Appendix A

Methodology

Pollutant Modeling

Carbon Monoxide

Predictions of existing and future localized air pollution concentrations for this and most other roadway air quality studies are made for CO only. Most other pollutants must be monitored and dealt with regionally. This is done for four reasons:

- Total CO emissions in the atmosphere from automobiles are greater than the emissions of all other pollutants combined; for example, in 2015 an average automobile traveling at 35 mph is expected to emit approximately 13.6 grams of CO per mile of travel, but only 1.5 and 2.2 grams of hydrocarbons (HC) and NO_X, respectively (Mobile 5a results).
- Motor vehicles are the greatest source of CO emissions, accounting for more than 90 percent of total CO emissions in urban areas; therefore, it is generally not necessary to account for other, often unquantified, sources of CO near the project area (EPA, 1993).
- The complex reactive natures of some of the other pollutants, such as ozone, are such that accurate predictions of local ambient concentrations cannot be made using current modeling procedures (Wayne, 1991).
- CO emissions from motor vehicles may be high enough to affect individuals in the immediate area, while most other pollutants are not (Erlich, 1977).

Ozone

Ozone concentrations as a result of this project were not modeled because ozone is a secondary pollutant that is generated through a series of complex reactions between pollutants emitted from motor vehicles and other sources (DEQ, 2006).

Due to recent changes in the federal Clean Air Act, the Vancouver- Clark County area is no longer required to model regional conformity for 1-hour ozone.

PM_{10}

Analysis for operational effects for PM_{10} were not analyzed for this project as the project is outside any PM_{10} maintenance or nonattainment areas.

Particulate emissions, however, are qualitatively evaluated for construction activities (see 3.0, Effects and 4.0, Mitigation).

Selection of Modeling Years

The purpose of air quality modeling is to determine whether CO concentrations, as a result of project operation, would exceed air quality standards. Projects must predict air quality in a manner that is consistent with regional transportation plans. During 2005, RTC adopted 2030 for the planning year.

Modeling for the year of opening is also required. Air quality agencies have discussed how to identify potential air quality violations between the existing and horizon years, and agreed on the year of opening as an interim check on CO (2017 is the opening year for this project).

Intersection Selection for Modeling

- The Federal Conformity Rule requires that projects model intersections for CO that are at or would be at an LOS D, E, or F as a result of the project. If the intersections with the worst level of service on the project are modeled and do not exceed the NAAQS, then it can be assumed that all other intersections would not exceed them.
- Table A-1 shows the intersections in the project and their LOS for all years and alternatives. Intersections shown in bold have an LOS of D, E, or F in the existing, year of opening, or design year Proposed Build Alternative conditions. Federal law requires that these intersections must be modeled quantitatively.
- Federal guidance allows intersections to be selected for modeling if they represent the worst case for delay and volume. If the three worst intersections do not exceed the NAAQS, then it can be assumed that the other intersections do not.

Table A-1: Project Intersection and Level of Service (LOS)

			2013 Phase Opening Year				2017 Opening Year				2030 Horizon Year			
	Existing 2005		No Build		Proposed Build		No Build		Proposed Build		No Build		Proposed Build	
Intersection	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
NW 139th at Tenney	B*	B*	B*	B*	A	B	B*	B*	A	B	C*	F*	C	B
NE 139th at 10th Ave.	B*	B*	C	E	B	C	D*	F*	C	C	D*	F*	C	D
NE 139th at I-5 SB on ramp	NA	NA	NA	NA	A	A	NA	NA	A	A	NA	NA	A	A
NE 139th at I-5 NB on ramp	NA	NA	NA	NA	B*	C*	NA	NA	B*	C*	NA	NA	C*	E*
NE 139th at I-5 NB off ramp	NA	NA	NA	NA	A	B	NA	NA	A	B	NA	NA	B	B
NE 139th at 20th Ave.	B	B	C	E	B	C	D	F	C	C	E	F	C	D
NE 139th at 23rd Ave	A*	B	B	B	B	B	B	C	B	B	B	D	C	C
NE 139th at 29th Ave	B*	C*	B	C	B	C	B	C	B	C	E	F	E	F
NE 134th at 10th Ave.	A	B	D	A	B	C	B	B	B	B	B	D	B	B
NE 134th at I-5 SB ramp	A	B	D	F	C	A	A	A	A	A	D	A	B	A
NE 134th at I-5 NB ramp	C	F	D	F	A	A	D	F	A	A	D	F	B	C
NE 134th at 20th Ave.	C	C	D	E	C	D	E	F	C	D	F	E	C	F
NE 134th at 23rd Ave.	B	C	D	E	C	E	D	F	C	E	F	F	C	C

**Unsignalized intersection in this year and alternative*
***Bold** LOS indicates intersection requiring hot spot dispersion modeling*

WASIST Model

WASIST Version 1.0, Washington State's Intersection Screening Tool, is a Windows®-based screening model used for determining worst-case CO concentrations at signalized intersections and metered roadways throughout the state of Washington. WASIST is a project-based intersection screening tool that uses the most conservative, Washington state-specific background assumptions to ensure compliance with federal and state conformity regulations for CO.

