Runspec Selections

Input Name	Selection
Scale	Project
Calculation Type	Inventory
Time Span	Hour, analysis year (2017 & 2035), January, weekday, 4:00 - 5:00 p.m.
Geographic Bounds[a]	Oregon, Multnomah County (consistent with Metro regional conformity analysis)
Vehicles/Equipment	Used all gasoline and diesel vehicles
Road Types	Urban unrestricted specific to project
Pollutants and Processes[b]	Running exhaust and crankcase running as given in EPA guidance
Output	Selected distance traveled and population and grams, miles

Note:

[a] Provided by Metro, April, 2015

[b] Using MOVES2014 in Project-level Carbon Monoxide Analyses, March 2015. EPA-420-B-15-028

Table 3. ODOT MOVES Project Level Data Manager Inputs

MOVES Database Name	Data Source
Fuel Supply and Fuel Formulation	Provided by Metro, April 2015
Fuel Fraction Usage and Alternative Vehicles Fuels and Technologies	Default MOVES2014a
Meteorology	Provided by Metro, April 2015
Inspection and Maintenance Coverage	Provided by Metro, April 2015
Source Type Age Distribution	Provided by Metro, April 2015
Project Links	Project specific. One link per roadway project speed. The specific roadway length and types will be characterized in dispersion model.
Link Source Type Hour	The link source type data was developed based on the vehicle miles traveled by each vehicle type in the MOVES database for urban unrestricted roadways in Multnomah County.

Using professional judgment, ODOT developed the link and link source type databases. The link database was developed based on the posted vehicle speeds for project roadways under No Build and average speeds for Build. The link source type data was developed based on the vehicle miles traveled by each vehicle type in Multnomah County for urban unrestricted roadways.

The emission rates calculated by MOVES2014a are shown in Table 4 and the MOVES2014a input and output file names are listed in Appendix C.

Table 4. CO Emission Rates used in CAL3QHC Modeling					
			Emissions Rates (grams/mile)		
Year	**Scenario**	**Speed (mph)**	**2017**	**2035**	**Link**
Idle	Both	idle (grams/hour)	23.76	1.66	idle
2017	Both	9	8.25	NA	southbound right
	Both	30	4.69		north & south
	No Build	20	5.89		east & west
	Build	19	6.12		east & west
2035	Both	9	NA	1.65	southbound right
	Both	30		1.01	north & south
	No Build	16		1.39	east & west
	Build	15		1.42	east & west

5.2. Dispersion Model

The CO project concentrations were calculated using the EPA-approved CAL3QHC dispersion model (version 95221, Environmental Protection Agency (EPA) 1992 and 1995) for the opening year (2017) and the design year (2035). Inputs into the dispersion model include traffic volumes, signal timing, intersection geometry and receptor locations. Traffic information was taken from SYNCHRO files provided by PBOT Traffic Section (PBOT, 2016). CAL3QHC inputs were selected by using the guidance provided in the ODOT Air Quality Manual (ODOT, 2008) and EPA Guideline for Modeling Carbon Monoxide from Roadway Intersections (EPA, 1992). Table 5 summarizes CAL3QHC model inputs.

Table 5. CAL3QHC Model Inputs	
Meteorological Variables	
Averaging Time	60 minutes
Surface Roughness	175 (office)
Wind Speed	1 meter per second
Wind Angle	0 to 360 degrees in 10-degree increments
Stability Class	4 (D) neutral
Mixing Height	1,000 meters
Ambient Background Concentration	
Portland	2 parts per million
Persistence Factor	0.82
Site Variables	
Receptor Coordinates	10 feet from each traveled roadway on both sides of the street at distances of 10 feet, 82.5 feet (25m) and 164 feet (50 m) from the cross street. Height 6.0 feet
Note: The persistence factor is based at SE 82nd Avenue and Division Street	

The maximum 1 hour CO concentration for each model run was added to the ambient background CO concentration of 2.0 ppm as recommended in the ODOT Air Quality Manual, (ODOT, 2008). The 1 hour CO concentrations were converted to the 8 hour concentrations using a persistence factor of 0.82 which was also recommended by the ODOT Manual. These resulting concentrations were compared to the applicable 1 hour and 8 hour CO NAAQs.

