AIR QUALITY REPORT

US 26 (Powell Boulevard): SE20th-SE 34th
Multnomah County

Key Number 18795

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1. Introduction

An Air Quality analysis was conducted for the US 26 (Powell Boulevard) Southeast 20th to Southeast 34th Avenue project, which is located in Portland, Oregon. The project will improve pedestrian safety and sight distance along the corridor by improving lighting and removing trees. The project will also add protected left turn signals at four intersections which changes the signalization and is a trigger for air analysis. 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 (2040) were predicted to be 2.5 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 2040 will be 3.0 ppm and 2.1 ppm respectively, which are also well below the 1-hour CO NAAQs of 35 ppm.

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

2. Project Description

The project will increase safety along Southeast Powell Boulevard between 20th Avenue to 34th Avenue. The project originally included two alternative options: Option 1 was the 21st Side Street Protected Phasing and Option 2 was the 21st Side Street Split Phasing. Option 1 was selected. Improvements include:

- New pedestrian signals (Rectangular Rapid Flashing Beacons) with median islands at the 24th, 31st, and 34th Avenue intersections.
- New signals at 21st, 26th, and 33rd Avenues, with protected left turns from Powell Boulevard onto the side streets
- Protected left turns onto Powell Boulevard at 26th Avenue
- Expanded pedestrian waiting area near Cleveland High School at 26th Avenue
- Select tree removal to improve sight distance
- Improved intersection signing and illumination
- New pedestrian signals and pushbuttons
- Upgraded sidewalk corner ramps

Figure 1 shows the project location. Figure 2 shows the project schematic. Figure 3 shows the existing and build scenario roadway layout for the intersection analyzed for air quality. Figures are located at the end of the report.

3. Traffic Analysis

The traffic data was provided by the ODOT Region 1 Traffic Unit (ODOT, 2016). The traffic data included a.m. and p.m. peak hour operation data for the signalized intersection for opening year (2017) and design year (2040) for four signalized intersections. Both traffic options were provided. 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 2040. The worst performing intersection in the traffic analysis was SE 21st Avenue and Powell Boulevard Option two for split phasing for p.m. hour in 2040. Even though option two is not being selected, this alternative was chosen to identify the worst case scenario for the project area.
Table 1 shows the operation traffic data for the Build scenario in 2040. 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 Powell Boulevard for Design Year Build Scenario 2040 PM Peak Hour

Intersection with Powell Boulevard	V/C [1]	Delay (sec/veh)	LOS[2]	Sum of Approaching Volumes
SE 21st Ave[3]	**1.00**	**86.5**	**F**	**4,000**
SE 26th Ave	0.95	43.0	D	4,230
SE 28th Ave	0.67	9.6	A	3,500
SE 33rd Ave	0.69	7.2	A	3,565

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 2040 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 emissions and from recently completed CO analyses in the Portland area they provide little to no change in concentrations which are 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 & 2040), 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		
	2017	**2040**
Speed	(grams/hour)	(grams/hour)
Idle	23.76	1.47
	(grams/vehicle-mile)	(grams/vehicle-mile)
25 (Northbound/Southbound)	4.96	0.84
35 (Eastbound/Westbound)	4.22	0.77

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 (2040). Inputs into the dispersion model include traffic volumes, signal timing, intersection geometry and receptor locations. Traffic information was taken from SYNCHRO files prepared by the Region 1 Traffic Unit which were provided by the ODOT Region 1 Traffic Unit (ODOT, 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 higher than No Build scenario in 2017. In 2017, the highest Build concentration occurred in the eastbound depart and westbound approach receptors of the intersection. In 2040, the highest Build concentrations occurred at most receptors modeled along the approach and depart lanes of Powell, 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 3.0 ppm and 2.5 ppm, respectively which will occur in 2017. Since concentrations are well below the NAAQs at the intersection analyzed all other intersection is the project area are also determined to be well below the NAAQs.