WASIST uses readily available data in a user-friendly application to make a conservative estimate of project CO levels. This is done by using a combination of worst-case conditions that, when occurring simultaneously, produce the highest levels of CO. If the results from WASIST do not violate NAAQS for CO, the effect from any other combination of conditions would also be below the standards and no further modeling is required. If the results from WASIST indicate the project may cause a NAAQS violation, a detailed analysis should be performed to better evaluate project CO levels.

WASIST was developed in coordination with WDOE and EPA. In order to formally use this tool for project-level transportation conformity determinations, WASIST relies on the same models required by the EPA for full project-level conformity analyses: The MOBILE6 emission factor model and CAL3QHC dispersion model (EPA, 1994; EPA, 1995). It uses computer programming to assemble and run the CAL3QHC dispersion model to determine CO concentrations for 16 different intersection types (including roundabouts and single-direction highway ramps).

WASIST provides more protective evaluations of anticipated carbon monoxide emissions for intersection improvements than full, project-specific analyses using CAL3QHC. The time to conduct an intersection analysis can be greatly reduced with WASIST when making project level conformity determinations.

Inert pollutant concentrations are predicted in ppm averaged over a 1-hour period. Project information is input into the model to predict pollutant concentrations near the selected intersections.

To run a complete screen analysis, inputs are separated into three categories: general, intersection, and receptor inputs. After the three sets of input variables are entered, the inputs can be accessed and changed in any order.

WASIST input variables include:

- The location of the intersection and whether or not there is a vehicle inspection and maintenance program in the area.
- Traffic volume and signal timing on the busiest leg of the intersection.
- Peak hour average approach speed.
- Closest receptor distance to any one edge of roadway.
- Background CO concentrations were assumed to be 3 ppm averaged over 1-hour to represent a suburban business area (WDOE, 1995). Background CO concentrations were added to the 1-hour and 8-hour maximum concentrations after modeling.

The conditions usually do not persist for an 8-hour period; therefore, the worst-case 8-hour CO concentrations are lower than the maximum 1-hour concentrations.

The 8-hour average CO concentration is calculated by multiplying the maximum 1-hour concentration by a persistence factor, which accounts for the time variance in traffic and meteorological conditions.

Traffic

Traffic volumes used in this study were obtained from project engineers. Consultant engineers coordinated with RTC to establish traffic volumes for the project that are consistent with regional traffic trends.

- Traffic model inputs include peak hour traffic flow (PM) to predict the worst-case CO concentrations.
- Free-flow traffic was modeled at the posted speed limits for the street at each leg of the intersection.
- Traffic operations data, including turn movements, signal times, and saturation flow rates, were taken from the Synchro 6 runs that were completed as part of the project engineer's transportation study.
- See Appendix D for detailed traffic inputs to the model.

Receptors

Specific locations where CO concentrations are predicted are known as receptors. Receptors are modeled in locations where the general public would have access, and where maximum concentrations likely would occur because of traffic mobility (EPA, 1992).

In accordance with Ecology guidelines (WDOE, 1995) receptors were located in areas accessible to the general public at a 10 foot distance from the edge of the travel lane and 6 feet off the ground.

Only the highest concentration of CO at each intersection was reported for each modeled alternative.

Typical link and receptor geometry is illustrated in Figure A-1, Receptor Geometry, shown on the following page.