6. CO Hot Spot Results

CO concentrations for Build are slightly lower than No Build scenario since the project is moving vehicles further from receptors by reducing thru lanes from four to three lanes. In 2017, the highest Build concentration occurred in the southbound depart and northbound approach receptors of the intersection. In 2035, the highest Build concentration occurred at most receptors modeled because the overall concentration was 2.1 ppm which was only slightly higher than the background concentration of 2.0 ppm. Table 6 summarizes the CAL3QHC modeling results by year and scenario type. The modeled CO concentrations are well below the 1 hour and 8 hour CO NAAQs for all scenarios and analysis years.

The maximum modeled 1 hour and 8 hour Build concentrations are 2.9 ppm and 2.4 ppm, respectively which will occur in 2017. Since concentrations are well below the NAAQs at the intersection analyzed all other intersections in the project area are also determined to be well below the NAAQs.

Table 6. CO Concentrations for Foster Road and SE 82nd Avenue

Scenario	**Analysis Year**	**LOS[1]**	**1 Hour Concentration[2]**	**8 Hour Concentration[2]**	**Location of Highest Conc.**
			(ppm[3])	(ppm[3])	
No Build	2017	E	3.2	2.6	Northeast Quadrant
Build	2017	E	2.9	2.4	Southbound depart and North bound approach
No Build	2035	F	2.2	1.8	Westbound approach and eastbound depart
Build	2035	F	2.1	1.7	most locations
NAAQS[4] (ppm)			35	9	

Note: Persistence factor of 0.82 was used to convert 1 Hour concentrations to 8 Hour concentrations

[1]LOS – Level of service

[2] Includes background concentration of 2 ppm.

[3]PPM- Parts per million

[4]NAAQs – National Ambient Air Quality Standard

7. Construction Activities

During construction CO and particulate matter with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) are expected to increase. These increased emissions are due to heavy construction vehicles, lowered traffic speeds and earth excavation. These emissions create temporary impacts on the ambient air quality

7.1 Construction Mitigation

Construction contractors are required to comply with Division 208 of OAR 340, which addresses visible emissions and nuisance requirements. Subsection of OAR 340-208 places limits on fugitive dust that causes a nuisance or violates other regulations. Violations of the regulations can result in enforcement action and fines. The regulation provides that the following reasonable precautions be taken to avoid dust emissions (OAR 340-208, Subsection 210):

- Use of water or chemicals, where possible, for the control of dust in the demolition of existing buildings or structures, construction operations, the grading of roads or the clearing of land;
- Application of asphalt, oil, water, or other suitable chemicals on unpaved roads, materials stockpiles, and other surfaces which can create airborne dusts;
- Full or partial enclosure of materials stockpiled in cases where application of oil, water, or chemicals are not sufficient to prevent particulate matter from becoming airborne;
- Installation and use of hoods, fans, and fabric filters to enclose and vent the handling of dusty materials;
- Adequate containment during sandblasting or other similar operations;
- When in motion, always cover open-bodied trucks transporting materials likely to become airborne;
- The prompt removal from paved streets of earth or other material that does or may become airborne.

In addition, contractors are required to comply with ODOT standard specifications Section 290 that has requirements for environmental protection, which include air-pollution control measures. These control measures, which include vehicle and equipment idling limitations, are designed to minimize vehicle track-out and fugitive dust. These measures would be documented in the erosion and sediment control plan that the contractor is required to submit prior to the pre-construction conference. To reduce the impact of construction delays on traffic flow and resultant emissions, road or lane closures should be restricted to non-peak traffic periods when possible.