Table 6. CO Concentrations for Powell Boulevard in Portland, Oregon

Scenario	**Analysis Year**	**LOS**[1]	**1 Hour Concentration**[2]	**8 Hour Concentrati on**[2]	**Location of Highest Conc.**
			(ppm[3])	(ppm[3])	
No Build	2017	C	2.8	2.3	Eastbound approach and Eastern Quadrant
Build	2017	E	3.0	2.5	Eastern Quadrant
No Build	2040	C	2.1	1.7	Eastern Quadrant
Build	2040	F	2.1	1.7	Eastern Quadrant
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 safety to the travelling public by constructing protected turn lanes, improving lighting, and removing trees to increase sight distance as well as other pedestrian safety features. 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 traffic volumes, 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 alternative.

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 2040 (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.

ODOT, 2016. Correspondence between Franke Belleque, ODOT Region 1 Traffic Unit, regarding traffic data needed for air quality analysis. October, 2016.

Figure 1. Project Location Map

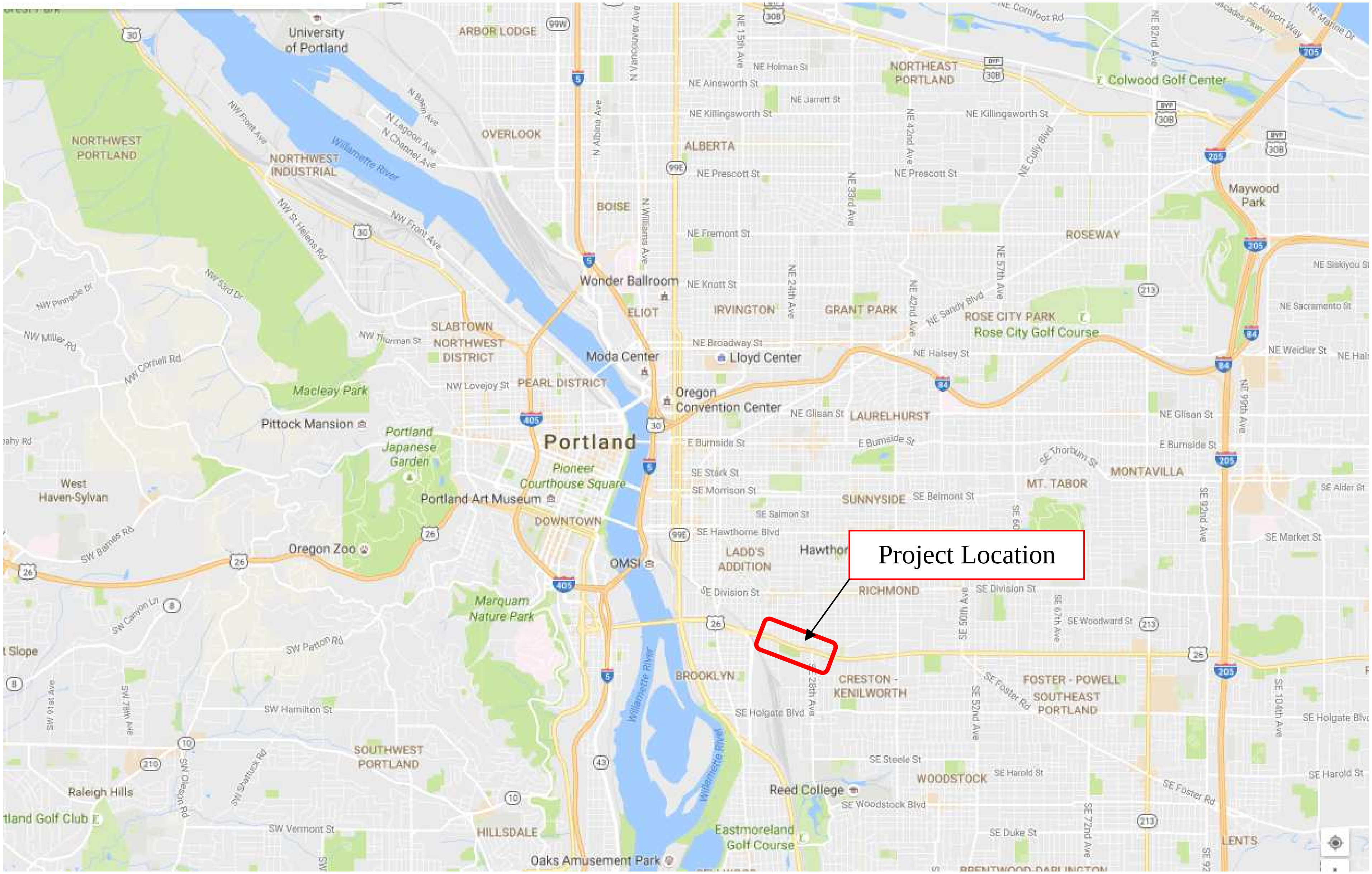

Figure 2. Project Schematic

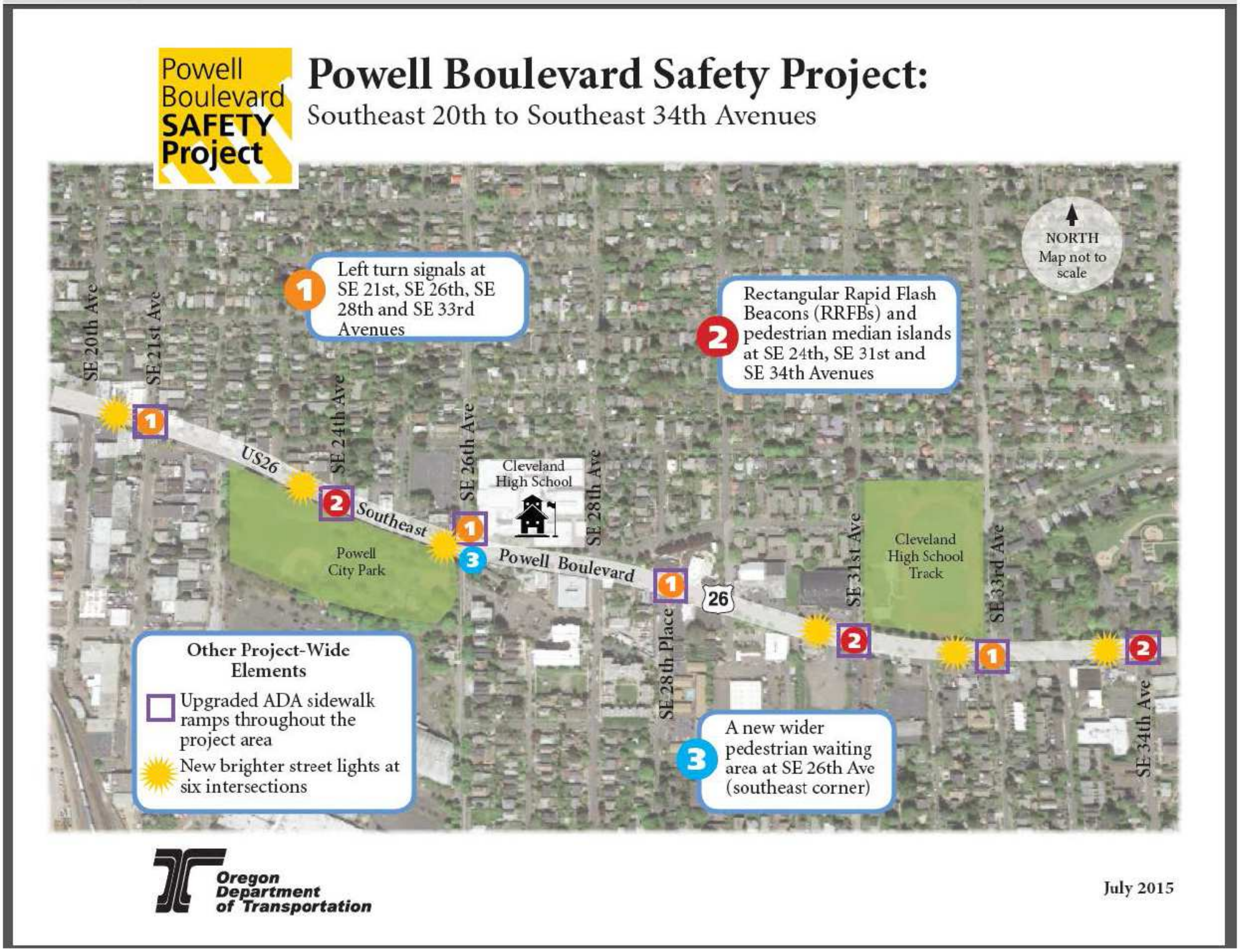

Figure 3. Powell Boulevard and Southeast 21st Avenue - Intersection Analyzed For Air Analysis