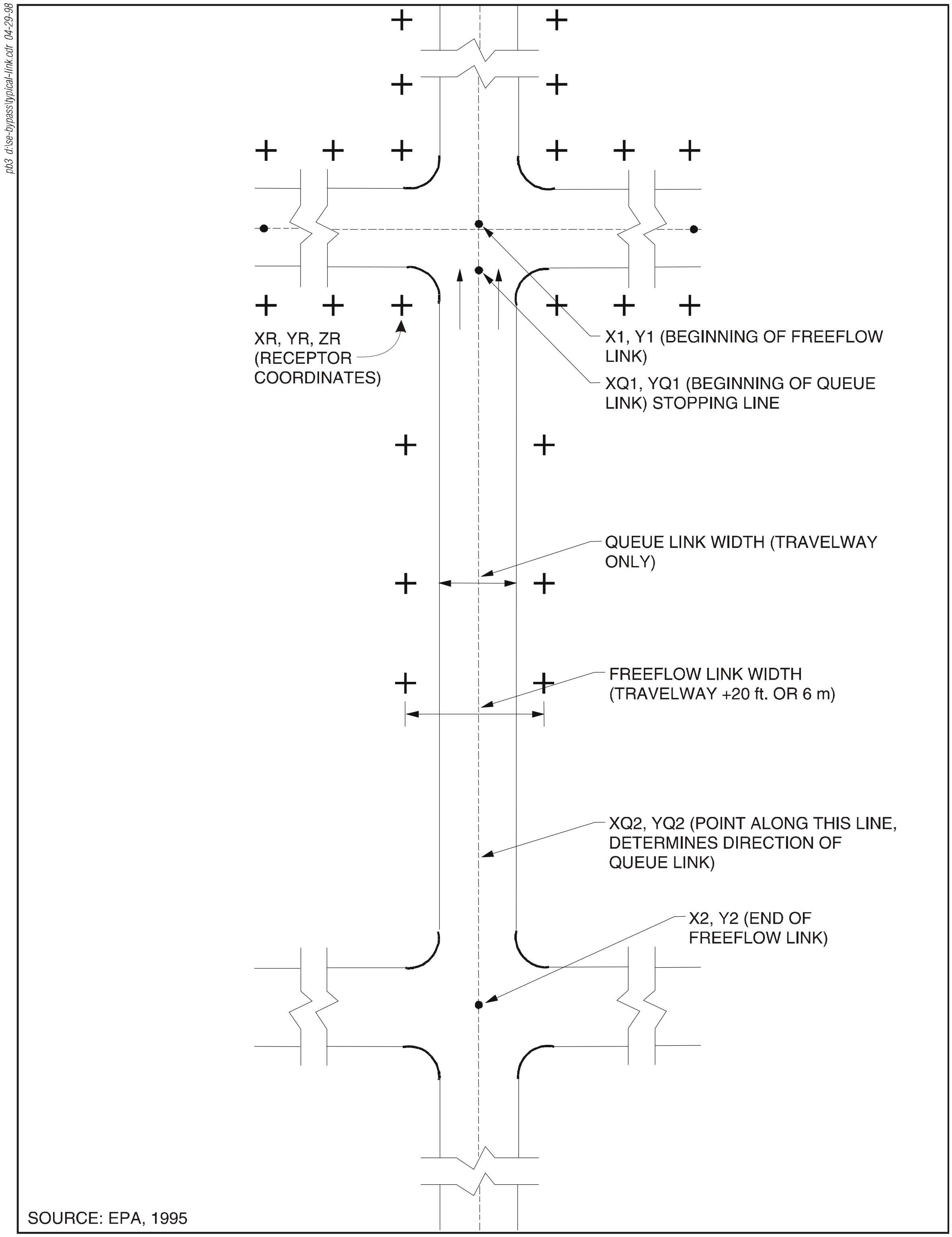

Figure A-1, Receptor Geometry

National Ambient Air Quality Standards (NAAQS)

Under the Clean Air Act, EPA has established the NAAQS, which specifies maximum concentrations for CO, particulate matter less than 10 micrometers in size (PM_{10}), particulate matter less than 2.5 micrometers in size ($PM_{2.5}$), ozone, sulfur dioxide, lead, and nitrogen dioxide. The standards applicable to transportation projects are summarized in Table A-2.

The 8-hour CO standard of 9 parts per million (ppm) is the standard most likely to be exceeded as the result of transportation projects. Nonconformance with NAAQS may threaten funding of transportation projects in the area.

Table A-2: Summary of Ambient Air Quality Standards

Pollutant	National Primary Standard	Washington State Standard	SWCAA Regional Standard
CARBON MONOXIDE (ppm)			
One-Hour Average (not to be exceeded more than once per year)	35	35	35
Eight-Hour Average (not to be exceeded more than once per year)	9	9	9
PM_{10} (µg/m^3)			
Annual Arithmetic Mean	50	50	50
24-Hour Average Concentration (not to be exceeded more than once per year)	150	150	150
$PM_{2.5}$ (µg/m^3)			
Annual Arithmetic Mean	15		
24-Hour Average Concentration (not to be exceeded more than once per year)	65		
TOTAL SUSPENDED PARTICULATES (µg/m^3)			
Annual Arithmetic Mean		60	60
24-Hour Average Concentration (not to be exceeded more than once per year)		150	150
OZONE (ppm)			
One-Hour Average (not to be exceeded more than once per year)	0.12	0.12	0.12
Eight-Hour Average (not to be exceeded more than once per year)	0.08		

ppm = parts per million
µg/m^3 = micrograms per cubic meter
Sources: SWCAA Regulation 1 (SWCAA 2007)
40 CFR Part 50 (EPA 1997)
WAC chapters. 173-470, 173-474, 173-175