8. MSAT

The purpose of this project is to improve pedestrian and bicycle crossing and safety and access to the transit. As part of this project the four lane section on Foster will be reduced to a three lane section. The highest 2035 No Build annual average daily traffic (AADT) on Foster Road is

28,000 and this will be reduced with the project to Build AADT is 25,000. This project has been determined to generate minimal air quality impacts for Clean Air Act criteria pollutants and has not been linked with any special mobile source air toxic (MSAT) concerns. As such, this project will not result in changes in vehicle mix, basic project location, or any other factor that would cause a meaningful increase in MSAT impacts of the project from that of the No Build scenario. However, the project will reduce traffic volumes in the project area by 3000 vehicles a day which will increase traffic volumes in other areas where the traffic is rerouted and this will have the effect of moving some traffic closer to nearby homes, schools and businesses. Overall though, the traffic volumes in the project are very low and the effect of this project is considered exempt from MSAT analysis based on the Federal Highway Agency's (FHWA) Interim Guidance on Mobile Source Air Toxics Analysis in National Environmental Policy Act Documents, dated October 18, 2016. (FHWA, 2016)

Moreover, Environmental Protection Agency (EPA) regulations for vehicle engines and fuels will cause overall MSAT emissions to decline significantly over the next several decades. Based on regulations now in effect, an analysis of national trends with EPA's MOVES2014 model forecasts a combined reduction of over 90 percent in the total annual emissions rate for the priority MSAT from 2010 to 2050 while vehicle-miles of travel are projected to increase by over 45 percent. This will both reduce the background level of MSAT as well as the possibility of even minor MSAT emissions from this project.

9. Project-Level Conformity Determination

A project level hot spot analysis predicted that at the closest receptor, the 8 hour CO concentration will be well below the NAAQs in 2017 (opening year) and 2035 (design year).

The proposed project is fiscally constrained and is in the 2014 Regional Transportation Plan (RTP) and Metro's financially constrained Air Quality Conformity Determination for the amended 2015-2018 Metropolitan Transportation Improvement Program (MTIP) which were both adopted on July 17, 2014. The air quality conformity finding for RTP and MTIP was issued by FHWA and Federal Transit Administration (FTA) on May 20, 2015. The design concept and scope of the proposed project in this report is consistent with the project description in the RTP, the MTIP and the assumptions in the Metro's regional emissions analysis. Appendix A contains project documentation from the amended State Transportation Improvement Program (STIP).

The project will be in conformance with the SIP for the Portland Area Carbon Monoxide Maintenance Plan (ODEQ, 2004) and the project will not:

- Cause or contribute to any new violations of any standard,
- Increase the frequency or severity of any existing violation or any standard, or
- Delay timely attainment of any transportation control measures (TCM).

The project area Mobile Source Air Toxic emissions are expected to decrease in the future relative to existing conditions.

10. References

Environmental Protection Agency. U.S. Code of Federal Regulations. 40 CFR Part 93, Subpart A. "*Conformity to State or Federal Implementation Plans of Transportation Plans, Programs, and Projects Developed, Funded or Approved Under Title 23 U.S.C. or the Federal Transit Laws*."

Environmental Protection Agency, "*Guideline for Modeling Carbon Monoxide from Roadway Intersections*, EPA-454/R-82-005", November 1992.

Environmental Protection Agency. "*User's Guide to CAL3QHC Version 2.0."* EPA 454-R-92-006R. 1995.

Environmental Protection Agency. "*Using MOVES in Project- Level Carbon Monoxide Analysis."* EPA-420-B-10-041. March, 2015.

Federal Highway Administration. FHWA, 2016. "Updated *Interim Guidance on Air Toxic Analysis in NEPA Documents*." Memorandum from Emily Biondi, Acting Director, Office of Natural Environment. October 18, 2016.

Metro, 2015. MOVES2014a database files from Metro Regional Conformity Analysis performed in 2015. April, 2015.

Oregon Department of Environmental Quality. Oregon Administrative Rules, Division 252. "*Transportation Conformity"*.

ODEQ, 2004. Oregon Department of Environmental Quality. "*Portland Area Carbon Monoxide Maintenance Plan, State Implementation Plan, Volume 2, Section 4.58"*. December 10, 2004.