Appendix A - Amended STIP, 2015-2018

MULTNOMAH

Name:	**US26 (POWELL BLVD): SE 20TH - SE 34TH**	**Key:**	**18795**
		Region:	1

Highway:	MT HOOD	**ACT:**	REGION 1 ACT
Route:	US-26	**MPO:**	Portland Metro MPO
Mile points:	1.97 to 2.47	**Applicant:**	ODOT
Length:	0.50	**Status:**	Construction Scheduled to Begin
Description:	CROSSWALK SIGNALS, RF BEACONS, STRIPING, SIGNING, ADA UPGRADES & ILLUMINATION	**Work Type:**	SAFETY

Approved STIP Amounts

	Planning	Preliminary Engineering	Right of Way	Utility Relocation	Construction	Other	Total STIP Amount
Phase Total:		**$494,200**	**$400,000**		**$2,863,455**		**$3,757,655**

Current Project Estimate

	Planning	Preliminary Engineering	Right of Way	Utility Relocation	Construction	Other	Project Total
Year:		2014	2015		2017		
Phase Total:		**$494,200**	**$400,000**		**$2,863,455**		**$3,757,655**
Second Fund:					STP-FLX $314,055		
Match:					$35,945		
First Fund:		HSIP $455,751	HSIP $368,880		HSIP $2,317,908		
Match:		$38,449	$31,120		$195,547		

Amendment No:	NEW	**Approval Date:**	12/18/2015
Requested Action:	Slip CN to 2017		

AMENDED

Appendix B -Traffic Data

Traffic Volumes, Level of Service, Delay, Vehicle Capacity Ratio for No Build and Build Year 2017 & 2040

Table 1: Arrival Type (PM Peak Hour)

Roadway		Arrival Type				
		Existing 2015	2017 No-Build	2017 Build	2040 No-Build	2040 Build
SE Powell Blvd	Westbound	4	4	3	4	3
	Eastbound	4	4	3	4	3
SE 21st Ave	Northbound	3	3	3	3	3
	Southbound	3	3	3	3	3
SE 26th Ave	Northbound	3	3	3	3	3
	Southbound	3	3	3	3	3

Table 2: Annual Average Daily Traffic (AADT)

Roadway		2014 AADT	2017 AADT	2037 AADT	2040 AADT
SE Powell Blvd	West & East Legs	35,000	35,520	39,000	39,520
SE 21st Ave	North Leg	2800	2840	3100	3140
	South Leg	2500	2540	2800	2840
SE 26th Ave	North Leg	3800	3850	4200	4250
	South Leg	3700	3750	4100	4150

* 8.5% of AADT on Powell from Heavy Trucks
*Side streets projected using Local street counts

Table 3: Average Free Flow Speed

Roadway		Posted Speed (mph)	Average Free Flow Speed (mph)		
			Existing 2015	No-Build 2040	Build 2040
SE Powell Blvd	Westbound	35	35	35	35
	Eastbound	35	35	35	35
SE 21st Ave	Southbound (North Leg)	25	25	25	25
	Northbound (South Leg)	25	25	25	25
SE 26th Ave	Southbound (North Leg)	25	25	25	25
	Northbound (South Leg)	25	25	25	25

* All are assumed to be the same as posted speed

Powell Operation Summary Traffic Data SE 20th Ave - SE 34th Ave

	Intersection Name	Existing Year 2015				Future Year 2017 No Build				Future Year 2040 No Build			
		In Volume	v/c	Delay	LOS	In Volume	v/c	Delay	LOS	In Volume	v/c	Delay	LOS
4-5 p.m. PM Peak	SE 21st Ave	3,600	0.81	21.7	C	3,665	0.83	22.3	C	4,000	0.90	26.4	C
	SE 26th Ave	3,810	0.85	38.9	D	3,840	0.86	39.2	D	4,230	0.95	48.7	D
	SE 28th Ave	3,160	0.64	7.0	A	3,190	0.64	7.1	A	3,500	0.67	8.4	A
	SE 33rd Ave	3,230	0.64	3.7	A	3,260	0.64	3.7	A	3,565	0.67	3.8	A