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Appendix B

Climate and Pollutant Descriptions

Climate

Weather directly influences air quality. Important meteorological factors include wind speed and direction, atmospheric stability, temperature, sunlight intensity, and mixing depth. Temperature inversions, which are associated with higher air pollution concentrations, occur when warmer air overlies cooler air. During temperature inversions in late fall and winter, particulates and CO from wood stoves and vehicle sources can be trapped close to the ground, which can lead to violations of the NAAQS.

Elevated ground level ozone concentrations in the Portland/Vancouver airshed have slightly decreased in the period between 1992 and 2005. In the same period, ozone precursor VOCs and NO_X levels decreased slightly, while maximum summertime temperatures rose. Population and vehicle miles traveled also increased. When comparing similar temperature episodes between years, the ozone levels declined slightly. Temperature episodes are defined as three or more days with maximum temperatures above 90ºF, average wind speeds less than 10 mph, and solar radiation above 1.0 langley/hr. Warm summer weather, combined with still conditions or a temperature inversion, are optimal conditions for photochemical smog (ozone) formation.

The National Weather Service currently issues an Air Stagnation Advisory when poor atmospheric dispersion conditions exist and are forecast to persist for 24 hours or longer. The Department of Ecology's Air Pollution Episode Plan has four stages based on the Pollutant Standards Index (a scale of daily concentrations of individual air pollutants), under which certain activities may be curtailed. When an Air Stagnation Advisory is issued, the Department of Ecology declares a forecast (or first stage), of the episode plan.

Carbon Monoxide

CO is a colorless, odorless, and poisonous gas that reduces the oxygen-carrying capacity of the blood by bonding with hemoglobin and forming carboxyhemoglobin, which prevents oxygenation of the blood. Exposure to CO concentrations of 80 ppm over 8 hours results in a carboxyhemoglobin level of approximately 15 percent (Erlich, 1977). Acute health effects, such as headaches, slowed reflexes, weakened judgment, and impaired perception begin at about 3 percent carboxyhemoglobin (carbon monoxide bonding with 3 percent of the hemoglobin). Chronic effects include aggravation of pre-existing cardiovascular disease and increased heart disease risk in healthy individuals. At carboxyhemoglobin levels of approximately 30 percent, individuals become nauseous and collapse and at very high levels (above 50 percent carboxyhemoglobin) individuals die.

The major source of CO is vehicular traffic, along with industry, wood stoves, and slash burns. In urban areas, motor vehicles are often the source of more than 90 percent of the CO emissions that cause ambient levels to exceed the NAAQS (EPA, 1993a).

Areas of high CO concentrations usually are localized, occurring near congested roadways and intersections during autumn and winter, and are associated with light winds and stable atmospheric conditions. These localized areas of elevated CO levels are referred to as CO hot spots. CO concentration decreases in most areas have resulted from more stringent federal emission standards for new vehicles and the gradual replacement of older, more polluting vehicles. CO levels have been declining in urban areas, but are leveling off or increasing in areas with rapid growth in traffic volumes.

The Vancouver Air Quality Maintenance Area (AQMA) meets the current 8-hour air quality health standard for carbon monoxide. The Southwest Clean Air Agency (SWCAA) has updated the Vancouver Carbon Monoxide Maintenance Plan. The proposed plan shows the area is expected to maintain levels well below the health standard until 2016 with existing controls. No new requirements are proposed.

Particulate Matter

Particulate matter includes small particles of dust, soot, and organic matter suspended in the atmosphere. Particulates less than 100 micrometers in diameter are measured as total suspended particulates (TSP). Particles less than 10 micrometers in size are measured as PM_{10}, a component of TSP. Particles less than 2.5 micrometers in size are measured as $PM_{2.5}$, a component of PM_{10} and TSP.

The smaller $PM_{2.5}$ and PM_{10} particles can be inhaled deeply into the lungs, potentially leading to respiratory diseases and cancer. Particulate matter may carry absorbed toxic substances, and the particle itself may be inherently toxic. Particulate matter can affect visibility, plant growth, and building materials.