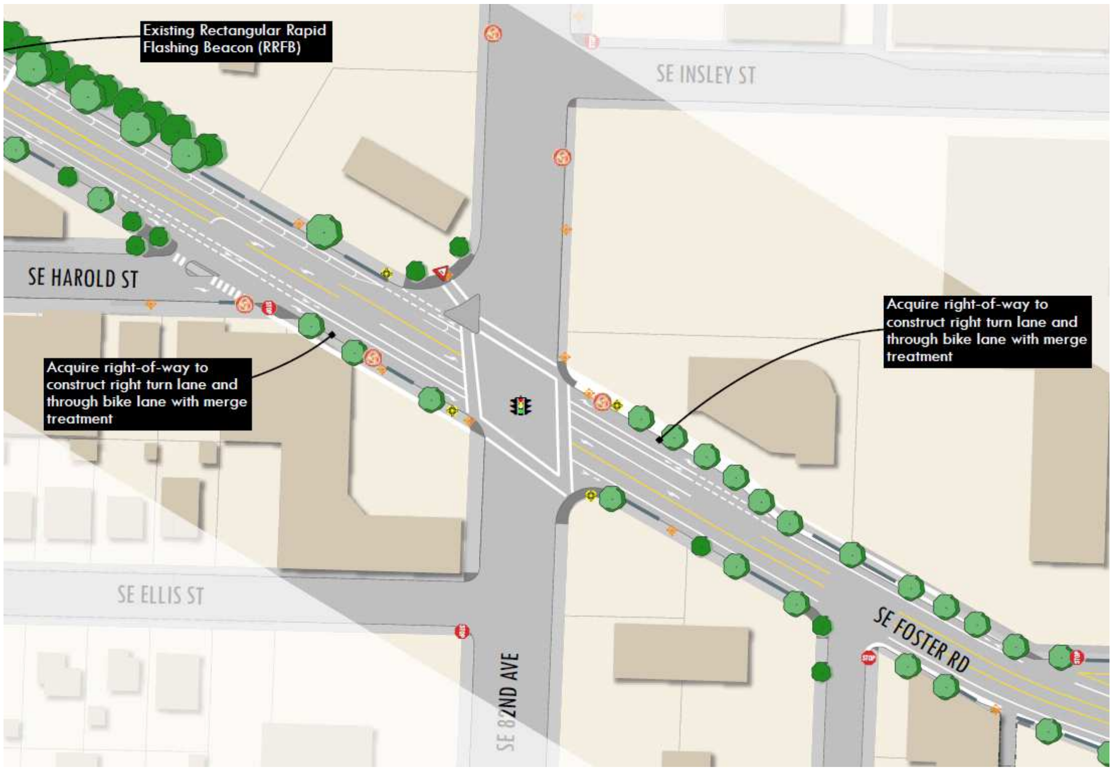
ODOT, 2008. "*Oregon Department of Transportation Air Quality Manual*" September, 2008.

PBOT, 2016. Multiple email correspondence between Ning Zhou and ODOT regarding traffic data needed for air quality analysis. June, 2016.

Figure 1. Project Location Map

Figure 2. Project Schematic

Figure 3. Foster Road and Southeast 82nd Avenue - Intersection Analyzed For Air Analysis



Appendix A - Amended STIP, 2015-2018

and OT to 2017.

MULTNOMAH

Name: FOSTER ROAD STREETSCAPE: SE 50TH-SE 92ND AVE **Key:** 18022
Region: 1

Highway:
Route:
Mile points:
Length:
Description: Reallocate roadway space to create 1 motor vehicle lane and 1 bike lane in each direction with a center turn lane. Construction of curb extensions, sidewalk infill, pedestrian lighting, street trees, rapid flash beacons and traffic signal upgrades.