Option 1: 21st Side Street Protected Phasing

	Intersection Name	Future Year 2017 Build				Future Year 2040 Build			
		In Volume	v/c	Delay	LOS	In Volume	v/c	Delay	LOS
4-5 p.m. PM Peak	SE 21st Ave	3,665	0.83	33.0	C	4,000	0.88	37.6	D
	SE 26th Ave	3,840	0.86	37.6	D	4,230	0.95	46.6	D
	SE 28th Ave	3,190	0.64	7.7	A	3,500	0.67	9.4	A
	SE 33rd Ave	3,260	0.68	7.2	A	3,565	0.69	7.2	A

Optio 2: 21st Side Street Split Phasing

	Intersection Name	Future Year 2017 Build				Future Year 2040 Build			
		In Volume	v/c	Delay	LOS	In Volume	v/c	Delay	LOS
4-5 p.m. PM Peak	SE 21st Ave	3665	0.94	58.7	E	4,000	1.00	86.5	F
	SE 26th Ave	3840	0.86	36.1	D	4,230	0.95	43.0	D
	SE 28th Ave	3190	0.64	8.2	A	3,500	0.67	9.6	A
	SE 33rd Ave	3260	0.68	7.2	A	3,565	0.69	7.2	A

Table 1 - Powell Operation Summary Traffic Data SE 20th Ave - SE 34th Ave

	Intersection Name	Existing Year 2015				Future Year 2017 No Build				Future Year 2017 Build				Future Year 2040 No Build				Future Year 2040 Build			
		In Volume	v/c	Delay	LOS	In Volume	v/c	Delay	LOS	In Volume	v/c	Delay	LOS	In Volume	v/c	Delay	LOS	In Volume	v/c	Delay	LOS
7-8 a.m. AM Peak	SE 21st Ave	2,790	0.71	13.6	B	2,825	0.71	13.8	B					3,255	0.76	16.2	B				
	SE 26th Ave	3,010	0.78	29.9	C	3,045	0.78	30.3	C					3,480	0.82	36.9	D				
	SE 28th Ave	2,605	0.62	5.3	A	2,625	0.62	5.3	A					2,960	0.64	5.4	A				
	SE 33rd Ave	2,630	0.61	10.3	B	2,685	0.61	10.4	B					3,015	0.66	14.7	B				

All data from HCM 2000 Signalized Intersection Capacity Analysis Report generated by Synchro 8 models.

HCM Signalized Intersection Capacity Analysis
11: SE 21st Avenue & SE Powell Blvd.

10/7/2016

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	90	1860	5	10	1240	40	135	50	10	80	65	80
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			0.97	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			0.98			0.99	
Frt	1.00	1.00		1.00	1.00			0.99			0.95	
Flt Protected	0.95	1.00		0.95	1.00			0.97			0.98	
Satd. Flow (prot)	1736	3468		1530	3451			1703			1657	
Flt Permitted	0.16	1.00		0.05	1.00			0.56			0.83	
Satd. Flow (perm)	285	3468		82	3451			985			1405	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	95	1958	5	11	1305	42	142	53	11	84	68	84
RTOR Reduction (vph)	0	0	0	0	2	0	0	2	0	0	18	0
Lane Group Flow (vph)	95	1963	0	11	1345	0	0	204	0	0	218	0
Confl. Peds. (#/hr)	3		43	43		3	34		42	42		34
Confl. Bikes (#/hr)									11			24
Heavy Vehicles (%)	4%	4%	3%	18%	4%	4%	4%	2%	25%	2%	3%	3%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			4			4	
Permitted Phases	2			6			4			4		
Actuated Green, G (s)	83.2	83.2		83.2	83.2			27.7			27.7	
Effective Green, g (s)	84.1	84.1		84.1	84.1			27.9			27.9	
Actuated g/C Ratio	0.70	0.70		0.70	0.70			0.23			0.23	
Clearance Time (s)	4.9	4.9		4.9	4.9			4.2			4.2	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	199	2430		57	2418			229			326	
v/s Ratio Prot		c0.57			0.39							
v/s Ratio Perm	0.33			0.13				c0.21			0.16	
v/c Ratio	0.48	0.81		0.19	0.56			0.89			0.67	
Uniform Delay, d1	8.1	12.4		6.2	8.8			44.6			41.9	
Progression Factor	1.73	1.65		0.76	1.10			1.00			1.00	
Incremental Delay, d2	4.4	1.6		5.4	0.7			32.3			5.2	
Delay (s)	18.3	22.1		10.2	10.3			76.9			47.0	
Level of Service	B	C		B	B			E			D	
Approach Delay (s)		21.9			10.3			76.9			47.0	
Approach LOS		C			B			E			D	

Intersection Summary			
HCM 2000 Control Delay	22.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	84.8%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Build 2017

HCM Signalized Intersection Capacity Analysis
11: SE 21st Avenue & SE Powell Blvd.