Sources of particulates include motor vehicles, industrial boilers, wood stoves, open burning, and dust from roads, quarries, and construction activities. Most vehicular emissions are in the $PM_{2.5}$-size range, while road and construction dust is often in the larger PM_{10} range.

Most vehicle fine particulate emissions result from diesel vehicles, which release fine particulates both directly, mostly as carbon compounds, and indirectly in the form of sulfur dioxide (SO_2), a gas that reacts in the atmosphere to form sulfate particulates.

High $PM_{2.5}$ and PM_{10} concentrations occur in fall and winter during periods of air stagnation and high use of wood for heat. Fireplaces and woodstoves account for almost two-thirds of winter $PM_{2.5}$ emissions. On-road vehicle emissions contribute approximately 12% of the regions $PM_{2.5}$ emissions, while construction and other dust sources contribute approximately 6%. As with ozone, the recently adopted $PM_{2.5}$ standard has been upheld by the U.S. Supreme Court, but has not yet been implemented.

Particulates emitted from diesel vehicles pose specific health risks when compared to other types of particulate matter. The EPA's Clean Air Scientific Advisory Committee is currently reviewing recent health assessment data on diesel emissions; however, the data is not yet available for citation. Previous EPA research (EPA, 1993b) found that components of diesel particulates, primarily high-molecular-weight organic compounds, have several negative health effects, including carcinogenisis, accumulation of particles in the lungs, tissue inflammation, respiratory irritation, and other related effects. Health effects associated with diesel particulates was one of the major contributing factors to establishing the new $PM_{2.5}$ standard.

Ozone

Ozone is a highly toxic form of oxygen and is a major component of the complex chemical mixture that forms photochemical smog. Ozone is not produced directly but is formed by a reaction between sunlight, nitrogen oxides (NO_X), and hydrocarbons (HC). Ozone primarily is a product of regional vehicular traffic, point source, and fugitive emissions (emissions from a variety of uncontrolled sources) of the ozone precursors. Tropospheric (ground-level) ozone, which results from ground-level precursor emissions, is a health risk. Stratospheric (upper-atmosphere) ozone is produced through a different set of chemical reactions that only require oxygen and intense sunlight and protects people from harmful solar radiation. In the remainder of this report, the term ozone refers to tropospheric ozone.

Ozone irritates the eyes and respiratory tract and increases the risk of respiratory and heart diseases. Ozone reduces the lung function of healthy people during exercise, can cause breathing difficulty in susceptible populations (such as asthmatics and the elderly), and damages crops, trees, paint, fabric, and synthetic rubber products. The severity of the health effects are both dose- and exposure-duration-related (National Research Council, 1992). The EPA has adopted a new 8-hour ozone standard; however, the old 1-hour standard is still in place with a simplified maintenance plan under section 110(1)(a) of the federal Clean Air Act, but no longer requires regional conformity determinations. The 8-hour standard was challenged and recently upheld by the U.S. Supreme court. However, the Portland/Vancouver area is currently in attainment for the 8-hour ozone standard.

In the Portland/Vancouver area, the ozone levels start to approach Air Quality Index levels of unhealthy for sensitive groups and NAAQS when temperatures are near or above 90ºF for three consecutive days or more with poor ventilation. Maximum ozone levels generally occur between noon and early evening at locations several miles downwind from the sources, after NO_X and HC have had time to mix and react under sunlight.

Hazardous Air Pollutants (Mobile Source Air Toxic Emissions)

Other chemicals or classes of chemicals in motor vehicle emissions considered hazardous by the EPA include benzene, formaldehyde, 1,3-butadiene, acetaldehyde, and gasoline vapors (EPA, 1993b). Ambient air toxic levels in Vancouver are similar to levels in other urban areas. Many compounds measured in Vancouver in 2005 were lower than those measured during 2001; however, the two monitoring sites were located in different areas within Vancouver.

Benzene and acetaldehyde concentrations were relatively constant throughout a sampling period and likely the result of mobile sources in the area. Arsenic concentrations were noticeably higher during wintertime and may be due to emissions from building heating (it is a trace element in both natural gas and fuel oil, and is present in treated wood). Ambient concentrations of these compounds were similar to those found in other toxic studies in the Pacific Northwest.

Greenhouse Gases

Automobiles also emit greenhouse gases, primarily carbon dioxide (CO_2). CO_2 emissions are proportional to fuel consumption. Passenger cars emit on average 225 grams CO_2 per kilometer traveled (0.8 pounds per mile) and sport-utility vehicles and light trucks emit approximately 50 percent more CO_2 per mile. CO emissions are an order-of-magnitude greater than the emissions of CO and would vary between the alternatives in a similar fashion to CO.

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