ACT: REGION 1 ACT
MPO: Portland Metro MPO
Applicant: CITY OF PORTLAND
Status: Construction Scheduled to Begin
Work Type: SAFETY

Approved STIP Amounts

	Planning	Preliminary Engineering	Right of Way	Utility Relocation	Construction	Other	Total STIP Amount
Phase Total:			$75,000		$3,054,000		$3,129,000

Current Project Estimate

	Planning	Preliminary Engineering	Right of Way	Utility Relocation	Construction	Other	Project Total
Year:		2016	2017		2017		
Phase Total:		$1,342,000	$75,000		$3,054,000		$4,471,000
Second Fund:					OTHER		
Match:					$778,365		
First Fund:		STP >200K $1,204,177	STP>200K $67,298		STP>200K $2,041,927		
Match:		$137,823	$7,703		$233,708		

Amendment No: 15-18-976 **Approval Date:** 05/03/2016

Requested Action: Combine K19302 into K18022. Add a RW phase, slip CN to 2017, change the project name and description. Increase total project cost by $278,367 (higher than the $2,299,565 from K19302). **AMENDED**

Appendix B -Traffic Data

Traffic Volumes, Level of Service, Delay, Vehicle Capacity Ratio for No Build and Build Year 2017 & 2035

Traffic Data Provided by Portland Bureau of Transportation					
		2017		2035	
		NoBuild	3-Lane	NoBuild	3-Lane
Σ Vol	50th	4156	3928	4465	4135
	52nd	2604	2179	2890	2285
	56th	1944	1467	2120	1530
	Holgate	2536	2086	2900	2415
	64th	1813	1156	2020	1250
	67th	1933	1219	2230	1340
	72nd	2438	1788	2900	2125
	78th	1780	1136	2015	1175
	82nd	3833	3287	4385	3725
	87th	1869	1400	2065	1580
LOS	50th	E	F	F	F
	52nd	C	C	C	C
	56th	A	B	A	B
	Holgate	C	D	C	D
	64th	A	A	A	A
	67th	A	A	A	A
	72nd	B	C	C	C
	78th	A	A	A	A
	82nd	E	E	F	F
	87th	A	A	A	A
Delay	50th	79.9	84.1	90.8	92.6
	52nd	3.0	29.3	31.8	31.8
	56th	6.1	13.6	5.9	13.3
	Holgate	20.9	37.7	26.6	52.8
	64th	6.5	5.4	7.0	6.1
	67th	4.1	5.3	4.3	5.9
	72nd	19.9	24.6	26.8	29.7
	78th	2.6	4.9	3.9	5.0
	82nd	71.0	62.2	106.2	87.9
	87th	2.1	3.0	2.5	3.3
V/C	50th	1.03	1.09	1.08	1.10
	52nd	0.67	0.82	0.73	0.84
	56th	0.64	0.59	0.45	0.57
	Holgate	0.63	0.84	0.69	0.91
	64th	0.41	0.56	0.44	0.55
	67th	0.45	0.50	0.50	0.52
	72nd	0.75	0.68	0.86	0.81
	78th	0.37	0.40	0.40	0.39
	82nd	1.00	0.99	1.13	1.11
	87th	0.35	0.47	0.39	0.52