10/10/2016

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↱		↰	↑↱			✣			✣	
Volume (vph)	90	1860	5	10	1240	40	135	50	10	80	65	80
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.6	4.0		2.6	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			0.97	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	1.00		1.00	1.00			0.99			0.95	
Flt Protected	0.95	1.00		0.95	1.00			0.97			0.98	
Satd. Flow (prot)	1736	3468		1530	3451			1735			1674	
Flt Permitted	0.95	1.00		0.95	1.00			0.97			0.98	
Satd. Flow (perm)	1736	3468		1530	3451			1735			1674	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	95	1958	5	11	1305	42	142	53	11	84	68	84
RTOR Reduction (vph)	0	0	0	0	2	0	0	2	0	0	18	0
Lane Group Flow (vph)	95	1963	0	11	1345	0	0	204	0	0	219	0
Confl. Peds. (#/hr)	3		43	43		3	34		42	42		34
Confl. Bikes (#/hr)									11			24
Heavy Vehicles (%)	4%	4%	3%	18%	4%	4%	4%	2%	25%	2%	3%	3%
Turn Type	Prot	NA		Prot	NA		Split	NA		Split	NA	
Protected Phases	5	2		1	6		8	8		4	4	
Permitted Phases												
Actuated Green, G (s)	11.1	63.0		1.6	53.5			18.8			19.8	
Effective Green, g (s)	12.0	63.9		2.5	54.4			19.0			20.0	
Actuated g/C Ratio	0.10	0.53		0.02	0.45			0.16			0.17	
Clearance Time (s)	3.5	4.9		3.5	4.9			4.2			4.2	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	173	1846		31	1564			274			279	
v/s Ratio Prot	c0.05	c0.57		0.01	0.39			c0.12			c0.13	
v/s Ratio Perm												
v/c Ratio	0.55	1.06		0.35	0.86			0.75			0.78	
Uniform Delay, d1	51.4	28.1		58.0	29.4			48.2			47.9	
Progression Factor	1.05	1.27		0.71	1.21			1.00			1.00	
Incremental Delay, d2	1.9	35.6		5.0	4.8			10.5			13.4	
Delay (s)	56.1	71.2		46.3	40.5			58.7			61.3	
Level of Service	E	E		D	D			E			E	
Approach Delay (s)		70.5			40.5			58.7			61.3	
Approach LOS		E			D			E			E	

Intersection Summary			
HCM 2000 Control Delay	58.7	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	0.94		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	14.6
Intersection Capacity Utilization	84.8%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

No Build 2040

HCM Signalized Intersection Capacity Analysis
11: SE 21st Avenue & SE Powell Blvd.

10/7/2016

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	1940	5	10	1325	135	135	50	10	80	65	125
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			0.96	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			0.98			0.99	
Frt	1.00	1.00		1.00	0.99			0.99			0.94	
Flt Protected	0.95	1.00		0.95	1.00			0.97			0.99	
Satd. Flow (prot)	1736	3468		1530	3413			1707			1624	
Flt Permitted	0.11	1.00		0.05	1.00			0.50			0.86	
Satd. Flow (perm)	206	3468		78	3413			889			1411	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	126	2042	5	11	1395	142	142	53	11	84	68	132
RTOR Reduction (vph)	0	0	0	0	6	0	0	2	0	0	27	0
Lane Group Flow (vph)	126	2047	0	11	1531	0	0	204	0	0	257	0
Confl. Peds. (#/hr)	3		43	43		3	34		42	42		34
Confl. Bikes (#/hr)									11			24
Heavy Vehicles (%)	4%	4%	3%	18%	4%	4%	4%	2%	25%	2%	3%	3%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			4			4	
Permitted Phases	2			6			4			4		
Actuated Green, G (s)	81.4	81.4		81.4	81.4			29.5			29.5	
Effective Green, g (s)	82.3	82.3		82.3	82.3			29.7			29.7	
Actuated g/C Ratio	0.69	0.69		0.69	0.69			0.25			0.25	
Clearance Time (s)	4.9	4.9		4.9	4.9			4.2			4.2	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	141	2378		53	2340			220			349	
v/s Ratio Prot		0.59			0.45							
v/s Ratio Perm	c0.61			0.14				c0.23			0.18	
v/c Ratio	0.89	0.86		0.21	0.65			0.93			0.74	
Uniform Delay, d1	15.3	14.5		6.9	10.7			44.1			41.5	
Progression Factor	1.64	1.63		0.73	1.06			1.00			1.00	
Incremental Delay, d2	33.8	2.4		5.1	0.8			41.0			7.9	
Delay (s)	58.8	26.0		10.1	12.3			85.2			49.4	
Level of Service	E	C		B	B			F			D	
Approach Delay (s)		27.9			12.3			85.2			49.4	
Approach LOS		C			B			F			D	