Note: Data received from Ning Zhou (PBOT) June 17, 2016.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↱		↰	↑↱		↰	↑↱		↰	↑↑	↱
Volume (vph)	119	719	146	153	614	127	152	722	81	158	807	35
Ideal Flow (vphpl)	1600	1600	1600	1700	1700	1700	1700	1700	1700	1700	1700	1700
Lane Width	11	11	11	11	11	11	11	11	11	11	11	11
Total Lost time (s)	3.0	5.0		3.0	5.0		3.0	5.0		3.0	5.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	1.00		1.00	1.00	0.88
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	0.97		1.00	0.97		1.00	0.98		1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1441	2786		1531	2943		1531	2851		1531	3061	1211
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	1441	2786		1531	2943		1531	2851		1531	3061	1211
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	129	782	159	166	667	138	165	785	88	172	877	38
RTOR Reduction (vph)	0	16	0	0	15	0	0	8	0	0	0	13
Lane Group Flow (vph)	129	925	0	166	790	0	165	866	0	172	877	25
Confl. Peds. (#/hr)			34			64			19			61
Bus Blockages (#/hr)	0	0	9	0	0	6	0	0	0	0	0	0
Parking (#/hr)								0				
Turn Type	Prot	NA		Prot	NA		Prot	NA		Prot	NA	custom
Protected Phases	3	8		7	4		1	6		5	2	
Permitted Phases												2 4
Actuated Green, G (s)	12.4	32.0		13.2	32.8		12.0	35.0		13.8	36.8	69.6
Effective Green, g (s)	12.4	32.0		13.2	32.8		12.0	35.0		13.8	36.8	69.6
Actuated g/C Ratio	0.11	0.29		0.12	0.30		0.11	0.32		0.13	0.33	0.63
Clearance Time (s)	3.0	5.0		3.0	5.0		3.0	5.0		3.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	162	810		183	877		167	907		192	1024	766
v/s Ratio Prot	0.09	c0.33		c0.11	0.27		0.11	c0.30		c0.11	0.29	
v/s Ratio Perm												0.02
v/c Ratio	0.80	1.14		0.91	0.90		0.99	0.95		0.90	0.86	0.03
Uniform Delay, d1	47.6	39.0		47.8	37.0		48.9	36.7		47.4	34.1	7.6
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	23.1	78.6		40.8	12.2		65.5	20.7		37.1	9.2	0.0
Delay (s)	70.7	117.6		88.6	49.3		114.4	57.4		84.5	43.3	7.6
Level of Service	E	F		F	D		F	E		F	D	A
Approach Delay (s)		112.0			56.0			66.4			48.6	
Approach LOS		F			E			E			D	

Intersection Summary			
HCM 2000 Control Delay	71.0	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.00		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	89.3%	ICU Level of Service	E
Analysis Period (min)	15		
Description: Calibrated counts + existing timing plan			
c Critical Lane Group			

2017 Build Scenario

HCM Signalized Intersection Capacity Analysis — 9: 82nd & Foster
Foster Traffic Study -- 2017PM 3-Lanes — Timing Plan: OPTI SPLIT TIMMI

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	67	474	52	98	446	124	76	813	45	183	895	13
Ideal Flow (vphpl)	1600	1600	1600	1700	1700	1700	1700	1700	1700	1700	1700	1700
Lane Width	11	11	11	11	11	11	11	11	11	11	11	11
Total Lost time (s)	3.0	5.0	3.0	3.0	5.0	5.0	3.0	5.0		3.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.96	1.00	1.00	0.89	1.00	1.00		1.00	1.00	0.81
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1441	1516	1195	1531	1611	1189	1531	2874		1531	3061	1105
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	1441	1516	1195	1531	1611	1189	1531	2874		1531	3061	1105
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	73	515	57	107	485	135	83	884	49	199	973	14
RTOR Reduction (vph)	0	0	35	0	0	43	0	4	0	0	0	4
Lane Group Flow (vph)	73	515	22	107	485	92	83	929	0	199	973	10
Confl. Peds. (#/hr)			34			64			19			61
Bus Blockages (#/hr)	0	0	9	0	0	6	0	0	0	0	0	0
Parking (#/hr)								0				
Turn Type	Prot	NA	custom	Prot	NA	custom	Prot	NA		Prot	NA	custom
Protected Phases	3	8		7	4		1	6		5	2	
Permitted Phases			1 8			4 5						2 4
Actuated Green, G (s)	6.0	34.0	46.9	8.0	36.0	50.4	7.9	37.6		14.4	44.1	80.1
Effective Green, g (s)	6.0	34.0	41.9	8.0	36.0	50.4	7.9	37.6		14.4	44.1	80.1
Actuated g/C Ratio	0.05	0.31	0.38	0.07	0.33	0.46	0.07	0.34		0.13	0.40	0.73
Clearance Time (s)	3.0	5.0		3.0	5.0		3.0	5.0		3.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	78	468	455	111	527	544	109	982		200	1227	804
v/s Ratio Prot	0.05	c0.34		c0.07	0.30		0.05	c0.32		c0.13	0.32	
v/s Ratio Perm			0.02			0.08						0.01
v/c Ratio	0.94	1.10	0.05	0.96	0.92	0.17	0.76	0.95		0.99	0.79	0.01
Uniform Delay, d1	51.8	38.0	21.5	50.9	35.6	17.5	50.1	35.2		47.8	28.9	4.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	79.6	71.7	0.0	73.4	21.5	0.1	26.4	18.3		61.9	5.3	0.0
Delay (s)	131.4	109.7	21.5	124.3	57.1	17.7	76.5	53.5		109.6	34.3	4.1
Level of Service	F	F	C	F	E	B	E	D		F	C	A
Approach Delay (s)		104.4			59.7			55.4			46.5	
Approach LOS		F			E			E			D	

Intersection Summary			
HCM 2000 Control Delay	62.2	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	0.99		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	88.8%	ICU Level of Service	E
Analysis Period (min)	15		

Description: with inflated volumes to replicate the observed eb queue length.

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	135	770	150	165	735	135	195	835	120	170	920	55
Ideal Flow (vphpl)	1600	1600	1600	1700	1700	1700	1700	1700	1700	1700	1700	1700
Lane Width	11	11	11	11	11	11	11	11	11	11	11	11
Total Lost time (s)	3.0	5.0		3.0	5.0		3.0	5.0		3.0	5.0	5.0
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	0.99		1.00	1.00	0.88
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	0.98		1.00	0.98		1.00	0.98		1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1441	2789		1531	2954		1531	2838		1531	3061	1211
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	1441	2789		1531	2954		1531	2838		1531	3061	1211
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	147	837	163	179	799	147	212	908	130	185	1000	60
RTOR Reduction (vph)	0	15	0	0	13	0	0	10	0	0	0	19
Lane Group Flow (vph)	147	985	0	179	933	0	212	1028	0	185	1000	41
Confl. Peds. (#/hr)			34			64			19			61
Bus Blockages (#/hr)	0	0	9	0	0	6	0	0	0	0	0	0
Parking (#/hr)								0				
Turn Type	Prot	NA		Prot	NA		Prot	NA		Prot	NA	custom
Protected Phases	3	8		7	4		1	6		5	2	
Permitted Phases												2 4
Actuated Green, G (s)	12.8	32.0		13.0	32.2		12.0	35.0		14.0	37.0	69.2
Effective Green, g (s)	12.8	32.0		13.0	32.2		12.0	35.0		14.0	37.0	69.2
Actuated g/C Ratio	0.12	0.29		0.12	0.29		0.11	0.32		0.13	0.34	0.63
Clearance Time (s)	3.0	5.0		3.0	5.0		3.0	5.0		3.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	167	811		180	864		167	903		194	1029	761
v/s Ratio Prot	0.10	c0.35		c0.12	0.32		c0.14	c0.36		0.12	c0.33	
v/s Ratio Perm												0.03
v/c Ratio	0.88	1.21		0.99	1.08		1.27	1.14		0.95	0.97	0.05
Uniform Delay, d1	47.8	39.0		48.5	38.9		49.0	37.5		47.7	36.0	7.8
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	37.7	107.9		65.1	54.3		159.8	75.7		51.0	22.0	0.0
Delay (s)	85.5	146.9		113.6	93.2		208.8	113.2		98.7	58.0	7.9
Level of Service	F	F		F	F		F	F		F	E	A
Approach Delay (s)		139.0			96.5			129.4			61.6	
Approach LOS		F			F			F			E	

Intersection Summary			
HCM 2000 Control Delay	106.2	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.13		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	97.5%	ICU Level of Service	F
Analysis Period (min)	15		
Description: Calibrated counts + existing timing plan			

c Critical Lane Group

2035 Build Scenario

HCM Signalized Intersection Capacity Analysis
Foster Traffic Study -- Alt. 1 -- 3025PM 3-Lane