Intersection Summary			
HCM 2000 Control Delay	26.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.90		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	89.7%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Build 2040

HCM Signalized Intersection Capacity Analysis
11: SE 21st Avenue & SE Powell Blvd.

10/10/2016

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	1940	5	10	1325	135	135	50	10	80	65	125
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.6	4.0		2.6	4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			0.96	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	1.00		1.00	0.99			0.99			0.94	
Flt Protected	0.95	1.00		0.95	1.00			0.97			0.99	
Satd. Flow (prot)	1736	3468		1530	3413			1735			1637	
Flt Permitted	0.95	1.00		0.95	1.00			0.97			0.99	
Satd. Flow (perm)	1736	3468		1530	3413			1735			1637	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	126	2042	5	11	1395	142	142	53	11	84	68	132
RTOR Reduction (vph)	0	0	0	0	6	0	0	2	0	0	27	0
Lane Group Flow (vph)	126	2047	0	11	1531	0	0	204	0	0	257	0
Confl. Peds. (#/hr)	3		43	43		3	34		42	42		34
Confl. Bikes (#/hr)									11			24
Heavy Vehicles (%)	4%	4%	3%	18%	4%	4%	4%	2%	25%	2%	3%	3%
Turn Type	Prot	NA		Prot	NA		Split	NA		Split	NA	
Protected Phases	5	2		1	6		8	8		4	4	
Permitted Phases												
Actuated Green, G (s)	12.3	61.1		1.6	50.4			18.8			21.7	
Effective Green, g (s)	13.2	62.0		2.5	51.3			19.0			21.9	
Actuated g/C Ratio	0.11	0.52		0.02	0.43			0.16			0.18	
Clearance Time (s)	3.5	4.9		3.5	4.9			4.2			4.2	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	190	1791		31	1459			274			298	
v/s Ratio Prot	c0.07	c0.59		0.01	0.45			c0.12			c0.16	
v/s Ratio Perm												
v/c Ratio	0.66	1.14		0.35	1.05			0.75			0.86	
Uniform Delay, d1	51.3	29.0		58.0	34.4			48.2			47.6	
Progression Factor	1.06	1.24		0.79	1.15			1.00			1.00	
Incremental Delay, d2	4.6	68.4		4.0	32.7			10.5			21.8	
Delay (s)	59.1	104.4		49.6	72.0			58.7			69.3	
Level of Service	E	F		D	E			E			E	
Approach Delay (s)		101.7			71.9			58.7			69.3	
Approach LOS		F			E			E			E	

Intersection Summary			
HCM 2000 Control Delay	86.5	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.00		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	14.6
Intersection Capacity Utilization	89.7%	ICU Level of Service	E
Analysis Period (min)	15		

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_2040_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. Powell17.mrs
   b. Powell35.mrs

C. MOVES 2014a Output
   a. Emissionrates_2017.csv
   b. Emissionrates_2040.csv

D. CAL3QHC Input Files
   a. Powell2017Build.in2
   b. Powell2017nNB.in2
   c. Powell2040Build.in2
   d. Powell2040NB.in2

E. CAL3QHC Output Files
   a. Powell2017Build.ou2
   b. Powell2017NB.ou2
   c. Powell2040Build.ou2
   d. Powell2040NB.ou2