9: 82nd & Foster
Timing Plan: OPTI SPLIT TIMMI

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	75	470	60	110	520	140	80	915	115	195	1040	5
Ideal Flow (vphpl)	1600	1600	1600	1700	1700	1700	1700	1700	1700	1700	1700	1700
Lane Width	11	11	11	11	11	11	11	11	11	11	11	11
Total Lost time (s)	3.0	5.0	3.0	3.0	5.0	5.0	3.0	5.0		3.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95		1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.96	1.00	1.00	0.89	1.00	0.99		1.00	1.00	0.81
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.98		1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1441	1516	1195	1531	1611	1189	1531	2836		1531	3061	1105
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (perm)	1441	1516	1195	1531	1611	1189	1531	2836		1531	3061	1105
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	82	511	65	120	565	152	87	995	125	212	1130	5
RTOR Reduction (vph)	0	0	40	0	0	43	0	9	0	0	0	1
Lane Group Flow (vph)	82	511	25	120	565	109	87	1111	0	212	1130	4
Confl. Peds. (#/hr)			34			64			19			61
Bus Blockages (#/hr)	0	0	9	0	0	6	0	0	0	0	0	0
Parking (#/hr)								0				
Turn Type	Prot	NA	custom	Prot	NA	custom	Prot	NA		Prot	NA	custom
Protected Phases	3	8		7	4		1	6		5	2	
Permitted Phases			1 8			4 5						2 4
Actuated Green, G (s)	6.0	34.0	47.0	8.0	36.0	50.0	8.0	38.0		14.0	44.0	80.0
Effective Green, g (s)	6.0	34.0	42.0	8.0	36.0	50.0	8.0	38.0		14.0	44.0	80.0
Actuated g/C Ratio	0.05	0.31	0.38	0.07	0.33	0.45	0.07	0.35		0.13	0.40	0.73
Clearance Time (s)	3.0	5.0		3.0	5.0		3.0	5.0		3.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	78	468	456	111	527	540	111	979		194	1224	803
v/s Ratio Prot	0.06	0.34		c0.08	c0.35		0.06	c0.39		c0.14	0.37	
v/s Ratio Perm			0.02			0.09						0.00
v/c Ratio	1.05	1.09	0.05	1.08	1.07	0.20	0.78	1.14		1.09	0.92	0.00
Uniform Delay, d1	52.0	38.0	21.5	51.0	37.0	18.0	50.1	36.0		48.0	31.4	4.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	116.7	68.8	0.0	108.9	59.9	0.2	29.4	73.7		91.6	12.9	0.0
Delay (s)	168.7	106.8	21.5	159.9	96.9	18.2	79.6	109.7		139.6	44.3	4.1
Level of Service	F	F	C	F	F	B	E	F		F	D	A
Approach Delay (s)		106.1			91.7			107.5			59.1	
Approach LOS		F			F			F			E	

Intersection Summary			
HCM 2000 Control Delay	87.9	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.11		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	95.8%	ICU Level of Service	F
Analysis Period (min)	15		
Description: with inflated volumes to replicate the observed eb queue length.			

c Critical Lane Group

Appendix C – List of Modeling Files

Electronic copies of modeling files are available on request from Region 1 Environmental Section.

A. MOVES2014a database files.
    a. Fuelformulation_OR.csv (Metro, 2015)
    b. FuelSupply_2012+_OR.csv (Metro, 2015)
    c. Fueldefault.xls (MOVES default for Fuelusagefraction and AVFT export November 2016)
    d. IMCoverage_2017_OR.csv & IMCoverage_2035_OR.csv (Metro, 2014)
    e. Links.xls (ODOT)
    f. Linksourcetype.xls (ODOT)
    g. ZoneMonthhour_Or.csv (Metro, 2015)
    h. sourceTypeAgeDistribution_2017_OR.csv (Metro, 2015)

B. MOVEs 2014a runspecs:
    a. Foster17.mrs
    b. Foster35.mrs

C. MOVES 2014a Output
    a. Emissionrates_2017.csv
    b. Emissionrates_2035.csv

D. CAL3QHC Input Files
    a. Foster2017Build.in2
    b. Foster2017nNB.in2
    c. Foster2035Build.in2
    d. Foster2035NB.in2

E. CAL3QHC Output Files
    a. Foster2017Build.ou2
    b. Foster2017NB.ou2
    c. Foster2035Build.ou2
    d. Foster2035NB.ou2